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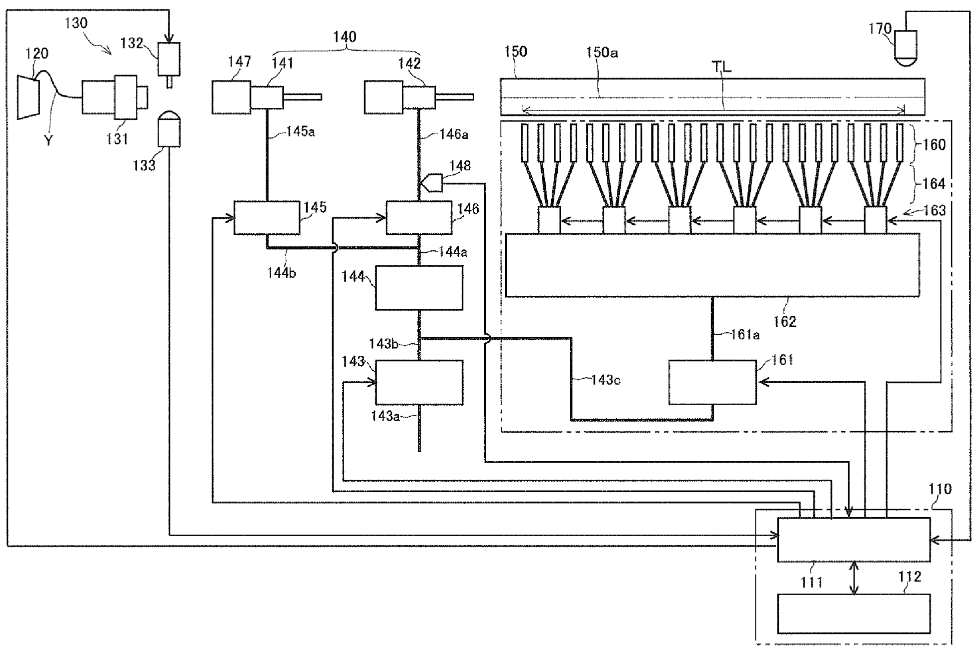
(54) CONTROL DEVICE OF AIR JET LOOM

(57) A control device of an air jet loom of that injects compressed air through a nozzle (140, 141, 142, 160) in accordance with opening or closing of an electromagnetic valve (145, 146, 163) includes a control unit (110) configured to supply to the electromagnetic valve (146) an overexcitation voltage that determines a rise characteristic of an injection pressure of the nozzle (142) while the electromagnetic valve (146) is opening and the injection pressure of the nozzle (142) rising, and to supply to the electromagnetic valve (146) a holding voltage for keeping the electromagnetic valve (146) open after the rising of the electromagnetic valve (146) is completed; and a pressure detection unit (148) configured to detect a pressure of the compressed air that has passed through the electromagnetic valve (146). The control unit (110) adjusts the overexcitation voltage based on a detection results by the pressure detection unit (148).

FIG. 1

100



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Description

BACKGROUND ART

[0001] The present invention relates to a control device of an air jet loom.

[0002] Air jet looms are configured such that a weft yarn in a yarn feeding portion is stored in a weft yarn measuring and storing portion, the stored weft yarn is unwound to start a weft insertion by a main nozzle, and the inserted weft yarn is transferred by sub-nozzles across the weaving width, and the weft insertion is ended. This type of air jet loom injects compressed air through the main nozzle and the sub-nozzles to thereby control traveling of the weft yarn. Thus, appropriate air injection is important for the air jet looms. For the appropriate air injection, a main valve through which compressed air is supplied to the main nozzle need be driven properly.

[0003] In order to control a rise characteristic of injection pressure of the main nozzle for weft insertion properly, the main valve is driven with an overexcitation voltage that is higher than a rated voltage while the injection pressure of the main nozzle is rising, and then the main valve is driven with a holding voltage which is the rated voltage, so that the pressure is maintained at a specified level. An air jet loom which uses a main valve in the way described above is proposed in Japanese Patent Application Publication No. H06-306739.

[0004] High-speed responsiveness of the main nozzle for weft insertion, that is, the rise characteristic of injection pressure of the main nozzle, has various influences on the weft insertion condition of a weft yarn. In a case of a filament yarn or a hard-twisted yarn, if a weft insertion is performed with an injection pressure which is risen in a short period of time, the yarn may be caught easily by warp yarns. In such case, by making the start-up of the main valve gentle, i.e., making the valve start-up time longer, position of the end of the weft yarn is stabilized and the number of mispicks may be reduced.

[0005] Meanwhile, adjusting the overexcitation voltage so that the rising waveform becomes gentle may cause variations in the rise characteristic of the injection pressure of the main nozzle, depending on the individual differences of the main valves. Therefore, suppression of variations in the rise characteristic has been desired even when such adjustment is performed with an overexcitation voltage to make the rising waveform gentle.

[0006] The present invention has been made in view of the above problem, and is directed to a control device of an air jet loom which drives a valve with an overexcitation voltage and adjusts a rise characteristic of an injection pressure of a nozzle properly.

SUMMARY

[0007] In accordance with an aspect of the present invention, there is provided a control device of an air jet loom that injects compressed air through a nozzle in accordance with opening or closing of an electromagnetic valve to thereby control traveling of a weft yarn. The control device includes a control unit configured to supply, to the electromagnetic valve, an overexcitation voltage that determines a rise characteristic of an injection pressure of the nozzle while the electromagnetic valve is opening and the injection pressure of the nozzle rising, and to supply, to the electromagnetic valve, a holding voltage for keeping the electromagnetic valve open after the rising of the injection pressure is completed; and a pressure detection unit configured to detect a pressure of the compressed air that has passed through the electromagnetic valve. The control unit adjusts the overexcitation voltage based on a detection results by the pressure detection unit.

[0008] Other aspects and advantages of the disclosure will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The disclosure, together with objects and advantages thereof, may best be understood by reference to the following description of the embodiments together with the accompanying drawings in which:

FIG. 1 is a schematic view illustrating a configuration of a weft insertion apparatus of an air jet loom according to a first embodiment of the present invention;

FIG. 2 is a chart showing a drive voltage of a main valve and a characteristic of a pressure of compressed air in a normal state, according to the first embodiment of the present invention;

FIG. 3 is a chart showing a drive voltage of the main valve and a characteristic of a pressure of the compressed air in a slow state, according to the first embodiment of the present invention;

FIG. 4 is a chart showing the drive voltage of the main valve and other characteristics of the pressure of the compressed air in the slow state, according to the first embodiment of the present invention;

FIG. 5 is an explanatory view of an adjustment mode screen, according to the first embodiment of the present invention;

FIG. 6 is an explanatory view of the adjustment mode screen, according to the first embodiment of the present invention;

FIG. 7 is an explanatory view of the adjustment mode screen, according to the first embodiment of the present invention;

FIG. 8 is an explanatory view of the adjustment mode screen, according to the first embodiment of the present invention;

FIG. 9 is an explanatory view of the adjustment mode screen, according to the first embodiment of the present invention;

FIG. 10 is a chart showing characteristics during an adjustment of the slow state of the main valve, according to the first embodiment of the present invention;

FIG. 11 is an explanatory view of the adjustment mode screen, according to the first embodiment of the present invention;

FIG. 12 is an explanatory view of the adjustment mode screen, according to the first embodiment of the present invention;

FIG. 13 is a chart showing characteristics after the adjustment of the main valve in the slow state is completed, according to the first embodiment of the present invention;

FIG. 14 is an explanatory view of the adjustment mode screen, according to the first embodiment of the present invention;

FIG. 15 is an explanatory view of the adjustment mode screen, according to the first embodiment of the present invention;

FIG. 16 is an explanatory view of the adjustment mode screen, according to the first embodiment of the present invention; and

FIG. 17 is a chart showing a characteristic after the adjustment of the main valve in the slow state is completed, according to the first embodiment of the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0010] The following will describe an embodiment of a control device of an air jet loom according to the present invention with reference to the accompanying drawings. It is to be noted that in the drawings, like elements and like parts are designated by the same reference numerals.

First Embodiment

[0011] The following will first describe a configuration of a weft insertion apparatus 100 that includes a control device of an air jet loom according to a first embodiment of the present invention, with reference to FIG. 1. FIG. 1 is a schematic view illustrating a configuration of the weft insertion apparatus 100 of an air jet loom according to the first embodiment of the present invention. It is to be noted that in the description of the present invention, with respect to a weft insertion direction in which a weft yarn is inserted into a shed of warp yarns and transferred, the side from which the weft yarn is inserted is referred to as the upstream side, and the side opposite to the weft insertion side is referred to as the downstream side. Also, with respect to a direction in which compressed air flows, the air source side is referred to as the upstream side and the side opposite to the air source side is referred to as the downstream side.

[Configuration of Weft Insertion Apparatus 100]

[0012] Referring to FIG. 1, the weft insertion apparatus 100 includes a control unit 110, a yarn feeding portion 120, a weft yarn measuring and storing portion 130, a weft insertion nozzle 140, a reed 150, a sub-nozzle 160, and a weft yarn arrival sensor 170. It is noted that the control unit 110 corresponds to the control device of the air jet loom. The control unit 110 includes a CPU 111 and a function panel 112. The CPU 111 performs various controls for the weft insertion apparatus 100. The function panel 112, which functions as a display unit and an input unit, displays various pieces of information in response to instructions from the CPU 111, and transmits input information to the CPU 111.

[0013] The yarn feeding portion 120 is disposed upstream of the weft yarn measuring and storing portion 130 and has therein a weft yarn Y The weft yarn Y of the yarn feeding portion 120 is drawn out by the weft yarn measuring and storing portion 130.

[0014] The weft yarn measuring and storing portion 130 includes a yarn storing drum 131 and a weft yarn stop pin 132, and a balloon sensor 133. The yarn storing drum 131 draws out the weft yarn Y from the yarn feeding portion 120 and stores the weft yarn Y in a wound state. The weft yarn stop pin 132 and the balloon sensor 133 are disposed around the yarn storing drum 131. The weft yarn stop pin 132 and the yarn storing drum 131 are disposed side by side in a direction in which the weft yarn Y is unwound.

[0015] The weft yarn stop pin 132 is configured to release the weft yarn Y stored in the yarn storing drum 131 for unwinding when the air jet loom is at a specified rotational angle that is set in the control unit 110. The timing at which the weft yarn stop pin 132 releases the weft yarn Y corresponds to a weft insertion start timing.

[0016] The weft yarn stop pin 132 is configured to detect a weft yarn Y that is unwound from the yarn storing drum 131 during a weft insertion, and issue, to the control unit 110, a signal indicative of the unwinding of the weft yarn (the weft yarn unwinding signal). The control unit 110 is configured to actuate the weft yarn stop pin 132 when the number of times of receiving the weft yarn unwinding signal reaches a prescribed value. In the present embodiment, three is set as the prescribed value. The weft yarn stop pin 132 fixes the weft yarn Y that is unwound from the yarn storing drum 131 to end the weft insertion.

[0017] The actuation timing of the weft yarn stop pin 132 for fixing the weft yarn Y is determined appropriately in accordance with the required number of times of winding the weft yarn Y, which is of a length corresponding to a weaving width TL of the air jet loom, around the yarn storing drum 131. In the present embodiment, the length of the weft yarn Y wound three times around the yarn storing drum 131 corresponds to the weaving width TL. Accordingly, the control unit 110 is programmed to issue, to the weft yarn stop pin 132, an actuating signal for fixing the weft yarn Y when the control unit 110 receives the weft yarn unwinding signal three times from the weft yarn stop pin 132. The weft yarn detection signal of the weft yarn stop pin 132 herein refers to a signal indicative of unwinding of the weft yarn Y from the yarn storing drum 131. The weft yarn detection signal is recognized by the control unit 110 as the timing for unwinding the weft yarn Y based on the signal indicative of a rotational angle of the air jet loom acquired from an encoder.

[0018] The weft insertion nozzle 140 includes a tandem nozzle 141 and a main nozzle 142. The tandem nozzle 141 is configured to draw out the weft yarn Y from the yarn storing drum 131 by injecting compressed air. The main nozzle 142 is configured to insert the weft yarn Y into a weft yarn passage 150a of the reed 150 by injecting compressed air.

[0019] A brake 147 is disposed upstream of the tandem nozzle 141. The brake 147 is configured to apply a brake on the traveling weft yarn Y before an end of a weft insertion.

[0020] The main nozzle 142 is connected to the main valve 146 via a pipe 146a. Compressed air is supplied to the main nozzle 142 through the main valve 146. The main valve 146 is connected to the main tank 144 via a pipe 144a. A pressure detection unit 148 is disposed on an outlet side of the main valve 146 or on the pipe 146a at a position close to the outlet of the main valve 146. The pressure detection unit 148 is configured to detect a pressure of compressed air that has passed through the main valve 146, and to send a detection result to the control unit 110. It is to be noted that as the pressure detection unit 148, a pressure switch which turns on when a prescribed pressure is reached may be used. Using the pressure switch, a time elapsed from a start of supply of an overexcitation voltage until when the pressure of the compressed air having passed through the main valve 146 reaches its peak value is measured, so that the rise characteristic of the pressure is measured using the measured elapsed time.

[0021] The tandem nozzle 141 is connected to the tandem valve 145 via a pipe 145a. The tandem valve 145 is connected to the main tank 144 via a pipe 144b. The main tank 144 is shared with the main valve 146. The main tank 144 is supplied, through a main regulator 143, with compressed air discharged from a commonly used air compressor (not shown) that is installed in a weaving factory. The main tank 144 stores therein compressed air that is supplied from the air compressor and adjusted to a set pressure by the main regulator 143.

[0022] The reed 150 is disposed downstream of the weft insertion nozzle 140. The reed 150 is formed of a plurality of reed wires and has therein a weft yarn passage 150a. A plurality of nozzles constituting the sub-nozzle 160 and the weft yarn arrival sensor 170 are arranged along the weft yarn passage 150a.

[0023] The sub-nozzle 160 is disposed along the weft yarn passage 150a of the reed 150, and comprises the plurality of nozzles. The sub-nozzle 160 is divided, for example, into six groups each comprising four nozzles. Six sub-valves 163 are disposed corresponding to the six nozzle groups of the sub-nozzle 160. The nozzles of each nozzle group of the sub-nozzle 160 are connected to the sub-valve 163 that is to be connected with the corresponding nozzle group through pipes 164. The sub-valves 163 of the nozzle groups are connected commonly to a sub-tank 162.

[0024] The sub-tank 162 is connected to a sub-regulator 161 via a pipe 161a. The sub-regulator 161 is connected via a pipe 143c to a pipe 143b connecting the main tank 144 to the main regulator 143. Thus, compressed air that has passed through the main regulator 143 and is adjusted to a set pressure by the sub-regulator 161 is stored in the sub-tank 162.

[0025] The weft yarn arrival sensor 170 is disposed downstream of the weft yarn passage 150a and also downstream of the weaving width TL, and configured to optically detect arrival of the weft yarn Y. Upon detecting the weft yarn Y, the weft yarn arrival sensor 170 generates a weft yarn detection signal and sends the signal to the control unit 110. The weft yarn detection signal of the weft yarn arrival sensor 170 is a signal that indicates an arrival of the weft yarn Y. The weft yarn detection signal is recognized by the control unit 110 as the timing for ending a weft insertion (hereinafter, the weft insertion end timing IE) based on the signal indicative of a rotational angle of the air jet loom acquired from the encoder.

[0026] The main nozzle 142, the reed 150, and the sub-nozzle 160 are mounted on a sley (not shown) of the air jet loom, and swung in a back and forth direction of the air jet loom. The yarn feeding portion 120, the weft yarn measuring and storing portion 130, the tandem nozzle 141, and the brake 147 are fixed to a frame (not shown) of the air jet loom or to a bracket (not shown) mounted on the floor.

[0027] In the above configuration, the control unit 110 controls an operational timing and an operational period for each of the main valve 146, the tandem valve 145, the sub-valves 163, and the brake 147. It is noted that the main valve 146, the tandem valve 145, and the sub-valves 163 are provided by electromagnetic valves.

[0028] The control unit 110 issues an operation instruction signal to the tandem valve 145 and the main valve

146 at a timing earlier than a weft insertion start timing at which the weft yarn stop pin 132 is actuated, and compressed air is injected from the main nozzle 142 and the tandem nozzle 141.

[0029] The control unit 110 issues an operation instruction signal to the brake 147 at a timing earlier than the weft insertion end timing IE at which the weft yarn stop pin 132 is actuated to fix or stop the weft yarn Y from the yarn storing drum 131. The brake 147 applies a brake on the weft yarn Y traveling at a high speed, so that the traveling speed of the weft yarn Y is reduced to thereby mitigate an impact on the weft yarn Y applied at the weft insertion end timing IE.

[0030] It is to be noted that FIG. 1 shows a single weft insertion apparatus 100 and description is made above as to the weft insertion apparatus 100. However, the present invention may be configured as a multi-color weft insertion apparatus comprising two or more weft insertion apparatuses 100. Also, the idea of the multi-color weft insertion apparatus also includes a configuration comprising a plurality of weft insertion apparatuses 100 for inserting weft yarns Y of the same color.

[Driving Main valve]

[0031] Driving of the main valve 146 for opening and closing will now be described with reference to FIG. 2. FIG. 2 is a chart showing a drive voltage of the main valve 146 and a characteristic of a pressure of compressed air of the main nozzle 142 in a normal state, according to the first embodiment of the present invention. The normal state is used herein in connection with the rise of the injection pressure of the main nozzle 142.

[0032] FIG. 2 at (a) shows the characteristic of the pressure of the compressed air of the main nozzle 142, in the normal state, over the rotational angle of the air jet loom. The pressure is detected by the pressure detection unit 148 disposed on the outlet side of the main valve 146. FIG. 2 at (b) shows the characteristic of the voltage supplied to the main valve 146 driven in the normal state.

[0033] In order for a control to achieve an appropriate rise characteristic of the injection pressure of the main nozzle 142, in a region of FIG. 2 at (b) which corresponds to the region of FIG. 2 at (a) during which the main valve 146 is opening and the injection pressure of the main nozzle 142 rising, the main valve 146 is driven with an overexcitation voltage as the drive voltage that is equal to or greater than a rated voltage. That is, the rise characteristic of the injection pressure of the main nozzle 142 is determined by the overexcitation voltage while the main valve 146 is opening and the injection pressure of the main nozzle 142 rising.

[0034] In the flat region of FIG. 2 at (a) that follows the aforementioned rising region of the injection pressure of the main nozzle 142, in order to keep the injection pressure of the main nozzle 142 at a specified level, the main valve 146 is driven with a rated holding voltage as the drive voltage as shown in FIG. 2 at (b) so that the main valve 146 is kept open. Specifically, the control unit 110 supplies the main valve 146 with the holding voltage for keeping the main valve 146 open after the rising of the injection pressure of the main nozzle 142 is completed.

[0035] FIG. 2 at (c) shows a pulse current that is generated by the control unit 110 and that causes the overexcitation voltage and the holding voltage shown in FIG. 2 at (b). The pulse current is controlled, for example, by the pulse width modulation, the pulse number modulation, or the pulse density modulation. In the present embodiment, the pulse density modulation is used, and FIG. 2 at (c) shows adjustment of the overexcitation voltage and the holding voltage made in accordance with a value of the pulse-density-modulated current to be supplied to the main valve 146. The control unit 110 adjusts the overexcitation voltage and the holding voltage in accordance with a value of the pulse-density-modulated current supplied to the main valve 146.

[0036] Driving of the main valve 146 will now be described with reference to FIG. 3. FIG. 3 is a chart showing the drive voltage and a characteristic of the pressure of the compressed air related to the main valve 146 in a slow state, according to the first embodiment of the present invention.

[0037] FIG. 3 at (a) shows a characteristic of the pressure of the compressed air of the main nozzle 142, in the slow state, over the rotational angle of the air jet loom. The pressure is detected by the pressure detection unit 148 disposed on the outlet side of the main valve 146. FIG. 3 at (b) shows a characteristic of the voltage supplied to the main valve 146 when the main valve 146 is driven in the slow state. The slow state herein refers to a state in which the injection pressure of the main nozzle 142 for weft insertion rises slowly or more gently, as compared with the normal state described in connection with FIG. 2.

[0038] In order to control the rise characteristic of the injection pressure of the main nozzle 142 shown in FIG. 3 at (a) properly as the slow state, in a region of FIG. 3 at (b) which corresponds to the region of FIG. 3 at (a) during which the main valve 146 is opening and the injection pressure of the main nozzle 142 rising, the main valve 146 is driven with the overexcitation voltage as the drive voltage that is equal to or greater than the rated voltage. It is to be noted that the overexcitation voltage in the slow state shown in FIG. 3 at (b) is lower than the overexcitation voltage in the normal state shown in FIG. 2 at (b).

[0039] In the flat region of FIG. 3 at (a) that follows the rising region of the injection pressure of the main nozzle 142, in order to keep the injection pressure of the main nozzle 142 at a specified level, in a region of FIG. 3 at (b) which corresponds to the rising region of FIG. 3 at (a), the main valve 146 is driven with a rated holding voltage as the drive voltage so that the main valve 146 is kept open.

[0040] FIG. 3 at (c) shows a manner in which the overexcitation voltage and the holding voltage shown in FIG.

3 at (b) are attained in accordance with a pulse current that is generated by the control unit 110. FIG. 3 at (c) shows an example of the adjustment of the overexcitation voltage and the holding voltage made in accordance with a value of the pulse-density-modulated current to be supplied to the main valve 146. The control unit 110 adjusts the overexcitation voltage and the holding voltage in accordance with a value of the pulse-density-modulated current supplied to the main valve 146.

[0041] Another state of the driving of the main valve 146 will now be described with reference to FIG. 4. FIG. 4 is a chart showing the drive voltage of the main valve 146 and other characteristics of the pressure of the compressed air of the main nozzle 142, in the slow state, according to the first embodiment of the present invention.

[0042] In the rising region of FIG. 4 at (a) during which the main valve 146 is opening and the injection pressure of the main nozzle 142 rising, the following three rise characteristics may be observed depending on the individual differences of the main valves 146: the natural rise characteristic (see line 1 of the graph); a rise characteristic in which the rising of the injection pressure of the main nozzle 142 is completed faster than the natural rise characteristic (see line 2); and a rise characteristic in which the rising of the injection pressure of the main nozzle 142 is completed later than the natural rise characteristic (see line 3). As illustrated as lines 2 and 3 in FIG. 4 at (a), the sire characteristic has fluctuation. In order to correct such fluctuation to a desired state shown as line 1 in FIG. 4 at (a), the control unit 110 adjusts the overexcitation voltage based on the detection result by the pressure detection unit 148, the details of which is herein described later.

[Adjustment of Main Valve (1)]

[0043] Adjustment of the driving state of the main valve 146 will now be described with reference to FIGS. 5 to 7. FIGS. 5 to 7 are each an explanatory view of an adjustment mode screen, according to the first embodiment of the present invention. FIG. 5 shows an adjustment mode screen 112a that is displayed on the function panel 112 when an adjustment is made to the main valve 146 with the rise characteristic of the injection pressure of the main nozzle 142 in the normal state.

[0044] FIG. 5 shows a state in which adjustment is made to two main valves 146, namely, COLOR 1 and COLOR 2, with the rise characteristic of the injection pressure of the main nozzle 142 being NORMAL (the normal state). In this state, an initial value of the rise time of the is 3.0, and a target value of the rise time is 3.0, for both of the main valves 146.

[0045] In the adjustment mode screen 112a of FIG. 5, when an operator clicks ADJUSTMENT START indicated by (a), the function panel 112 notifies the control unit 110 of the operation by the operator. In response to this, the control unit 110 starts adjustment of the normal mode, and changes the display of the function panel 112 to a screen such as an adjustment mode screen 112b of FIG. 6. In FIG. 6, ADJUSTING indicated by (b1) shows that an adjustment is being made, and (b2) indicates measured values. In the case of FIG. 6, with the matching between the measured values of the rise time and the target values, the adjustment is ended.

[0046] When the adjustment of the main valve 146 in the normal state is completed, the control unit 110 displays a screen such as an adjustment mode screen 112c of FIG. 7 on the function panel 112. In the adjustment mode screen 112c, ADJUSTMENT ENDED indicated by (c1) shows that the adjustment is ended, and values indicated by (c2) are set values when the adjustment was completed.

[Adjustment of Main valve (2)]

[0047] Adjustment of the driving state of the main valve 146 will now be described with reference to FIG. 8 and other subsequent drawings. FIGS. 8 and 9 are each an explanatory view of the adjustment mode screen according to the first embodiment of the present invention.

[0048] FIG. 8 shows an adjustment mode screen 112a that is displayed on the function panel 112 when an adjustment is made to the main valve 146 with the rise characteristic in the slow state. FIG. 8 shows a state in which adjustment is made to the two main valves 146, namely, COLOR 1 and COLOR 2, with the rise characteristic of the injection pressure of the main nozzle 142 being SLOW. In this state, the initial value of the rise time of the injection pressure of the main nozzle 142 is 6.0, and the target value of the rise time is 6.0, for both of the main valves 146.

[0049] In the adjustment mode screen 112a of FIG. 8, when the operator clicks ADJUSTMENT START indicated by (a), the function panel 112 notifies the control unit 110 of the operation by the operator. In response to this, the control unit 110 starts adjustment of the slow mode, and changes the display of the function panel 112 to a screen such as an adjustment mode screen 112b of FIG. 9.

[0050] In the adjustment mode screen 112b of FIG. 9, ADJUSTING indicated by (b1) shows that an adjustment is being made, and (b2) indicates measured values. In this state, the target value of the rise time of the injection pressure of the main nozzle 142 is 6.0 for both of COLOR 1 and COLOR 2, whereas the measured values for COLOR 1 and COLOR 2 are 6.0 and 8.0, respectively.

[0051] FIG. 10 is a chart showing characteristics that correspond to the measured values shown in the adjustment mode screen 112b of FIG. 9. FIG. 10 is a chart showing characteristics observed during the adjustment of the main valve 146 in the slow state, according to the first embodiment of the present invention. FIG. 10 at (a1) shows a characteristic of the pressure in the slow state associated with COLOR 1 of FIG. 9, where the measured value matches up with the target value. FIG. 10 at (a2) shows a characteristic of the pressure in the slow state associated with COLOR 2 of FIG. 9, where the measured value does not match up with the target value. Referring to FIG. 10 at (a2), a delay is observed in the rise characteristic, as compared with the rise characteristic at FIG. 10 (a1).

[0052] In the case of a delay in the rise characteristic associated with COLOR 2, the control unit 110 adjusts the overexcitation voltage based on the detection result by the pressure detection unit 148 so that the rise characteristic becomes a desired state.

[0053] Specifically, the control unit 110 repeats the adjustment by returning a feedback to the overexcitation voltage based on the detection result by the pressure detection unit 148 until a desired state of the rise characteristic is achieved for the delayed rising of COLOR 2.

[0054] In the adjustment mode screen 112c of FIG. 11, 0.7 indicated by (c1) shows that the overexcitation factor of COLOR 2 has risen from 0.5 to 0.7, meaning that the control unit 110 increased the overexcitation voltage. The result of FIG. 11 at (c2) shows that the measured values of the rise time of the injection pressure of the main nozzle 142 are 6.0 and 6.0 for COLOR 1 and COLOR 2 relative to the target values 6.0 and 6.0, respectively. That is, the target values are attained.

[0055] As described above, when the measured values of the rise time match up with the target values, the control unit 110 ends the adjustment. When the adjustment of the main valve 146 in the slow state is completed, the control unit 110 displays a screen such as an adjustment mode screen 112d of FIG. 12 on the function panel 112. In the adjustment mode screen 112d, ADJUSTMENT ENDED indicated by (d1) shows that the adjustment is ended, and values indicated by (d2) are set values when the adjustment was ended.

[0056] A state of the main valve 146 after adjustment will now be described with reference to FIG. 13. FIG. 13 is a chart showing a characteristic observed after the adjustment of the main valve 146 in the slow state, according to the first embodiment of the present invention. In the rising region of the injection pressure of the main nozzle 412 of FIG. 13 at (a), a broken line shows the rise characteristic before adjustment, which is delayed, and a solid line shows the rise characteristic after adjustment. As the solid line shows, the natural rise characteristic is achieved after the adjustment.

[0057] In order to achieve the natural rise characteristic of FIG. 13 at (a), the overexcitation factor shown in FIGS. 11 and 12 is corrected, and a voltage that is higher than that before adjustment is set for the overexcitation voltage after the adjustment, as shown in FIG. 13 at (b), where a broken line shows the overexcitation voltage before adjustment and a solid line shows the overexcitation voltage after the adjustment. In other words, the control unit 110 adjusts the overexcitation voltage of the COLOR 2 based on the detection result by the pressure detection unit 148 so that the desired rise state shown in FIG. 13 at (a) is attained.

[0058] As shown in FIG. 13 at (c), the overexcitation voltage of FIG. 13 at (b) may be achieved in accordance with a pulse current generated by the control unit 110. In this case, the overexcitation voltage is adjusted to a high voltage. Thus, the pulse width or the pulse density of the pulse current of FIG. 13 at (c) is adjusted so that a higher value is attained, as compared with that of the pulse current of FIG. 3 at (c) in a proper state. Accordingly, the rise characteristic of the injection pressure of the main nozzle 142 is adjusted properly.

[Adjustment of Main valve (3)]

[0059] Adjustment of the driving state of the main valve 146 will now be described with reference to FIGS. 14 to 17. FIGS. 14 to 16 are each an explanatory view of the adjustment mode screen, according to the first embodiment of the present invention. FIG. 17 is a chart showing a characteristic observed after the adjustment of the main valve 146 in the slow state, according to the first embodiment of the present invention.

[0060] In the adjustment mode screen 112a of FIG. 14, ADJUSTING indicated by (a1) shows that an adjustment is being made, and (a2) indicates measured values. In this state, the target value of the rise time of the injection pressure of the main nozzle 142 is 6.0 for both of COLOR 1 and COLOR 2, whereas the measured values for COLOR 1 and COLOR 2 are 6.0 and 5.0, respectively. Referring to COLOR 2 of FIG. 14, the target value of the rise time is 6.0, whereas the measured value is 5.0, indicating that the rise characteristic is advanced relative to the target value.

[0061] In the case of an advance in the rise characteristic associated with COLOR 2, the control unit 110 adjusts the overexcitation voltage based on the detection result by the pressure detection unit 148 so that the rise characteristic becomes a desired state. Specifically, the control unit 110 repeats the adjustment by returning a feedback to the overexcitation voltage based on the detection result by the pressure detection unit 148 until a desired state of the rise characteristic is achieved for the advanced rise of COLOR 2.

[0062] In the adjustment mode screen 112b of FIG. 15, 0.4 indicated by (b1) shows that the overexcitation factor of COLOR 2 has dropped from 0.5 to 0.4, meaning that the control unit 110 reduced the overexcitation voltage. As shown in FIG. 15 at (b2), the measured values of the rise time of the injection pressure of the main nozzle 142 are 6.0 and 6.0 for COLOR 1 and COLOR 2 relative to the target values 6.0 and 6.0, respectively. That is, the target values are resultantly attained.

[0063] As described above, when the measured values of the rise time of the injection pressure of the main nozzle 142 match up with the target values, the control unit 110 ends the adjustment. When the adjustment of the main valve 146 in the slow state is completed, the control unit 110 displays a screen such as an adjustment mode screen 112c of FIG. 16 on the function panel 112.

In the adjustment mode screen 112c, ADJUSTMENT ENDED indicated by (c1) shows that the adjustment is ended, and values indicated by (c2) are set values when the adjustment was completed.

[0064] A state of the main valve 146 after adjustment will now be described with reference to FIG. 17. FIG. 17 is a chart showing a characteristic observed after the adjustment of the slow state of the main valve 146, according to the first embodiment of the present invention. In the rising region of the injection pressure of the main nozzle 142 of FIG. 17 at (a), a broken line shows the rise characteristic before adjustment, which is advanced, and a solid line shows the rise characteristic after adjustment. As indicated by the solid line, after the adjustment, the natural rise characteristic is achieved.

[0065] In order to achieve the natural rise characteristic of the injection pressure of the main nozzle 142 of FIG. 17 at (a), the overexcitation voltage factors shown in FIGS. 15 and 16 are corrected, and a voltage that is lower than that before adjustment is set for the overexcitation voltage after the adjustment, as shown in FIG. 17 at (b), where a broken line shows the overexcitation voltage before adjustment and a solid line shows the overexcitation voltage after adjustment. In other words, the control unit 110 adjusts the overexcitation voltage of COLOR 2 based on the detection result by the pressure detection unit 148 so that the desired rise state shown in FIG. 17 at (a) by the solid line is attained.

[0066] As shown in FIG. 17 at (c), the overexcitation voltage of FIG. 17 at (b) may be achieved in accordance with a pulse current generated by the control unit 110. In this case, the overexcitation voltage is adjusted to a low voltage. Thus, the pulse width or the pulse density of the pulse current of FIG. 17 at (c) is adjusted so that a lower value is attained, as compared with that of the pulse current of FIG. 3 at (c) in a proper state. Accordingly, the rise characteristic of the injection pressure of the main nozzle 142 is adjusted properly.

[Other Embodiments]

[0067] Modifications of the first embodiment will be described below. In the above description, the overexcitation voltage of the main valve 146 is adjusted in order to adjust the rise characteristic of the injection pressure of the main nozzle 142. However, in the first embodiment, a pressure detection unit may be provided also to the tandem valve 145, in addition to the main valve 146. In such a case, the rise characteristic of the injection pressure of the tandem nozzle 141 may be adjusted properly.

[0068] Furthermore, in the description of the above embodiment, adjustments are made for two colors, namely, COLOR 1 and COLOR 2. However, a good effect is obtained also in the case of adjustment for a single color. Also, by adjusting the rise characteristic of injection pressure of the main nozzles 142 to be equal among a plurality of air jet looms, the quality of the woven products is maintained uniformly.

[0069] A control device of an air jet loom of that injects compressed air through a nozzle (140, 141, 142, 160) in accordance with opening or closing of an electromagnetic valve (145, 146, 163) includes a control unit (110) configured to supply to the electromagnetic valve (146) an overexcitation voltage that determines a rise characteristic of an injection pressure of the nozzle (142) while the electromagnetic valve (146) is opening and the injection pressure of the nozzle (142) rising, and to supply to the electromagnetic valve (146) a holding voltage for keeping the electromagnetic valve (146) open after the rising of the electromagnetic valve (146) is completed; and a pressure detection unit (148) configured to detect a pressure of the compressed air that has passed through the electromagnetic valve (146). The control unit (110) adjusts the overexcitation voltage based on a detection results by the pressure detection unit (148).

Claims

1. A control device of an air jet loom that injects compressed air through a nozzle (140, 141, 142, 160) in accordance with opening or closing of an electromagnetic valve (145, 146, 163) to thereby control traveling of a weft yarn (Y), the control device comprising:

   a control unit (110) configured to supply, to the electromagnetic valve (146), an overexcitation voltage that determines a rise characteristic of an injection pressure of the nozzle (142) while the electromagnetic valve (146) is opening and the injection pressure of the nozzle (142) rising, and to supply, to the electromagnetic valve (146), a holding voltage for keeping the electromagnetic valve (146) open after the rising of the injection pressure of the nozzle (142) is completed; and
   a pressure detection unit (148) configured to detect a pressure of the compressed air that has passed through the electromagnetic valve (146), **characterized in that**
   the control unit (110) adjusts the overexcitation voltage based on a detection result by the pressure detection unit (148).

2. The control device of an air jet loom according to claim 1, **characterized in that**
   the pressure detection unit (148) is provided by a pressure switch which turns on when a prescribed pressure is reached, and
   the pressure detection unit (148) measures a time elapsed from a start of the supply of the overexcitation voltage until when the pressure of the compressed air having passed through the electromagnetic valve (146) reaches a peak value, and measures the rise characteristic of the injection pressure

of the nozzle (142) using the measured elapsed time.

3. The control device of an air jet loom according to claim 1 or 2, **characterized in that** the control unit (110) adjusts the overexcitation voltage and the holding voltage in accordance with a value of a current supplied to the electromagnetic valve (146).

4. The control device of an air jet loom according to any one of claims 1 to 3, **characterized in that** the electromagnetic valve (146) is a main valve through which compressed air is supplied to a main nozzle (142) that is configured to insert the weft yarn (Y) into a weft yarn passage (150a) by injecting the compressed air.

FIG. 1

100

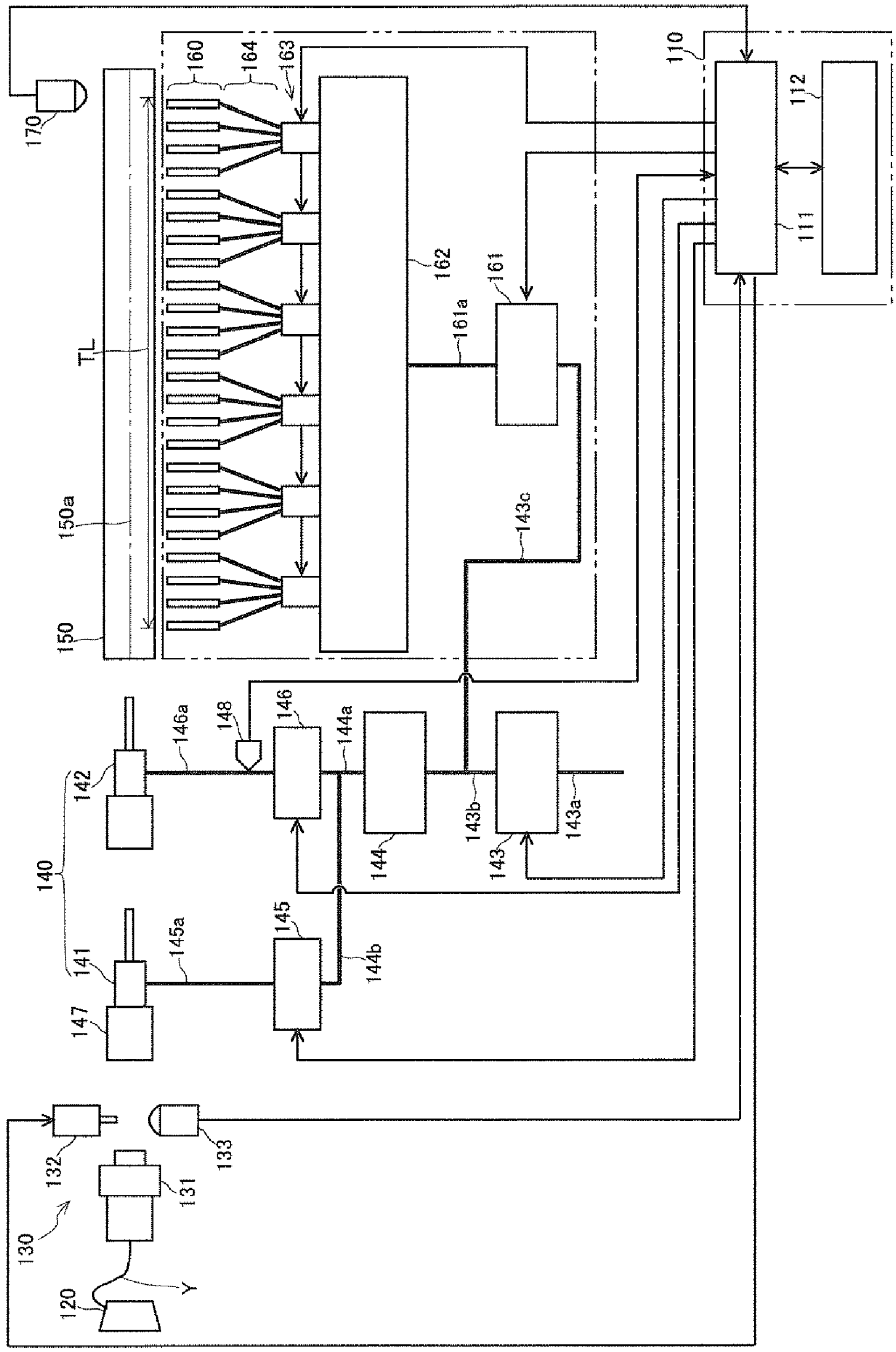

110
111
112
120
Y
130
131
132
133
140
141
142
143
143a
143b
143c
144
144a
144b
145
145a
146
146a
147
148
150
150a
TL
160
161
161a
162
163
164
170

FIG. 2

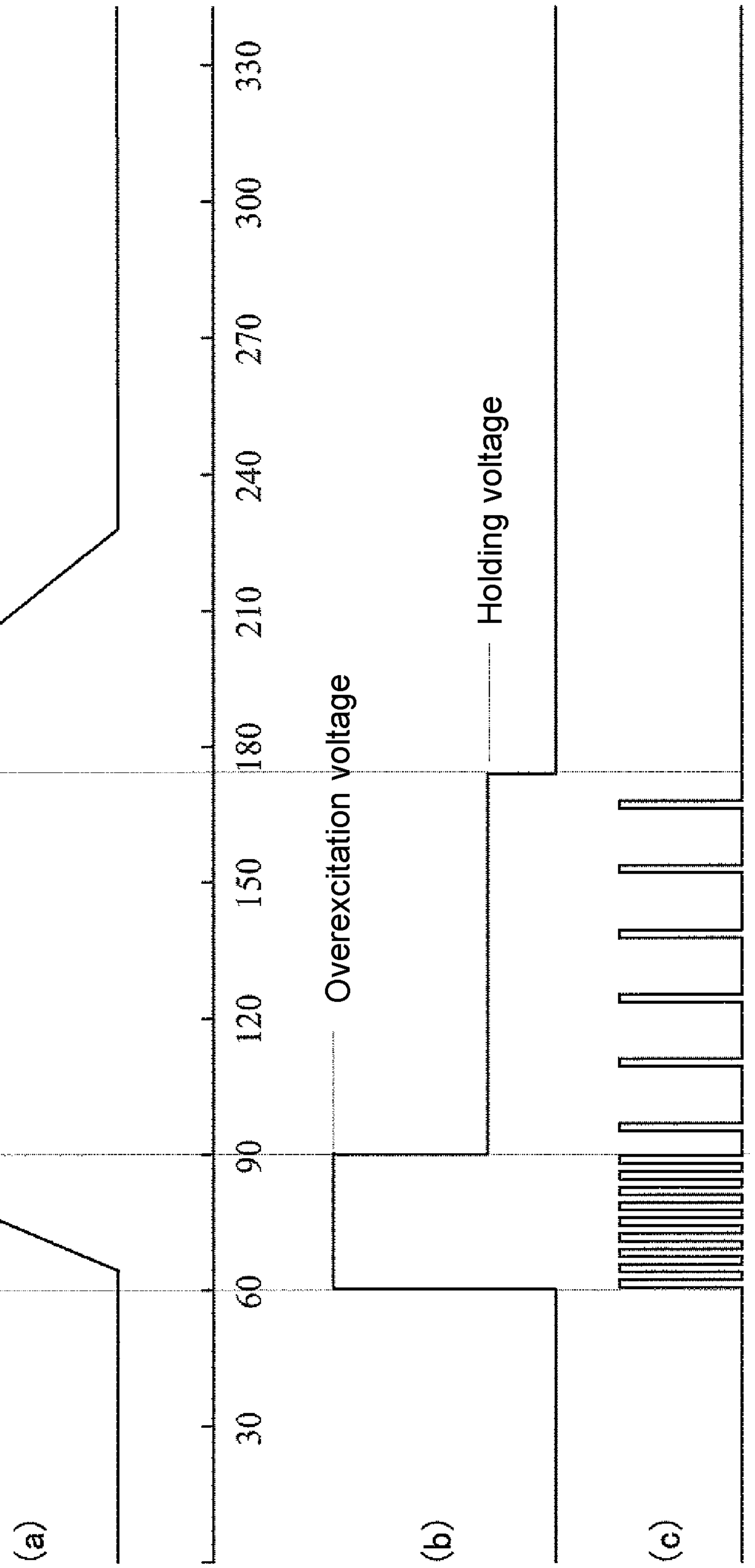

(a)
(b)
(c)
30
60
90
120
150
180
210
240
270
300
330
Overexcitation voltage
Holding voltage

FIG. 3

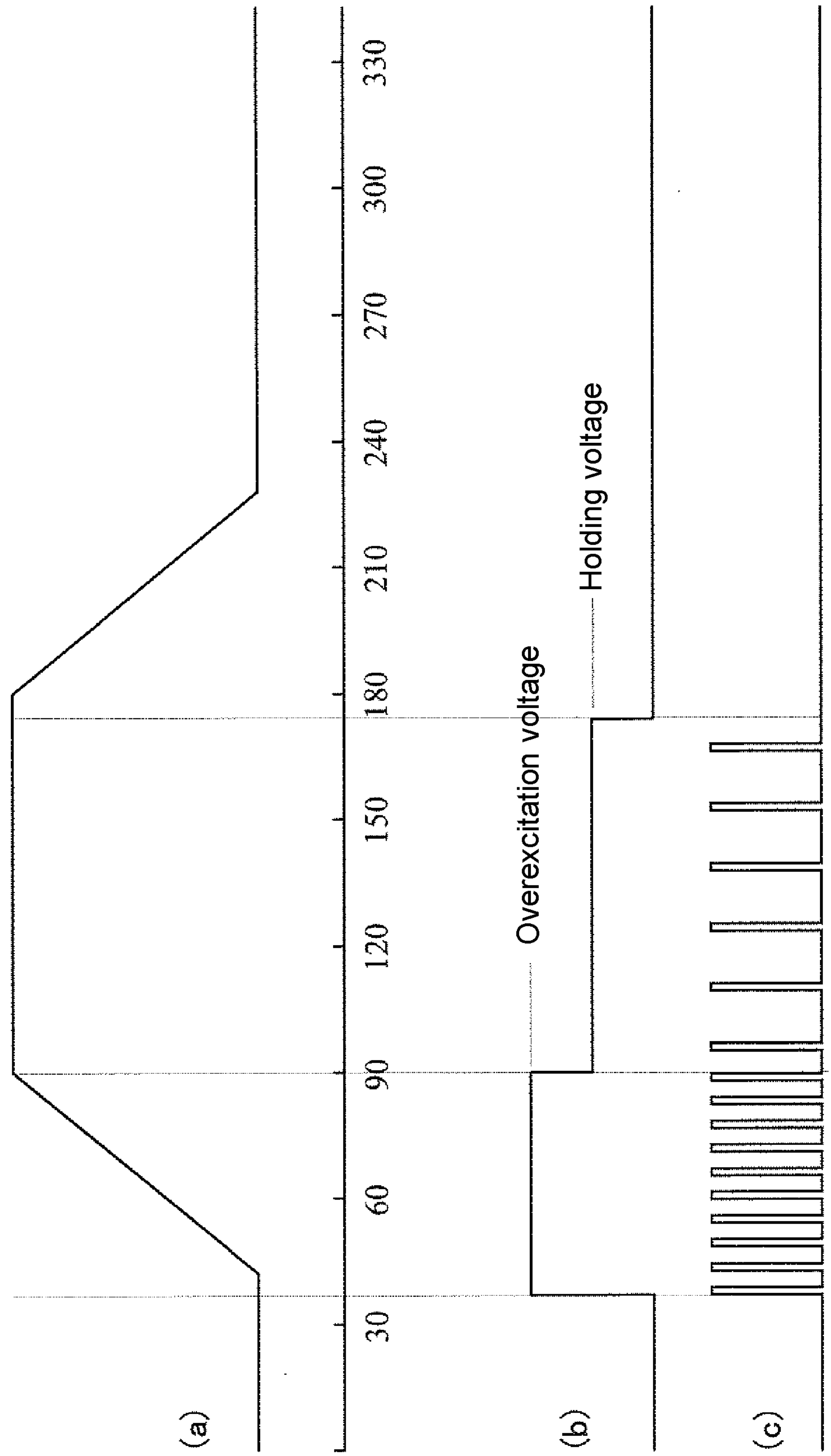

(a)
(b)
(c)
30
60
90
120
150
180
210
240
270
300
330
Overexcitation voltage
Holding voltage

FIG. 4

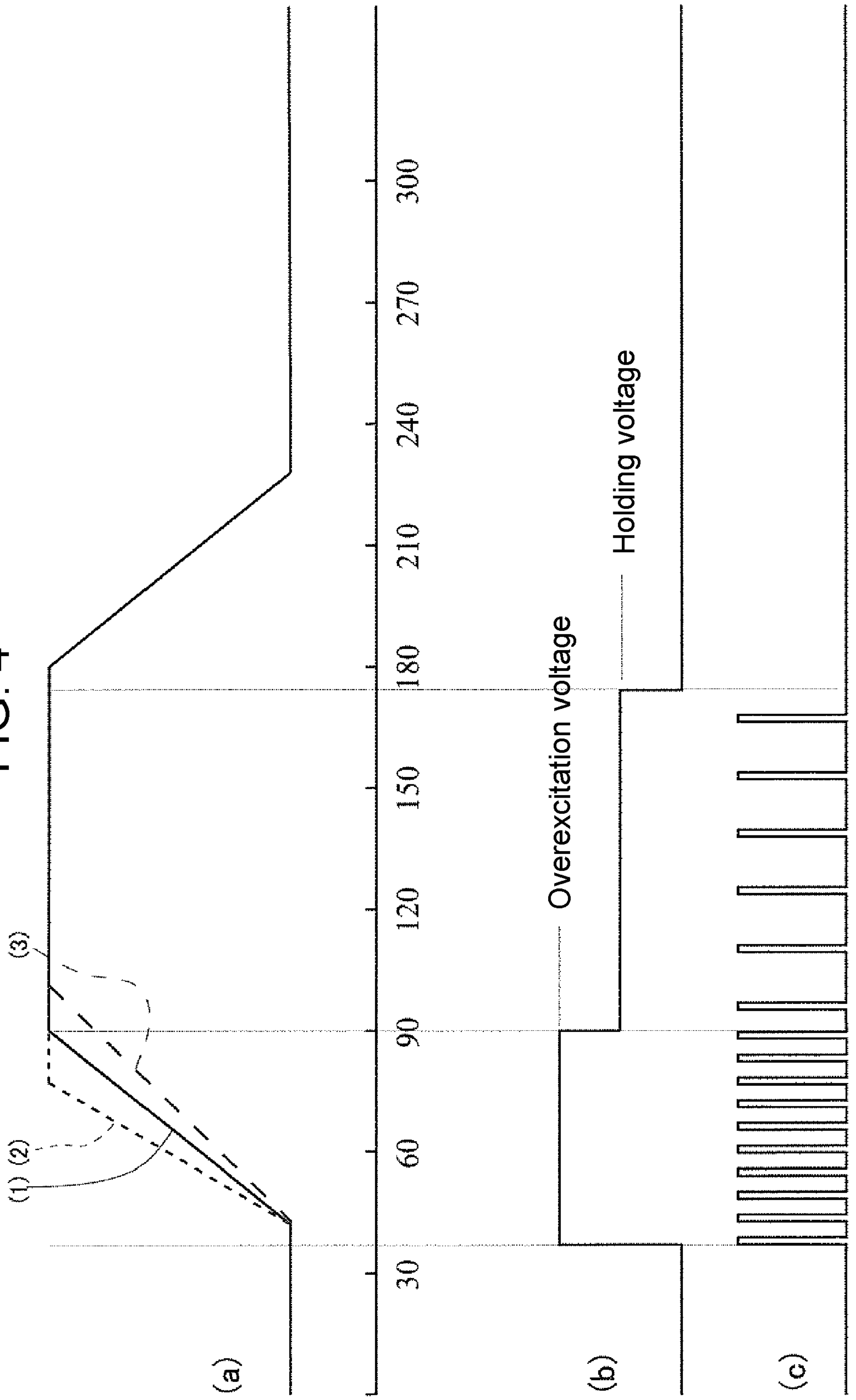

(a)
(b)
(c)
(1)
(2)
(3)
30
60
90
120
150
180
210
240
270
300
Overexcitation voltage
Holding voltage

FIG. 5

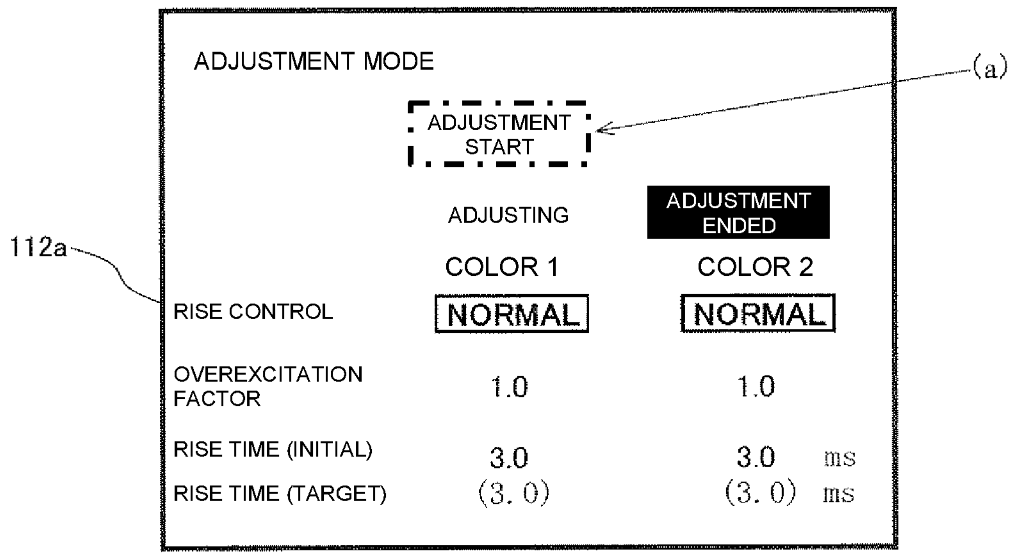

ADJUSTMENT MODE
(a)
ADJUSTMENT START
ADJUSTING
ADJUSTMENT ENDED
112a
COLOR 1
COLOR 2
RISE CONTROL
NORMAL
NORMAL
OVEREXCITATION FACTOR
1.0
1.0
RISE TIME (INITIAL)
3.0
3.0
ms
RISE TIME (TARGET)
(3.0)
(3.0)
ms

FIG. 6

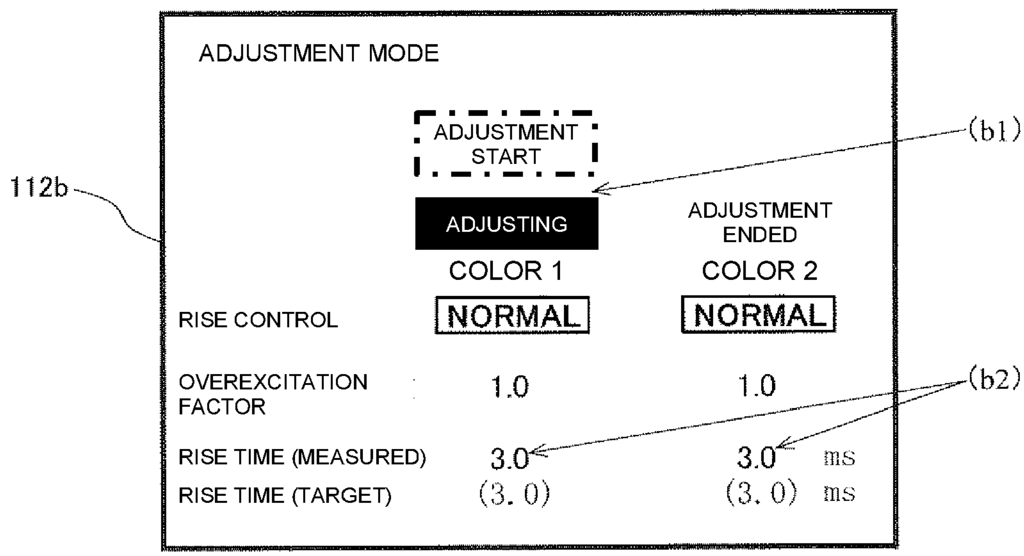

ADJUSTMENT MODE
ADJUSTMENT START
(b1)
112b
ADJUSTING
ADJUSTMENT ENDED
COLOR 1
COLOR 2
RISE CONTROL
NORMAL
NORMAL
OVEREXCITATION FACTOR
1.0
1.0
(b2)
RISE TIME (MEASURED)
3.0
3.0
ms
RISE TIME (TARGET)
(3.0)
(3.0)
ms

FIG. 7

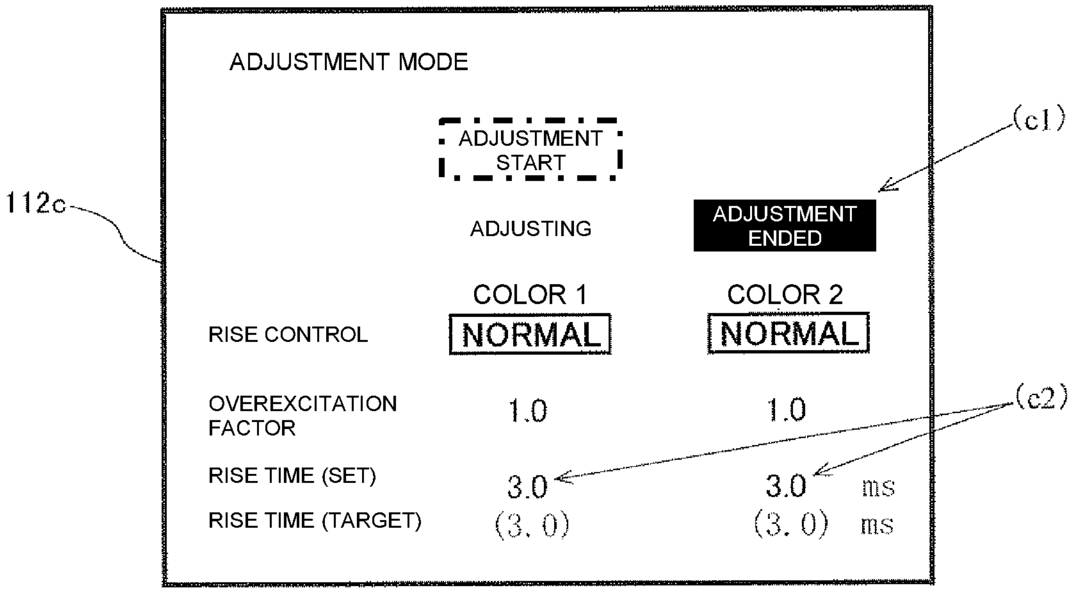

ADJUSTMENT MODE
ADJUSTMENT START
ADJUSTING
ADJUSTMENT ENDED
(c1)
112c
COLOR 1
COLOR 2
RISE CONTROL
NORMAL
NORMAL
OVEREXCITATION FACTOR
1.0
1.0
(c2)
RISE TIME (SET)
3.0
3.0
ms
RISE TIME (TARGET)
(3. 0)
(3. 0)
ms

FIG. 8

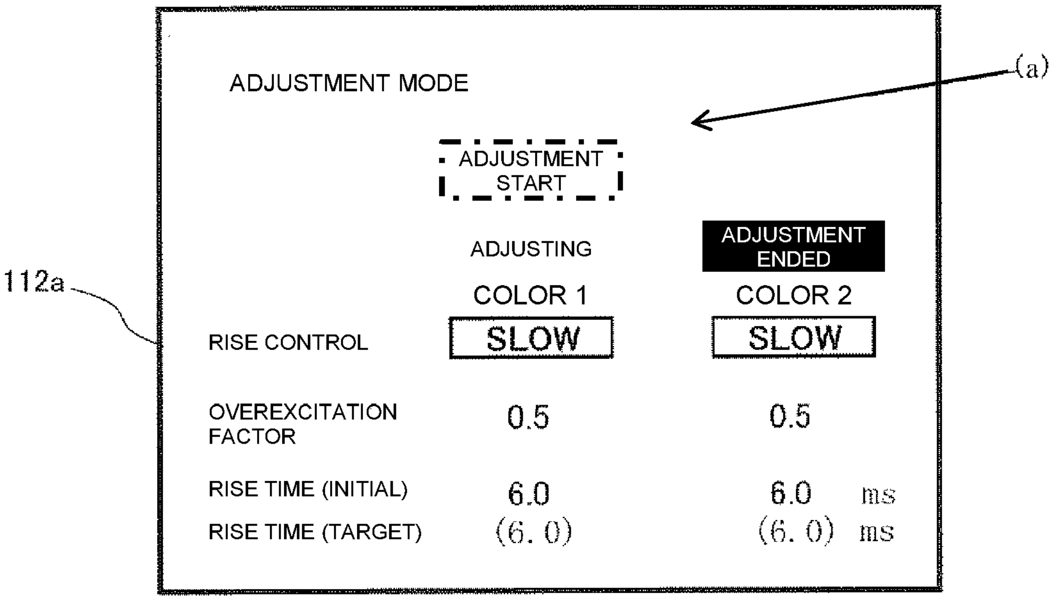

ADJUSTMENT MODE
(a)
ADJUSTMENT START
ADJUSTING
ADJUSTMENT ENDED
112a
COLOR 1
COLOR 2
RISE CONTROL
SLOW
SLOW
OVEREXCITATION FACTOR
0.5
0.5
RISE TIME (INITIAL)
6.0
6.0
ms
RISE TIME (TARGET)
(6. 0)
(6. 0)
ms

FIG. 9

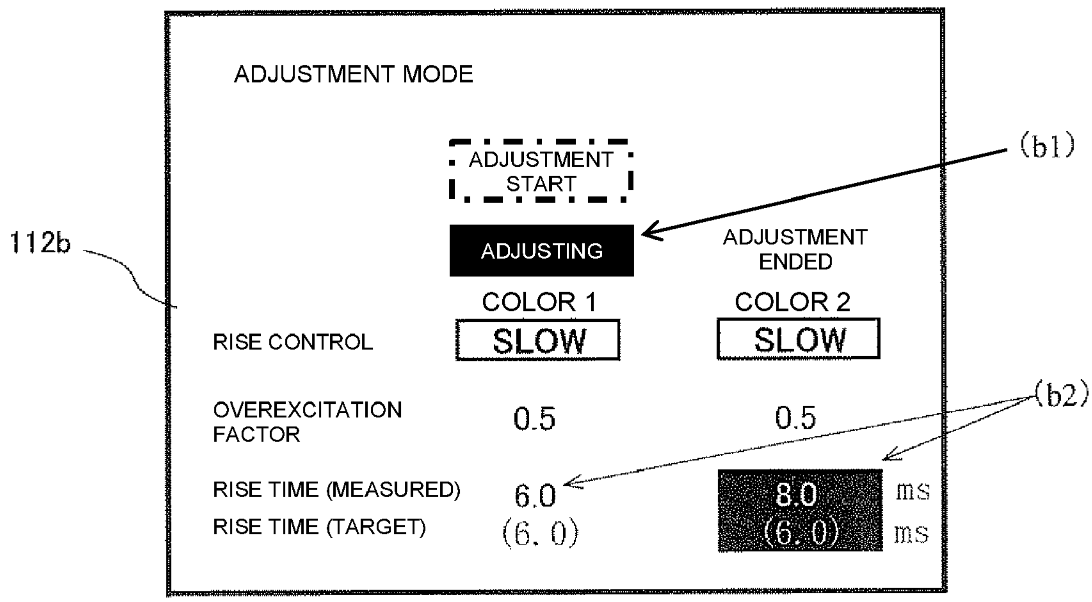

ADJUSTMENT MODE
ADJUSTMENT START
(b1)
112b
ADJUSTING
ADJUSTMENT ENDED
COLOR 1
COLOR 2
RISE CONTROL
SLOW
SLOW
OVEREXCITATION FACTOR
0.5
0.5
(b2)
RISE TIME (MEASURED)
6.0
8.0
ms
RISE TIME (TARGET)
(6.0)
(6.0)
ms

FIG. 10

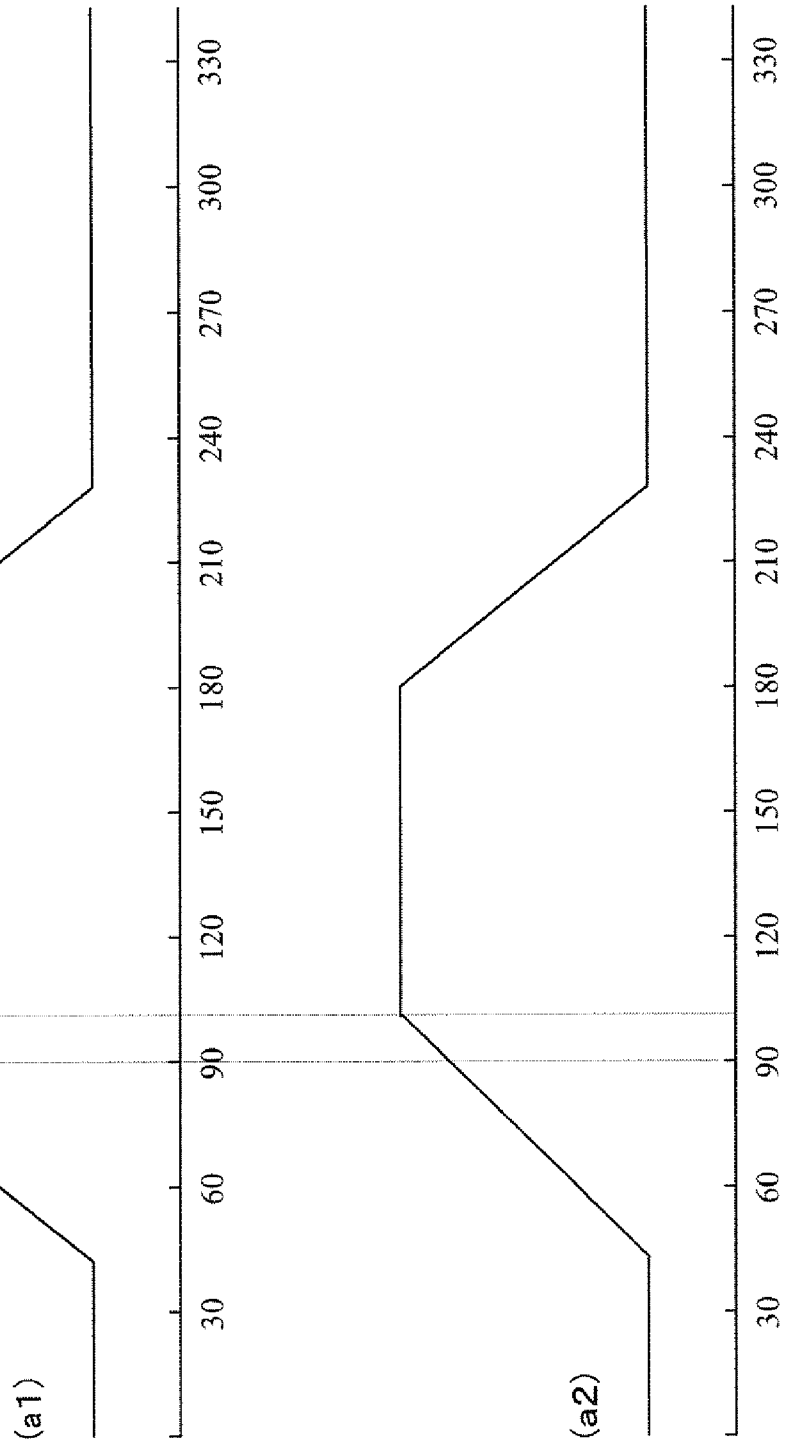


FIG. 11

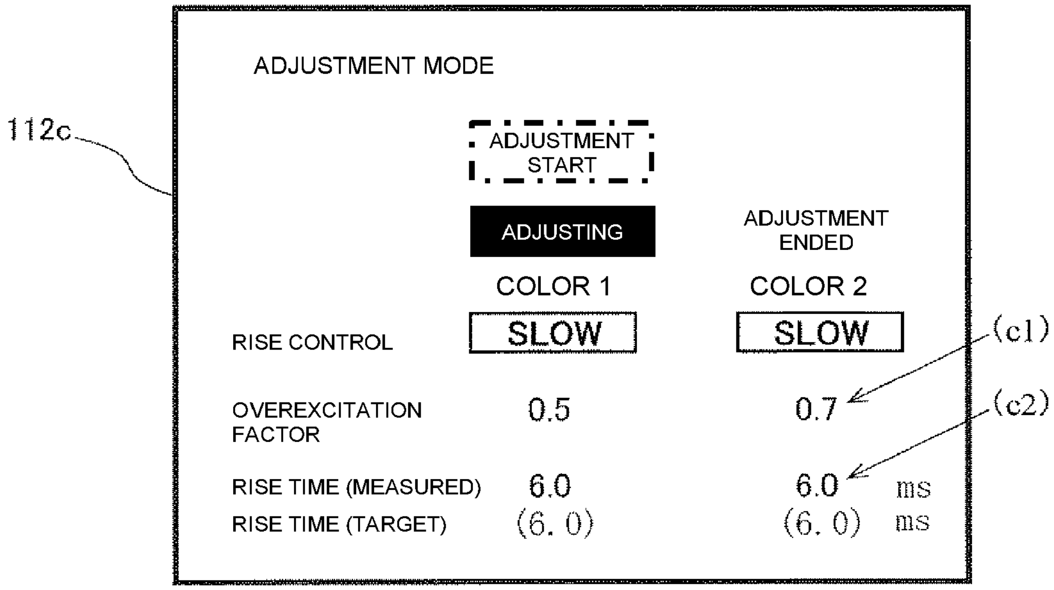

112c
ADJUSTMENT MODE
ADJUSTMENT START
ADJUSTING
ADJUSTMENT ENDED
COLOR 1
COLOR 2
RISE CONTROL
SLOW
SLOW
(c1)
OVEREXCITATION FACTOR
0.5
0.7
(c2)
RISE TIME (MEASURED)
6.0
6.0
ms
RISE TIME (TARGET)
(6. 0)
(6. 0)
ms

FIG. 12

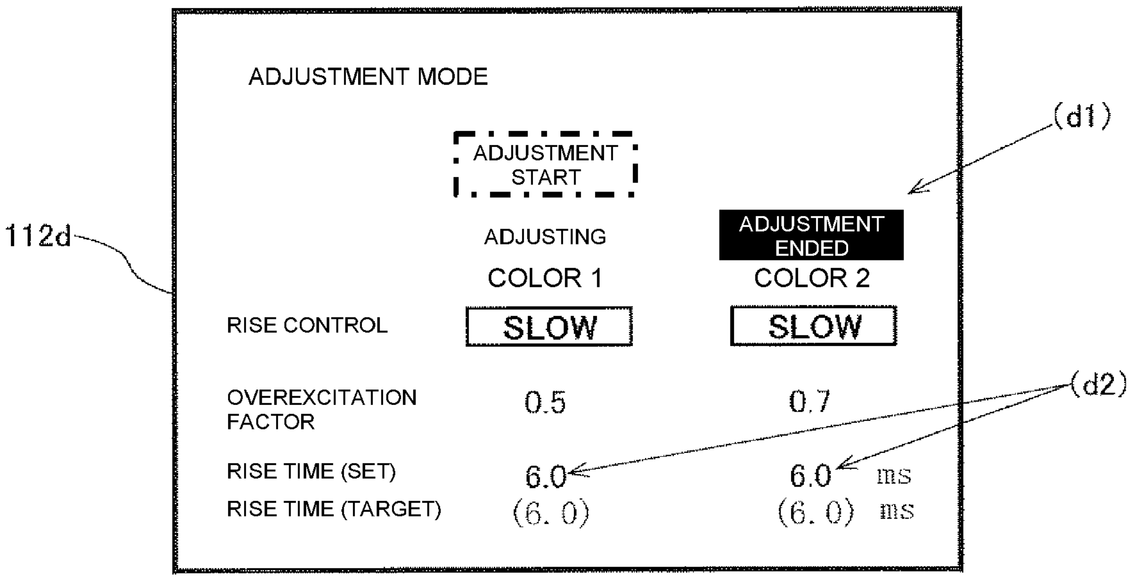
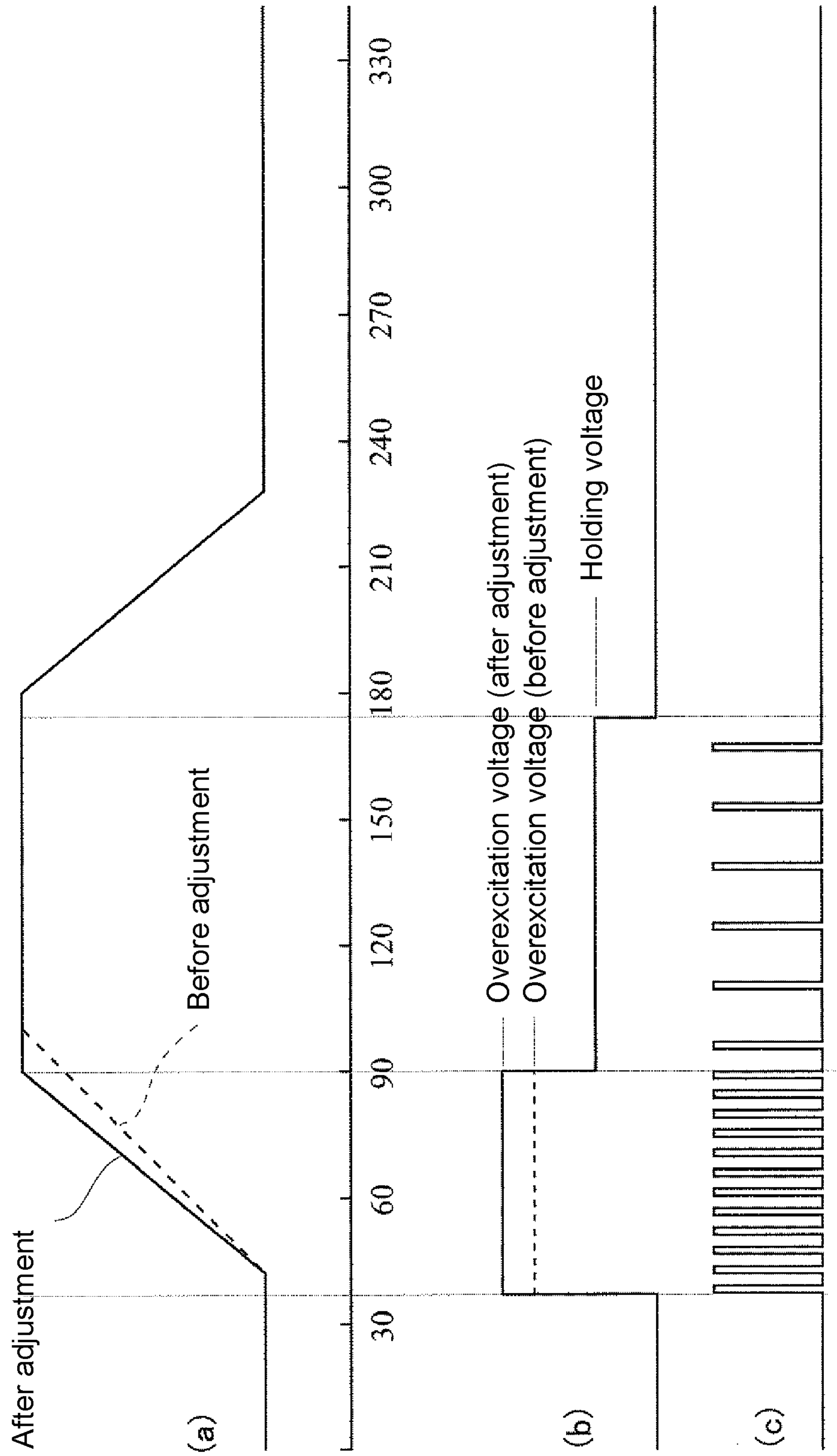

112d
ADJUSTMENT MODE
ADJUSTMENT START
(d1)
ADJUSTING
ADJUSTMENT ENDED
COLOR 1
COLOR 2
RISE CONTROL
SLOW
SLOW
OVEREXCITATION FACTOR
0.5
0.7
(d2)
RISE TIME (SET)
6.0
6.0
ms
RISE TIME (TARGET)
(6. 0)
(6. 0)
ms

FIG. 13



After adjustment
Before adjustment
(a)
(b)
(c)
30
60
90
120
150
180
210
240
270
300
330
Overexcitation voltage (after adjustment)
Overexcitation voltage (before adjustment)
Holding voltage

FIG. 14

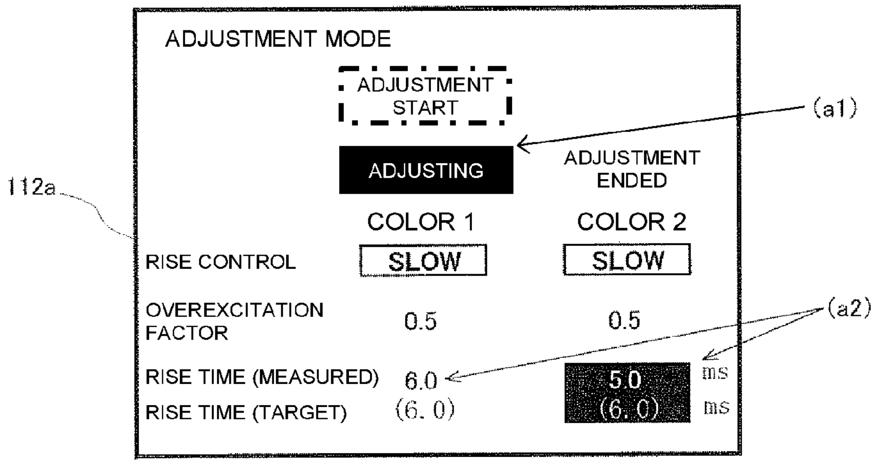


FIG. 15

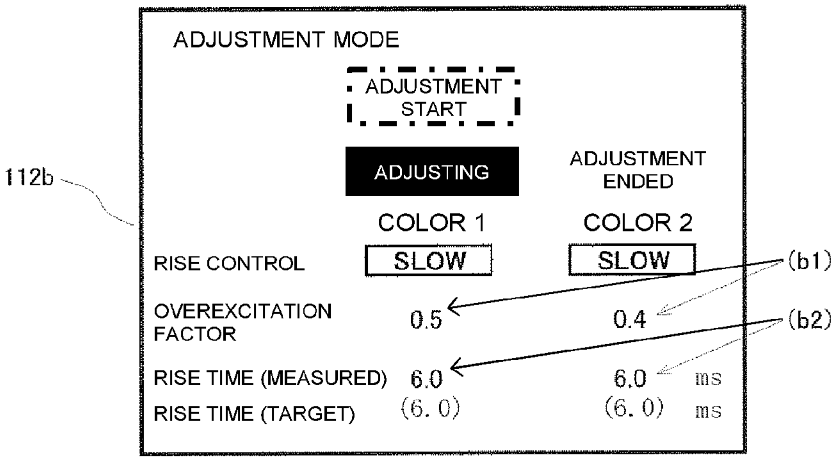


FIG. 16

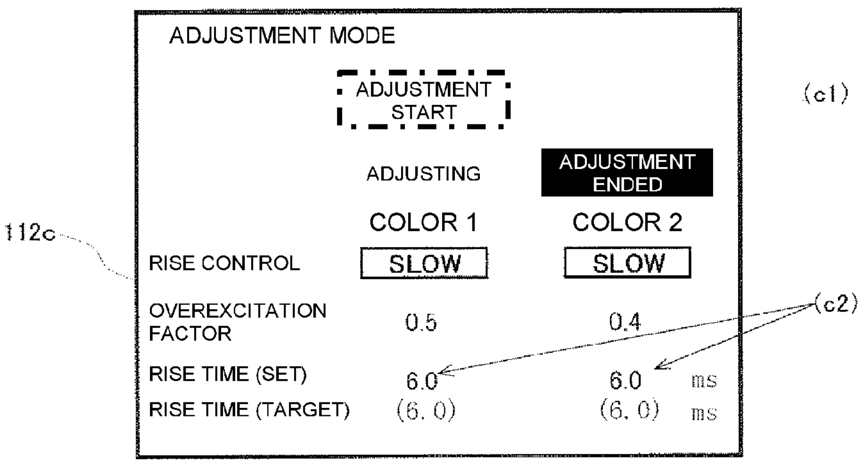
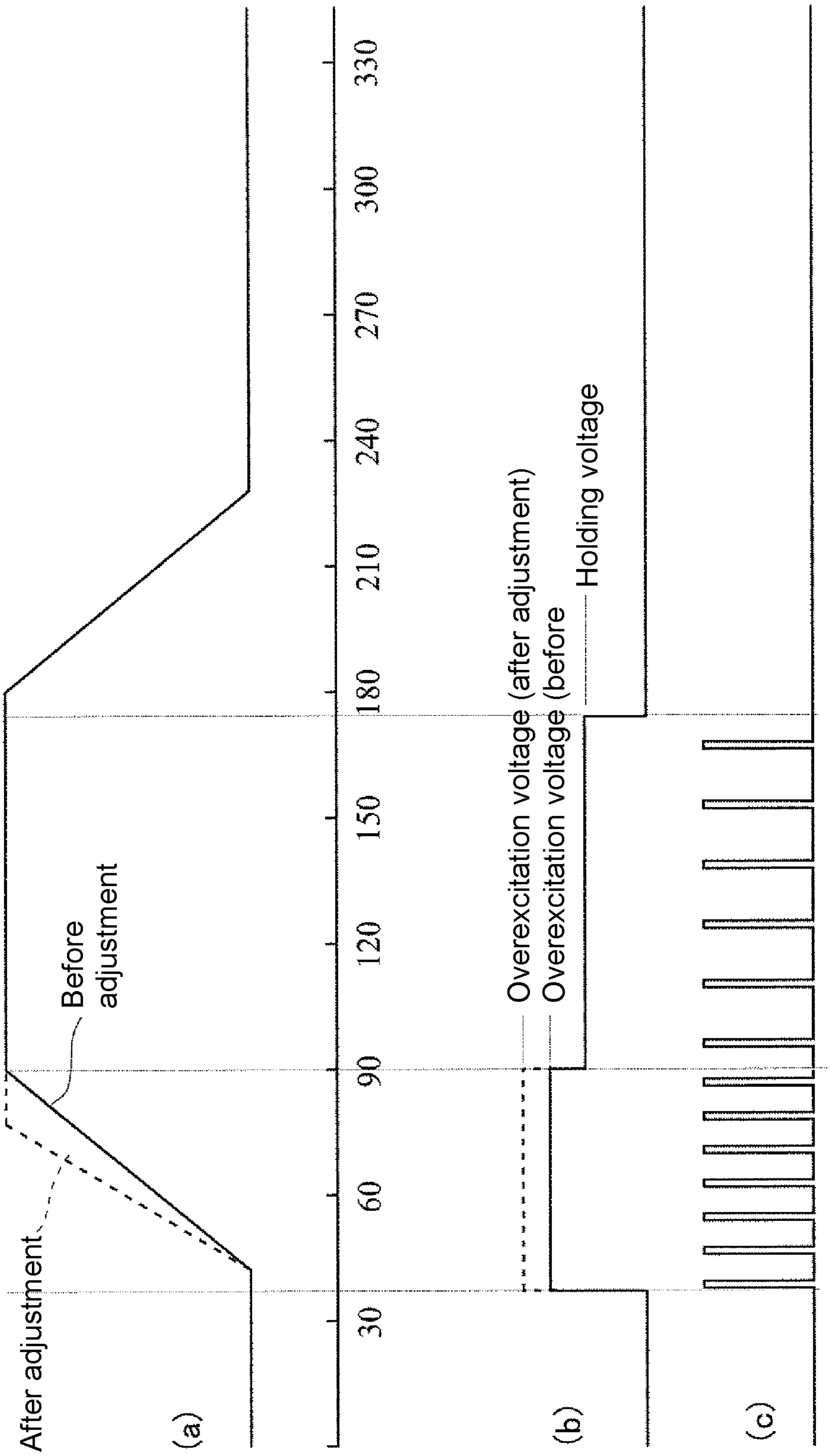


FIG. 17


(a)
After adjustment
Before adjustment
30
60
90
120
150
180
210
240
270
300
330
(b)
Overexcitation voltage (after adjustment)
Overexcitation voltage (before
Holding voltage
(c)

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EUROPEAN SEARCH REPORT

Application Number
EP 20 20 2485

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,D	JP H06 306739 A (TOYODA AUTOMATIC LOOM WORKS) 1 November 1994 (1994-11-01) * paragraph [0009] - paragraph [0025] * * figures 1-6 * -----	1-4	INV. D03D47/30
A	DE 35 30 119 A1 (SCHEFFEL BERND DIPL ING) 26 February 1987 (1987-02-26) * claims 1-4 * * column 3, line 30 - column 4, line 43 * * figures 1-4 * -----	1-4	
A	JP 2002 138345 A (TSUDAKOMA IND CO LTD; LION POWER KK) 14 May 2002 (2002-05-14) * paragraph [0033] - paragraph [0041] * * paragraph [0060] - paragraph [0075] * * figures 1-8 * -----	1-4	

TECHNICAL FIELDS SEARCHED (IPC)

D03D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	12 March 2021	Hausding, Jan

CATEGORY OF CITED DOCUMENTS

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12-03-2021

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP H06306739 A	01-11-1994	NONE	
DE 3530119 A1	26-02-1987	NONE	
JP 2002138345 A	14-05-2002	NONE	

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

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

• JP H06306739 B **[0003]**