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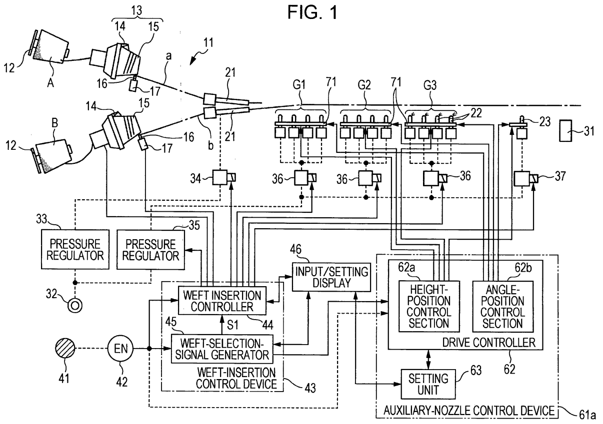
# (54) METHOD AND APPARATUS FOR ADJUSTING EJECTION POSITION OF AUXILIARY NOZZLE IN AIR JET LOOM

(57) The invention refers to a method for adjusting an ejection position of an auxiliary nozzle in an air jet loom which includes a plurality of auxiliary nozzles including a plurality of sub-nozzles (22) arranged along a weft insertion path and a passage detection sensor (31) that detects a passage of a leading end of a weft yarn subjected to weft insertion as a sensor for detecting a travelling condition of the weft yarn, the method comprising the steps of setting at least one of the auxiliary nozzles as an adjustment target and allowing an ejection position of the auxiliary nozzle set as the adjustment target to be adjusted by an actuator (M1, M2); and setting a reference value in advance, the reference value corresponding to a rotational angle of a main shaft of the air jet loom at the time when the leading end of the weft yarn passes a position of the passage detection sensor (31) in a loom width direction; comparing the reference value with the rotational angle at the time when the weft yarn is actually detected by the passage detection sensor (31); and when there is a deviation between the reference value and the rotational angle at the time when the weft yarn is detected by the passage detection sensor (31) due to a change in the travelling condition, driving the actuator (M1, M2) in a direction for eliminating the deviation to adjust the ejection position of the auxiliary nozzle set as the adjustment target.

FIG. 1

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## Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

**[0001]** The present invention relates to a method and an apparatus for adjusting an ejection position of an auxiliary nozzle in an air jet loom which includes a plurality of auxiliary nozzles including a plurality of sub-nozzles arranged along a weft insertion path and which performs a weaving operation that involves a change in a weaving state.

**[0002]** In the present application, the "auxiliary nozzles" include at least the sub-nozzles. More specifically, the auxiliary nozzles may include only the sub-nozzles, or both the sub-nozzles and a stretch nozzle.

**[0003]** In the present invention, the stretch nozzle has a structure similar to that of the sub-nozzles. Of the auxiliary nozzles arranged next to each other in the loom, the stretch nozzle is located closest to a weft arrival side, which is opposite to a weft insertion side, and is spaced from the weft insertion path in front view of the weft insertion path. The stretch nozzle is arranged so that an air ejection hole, more specifically, a direction in which compressed air is ejected toward the weft arrival side from the air ejection hole, forms an acute angle toward the weft arrival side with respect to a weft yarn.

**[0004]** In the present application, the "ejection position" is at least one of an ejection height position and an ejection angle position.

**[0005]** The "ejection height position" is a position of an air ejection hole in a sub-nozzle or a stretch nozzle in an axial direction, more specifically, a height position relative to a reference point. Referring to Fig. 6, the reference point is defined as the lowest point in a movable range of an air ejection hole 22a in the axial direction of the auxiliary nozzle.

**[0006]** The "ejection angle position" is an angular position of the air ejection hole formed in the auxiliary nozzle around an axial line thereof with respect to the axial line. Here, a sub-nozzle 22 will be described with reference to Fig. 7 as an example of an auxiliary nozzle. In a top view of the sub-nozzle 22, the "ejection angle position" is an angle of a straight line that extends from the axial line through an air ejection hole (center of the air ejection hole) 22a with respect to a weft insertion direction.

2. Description of the Related Art

**[0007]** An air jet loom includes a main nozzle that ejects a weft yarn and a plurality of sub-nozzles arranged along a weft insertion path. In a weft insertion process, the main nozzle ejects compressed air so that a weft yarn is ejected from the main nozzle and travels toward a weft arrival side. In addition, the sub-nozzles also eject compressed air within preset periods so that the compressed air ejected from the sub-nozzles serves to assist the movement of the weft yarn.

**[0008]** In such an air jet loom, the ejection positions of the sub-nozzles generally affect the movement of the weft yarn. Accordingly, the ejection positions of the sub-nozzles have been adjusted in accordance with a weaving condition, such as the type of the weft yarn used in the weaving operation. In the present application, the "weaving condition" includes, for example, the type of the weft yarn, a weave structure, and a rotational speed of the loom.

**[0009]** Japanese Unexamined Patent Application Publication No. 2-26958 (hereinafter referred to as Patent Document 1), for example, discloses an example of the related art for adjusting the ejection positions of the sub-nozzles. According to Patent Document 1, sub-nozzles according to the present application are connected to motors capable of adjusting the heights of the sub-nozzles. The height positions of the air ejection holes in the sub-nozzles in the weft insertion are adjusted by the motors in a preparation stage of the loom (while the loom is stopped).

**[0010]** Japanese Examined Utility Model Registration Application Publication No. 3-15576 (hereinafter referred to as Patent Document 2) discloses another example of the related art for adjusting the ejection positions of the sub-nozzles. According to Patent Document 2, a rack-and-pinion mechanism is used. More specifically, a single rack that extends along a weft insertion path is engaged with the sub-nozzles according to the present application, and a rotating mechanism including a pinion is provided at a weft insertion side of the rack. In this case, the ejection angle positions of the air ejection holes in the sub-nozzles at the time of weft insertion are adjusted by the rotating mechanism in a preparation stage of the loom.

**[0011]** In some air jet looms, the weaving condition is changed while the looms are in operation (during the weaving operation). When the weaving condition is changed, the travelling condition of the weft yarn may change accordingly. Therefore, the ejection positions of the sub-nozzles are also preferably changed in accordance with the change in the weaving condition. The ejection positions of the sub-nozzles are preferably changed in accordance with not only the change in the weaving condition but with the change in the weaving state. Here, the "weaving state" includes the weaving condition and a weft travelling condition, such as a weft arrival time, which is the time when the leading end of the weft yarn that travels reaches a predetermined position on the weft insertion path.

**[0012]** However, in the above-described examples of the related art described in Patent Documents 1 and 2, the ejection positions of the sub-nozzles at the time of weft insertion are adjusted and set before the weaving operation is started, that is, in the weaving preparation stage. In addition, the ejection positions are maintained constant in the weft insertion during the weaving operation. Thus, in the above-described examples of the related art described in Patent Documents 1 and 2, the ejection positions of the sub-nozzles cannot be changed in response to a change in the weaving condition during the weaving operation. Therefore, the weft insertion cannot be optimized in accordance with the weaving condition.

**[0013]** According to Patent Document 1, the ejection height positions of the sub-nozzles are changed in the weaving operation. However, the ejection height positions of the sub-nozzles are simply changed between positions for when the weft insertion is performed and positions for when the weft insertion is not performed in the weaving operation. Therefore, the ejection height positions of the sub-nozzles are constant during the weft insertion in the weaving operation.

**[0014]** In addition, only the adjustment for the sub-nozzles according to the present application is described in Patent Documents 1 and 2, and an adjustment for a stretch nozzle that is arranged on the weft arrival side of the sub-nozzles is not described. However, when the stretch nozzle has a structure similar to that of the sub-nozzles, it is conceivable that an adjustment similar to that for the sub-nozzles may be performed for the stretch nozzle.

## SUMMARY OF THE INVENTION

**[0015]** The present invention has been made in view of the above-described circumstances, and an object of the present invention is to provide a method and an apparatus for adjusting an ejection position of an auxiliary nozzle so that weft insertion can be optimized in accordance with a weaving state during a weaving operation.

**[0016]** The present invention is applied to an air jet loom which includes a plurality of auxiliary nozzles including a plurality of sub-nozzles arranged along a weft insertion path and which performs a weaving operation that involves a change in a weaving state.

**[0017]** According to an aspect of the present invention, a method for adjusting an ejection position of an auxiliary nozzle in the above-described air jet loom includes the step of setting at least one of the auxiliary nozzles as an adjustment target and allowing an ejection position of the auxiliary nozzle set as the adjustment target to be adjusted by an actuator, and the step of adjusting the ejection position of the auxiliary nozzle set as the adjustment target in response to the change in the weaving state during the weaving operation.

**[0018]** According to another aspect of the present invention, an apparatus for adjusting an ejection position of an auxiliary nozzle that corresponds to the above-described adjusting method includes a drive device that adjusts an ejection position of at least one of the auxiliary nozzles that is set as an adjustment target, the at least one of the auxiliary nozzles being supported by a support body such that the ejection position thereof is adjustable. The drive device includes an actuator connected to the auxiliary nozzle set as the adjustment target, and a control device that controls a driving operation of the actuator so as to adjust the ejection position of the auxiliary nozzle set as the adjustment target in response to the change in the weaving state during the weaving operation.

**[0019]** In the above-described adjusting method and the adjusting apparatus, the auxiliary nozzles may include the sub-nozzles and a stretch nozzle that is arranged next to the sub-nozzles on a weft arrival side of the sub-nozzles. More specifically, in the adjustment of the ejection position of the auxiliary nozzle set as the adjustment target, at least one sub-nozzle is set as the adjustment target when the auxiliary nozzles include only the sub-nozzles, and at least one of the sub-nozzles and the stretch nozzle is set as the adjustment target when the auxiliary nozzles include the sub-nozzles and the stretch nozzle.

**[0020]** In the adjusting method and the adjusting apparatus, the ejection position of the auxiliary nozzle may be adjusted in accordance with the setting stored in advance in a database.

**[0021]** Accordingly, the air jet loom may be set so as to automatically change the weaving condition during the weaving operation in accordance with a plurality of weaving conditions that are set in advance. In this case, the adjusting method may be used to adjust the ejection position in response to the change in the weaving condition, and may further include the step of setting a database in advance, the database including the ejection position in association with each of the set weaving conditions, and the step of selecting, in response to the change in the weaving condition, the ejection position corresponding to the weaving condition after the change from the database and driving the actuator on the basis of the selected ejection position.

**[0022]** Similarly, in the adjusting apparatus, the control device may include a setting unit in which a database is set, the database including the ejection position in association with each of the set weaving conditions, and a drive controller that selects, in response to the change in the weaving condition, the ejection position corresponding to the weaving condition after the change from the database and controls a driving operation of the actuator connected to the auxiliary nozzle set as the adjustment target on the basis of the selected ejection position.

**[0023]** In particular, the air jet loom may be a multicolor weft insertion loom and the weaving condition may be a weft selection pattern based on which two or more weft yarns of different yarn types are selectively subjected to weft insertion. In this case, in the adjusting method, the database may include the ejection position in association with each of the weft yarns subjected to weft insertion, and when the weft yarns are switched during the weaving operation, the actuator is driven on the basis of the ejection position corresponding to the weft yarn set after the switching.

**[0024]** Similarly, the adjusting apparatus may be used in a loom including a multi-color weft insertion device that includes a weft-selection-signal generator that outputs a weft selection signal in accordance with the weft selection pattern, and the database set in the setting unit may include the ejection position in association with each of the weft yarns subjected to weft insertion. In this case, in response to an input of the weft selection signal from the weft-selection-signal generator, the drive controller may read a set value of the ejection position corresponding to the selected weft yarn from the database.

**[0025]** In the above-described adjusting method and the adjusting apparatus, a sensor may be provided to detect whether or not the ejection position has been appropriately adjusted to the set ejection position. If the ejection position has not been adjusted to the set ejection position, the adjustment may be performed again.

**[0026]** More specifically, the adjusting method may further include the steps of detecting the ejection position after the ejection position is changed, comparing a detection value obtained as a result of the detection with the ejection position selected in accordance with the weaving condition, and, when there is a deviation between the detection value and the selected ejection position, driving the actuator so as to eliminate the deviation.

**[0027]** Similarly, the adjusting apparatus may further include an ejection-position detection sensor that detects the ejection position. The control device may further include a determination unit that compares a detection value obtained by the ejection-position detection sensor after the ejection position is changed with the ejection position selected in accordance with the weaving condition. When there is a deviation between the selected ejection position and the detection value obtained by the ejection-position detection sensor as a result of the comparison performed by the determination unit, the drive controller drives the actuator so as to eliminate the deviation.

**[0028]** The adjusting method and the adjusting apparatus according to the present invention are not limited to those in which the ejection position is changed in accordance with the change in the weaving condition as described above, and the ejection position may instead be adjusted in accordance with the travelling condition of the weft yarn detected by a sensor.

**[0029]** In this case, in the adjusting method, the air jet loom may further include a passage detection sensor that detects the travelling condition of the weft yarn by detecting a passage of a leading end of a weft yarn subjected to weft insertion, and the method may further include the steps of setting a reference value in the setting unit in advance, the reference value corresponding to a rotational angle of a main shaft of the air jet loom at the time when the leading end of the weft yarn passes a position of the passage detection sensor, comparing the reference value with the rotational angle at the time when the weft yarn is actually detected, and, when there is a deviation between the reference value and the rotational angle at the time when the weft yarn is actually detected, driving the actuator in a direction for eliminating the deviation.

**[0030]** Similarly, in the adjusting apparatus, the air jet loom may further include the passage detection sensor and the control device may include the setting unit, a comparator that compares the reference value with the rotational angle at the time when the weft yarn is detected by the passage detection sensor during the weft insertion, and a drive controller which, when there is a deviation between the reference value and the rotational angle at the time when the weft yarn is detected by the passage detection sensor as a result of the comparison performed by the comparator, controls the driving operation of the actuator in a direction for eliminating the deviation.

**[0031]** Here, the process in which "the actuator is driven in a direction for eliminating the deviation" means the process in which the actuator is driven so as to reduce or eliminate the above-described deviation. More specifically, the ejection position of the auxiliary nozzle is adjusted by the actuator to adjust the travelling condition of the weft yarn so that the time at which the leading end of the weft yarn reaches the position of the passage detection sensor approaches the reference value. In this case, the amount by which the actuator is driven corresponds to the above-described deviation, but is not limited to the amount by which the deviation can be eliminated by a single driving operation of the actuator. The actuator may instead be driven by a preset amount in accordance with the direction of the deviation.

**[0032]** According to the present invention, the optimum weft insertion can be performed by adjusting the ejection position of the auxiliary nozzle set as the adjustment target in response to the change in the weaving state during the weaving operation. As a result, the weaving performance and the quality of woven cloth may be improved.

**[0033]** In addition, the database regarding the ejection position may be provided. The ejection position corresponding to the weaving condition may be selected from the database, and the actuator may be driven in accordance with the selected ejection position. In this case, in the air jet loom in which the weaving condition (for example, the weft insertion pattern for selectively subjecting two or more weft yarns of different yarn types to weft insertion) is changed during the weaving operation, when the weaving condition is changed, the ejection position corresponding to the weaving condition after the change is selected from the database. Then, the actuator is driven in accordance with the selected ejection position, so that the ejection position is automatically adjusted. Thus, the ejection position may be adjusted to an optimum position for the weaving condition in the weaving operation without stopping the loom, and the weft insertion may be optimized for each weaving condition in the weaving operation.

**[0034]** In this case, the ejection-position detection sensor that detects the ejection position of each auxiliary nozzle may be provided, and the ejection position that has been adjusted in accordance with the change in the weaving condition may be detected by the ejection-position detection sensor. In this case, the detection value and the ejection position (set value) set in accordance with the weaving condition after the change is compared with each other. When there is a deviation between the detection value and the set value, the actuator is driven so as to eliminate the deviation, so that the ejection position can be reliably optimized in accordance with the weaving condition.

**[0035]** In addition, the passage detection sensor that detects the passage of the leading end of the weft yarn may be provided, and the detection value obtained by the passage detection sensor (the rotational angle of the main shaft of the air jet loom at the time when the weft yarn is actually detected) may be compared with the reference value of the rotational angle of the main shaft of the air jet loom at the time when the leading end of the weft yarn passes the position of the sensor. When there is a deviation between the detection value and the reference value, the actuator is driven in a direction for eliminating the deviation, so that the ejection position is changed in accordance with the travelling condition of the weft yarn. As a result, the travelling condition of the weft yarn that changes as the weaving operation progresses or due to the influence of disturbance may be corrected, and the state in which the weft insertion is appropriately performed can be maintained.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0036]**

Fig. 1 illustrates the main part of a weft insertion device included in an air jet loom and an adjusting device for adjusting an ejection position of an auxiliary nozzle;
Fig. 2 illustrates a driving-force transmitting mechanism for sub-nozzles;
Fig. 3A is a partially cutaway side view of Fig. 2;
Fig. 3B is a sectional view of Fig. 2 taken along line IIIB-IIIB;
Fig. 4 illustrates a modification of the embodiment illustrated in Fig. 1;
Fig. 5 illustrates an adjusting device for adjusting an ejection position of an auxiliary nozzle according to another embodiment;
Fig. 6 illustrates an ejection height position of an auxiliary nozzle; and
Fig. 7 illustrates an ejection angle position of an auxiliary nozzle.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

**[0037]** Fig. 1 illustrates the main part of a loom including a multi-color weft insertion device as an example of an air jet loom to which the present invention can be applied. A two-color weft insertion device 11 for inserting two types of weft yarns, which are a weft yarn a wound around a weft supply package A and a weft yarn b wound around a weft supply package B, is illustrated in Fig. 1. The two-color weft insertion device 11 corresponds to a multi-color weft insertion device according to the present invention.

**[0038]** In the weft insertion device 11 illustrated in Fig. 1, the weft yarns a and b are respectively pulled out from the yarn supply packages A and B supported by respective yarn-supply-package stands 12, and are guided to, for example, yarn winding arms 14 included in drum-type measuring-and-storing devices 13. The yarn winding arms 14 rotate while the weft yarns a and b are retained by stopper pins 16 on outer peripheral surfaces of drums 15 in a stationary state, so that the weft yarns a and b are wound around the outer peripheral surfaces of the drums 15. Thus, a predetermined length of each of the weft yarns a and b that is necessary for a single cycle of weft insertion is wound around the outer peripheral surface of the corresponding drum 15 and is stored until weft insertion is executed.

**[0039]** The operations of the measuring-and-storing devices 13 (rotating operations of the yarn winding arms 14 and the reciprocal operations of the stopper pins 16) and the operations of weft-insertion main nozzles 21 are controlled by a weft insertion controller 44 in a weft-insertion control device 43 on the basis of a weft selection pattern defined by a weft insertion pattern.

**[0040]** At a weft-insertion start time, the stopper pin 16 corresponding to the weft yarn (weft yarn b in the illustrated example) selected by the weft insertion controller 44 is removed from the outer peripheral surface of the corresponding drum 15 by an operating unit 17. Accordingly, the weft yarn b wound around the outer peripheral surface of the drum 15, that is, the predetermined length of weft yarn b that is necessary for a single cycle of weft insertion, is set to a releasable state on the drum 15. Then, the weft-insertion main nozzle 21 through which the weft yarn b extends performs an ejection operation so that the weft yarn b, which extends from the drum 15, is released from the drum 15 and subjected to weft insertion.

**[0041]** At the set weft-insertion start time, the main nozzle 21 corresponding to the selected weft yarn b starts to eject compressed air toward a shed of warp yarns. The ejection of the compressed air is continued for a set ejection period, so that the predetermined length of weft yarn b is inserted into the shed. In this weft insertion operation, the weft yarn b travels along a weft insertion path in the shed. The compressed air is supplied from a compressed air source 32 to a pressure regulator 33, which adjusts the pressure of the compressed air to a pressure suitable for weft insertion. Then, the compressed air is supplied to the main nozzle 21 through an electromagnetic on-off valve 34. The electromagnetic on-off valve 34 is operated in accordance with the weft selection pattern defined by the weft insertion pattern under the control of the weft insertion controller 44.

**[0042]** As described above, the weft insertion device 11 shown in Fig. 1 is a two-color weft insertion device. In the case where multi-color weft insertion of three or more colors, for example, is to be performed, the same number of yarn supply packages, measuring-and-storing devices 13, main nozzles 21, etc. (excluding auxiliary nozzles (sub-nozzles 22 and a stretch nozzle 23 in the present embodiment) and a weft feeler 31, which will be described below), as the number of colors (number of weft yarns) are provided and the weft yarns are subjected to the weft insertion operation in accordance with the weft selection pattern defined by the weft insertion pattern. In the case where single-color weft insertion is performed, a single yarn supply package, a single measuring-and-storing device 13, a single main nozzle 21, etc., are provided.

**[0043]** While the weft yarn b ejected from the main nozzle 21 travels along the weft insertion path in the shed, the multiple sub-nozzles 22 included in the auxiliary nozzles are caused to perform relay ejection in which the compressed air is ejected into the weft insertion path in the travelling direction of the weft yarn b. Thus, the movement of the weft yarn b is assisted in the weft insertion direction. More specifically, the sub-nozzles 22 are arranged along the weft insertion path with intervals therebetween, and are divided into groups in order from the weft insertion side to the weft arrival side. Each group includes a plurality of sub-nozzles 22 (four sub-nozzles 22 in the illustrated example) that are connected to a common electromagnetic on-off valve 36. The sub-nozzles 22 that are connected to the common electromagnetic on-off valve 36 form a single sub-nozzle group. In the figure, the sub-nozzle groups are denoted by G1, G2, G3, ..., in the order of arrangement from the weft insertion side.

**[0044]** The compressed air is supplied from the compressed air source 32 to a pressure regulator 35, which adjusts the pressure of the compressed air to a suitable air pressure. Then, the compressed air is supplied to the sub-nozzles 22 of each sub-nozzle group through the corresponding electromagnetic on-off valve 36. In the weft insertion operation, each electromagnetic on-off valve 36 supplies the compressed air to the sub-nozzles 22 in the corresponding sub-nozzle group for the set ejection period under the control of the weft insertion controller 44. Thus, the sub-nozzles 22 are caused to eject the compressed air so as to assist the movement of the weft yarn b in the weft insertion direction.

**[0045]** When the leading end of the weft yarn b reaches a position closer to the weft arrival side than the sub-nozzle 22 closest to the weft arrival side, the stretch nozzle 23 included in the auxiliary nozzles ejects compressed air to apply a tension to the weft yarn b. For this purpose, the stretch nozzle 23 is disposed at a position closer to the weft arrival side than the sub-nozzles 22 arranged along the weft insertion path, that is, than the sub-nozzle 22 closest to the weft arrival side, with a gap between the stretch nozzle 23 and the sub-nozzles 22. Similar to the sub-nozzles 22, the stretch nozzle 23 is also connected to an electromagnetic on-off valve 37.

**[0046]** When the weft insertion of the weft yarn b is normally performed as a result of the ejection operation performed by the main nozzle 21, the sub-nozzles 22 of each sub-nozzle group, and the stretch nozzle 23, a beating up motion is performed in which the weft yarn b is beaten up against a cloth fell of a woven cloth by a reed (not shown). Thus, the weft yarn b is woven into the woven cloth. Then, the weft yarn b is cut by a yarn cutter (not shown) at the weft insertion side, and is separated from the weft yarn b in the main nozzle 21. Whether or not the weft insertion has been normally performed is determined by a main controller (not shown) of the loom on the basis of a signal from a weft feeler 31 that detects the arrival of the weft yarn b. In the illustrated example, the weft feeler 31 is located outside the line of warp yarns (not shown) at the weft arrival side (at a position closer to the weft arrival side than the stretch nozzle 23 along the weft insertion path).

**[0047]** An encoder 42 is connected to a main shaft 41 to detect a rotational angle of the main shaft 41. The encoder 42 generates a signal representing the rotational angle of the main shaft 41 in the weaving operation, and outputs the signal to the main controller (not shown) of the loom and to the weft insertion controller 44 and the weft-selection-signal generator 45 of the weft-insertion control device 43.

**[0048]** The weft-selection-signal generator 45 in the weft-insertion control device 43 determines the weaving cycle of the loom on the basis of the rotational angle obtained from the encoder 42 and selects one of the weft yarns (weft yarn a or weft yarn b) for each weaving cycle in accordance with the weft selection pattern that is set in advance in the weft insertion pattern. Then, the weft-selection-signal generator 45 transmits a weft selection signal S1 corresponding to the selected weft yarn to the weft insertion controller 44 for each weaving cycle. The weft insertion controller 44 controls, in accordance with set control values, the operations of the measuring-and-storing device 13 and the main nozzle 21 corresponding to the selected weft yarn, the sub-nozzles 22, the stretch nozzle 23, etc., at appropriate rotational angles. Thus, the weft insertion operation of the selected weft yarn is performed.

**[0049]** The weft-insertion control device 43 described above may be structured as a combination of functional blocks. For example, the weft-insertion control device 43 may be provided as a combination of devices constituted by the blocks. Alternatively, predetermined software may be installed in a computer and be executed so that input/output means, storage means, and arithmetic/control means of the computer and the software cooperatively form the blocks, and the weft-insertion control device 43 may be provided as a combination of these blocks.

**[0050]** An input/setting display 46 is connected to the weft-insertion control device 43 so as to allow communication therebetween, so that data of weaving states or the like can be set in the weft-insertion control device 43.

**[0051]** The input/setting display 46 is a display device, and a portion of the display screen of the input/setting display 46 functions as a touch-panel input device. The operator can input settings of various data, display requests, various commands, etc., by touching buttons shown on the display screen.

**[0052]** In the above-described air jet loom, according to the present invention, the weft insertion device 11 includes an adjusting device for adjusting an ejection position of each auxiliary nozzle in addition to the above-described basic structure. In the present embodiment, all of the auxiliary nozzles, that is, all of the sub-nozzles 22 (more specifically, all of sub-nozzles 22 included in all of the sub-nozzle groups) and the stretch nozzle 23, are set as adjustment targets. In addition, both of the ejection height position and the ejection angle position are set as the ejection position to be adjusted. The adjusting device serves as a drive device that adjusts the ejection position of each auxiliary nozzle.

**[0053]** According to the present embodiment, the drive device includes actuators, driving-force transmitting mechanisms 71, and an auxiliary-nozzle control device 61a that serves as a control device. The actuators include two types of drive motors M1 and M2, which are height-position-adjusting drive motors M1 used to adjust the ejection height position and angle-position-adjusting drive motors M2 used to adjust the ejection angle position. A single pair of drive motors M1 and M2 is provided for each of the sub-nozzle groups and the stretch nozzle 23, and is connected to each auxiliary nozzle by the corresponding driving-force transmitting mechanism 71. Thus, in the present embodiment, the sub-nozzles 22 are subjected to the adjustment of the ejection position in units of sub-nozzle groups. Fig. 2 is a front view illustrating the structure in which the sub-nozzles 22 included in each sub-nozzle group are connected to the drive motors M1 and M2 by the corresponding driving-force transmitting mechanism 71. Fig. 3A is a side view of Fig. 2. Fig. 3B is a sectional view of Fig. 2 taken along line IIIB-IIIB. With regard to the stretch nozzle 23, it is connected to each of the drive motors M1 and M2 in one-on-one correspondence (not shown) since there is only one stretch nozzle 23.

**[0054]** Each sub-nozzle 22 is a hollow rod that extends along a straight line. A compressed-air supply port is formed at the proximal end of the sub-nozzle 22. The distal end of the sub-nozzle 22 is closed, and an air ejection hole 22a is formed in a side surface of a distal end portion of the sub-nozzle 22. The air ejection hole 22a extends through the side wall of the sub-nozzle 22 in a direction that is substantially orthogonal to the axial direction of the sub-nozzle 22. Each sub-nozzle 22 has a thick stepped portion 22b that projects radially outward in an area closer to the proximal end than the distal end portion in which the air ejection hole 22a is formed. The thick stepped portion 22b is supported by a dedicated nozzle holder 24, which serves as a support body provided for each sub-nozzle 22, such that the thick stepped portion 22b is rotatable and slidable in the height direction. The dedicated nozzle holders 24 for the respective sub-nozzles 22 are fixed to a reed holder 25 with intervals therebetween along the weft insertion path, so that the sub-nozzles 22 are arranged along the weft insertion path. A reed (not shown) is supported by the reed holder 25.

**[0055]** The driving-force transmitting mechanism 71 includes a part having a height-position adjusting function and a part having an angle-position adjusting function. The detailed structure of each part will now be described.

**[0056]** In the present embodiment, the part of the driving-force transmitting mechanism 71 that has the height-position adjusting function includes a raising-and-lowering unit 72 as a main component. The raising-and-lowering unit 72 includes a plate-shaped base member 73 that extends in the direction in which the sub-nozzles 22 are arranged (hereinafter referred to as a "width direction"); a plurality of support columns 74 that stand upright on the base member 73 at a substantially right angle with respect to the base member 73, and a guide member 75 that is supported on the support columns 74 so as to extend parallel to the base member 73.

**[0057]** In the illustrated example, three support columns 74 are arranged so as to extend parallel to the direction of axial lines of the sub-nozzles 22 and support both end portions and a central portion of the guide member 75 in the width direction. In the following description, the direction of axial lines of the sub-nozzles 22 and directions parallel to the direction of axial lines are referred to as a "height direction".

**[0058]** Each of the guide member 75 and the base member 73 at least has a length that corresponds to the range in which four sub-nozzles 22 that belong to each sub-nozzle group are arranged in the width direction. The raising-and-lowering unit 72 is formed by assembling and integrating the guide member 75 and the base member 73 together with the support columns 74 provided therebetween.

**[0059]** Of the three support columns 74 that connect the guide member 75 to the base member 73, the support column 74 at the center has a threaded hole 81 that opens in an end face of the support column 74 that faces the base member 73 and that extends in the height direction. In addition, the base member 73 has a through hole 82 at a position such that the through hole 82 concentrically communicates with the threaded hole 81 when the base member 73 and the support column 74 are assembled together. The inner diameter of the through hole 82 is slightly greater than that of the threaded hole 81. A screw member 83 that is attached to an output shaft of the height-position-adjusting drive motor M1 is inserted through the through hole 82 and screwed into the threaded hole 81 formed in the support column 74 in the raising-and-lowering unit 72. With this structure, the raising-and-lowering unit 72 is raised or lowered in the height direction when the output shaft of the drive motor M1 is rotated. Thus, the threaded hole 81 in the support column 74 and the screw member 83 attached to the output shaft of the drive motor M1 form a so-called ball screw mechanism.

**[0060]** The drive motor M1 is supported by a support member 78 so that the axis of the output shaft is parallel to the height direction. The support member 78 is disposed in front of and below the reed holder 25 so as to extend in the width direction, and is fixed with screws or the like to a bracket 79 that is fixed to the reed holder 25. The bracket 79 has a through hole 79a at a position below each sub-nozzle 22, and a tube 22c that is connected to the sub-nozzle 22 extends through the though hole 79a.

**[0061]** A pair of guide rods 77 are provided on the support member 78 so as to extend in the height direction at positions corresponding to the support columns 74 at both ends of the raising-and-lowering unit 72. The raising-and-lowering unit 72 has guide holes 76 at positions corresponding to the support columns 74 at both ends. The guide holes 76 extend in the height direction through the base member 73 and into the support columns 74 at both ends. The guide rods 77 are fitted in the respective guide holes 76 in the raising-and-lowering unit 72. Thus, the raising-and-lowering movement of the raising-and-lowering unit 72 is guided in the direction in which the guide rods 77 extend, that is, in the height direction.

**[0062]** A pinion 52 is concentrically fixed to a proximal end portion of each sub-nozzle 22, more specifically, a portion that projects downward from the nozzle holder 24 in the height direction. The guide member 75 included in the raising-and-lowering unit 72 has a guide groove 75a that opens in a surface that faces the sub-nozzles 22. An outer peripheral portion of each pinion 52 is inserted in the guide groove 75a, so that the sub-nozzles 22 are connected to the raising-and-lowering unit 72 such that the sub-nozzles 22 are not movable relative to the raising-and-lowering unit 72 in the height direction. Thus, the position of each sub-nozzle 22 in the height direction is changed (adjusted) in response to the raising-and-lowering movement of the raising-and-lowering unit 72.

**[0063]** In the present embodiment, the part of the driving-force transmitting mechanism 71 that has the angle-position adjusting function includes a rack-and-pinion mechanism including a rack 51 and the above-described pinions 52.

**[0064]** The rack 51 has a length that is greater than that of the guide member 75 in the width direction. The rack 51 is inserted in the guide groove 75a in a manner such that the rack 51 is movable relative to the guide groove 75a in the width direction, and the movement of the rack 51 is guided by the inner surfaces of the guide groove 75a. The rack 51 meshes with each pinion 52 in the guide groove 75a. Therefore, in this structure, when the rack 51 moves in the width direction, the pinions 52 that mesh with the rack 51 are rotated, so that the sub-nozzles 22 rotate around the axes thereof in the forward or reverse direction.

**[0065]** As described above, the length of the rack 51 in the width direction is greater than that of the guide member 75 included in the raising-and-lowering unit 72. Therefore, in the state in which the rack 51 is inserted in the guide groove 75a, an end portion of the rack 51 projects from the guide member 75 in the width direction. The projecting portion of the rack 51 meshes with a pinion 53 that is attached to an output shaft of the angle-position-adjusting drive motor M2. In this structure, the rack 51 moves in the width direction in response to the rotation of the output shaft of the drive motor M2. As a result, the sub-nozzles 22 rotate in response to the rotation of the pinions 52, as described above, and the ejection angle position of each sub-nozzle 22 is changed (adjusted).

**[0066]** The drive motor M2 is supported by the base member 73 included in the raising-and-lowering unit 72. More specifically, similar to the rack 51, the base member 73 also has a length that is greater than that of the guide member 75 in the width direction. The raising-and-lowering unit 72 is configured such that the base member 73 projects from the guide member 75 at one end thereof in the width direction (right end in Fig. 2). The drive motor M2 is placed on the top surface of the projecting portion of the base member 73. Therefore, the position of the drive motor M2 in the height direction is changed together with that of the sub-nozzles 22 in response to the raising-and-lowering movement of the raising-and-lowering unit 72 in the height direction.

**[0067]** Referring to Fig. 1, the drive motors M1 and M2 are connected to the auxiliary-nozzle control device 61a, and are rotated when an exciting current is supplied from the auxiliary-nozzle control device 61a. Thus, the auxiliary nozzles including the sub-nozzles 22 and the stretch nozzle 23 are raised/lowered and rotated such that the ejection positions of the auxiliary nozzles are adjusted.

**[0068]** The auxiliary-nozzle control device 61a includes a drive controller 62, which includes a height-position control section 62a and an angle-position control section 62b, and a setting unit 63. The setting unit 63 is connected to the input/setting display 46 so as to allow communication therebetween. The setting unit 63 receives a database regarding the ejection positions of the sub-nozzles 22 and the stretch nozzle 23 from the input/setting display 46, the ejection positions being set in the input/setting display 46 by an input operation. The received database is set in the setting unit 63. As described above, in the present embodiment, the ejection positions of the sub-nozzles 22 are adjusted in units of sub-nozzle groups. Therefore, the ejection positions of the sub-nozzles 22 are set for each sub-nozzle group in the database.

**[0069]** This database includes, in association with the types of weft yarns (weft yarns a and b), the ejection positions for the sub-nozzles 22 (each sub-nozzle group) and the stretch nozzle 23 which are set as adjustment targets.

**[0070]** In other words, this database includes the ejection height position h and the ejection angle position $\theta$ for each sub-nozzle group and the stretch nozzle 23 in association with each of the weft yarns a and b. For example, h=r1 and $\theta$=x1° are set for the sub-nozzle group G1, h=r2 and $\theta$=x2° are set for the sub-nozzle group G2, h=r3 and $\theta$=x3° are set for the sub-nozzle group G3, ..., and h=rn and θ=xn° are set for the stretch nozzle 23 when the type of weft yarn to be inserted is the weft yarn a. Similarly, h=s1 and θ=y1° are set for the sub-nozzle group G1, h=s2 and θ=y2° are set for the sub-nozzle group G2, h=s3 and θ=y3° are set for the sub-nozzle group G3, ..., and h=sn and θ=yn° are set for the stretch nozzle 23 when the type of weft yarn to be inserted is the weft yarn b.

**[0071]** The drive controller 62 is connected to the setting unit 63 so as to allow communication therebetween, and is also connected to the weft-selection-signal generator 45 in the weft-insertion control device 43 so as to allow communication therebetween. The height-position control section 62a and the angle-position control section 62b of the drive controller 62 are connected to the corresponding drive motors M1 and M2. The weft selection signal S1, which is output from the weft-selection-signal generator 45 in each weaving cycle to switch the weft yarn to be inserted in the weaving operation, is also input to the drive controller 62. The height-position control section 62a and the angle-position control section 62b of the drive controller 62 read the set value of the ejection position that correspond to the weft selection signal S1, which has been received from the weft-selection-signal generator 45, from the database set in the setting unit 63. The height-position control section 62a and the angle-position control section 62b of the drive controller 62 drive the corresponding drive motors M1 and M2 by supplying an exciting current to the drive motors M1 and M2 in accordance with the set value read from the setting unit 63.

**[0072]** The adjusting device for adjusting the ejection position of each auxiliary nozzle adjusts the ejection position of each auxiliary nozzle by the method including the following steps:

(1) In a weaving preparation stage, the database including the above-described information is set in the setting unit 63 by the input/setting display 46.

(2) In the weaving operation, the weft-selection-signal generator 45 outputs the weft selection signal S1 to the weft insertion controller 44 in each weaving cycle. The weft selection signal S1 is output in accordance with the set weft selection pattern on the basis of the signal of the rotational angle (hereinafter referred to as a "crank angle") of the main shaft 41 obtained from the encoder 42. The weft insertion controller 44 selects a weft insertion condition corresponding to the selected weft yarn from a plurality of set weft insertion conditions on the basis of the weft selection signal S1. The weft insertion controller 44 drives the electromagnetic on-off valves 34, 36, and 37 in accordance with the selected weft insertion condition, thereby executing the insertion of the selected weft yarn. In the present embodiment, the weft selection signal S1 is output from the weft-selection-signal generator 45 in the period from the end of the weft insertion to the start of the next weaving cycle (0° in terms of the crank angle). For example, the weft selection signal S1 is output at 340° in terms of the crank angle.

(3) The weft selection signal S1 from the weft-selection-signal generator 45 is output also to the drive controller 62 in the auxiliary-nozzle control device 61a in each weaving cycle. On the basis of the weft selection signal S1, the height-position control section 62a of the drive controller 62 reads from the setting unit 63 the set value of the ejection height position that corresponds to the selected type of weft yarn for each of the sub-nozzle groups and the stretch nozzle 23. Similarly, on the basis of the weft selection signal S1, the angle-position control section 62b of the drive controller 62 reads from the setting unit 63 the set value of the ejection angle position that corresponds to the selected type of weft yarn for each of the sub-nozzle groups and the stretch nozzle 23.

(4) Subsequently, the height-position control section 62a of the drive controller 62 simultaneously drives each height-position-adjusting drive motor M1 on the basis of the set value read from the setting unit 63 so that the ejection height position of each of the sub-nozzle groups and the stretch nozzle 23 approaches the set value. Specifically, the height-position control section 62a of the drive controller 62 determines a deviation between the current set value of the ejection height position and the set value of the ejection height position read from the setting unit 63, and supplies an exciting current to each height-position-adjusting drive motor M1 so that the output shaft of the drive motor M1 is rotated by an angle corresponding to the deviation. Accordingly, the output shaft of each drive motor M1 is rotated and the ejection height position of each of the sub-nozzle groups and the stretch nozzle 23 is changed to the set value of the ejection height position read from the setting unit 63.

**[0073]** The angle-position control section 62b of the drive controller 62 performs a process similar to that performed by the height-position control section 62a. Accordingly, the output shaft of each angle-position-adjusting drive motor M2 is rotated and the ejection angle position of each of the sub-nozzle groups and the stretch nozzle 23 is changed to the set value of the ejection angle position read from the setting unit 63.

**[0074]** The above-described process of changing the ejection position of each auxiliary nozzle (the driving operation of the drive motors M1 and M2) performed by the height-position control section 62a and the angle-position control section 62b of the drive controller 62 in step (4) described above is completed, for example, before the time when the weft insertion for the next weaving cycle is started in response to the weft selection signal S1. Since the weft selection signal S1 is output for each weaving cycle, in the case where the weft selection pattern is such that weft yarns of the same type are to be successively inserted, the set vale of the ejection position may be the same as that in the previous weft insertion cycle. In such a case, the drive controller 62 determines that the above-described deviation is zero and controls the driving operation of the drive motors M1 and M2 so that the rotational angles of the output shafts of the drive motors M1 and M2 (the ejection position of each auxiliary nozzle) are maintained at the current angles.

**[0075]** In the illustrated example of the adjusting device for adjusting the ejection position of each auxiliary nozzle according to the present invention, a ball screw mechanism and a rack-and-pinion mechanism are used in the driving-force transmitting mechanism. However, a rotating gear, a worm gear, a worm wheel, a belt, a chain, etc., may be used instead. In addition, instead the drive motors M1 and M2, direct drive motors that directly drive an object to be driven or direct operated actuators (linear motors) may be used as the actuators.

**[0076]** In the illustrated example, a plurality of sub-nozzles 22 included in each sub-nozzle group are connected to a single height-position-adjusting actuator and a single angle-position-adjusting actuator, and the ejection positions of a plurality of sub-nozzles 22 can be simultaneously adjusted in units of sub-nozzle groups. Alternatively, however, the number of sub-nozzles 22 whose ejection positions are simultaneously adjusted may be smaller than the number of sub-nozzles 22 included in each sub-nozzle group (four in the illustrated example) or larger than the number of sub-nozzles 22 included in each sub-nozzle group. Alternatively, each sub-nozzle 22 may be connected a single height-position-adjusting actuator and a single angle-position-adjusting actuator, and the ejection positions of the sub-nozzles 22 may be adjusted individually. It is not necessary that the sub-nozzles 22 whose ejection positions are adjusted simultaneously be connected to the same actuator, and the ejection positions of the sub-nozzles 22 that are connected to different actuators may be simultaneously adjusted by the same amount.

**[0077]** In the above-described embodiment, the type of the weft yarn to be inserted is used as the weaving condition in accordance with which the ejection position is changed. However, the present invention is not limited to this, and the ejection position may be changed in accordance with other weaving conditions (e.g., the weave structure or the rotational speed of the loom). In an air jet loom (for example, a pile loom) in which a plurality of weaving conditions are simultaneously switched in the weaving operation, the ejection position may be changed for each of weaving patterns, in which the plurality of weaving conditions are switched, in response to a change in the weaving pattern. In this case, the ejection position for each weaving pattern is set in the database in consideration of the plurality of weaving conditions in the weaving pattern.

**[0078]** In the above-described embodiment, the drive controller 62 starts the control for adjusting the ejection position in response to the weft selection signal S1 input thereto, and the process of changing the ejection position is completed before the weft insertion for the next weaving cycle is started. However, the time when the control is started (the time when the driving operation of the actuators is started) is not limited to the time when the weft selection signal S1 is input, and may instead be set to a preset crank angle. Here, the crank angle is determined in consideration of the time required to adjust the ejection position with respect to the time when the weft insertion for the next weaving cycle is started. In such a case, the crank angle (set value) is set in the setting unit 63, and the crank angle signal output from the encoder 42 is input also to the drive controller 62 (see the dashed arrow in Fig. 1). When the crank angle reaches the set value set in the setting unit 63, the drive controller 62 starts the control for adjusting the ejection position and adjusts the ejection position of each auxiliary nozzle.

**[0079]** In the case where the drive controller 62 starts the control at the set crank angle, the ejection position of each auxiliary nozzle may be changed at a time corresponding to the ejection time thereof instead of simultaneously changing the ejection positions of the auxiliary nozzles set as the adjustment targets as in the above-described embodiment. More specifically, in a general air jet loom, the sub-nozzles 22 that belong to different sub-nozzle groups perform the ejection at different times so that relay ejection is performed by the sub-nozzle groups. Therefore, in the case where all of the sub-nozzles 22 are subjected to the adjustment in units of sub-nozzle groups as in the above-described embodiment, the time of adjustment may be set in accordance with the ejection start time of each sub-nozzle group.

**[0080]** In the case where the ejection position is adjusted in accordance with the set value thereof during the weaving operation as in the above-described embodiment, the ejection position of each auxiliary nozzle may be detected after the adjustment, and it can be determined whether or not the detected ejection position is the same as the set ejection position. When there is a displacement between the detected ejection position and the set ejection position, an operation of correcting the displacement may be performed. Here, the case in which "there is a displacement" is the case in which the ejection position cannot be adjusted to the set value and the ejection position after the adjustment differs from the set value because of, for example, control malfunction due to the influence of disturbance or the like, the auxiliary nozzles being caught by other members, such as warp yarns, or a mechanical failure.

**[0081]** Fig. 4 illustrates an auxiliary-nozzle control device 61b capable of correcting the above-described displacement in an adjusting device for adjusting the ejection position of each auxiliary nozzle. The auxiliary-nozzle control device 61b is a modification of the auxiliary-nozzle control device 61a according to the embodiment illustrated in Fig. 1. This adjusting device includes a sensor (not shown) provided on each actuator (each of the drive motors M1 and M2) or each auxiliary nozzle (one of the sub-nozzles 22 included in each sub-nozzle group and the stretch nozzle 23). This sensor is an ejection-position detection sensor (more specifically, an ejection-height-position detection sensor and an ejection-angle-position detection sensor) that detects an ejection position of each auxiliary nozzle. The auxiliary-nozzle control device 61b includes the drive controller 62 (the height-position control section 62a and the angle-position control section 62b) and the setting unit 63 similar to those in the auxiliary-nozzle control device 61a according to the embodiment illustrated in Fig. 1, and further includes a determination unit 64 connected to each ejection-position detection sensor.

**[0082]** The determination unit 64 included in the auxiliary-nozzle control device 61b is also connected to the drive controller 62 so as to allow communication therebetween. In the auxiliary-nozzle control device 61b, after the ejection position (the ejection height position and the ejection angle position) of each auxiliary nozzle set as the adjustment target is adjusted, the ejection position of the auxiliary nozzle is detected by the corresponding ejection-position detection sensor. Then, the detection value of the ejection position is output to the determination unit 64. The determination unit 64 compares the detection value with the set value read from the height-position control section 62a and the angle-position control section 62b of the drive controller 62. When there is a deviation between the detection value and the set value as a result of the comparison, the determination unit 64 outputs the result of the determination to the height-position control section 62a and the angle-position control section 62b of the drive controller 62.

**[0083]** More specifically, the adjusting device corrects the displacement of the ejection position of each auxiliary nozzle by the method including the following steps:

(1) After rotating the drive motors M1 and M2 to adjust the ejection position, the height-position control section 62a and the angle-position control section 62b of the drive controller 62 output the set values of the ejection position for the sub-nozzles 22 (sub-nozzle groups) and the stretch nozzle 23 set as the adjustment targets, which set values are read from the setting unit 63, to the determination unit 64.

(2) The ejection-position detection sensors detect the ejection positions of the sub-nozzle groups and the stretch nozzle 23 and output detection signals representing the detection values to the determination unit 64 at a predetermined time (for example, at a preset crank angle) after the operation of rotating the output shafts of the drive motors M1 and M2 is completed.

(3) The determination unit 64 compares the set value with the detection value for each of the sub-nozzle groups and the stretch nozzle 23 set as the adjustment targets. When there is a deviation (displacement), the determination unit 64 outputs a deviation signal representing the amount of deviation (displacements of the height position and the rotational angle) to the height-position control section 62a and the angle-position control section 62b of the drive controller 62 as the result of the determination. When there is no displacement, it is determined that the amount of deviation is zero (= 0), and the determination unit 64 outputs a deviation signal representing "amount of deviation = 0" to the height-position control section 62a and the angle-position control section 62b of the drive controller 62, or outputs no deviation signal to the height-position control section 62a and the angle-position control section 62b of the drive controller 62.

(4) In the case where there is a displacement, the height-position control section 62a and the angle-position control section 62b of the drive controller 62 drive the corresponding drive motors M1 and M2 on the basis of the deviation signal so as to eliminate the amount of deviation. More specifically, an exciting current is supplied to the drive motors M1 and M2 to rotate the output shafts of the drive motors M1 and M2 by an angle corresponding to the amount of deviation so as to reduce the amount of deviation to 0. Thus, the drive motors M1 and M2 are driven.

**[0084]** In the case where there is no displacement, the height-position control section 62a and the angle-position control section 62b of the drive controller 62 control the driving operation of the drive motors M1 and M2 so as to maintain the output shafts of the drive motors M1 and M2 at the current angle positions in response to the deviation signal representing "amount of deviation = 0" or in response to the absence of the deviation signal.

**[0085]** In addition, in the modification illustrated in Fig. 4, whether or not there is a displacement is determined each time the ejection position is adjusted. However, the determination may instead be performed every time the adjustment of the ejection position is performed a plurality of times.

**[0086]** In the above-described embodiment, the ejection position is changed in accordance with the weaving condition each time the weaving condition is switched. However, the ejection position may instead be changed on the basis of the detection result of a travelling condition of a weft yarn.

**[0087]** In the embodiment illustrated in Fig. 1, it is assumed that the travelling condition of the weft yarn changes when the weaving condition is switched, and the ejection position is changed in accordance with the change in the weaving condition. However, a change in the travelling condition may occur even between the weft yarns supplied from the same weft supply package (the weft supply package A or the weft supply package B) depending on, for example, the unwinding resistance applied to each weft yarn that changes as the weaving operation progresses. Therefore, the travelling condition of the inserted weft yarn may be detected, and the ejection position may be adjusted in accordance with the detection result. With regard to the detection of the travelling condition of the weft yarn, when the travelling condition of the weft yarn changes, the time (crank angle) at which the leading end of the weft yarn passes a certain position on the weft insertion path changes. Accordingly, a sensor that detects a passage (arrival) of the leading end of the weft yarn may be provided on the weft insertion path at, for example, a certain position in an intermediate area or a certain position at the weft arrival side, and such a sensor may be used to detect the travelling condition.

**[0088]** An adjusting device according to an embodiment in which the ejection position of each auxiliary nozzle is adjusted in accordance with the detection result of the travelling condition of the weft yarn as described above will now be described with reference to Fig. 5. The basic structure of the adjusting device according to this embodiment is similar to that of the embodiment illustrated in Fig. 1 except for the auxiliary-nozzle control device. Therefore, Fig. 5 illustrates only an auxiliary-nozzle control device 61c according to the present embodiment, and the auxiliary-nozzle control device 61c will be mainly explained in the following description.

**[0089]** As illustrated in Fig. 5, the auxiliary-nozzle control device 61c includes the drive controller 62 (the height-position control section 62a and the angle-position control section 62b) and the setting unit 63 similar to those in the auxiliary-nozzle control device 61a according to the embodiment illustrated in Fig. 1, and further includes a comparator 65. The comparator 65 included in the auxiliary-nozzle control device 61c is connected to each of the drive controller 62, the setting unit 63, and the main controller (not shown) so as to allow communication therebetween.

**[0090]** In this embodiment, the weft feeler 31 (see Fig. 1) disposed outside the line of warp yarns at the weft arrival side of the air jet loom is used as a sensor (passage detection sensor) for detecting a passage (arrival) of the leading end of the weft yarn. The weft feeler 31 (passage detection sensor), which is connected to the main controller, detects that the leading end of the inserted weft yarn has reached a detection range thereof and outputs a weft detection signal to the main controller. The main controller determines the weft arrival time (actual weft arrival time (detection value)) on the basis of the weft detection signal, and outputs the detection value to the comparator 65.

**[0091]** A target arrival time is set in the setting unit 63 of the auxiliary-nozzle control device 61c as a reference value. In addition, position adjustment amounts (height-position adjustment amounts and angle-position adjustment amounts) for the auxiliary nozzles are also set in association with an amount of deviation between the reference value and the actual weft arrival time (detection value). The comparator 65 in the auxiliary-nozzle control device 61c reads the reference value from the setting unit 63 in response to an input of the detection value and compares the detection value with the reference value. When there is a deviation between the detection value and the reference value as a result of the comparison, the comparator 65 outputs a deviation signal representing the amount of deviation to the height-position control section 62a and the angle-position control section 62b of the drive controller 62.

**[0092]** More specifically, the adjusting device changes the ejection position of each auxiliary nozzle by the method including the following steps:

(1) When the passage detection sensor (weft feeler 31) detects a passage of the leading end of the inserted weft yarn, the passage detection sensor outputs a detection signal indicating that the passage has been detected to the main controller (not shown).
(2) The main controller determines the actual weft arrival time (detection value) based on the detection signal, and outputs the determined detection value to the comparator 65.
(3) The comparator 65 reads the target weft arrival time (reference value) from the setting unit 63 in response to an input of the detection value, and compares the reference value with the detection value.
(4) When there is a deviation between the reference value and the detection value as a result of the comparison, the comparator 65 outputs a deviation signal representing the amount of deviation to the height-position control section 62a and the angle-position control section 62b of the drive controller 62. When there is no deviation, it is determined that the amount of deviation is zero (= 0), and the comparator 65 outputs a deviation signal representing "amount of deviation = 0" to the height-position control section 62a and the angle-position control section 62b of the drive controller 62, or outputs no deviation signal to the height-position control section 62a and the angle-position control section 62b of the drive controller 62.
(5) When there is a deviation, the height-position control section 62a and the angle-position control section 62b of the drive controller 62 change the ejection position by rotating the output shafts of the drive motors M1 and M2 in directions for eliminating the deviation on the basis of the deviation signal. More specifically, the height-position control section 62a and the angle-position control section 62b of the drive controller 62 read the position adjustment amount corresponding to the amount of deviation from the setting unit 63, and drives the corresponding drive motors M1 and M2 by supplying an exciting current to the drive motors M1 and M2 so as to rotate the output shafts of the drive motors M1 and M2 by angles corresponding to the position adjustment amount read from the setting unit 63.

**[0093]** In the case where there is no deviation, the height-position control section 62a and the angle-position control section 62b of the drive controller 62 control the driving operation of the drive motors M1 and M2 so as to maintain the output shafts of the drive motors M1 and M2 at the current angle positions in response to the deviation signal representing "amount of deviation = 0" or in response to the absence of the deviation signal.

**[0094]** The above-described steps (1) to (5) may be performed each time the weft insertion is performed. Alternatively, steps (1) to (5) may be performed every time the weft insertion is performed a certain number of times, or at a preset timing. In addition, the average value of detection values obtained by the passage detection sensor within a predetermined period may be determined, and the presence or absence of the deviation may be determined by comparing the average value with the reference value.

**[0095]** In the above-described adjusting method according to the present embodiment, the amount of deviation is used as a parameter, and the position adjustment amounts are set in association with the amount of deviation in the setting unit 63. Alternatively, however, the amount of deviation and the ejection position of each auxiliary nozzle before the adjustment may both be set as parameters, and the position adjustment amounts may be set in association with these parameters. For example, assume that the height-position adjustment amount is X and the angle-position adjustment amount is $\alpha$ when the amount of deviation is $\gamma$ and when the ejection height position and the ejection angle position of an auxiliary nozzle before the adjustment is h1 and $\theta 1$, respectively. In this case, even when the amount of deviation is $\gamma$, when the ejection height position and the ejection angle position of the auxiliary nozzle before the adjustment is h2 and $\theta 2$, respectively, the height-position adjustment amount is set to Y and the angle-position adjustment amount is set to $\beta$. Thus, the position adjustment amounts can be more finely set.

**[0096]** In the above-described method, the position adjustment amounts are set in advance in association with the amount of deviation, and the drive motors M1 and M2 are driven in accordance with the determined amount of deviation. Alternatively, however, the ejection position may be adjusted by a predetermined position adjustment amount in accordance with only the direction of deviation. Here, the direction of deviation described herein corresponds to the magnitude relation between the reference value and the detection value, and is either + or -. In this case, instead of the above-described position adjustment amounts associated with the amount of deviation, only the predetermined position adjustment amount is set in the setting unit 63. Here, different position adjustment amounts may be set for the respective directions of deviation (+ and -) in the setting unit 63.

**[0097]** More specifically, in the control process performed in step (5), when there is a deviation, the height-position control section 62a and the angle-position control section 62b of the drive controller 62 read the position adjustment amount from the setting unit 63 in response to the input of the deviation signal. Then, an exciting current is supplied to the drive motors M1 and M2 to rotate the output shafts of the drive motors M1 and M2 by angles corresponding to the position adjustment amount read from the setting unit 63 in a direction corresponding to the direction of the deviation indicated by the deviation signal. Thus, the drive motors M1 and M2 are driven. The above-described steps (1) to (4) and step (5) in which only the direction of the deviation is taken into account are repeated until the deviation is eliminated.

**[0098]** In the above-described example, the travelling condition of the weft yarn is detected by detecting the time at which the leading end of the weft yarn reaches the arrangement position of the weft feeler 31 at the weft arrival side of the weft insertion path. However, the travelling condition of the weft yarn may instead be detected by detecting the time at which the leading end of the weft yarn reaches a predetermined intermediate position on the weft insertion path in the weaving width direction (hereinafter referred to simply as a "predetermined intermediate position"). In this case, the detection is performed by a release sensor provided on each measuring-and-storing device 13 or a dedicated sensor provided at the predetermined intermediate position instead of the weft feeler 31 at the weft arrival side.

**[0099]** The case in which the release sensor is used will now be described. The release sensor is provided on each measuring-and-storing device 13 described above in the embodiment of Fig. 1, and is used to detect the length of the weft yarn released from the state in which the weft yarn is wound around the drum 15 in the measuring-and-storing device 13 in units of turns. More specifically, a predetermined length of weft yarn that is necessary for a single cycle of weft insertion is wound around the outer peripheral surface of the drum 15 in each measuring-and-storing device 13 illustrated in Fig. 1, and is retained by the stopper pin 16. When the weft insertion is started, the stopper pin 16 is removed from the outer peripheral surface of the drum 15 so that the weft yarn is released, and the main nozzle 21 performs the ejecting operation. Accordingly, the weft yarn is released from the drum 15 and is subjected to weft insertion. In this process, the release sensor detects the number of times the released weft yarn has passed the sensor range thereof, and outputs a signal representing the result of the detection to the weft-insertion control device 43 (weft insertion controller 44). Accordingly, the weft-insertion control device 43 recognizes that the predetermined length of weft yarn has been released from the drum 15, and causes the stopper pin 16 to retain the weft yarn again. As a result, the predetermined length of weft yarn is subjected to weft insertion.

**[0100]** In the case where the release sensor is used, when, for example, the length of the weft yarn necessary for a single cycle of weft insertion corresponds to four turns around the drum 15, the time at which it is detected that the weft yarn has been unwound two turns in the actual weft insertion process corresponds to the time at which the leading end of the weft yarn has reached a predetermined intermediate position. Accordingly, that time in terms of the crank angle (detection value) may be determined by the main controller on the basis of the signal from the release sensor, and the thus-determined detection value may be output to the comparator 65. In this case, a reference value of the time at which the weft yarn is unwound two turns is set in the setting unit 63 in terms of the crank angle. Then, the comparator 65 compares the reference value with the detection vale.

**[0101]** In the case where a dedicated sensor is used, the sensor is arranged near the predetermined intermediate position so that the sensor can detect the leading end of the weft yarn. A reference value of the time at which the leading end of the weft yarn passes the position of the sensor is set in the setting unit 63 in terms of the crank angle. Similar to the above-described case, the main controller determines the arrival time (detection value) of the weft yarn at the predetermined intermediate position in terms of the crank angle on the basis of the signal from the sensor. Then, the comparator 65 compares the detection value with the reference value.

**[0102]** The present invention is not limited to the above-described embodiments, and the following modifications, for example, are possible.

**[0103]** In the above-described embodiments, all of the auxiliary nozzles, that is, all of the sub-nozzles 22 included in all of the sub-nozzle groups and the stretch nozzle 23, are set as the adjustment targets, and the ejection positions of all of the sub-nozzles 22 and the stretch nozzle 23 are adjusted. In other words, all of the auxiliary nozzles included in the loom are set as the adjustment targets. However, the adjusting device of the present invention is not limited to this, and may instead be such that only some of the sub-nozzles 22 are set as the adjustment targets.

**[0104]** For example, in the case where the sub-nozzles 22 are set as the adjustment targets in units of sub-nozzle groups, all of the sub-nozzles 22 included in a sub-nozzle group having a small influence on the travelling condition of the weft yarn (for example, a sub-nozzle group at an intermediate position in the weaving width direction) may be excluded from the adjustment targets. Alternatively, the setting may be such that only some of the sub-nozzles 22 included in one or more sub-nozzle groups are set as the auxiliary nozzles that serve as the adjustment targets. Also in this case, effects similar to those of the above-described embodiments can be obtained.

**[0105]** The stretch nozzle 23 may also be excluded from the auxiliary nozzles that serve as the adjustment targets. The stretch nozzle 23 is not provided to assist the movement of the weft yarn, but is provided to maintain the stretched state of the weft yarn that has been inserted. In the case where the change in the weaving condition is such that the stretched state of the weft yarn is not largely influenced by the adjustment of the ejection position of the stretch nozzle 23, the stretch nozzle 23 may be excluded from the adjustment targets.

**[0106]** In the above-described embodiments, both of the ejection height position and the ejection angle position are adjusted. However, the present invention is not limited to this, and the adjustment may be such that only one of the ejection height position and the ejection angle position is adjusted.

**[0107]** In the above-described embodiments, the present invention is applied to the air jet loom in which two types of weft yarns are subjected to weft insertion. However, the present invention may also be applied to air jet looms in which a single type of weft yarn or three or more types of weft yarns are subjected to weft insertion.

## Claims

1. A method for adjusting an ejection position of an auxiliary nozzle in an air jet loom which includes a plurality of auxiliary nozzles including a plurality of sub-nozzles (22) arranged along a weft insertion path and a passage detection sensor (31) that detects a passage of a leading end of a weft yarn subjected to weft insertion as a sensor for detecting a travelling condition of the weft yarn, the method comprising the steps of:

   setting at least one of the auxiliary nozzles as an adjustment target and allowing an ejection position of the auxiliary nozzle set as the adjustment target to be adjusted by an actuator (M1, M2); and
   setting a reference value in advance, the reference value corresponding to a rotational angle of a main shaft of the air jet loom at the time when the leading end of the weft yarn passes a position of the passage detection sensor (31) in a loom width direction;
   comparing the reference value with the rotational angle at the time when the weft yarn is actually detected by the passage detection sensor (31); and
   when there is a deviation between the reference value and the rotational angle at the time when the weft yarn is detected by the passage detection sensor (31) due to a change in the travelling condition, driving the actuator (M1, M2) in a direction for eliminating the deviation to adjust the ejection position of the auxiliary nozzle set as the adjustment target.

2. The method according to Claim 1, wherein the auxiliary nozzles include the plurality of sub-nozzles (22) and a stretch nozzle (23) that is arranged next to the plurality of sub-nozzles (22) on a weft arrival side of the sub-nozzles (22).

3. An air jet loom which includes a plurality of auxiliary nozzles including a plurality of sub-nozzles (22) arranged along a weft insertion path and a passage

detection sensor (31) that detects a passage of a leading end of a weft yarn subjected to weft insertion as a sensor for detecting a travelling condition of the weft yarn, the air jet loom comprising:

an apparatus for adjusting an ejection position of an auxiliary nozzle,
wherein the apparatus includes

a drive device that adjusts an ejection position of at least one of the auxiliary nozzles that is set as an adjustment target, the auxiliary nozzle set as the adjustment target being supported by a support body such that the ejection position thereof is adjustable,

wherein the drive device includes an actuator (M1, M2) connected to the auxiliary nozzle set as the adjustment target, and a control device (61c) that controls a driving operation of the actuator (M1, M2),
wherein the control device (61c) includes a setting unit (63) in which a reference value is set, the reference value corresponding to a rotational angle of a main shaft of the air jet loom at the time when the leading end of the weft yarn passes a position of the passage detection sensor (31), a comparator (65) that compares the reference value with the rotational angle at the time when the leading end of the weft yarn is detected by the passage detection sensor (31) during the weft insertion, and a drive controller (62) which, when there is a deviation between the reference value and the rotational angle at the time when the weft yarn is detected by the passage detection sensor (31) as a result of the comparison performed by the comparator (65), controls the driving operation of the actuator (M1, M2) in a direction for eliminating the deviation.

**4.** The air jet loom according to Claim 3, wherein the auxiliary nozzles include the plurality of sub-nozzles (22) and a stretch nozzle (23) that is arranged next to the plurality of sub-nozzles (22) on a weft arrival side of the sub-nozzles (22).

FIG. 1

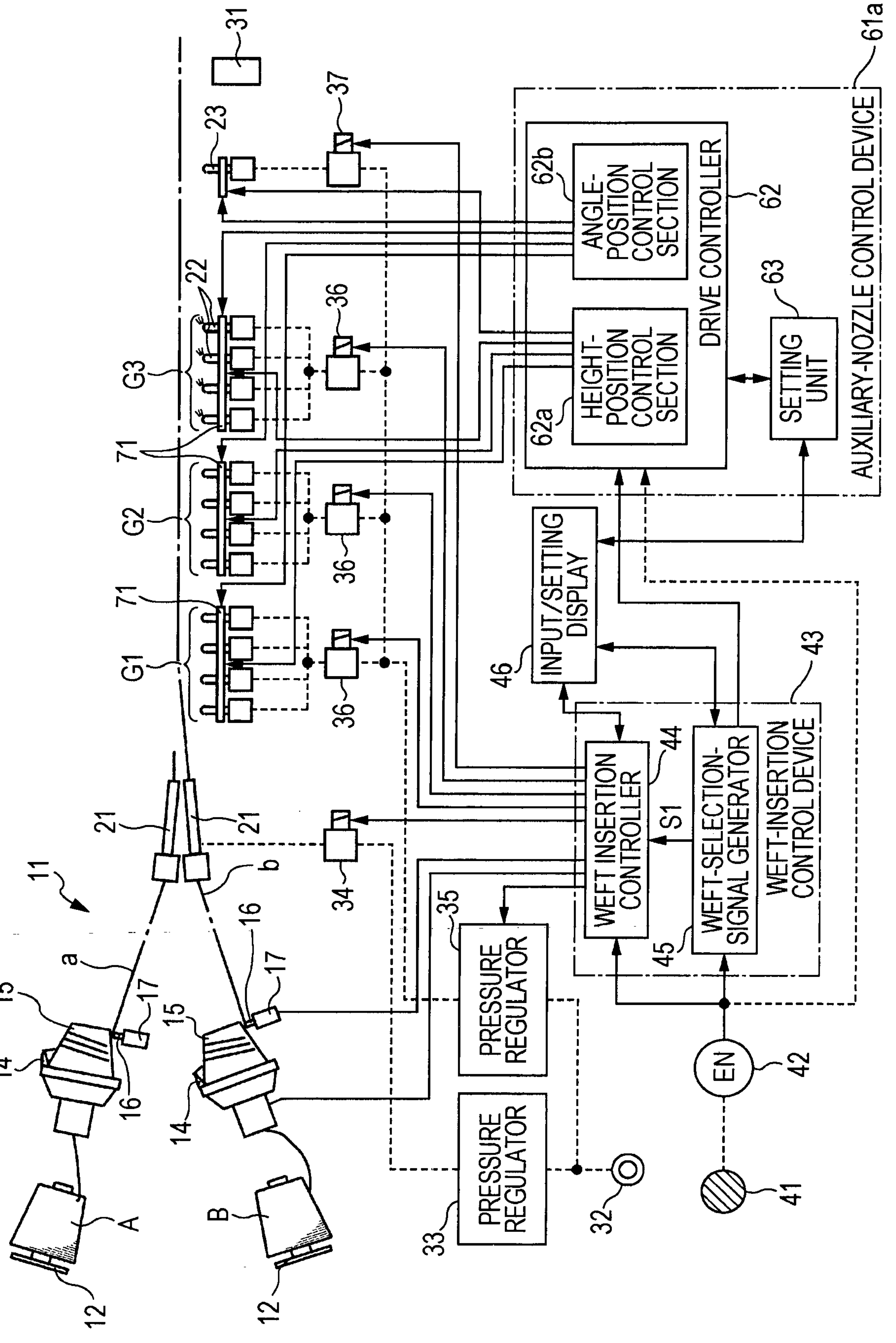

AUXILIARY-NOZZLE CONTROL DEVICE
DRIVE CONTROLLER
ANGLE-POSITION CONTROL SECTION
HEIGHT-POSITION CONTROL SECTION
SETTING UNIT
INPUT/SETTING DISPLAY
WEFT INSERTION CONTROLLER
WEFT-SELECTION-SIGNAL GENERATOR
WEFT-INSERTION CONTROL DEVICE
PRESSURE REGULATOR
PRESSURE REGULATOR
EN
S1
61a
62
62a
62b
63
43
44
45
46
41
42
31
32
33
34
35
36
37
23
22
21
71
G1
G2
G3
11
12
13
14
15
16
17
A
B
a
b

FIG. 2

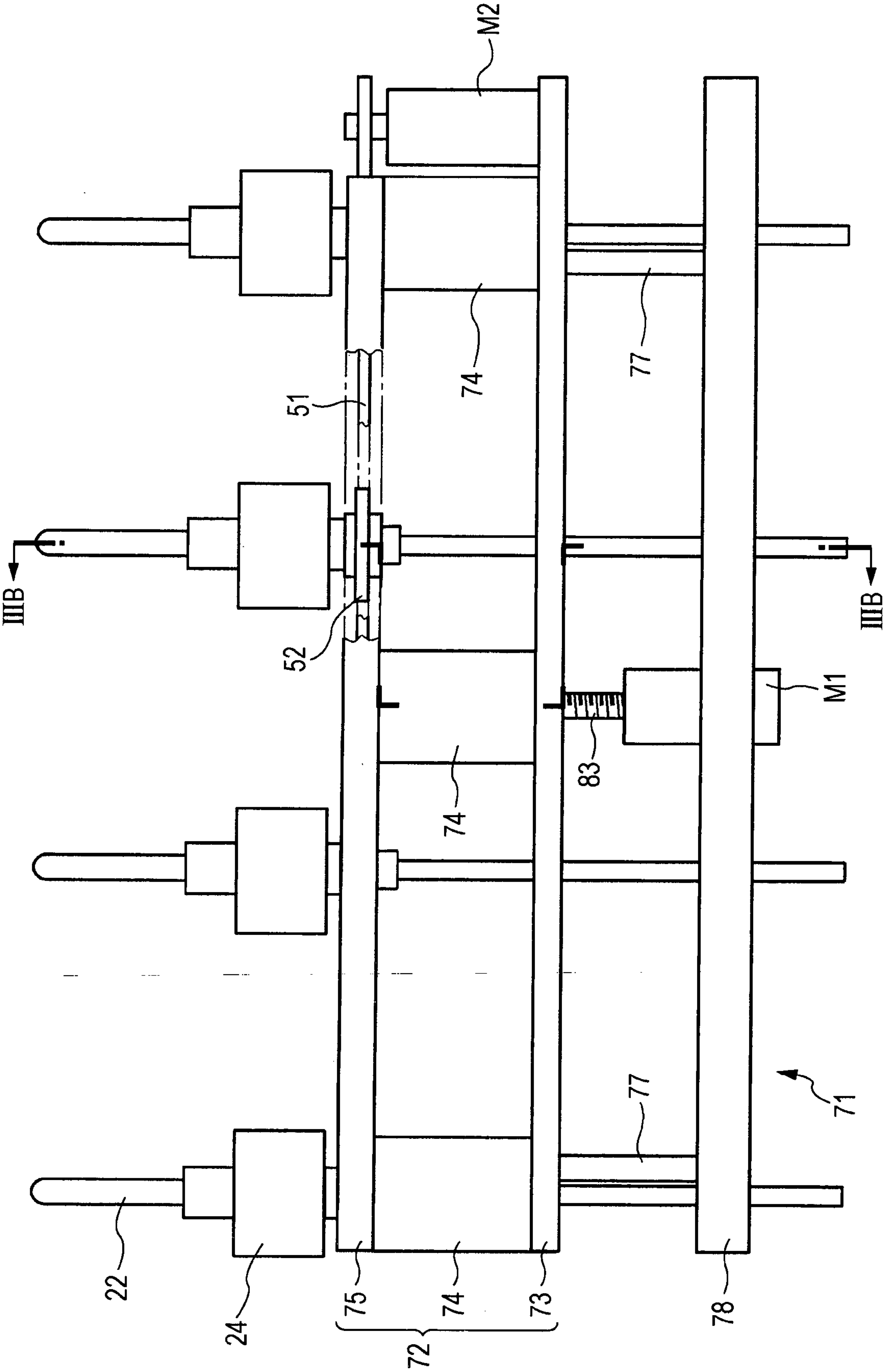


FIG. 3A

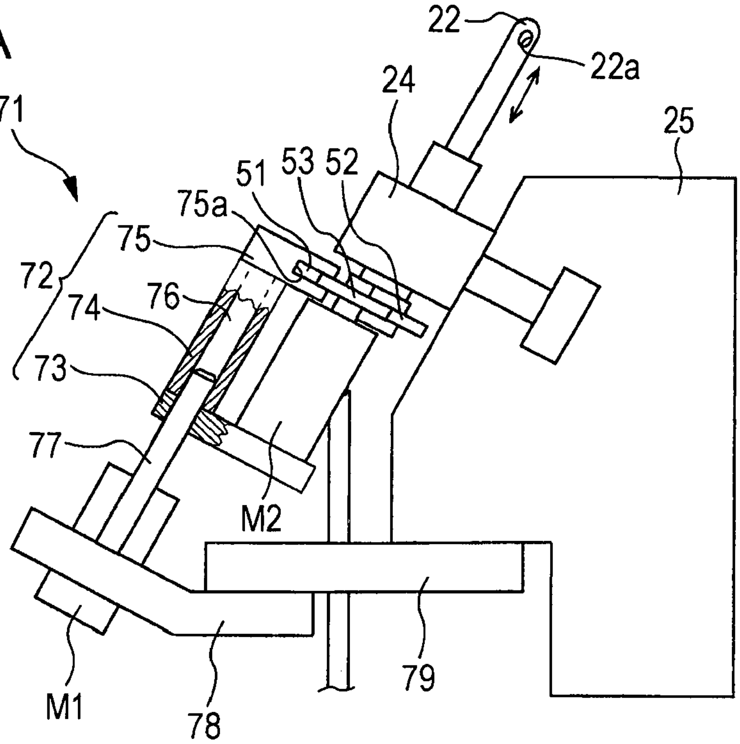

22
22a
24
25
71
51
53
52
75a
75
72
76
74
73
77
M2
M1
78
79

FIG. 3B

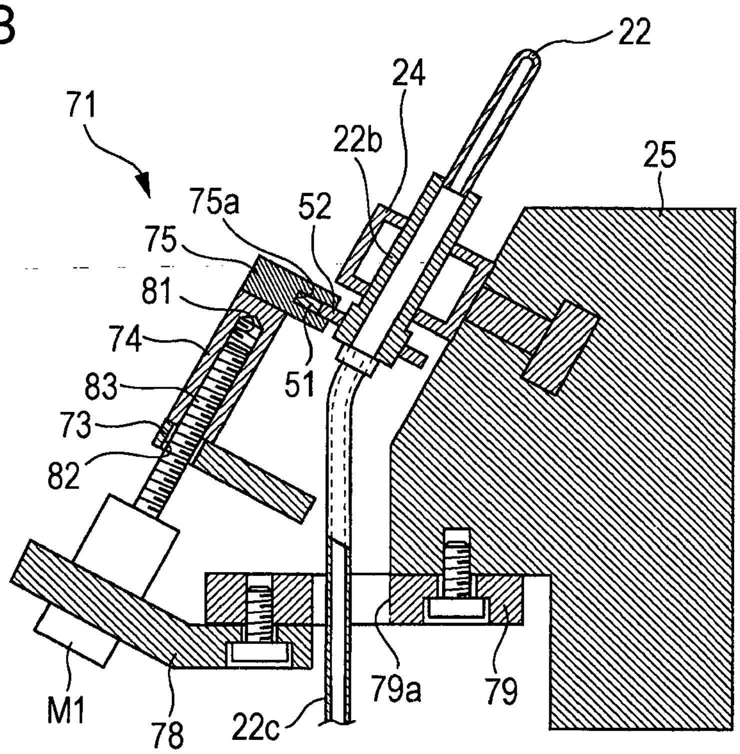

22
24
22b
25
71
75a
52
75
81
74
51
83
73
82
M1
78
22c
79a
79

FIG. 4

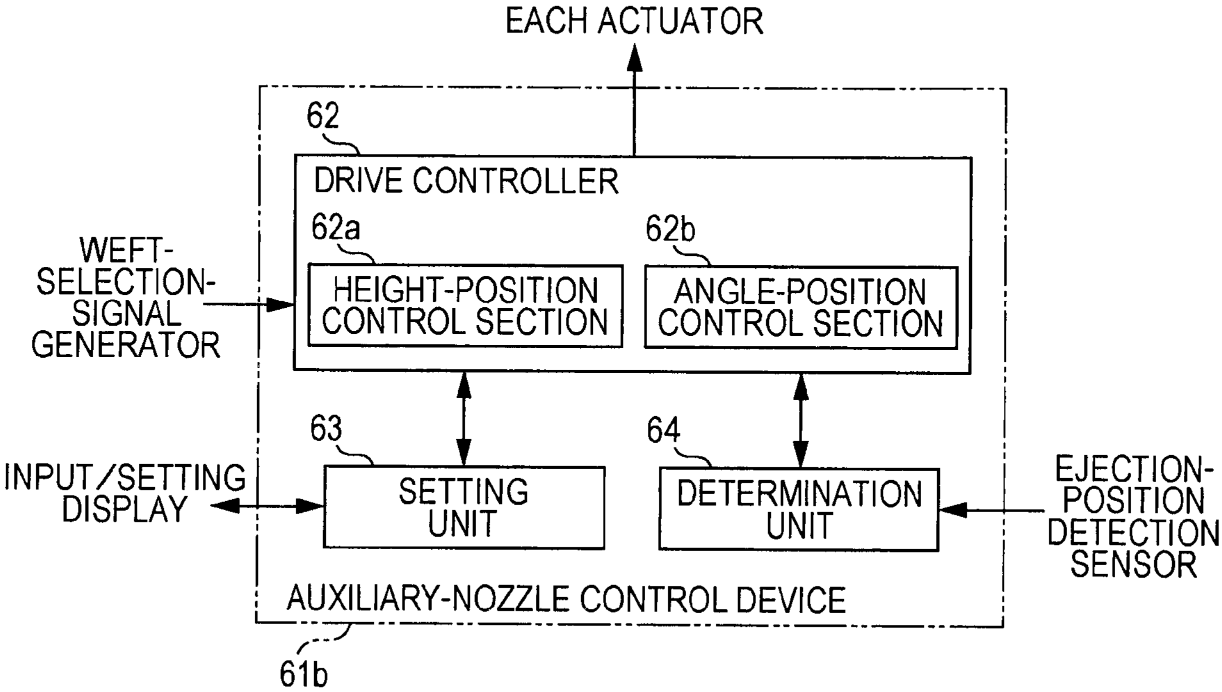

EACH ACTUATOR
62
DRIVE CONTROLLER
62a
62b
HEIGHT-POSITION CONTROL SECTION
ANGLE-POSITION CONTROL SECTION
WEFT-SELECTION-SIGNAL GENERATOR
63
64
INPUT/SETTING DISPLAY
SETTING UNIT
DETERMINATION UNIT
EJECTION-POSITION DETECTION SENSOR
AUXILIARY-NOZZLE CONTROL DEVICE
61b

FIG. 5

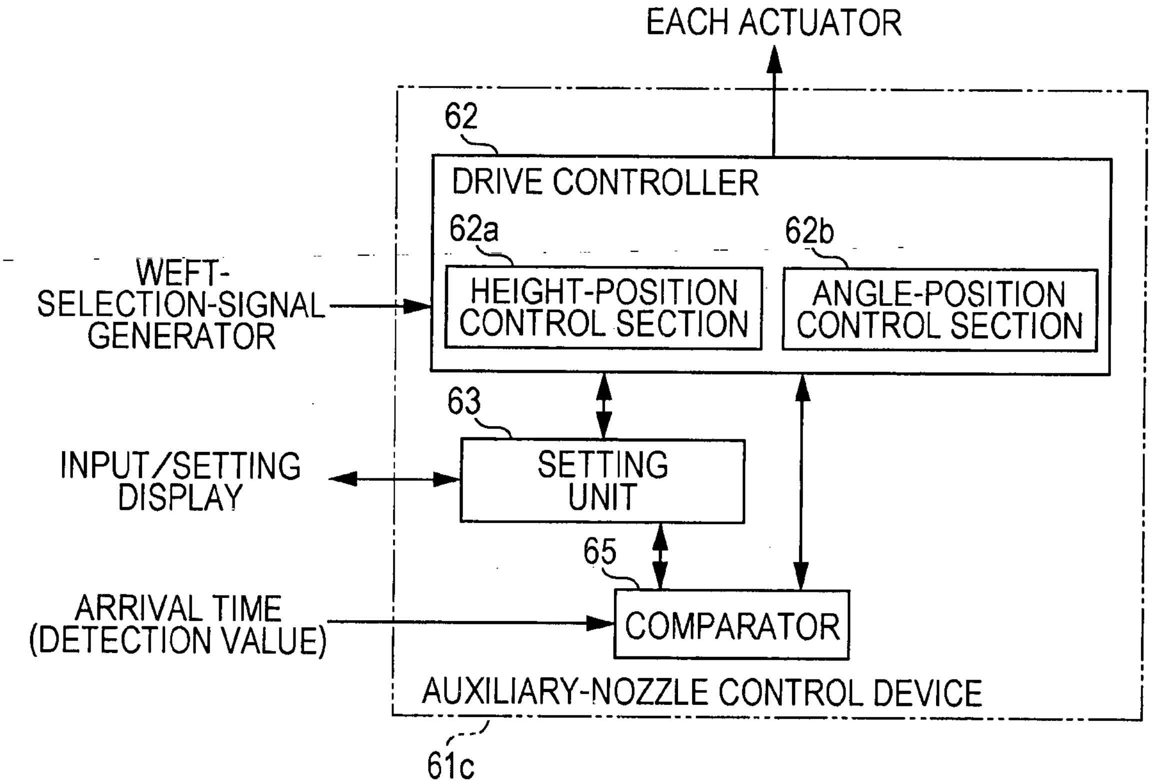

EACH ACTUATOR
62
DRIVE CONTROLLER
62a
62b
WEFT-SELECTION-SIGNAL GENERATOR
HEIGHT-POSITION CONTROL SECTION
ANGLE-POSITION CONTROL SECTION
63
INPUT/SETTING DISPLAY
SETTING UNIT
65
ARRIVAL TIME (DETECTION VALUE)
COMPARATOR
AUXILIARY-NOZZLE CONTROL DEVICE
61c

FIG. 6

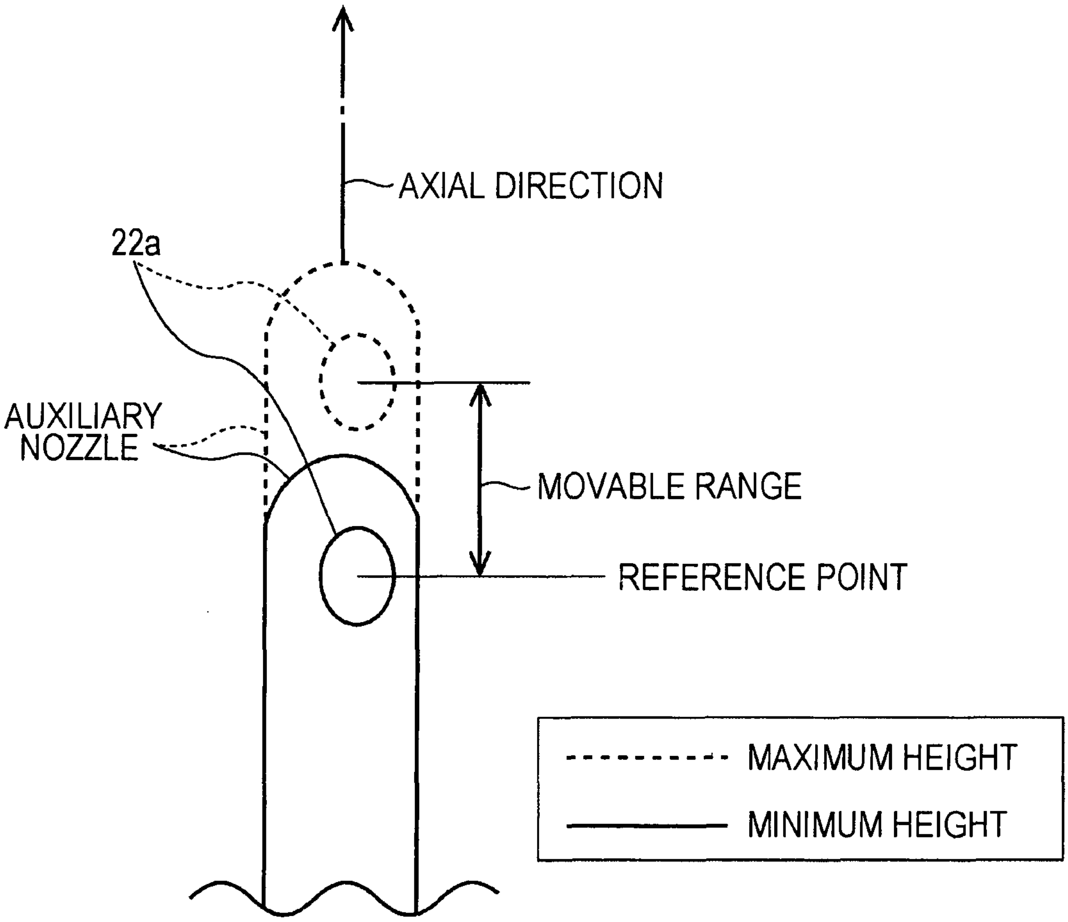
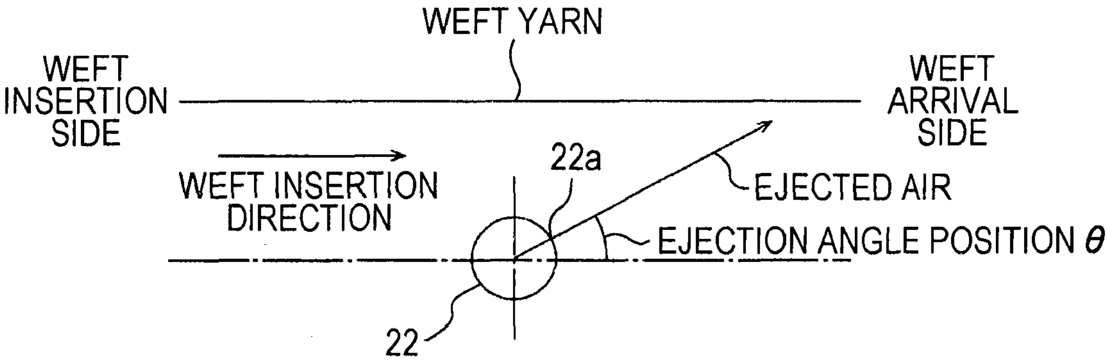

AXIAL DIRECTION
22a
AUXILIARY NOZZLE
MOVABLE RANGE
REFERENCE POINT
MAXIMUM HEIGHT
MINIMUM HEIGHT

FIG. 7


WEFT YARN
WEFT INSERTION SIDE
WEFT ARRIVAL SIDE
WEFT INSERTION DIRECTION
22a
EJECTED AIR
EJECTION ANGLE POSITION θ
22

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# EUROPEAN SEARCH REPORT

Application Number
EP 17 00 0362

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
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| A | GB 2 060 720 A (RUETI TE STRAKE BV) 7 May 1981 (1981-05-07) * page 1, line 128 - page 2, line 65; figures 1-3 * ----- | 1-4 | |
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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 | 20 June 2017 | Iamandi, Daniela |

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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P : intermediate document

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## ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 17 00 0362

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The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

20-06-2017

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| | | NL 7907050 A | 24-03-1981 |
| | | US 4487236 A | 11-12-1984 |
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