



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
24.10.2012 Bulletin 2012/43

(51) Int Cl.:
D03D 47/30 (2006.01)

(21) Application number: **12001282.8**

(22) Date of filing: **27.02.2012**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(72) Inventors:
• **Kita, Kouichi**
Ishikawa-ken 921-8650 (JP)
• **Matsuyama, Yutaka**
Ishikawa-ken 921-8650 (JP)

(30) Priority: **20.04.2011 JP 2011093893**

(71) Applicant: **Tsudakoma Kogyo Kabushiki Kaisha**
Kanazawa-shi, Ishikawa-ken 921-8650 (JP)

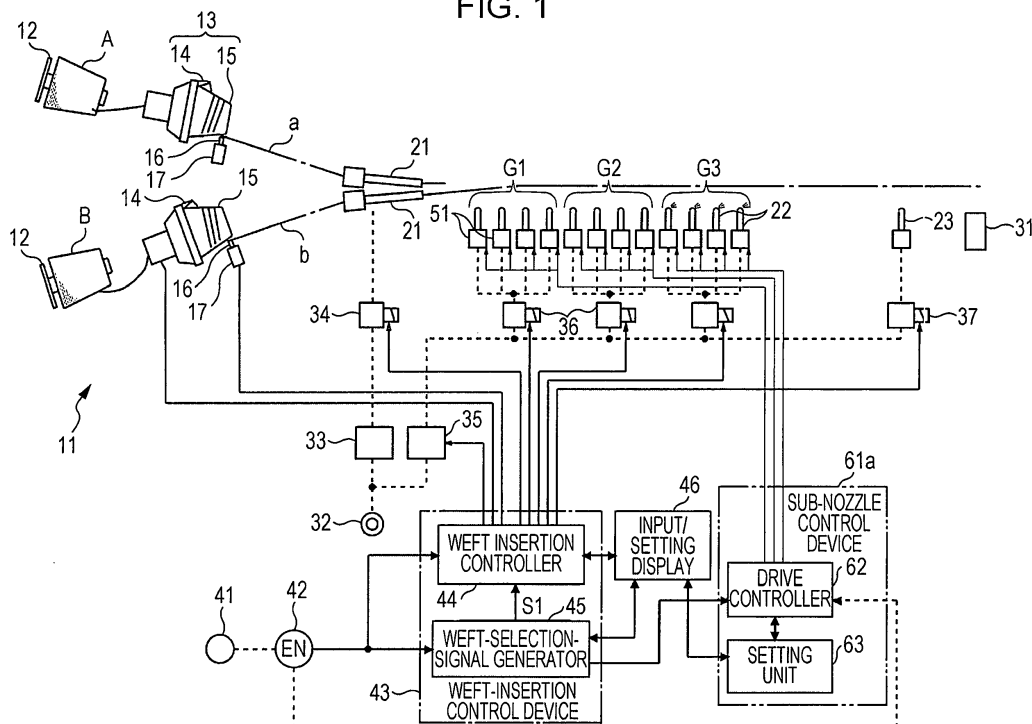
(74) Representative: **Samson & Partner**
Widenmayerstrasse 5
80538 München (DE)

(54) **Method and apparatus for adjusting ejection angle position of sub-nozzle in an air jet loom**

(57) A method for adjusting an ejection angle position of a sub-nozzle (22) in an air jet loom is provided. The air jet loom includes a plurality of sub-nozzles (22) arranged along a weft insertion path and a plurality of electromagnetic on-off valves (36) provided to supply compressed air to the sub-nozzles (22), each electromagnetic on-off valve (36) being connected to one or more of the sub-nozzles (22), the sub-nozzles (22) connected to

each electromagnetic on-off valve (36) ejecting the air to perform weft insertion. The method includes the steps of driving one or more sub-nozzles (22) that belong to an adjustment unit with at least one actuator (51, 74), the adjustment unit including at least one of the one or more sub-nozzles (22) connected to at least one of the electromagnetic on-off valves (36), and adjusting an ejection angle position of each sub-nozzle (22) included in the adjustment unit by the same angle.

FIG. 1



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 angle position of a sub-nozzle in air jet looms, more particularly, in an air jet loom including a plurality of sub-nozzles arranged along a weft insertion path and a plurality of electromagnetic on-off valves provided to supply compressed air to the sub-nozzles. Each electromagnetic on-off valve is connected to one or more of the sub-nozzles, and the one or more sub-nozzles connected to each electromagnetic on-off valve eject the air to perform weft insertion.

[0002] In this description, the "ejection angle position" is an angular position of an air ejection hole formed in a sub-nozzle around an axial line thereof with respect to the axial line. More specifically, as illustrated in Fig. 7, in a top view of a 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

[0003] 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. A plurality of electromagnetic on-off valves are provided to supply compressed air to the sub-nozzles, and each electromagnetic on-off valve is generally connected to multiple sub-nozzles. In a weft insertion process, the main nozzle ejects the compressed air so that a weft yarn is ejected from the main nozzle and travels toward a weft arrival side. In addition, the electromagnetic on-off valves are turned on and off at preset times so that the sub-nozzles also eject the compressed air. The compressed air ejected from the sub-nozzles serves to assist the movement of the weft yarn.

[0004] In the air jet loom, when, for example, a weaving condition is changed in accordance with a style change or the like, the ejection angle position of each sub-nozzle may be adjusted to change a weft travelling condition to that corresponding to the weaving condition after the change thereof. The adjustment of the ejection angle position has generally been performed manually by an operator. The manual adjustment is mechanically performed for each of the sub-nozzles by the operator. Therefore, the adjustment requires a very long time and is very cumbersome.

[0005] Japanese Examined Utility Model Registration Application Publication No. 3-15576 (hereinafter referred to as Patent Document 1) discloses an example of the related art that facilitates the adjustment of the ejection angle position of each sub-nozzle and reduces the time required for the adjustment by using a rack-and-pinion mechanism. More specifically, according to the related

art disclosed in Patent Document 1, a single rack that extends along a weft insertion path is mechanically connected to each of the sub-nozzles. A rotating mechanism including a pinion is provided at a weft insertion side of the rack, and is operated so as to move the rack toward the weft insertion side or a weft arrival side, which is opposite to the weft insertion side. Accordingly, the ejection angle positions of all of the sub-nozzles are simultaneously adjusted.

[0006] According to Patent Document 1, all of the sub-nozzles may be divided into two groups, which are a group at the weft insertion side and a group at the weft arrival side, and two racks may be provided so as to individually extend along the weft insertion path at the weft insertion side and the weft arrival side. The racks are operated by rotating mechanisms provided in correspondence with the racks, so that the ejection angle positions of the sub-nozzles included in each group can be simultaneously adjusted.

[0007] However, in the adjustment of the ejection angle position of each sub-nozzle according to the related art described in Patent Document 1, the ejection angle positions of all of the sub-nozzles are simultaneously adjusted by the same amount, or the ejection angle positions of the sub-nozzles in each of the two groups at the weft insertion side and the weft arrival side are simultaneously adjusted by the same amount. Therefore, fine adjustment of the ejection angle positions of individual each sub-nozzles cannot be performed.

[0008] In addition, since the adjustment can be performed only manually, the ejection angle position of each sub-nozzle cannot be adjusted in accordance with the weaving state during a weaving operation. Here, the "weaving state" includes a weaving condition, such as the type of weft, a weave structure, or a rotational speed of the loom, 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.

SUMMARY OF THE INVENTION

[0009] 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 finely adjusting an ejection angle position of a sub-nozzle in accordance with a weaving state.

[0010] The present invention is applied to an air jet loom including a plurality of sub-nozzles arranged along a weft insertion path and a plurality of electromagnetic on-off valves provided to supply compressed air to the sub-nozzles, each electromagnetic on-off valve being connected to one or more of the sub-nozzles, the one or more sub-nozzles connected to each electromagnetic on-off valve ejecting the air to perform weft insertion.

[0011] According to an aspect of the present invention, a method for adjusting an ejection angle position of a sub-nozzle in the above-described air jet loom includes

the steps of driving one or more sub-nozzles that belong to an adjustment unit with at least one actuator, the adjustment unit including at least one of the one or more sub-nozzles connected to at least one of the electromagnetic on-off valves; and adjusting an ejection angle position of each sub-nozzle included in the adjustment unit by the same angle.

[0012] According to another aspect of the present invention, an apparatus for adjusting an ejection angle position of a sub-nozzle that corresponds to the above-described adjusting method includes a drive device that adjusts an ejection angle position of each sub-nozzle that belong to an adjustment unit, the adjustment unit including at least one of the one or more sub-nozzles connected to at least one of the electromagnetic on-off valves. The drive device includes at least one actuator that is connected to each sub-nozzle included in the adjustment unit so as to rotate each sub-nozzle by the same angle, and a control device that controls a driving operation of the actuator so that the ejection angle position of each sub-nozzle included in the adjustment unit is adjusted by the same angle.

[0013] In the adjusting method and the adjusting apparatus according to the present invention, the adjustment unit includes at least one of the one or more sub-nozzles connected to one of the single electromagnetic on-off valves. The minimum number of sub-nozzles that belong to the adjustment unit may be one.

[0014] In the adjusting method, the adjustment unit may include a plurality of sub-nozzles connected to one of the electromagnetic on-off valves.

[0015] Similarly, in the adjusting apparatus, the drive device may further include a driving-force transmitting mechanism that is linked to a plurality of sub-nozzles that belong to the adjustment unit and that are connected to one of the electromagnetic on-off valves.

[0016] In the adjusting method and the adjusting apparatus, the ejection angle position of each sub-nozzle may be adjusted in accordance with the setting stored in advance in a database.

[0017] Accordingly, the adjusting method may further include the steps of setting the database in advance, the database including the ejection angle position in association with each of a plurality of weaving conditions that are settable for a weaving operation performed by the air jet loom, and selecting the ejection angle position corresponding to a set weaving condition from the database and driving the actuator on the basis of the selected ejection angle position.

[0018] Similarly, in the adjusting apparatus, the control device may include a setting unit in which the database is set, the database including the ejection angle position in association with each of a plurality of weaving conditions that are settable in the air jet loom for a weaving operation, and a drive controller that selects the ejection angle position corresponding to a set weaving condition from the database and controls the driving operation of the actuator on the basis of the selected ejection angle

position.

[0019] According to the adjusting method and the adjusting apparatus that use the database, the adjustment may be made while the loom is stopped, or be made automatically during the weaving operation of the loom.

[0020] The adjustment is made while the loom is stopped when, for example, the ejection angle position is adjusted in accordance with the weaving condition set by the operator as the initial setting in the weaving preparation stage, or when it has become necessary to change the setting of the weaving condition in the weaving operation. In these cases, the setting is changed by the operator while the loom is stopped, and the ejection angle position is adjusted in accordance with the change in the setting.

[0021] In contrast, the adjustment is made automatically during the weaving operation when the air jet loom is set so as to switch weaving conditions automatically during the weaving operation and the ejection angle position is adjusted accordingly. In this case, in the adjusting method, when the weaving conditions are switched during the weaving operation, the ejection angle position corresponding to the weaving condition set after the switching is performed may be selected from the database, and the actuator may be driven on the basis of the selected ejection angle position.

[0022] Similarly, in the adjusting apparatus, when the weaving conditions are switched during the weaving operation, the drive controller may select the ejection angle position corresponding to the weaving condition set after the switching is performed from the database set in the setting unit.

[0023] In particular, the air jet loom may be a multi-color 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 angle position in association with each of the weft yarns subjected to weft insertion. When the weft yarns are switched during the weaving operation, the actuator may be driven in accordance with the ejection angle position corresponding to the weft yarn set after the switching is performed.

[0024] Similarly, in the adjusting apparatus, the database set in the setting unit may include the ejection angle position in association with each of the weft yarns subjected to weft insertion. When the weft yarns are switched during the weaving operation, the drive controller may select the ejection angle position corresponding to the weft yarn set after the switching is performed from the database set in the setting unit.

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

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

[0027] Similarly, the adjusting apparatus may further include an angle-position detection sensor that detects the ejection angle position, and the control device may include a determination unit that compares a detection value obtained by the angle-position detection sensor after the ejection angle position is changed with the ejection angle position selected in accordance with the weaving condition. When there is a deviation between the selected ejection angle position and the detection value obtained by the angle-position detection sensor as a result of the comparison performed by the determination unit, the drive controller may drive 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 angle position is changed in accordance with a change in the weaving condition as described above, and the ejection angle 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 a passage of a leading end of the 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, and comparing the reference value with a rotational angle at the time when the weft yarn is actually detected. When there is a deviation between the reference value and the rotational angle at the time when the weft yarn is actually detected, the actuator may be driven 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 actually detected, 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 actually detected 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, each sub-nozzle is rotated 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, in the adjustment of the ejection angle position, an adjustment unit is defined so as to include one or more of the sub-nozzles connected to an electromagnetic on-off valve, and the ejection angle position of each sub-nozzle included in the adjustment unit is adjusted by the actuator. Therefore, fine adjustment of the ejection angle position may be performed in accordance with the weaving state. As a result, weft insertion may be optimized in accordance with the weaving state, and the weaving performance and the quality of woven cloth may be improved.

[0033] In addition, the database regarding the ejection angle position may be provided. The ejection angle position corresponding to the weaving condition may be selected from the database, and the actuator may be driven in accordance with the selected ejection angle position. In this case, when the ejection angle position of each sub-nozzle is adjusted in accordance with the setting of or change in the weaving condition while the loom is stopped, the operator is required simply to set the weaving condition necessary for the weaving operation. Accordingly, the ejection angle position corresponding to the set weaving condition is selected from the database, and the adjustment is performed in accordance with the selected ejection angle position. Thus, the setting operation performed by the operator can be facilitated, and the time and labor required for the adjustment can be reduced.

[0034] 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 angle 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 angle position, so that the ejection angle position is automatically adjusted. Thus, the ejection angle 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.

[0035] In this case, the angle-position detection sensor that detects the ejection angle position of each sub-nozzle may be provided, and the ejection angle position that has been adjusted in accordance with the change in the

weaving condition may be detected by the angle-position detection sensor. In this case, the detection value and the ejection angle 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 angle position can be reliably optimized in accordance with the weaving condition.

[0036] 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 angle 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

[0037]

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 angle position of a sub-nozzle;

Fig. 2 illustrates the structure of a sub-nozzle and a support structure thereof;

Fig. 3 illustrates a modification of the embodiment illustrated in Fig. 1;

Fig. 4 illustrates an adjusting device for adjusting an ejection angle position of a sub-nozzle according to another embodiment;

Figs. 5A to 5C illustrate examples of structures for indirectly driving a sub-nozzle through a driving-force transmitting mechanism;

Fig. 6 illustrates an example of a structure for simultaneously rotating two sub-nozzles; and

Fig. 7 illustrates the ejection angle position.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0038] 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.

[0039] 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.

[0040] 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.

[0041] 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.

[0042] 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.

[0043] 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 sub-nozzles 22, a stretch nozzle 23, 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.

[0044] 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 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.

[0045] 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.

[0046] 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 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.

[0047] 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).

[0048] 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.

[0049] 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, etc. at appropriate rotational angles. Thus, the weft insertion operation of the selected weft yarn is performed.

[0050] 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.

[0051] 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 conditions or the like can be set in the weft-insertion control device 43.

[0052] 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.

[0053] In addition to the above-described basic structure, the weft insertion device 11 of the air jet loom includes an adjusting device for adjusting an ejection angle position of each sub-nozzle 22. In the illustrated example, as described above, each of the sub-nozzle groups G1, G2, ... includes four sub-nozzles 22 that are connected to the corresponding electromagnetic on-off valve 36. In the present embodiment, all of the sub-nozzle groups are set as the groups including the sub-nozzles 22 to be subjected to the adjustment, that is, as the groups to be subjected to the adjustment. In addition, all of the sub-nozzles (four sub-nozzles) 22 included in each sub-nozzle group are set as the sub-nozzles to be subjected to the adjustment. The four sub-nozzles 22 included in each sub-nozzle group form an adjustment unit. The adjusting device serves as a drive device that adjusts the ejection angle positions of all of the sub-nozzles 22 included in each adjustment unit by the same angle.

[0054] According to the present embodiment, the drive device includes dedicated actuators 51 provided for the individual sub-nozzles 22 and a sub-nozzle control device 61a that serves as a control device. Each actuator 51 is a direct drive motor (hereinafter referred to as a "DD motor") that directly drives an object to be driven without using a driving-force transmitting mechanism, such as a gear. As described in detail below, the sub-nozzle control device 61a controls the driving operation of the DD motors 51 for each adjustment unit so that the ejection angle positions of all of the sub-nozzles 22 included in the adjustment unit are adjusted by the same angle.

[0055] In the present embodiment, the adjustment of the ejection angle position of each sub-nozzle 22 is performed by the drive device in accordance with the weft selection pattern, which is a weaving condition, when the type of weft yarn is changed in the weaving operation.

[0056] Fig. 2 illustrates the structure of each sub-nozzle 22 and a support structure thereof.

[0057] The sub-nozzle 22 is a hollow rod that extends along a straight line. The proximal end of the sub-nozzle 22 is open so as to serve as an inlet for the compressed air. 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 rotatably supported by a dedicated nozzle holder 24 provided for each sub-nozzle 22. 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.

[0058] Each nozzle holder 24 includes bearings 26 that support the corresponding sub-nozzle 22 in a rotatable manner and the DD motor 51 that serves as a drive source for rotating the sub-nozzle 22. The bearings 26 are arranged concentrically with the sub-nozzle 22 in the nozzle holder 24 and includes inner rings that are non-rotatably assembled to the sub-nozzle 22 and outer rings that are non-rotatably assembled to the nozzle holder 24.

[0059] Each DD motor 51 is arranged concentrically with the corresponding sub-nozzle 22 in the nozzle holder 24, and includes a stator 51a and a rotor 51b. The stator 51a is non-rotatably assembled to the nozzle holder 24 at the outer peripheral surface thereof. The rotor 51b is arranged so as to face the inner peripheral surface of the stator 51a and fixed to the outer peripheral surface of the sub-nozzle 22. When the rotor 51b is rotated, the sub-nozzle 22 rotates together with the rotor 51b, so that the air ejection hole 22a rotates around the axis of the sub-nozzle 22. Accordingly, the ejection angle position of the sub-nozzle 22 is changed. The DD motor 51 is connected to the sub-nozzle control device 61a, and the sub-nozzle control device 61a supplies an exciting current to the stator 51a to rotate the stator 51a.

[0060] The sub-nozzle control device 61a includes a drive controller 62 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 angle position of each sub-nozzle group, which has been set in the input/setting display 46 by an input operation, from the input/setting display 46. The received database is set in the setting unit 63. This database includes the ejection angle position for each sub-nozzle group (more specifically, the ejection angle position of the sub-nozzles 22 included in each sub-nozzle group, which serves as an adjustment unit) in association with the types of weft yarns (weft yarns a and b).

[0061] In other words, this database includes the ejection angle position θ for each sub-nozzle group in association with each of the weft yarns a and b. For example, the ejection angle position θ is set to $\theta=x1^\circ$ for the sub-nozzle group G1, $\theta=x2^\circ$ for the sub-nozzle group G2, $\theta=x3^\circ$ for the sub-nozzle group G3, and so on when the type of weft yarn to be inserted is the weft yarn a, and is set to $\theta=y1^\circ$ for the sub-nozzle group G1, $\theta=y2^\circ$ for the sub-nozzle group G2, $\theta=y3^\circ$ for the sub-nozzle group G3, and so on when the type of weft yarn to be inserted is the weft yarn b.

[0062] 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 DD motors 51 are connected to the drive controller 62. 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 drive controller 62 reads the set values of the ejection angle 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 drive controller 62 drives the DD motors 51 by supplying the exciting current to the DD motors 51 in accordance with the set values read from the setting unit 63.

[0063] The adjusting device for adjusting the ejection angle position of each sub-nozzle 22 adjusts the ejection angle position of each sub-nozzle 22 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 sub-nozzle control device 61a in each weaving cycle. When the weft selection signal S1 is input to the drive controller 62, the drive controller 62 reads the set value of the ejection angle position for each sub-nozzle group that corresponds to the selected type of weft yarn from the setting unit 63.

(4) Subsequently, the drive controller 62 simultaneously drives the DD motors 51 corresponding to each sub-nozzle group on the basis of the set value read from the setting unit 63 so that the ejection angle position of each sub-nozzle group (more specifically, the ejection angle position of the sub-nozzles 22 included in each sub-nozzle group) approaches the set value. Specifically, the drive controller 62 determines an angle difference between the current set value of the ejection angle position and the set value

of the ejection angle position read from the setting unit 63, and supplies an exciting current to the stators 51a of the DD motors 51 so that the rotors 51b of the DD motors 51 are rotated by an amount corresponding to the angle difference. Accordingly, the rotors 51b of the DD motors 51 are rotated together with the sub-nozzles 22, and the ejection angle position of each sub-nozzle 22 is changed to the set value of the ejection angle position read from the setting unit 63.

(5) After the rotors 51b of the DD motors 51 are rotated so as to change the ejection angle position of each sub-nozzle 22, the drive controller 62 controls the driving operation of the DD motors 51 so as to maintain the exciting current at the level of a holding current, so that the ejection angle position is maintained constant after it has been changed.

[0064] The above-described process of changing the ejection angle position of each sub-nozzle 22 (the driving operation of the DD motors 51) performed by the drive controller 62 in step (4) 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 the same type of weft yarns are to be successively inserted, the set value of the ejection angle 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 angle difference is zero and controls the driving operation of the DD motors 51 so that the rotational angle of the rotors 51b (the ejection angle position of each sub-nozzle 22) is maintained at the current angle.

[0065] In the above-described example of the adjusting device for adjusting the ejection angle position of each sub-nozzle 22 according to the present invention, the ejection angle position is changed in accordance with the type of the weft yarn to be inserted. However, the present invention is not limited to this, and the ejection angle position may be changed in accordance with other weaving conditions (e.g., the weave structure or the rotational speed of the loom).

[0066] As a modification of the above-described embodiment, 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 angle position may be changed for each of the weaving patterns in which the plurality of weaving conditions are switched. In this case, the ejection angle position for each of the weaving patterns is set in the database in consideration of the plurality of weaving conditions.

[0067] In the above-described embodiment, the drive controller 62 starts the control for adjusting the ejection angle position in response to the weft selection signal S1 input thereto, and the process of changing the ejection angle position is completed before the weft insertion for

the next weaving cycle is started. However, the ejection angle position may instead be changed at a preset crank angle. 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 angle position and adjusts the ejection angle position of each sub-nozzle 22.

[0068] In the case where the drive controller 62 performs the control at the set crank angle, the ejection angle position of each sub-nozzle 22 may be changed at a time corresponding to the ejection time thereof instead of simultaneously changing the ejection angle positions of all of the sub-nozzles 22 to be subjected to the adjustment as in the above-described embodiment. More specifically, as in the above-described embodiment, the sub-nozzles 22 in a plurality of sub-nozzle groups may be subjected to the adjustment in units of sub-nozzle groups. In such a case, since the ejection start time differs between the sub-nozzle groups, the adjustment time may be changed in accordance with the ejection start time of each sub-nozzle group.

[0069] In the case where the ejection angle position is adjusted in accordance with the set value during the weaving operation, the ejection angle position of each sub-nozzle 22 subjected to the adjustment may be detected after the adjustment. Then, when there is a displacement between the ejection angle position after the adjustment and the set ejection angle 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 angle position cannot be adjusted to the set value and the ejection angle 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 sub-nozzles 22 being caught by other members, such as warp yarns, or a mechanical failure.

[0070] Fig. 3 illustrates a sub-nozzle control device 61b capable of correcting the above-described displacement in an adjusting device for adjusting the ejection angle position of each sub-nozzle 22. The sub-nozzle control device 61b is a modification of the sub-nozzle control device 61a according to the embodiment illustrated in Fig. 1. This adjusting device includes a sensor (not shown) provided on each actuator 51 or each sub-nozzle 22. This sensor is an angle-position detection sensor that detects an ejection angle position of each sub-nozzle 22. The sub-nozzle control device 61b includes the drive controller 62 and the setting unit 63 similar to those in the sub-nozzle control device 61a according to the embodiment illustrated in Fig. 1, and further includes a determination unit 64 connected to each angle-position detection sensor.

[0071] The determination unit 64 included in the sub-nozzle control device 61b is also connected to the drive

controller 62 so as to allow communication therebetween. In the sub-nozzle control device 61b, the ejection angle position of each sub-nozzle 22 is detected by the angle-position detection sensor after the adjustment of the ejection angle position, and the detection value of the ejection angle position is output to the determination unit 64. Then, the determination unit 64 compares the detection value with the set value read from the drive controller 62, and outputs a determination result to the drive controller 62 when there is a deviation between the detection value and the set value as a result of the comparison.

[0072] More specifically, the adjusting device corrects the displacement of the ejection angle position of each sub-nozzle 22 by the method including the following steps:

(1) After rotating the DD motors 51 to adjust the ejection angle position, the drive controller 62 reads the set value for each sub-nozzle group to be subjected to the adjustment (more specifically, the set value of the ejection angle position of the sub-nozzles 22 included in each sub-nozzle group) from the setting unit 63, and outputs the set value to the determination unit 64.

(2) Each angle-position detection sensor detects the ejection angle position of the corresponding sub-nozzle 22 and outputs a detection signal representing the detection value to the determination unit 64 at a predetermined time (for example, at a preset crank angle) after the rotation of the corresponding DD motor 51 is stopped.

(3) The determination unit 64 compares the set value with the detection value for each sub-nozzle group. When there is a deviation (displacement), the determination unit 64 outputs a deviation signal representing the amount of deviation (displacement in terms of the rotational angle) to 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 drive controller 62, or outputs no deviation signal to the drive controller 62.

(4) In the case where there is a displacement, the drive controller 62 drives each DD motor 51 on the basis of the deviation signal so as to eliminate the amount of deviation. More specifically, the drive controller 62 supplies an exciting current to the stator 51a of each DD motor 51 to rotate the rotor 51b of the DD motor 51 by an angle corresponding to the angle difference so as to reduce the amount of deviation to 0.

[0073] In the case where there is no displacement, the drive controller 62 controls the driving operation of each DD motor 51 so as to maintain the rotor 51b of the DD motor 51 at the current angle position in response to the deviation signal representing "amount of deviation = 0"

or in response to the absence of the deviation signal.

[0074] In the modification illustrated in Fig. 3, the angle-position detection sensor is provided on each actuator 51 or each sub-nozzle 22 to detect the ejection angle position of each sub-nozzle 22, and the control for correcting the displacement of the ejection angle position of the corresponding sub-nozzle 22 is performed on the basis of the detection result. However, the angle-position detection sensor may instead be provided on one of the sub-nozzles 22 included in each adjustment unit so that only the ejection angle position of that sub-nozzle 22 is detected, and the control for correcting the displacement may be performed for all of the sub-nozzles 22 included in the adjustment unit on the basis of the detection result.

[0075] In addition, in the modification illustrated in Fig. 3, whether or not there is a displacement is determined each time the ejection angle position is adjusted. However, the determination may instead be performed every time the adjustment of the ejection angle position is performed a plurality of times.

[0076] In the above-described embodiment, the ejection angle position is changed in accordance with the weaving condition each time the weaving condition is switched. However, the ejection angle position may instead be changed on the basis of the detection result of a travelling condition of a weft yarn.

[0077] 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 angle 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 angle 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.

[0078] An adjusting device according to an embodiment in which the ejection angle position of each sub-nozzle 22 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. 4. 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 sub-nozzle control device. Therefore, Fig. 4 illustrates only a sub-nozzle

control device 61c according to the present embodiment, and the sub-nozzle control device 61c will be mainly explained in the following description.

[0079] As illustrated in Fig. 4, the sub-nozzle control device 61c includes the drive controller 62 and the setting unit 63 similar to those in the sub-nozzle control device 61a according to the embodiment illustrated in Fig. 1, and further includes a comparator 65. The comparator 65 included in the sub-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.

[0080] 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.

[0081] A target arrival time is set in the setting unit 63 of the sub-nozzle control device 61c as a reference value. In addition, angle adjustment amounts for the sub-nozzles 22 are also set in association with an amount of deviation between the reference value and the actual weft arrival time (detection value).

[0082] The comparator 65 in the sub-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 drive controller 62.

[0083] More specifically, the adjusting device changes the ejection angle position of each sub-nozzle 22 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 com-

parison, the comparator 65 outputs a deviation signal representing the amount of deviation to 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 drive controller 62, or outputs no deviation signal to the drive controller 62.

(5) When there is a deviation, the drive controller 62 changes the ejection angle position by rotating the rotor 51b of each DD motor 51 in a direction for eliminating the deviation on the basis of the deviation signal. More specifically, the drive controller 62 reads the angle adjustment amount corresponding to the amount of deviation from the setting unit 63, and drives each DD motor 51 by supplying an exciting current to the stator 51a of the DD motor 51 so as to rotate the rotor 51b of the DD motor by an angle corresponding to the angle adjustment amount read from the setting unit 63.

[0084] In the case where there is no deviation, the drive controller 62 controls the driving operation of each DD motor 51 so as to maintain the rotor 51b of the DD motor 51 at the current angle position in response to the deviation signal representing "amount of deviation = 0" or in response to the absence of the deviation signal.

[0085] 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.

[0086] In the above-described adjusting method according to the present embodiment, the amount of deviation is used as a parameter, and the angle 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 angle position of each sub-nozzle 22 before the adjustment may both be set as parameters, and the angle adjustment amounts may be set in association with these parameters. For example, assume that the angle adjustment amount is α when the amount of deviation is γ and the ejection angle position of each sub-nozzle 22 before the adjustment is θ_1 . In this case, even when the amount of deviation is γ , when the ejection angle position of each sub-nozzle 22 before the adjustment is θ_2 , the angle adjustment amount is set to β . In this case, the angle adjustment amount can be more finely set.

[0087] In the above-described method, the angle adjustment amounts are set in advance in association with the amount of deviation, and each DD motor 51 is driven in accordance with the determined amount of deviation. Alternatively, however, the ejection angle position may be adjusted by a predetermined angle 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, only the predetermined angle adjustment amount is set in the setting unit 63 instead of setting the angle adjustment amounts in association with the amount of deviation. Here, different angle adjustment amounts may be set for the respective directions of deviation (+ and -) in the setting unit 63.

[0088] More specifically, in the control process performed in step (5), when there is a deviation, the drive controller 62 reads the angle adjustment amount from the setting unit 63 in response to the input of the deviation signal. Then, the drive controller 62 drives each DD motor 51 by supplying an exciting current to the stator 51a of the DD motor 51 so that the rotor 51b of the DD motor 51 is rotated by an angle corresponding to the angle adjustment amount read from the setting unit 63 in a direction corresponding to the direction of the deviation indicated by the deviation signal. The above-described steps (1) to (4) and step (5) in which only the direction of the deviation is taken into account as in this example is repeated until the deviation is eliminated.

[0089] 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.

[0090] 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 de-

vice 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.

[0091] 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 value.

[0092] 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.

[0093] The present invention is not limited to the above-described embodiments, and the following modifications, for example, are possible.

[0094] According to the above-described embodiments, in the air jet loom to which the present invention is applied, a plurality of sub-nozzles 22 (four sub-nozzles 22 in the above-described embodiments) are connected to each electromagnetic on-off valve 36, and each sub-nozzle group includes a plurality of sub-nozzles 22. However, each electromagnetic on-off valve 36 may instead be connected to a single sub-nozzle 22. In this case, although the sub-nozzles 22 are not actually grouped, it can be said that each sub-nozzle group includes a single sub-nozzle 22. In this case, the maximum number of sub-nozzles 22 included in each adjustment unit is one. In other words, the ejection angle position of each sub-nozzle 22 is individually adjusted. In the case where each sub-nozzle group includes a plurality of sub-nozzles, the number of sub-nozzles included in each sub-nozzle group is not limited to four as in the above-described embodiments, and may instead be three or less or five or more.

[0095] In the above-described embodiments, all of the sub-nozzle groups, which each includes the sub-nozzles connected to the common electromagnetic on-off valve

36, are set as the above-described groups to be subjected to the adjustment, that is, as the groups including the sub-nozzles 22 to be subjected to the adjustment. In addition, the ejection angle positions of all of the sub-nozzles 22 included in each sub-nozzle group are adjusted. In other words, all of the sub-nozzles 22 arranged in the loom are subjected to the adjustment. However, the adjusting device of the present invention is not limited to this as long as one or more sub-nozzles connected to at least one electromagnetic on-off valve 36 are subjected to the adjustment.

[0096] For example, the case in which the sub-nozzles included in each sub-nozzle group form an adjustment unit will be considered. Here, the sub-nozzle group that is closest to the weft arrival side has a large influence on the amount by which the inserted weft yarn is stretched. Therefore, only the sub-nozzle group closest to the weft arrival side, or a number of sub-nozzle groups including the sub-nozzle group closest to the weft arrival side (for example, three sub-nozzle groups that are closest to the weft arrival side), the number being smaller than the total number of sub-nozzle groups, may be set as the groups to be subjected to the adjustment. In this case, the sub-nozzles 22 included in each of the groups to be subjected to the adjustment form an adjustment unit. In addition, the setting may be such that only the sub-nozzles 22 included in the sub-nozzle group closest to the weft insertion side or a number of sub-nozzle groups including the sub-nozzle group closest to the weft insertion side, the number being smaller than the total number of sub-nozzle groups, are set as the sub-nozzles 22 to be subjected to the adjustment. Alternatively, the setting may be such that only the sub-nozzles 22 included in one or more sub-nozzle groups in an intermediate area in the weaving width direction are set as the sub-nozzles 22 to be subjected to the adjustment.

[0097] According to the above-described embodiments, in the air jet loom in which each sub-nozzle group includes a plurality of sub-nozzles 22, an adjustment unit is formed of all of the sub-nozzles 22 in each sub-nozzle group. However, the present invention is not limited to this, and an adjustment unit may instead be formed of a smaller number of sub-nozzles 22 than the total number of sub-nozzles 22 included in each sub-nozzle group.

[0098] For example, in the case where each sub-nozzle group includes four sub-nozzles 22, an adjustment unit may be formed of three or less sub-nozzles 22. Alternatively, even when each sub-nozzle group includes a plurality of sub-nozzles 22, an adjustment unit may be formed of a single sub-nozzle 22.

[0099] In addition, in the above-described embodiments, a plurality of sub-nozzle groups are set as the groups to be subjected to the adjustment, and the number of sub-nozzles 22 that belong to an adjustment unit is the same (four) between all of the sub-nozzle groups to be subjected to the adjustment. However, the present invention is not limited to this, and the number of sub-nozzles 22 included in each adjustment unit in some sub-

nozzle groups may differ from that in other sub-nozzle groups.

[0100] In addition, in the above-described embodiments, each sub-nozzle group includes only one adjustment unit. However, the present invention is not limited to this, and each sub-nozzle group including a plurality of sub-nozzles 22 may include two or more adjustment units.

[0101] For example, a sub-nozzle group including four sub-nozzles 22 may include two adjustment units, which are an adjustment unit formed of two sub-nozzles 22 at the weft insertion side and an adjustment unit formed of two sub-nozzles 22 at the weft arrival side.

[0102] In the above-described embodiment, the DD motor 51 is provided on each sub-nozzle 22 to directly drive the sub-nozzle 22. The DD motor 51 serves as the drive device for changing the ejection angle position of each sub-nozzle 22. However, the drive device in the adjusting device according to the present invention is not limited to this, and may indirectly drive each sub-nozzle 22 by using a driving-force transmitting mechanism and an actuator (a drive motor, a rotary solenoid, etc.) 74 that is connected to the sub-nozzle 22 through the driving-force transmitting mechanism. In this case, the driving-force transmitting mechanism may be, for example, a rotating gear, a worm gear/worm wheel mechanism, a rack-and-pinion mechanism, a belt, or a chain. Figs. 5A to 5C illustrate examples of the driving-force transmitting mechanisms.

[0103] Fig. 5A illustrates a driving-force transmitting mechanism 71a, which is a rack-and-pinion mechanism, and an AC motor 74 that serves as an actuator. A pinion 72 is concentrically fixed to each sub-nozzle 22 at a proximal end thereof, and a pinion 75 is concentrically fixed to an output shaft of the AC motor 74. The pinion 72 and the pinion 75 mesh with a rack 73. When the AC motor 74 is driven, the sub-nozzle 22 is rotated by an amount corresponding to an amount of rotation of the output shaft of the AC motor 74. Thus, the ejection angle position of the sub-nozzle 22 is adjusted.

[0104] Fig. 5B illustrates a driving-force transmitting mechanism 71b, which is a worm gear/worm wheel mechanism, and an AC motor 74. A worm wheel 76 is concentrically fixed to each sub-nozzle 22 at a proximal end thereof, and a worm gear 77 is concentrically fixed to an output shaft of the AC motor 74. The worm wheel 76 meshes with the worm gear 77. When the AC motor 74 is driven, the sub-nozzle 22 is rotated by an amount corresponding to an amount of rotation of the output shaft of the AC motor 74. Thus, the ejection angle position of the sub-nozzle 22 is adjusted.

[0105] Fig. 5C illustrates a driving-force transmitting mechanism 71c, which is a worm gear/worm wheel mechanism, and an AC motor 74. This structure is similar to the structure illustrated in Fig. 5B, except the worm wheel 76 is replaced by an annular tooth groove portion 78. The annular tooth groove portion 78 is provided on the outer peripheral surface of the sub-nozzle 22 at the

proximal end thereof, and meshes with the worm gear 77 that is concentrically fixed to the output shaft of the AC motor 74.

[0106] In the above-described embodiments, each sub-nozzle 22 is provided with a single actuator (AC motor) 74. However, the present invention is not limited to this. In the case where an adjustment unit includes a plurality of sub-nozzles 22, a smaller number of sub-nozzles 22 than the total number of sub-nozzles 22 in the adjustment unit, or all of the sub-nozzles 22 in the adjustment unit may be driven by a single actuator 74 through a driving-force transmitting mechanism 71.

[0107] Fig. 6 illustrates an example of such a structure. A drive device in this example drives two sub-nozzles 22 with a single actuator 74, and includes a driving-force transmitting mechanism 71d, which is a rack-and-pinion structure, and the AC motor 74. More specifically, pinions 72 are concentrically fixed to the respective sub-nozzles 22 at the proximal end thereof, and a pinion 75 is concentrically fixed to an output shaft of the AC motor 74. The two pinions 72 and the pinion 75 mesh with a rack 73. When the AC motor 74 is driven, the two sub-nozzles 22 are simultaneously rotated by the same amount. Thus, the ejection angle positions of the sub-nozzles 22 are adjusted.

[0108] In the above-described embodiments, the ejection angle position of each sub-nozzle 22 is adjusted (changed) in accordance with a change in the weaving state in the weaving operation (in the continuous operation of the loom). However, the above-described method for adjusting the ejection angle position of each sub-nozzle 22 using the adjusting device according to the present invention is not limited to this. The method may also be applied to the case in which the ejection angle position of each sub-nozzle 22 is adjusted (set) in a weave preparation stage before the weaving operation is started or while the loom is temporarily stopped in the weaving operation. In this case, the ejection angle position of each sub-nozzle 22 may be automatically set in accordance with the weaving condition set by an operator in the weave preparation stage. If the setting of the weaving condition is changed by the operator while the loom is temporarily stopped in the weaving operation, the ejection angle position of each sub-nozzle 22 may be automatically changed in accordance with the change in the weaving condition.

[0109] The present invention is not limited to the air jet loom in which two types of weft yarns are subjected to weft insertion as in the above-described embodiment, and 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 angle position of a sub-nozzle (22) in an air jet loom including a plu-

ality of sub-nozzles (22) arranged along a weft insertion path and a plurality of electromagnetic on-off valves (36) provided to supply compressed air to the sub-nozzles (22), each electromagnetic on-off valve (36) being connected to one or more of the sub-nozzles (22), the one or more sub-nozzles (22) connected to each electromagnetic on-off valve (36) ejecting the air to perform weft insertion, the method comprising the steps of:

driving one or more sub-nozzles (22) that belong to an adjustment unit with at least one actuator (51, 74), the adjustment unit including at least one of the one or more sub-nozzles (22) connected to at least one of the electromagnetic on-off valves (36); and
adjusting an ejection angle position of each sub-nozzle (22) included in the adjustment unit by the same angle.

2. The method according to Claim 1, wherein the adjustment unit includes a plurality of sub-nozzles (22) connected to one of the electromagnetic on-off valves (36).

3. The method according to Claim 1 or 2, further comprising the steps of:

setting a database in advance, the database including the ejection angle position in association with each of a plurality of weaving conditions that are settable for a weaving operation performed by the air jet loom; and
selecting the ejection angle position corresponding to a set weaving condition from the database and driving the actuator (51, 74) on the basis of the selected ejection angle position.

4. The method according to Claim 3, wherein the air jet loom switches weaving conditions during the weaving operation, and
wherein, when the weaving conditions are switched during the weaving operation, the ejection angle position corresponding to the weaving condition set after the switching is performed is selected from the database, and the actuator (51, 74) is driven on the basis of the selected ejection angle position.

5. The method according to Claim 4, wherein the air jet loom includes a multi-color weft insertion device (11) that selectively subjects two or more weft yarns (a, b) of different yarn types to weft insertion in accordance with a weft selection pattern set as the weaving condition,
wherein the database includes the ejection angle position in association with each of the weft yarns (a, b) subjected to weft insertion, and
wherein, when the weft yarns (a, b) are switched

during the weaving operation, the actuator (51, 74) is driven in accordance with the ejection angle position corresponding to the weft yarn set after the switching is performed.

6. The method according to Claim 4 or 5, further comprising the steps of:

detecting the ejection angle position after the ejection angle position is changed; and
comparing a detection value of the ejection angle position with the ejection angle position selected in accordance with the weaving condition,

wherein, when there is a deviation between the detection value and the selected ejection angle position, the actuator (51, 74) is driven so as to eliminate the deviation.

7. The method according to Claim 1 or 2, wherein the air jet loom further includes a passage detection sensor (31) that detects a passage of a leading end of the weft yarn subjected to weft insertion, wherein the method further comprises the steps of:

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); and
comparing the reference value with the rotational angle at the time when the weft yarn is actually detected, and

wherein, when there is a deviation between the reference value and the rotational angle at the time when the weft yarn is actually detected, the actuator (51, 74) is driven in a direction for eliminating the deviation.

8. An apparatus for adjusting an ejection angle position of a sub-nozzle (22) in an air jet loom including a plurality of sub-nozzles (22) arranged along a weft insertion path and a plurality of electromagnetic on-off valves (36) provided to supply compressed air to the sub-nozzles (22), each electromagnetic on-off valve (36) being connected to one or more of the sub-nozzles (22), the one or more sub-nozzles (22) connected to each electromagnetic on-off valve (36) ejecting the air to perform weft insertion, the apparatus comprising:

a drive device that adjusts an ejection angle position of each sub-nozzle (22) that belong to an adjustment unit, the adjustment unit including at least one of the one or more sub-nozzles (22) connected to at least one of the electromagnetic

on-off valves (36),

wherein the drive device includes at least one actuator (51, 74) that is connected to each sub-nozzle (22) included in the adjustment unit and a control device (61a, 61b, 61c) that controls a driving operation of the actuator (51, 74) so that the ejection angle position of each sub-nozzle (22) included in the adjustment unit is adjusted by the same angle.

9. The apparatus according to Claim 8, wherein the drive device further includes a driving-force transmitting mechanism that is linked to a plurality of sub-nozzles (22) that belong to the adjustment unit and that are connected to one of the electromagnetic on-off valves (36).

10. The apparatus according to Claim 8 or 9, wherein the control device (61a, 61b, 61c) includes a setting unit (63) in which a database is set, the database including the ejection angle position in association with each of a plurality of weaving conditions that are settable in the air jet loom for a weaving operation, and a drive controller (62) that selects the ejection angle position corresponding to a set weaving condition from the database and controls the driving operation of the actuator (51, 74) on the basis of the selected ejection angle position.

11. The apparatus according to Claim 10, wherein the air jet loom switches weaving conditions during the weaving operation, and wherein, when the weaving conditions are switched during the weaving operation, the drive controller (62) selects the ejection angle position corresponding to the weaving condition set after the switching is performed from the database set in the setting unit (63).

12. The apparatus according to Claim 11, wherein the air jet loom includes a multi-color weft insertion device (11) that selectively subjects two or more weft yarns (a, b) of different yarn types to weft insertion in accordance with a weft selection pattern set as the weaving condition, wherein the database set in the setting unit (63) includes the ejection angle position in association with each of the weft yarns (a, b) subjected to weft insertion, and wherein, when the weft yarns (a, b) are switched during the weaving operation, the drive controller (62) selects the ejection angle position corresponding to the weft yarn set after the switching is performed from the database set in the setting unit (63).

13. The apparatus according to Claim 11 or 12, further comprising:

an angle-position detection sensor that detects the ejection angle position,

wherein the control device (61b) includes a determination unit (64) that compares a detection value obtained by the angle-position detection sensor after the ejection angle position is changed with the ejection angle position selected in accordance with the weaving condition, and

wherein, when there is a deviation between the selected ejection angle position and the detection value obtained by the angle-position detection sensor as a result of the comparison performed by the determination unit (64), the drive controller (62) drives the actuator (51, 74) so as to eliminate the deviation.

14. The apparatus according to Claim 8 or 9, wherein the air jet loom further includes a passage detection sensor (31) that detects a passage of a leading end of the weft yarn subjected to weft insertion, and 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 weft yarn is actually detected, 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 actually detected as a result of the comparison performed by the comparator (65), controls the driving operation of the actuator (51, 74) in a direction for eliminating the deviation.

FIG. 1

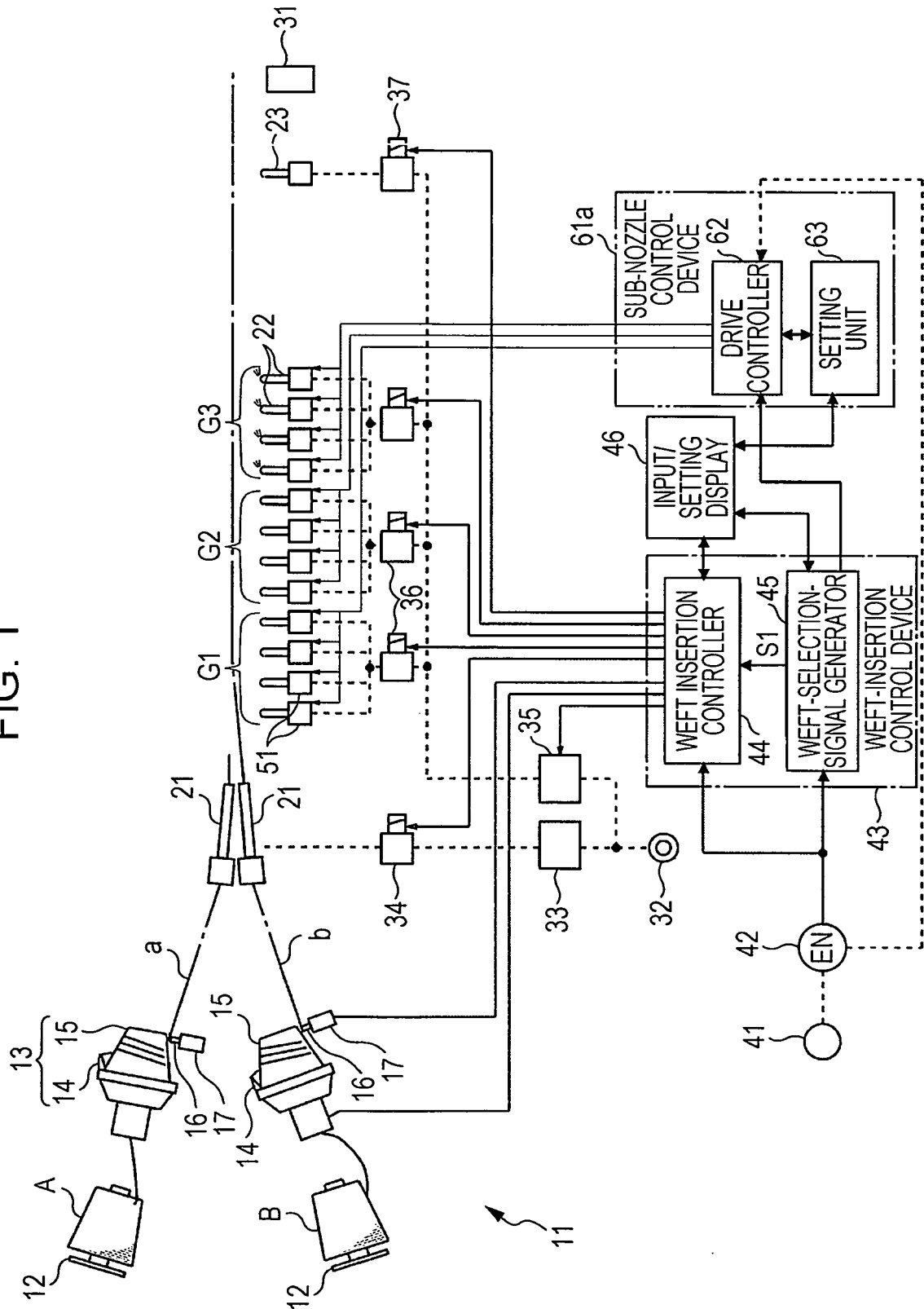


FIG. 2

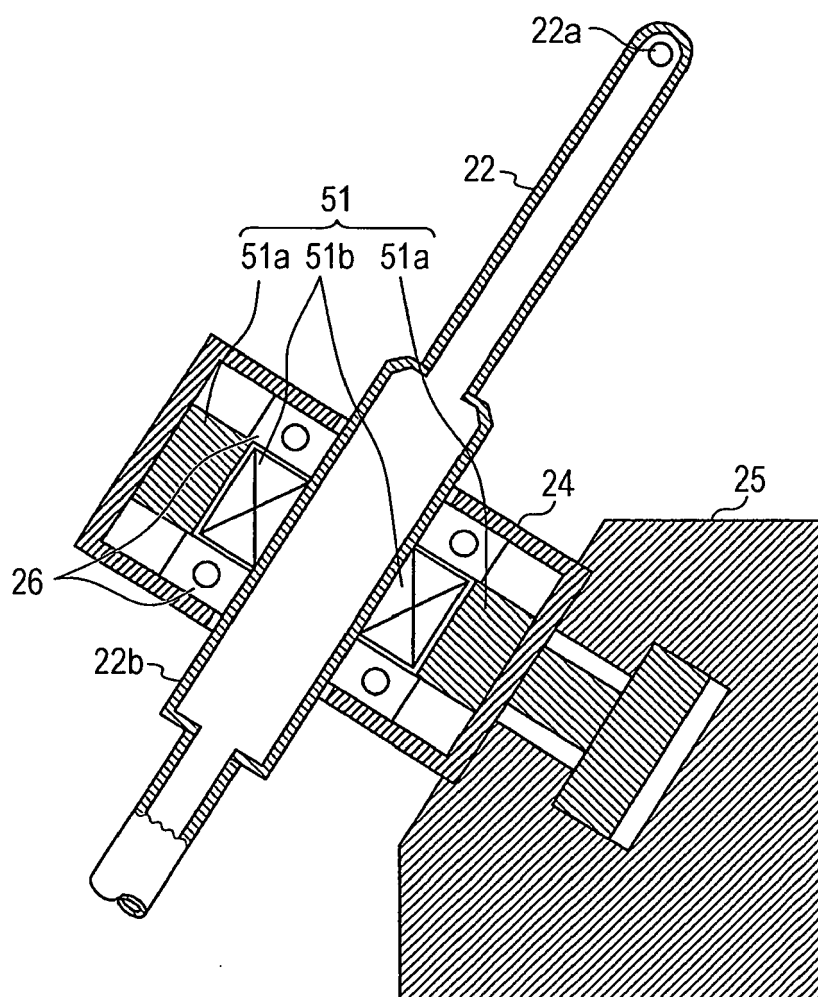


FIG. 3

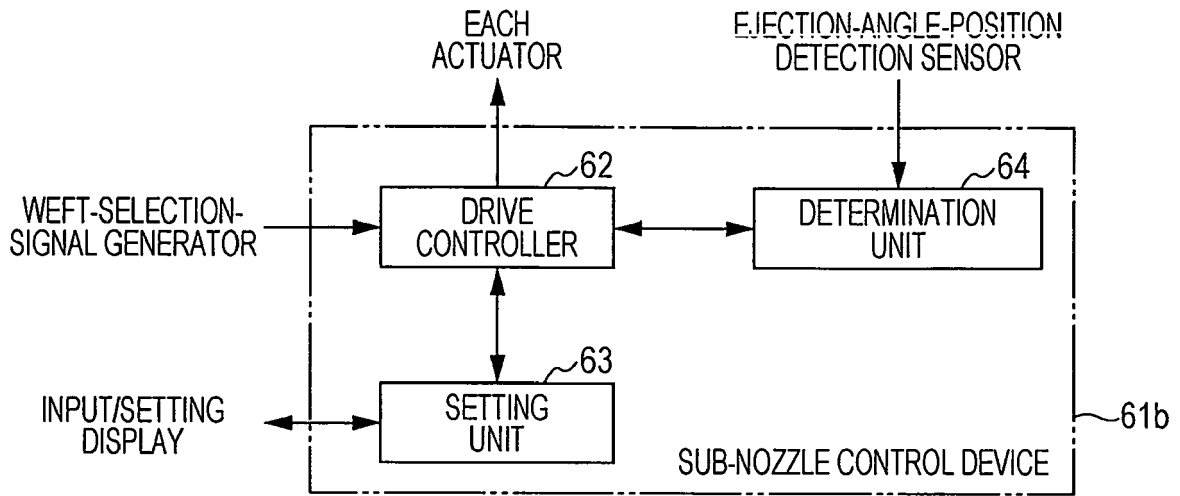


FIG. 4

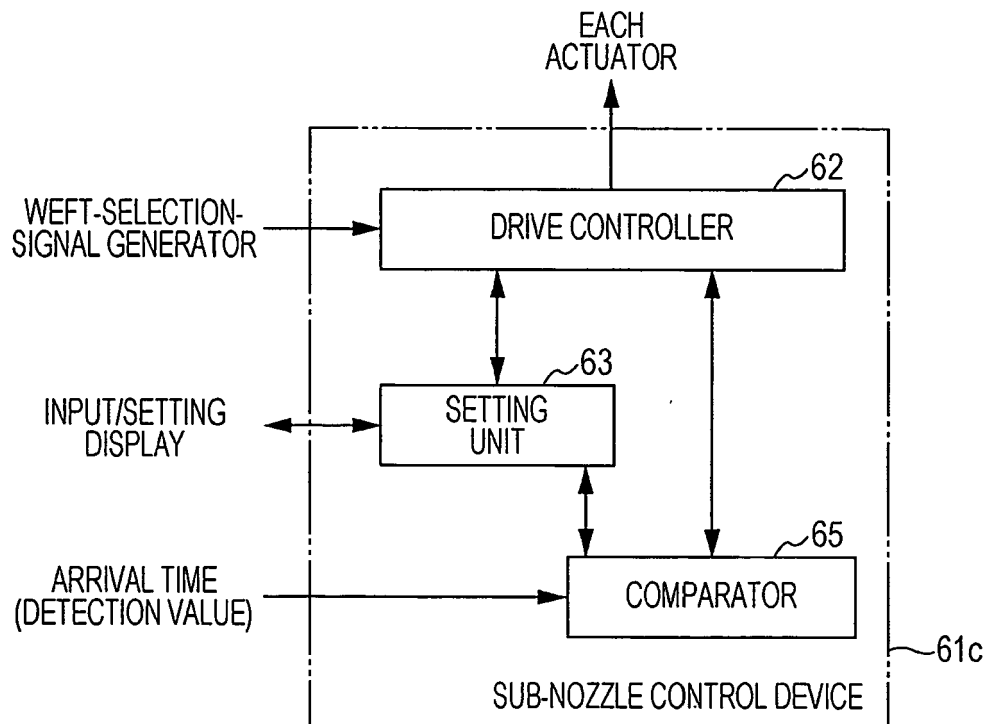


FIG. 5A

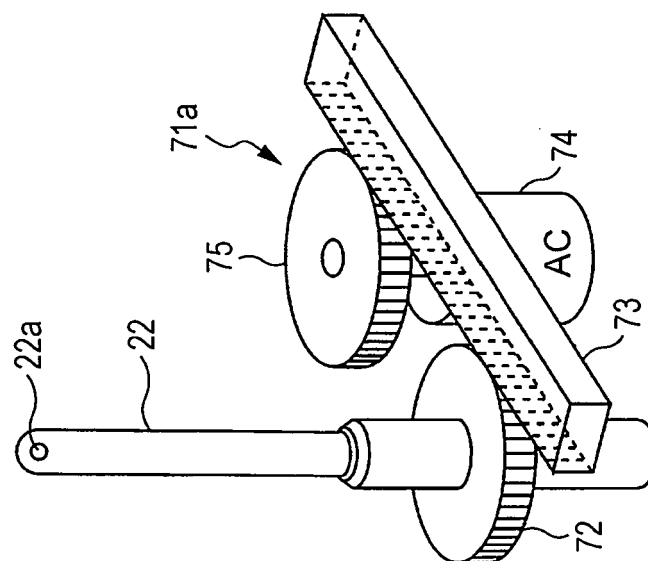


FIG. 5B

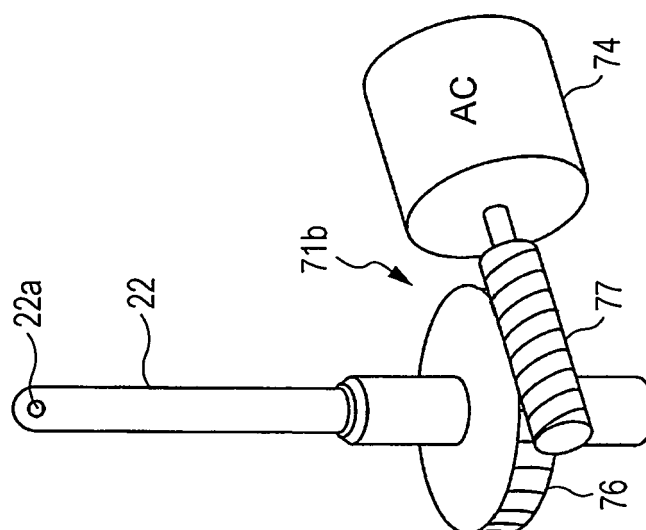


FIG. 5C

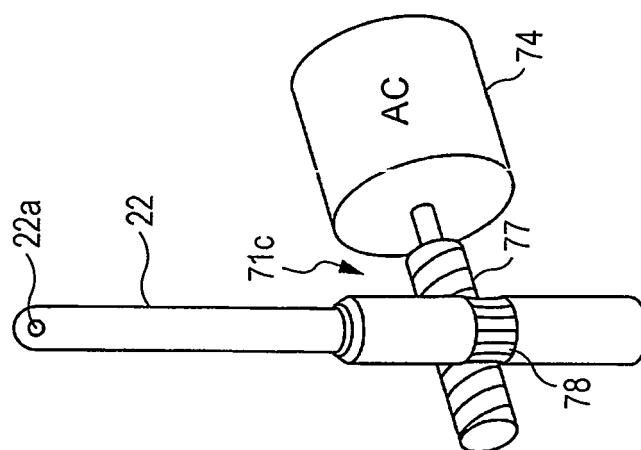


FIG. 6

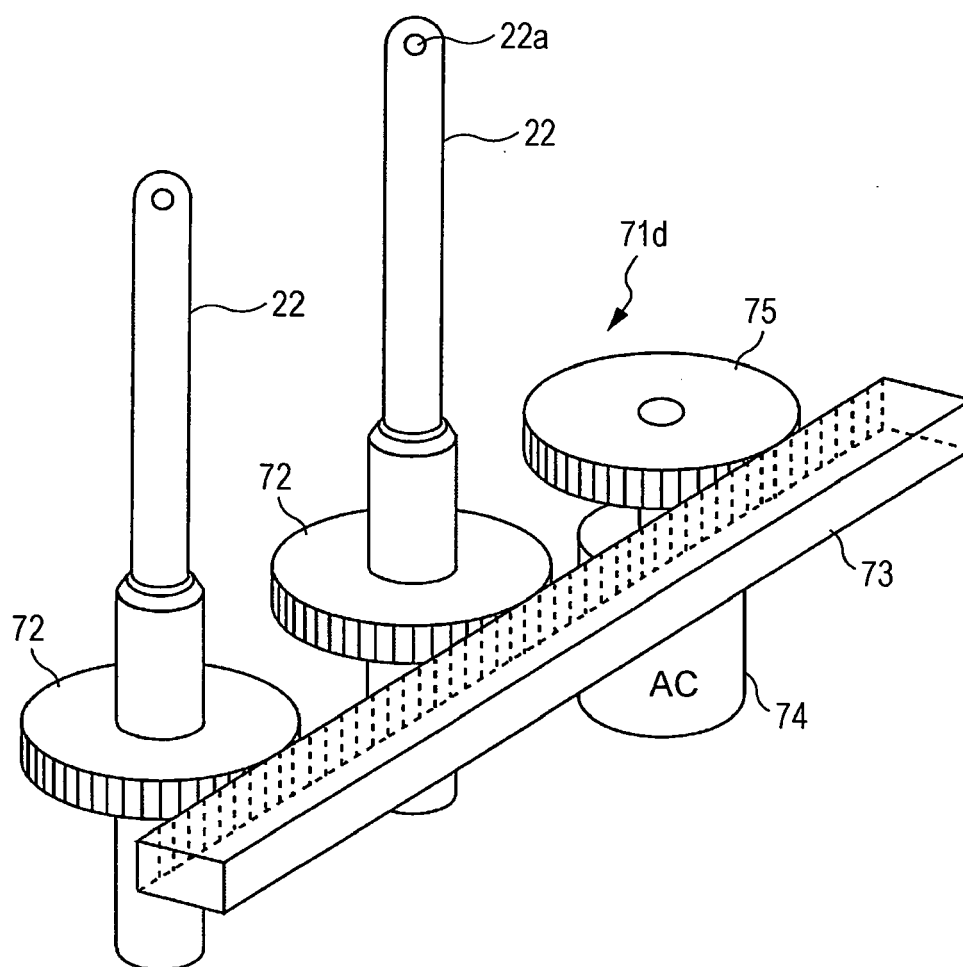
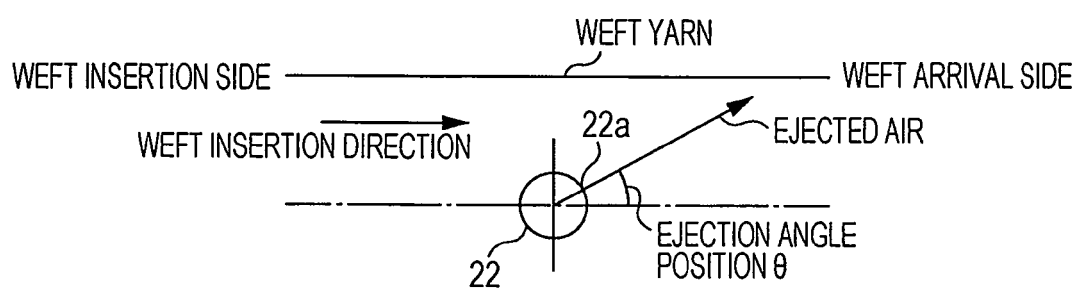


FIG. 7



REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 3015576 A [0005]