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

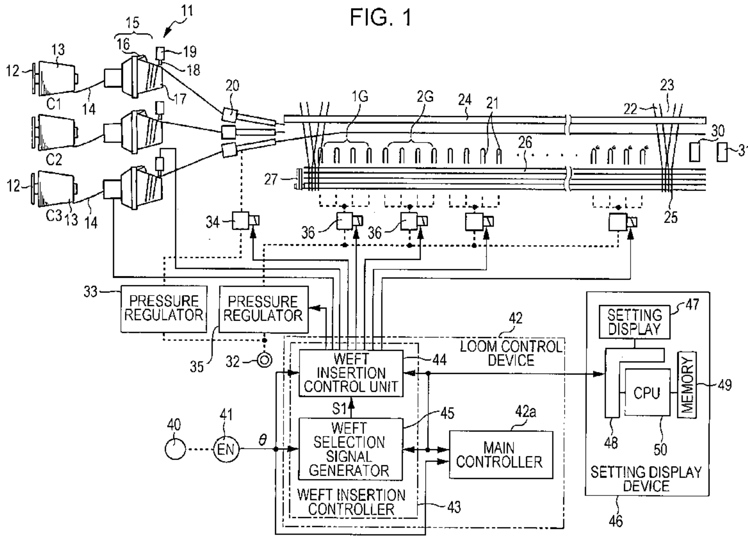
(72) Inventors:
- **Banba, Hideki**
  Ishikawa 921-8650 (JP)
- **Matsumoto, Masato**
  Ishikawa 921-8650 (JP)
- **Kuchida, Norio**
  Ishikawa 921-8650 (JP)
- **Kawada, Ayaka**
  Ishikawa 921-8650 (JP)
- **Yamazaki, Koki**
  Ishikawa 921-8650 (JP)

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

(54) Ejection-period setting method for sub-nozzles in air jet loom

(57) An ejection-period setting method for sub-nozzles (21) in an air jet loom is provided. The sub-nozzles (21) are divided into groups (1G to 13G) of sub-nozzles (21) that are connected to a common electromagnetic on-off valve (36). The groups (1G to 13G) are divided into downstream and upstream group sets (GU1 and GU3) which each include two or more groups and an intermediate group set (GU2) including the remaining groups. Ejection-amount reducing patterns (patterns hereinafter) are determined and stored in advance in an arbitrarily selectable state, each pattern being determined by setting an ejection-period reducing mode for each of subject group sets in units of predetermined periods so that each pattern includes the ejection-period reducing modes for all of the subject group sets, the subject group sets including the intermediate and upstream group sets (GU2 and GU3). In a process of setting the ejection periods of the sub-nozzles (21), ejection end times of the ejection periods are corrected when a pattern is selected by an operator.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a method for setting ejection periods (periods from ejection start time to ejection end time) of sub-nozzles in an air jet loom.

2. Description of the Related Art

[0002] In air jet looms, multiple sub-nozzles that are arranged along a weft insertion path are caused to eject air in preset periods, so that weft insertion is performed for a weft yarn that is ejected from a main nozzle. In general, the sub-nozzles are divided into groups in the order of arrangement thereof, each group including a plurality of sub-nozzles. The sub-nozzles that belong to the same group are connected to a common on-off valve and are caused to eject air simultaneously. These groups correspond to "sub-nozzle groups" described herein. As illustrated in Fig. 6, the ejection periods are set such that the sub-nozzle groups perform relay ejection so as to successively eject air in the order of arrangement during the weft insertion, starting from the one closest to the weft insertion side.

[0003] The ejection periods of the sub-nozzle groups are generally set in consideration of only the stability of weft insertion. Therefore, the ejection periods are not always set to minimum required periods, but are sometimes set to excessively long periods. More specifically, in the case where only the stability of weft insertion is considered, the air ejection periods of the sub-nozzle groups can be simply increased. However, in such a case, air ejection amounts increase, which is not preferable from the viewpoint of saving energy (reducing the air ejection amounts).

[0004] Accordingly, Japanese Unexamined Patent Application Publication No. 5-86542 (hereinafter referred to as Patent Document 1) discloses a method for setting ejection periods of sub-nozzles with which weft insertion can be stabilized and air ejection amounts can be reduced at the same time. The setting method according to Patent Document 1 will now be briefly described.

[0005] First, of ejection periods of sub-nozzle groups that are set in advance, the ejection period of the sub-nozzle group closest to a weft arrival side (side opposite to a weft insertion side) is reduced by a preset short time by advancing the ejection end time of the ejection period. Then, weft insertion is performed in that state and a weft arrival time is detected. If the detection value is less than or equal to a desired value, the next ejection period that is upstream of the previous sub-nozzle group in the weft insertion direction is changed in a similar manner. If the detection value is greater than the desired value, the change is canceled and the setting process is ended. If the detection value is still less than or equal to the desired value after the ejection period of the sub-nozzle group closest to the weft insertion side is changed, the process of changing the ejection periods of the sub-nozzle groups is repeated in the order of arrangement from the sub-nozzle group closest to the weft arrival side. Thus, the ejection end times of the sub-nozzle groups are successively changed in the order of arrangement from the sub-nozzle group closest to the weft arrival side. Accordingly, the air ejection amounts are reduced within the range in which the weft arrival time is earlier than or equal to the desired time, that is, within the range in which the weft insertion can be stabilized.

[0006] The technical idea of the setting method according to Patent Document 1 is simply to advance the ejection end times in the order of arrangement from the sub-nozzle group closest to the weft arrival side. In this case, the amounts of reduction in the air ejection amounts of the second and following sub-nozzle groups counted from the weft arrival side are smaller than or equal to those of the sub-nozzle groups that are downstream thereof in the weft insertion direction.

[0007] However, the air ejection amounts cannot be sufficiently reduced by such a setting method. This will be described in more detail.

[0008] The sub-nozzle groups at the weft arrival side eject the air not only to convey a weft yarn but also to retain a leading end portion of the weft yarn having a predetermined length that has been inserted and pull the weft yarn at the leading end portion. Therefore, the amounts by which the ejection periods, which affect the air ejection amounts, can be reduced are limited. If the ejection periods are excessively reduced, the weft yarn will become slack before being restrained by warp yarns and the woven cloth will become defective.

[0009] Compared to the sub-nozzle groups at the weft arrival side, the sub-nozzle groups in an intermediate area in the weft insertion direction have less influence on the weft insertion (weft arrival time, slacking of the wert yarn, etc.) when the ejection periods thereof are reduced. Therefore, the ejection periods can be reduced by a larger amount.

[0010] However, according to the setting method of Patent Document 1, unless the ejection periods of the sub-nozzle groups at the weft arrival side are reduced, the ejection periods of the sub-nozzle groups that are closer to the weft insertion side than the sub-nozzle groups at the weft arrival side cannot be reduced. Therefore, the amounts of reduction in the ejection periods of the sub-nozzle groups in the intermediate area in the weft insertion direction cannot be larger than those of the sub-nozzle groups at the weft arrival side. Therefore, the air ejection amounts cannot be sufficiently reduced.

SUMMARY OF THE INVENTION

[0011] The present invention has been made in view of the above-described circumstances. An object of the present invention is to provide a method for appropriately and easily setting ejection periods of sub-nozzles with which weft insertion can be stabilized and air ejection amounts can be reduced at the same time in an air jet loom.

[0012] The present invention is applied to an air jet loom including a plurality of sub-nozzles arranged along a weft insertion path, the sub-nozzles being divided into a plurality of sub-nozzle groups which each include a plurality of sub-nozzles that are connected to a common electromagnetic on-off valve, the sub-nozzle groups ejecting air in ejection periods set individually for the sub-nozzle groups to assist, with the ejected air, a movement of a weft yarn ejected from a main nozzle in a weft insertion process.

[0013] An ejection-period setting method for the sub-nozzles in the air jet loom includes dividing the sub-nozzle groups into a downstream sub-nozzle-group set including two or more sub-nozzle groups including the sub-nozzle group that is closest to a weft arrival side, an upstream sub-nozzle-group set including two or more sub-nozzle groups including the sub-nozzle group that is closest to a weft insertion side, and at least one intermediate sub-nozzle-group set including sub-nozzle groups excluding the sub-nozzle groups included in the downstream and upstream sub-nozzle-group sets; determining a plurality of air-ejection-amount reducing patterns that differ from each other and storing the determined air-ejection-amount reducing patterns in advance in an arbitrarily selectable state, each air-ejection-amount reducing pattern being determined by individually setting an ejection-period reducing mode for each of subject sub-nozzle-group sets in units of predetermined periods so that each air-ejection-amount reducing pattern includes the individual ejection-period reducing modes for all of the subject sub-nozzle-group sets, the subject sub-nozzle-group sets including at least the intermediate sub-nozzle-group set and the upstream sub-nozzle-group set; and correcting, in a process of setting the ejection periods of the sub-nozzles, ejection end times of set values of the set ejection periods on the basis of an air-ejection-amount reducing pattern that is selected arbitrarily by an operator from the plurality of air-ejection-amount reducing patterns.

[0014] The "set values of the set ejection periods" may be initial set values determined on the basis of the set weaving conditions (a rotational speed of the loom, a weaving width, a weft type, etc.) or set values obtained as a result of correction of the initial set values.

[0015] The air-ejection-amount reducing patterns are not limited to those in which the ejection periods of all of the subject sub-nozzle-group sets are reduced as long as the ejection periods of at least one of the subject sub-nozzle-group sets are reduced. Therefore, when, for example, the subject sub-nozzle-group sets are the upstream and intermediate sub-nozzle-group sets, the air-ejection-amount reducing patterns may include, for example, a pattern in which the ejection-period reducing mode for the intermediate sub-nozzle group is set to "1" unit and that for the upstream sub-nozzle-group set is set to "0" unit, a pattern in which the ejection-period reducing mode for the intermediate sub-nozzle group is set to "0" unit and that for the upstream sub-nozzle-group set is set to "1" unit, or a pattern in which the ejection-period reducing modes for the upstream and intermediate sub-nozzle groups are both set to "1" unit. Other examples of preferred manners in which the air ejection amounts are reduced will now be described.

[0016] The plurality of air-ejection-amount reducing patterns may include a first reducing pattern and a second reducing pattern. The first reducing pattern is set such that the ejection periods of at least the upstream sub-nozzle-group set are reduced and an amount of reduction in the ejection periods of the intermediate sub-nozzle-group set is smaller than or equal to an amount of reduction in the ejection periods of the upstream sub-nozzle-group set. The second reducing pattern is set such that an amount of reduction in the ejection periods of the intermediate sub-nozzle-group set is larger than amounts of rejection in the ejection periods of the other sub-nozzle-group sets.

[0017] The first reducing pattern may include a plurality of reducing patterns in each of which the amount of reduction in the ejection periods of the upstream sub-nozzle-group set is equal to the amount of reduction in the ejection periods of the intermediate sub-nozzle-group set and which have different total amounts of reduction. The second reducing pattern may include a plurality of reducing patterns in which amounts of reduction in the ejection periods of the intermediate sub-nozzle-group set differ from each other.

[0018] The air jet loom is not limited to those including a weft insertion device for inserting a weft yarn of a single color, and may instead be a loom including a weft insertion device for inserting weft yarns of multiple colors (multi-color weft insertion device). The following structure is a preferred example of the present invention.

[0019] That is, the air jet loom includes a multi-color weft insertion device including a plurality of the weft insertion systems, and the ejection end times are corrected for each of the weft insertion systems.

[0020] According to the present invention, the operator can arbitrarily select an air-ejection-amount reducing pattern so that the amounts of reduction in the air ejection amounts can be set without being limited to the amounts of reduction in the ejection periods (air ejection amounts) of the downstream sub-nozzle-group set. Therefore, for example, the ejection periods of the intermediate sub-nozzle-group set, which have relatively small influence on the weft insertion, can be reduced. Thus, the amounts of reduction in the air ejection amounts can be effectively set on the premise that the weft insertion can be appropriately performed. In addition, since the air-ejection-amount reducing patterns are stored in advance in an arbitrarily selectable state, the operator can easily set the amounts of reduction in the air ejection amounts.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021]

Fig. 1 is a diagram illustrating the main part of a weft insertion device included in an air jet loom;
Fig. 2 is a diagram illustrating a display screen of a setting display device displayed when an air-ejection-amount reducing pattern is selected;
Fig. 3 is a diagram illustrating the details of air-ejection-amount reducing patterns;
Figs. 4A and 4B are diagrams illustrating details of air-ejection-amount reducing patterns according to a modification;
Figs. 5A and 5B are diagrams illustrating details of air-ejection-amount reducing patterns according to another modification; and
Fig. 6 is a graph illustrating general ejection periods of sub-nozzles in an air jet loom according to the related art.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0022] 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. Although only three weft insertion systems are illustrated in Fig. 1, it is assumed that the weft insertion device is a six-color weft insertion device including six weft insertion systems. The following description is based on this assumption. The six-color weft insertion device corresponds to a multi-color weft insertion device according to the present invention. Here, each "weft insertion system" is a group of weft-insertion-related devices (a measuring-and-storing device 15, a main nozzle 20, sub-nozzles 21, etc.) that operate in cooperation with each other to perform a single cycle of weft insertion. The sub-nozzles 21 are used in common for all of the weft insertion systems.

[0023] In a weft insertion device 11 shown in Fig. 1, weft yarns 14 of colors C1, C2, C3, ..., are pulled out from respective yarn suppliers 13 that are supported by supplier stands 12. The weft yarns 14 are guided into, for example, yarn winding arms 16 included in drum-type measuring-and-storing devices 15. The yarn winding arms 16 rotate while the weft yarns 14 are retained by stopper pins 18 on outer peripheral surfaces of drums 17 in a stationary state, so that the weft yarns 14 are wound around the outer peripheral surfaces of the drums 17. Thus, a predetermined length of each weft yarn 14 that is necessary for a single cycle of weft insertion is wound around the corresponding drum 17 and is stored until weft insertion of the weft yarn 14 is executed.

[0024] The operations of the measuring-and-storing devices 15 (rotating operations of the yarn winding arms 16 and the reciprocal operations of the stopper pins 18) and the operations of weft-insertion main nozzles 20, which will be described below, are controlled by a weft insertion control unit 44 in a loom control device 42 on the basis of the order of weft yarn selection defined by a weft insertion pattern.

[0025] At a weft-insertion start time, the stopper pin 18 corresponding to the weft yarn 14 selected by the weft insertion control unit 44 is removed from the outer peripheral surface of the corresponding drum 17 by an operating unit 19. Accordingly, the weft yarn 14 wound around the outer peripheral surface of the drum 17, that is, the predetermined length of weft yarn 14 that is necessary for a single cycle of weft insertion, is set to a releasable state on the drum 17. Then, the weft-insertion main nozzle 20 through which the weft yarn 14 extends performs an air ejection operation so that the weft yarn 14, which extends from the drum 17, is released from the drum 17 and subjected to weft insertion.

[0026] At the set weft-insertion start time, the main nozzle 20 corresponding to the selected weft yarn 14 starts to eject compressed air toward a shed 23 of warp yarns 22. The ejection of the compressed air is continued for a set ejection period, so that the predetermined length of weft yarn 14 is inserted into the shed 23. In this weft insertion operation, the weft yarn 14 travels along a weft insertion path in the shed 23. 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 20 through an electromagnetic on-off valve 34. The electromagnetic on-off valve 34 is operated on the basis of the order of weft selection defined by the weft insertion pattern under the control of the weft insertion control unit 44.

[0027] As described above, the weft insertion device 11 shown in Fig. 1 is a six-color weft insertion device. In the case where multi-color weft insertion of two or more colors, for example, is to be performed, the same number of yarn suppliers 13, measuring-and-storing devices 15, main nozzles 20, etc., as the number of colors (number of weft yarns) are provided and the weft yarns are subjected to the weft insertion operation in the order of weft selection defined by the weft insertion pattern. In the case where single-color weft insertion is performed, a single yarn supplier 13, a single measuring-and-storing device 15, a single main nozzle 20, etc., are provided.

[0028] While the weft yarn 14 ejected from the main nozzle 20 travels along the weft insertion path in the shed 23, the multiple sub-nozzles 21 are caused to perform relay ejection in which the compressed air is ejected into the weft insertion path in the traveling direction of the weft yarn 14. Thus, the movement of the weft yarn 14 is assisted in the weft insertion direction. More specifically, the sub-nozzles 21 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 21 (four sub-nozzles 21 in the illustrated example) that are connected to a common electromagnetic on-off valve 36. The sub-nozzles 21 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 1G, 2G, ..., in the order of arrangement from the weft insertion side. Although only four electromagnetic on-off valves 36 are illustrated in Fig. 1, thirteen electromagnetic on-off valves 36 are provided in practice. In the following description, it is assumed that thirteen sub-nozzle groups are formed.

[0029] 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 21 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 21 in the corresponding sub-nozzle group for the set ejection period (period from the ejection start time to the ejection end time) under the control of the weft insertion control unit 44. Thus, the movement of the weft yarn 14 is assisted in the weft insertion direction.

[0030] When the weft insertion of the weft yarn 14 is normally performed as a result of the ejection operation performed by the main nozzle 20 and the sub-nozzles 21 of each sub-nozzle group, a beating up motion is performed in which the weft yarn 14 is beaten up against a cloth fell 26 of a woven cloth 25 by a reed 24. Thus, the weft yarn 14 is woven into the woven cloth 25. Then, the weft yarn 14 is cut by a yarn cutter 27 at the weft insertion side, and is separated from the weft yarn 14 in the main nozzle 20. Whether or not the weft insertion has been normally performed is determined on the basis of signals from feeler heads 30 and 31 that detect the arrival of the weft yarn 14.

[0031] The loom control device 42 includes the main controller 42a and the weft insertion controller 43 (which includes the weft insertion control unit 44 and a weft-selection-signal generator 45). An encoder 41 is connected to the main shaft 40 to detect a rotational angle θ of the main shaft 40. The encoder 41 generates a signal representing the rotational angle θ of the main shaft 40 in the weaving operation, and outputs the signal to the main controller 42a and to the weft insertion control unit 44 and the weft-selection-signal generator 45 of the weft insertion controller 43.

[0032] The main controller 42a controls the main operation of the loom or the operation of stopping the loom on the basis of the signal representing the rotational angle θ of the main shaft 40. The weft-selection-signal generator 45 in the weft insertion controller 43 determines the weaving cycle of the loom on the basis of the rotational angle θ obtained from the encoder 41 and selects one of the weft yarns 14 in accordance with the order of weft selection 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 14 to the weft insertion control unit 44. The weft insertion control unit 44 controls, in accordance with set control values, the operations of the measuring-and-storing device 15, the main nozzle 20, the sub-nozzles 21, etc. which belong to the weft insertion system corresponding to the selected weft yarn 14 on the basis of the rotational angle θ. Thus, the weft insertion operation of the selected weft yarn 14 is performed by the corresponding weft insertion system.

[0033] The loom control device 42 described above may be structured as a combination of functional blocks. For example, the loom control device 42 may be provided as a combination of devices provided as 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 cooperate with each other to provide the blocks, and the loom control device 42 may be provided as a combination of the thus-obtained blocks.

[0034] A setting display device 46, which functions as a setting device and which is capable of two-way communication, is provided to exchange data of weaving conditions with the main controller 42a and the weft insertion controller 43.

[0035] The setting display device 46 includes a setting display 47, a port 48, a memory 49 which functions as a storage unit, and a central processing unit (CPU) 50 which functions as a processor. The port 48 receives data (including various signals) from the setting display 47, the CPU 50, and the loom control device 42 and transmits data therebetween.

[0036] The memory 49 is rewritable. The memory 49 stores a program for controlling the setting display 47, which is a touch-panel display, other necessary software, and other necessary data.

[0037] The setting display 47 is a display device, and a portion of the display screen of the setting display 47 functions as a touch-panel input device. The operator can input display requests, various commands, etc., by touching buttons shown on the display screen.

[0038] The CPU 50 is a so-called microprocessor and controls an input/output operation of the port 48 in accordance with predetermined software stored in the memory 49. The CPU 50 also controls the setting display 47, reads predetermined data from the memory 49 in response to screen display requests from the setting display 47, and causes the setting display 47 to show the required display screen.

[0039] Fig. 2 illustrates an example of a display shown on the display screen of the setting display 47. In the example illustrated in Fig. 2, a display that allows the ejection period (period from the ejection start time to the ejection end time) of each sub-nozzle-group to be changed for each weft insertion system is shown on a single display screen.

[0040] The left half of the display shows a bar chart of the ejection period of each sub-nozzle group. In this graph, the horizontal scale indicates the crank angle (rotational angle of the loom main shaft), and the vertical scale indicates the weaving width with respect to the edge at the weft insertion side. The ejection period of each of the thirteen sub-nozzle groups according to the present embodiment is indicated by the length of a bar at the corresponding position along the vertical axis that indicates the weaving width. The sub-nozzle group that is closest to the weft insertion side is denoted by 1G, and the following sub-nozzle groups are denoted by 2G, 3G, and so on in the order of arrangement. The straight line that obliquely extends through the bar graph schematically illustrates the manner in which the weft yarn travels. In the illustrated example, the weft insertion start time is 90° in terms of the crank angle, and the desired weft insertion arrival time is 230° in terms of the crank angle.

[0041] In the illustrated example, six types of air-ejection-amount reducing patterns, each of which can be arbitrarily selected, are provided. The patterns can be selected by using buttons that are vertically aligned at the right side of the bar graph. The buttons are formed of hatched squares having patterns that can be distinguished from each other, and numbers corresponding to the patterns are displayed at the centers of the hatched squares. In this screen, it is assumed that the pattern corresponding to the button numbered 6 is selected. The buttons numbered 2 to 6 are provided with characters "+ pattern" and small squares with numbers smaller by 1 than the numbers of the buttons at the sides thereof. This visually shows that the air-ejection-amount reducing pattern No. 2, for example, includes the air-ejection-amount reducing pattern No. 1.

[0042] In the illustrated example, the air-ejection-amount reducing pattern can be set for each of the weft insertion systems. The weft insertion systems can be selected by using additional buttons that are vertically aligned at the right end of the screen. These buttons are formed of squares having yarn supplier marks therein, and numbers corresponding to the weft insertion systems are displayed on the yarn supplier marks. The screen shows buttons with yarn supplier marks numbered 1 to 8, and the buttons with yarn supplier marks numbered 1 to 6 are in a selectable state. The buttons that are in a selectable state are shown with high brightness, and the button that is being selected is shown with low brightness. In this screen, the weft insertion system corresponding to the button numbered 1 is selected. The buttons with yarn supplier marks numbered 7 and 8 are displayed at low density to show that they are not selectable.

[0043] In the present embodiment, it is assumed that the initial set values of the ejection periods of the sub-nozzle groups are automatically determined on the basis of the weaving conditions (a rotational speed of the loom, a weaving width, a weft type, etc.) that are set in advance in the main controller 42a. The initial set values are corrected on the basis of the air-ejection-amount reducing patterns illustrated in Fig. 2 that are independent of each other (non-combinable).

[0044] Fig. 3 shows bar-chart-shaped diagrams illustrating the initial set values of the ejection periods of the sub-nozzle groups and the air-ejection-amount reducing patterns illustrated in Fig. 2. In Fig. 2, the horizontal bars corresponding to the ejection periods of the sub-nozzle groups are positioned in accordance with the crank angles along the horizontal axis. However, in Fig. 3, the horizontal bars are aligned at the right ends (ejection end times) thereof to facilitate understanding of the relationship between the initial set values of the ejection periods of the sub-nozzle groups and the air-ejection-amount reducing patterns.

[0045] First, the initial set values of the ejection periods of the sub-nozzle groups will be described in detail. In the illustrated example, as described above, the horizontal rectangular bars that indicate the initial set values of the ejection periods of the sub-nozzle groups are vertically arranged at the left side. The horizontal bars corresponding to the sub-nozzle groups are stacked in order from the weft insertion side to the weft arrival side such that they are aligned at the right ends thereof. The initial set values of the ejection start times and the ejection end times of the ejection periods of the sub-nozzle groups in terms of the crank angle are shown at the left and right ends, respectively, of the stacked horizontal bars. The crank angles of the ejection start times and the ejection end times gradually increase in the order of arrangement from the weft insertion side to the weft arrival side. With regard to the ejection periods defined by the ejection start times and the ejection end times, the sub-nozzle group closest to the weft arrival side has the longest ejection period, and the sub-nozzle group closest to the weft insertion side has the shortest ejection period. The other sub-nozzle groups have ejection periods that are longer than or equal to those of the sub-nozzle groups on the weft insertion side thereof. The areas of the horizontal bars correspond to the air ejection amounts.

[0046] The setting of the ejection periods is performed not for each sub-nozzle group but for each of sub-nozzle-group sets which each include two or more sub-nozzle groups that are arranged next to each other. The "downstream sub-nozzle-group set" according to the present invention corresponds to a set of two or more sub-nozzle groups including the sub-nozzle group closest to the weft arrival side. The "upstream sub-nozzle-group set" according to the present invention corresponds to a set of two or more sub-nozzle groups including the sub-nozzle group closest to the weft insertion side. The "intermediate sub-nozzle-group set" according to the present invention corresponds to one or more sets of sub-nozzle groups excluding the sub-nozzle groups that belong to the downstream and upstream sub-nozzle-group sets.

[0047] In the illustrated example, three sub-nozzle groups 13G to 11G that include the sub-nozzle group 13G closest to the weft arrival side and that are arranged toward the weft insertion side form a downstream sub-nozzle-group set GU1. In addition, four sub-nozzle groups 1G to 4G that include the sub-nozzle group 1G closest to the weft insertion side and that are arranged toward the weft arrival side form an upstream sub-nozzle-group set GU3. The sub-nozzle groups 5G to 10G excluding the sub-nozzle groups that belong to the upstream and downstream sub-nozzle-group sets form a single intermediate sub-nozzle-group set GU2. In the illustrated example, all of the three sub-nozzle-group sets GU1 to GU3 are set as subject sub-nozzle-group sets for which the air-ejection-amount reducing patterns are to be determined.

[0048] The air-ejection-amount reducing patterns will now be described in detail. Each air-ejection-amount reducing pattern includes individual ejection-period reducing modes for all of the subject sub-nozzle-group sets. In the present embodiment, all of the three sub-nozzle-group sets are set as the subject sub-nozzle-group sets. With regard to the individual ejection-period reducing modes, a predetermined period is defined as a single unit, and the ejection-period reducing modes (amounts of reduction) are determined in terms of the number of units for each of the subject sub-nozzle-group sets. The air-ejection-amount reducing patterns are prepared in advance, and are stored in the memory 49 in the setting display device 46 illustrated in Fig. 1. In the example illustrated in Fig. 3, six types of air-ejection-amount reducing patterns (patterns 1 to 6) that differ from each other are provided. In Fig. 3, to visualize the amounts of reduction in the air ejection amounts with respect to the initial set values of the ejection periods of the sub-nozzle groups, the patterns are illustrated as follows. That is, for each pattern, horizontal bars having the same shapes as those of the initial set values of the ejection periods of the sub-nozzle groups are drawn, and hatched vertical bars that indicate the ejection-period reducing modes are drawn at the right ends of the horizontal bars. The number of vertical bars arranged in the horizontal direction corresponds to the number of the above-described units. In the present embodiment, a single unit corresponds to 4° in terms of the crank angle. That is, when, for example, the ejection periods are reduced by a single unit, the ejection end times of the ejection periods of the subject sub-nozzle-group sets are advanced (reduced) by 4° in terms of the crank angle from the initial set values thereof.

[0049] Table 1 shows patterns 1 to 6 that correspond to the air-ejection-amount reducing patterns illustrated in Fig. 3 that differ from each other.

Table 1

Sub-nozzle-group set	Pattern 1	Pattern 2	Pattern 3	Pattern 4	Pattern 5	Pattern 6
Downstream	1	1	1	1	1	1
Intermediate	1	2	3	4	5	6
Upstream	1	2	3	4	4	4

[0050] Each of the numbers in Table 1 indicates the number of units of the amount of reduction, which corresponds to "an ejection-period reducing mode that is set individually for each of sub-nozzle-group sets" according to the present invention. In Table 1, in each of the lines corresponding to the upstream, intermediate, and downstream sub-nozzle-group sets, the above-described number in each pattern may be the same as those in other patterns. However, the combination of the numbers in each pattern differs from those in other patterns.

[0051] The patterns 1 to 4 correspond to a "first reducing pattern" according to the present invention. The first reducing pattern is a pattern in which at least the ejection periods of the upstream sub-nozzle-group set are reduced and the ejection periods of the intermediate sub-nozzle-group set are reduced by the same amount as the amount of reduction in the ejection periods of the upstream sub-nozzle-group set. Further, the patterns 1 to 4 correspond to the "first reducing pattern including a plurality of reducing patterns in each of which the amount of reduction in the ejection periods of the upstream sub-nozzle-group set is equal to that in the ejection periods of the intermediate sub-nozzle-group set and which have different total amounts of reduction" according to the present invention.

[0052] The patterns 5 and 6 correspond to a "second reducing pattern" according to the present invention. The second reducing pattern is a pattern in which the amount of reduction in the ejection periods of the intermediate sub-nozzle-group set is larger than the amounts of reduction in the ejection periods of the other sub-nozzle-group sets. Further, the patterns 5 and 6 correspond to the "second reducing pattern including a plurality of reducing patterns in which amounts of reduction in the ejection periods of the intermediate sub-nozzle-group set differ from each other" according to the present invention.

[0053] In the above-described multi-color weft insertion loom, weaving conditions are set as the initial settings through the setting display 47 in the setting display device 46. The weaving conditions include the weaving width, the rotational speed of the loom, the types of weft yarns to be used in the weft insertion, and the weft insertion pattern that defines the order of selection of the weft yarns. The weaving conditions are stored in the memory (not shown) included in the main controller 42a of the loom control device 42.

[0054] The CPU 50 included in the setting display device 46 executes a predetermined program to determine the initial set values of the ejection periods of each sub-nozzle-group set on the basis of the conditions regarding the ejection periods of the sub-nozzles (the weaving width, the rotational speed, the weft type, etc.) included in the weaving conditions. The thus-determined initial set values are stored in the memory included in the main controller 42a.

[0055] The ejection periods of each sub-nozzle-group set are set in accordance with the following procedure.

(1) First, the operator causes the setting display to display the screen illustrated in Fig. 2. The graph of initial set values illustrated in Fig. 6 is initially displayed at the left half of Fig. 2.

(2) Then, the operator selects one of the patterns. Accordingly, the ejection end times of the ejection periods of each sub-nozzle-group set are corrected. The patterns can be arbitrarily selected, and the operator may select any one of the patterns. For example, in the case where it has been experimentally confirmed that the weft yarn to be inserted by the weft insertion system for which the setting is being made can be appropriately inserted even when the amount of reduction is increased (the ejection periods are reduced) for the intermediate sub-nozzle-group set, the pattern 5 or 6 may be selected from the start. If it is not known how much the ejection periods can be reduced, the pattern 1 or 2, in which the amounts of reduction are small, may be selected.

(3) The correcting process (correction of the ejection end times of the initially set ejection periods) is performed for each of the weft insertion systems. When the correction is performed for all of the weft insertion systems, the corrected set values are transmitted to the weft insertion control unit 44 and are stored in a memory (not shown) in the weft insertion control unit 44.

[0056] As a result, the weft insertion control unit 44 controls the operations of the electromagnetic on-off valves 36 for the sub-nozzles during the weft insertion on the basis of the weft selection signal S1 obtained from the weft-selection-signal generator 45 and the ejection periods of each sub-nozzle-group set that are set for the selected weft insertion system.

(4) After the above-described setting process, the operator checks whether or not the selected air-ejection-amount reducing patterns are appropriate by carrying out test weaving. For example, when the weft insertion is performed on the basis of the above-described settings, there may be a case in which a weft yarn inserted by one of the weft insertion systems will arrive at a time later than an allowable range of the desired weft arrival time. Alternatively, there may be a case in which the weft yarn will become slack. In such cases, it is determined that the amounts of reduction are excessively large, and the pattern used for the correction is changed to a pattern with amounts of reduction that are smaller by one step than those of the currently selected pattern. Thus, the ejection periods are set again.

[0057] Alternatively, there may be a case in which the weft yarn will arrive within the allowable range of the desired weft arrival time and in which the ejection periods are set as a result of correction based on a pattern with small amounts of reduction. In such a case, to check whether the air ejection amounts can be further reduced, the pattern used for the correction may be changed to a pattern with amounts of reduction that are larger by one step than those of the currently selected pattern. The ejection periods may thus be set again.

(5) The above-described setting process, test weaving process, and correcting/changing process are repeatedly performed. As a result, amounts of reduction in the air ejection amounts can be appropriately set for the initial set values of the ejection periods of the sub-nozzle groups for each of the weft insertion systems.

[0058] The air-ejection-amount reducing patterns that are stored in advance are not limited to those in the above-described embodiment, and may be modified as in examples (modifications) illustrated in Figs. 4 and 5. The modifications will now be briefly described. In the above-described embodiment, one of the patterns that are independent of each other (non-combinable) is selected to correct the initial set values of the ejection periods. However, in the modifications illustrated in Figs. 4A and 4B and Figs. 5A and 5B, a plurality of air-ejection-amount reducing patterns that can be selected in combination are stored in advance, and the amounts of reduction in the air ejection amounts are set by selecting the patterns in combination. The modifications will now be described in the order of drawing numbers.

[0059] In the modification illustrated in Figs. 4A and 4B, three types of air-ejection-amount reducing patterns 1 to 3 that differ from each other are provided, as illustrated in Fig. 4A. Table 2 shows each of the air-ejection-amount reducing patterns. Also in this modification, all of the three sub-nozzle-group sets are set as the subject sub-nozzle-group sets (subjects for which the ejection-period reducing modes are set).

Table 2

Sub-nozzle-group set	Pattern 1	Pattern 2	Pattern 3
Downstream	1	0	0
Intermediate	1	1	1
Upstream	1	1	0

[0060] Each of the numbers in Table 2 indicates the number of units of the amount of reduction. The patterns 1 and 2 correspond to the "first reducing pattern", and the pattern 3 corresponds to the "second reducing pattern".

[0061] Fig. 4B illustrates four examples of combination patterns obtained by combining the above-described patterns 1 to 3.

[0062] The combination pattern <1> is obtained by combining a single set of pattern 1 and a single set of pattern 2.

[0063] The combination pattern <2> is obtained by combining a single set of pattern 1 and two sets of pattern 2.

[0064] The combination pattern <3> is obtained by combining a single set of pattern 1, three sets of pattern 2, and a single set of pattern 3.

[0065] The combination pattern <4> is obtained by combining a single set of pattern 1, three sets of pattern 2, and two sets of pattern 3.

[0066] In the above-described embodiment, the maximum number of units that can be set as the amounts of reduction in the air ejection amounts of the upstream sub-nozzle-group sets is four. In contrast, according to the present modification, the amounts of reduction can be set to five or more units.

[0067] In the modification illustrated in Figs. 5A and 5B, three types of air-ejection-amount reducing patterns 1 to 3 that differ from each other are provided, as illustrated in Fig. 5A. Table 3 shows each of the air-ejection-amount reducing patterns. Also in this modification, all of the three sub-nozzle-group sets are set as the subject sub-nozzle-group sets (subjects for which the ejection-period reducing modes are set).

Table 3

Sub-nozzle-group set	Pattern 1	Pattern 2	Pattern 3
Downstream	1	0	0
Intermediate	0	1	0
Upstream	0	0	1

[0068] Each of the numbers in Table 3 indicates the number of units of the amount of reduction. The pattern 3 corresponds to the "first reducing pattern", and the pattern 2 corresponds to the "second reducing pattern".

[0069] Fig. 5B illustrates four examples of combination patterns obtained by combining the above-described patterns 1 to 3.

[0070] The combination pattern <1> is obtained by combining two sets of pattern 2.

[0071] The combination pattern <2> is obtained by combining four sets of pattern 2 and a single set of pattern 3.

[0072] The combination pattern <3> is obtained by combining four sets of pattern 2 and three sets of pattern 3.

[0073] The combination pattern <4> is obtained by combining a single set of pattern 1, four sets of pattern 2, and three sets of pattern 3.

[0074] According to this modification, the amounts of reduction can be more finely set. For example, in the case where it has been experimentally confirmed that the air ejection amounts can be reduced by a largest amount for the intermediate sub-nozzle-group set, by the second largest amount for the upstream sub-nozzle-group set, and by a small amount for the downstream sub-nozzle-group set, the amounts of reduction may be determined as follows. That is, the amounts of reduction can be reduced stepwise in the order of the intermediate sub-nozzle-group set (pattern 2), the upstream sub-nozzle-group set (pattern 3), and the downstream sub-nozzle-group set (pattern 4).

[0075] The present invention is not limited to the above-described embodiment and the two modifications. For example, in the above-described embodiment and modifications, the subjects of the air-ejection-amount reducing patterns (subjects for which the ejection-period reducing modes are set) include the downstream sub-nozzle-group set. However, according to the present invention, it is not necessary that the subject sub-nozzle-group sets include the downstream sub-nozzle-group set, and the subject sub-nozzle-group sets may include only the intermediate sub-nozzle-group set and/or the upstream sub-nozzle-group set.

[0076] The reason for this is as follows. That is, as described above in the Description of the Related Art section, the sub-nozzle groups at the weft arrival side provides not only a function of conveying the weft yarn that is being inserted (that is travelling) but also a function of preventing the weft yarn from becoming slack (stretching function) after the leading end of the weft yarn reaches the weft arrival side. Accordingly, it is often not preferable to advance the ejection end times. Therefore, according to the present invention, the downstream sub-nozzle-group set including the sub-nozzle group closest to the weft arrival side may be excluded from the subjects of the air-ejection-amount reducing patterns.

[0077] In addition, the numbers of sub-nozzle groups included in the downstream and upstream sub-nozzle-group sets are not limited to those in the above-described embodiment and modifications as long as the downstream sub-nozzle-group set includes the sub-nozzle group closest to the weft arrival side and one or more sub-nozzle groups adjacent thereto, and the upstream sub-nozzle-group set includes the sub-nozzle group closest to the weft insertion side and one or more sub-nozzle groups adjacent thereto.

[0078] In addition, according to the present invention, it is not necessary that the sub-nozzle groups other than those included in the downstream and upstream sub-nozzle-group sets belong to a single intermediate sub-nozzle-group set as in the above-described embodiment and modifications. The sub-nozzle groups other than those included in the downstream and upstream sub-nozzle-group sets may instead be divided into two or more intermediate sub-nozzle-group sets in the order of arrangement. In this case, different ejection-period reducing modes may be set for the two or more intermediate sub-nozzle-group sets.

[0079] In addition, according to the present invention, the unit of the amounts of reduction in the air-ejection-amount reducing patterns is not limited to the unit in terms of the crank angle as in the above-described embodiment and modifications, and may instead be, for example, a unit of time.

Claims

1. An ejection-period setting method for a plurality of sub-nozzles (21) arranged along a weft insertion path in an air jet loom, the sub-nozzles (21) being divided into a plurality of sub-nozzle groups (1G to 13G) which each include a plurality of sub-nozzles (21) that are connected to a common electromagnetic on-off valve (36), the sub-nozzle groups (1G to 13G) ejecting air in ejection periods set individually for the sub-nozzle groups (1G to 13G) to assist, with the ejected air, a movement of a weft yarn ejected from a main nozzle in a weft insertion process, the ejection-period setting method comprising the steps of:

   dividing the sub-nozzle groups (1G to 13G) into a downstream sub-nozzle-group set (GU1) including two or more sub-nozzle groups including the sub-nozzle group that is closest to a weft arrival side, an upstream sub-nozzle-group set (GU3) including two or more sub-nozzle groups including the sub-nozzle group that is closest to a weft insertion side, and at least one intermediate sub-nozzle-group set (GU2) including sub-nozzle groups excluding the sub-nozzle groups included in the downstream and upstream sub-nozzle-group sets (GU1 and GU3);
   determining a plurality of air-ejection-amount reducing patterns that differ from each other and storing the determined air-ejection-amount reducing patterns in advance in an arbitrarily selectable state, each air-ejection-amount reducing pattern being determined by individually setting an ejection-period reducing mode for each of subject sub-nozzle-group sets in units of predetermined periods so that each air-ejection-amount reducing pattern includes the individual ejection-period reducing modes for all of the subject sub-nozzle-group sets, the subject sub-nozzle-group sets including at least the intermediate sub-nozzle-group set (GU2) and the upstream sub-nozzle-group set (GU3); and
   correcting, in a process of setting the ejection periods of the sub-nozzles (21), ejection end times of set values of the set ejection periods on the basis of an air-ejection-amount reducing pattern that is selected arbitrarily by an operator from the plurality of air-ejection-amount reducing patterns.

2. The ejection-period setting method according to Claim 1, wherein the plurality of air-ejection-amount reducing patterns include a first reducing pattern and a second reducing pattern, the first reducing pattern being set such that the ejection periods of at least the upstream sub-nozzle-group set (GU3) are reduced and an amount of reduction in the ejection periods of the intermediate sub-nozzle-group set (GU2) is smaller than or equal to an amount of reduction in the ejection periods of the upstream sub-nozzle-group set (GU3), and the second reducing pattern being set such that an amount of reduction in the ejection periods of the intermediate sub-nozzle-group set (GU2) is larger than amounts of rejection in the ejection periods of the other sub-nozzle-group sets.

3. The ejection-period setting method according to Claim 2, wherein the first reducing pattern includes a plurality of reducing patterns in each of which the amount of reduction in the ejection periods of the upstream sub-nozzle-group set (GU3) is equal to the amount of reduction in the ejection periods of the intermediate sub-nozzle-group set (GU2) and which have different total amounts of reduction, and

wherein the second reducing pattern includes a plurality of reducing patterns in which amounts of reduction in the ejection periods of the intermediate sub-nozzle-group set (GU2) differ from each other.

4. The ejection-period setting method according to one of Claims 1, 2, and 3, wherein the air jet loom includes a multi-color weft insertion device including a plurality of the weft insertion systems, and the ejection end times are corrected for each of the weft insertion systems.

FIG. 1

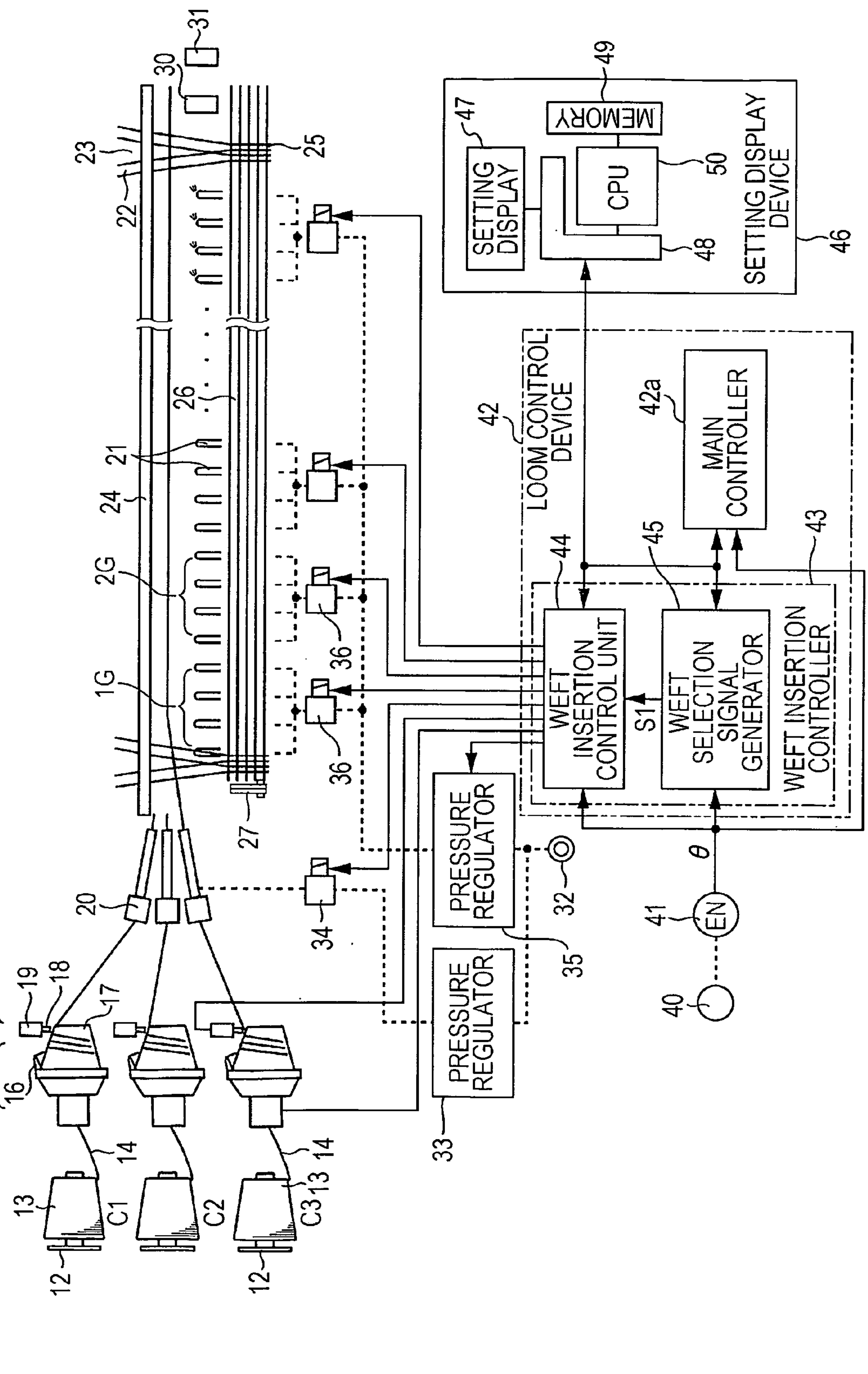

SETTING DISPLAY
MEMORY
CPU
SETTING DISPLAY DEVICE
LOOM CONTROL DEVICE
MAIN CONTROLLER
WEFT INSERTION CONTROL UNIT
WEFT SELECTION SIGNAL GENERATOR
WEFT INSERTION CONTROLLER
S1
PRESSURE REGULATOR
PRESSURE REGULATOR
EN
θ
C1
C2
C3
1G
2G

FIG. 2

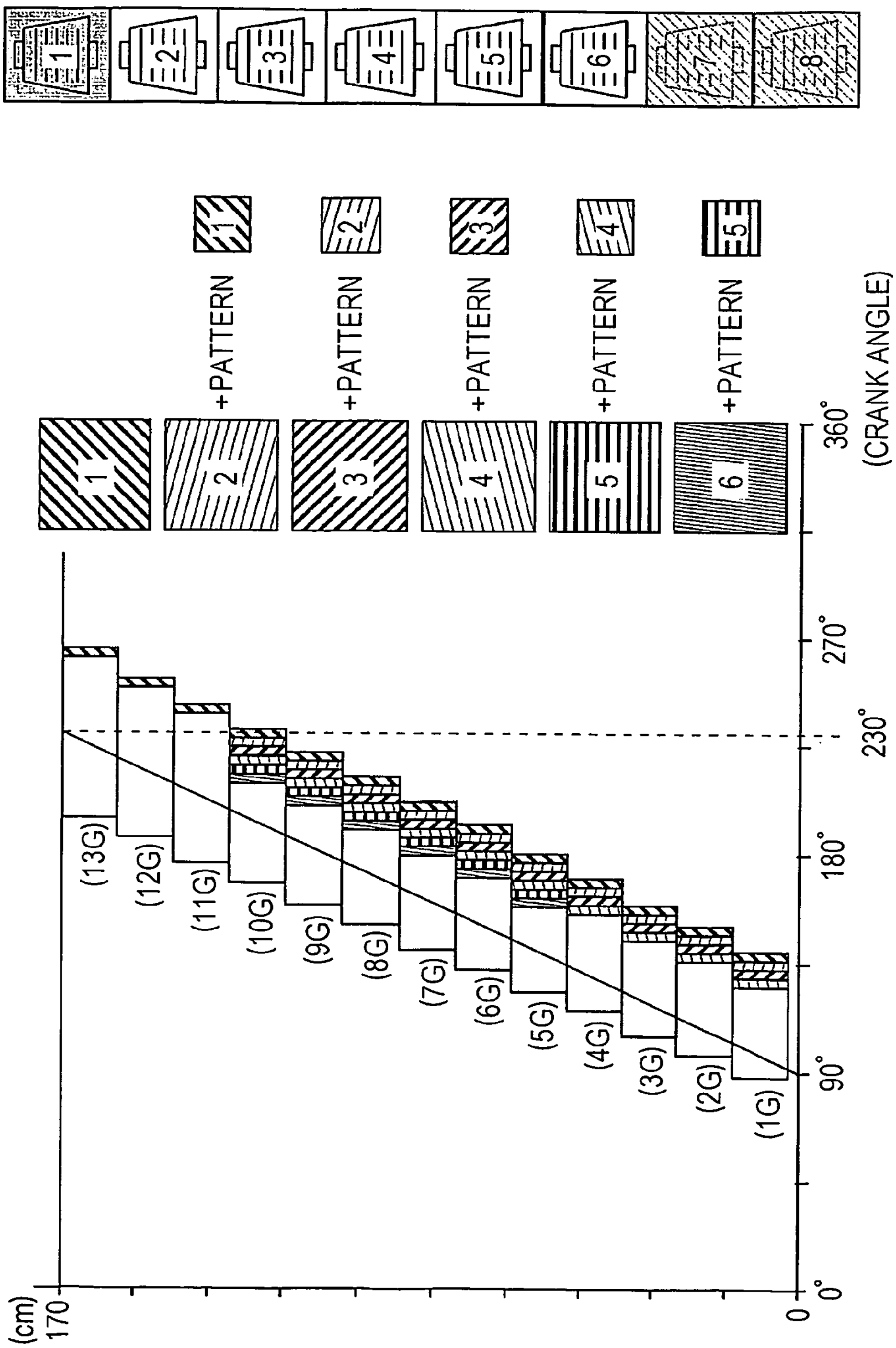

(cm)
170
0
0°
90°
180°
230°
270°
360°
(CRANK ANGLE)
(1G)
(2G)
(3G)
(4G)
(5G)
(6G)
(7G)
(8G)
(9G)
(10G)
(11G)
(12G)
(13G)
+PATTERN
+PATTERN
+PATTERN
+PATTERN
+PATTERN

FIG. 3

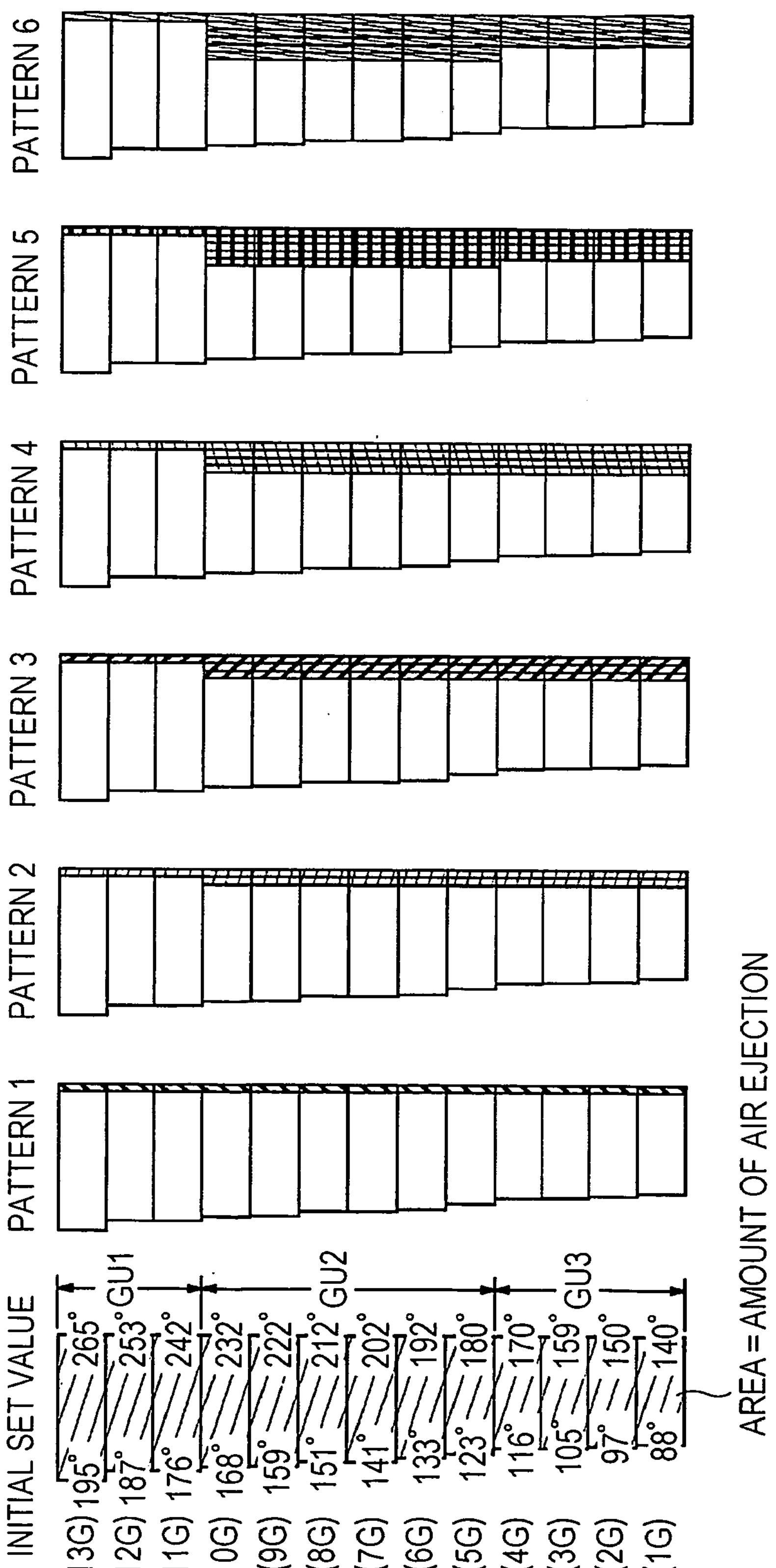

INITIAL SET VALUE
PATTERN 1
PATTERN 2
PATTERN 3
PATTERN 4
PATTERN 5
PATTERN 6
(13G) 195° 265°
(12G) 187° 253°
(11G) 176° 242°
(10G) 168° 232°
(9G) 159° 222°
(8G) 151° 212°
(7G) 141° 202°
(6G) 133° 192°
(5G) 123° 180°
(4G) 116° 170°
(3G) 105° 159°
(2G) 97° 150°
(1G) 88° 140°
GU1
GU2
GU3
AREA=AMOUNT OF AIR EJECTION

FIG. 4A

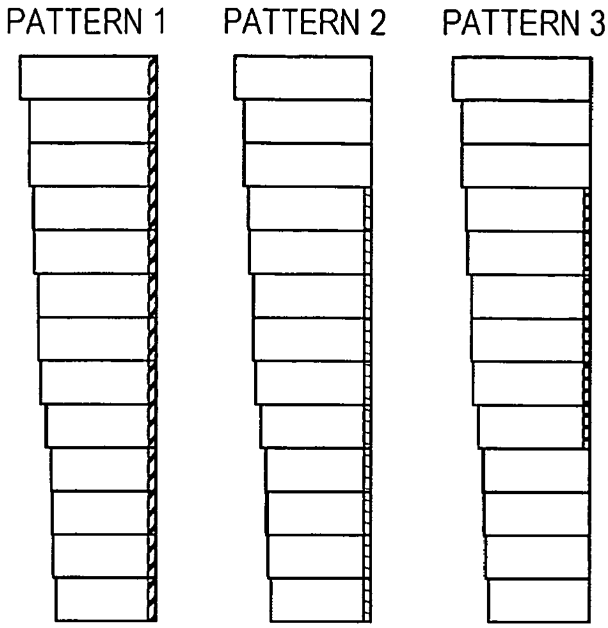

PATTERN 1
PATTERN 2
PATTERN 3

FIG. 4B

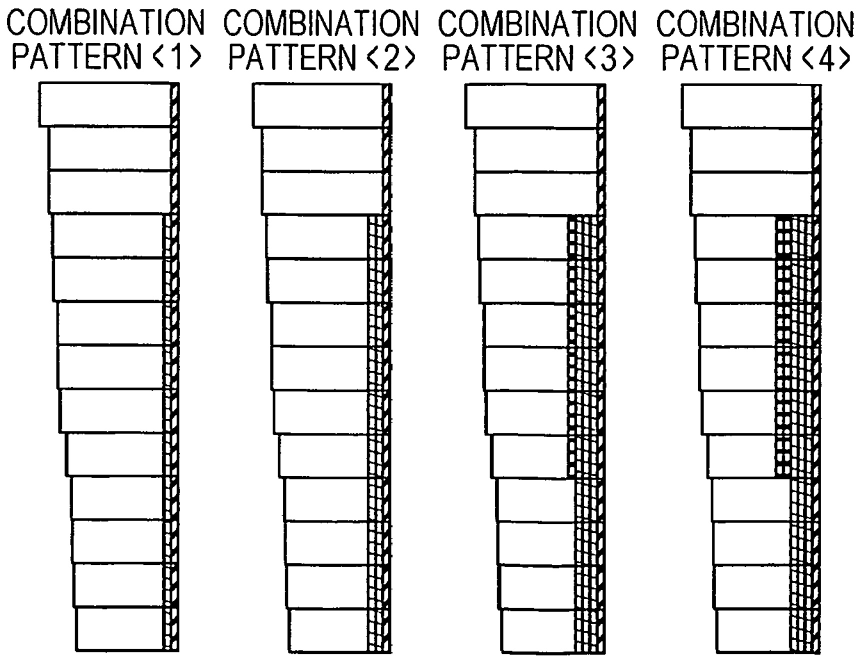

COMBINATION PATTERN <1>
COMBINATION PATTERN <2>
COMBINATION PATTERN <3>
COMBINATION PATTERN <4>

FIG. 5A

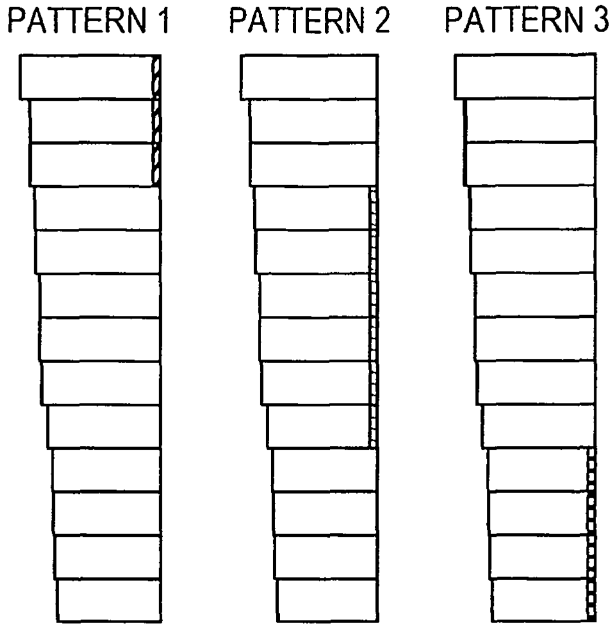

PATTERN 1
PATTERN 2
PATTERN 3

FIG. 5B

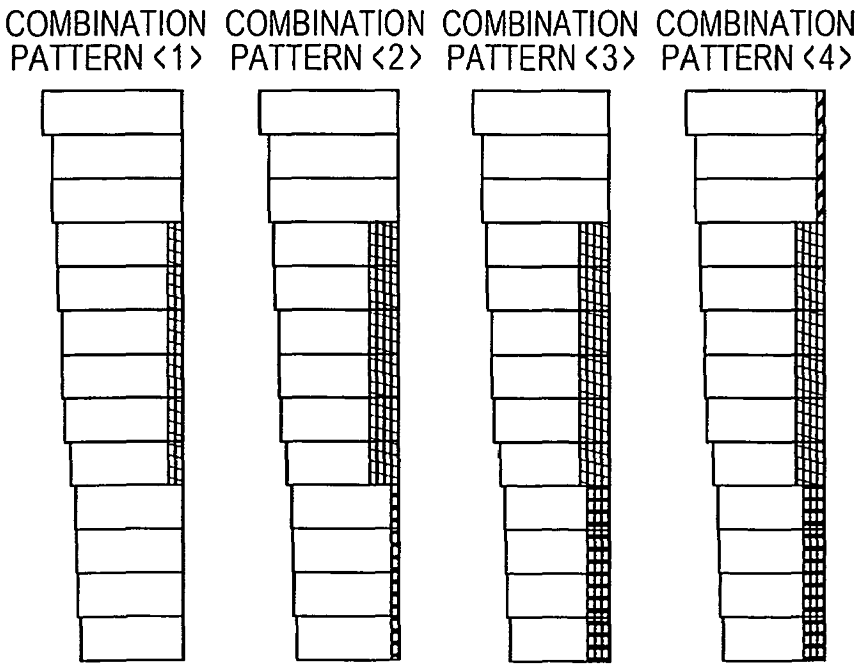
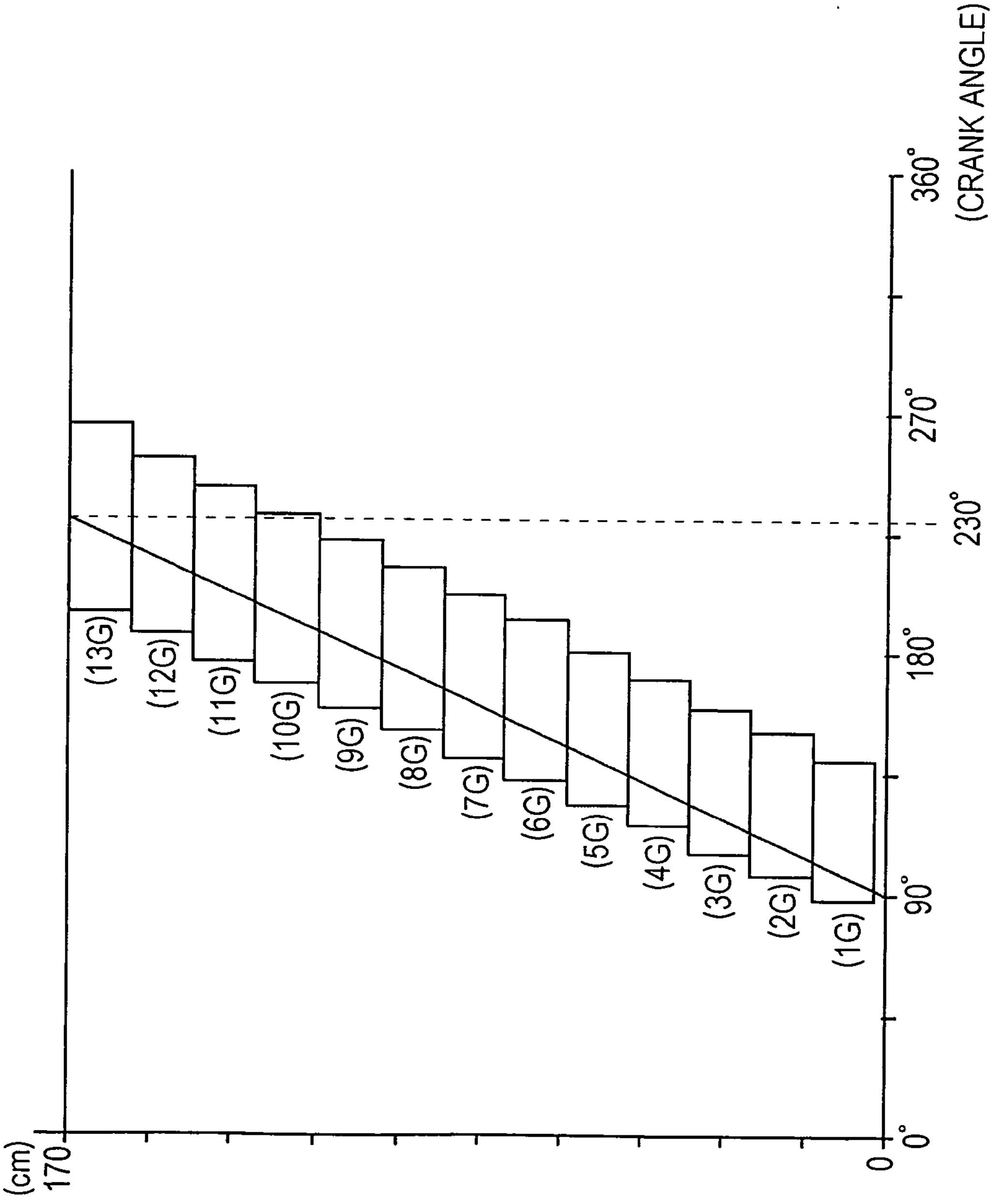

COMBINATION PATTERN <1>
COMBINATION PATTERN <2>
COMBINATION PATTERN <3>
COMBINATION PATTERN <4>

FIG. 6


(cm)
170
0
0°
90°
180°
230°
270°
360°
(CRANK ANGLE)
(1G)
(2G)
(3G)
(4G)
(5G)
(6G)
(7G)
(8G)
(9G)
(10G)
(11G)
(12G)
(13G)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 5086542 A **[0004]**