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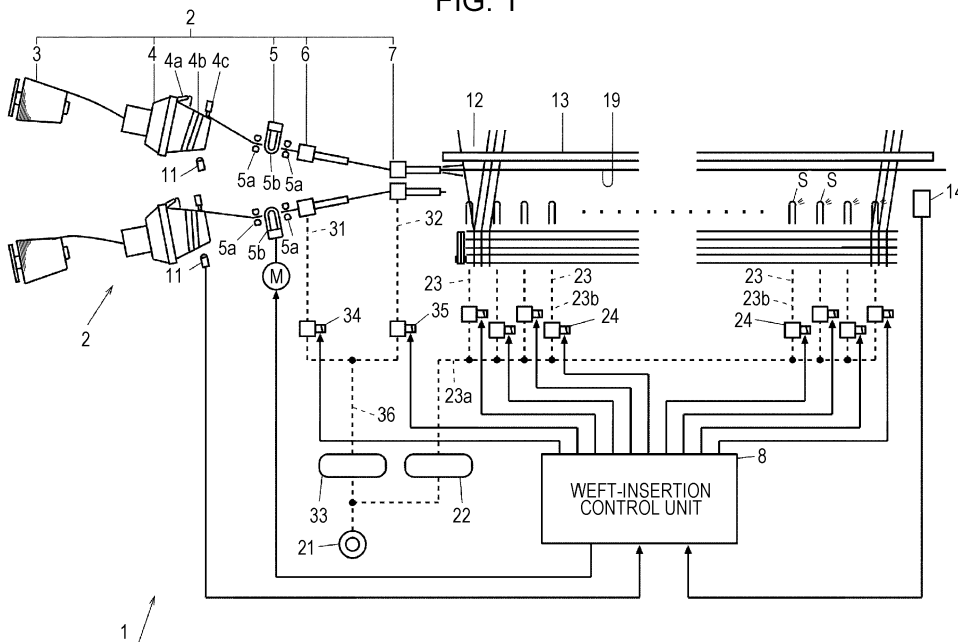
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(54) **METHOD OF SETTING WEFT TRAVEL INFORMATION FOR AIR JET LOOM**

(57) The invention provides a method of setting weft travel information for an air jet loom including a weft-insertion device that executes a jetting operation of each sub-nozzle during weft insertion in a jetting mode set based on weft travel information including information that allows a weft travel status to be plotted in a travel line form in a graph region whose horizontal and vertical axes indicate a crank angle and a distance from a weft-in-

section start position in a weaving-width direction, the method including setting first and second positions on a weft supply side and an opposite side in a travel passage from the start position to an arrival position; dividing the travel line into first to third continuous partial travel lines in first to third sections divided at the start, first, second, and arrival positions; and setting the weft travel information as including information about each partial travel line.

FIG. 1



Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a method of setting weft travel information for an air jet loom, the weft travel information being information about a weft travel status, the weft travel information being set to allow the weft travel status to be plotted in a travel line form in a graph region whose horizontal axis indicates one of a rotational angle of a loom main shaft and a distance from a weft-insertion start position in a weaving-width direction and whose vertical axis indicates the other one, a jetting mode of each sub-nozzle being determined on the basis of the set weft travel information.

2. Description of the Related Art

[0002] With an air jet loom, each sub-nozzle jets compressed air to assist travel of a weft ejected from a main nozzle during weft insertion desirably in a jetting mode (jetting start timing, jetting end timing) corresponding to a weft travel status during the weft insertion (hereinafter, referred to as "actual weft travel status"). If the jetting mode of each sub-nozzle (hereinafter, also merely referred to as "jetting mode") is not determined suitably for the actual weft travel status, problems may occur such that the air is wastefully jetted and the air consumption is increased, and the unsuitable jetting mode adversely affects the weft insertion (the travel of the weft, the status of the traveling weft, etc.). In other words, such problems can be prevented as long as the jetting mode is determined suitably for the actual weft travel status.

[0003] To set the jetting mode of each sub-nozzle, there has been an existing method of obtaining information (weft travel information) about an expected weft travel status (referred to as "expected weft travel status" in contrast to the aforementioned "actual weft travel status," the same applies hereinafter), and setting the jetting mode on the basis of the obtained weft travel information. Note that the weft travel information is information that allows the expected weft travel status to be plotted in a line graph (travel line) form in a graph region, for example, whose horizontal axis indicates a rotational angle of a loom main shaft (hereinafter, also referred to as "crank angle") and whose vertical axis indicates a distance from a weft-insertion start position (a distal end position of a main nozzle in the weaving-width direction). The travel line plotted in the graph region is a line graph that connects the distal end position of a weft at each crank angle when it is assumed that the weft travels in the expected weft travel status. The travel line corresponds to a travel locus of the distal end of the weft in this case. For example, Japanese Unexamined Patent Application Publication Nos. 63-92754 and 62-125049 disclose a technology of determining such a jetting mode of each sub-nozzle.

[0004] In related art, the weft travel information obtained (set) when the jetting mode of each sub-nozzle is determined as described above is information not corresponding to the actual weft travel status. Owing to this, in related art, the jetting mode of each sub-nozzle determined on the basis of the weft travel information is not suitable for the actual weft travel status. The details are described below.

[0005] In related art, the weft travel information is set as information in which the expected weft travel status is plotted by using a travel line that directly connects the set weft-insertion start timing and a target arrival timing to each other as described in Japanese Unexamined Patent Application Publication No. 63-92754. Alternatively, the weft travel information is set as information in which the expected weft travel status is plotted by using a slightly curved travel line that connects the set weft-insertion start timing and the target arrival timing to each other as described in Japanese Unexamined Patent Application Publication No. 62-125049. That is, in related art for determining the jetting mode of each sub-nozzle, the weft travel information is information set such that the travel speed of the weft does not change or almost does not change over the weft-insertion period.

[0006] However, regarding the actual weft insertion, when the weft-insertion period is divided into a weft-insertion initial period just after the start of the weft insertion, a weft-insertion end period near the end of the weft insertion, and a weft-insertion middle period existing therebetween, the weft travel speed in the weft-insertion initial period (initial-period travel speed) is largely different from the travel speed in the weft-insertion middle period (middle-period travel speed). Also, the middle-period travel speed is largely different from the travel speed in the weft-insertion end period (end-period travel speed). The details are described below.

[0007] In the weft-insertion initial period, the weft travel speed is lower than the weft travel speed in the weft-insertion middle period, because the weft-insertion initial period includes a transient period in which the pressure of the compressed air jetted by the main nozzle rises, the weft insertion is performed only by the main nozzle just after the start of the weft insertion, or the inertia of the weft and the resistance of release of the weft from a weft supply package are large when the weft starts moving from a stop status.

[0008] In contrast, regarding the weft travel speed in the weft-insertion end period; it is known that a weft brake device is provided for the loom. With the air jet loom provided with the weft brake device, the weft travel speed is lower than the weft travel speed in the weft-insertion middle period before the weft brake device is operated, by the effect of the weft brake device. Even when the weft brake device is not provided, with a typical air jet loom, the compressed air is jetted by the main nozzle not over the entire weft-insertion period, and is stopped before the weft-insertion end period. Due to this, the weft travel speed may be decreased in the weft-insertion end

period.

[0009] As described above, regarding the actual weft insertion, the travel speed is changed as described above in the weft-insertion initial period, the weft-insertion middle period, and the weft-insertion end period. In contrast, weft travel information is set such that the travel speed almost does not change in related art. The weft travel information is information obviously not corresponding to the actual weft travel status. Owing to this, the jetting mode of each sub-nozzle determined on the basis of the weft travel information according to the concept of related art is not suitable for the travel of the weft during the actual weft insertion, and consequently the aforementioned problems may occur.

SUMMARY OF THE INVENTION

[0010] The present invention is created in light of the situations, and an object of the invention is to cause the weft travel information which serves as the basis for setting the jetting mode of a sub-nozzle to correspond to the actual weft travel status as far as possible so that the jetting mode of the sub-nozzle is set more suitably for the actual weft travel status, for the above-described air jet loom.

[0011] The present invention presupposes an air jet loom including a plurality of sub-nozzles arranged along a weft travel passage, a weft measuring-and-storing device that includes a storing drum and that stores a weft to be inserted on the storing drum, and a release sensor that detects the weft released from the storing drum every release and that outputs a release signal every detection of the weft occurring a plurality of times during a weft-insertion period. The presupposed air jet loom includes a weft-insertion device. The weft-insertion device executes weft insertion in accordance with weft-insertion conditions including a weft-insertion start timing at which the weft insertion is started, and a target weft arrival timing at which a distal end of the inserted weft arrives at an arrival position set on a side opposite to a weft supply side. The weft-insertion device also executes a jetting operation of each of the sub-nozzles during the weft insertion in accordance with a jetting mode that is set on the basis of weft travel information being information about an expected weft travel status. For the presupposed air jet loom, the weft travel information is set, the weft travel information including information that allows the weft travel status to be plotted in a travel line form in a graph region whose horizontal axis indicates one of a crank angle being a rotational angle of a loom main shaft and a distance from the weft-insertion start position in a weaving-width direction and whose vertical axis indicates the other one.

[0012] The "weft travel status" mentioned here does not completely meet a weft travel status during actual weft insertion, and is an assumed (expected) weft travel status obtained by using a previously set value such as weaving conditions including weft-insertion conditions or

a detection value detected by a sensor or the like for a weft traveling during the actual weft insertion.

[0013] Also, the "jetting mode" (of a sub-nozzle) includes a jetting start timing and a jetting end timing (or jetting period) of each sub-nozzle. In actual fact, the jetting mode is determined to control driving of each of a plurality of electromagnetic on-off valves that are assigned to and connected to the plurality of corresponding sub-nozzles.

[0014] The present invention provides a method of setting the weft travel information for the air jet loom, the method including setting a first position determined on the weft supply side and a second position determined on the side opposite to the weft supply side in the travel passage from the weft insertion start position to the arrival position; recognizing the travel line expressed by the weft travel information by dividing the travel line into three continuous partial travel lines in the weaving-width direction including a first partial travel line in a first section from the weft-insertion start position to the first position, a second partial travel line in a second section from the first position to the second position, and a third partial travel line in a third section from the second position to the arrival position; and setting the weft travel information as information including information about each of the partial travel lines, and obtaining the information about each of the partial travel lines as information on corresponding one of (a) to (c) as follows.

[0015] (a) The second partial travel line is obtained as an approximate straight line with respect to passing points in the graph region obtained by using the crank angle at each time point when the release signal is output or expected to be output from the release sensor, and the distance at which the distal end of the weft is expected to arrive at each time point when the release signal is output, and the information about the second partial travel line is information obtained to allow the approximate straight line to be plotted in the second section in the graph region.

[0016] (b) The first partial travel line is obtained as a straight line that connects a start point obtained by using the crank angle set as the weft-insertion start timing at a position of zero of the distance corresponding to the weft-insertion start position and a start point of the second partial travel line to each other in the graph region, and the information about the first partial travel line is information obtained to allow the straight line to be plotted in the first section in the graph region.

[0017] (c) The third partial travel line is obtained as a straight line that connects an end point of the second partial travel line and an arrival point obtained by using the distance corresponding to the arrival position and the crank angle set as the target weft arrival timing to each other in the graph region, and the information about the third partial travel line is information obtained to allow the straight line to be plotted in the third section in the graph region.

[0018] With the present invention, the weft travel infor-

mation that is about the expected weft travel status and that serves as the basis for setting the jetting mode of each sub-nozzle is set as being more suitable for the actual weft travel status. Since the jetting mode of each sub-nozzle is set on the basis of the weft travel information, the jetting mode is set suitably for the actual weft travel status. Consequently, the problems such as the increase in air consumption and the adverse effect on the weft insertion as described above can be prevented from occurring as far as possible.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

Fig. 1 is an explanatory view showing an example of a weft-insertion device which is used for the present invention;

Fig. 2 is a block diagram showing the relationship between a weft-insertion control unit of the weft-insertion device, and devices relating to the weft-insertion control unit;

Fig. 3 is an explanatory view showing an example of a display screen of an input-and-setting unit of the weft-insertion device; and

Fig. 4 is an explanatory view showing a display screen displayed when a case where a travel line based on weft travel information and a jetting mode of each sub-nozzle are obtained according to the present invention is compared with a case of those obtained according to a method of related art.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] The present invention presupposes a weft-insertion device that executes weft insertion of an air jet loom in which a weft is inserted into a warp shed by using compressed air jetted by a weft insertion nozzle. Figs. 1 and 2 show an example of the weft-insertion device.

[0021] As shown in Fig. 1, a weft-insertion device 1 includes a weft supply system 2 including, as configurations relating to the weft insertion, a weft supply package 3, a weft measuring-and-storing device 4, and a main nozzle 7 serving as the weft insertion nozzle; and a weft-insertion control unit 8 that controls operations and so forth of the respective devices included in the weft supply system 2. Note that Fig. 1 illustrates the weft-insertion device 1 as a multi-color weft-insertion device including two aforementioned weft supply systems 2.

[0022] In each weft supply system 2, a weft 9 is pulled out from the weft supply package 3, is guided into a yarn winding arm 4a of the weft measuring-and-storing device 4, and is wound around a storing drum 4b by a rotational motion of the yarn winding arm 4a while the weft 9 is hooked by a hook pin 4c on (an outer peripheral surface of) the storing drum 4b at rest. Thus, the weft 9 having a length required for one-time weft insertion is wound around the storing drum 4b and is stored until the weft 9

is inserted.

[0023] Each weft supply system 2 includes, as a weft insertion nozzle in addition to the main nozzle 7, an auxiliary main nozzle 6 arranged on the upstream side of the main nozzle 7 (specifically, on the upstream side in a weft passage extending from the weft supply package 3 to the main nozzle 7). The auxiliary main nozzle 6 is a known weft insertion nozzle provided to assist insertion of the weft 9 into a warp shed 12 by the main nozzle 7. Moreover, each weft supply system 2 includes a weft brake device 5 arranged in the weft passage at a position next to the auxiliary main nozzle 6 on the upstream side of the auxiliary main nozzle 6.

[0024] When the hook pin 4c is driven at a weft-insertion start timing and is retracted from the outer peripheral surface of the storing drum 4b, the weft 9 wound around the storing drum 4b is brought into a state in which the weft 9 can be released on the storing drum 4b. The weft 9 extending from the storing drum 4b and passing through the auxiliary main nozzle 6 and the main nozzle 7 via the weft brake device 5 is released from the storing drum 4b and inserted by jetting operations performed by the auxiliary main nozzle 6 and the main nozzle 7.

[0025] The weft brake device 5 includes a pair of fixed guides 5a, 5a that guide the weft 9 and that are arranged to be separated from each other along the weft passage; a movable guide 5b that is provided rotatably between the fixed guides 5a, 5a and that can be engaged with the weft 9 by the rotation of the movable guide 5b; and a driving motor M serving as an actuator that rotationally drives the movable guide 5b. When the driving motor M is operated in a weft-insertion end period and the movable guide 5b rotates between the fixed guides 5a, 5a, the weft brake device 5 bends the weft 9 and causes a braking force to act on the weft 9. Thus, breakage of the weft 9 caused by restraint on the weft 9 by the weft measuring-and-storing device 4 (the hook pin 4c) at a weft-insertion end time point can be prevented.

[0026] In addition, a release sensor 11 (free drum pooling (FDP) sensor) is provided in each weft supply system 2 at a position near the storing drum 4b of the weft measuring-and-storing device 4. The release sensor 11 is provided to face the outer peripheral surface (in a drum radial direction) of the corresponding storing drum 4b. Fig. 1 shows that the release sensor 11 is provided at a position on the side opposite to the hook pin 4c with the storing drum 4b interposed for the convenience. However, the release sensor 11 is actually provided at a position shifted in a direction along the central axis of the storing drum 4b from a position the same as the position of the hook pin 4c around the storing drum 4b. Then, the release sensor 11 is electrically connected to a weft-insertion control unit 8.

[0027] With the weft insertion, the weft 9 on the storing drum 4b is released from the storing drum 4b. Every time when the weft 9 for one winding of the storing drum 4b is released from the storing drum 4b, the weft 9 passes between the storing drum 4b and the release sensor 11.

The release sensor 11 detects the passing, and generates a detection signal every detection. The detection signal is output as a release signal RS to the weft-insertion control unit 8 (see Fig. 2). Note that, depending on the weft-insertion device, the release signal RS may be used for driving control on the hook pin 4c.

[0028] Further, the weft-insertion device 1 includes a plurality of sub-nozzles S that are commonly provided for the two weft supply systems 2, 2 and that assist weft insertion by each weft supply system 2. The plurality of sub-nozzles S are provided such that adjacent sub-nozzles S, S are arranged at a predetermined interval on a reed holder (not shown) that supports a reed 13. With the weft-insertion device 1, the main nozzle 7 is also provided on the reed holder. The weft 9 inserted by the main nozzle 7 travels along a front surface (a surface on the loom front side) of the reed 13 on the reed holder. Hence, the plurality of sub-nozzles S are provided along a travel passage of the weft 9.

[0029] Each sub-nozzle S is connected to a common compressed-air supply source 21 via a supply channel 23 that is an air supply tube. Also, an air tank (sub-tank) 22 common to the sub-nozzles is provided in the supply channel 23 between each sub-nozzle S and the compressed-air supply source 21. Further, an electromagnetic on-off valve for controlling supply of compressed air to each sub-nozzle S is provided between the sub-tank 22 and the sub-nozzle S. In this embodiment, the electromagnetic on-off valve is provided for each sub-nozzle S. That is, the weft-insertion device 1 is configured such that the sub-nozzles S and the electromagnetic on-off valves 24 are provided in a one-to-one correspondence. Specifically, the supply channel 23 between each sub-nozzle S and the sub-tank 22 includes a common supply channel 23a extending from the sub-tank 22 toward the sub-nozzle S, and an individual supply channel 23b individually connecting the common supply channel 23a to the sub-nozzle S. The electromagnetic on-off valve 24 is not provided in the common supply channel 23a, and is provided in the individual supply channel 23b. Thus, with the weft-insertion device 1, a jetting mode (jetting start timing, jetting end timing (jetting period)) can be controlled for each sub-nozzle S.

[0030] The main nozzle 7 and the auxiliary main nozzle 6 are also connected to the compressed-air supply source 21, which is common to the sub-nozzles S, via supply channels that are air supply tubes. The supply channel that connects the main nozzle 7 and the compressed-air supply source 21 to each other, and the supply channel that connects the auxiliary main nozzle 6 and the compressed-air supply source 21 to each other are common on the side near the compressed-air supply source 21. Specifically, the supply channel that connects the main nozzle 7 and the compressed-air supply source 21 to each other is configured of a common supply channel 36 located on the side near the compressed-air supply source 21, and a supply channel 32 that is divided from the common supply channel 36 and connected to the

main nozzle 7. Also, the supply channel that connects the auxiliary main nozzle 6 and the compressed-air supply source 21 to each other is configured of the common supply channel 36, and a supply channel 31 that is divided from the common supply channel 36 and connected to the auxiliary main nozzle 6. Then, in the common supply channel 36, an air tank (main tank) 33 common to the main nozzle 7 and the auxiliary main nozzle 6 is provided. Further, an electromagnetic on-off valve 35 for controlling supply of compressed air to the main nozzle 7 is provided in the supply channel 32, and an electromagnetic on-off valve 34 for controlling supply of compressed air to the auxiliary main nozzle 6 is provided in the supply channel 31.

[0031] The electromagnetic on-off valves 24, 34, and 35 provided in the supply channels 23, 31, and 32 connected to the main nozzle 7, the auxiliary main nozzle 6, and the sub-nozzles S are electrically connected to the weft-insertion control unit 8. The weft-insertion control unit 8 causes the electromagnetic on-off valves 24, 34, and 35 to perform open-and-close operations (execute open-and-close control on the electromagnetic on-off valves 24, 35, and 35) on the basis of set values of jetting modes previously set for the main nozzle 7, the auxiliary main nozzle 6, and the sub-nozzles S. As shown in Fig. 2, the weft-insertion control unit 8 includes a controller 8a. The controller 8a executes the open-and-close control.

[0032] Also, the weft-insertion device 1 includes a weft feeler 14 provided for detecting an inserted weft. The weft feeler 14 is provided on the reed holder at a position at which a distal end of an inserted weft (hereinafter, also referred to as "weft end") arrives in a weft insertion direction (see Fig. 1). When the weft end arrives at the position in a predetermined detection period, the weft feeler 14 detects the weft and generates a detection signal. The weft feeler 14 is electrically connected to the weft-insertion control unit 8. Then, the weft feeler 14 outputs the generated detection signal as an arrival signal AS to the weft-insertion control unit 8.

[0033] Also, an input-and-setting unit 41 of the air jet loom is electrically connected to the weft-insertion control unit 8. Although specific illustration is omitted because the configuration is known, the input-and-setting unit 41 has a display screen and functions as a display unit. The display screen of the input-and-setting unit 41 is configured of what is called touch panel. Requests for various types of displays can be made and various set values (including the jetting modes) can be input and set through touch operation on the screen.

[0034] Then, the weft-insertion control unit 8 includes a memory 8b. The memory 8b stores the set values and so forth input and set by the input-and-setting unit 41. The memory 8b is electrically connected to the input-and-setting unit 41. The memory 8b is also electrically connected to the controller 8a.

[0035] An encoder EN that detects a rotational angle (crank angle) of a loom main shaft 15 is electrically con-

nected to the weft-insertion control unit 8. An angular signal θ as an output signal of the encoder EN is input to the weft-insertion control unit 8. The encoder EN is also electrically connected to a loom control device 16. The loom control device 16 detects the rotational speed of the loom main shaft 15 on the basis of the angular signal θ from the encoder EN.

[0036] As described above, the release signal RS output from the release sensor 11 is input to the weft-insertion control unit 8 in a weft-insertion period. The weft-insertion control unit 8 obtains the crank angle at the time point of generation of the release signal RS every time when the release signal RS is generated. Specifically, as shown in Fig. 2, the weft-insertion control unit 8 includes a timing detector 8c. The release signal RS output from the release sensor 11 is input to the timing detector 8c. The angular signal θ output from the encoder EN is also input to the timing detector 8c. Then, the weft-insertion control unit 8 obtains a crank angle (release timing) R θ at the time point of generation of the release signal RS on the basis of both the signals every time when the release signal RS is generated.

[0037] The timing detector 8c is also electrically connected to the memory 8b of the weft-insertion control unit 8. The release timing R θ obtained by the timing detector 8c is output to the memory 8b and stored in the memory 8b. In this embodiment, the weft-insertion length of one-time weft insertion is, for example, five windings (five turns) of the storing drum 4b of the weft measuring-and-storing device 4. In this case, the release timing R θ is obtained four times every weft insertion, that is, from a 1st-turn release timing R θ 1 to a 4th-turn release timing R θ 4. The memory 8b stores the four release timings R θ 1 to R θ 4 as data for one-time weft insertion relating to the release timing R θ .

[0038] As described above, at the time point when the weft feeler 14 generates the arrival signal AS, the arrival signal AS is output to the weft-insertion control unit 8. As shown in Fig. 2, the arrival signal AS is input to the timing detector 8c of the weft-insertion control unit 8. Then, the timing detector 8c also obtains a crank angle at the time point when the arrival signal AS is generated on the basis of the arrival signal AS and the angular signal θ from the encoder EN. Thus, with the weft-insertion control unit 8, the timing detector 8c obtains a crank angle (actual weft arrival timing) A θ at the time point when the weft end arrives at the position of the weft feeler 14 determined as the arrival position every weft insertion. The weft arrival timing A θ obtained by the timing detector 8c is output to the memory 8b.

[0039] The weft-insertion control unit 8 includes the controller 8a as described above. The controller 8a is also electrically connected to the weft brake device (specifically, the actuator (the driving motor M) that drives the movable guide) 5. The controller 8a controls the operation of the weft brake device 5 (driving of the actuator). The controller 8a controls the driving of the actuator of the weft brake device 5 so that a time point when a weft

having a predetermined length is inserted (a time point when the weft end arrives at a position at a predetermined distance to the arrival position ($\neq$ a time point of a constant crank angle)) meets a time point when braking of the weft brake device 5 on the weft is started. Specifically, the driving of the actuator is controlled as follows.

[0040] The braking start time point is set first. Note that the braking start time point is set by not using the constant crank angle, and is set by using a distance from the arrival position of a position on the side near the main nozzle with respect to the arrival position in the weft-insertion direction (for example, if the set value is "26 cm," a position separated by 26 cm from the arrival position toward the main nozzle). For the control, the drum diameter of the storing drum 4b of the weft measuring-and-storing device 4 is set, and a time point when the braking on the weft is stopped (braking end time point) is set by using the crank angle. The setting is performed by the input-and-setting unit 41, and the set value is stored in the memory 8b.

[0041] With the weft insertion, the weft-insertion control unit 8 obtains a travel speed of the weft (hereinafter, also merely referred to as "travel speed"). In this case, the weft-insertion control unit 8 includes an arithmetic element 8d that obtains the travel speed and that is electrically connected to the memory 8b and the controller 8a. The travel speed is obtained on the basis of the weft-insertion start timing, the release timing R θ obtained as described above, the set rotational speed of the loom, and the weft length for one winding of the storing drum 4b, by using an arithmetic expression stored in the arithmetic element 8d. The release timing R θ is stored in the memory 8b as described above. The weft-insertion start timing and the set rotational speed of the loom are also input and set by the input-and-setting unit 41 and previously stored in the memory 8b. The weft-insertion length for one winding of the storing drum 4b is obtained through an arithmetic operation by the arithmetic element 8d using the drum diameter stored in the memory 8b.

[0042] Then, the arithmetic element 8d obtains a driving start timing at which the driving of the actuator of the weft brake device 5 is started, on the basis of the obtained travel speed, the set rotational speed of the loom, the distance from the weft-insertion start position (a distal end position of the main nozzle) to the arrival position, the set value relating to the aforementioned braking start time point (the distance to the arrival position), and so forth, and outputs the obtained driving start timing to the controller 8a. The distance from the weft-insertion start position to the arrival position corresponds to the weft-insertion length. The distance may be set by actually measuring the distance (or by obtaining the distance through an arithmetic operation etc. by using known numerical values). Alternatively, a set value for a weaving width generally set as a weaving condition may be used. The set value for the weaving width is also stored in the memory 8b of the weft-insertion control unit 8.

[0043] The controller 8a starts the driving of the actu-

ator to bring the weft brake device 5 into an operating status of braking the weft in accordance with the obtained driving start timing. The operating status of the weft brake device 5 caused by the controller 8a is continued until the aforementioned braking end time point. At a time point when the crank angle arrives at the braking end time point, the driving of the actuator by the controller 8a is stopped.

[0044] The weft insertion is continuously executed in the loom; however, the weft travel status during each weft insertion is not always constant. The weft travel status may vary every insertion or may change as weaving progresses. In this case, the position of the weft end at the same crank angle is not constant. In such a situation, with the operational control of the weft brake device 5 by the weft-insertion control unit 8, the braking on the weft by the weft brake device 5 is started constantly at the time point when the weft end arrives at the position at the same distance from the weft-insertion start position.

[0045] To obtain the driving start timing, there are considered two methods including a method of obtaining the driving start timing by using the travel speed obtained during the same weaving cycle as the weaving cycle in which the weft brake device (actuator) 5 is driven, and a method of obtaining the driving start timing by using the travel speed obtained during the weaving cycle previous to the weaving cycle in which the weft brake device 5 is driven. In the former case, the travel speed is obtained on the basis of, for example, the release timing $R\theta$ in the first half of a weft-insertion period, and the driving start timing is obtained in the same weft-insertion period. In the latter case, for example, the driving start timing is obtained by using the travel speed obtained by weft insertion during the previous weaving cycle. Further, in the latter case, the driving start timing may be obtained every previously set number of (plural) weaving cycles instead of every weaving cycle. In this case, the weft brake device 5 is started at the same driving start timing until another driving start timing is obtained next.

[0046] With the weft-insertion device for the air jet loom, a method of setting the jetting mode of a sub-nozzle on the basis of weft travel information being information about an expected weft travel status (including a case of expectation based on the actual weft insertion and a case of expectation based on set values such as weaving conditions) is known. The weft travel information is information that allows the weft travel status to be plotted in a line graph (the line graph indicating the weft travel status is referred to as "travel line") form in a graph region whose horizontal axis indicates one of the crank angle and the distance from the weft-insertion start position in the weaving-width direction (hereinafter, also referred to as "weaving-width position") and whose vertical axis indicates the other one. The present invention presupposes such a setting method. Then, according to the present invention, for example, the weft travel information is obtained as follows. In this embodiment, an example of the present invention is described on the basis of the following pre-

suppositions.

[0047] The weft travel information is obtained as information that allows the expected weft travel status to be graphically displayed in the travel line form in the graph region whose horizontal axis indicates the crank angle and whose vertical axis indicates the weaving-width position. Fig. 3 shows a display example when a travel line g is displayed in a graph region on the display screen of the input-and-setting unit on the basis of weft travel information to be obtained as described below.

[0048] The weft-insertion length (from the weft-insertion start position to the arrival position) is substituted by the weaving width, which is 190 cm as illustrated. The set value of the weft-insertion start timing stored in the memory 8b of the weft-insertion control unit 8 is θ_s (in the illustrated example, corresponding to a crank angle of 80°). The set value of the target weft arrival timing is θ_e (in the illustrated example, corresponding to a crank angle of 236°), and is stored in the memory 8b via the input-and-setting unit 41. In Fig. 3, θ_s is displayed as a weft-insertion start angle, and θ_e is displayed as a target arrival angle. Thus, when the travel line g is plotted in the graph region as described above, the start point of the travel line g in the graph region is at a position of 0 (zero) (cm) along the vertical axis (weaving-width position) and a position of $\theta_s(^\circ)$ along the horizontal axis (crank angle) (the position corresponding to coordinates (0, θ_s), and indicated by reference sign "a" in Fig. 3). The arrival point is at a position of 190 (cm) along the vertical axis (weaving-width position) and a position of $\theta_e(^\circ)$ along the horizontal axis (crank angle) (the position corresponding to coordinates (190, θ_e), and indicated by reference sign "b" in Fig. 3).

[0049] Further, the set value of the distance set as the braking start time point of the weft brake device, that is, the distance to the arrival position is L_r (cm). That is, the setting at the braking start time point is setting that causes the weft brake device to start braking the weft at a time point when the weft end arrives at a position at a distance of $(190 - L_r)$ cm from the weft-insertion start position. The set value of L_r at the braking start time point in Fig. 3 is displayed as a WBS operating position. A first position and a second position according to the present invention are set on the basis of the above-described presuppositions.

[0050] The first position is a weaving-width position of the weft end at a time point when the travel speed of the weft is expected to reach a constant speed, and is set as a weaving-width position at a distance L_1 from the weft-insertion start position in the weaving-width direction (a position of L_1 along the vertical axis). The first position is obtained by performing test operation (test weaving) of the loom and finding out a suitable position.

[0051] In this embodiment, the second position is set as a weaving-width position (position at a distance of L_r to the arrival position) at the braking start time point of the weft brake device. In particular, when the weft brake device brakes the weft, the travel speed is changed (de-

creased) from the constant speed to a speed corresponding to the braking force. Hence, the weaving-width position at the braking start time point of the weft brake device is set as the second position. A distance L2 of the second position from the weft-insertion start position (a position of L2 along the vertical axis) is $L2 = 190 - Lr$ (cm).

[0052] With the setting of the first position and the second position as described above, the set value L1 for the first position is input and set by the input-and-setting unit and stored in the memory of the weft-insertion control unit. For the second position, a value obtained by the arithmetic element on the basis of the set value (Lr) at the braking start time point and the set value of the weaving width (190 (cm)) are set as the set value L2 (and stored in the memory).

[0053] Since the first position of L1 and the second position of L2 are set as described above, for the setting, the section of the weaving width in the weaving-width direction (weaving-width position: 0 to 190 (cm)) is divided into a first section in which the weaving-width position is from the position of 0 (cm) (the weft-insertion start position) to the first position of L1; a second section in which the weaving-width position is from the first position of L1 to the second position of L2; and a third section in which the weaving-width position is from the second position of L2 to the arrival position.

[0054] The travel line g corresponds to the locus of the weft end from the weft-insertion start position to the arrival position as described above, and is continued over the section of the weaving width. By dividing the section of the weaving width into the three sections, the travel line g can be recognized by dividing the travel line g into three corresponding portions. That is, the travel line g can be expected to be plotted in a continuous form of a first partial travel line g1 in the first section, a second partial travel line g2 in the second section, and a third partial travel line g3 in the third section.

[0055] Then, for each of the partial travel lines, information that is about the corresponding partial travel line and that causes the partial travel line to be plotted in the graph region as described above on the basis of the information is obtained by a method as follows. In the following description, for the respective partial travel lines, the first partial travel line is named first travel line, the second partial travel line is named second travel line, and the third partial travel line is named third travel line.

[0056] Information about the second travel line g2 is obtained as follows.

[0057] As the presuppositions, the four release timings R01 to R04 have been obtained for one-time weft insertion as described above. The four-time release signals RS serving as the basis of the four release timings R01 to R04 are output while the weft end passes through the second section. Since the travel speed reaches the constant speed before the release of the 1st turn is completed. The first position of L1 is set at a position nearer to the weft-insertion start position than the weft-weaving position of the weft end at the time point when the release

of the 1st turn is completed. The braking start time point of the weft brake device is set in the middle of the release of the last turn (5th turn). The braking start time point is set at a position nearer to the arrival position than the position of the weft end at the time point when the release of the 4th turn is completed.

[0058] Further, a weaving-width position (middle arrival position) at which the weft end arrives at each time point when the release of the weft of the 1st to 4th turns from the storing drum is completed is stored in the memory via the input-and-setting unit. Since the length of the weft released from the storing drum (weft-insertion length) corresponds to the weaving-width position of the weft end, the middle arrival position is obtained by multiplying the length of the weft for one winding of the storing drum by the number of release turns. The length of the weft for one winding of the storing drum is obtained by using the drum diameter of the storing drum input and set as described above. Each middle arrival position is stored in the memory in association with the number of release turns.

[0059] Based on the presuppositions, during weaving, the four release timings R01 to R04 are obtained for one-time weft insertion as described above. That is, the weft insertion according to this embodiment generates the four release timings R01 to R04 while the weft end passes through the second section every weft insertion. During weaving, the four release timings R01 to R04 are obtained as measured values on the basis of the release signals RS generated by actual weft insertion. Note that the four release timings R01 to R04 can be obtained as predicted values without actual weft insertion, by using, for example, data of weaving in the past, the configuration (status) of the weft-insertion device, and the weft-insertion conditions.

[0060] Each release timing R0 (measured value or predicted value) obtained as described above corresponds to a crank angle at a time point when the weft end arrives at the middle arrival position corresponding to the number of release turns. Hence, by obtaining the release timing R0, four coordinates (Xn, Yn) (X: crank angle, Y: weaving-width position, n = 1 to 4) that can be plotted in the graph region whose horizontal axis (X axis) is the crank angle and whose vertical axis (Y axis) is the weaving-width position are obtained. Then, based on the four obtained coordinates, an expression (approximate linear expression) expressing an approximate straight line (regression straight line) that can be plotted with respect to the points of the four coordinates in the graph region. Specifically, an arithmetic expression for obtaining the approximate linear expression (more specifically, the approximate linear expression is expressed in a form of a linear function of $Y = aX + b$, for obtaining a and b) is stored in the memory, and the approximate linear expression is obtained by the arithmetic element on the basis of the arithmetic expression and the four coordinates.

[0061] The straight line plotted in the graph region by using the approximate linear expression corresponds to

the second travel line g2. Note that the second travel line g2 expresses the weft travel status in the second section, and is plotted in the displayed graph region in a range from the first position of L1 to the second position of L2. Hence, the second travel line g2 is a partial straight line whose start point is an intersection between both straight lines obtained by the approximate linear expression expressing the approximate straight line ($Y = aX + b$) and by an expression expressing a straight line parallel to the X axis at the position of L1 ($Y = L1$) along the Y axis in the graph region, and whose end point is an intersection between both straight lines obtained by the approximate linear expression and by an expression expressing a straight line parallel to the X axis at the position of L2 ($Y = L2$) along the Y axis. The coordinates of the start point and the end point ((since the weaving-width positions are known L1 and L2,) the crank angle is obtained) are obtained by the arithmetic element by using the approximate linear expression and the set values of L1 and L2. The approximate linear expression and the coordinates of the start and end points obtained by the arithmetic element are output to the memory, and stored as information about the second travel line g2 in the memory.

[0062] For the release timings R01 to R04 obtained as the measured values, by taking into account a change that occurs every weft insertion and a change that occurs with progress of weft insertion, in this embodiment, average values of the release timings R01 to R04 for a predetermined number of times of weft insertion (hereinafter, referred to as "set number of times") are calculated, and the average values of the release timings R01 to R04 are used to obtain the information about the second travel line g2. The release timing R0 is calculated by the arithmetic element of the weft-insertion control unit. When the information about the second travel line g2 is obtained as described above during weaving, the release timing R0 based on the measured value is used. When the information about the second travel line g2 is obtained in an initial setting phase before weaving operation is started, the release timing R0 based on the predicted value is used.

[0063] Information about the first travel line g1 is obtained as follows.

[0064] In terms of the coordinates in the graph region, the start point of the travel line is the position of the weft-insertion start timing θ_s at the weft-insertion start position (the weaving-width position is 0 (zero)), and is the position of the coordinates $(X, Y) = (\theta_s, 0)$ (position a in Fig. 3). The start point of the travel line serves as the start point of the first travel line g1. Since the second travel line g2 continues from the first travel line g1, the end point of the first travel line g1 corresponds to the start point of the second travel line g2 obtained as described above. The arithmetic element obtains a linear expression (linear function) expressing the first travel line g1 by using the coordinates of the start point of the previously obtained second travel line g2 (the weaving-width position of L1 and the crank angle), and the weft-insertion start timing

θ_s stored in the memory. The linear expression, and the coordinates of the start point (and the end point) obtained by the arithmetic element are output to the memory, and stored as information about the first travel line g1 in the memory.

[0065] Information about the third travel line g3 is obtained as follows.

[0066] In terms of the coordinates in the graph region, the arrival point of the travel line is the position of the target weft arrival timing θ_e at the arrival position (in this embodiment, the weaving-width position is the position of 190 cm), and is the position of the coordinates $(X, Y) = (\theta_e, 190)$ (position b in Fig. 3). The arrival point serves as the end point of the third travel line g3. Since the third travel line g3 continues from the second travel line g2, the start point of the third travel line g3 corresponds to the end point of the second travel line g2 obtained as described above. The arithmetic element obtains a linear expression (linear function) expressing the third travel line g3 by using the coordinates of the end point of the previously obtained second travel line g2 (the weaving-width position of L2 and the crank angle), the set value (190 (cm)) of the weaving width stored in the memory, and the target weft arrival timing θ_e . The linear expression obtained by the arithmetic element, and the coordinates of (the start point and) the end point are output to the memory, and stored as information about the third travel line g3 in the memory.

[0067] By obtaining the information about the first, second, and third partial travel lines as described above, the weft travel information according to the present invention including the information about the partial travel lines is obtained, and the weft travel information is stored in the memory.

[0068] Since the weft travel information is stored in the memory as described above, the (expected) weft travel status indicated by the weft travel information can be plotted in the graph region in the form of the travel lines on the display screen of the input-and-setting unit. Specifically, when the input-and-setting unit is operated and a display request is generated, a display control unit (not shown) included in the input-and-setting unit reads required information including the weft travel information (information about the first, second, and third partial travel lines) from the memory of the weft-insertion control unit. The display control unit displays the graph region on the display screen in a predetermined display format on the basis of the information, and graphically displays the partial travel lines in a manner overlapping on the graph region (see Fig. 3).

[0069] The graphic display such as the travel lines on the display screen is to allow an operator to visually recognize the weft travel status and the like. When the jetting modes of the sub-nozzles are set on the basis of the travel lines, the setting can be made without the display. Therefore, the display is not essential for the present invention. Also, the display is not limited to the graphic display as shown in Fig. 3, and can be display expressed

with numerical values.

[0070] Regarding the display in Fig. 3, the display below the horizontal axis indicating the weaving-width position of 0 expresses the jetting modes of the main nozzle and the auxiliary main nozzle. Specifically, the upper display expresses the jetting mode of the main nozzle, and with reference to the display, the jetting start timing and the jetting end timing (jetting period) of the main nozzle can be recognized. Also, the lower display expresses the jetting mode of the auxiliary main nozzle, and with reference to the display, the jetting start timing and the jetting end timing (jetting period) of the auxiliary main nozzle can be recognized. In the illustrated example, the jetting start timings of the main nozzle and the auxiliary main nozzle are set to timings before the weft-insertion start timing θ_s . That is, with the weft-insertion device in this embodiment, the jetting of the main nozzle and the jetting of the auxiliary main nozzle are started before the weft-insertion start timing θ_s , and the weft insertion is started at a time point when the hook of the weft by the hook pin is released.

[0071] As described above, as the weft travel information is obtained as described above, the jetting modes of the sub-nozzles provided for the electromagnetic on-off valves in a one-to-one correspondence are set. For setting the jetting modes of the sub-nozzles on the basis of the weft travel information, various setting methods are suggested in Japanese Unexamined Patent Application Publication Nos. 63-92754 and 62-125049, and other documents of related art. Any of such setting methods can be employed. An example of such setting methods is described below. In the following description, the jetting start timing and the jetting end timing used for control during weft insertion are set as the information about the jetting modes of the sub-nozzles. Also, in the following description, for weaving with the weaving width of 190 cm, the pitch of the sub-nozzles is set to 65 mm, and the weft-insertion device includes 28 sub-nozzles S. Also, in the following description, when the 28 sub-nozzles S are distinguished from one another, a 1st sub-nozzle of the sub-nozzles counted from the side near the weft-insertion start position is denoted as S1, and the sub-nozzles are sequentially denoted as S2, S3, ..., and S28.

[0072] Regarding the weaving-width positions of the 28 sub-nozzles S1 to S28 included in the weft-insertion device, the jetting start timings and the jetting end timings of the sub-nozzles located in the second section (hereinafter, referred to as "sub-nozzles of second group") are set on the basis of the information about the second travel line g2 obtained as described above, a set lead angle which is previously set, and so forth.

[0073] Note that a lead angle in a jetting mode of a sub-nozzle is a lead jetting period in which the sub-nozzle performs jetting prior to the time point (crank angle) when the weft end is expected to arrive at the weaving-width position where the sub-nozzle is present, and is a period expressed in terms of the angular range of the crank angle (hereinafter, merely referred to as "angular range").

In the graphic display shown in Fig. 3 and described below, the display about the jetting mode of each sub-nozzle is expressed by a laterally elongated rectangle having a width in the vertical-axis (weaving-width position) direction. In the display, the position of the lower long side (on the side near the weft-insertion start position) of the two long sides of the rectangular corresponds to the weaving-width position of each sub-nozzle. In this example, the sub-nozzles of the second group are configured of the 3rd sub-nozzle S3 to the 25th sub-nozzle S25 counted from the side of the weft-insertion start position. The weaving-width positions of all sub-nozzles S are input and set previously by the input-and-setting unit, and stored in the memory in a manner associated with the respective sub-nozzles.

[0074] Then, the jetting modes of the sub-nozzles S3 to S25 of the second group are set as follows. First, the set value of the set lead angle used for setting the jetting modes is input and set by the input-and-setting unit, and previously stored in the memory. The set value of the set lead angle is input by the input-and-setting unit using numerical values. Alternatively, a plurality of angular ranges are previously set and stored, and are input selectively in accordance with the weaving conditions and so forth. Then, based on the set value of the set lead angle, the jetting start timing of each sub-nozzle S_m (m : 3 to 25) of the second group is obtained by the arithmetic element of the weft-insertion control unit in an initial setting phase or during weaving. The details are as follows.

[0075] The arithmetic element obtains a crank angle θ_m for each sub-nozzle S_m at a time point when the weft end is expected to arrive at the position of the sub-nozzle S_m by using the weaving-width position of the sub-nozzle S_m stored in the memory and the approximate linear expression in the information about the second travel line g2. Note that the obtained time point is a crank angle at which the weft end is expected to arrive at the position of the sub-nozzle S_m in a state in which the weft travels in the expected weft travel status (expected travel status). Then, the arithmetic element subtracts the set value θ_p of the set lead angle from the obtained crank angle θ_m for each sub-nozzle S_m . The crank angle obtained by the subtraction ($\theta_m - \theta_p$) is set as the jetting start timing of each sub-nozzle S_m . As the result that the jetting start timing is set as described above, the lead angle (angular range) in the jetting mode of each sub-nozzle S_m of the second group meets the set lead angle.

[0076] The jetting end timing of each sub-nozzle S_m of the second group is set to a proper timing on the basis of, for example, data and experience values in the past weaving, in accordance with the weaving-width position of the sub-nozzle S_m . Alternatively, the jetting end timing can be set on the basis of, for example, set values for a previously set latter jetting period (a period from the crank angle at which the weft end arrives at the position of the sub-nozzle S to the jetting end timing) or the entire jetting period. Specifically, the jetting end timing of each sub-nozzle S_m is set by previously storing the latter jetting

period, as a set value corresponding to the sub-nozzle S_m or a fixed set value, in the memory, and adding the set value of the latter jetting period to the crank angle at which the weft end is expected to arrive at the position of the sub-nozzle S_m obtained as described above.

[0077] The information about the jetting mode of each sub-nozzle S_m of the second group set as described above is stored in the memory of the weft-insertion control unit together with the weaving-width position in a manner associated with the sub-nozzle S_m .

[0078] Information about jetting modes (jetting start timings, jetting end timings) for the sub-nozzles located in the first section (sub-nozzles S_1 , S_2 of the first group) and the sub-nozzles located in the third section (sub-nozzles S_{26} to S_{28} of the third group) with respect to the weaving-width position are set as follows.

[0079] For the sub-nozzle S_1 of the sub-nozzles S_1 and S_2 of the first group (the sub-nozzle on the side near the weft-insertion start position), in this embodiment, the jetting start timing is set to meet the jetting start timing of the main nozzle. That is, the jetting start timing of the sub-nozzle S_1 is not obtained through an arithmetic operation; however, is set together with the setting of the jetting start timing of the main nozzle. Thus, when the jetting start timing of the main nozzle is changed, the jetting start timing of the sub-nozzle S_1 is also changed.

[0080] The jetting start timing of the sub-nozzle S_2 is obtained by the arithmetic element by a method similar to that of each sub-nozzle S_m of the second group. Specifically, first, by using the linear expression of the information about the first travel line g_1 stored in the memory, a crank angle at the time point when the weft end is expected to arrive at the weaving-width position of the sub-nozzle S_2 in the expected travel status is obtained on the basis of the linear expression and the weaving-width position of the sub-nozzle S_2 . Then, a crank angle obtained by using the obtained crank angle and the set value θ_p of the set lead angle is set as the jetting start timing of the sub-nozzle S_2 .

[0081] The jetting end timings of the sub-nozzles S_1 and S_2 of the first group are set by the same method as that of each sub-nozzle S_m of the second group. Information about the jetting modes of the sub-nozzles S_1 and S_2 of the first group set as described above is stored in the memory of the weft-insertion control unit together with the weaving-width positions in a manner associated with the sub-nozzles S_1 and S_2 .

[0082] For the sub-nozzles S_{26} to S_{28} of the third group, in this embodiment, the jetting start timings thereof are set to maintain the relationship with the jetting start timing of the sub-nozzle located on the side near the weft-insertion start position (previous sub-nozzle in the travel direction of the weft), regardless of the obtained travel line. Specifically, as the result that the jetting start timing of the sub-nozzle S_m of the second group is obtained as described above, when the difference between the jetting start timing of the sub-nozzle S_m and the jetting start timing of the sub-nozzle S_{m+1} is assumed as θ_d in terms

of the crank angle, the jetting start timing of the sub-nozzle S_{26} nearest to the weft-insertion start position among the sub-nozzles S_{26} to S_{28} of the third group is set to start jetting at a timing after the jetting start timing of the sub-nozzle S_{25} (the sub-nozzle nearest to the arrival position) of the second group only by the crank angle θ_d . Similarly for the sub-nozzles S_{27} and S_{28} , the jetting start timings of the sub-nozzles S_{27} and S_{28} are set on the basis of the jetting start timings of the sub-nozzles S_{26} and S_{27} near the weft-insertion start position. In this case, the lead angles (lead jetting periods) in the jetting modes of the sub-nozzles S_{26} to S_{28} are larger than the lead angle in the jetting mode of each sub-nozzle S_m of the second group.

[0083] The jetting end timings of the sub-nozzles S_{26} to S_{28} of the third group are set in forms different from those of the sub-nozzles of the first and second groups. Specifically, the jetting end timing of the sub-nozzle S_{26} is set to correspond to (for example, to meet) the latter jetting period of the sub-nozzle whose latter jetting period is just before that of the sub-nozzle S_{26} (the sub-nozzle S_{25} of the second group). In contrast, the jetting end timings of the sub-nozzles S_{27} and S_{28} are set at desirable crank angles. The jetting end timings of the sub-nozzles S_{27} and S_{28} are set at proper crank angles, with regard to the jetting mode of a stretch nozzle (not shown) provided on the side farther from the weft-insertion start position than the sub-nozzle S_{28} and the shedding motion of the warp, so as to prevent weft looseness at the time point when the weft insertion is ended (the time point when the weft end arrives at the arrival position) or later. Information about the jetting modes of the sub-nozzles S_{26} to S_{28} of the third group set as described above is also stored in the memory of the weft-insertion control unit together with the weaving-width positions in a manner associated with the sub-nozzles S_{26} to S_{28} .

[0084] The information about the jetting modes of the sub-nozzles is obtained and stored in the memory of the weft-insertion control unit as described above. Thus, the jetting modes of the sub-nozzles can be displayed on the display screen of the input-and-setting unit in the forms plotted on the graph region. Specifically, when the input-and-setting unit is operated and a display request is generated, the display control unit reads information about the jetting mode of each sub-nozzle from the memory, and graphically displays the jetting mode in a rectangular form as described above (Fig. 3) in the graph region where the travel line is plotted as described above. Also, the information about the jetting mode of each sub-nozzle is output to the controller of the weft-insertion control unit. The controller executes the open-and-close control of each electromagnetic on-off valve on the basis of the information about the jetting mode. Consequently, each sub-nozzle executes a jetting operation in accordance with the jetting mode during weaving, and hence the weft insertion (travel of the weft) by each weft supply system is assisted.

[0085] Fig. 4 shows the result that, when the weft travel

information is obtained according to the concept of related art, that is, when the travel line indicating the expected weft travel status is obtained in a form of a straight line connecting the start point a and the arrival point b, the jetting modes of the sub-nozzles (the sub-nozzles of the second group) located in the second section named according to the present invention are set on the basis of the travel line. In Fig. 4, a straight line f with a two-dot chain line indicates a travel line based on weft travel information obtained according to the concept of related art, and a curved line g with a solid line indicates a travel line based on weft travel information obtained according to the present invention as described above. In Fig. 4, the jetting modes of the sub-nozzles obtained as described above on the basis of the travel line g according to the present invention (jetting modes according to the present invention) are plotted with dotted lines. Then, in the drawing, the jetting modes obtained similarly to those as described above on the basis of the travel line f for the sub-nozzles Sm of the second group (jetting modes of related art) are plotted with solid lines. While Fig. 4 shows merely an example, in this example, the travel line f crosses the travel line g between the 18th sub-nozzle S18 and the 19th sub-nozzle S19 counted from the weft-insertion start position.

[0086] Referring to Fig. 4, the relationship between the jetting modes according to the present invention (the jetting mode based on the travel line g nearer to the actual weft travel status) and the jetting modes of related art can be understood as follows. The jetting modes of the sub-nozzles (sub-nozzles S3 to S18) nearer to the weft-insertion start position than the sub-nozzle S19 are set to have longer lead jetting periods as compared with the jetting modes according to the present invention. Thus, regarding the jetting modes of related art, for example, if lead jetting over a set lead angle is assumed as effective jetting, jetting is excessively performed for a period longer than the set lead angle, resulting in waste of air consumption. The jetting modes of the sub-nozzles (sub-nozzles S19 to S25) nearer to the arrival position than the sub-nozzle S18 are set to have shorter lead jetting periods as compared with the jetting modes according to the present invention. Hence, the weft travel status and the condition of the traveling weft may be degraded, and weft insertion may be defectively performed. In contrast, according to the present invention, the travel line is obtained in a form nearer to the actual weft travel status. The jetting modes of the sub-nozzles set on the basis of the travel line are more suitable for the actual weft travel status. The aforementioned problems can be prevented.

[0087] Initial setting is made for the setting of the jetting modes of the sub-nozzles according to the present invention before the weaving operation of the loom is started. For the initial setting, the information about the second travel line g2 is obtained by using the release timing R0 based on the predicted value as described above, the information about the first and third travel lines g1 and g3 are obtained on the basis of the information about the

second travel line g2, and the jetting modes of the sub-nozzles S are initially set on the basis of the information. Then, the weaving operation is started in the state in which the jetting modes of the sub-nozzles S are initially set in this way.

[0088] As the weaving operation is started and continued, the measured values of the release timings R01 to R04 are obtained every one loom cycle (one-time weft insertion), and are sequentially stored and accumulated in the memory as described above. It is assumed that, as described above, the rotational speed of the loom main shaft 15 (= the number of times of weft insertion) during weaving is counted by the loom control device 16 on the basis of the angular signal θ from the encoder EN as shown in Fig. 2.

[0089] When weft insertion is completed for the set number of times, in other words, at the time point when the release timings R0 by weft insertion for the set number of times are accumulated in the memory, a command signal C is output from the loom control device 16 to the arithmetic element 8d and the memory 8b. In response to the input of the command signal C, information on the release timings R0 for the set number of times (the number of turns, crank angle) are output from the memory 8b to the arithmetic element 8d, and the arithmetic element 8d obtains average values of the release timings R01 to R04. The, the arithmetic element 8d obtains the information about the second travel line g2 and the information about the first and third travel lines g1 and g3 on the basis of the average values of the release timings. The jetting modes of the sub-nozzles are set on the basis of the obtained information about the partial travel lines g1 to g3 as described above.

[0090] During weaving, the weft travel information, and the jetting mode of each sub-nozzle based on the weft travel information are set every set number of times of weft insertion. With the air jet loom, it is known that the actual weft travel status gradually changes with the progress of weaving due to, for example, a change in the wound diameter of the weft supply package. Thus, the jetting mode of each sub-nozzle set as described above is successively changed to a mode suitable for the actual weft travel status with the change in the actual weft travel status. The memory is reset when the information on the stored release timing R0 is output as described above. Then, the memory starts newly storing information for the next set number of times of weft insertion.

[0091] Note that the jetting mode of each sub-nozzle may be changed with the progress of weaving so that only the jetting start timing is changed, that is, only the jetting start timing may be obtained again on the basis of the changed new weft travel information. Alternatively, the jetting end timing may be also changed to maintain the entire jetting period in accordance with the change in jetting start timing. If the jetting end timing of the jetting mode of each sub-nozzle obtained during weaving is set on the basis of the set value for the previously set latter jetting period or entire jetting period, the jetting end timing

is also necessarily changed with the change in the weft travel information (jetting start timing).

[0092] With the air jet loom, control may be performed to change the weft-insertion start timing so that the actual weft arrival timing during weaving meets the target weft arrival timing. In particular, with the air jet loom, the actual weft arrival timing A₀ is obtained every weft insertion and stored in the memory as described above. With use of this, the actual weft arrival timing is compared with the target weft arrival timing every weft insertion. Alternatively, an average value of actual weft arrival timings for a predetermined number of times (for example, for the set number of times) of weft insertion is compared with the target weft arrival timing every predetermined number of times of weft insertion. If the difference between the actual weft arrival timing (or the average value) and the target weft arrival timing obtained through the comparison exceeds a previously set allowance value, control may be executed to change the weft start timing to dissolve the difference. When such control is executed, the weft travel status with respect to the crank angle is changed with the change in the weft-insertion start timing. Even in this case, a travel line is newly obtained as described above, and the setting of the jetting mode of each sub-nozzle is changed on the basis of the obtained travel line.

[0093] The present invention can be also implemented according to other embodiments (modifications) obtained by modifying the above-described embodiment (the embodiment) as stated in (1) to (7).

(1) A weft-insertion device for an air jet loom presupposed by the present invention, that is, a weft-insertion device to which the present invention is applied is not limited to the weft-insertion device described in the embodiment and provided with the sub-nozzles and the electromagnetic on-off valves in a one-to-one correspondence. The weft-insertion device for the air jet loom may include a weft-insertion device in which all sub-nozzles are divided into a plurality of groups each including two or more sub-nozzles, and all sub-nozzles included in each group may be connected to a common electromagnetic on-off valve. The present invention can be applied to such a weft-insertion device. With such a weft-insertion device, the jetting mode of the sub-nozzles of each group is set for the corresponding common electromagnetic on-off valve.

(2) The embodiment is an example in which the present invention is applied to the weft-insertion device including the weft brake device. That is, the embodiment is an example in which the present invention is applied to the weft-insertion device whose weft travel speed is changed by the weft brake device in the weft-insertion end period, with regard to the change in the travel speed. However, the present invention is effective for a weft-insertion device not including the weft brake device. This is because even

when the weft-insertion device does not include the weft brake device, the weft does not necessarily travel at the constant speed from the first position described in the embodiment to the arrival position (the travel speed is not necessarily constant) during weft insertion. The weft travel speed may be decreased in a final section of the weft-insertion period depending on the jetting mode of the main nozzle, the weaving conditions, and the like. Therefore, the weft-insertion device to which the present invention is applied is not limited to the weft-insertion device including the weft brake device like the embodiment, and may include a weft-insertion device not including the weft brake device.

(3) The first position set for obtaining the weft travel information is obtained on the basis of test weaving of the loom in the embodiment. However, according to the present invention, the first position may be obtained not on the basis of the test weaving, and for example, may be obtained on the basis of an experience value or an expected value of the past weaving.

[0094] The first position can be set on the basis of the position of a sub-nozzle arranged along the weft travel passage. This is because when the weft ejected from the main nozzle by the compressed air jetted from the main nozzle arrives at the position of the sub-nozzle, the weft travel status starts being influenced by the compressed air jetted from the sub-nozzle, and by receiving the influence, the weft travel speed is changed toward the constant speed. Thus, the first position may be set by considering the position of a sub-nozzle located near the weft-insertion start position (for example, one of sub-nozzles up to the third or fourth sub-nozzle) as the first position.

(4) For the second position set to obtain the weft travel information, in the embodiment, the second position is set as the braking start time point of the weft brake device (the position at the distance of L_r to the arrival position). However, since the present invention can be applied to the weft-insertion device not including the weft brake device as described above, when the present invention is applied to the weft-insertion device not including the weft brake device, the second position is not at the position set as the braking start time point of the weft brake device. In this case, for example, the second position may be obtained by performing test weaving or the like similarly to the case of the first position of the embodiment and finding a proper position, or by using an experience value or an expected value of the past weaving.

(5) In the embodiment, during weaving, the weft travel information is obtained every set number of times of weft insertion on the basis of the release timings R₀ (average value) obtained by the set number of

times of weft insertion. To obtain the weft insertion information, instead of obtaining the weft travel information on the basis of the release timings R_0 obtained by the set number of times of weft insertion every set number of times of weft insertion, the weft travel information may be obtained on the basis of the release timing R_0 obtained by weft insertion every weft insertion. In this case, the obtained weft travel information is reflected on weft insertion of the next loom cycle.

[0095] Even when the weft travel information is obtained on the basis of the release timings R_0 obtained by the set number of times of weft insertion similarly to the embodiment, the cycle for obtaining the weft travel information may be a smaller number of times of weft insertion than the set number of times of weft insertion. That is, when the set number of times is t , the weft travel information can be obtained by using the release timings R_0 obtained by the number t times of weft insertion in the past with respect to the time point when the weft travel information is obtained, and the weft travel information may be obtained every a number u times of weft insertion ($u < t$).

[0096] Further, in the embodiment, to obtain the weft travel information, the release timings R_0 for the set number of times of weft insertion are used, and the weft travel information is obtained by using the average value of the release timings R_0 . Alternatively, the weft travel information may be obtained by using the earliest values of the release timings R_{01} to R_{04} .

(6) In the method of setting the jetting mode of each sub-nozzle, in the embodiment, the jetting start timing of the 1st sub-nozzle S_1 among the sub-nozzles of the first group, and the jetting mode (jetting start timing) of each sub-nozzle of the third group are set by a method not based on the obtained weft travel information. The jetting start timing of each of such sub-nozzles may be also set on the basis of the obtained weft travel information similarly to the sub-nozzles of the second group.

(7) In the embodiment, weft travel information is obtained according to the present invention in each of the initial setting phase before the start of weaving operation and during weaving, and the jetting mode of each sub-nozzle is set on the basis of the weft travel information. However, the present invention is not limited to the embodiment. For example, the initial setting for the jetting mode of each sub-nozzle may be executed on the basis of weft travel information according to the concept of related art; and weft insertion information may be obtained according to the present invention and the jetting mode of each sub-nozzle may be set on the basis of the weft travel information only during weaving. Alternatively, weft insertion information may be obtained and the jetting mode of each sub-nozzle may be set according to

the present invention only for the initial setting. In the latter case, the responsive action to the change in the actual weft travel status during weaving may be made through other sub-nozzle jetting control or the like.

[0097] The present invention is not limited to the above-described embodiment and modifications, and may be appropriately changed within the scope of the invention.

Claims

1. A method of setting weft travel information for an air jet loom, the air jet loom including a plurality of sub-nozzles (S) arranged along a weft travel passage, a weft measuring-and-storing device (4) that includes a storing drum (4b) and that stores a weft to be inserted on the storing drum, and a release sensor (11) that detects the weft released from the storing drum every release and that outputs a release signal every detection of the weft occurring a plurality of times during a weft-insertion period, the air jet loom including a weft-insertion device, the weft-insertion device configured to execute weft insertion in accordance with weft-insertion conditions including a weft-insertion start timing at which the weft insertion is started, and a target weft arrival timing at which a distal end of the inserted weft arrives at an arrival position set on a side opposite to a weft supply side, the weft-insertion device also configured to execute a jetting operation of each of the sub-nozzles during the weft insertion in accordance with a jetting mode that is set on the basis of weft travel information being information about an expected weft travel status, the weft travel information including information that allows the weft travel status to be plotted in a travel line form in a graph region whose horizontal axis indicates one of a crank angle being a rotational angle of a loom main shaft (15) and a distance from a weft-insertion start position in a weaving-width direction and whose vertical axis indicates the other one being set, the method of setting the weft travel information for the air jet loom, comprising:

setting a first position determined on the weft supply side and a second position determined on the side opposite to the weft supply side in the travel passage from the weft-insertion start position to the arrival position;
recognizing the travel line expressed by the weft travel information by dividing the travel line into three continuous partial travel lines in the weaving-width direction including a first partial travel line in a first section from the weft-insertion start position to the first position, a second partial trav-

el line in a second section from the first position to the second position, and a third partial travel line in a third section from the second position to the arrival position; and

setting the weft travel information as information including information about each of the partial travel lines, and obtaining the information about each of the partial travel lines as information on corresponding one of (a) to (c),

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(a) the second partial travel line being obtained as an approximate straight line with respect to passing points in the graph region obtained by using the crank angle at each time point when the release signal is output or expected to be output from the release sensor, and the distance at which the distal end of the weft is expected to arrive at each time point when the release signal is output, the information about the second partial travel line being information obtained to allow the approximate straight line to be plotted in the second section in the graph region,

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(b) the first partial travel line being obtained as a straight line that connects a start point obtained by using the crank angle set as the weft-insertion start timing at a position of zero of the distance corresponding to the weft-insertion start position and a start point of the second partial travel line to each other in the graph region, the information about the first partial travel line being information obtained to allow the straight line to be plotted in the first section in the graph region, and

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(c) the third partial travel line being obtained as a straight line that connects an end point of the second partial travel line and an arrival point obtained by using the distance corresponding to the arrival position and the crank angle set as the target weft arrival timing to each other in the graph region, the information about the third partial travel line being information obtained to allow the straight line to be plotted in the third section in the graph region.

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FIG. 1

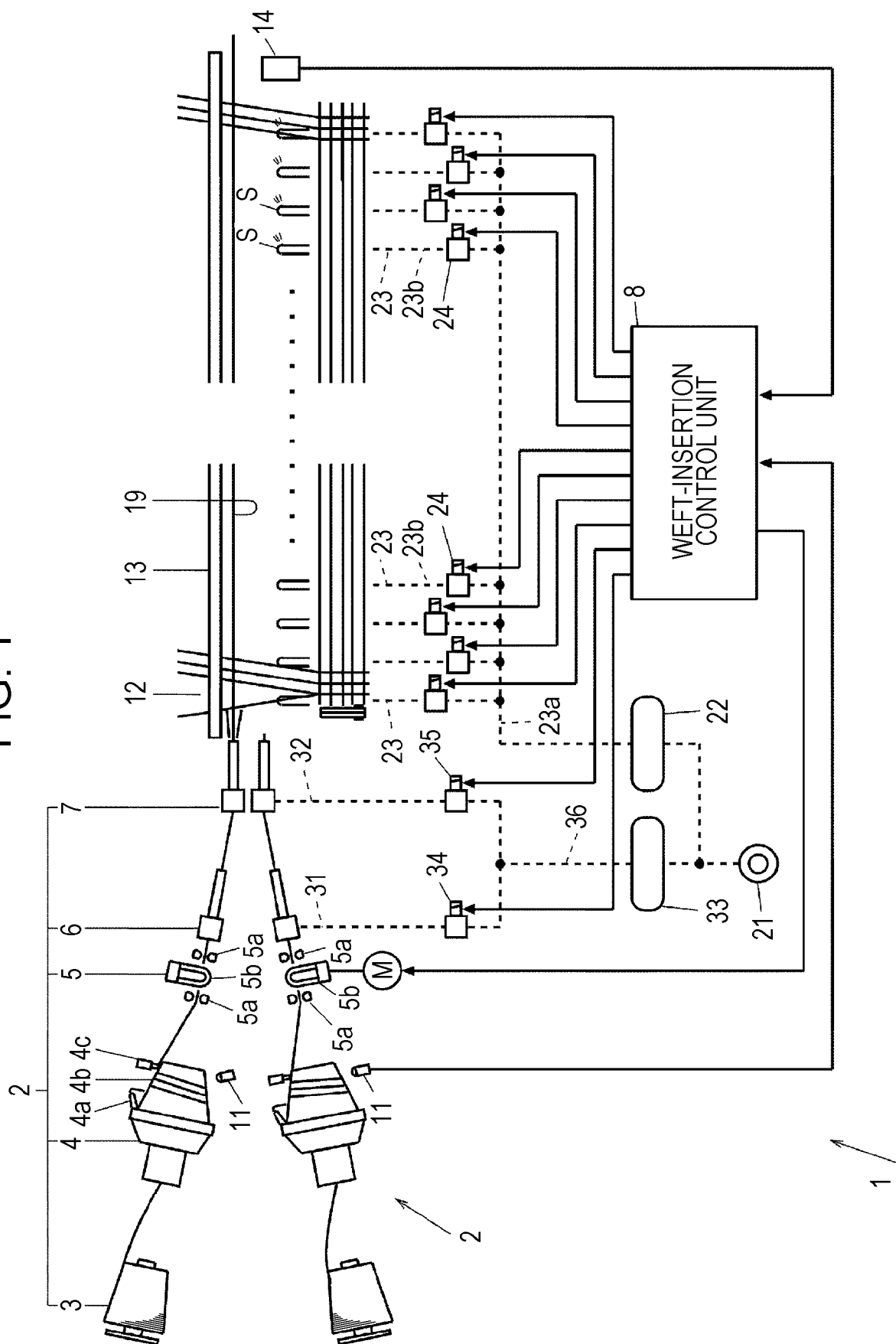


FIG. 2

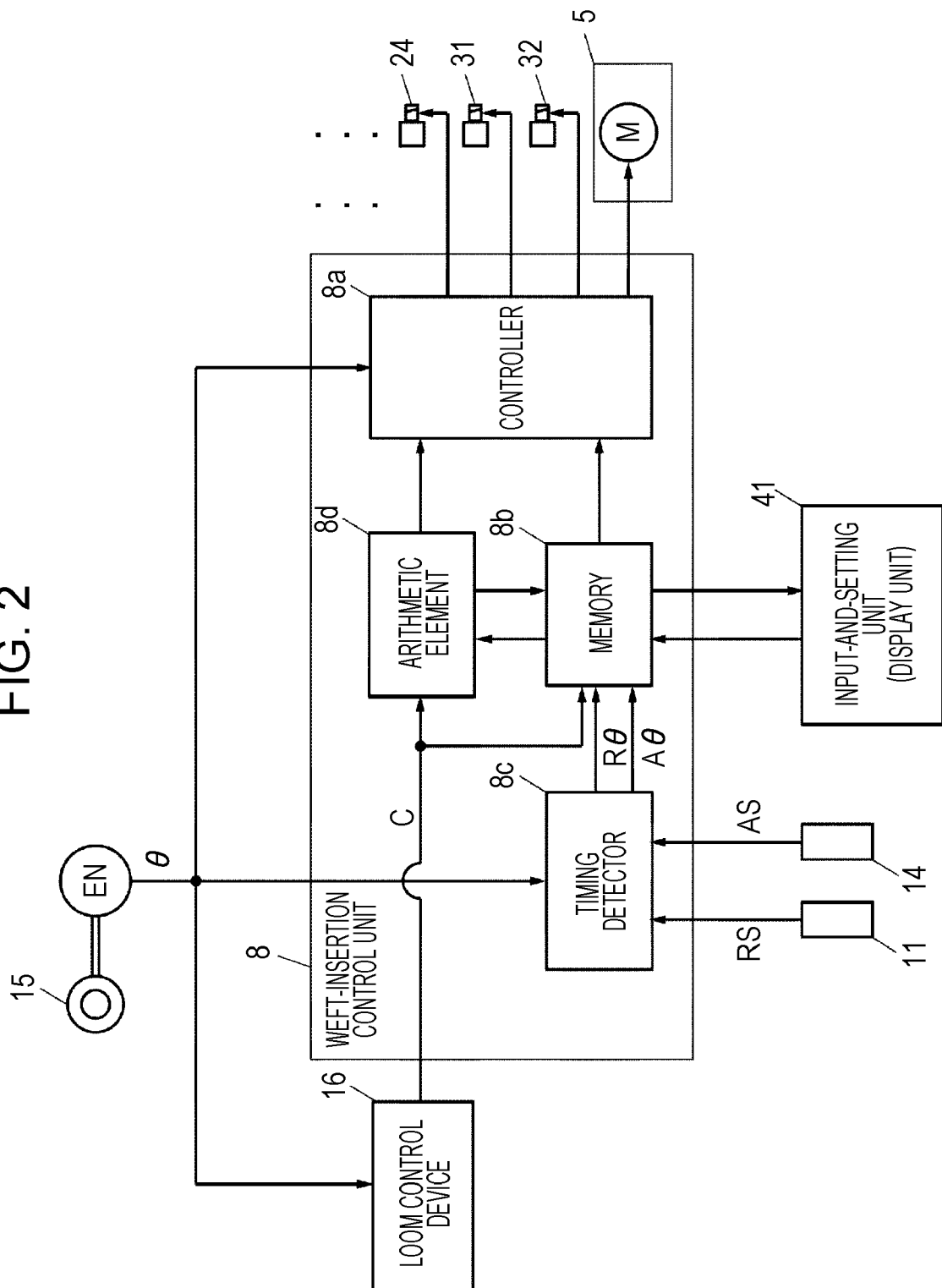


FIG. 3

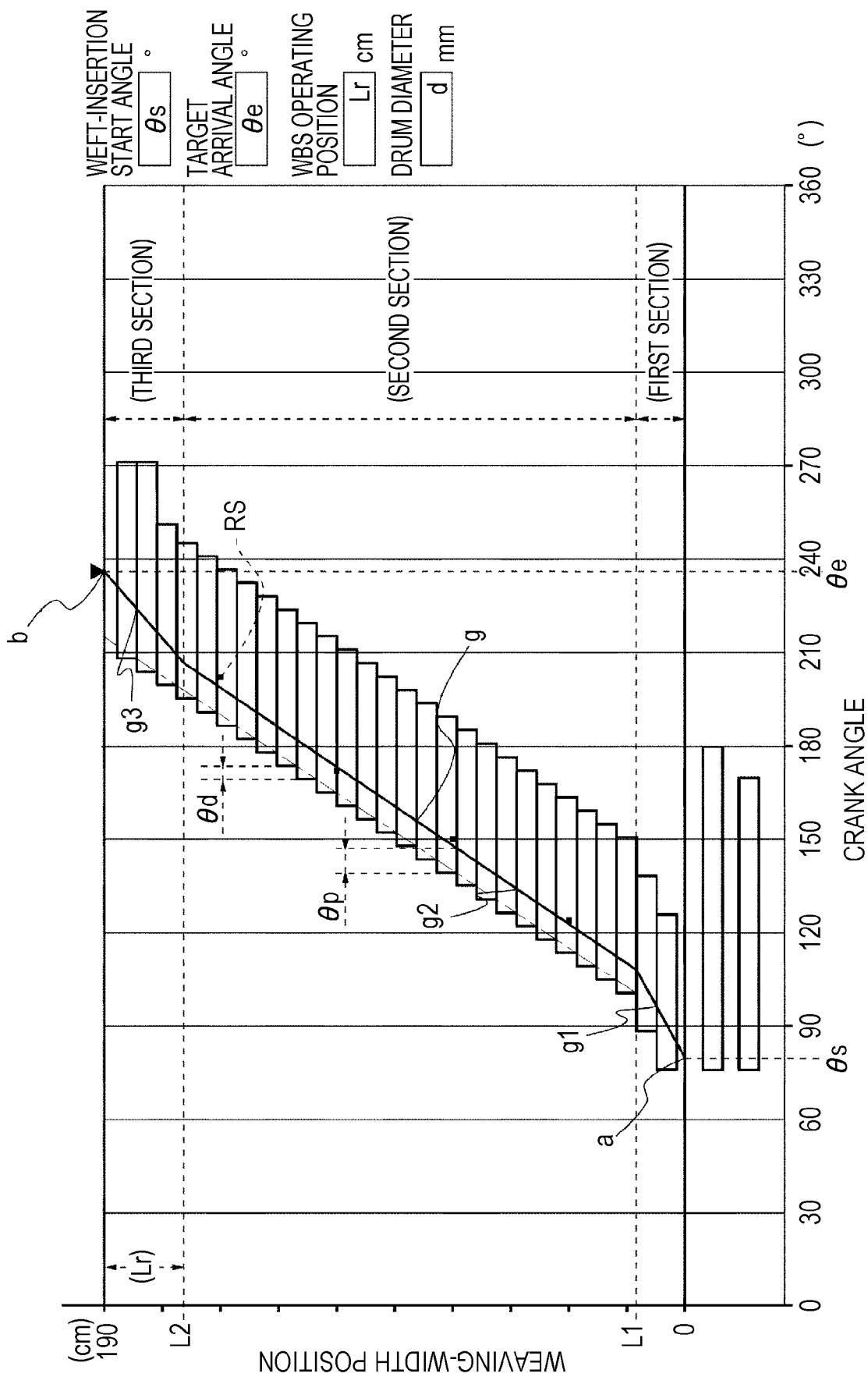
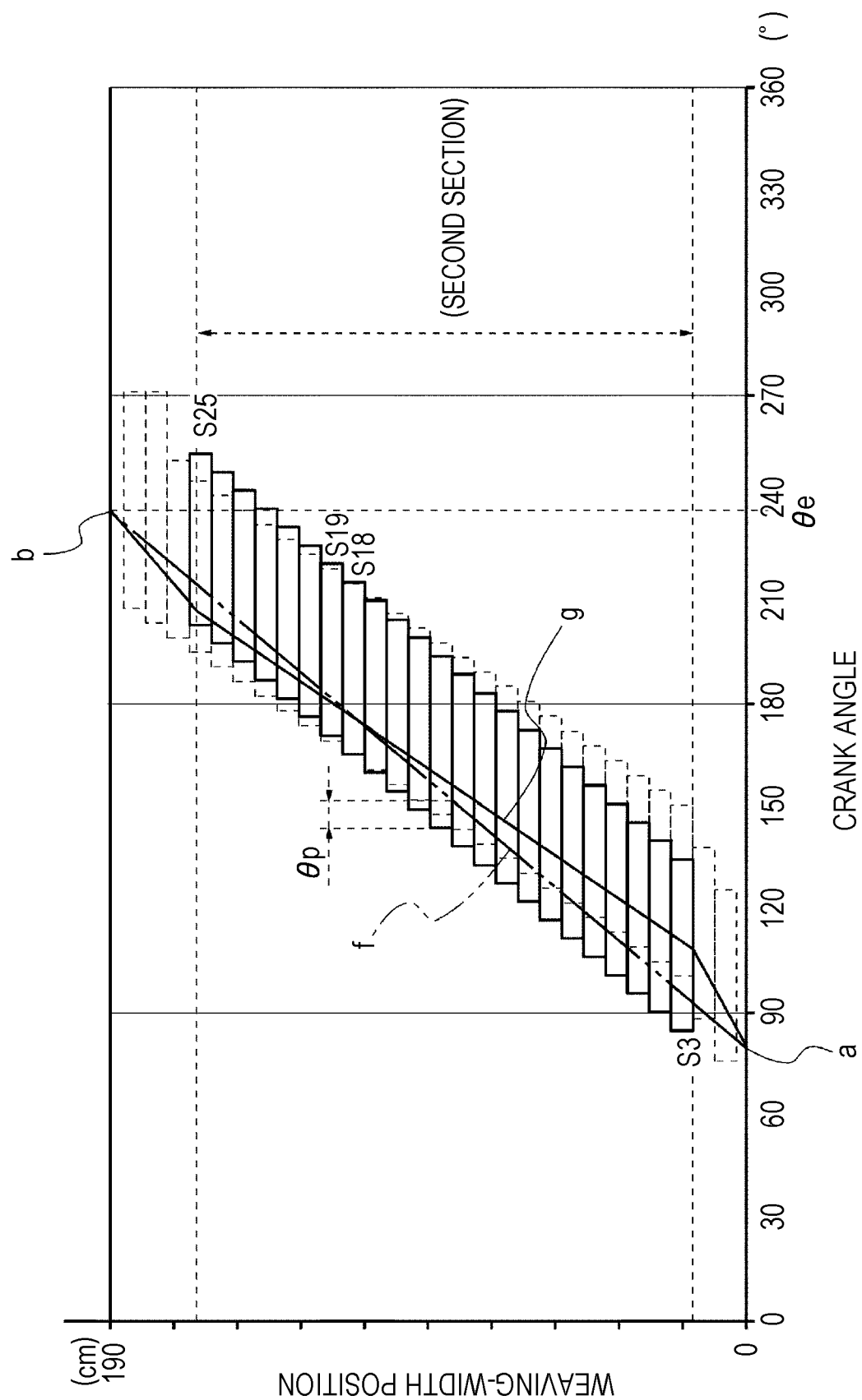


FIG. 4





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Application Number
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