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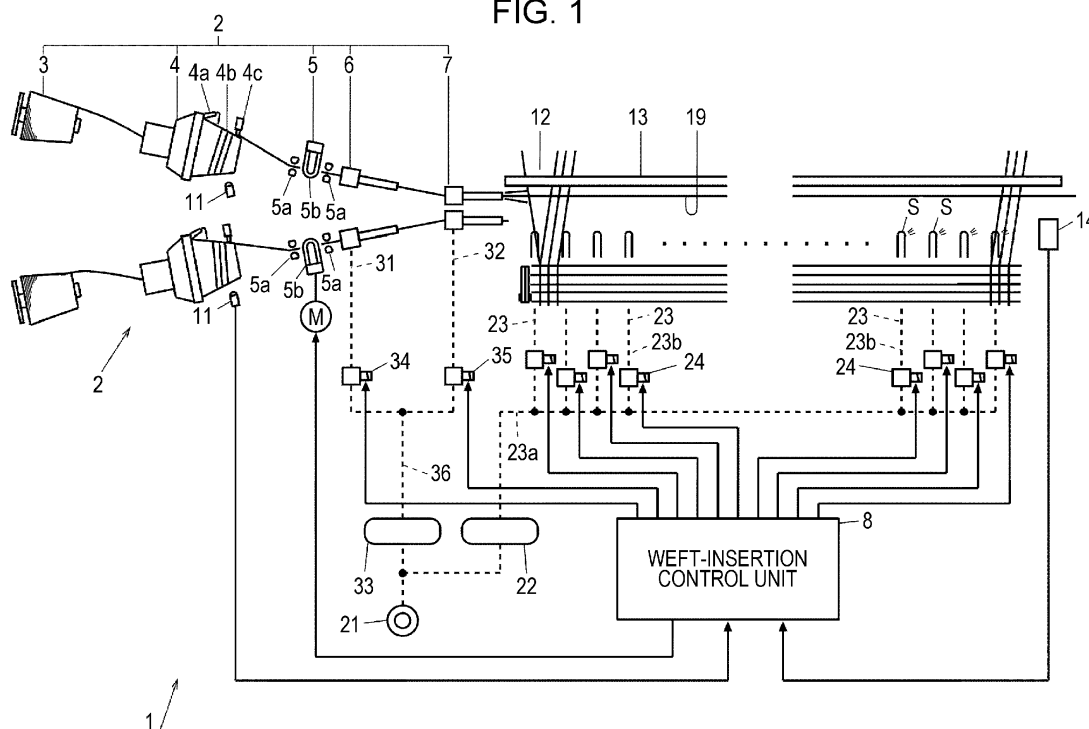
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(54) **METHOD OF SETTING WEFT TRAVEL INFORMATION FOR AIR JET LOOM**

(57) The invention provides a method of setting weft travel information for an air jet loom, a jetting mode of each sub-nozzle (S) being determined based on weft travel information about an expected weft travel status allowing the weft travel status to be plotted in a travel line form in a graph region whose horizontal and vertical axes indicate a rotational angle of a loom main shaft (15) and a distance from a weft-insertion start position in a weaving-width direction, weft insertion being executed under

weft-insertion conditions including the jetting mode and a target weft arrival timing. The method includes setting first and second positions on weft-supply and opposite sides; determining that the travel line is bent at first and second bend points at the first and second positions; and setting the second bend point using the rotational angle based on the target weft arrival timing, and the second position.

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, in which a jetting mode of each sub-nozzle is determined on the basis of weft travel information that is information about a weft travel status and that is 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.

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 No. 63-92754 discloses a technology of determining such a jetting mode of each sub-nozzle.

[0004] In Japanese Unexamined Patent Application

Publication No. 63-92754, 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 Japanese Unexamined Patent Application Publication No. 63-92754, 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. Specifically, 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. 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 over the weft-insertion period.

[0005] 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.

[0006] 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.

[0007] 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.

[0008] 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, the weft travel information is set such that the travel speed almost does not change in Japanese Unexamined Patent

Application Publication No. 63-92754. 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 Japanese Unexamined Patent Application Publication No. 63-92754 is not suitable for the travel of the weft during the actual weft insertion, and consequently the aforementioned problems may occur.

[0009] For the weft travel information obtained (set) when the jetting mode of each sub-nozzle is determined, the patent application of Japanese Patent Application No. 2017-197497 previously filed by the applicant of the subject patent application (hereinafter, referred to as "precedent application") suggests that the travel line is recognized by dividing the travel line into three continuous partial travel lines including a first partial travel line corresponding to the weft-insertion initial period, a second partial travel line corresponding to the weft-insertion middle period, and a third partial travel line corresponding to the weft-insertion end period; and weft travel information is set as information including information about the three partial travel lines. The precedent application also suggests that the weft travel information may be set in at least one of situations in an initial setting phase before the start of weaving operation and during weaving.

[0010] By setting the weft travel information like the invention (precedent invention) in the precedent application, the weft travel information becomes more suitable for the actual weft travel status, and an advantageous effect can be obtained such that the jetting mode of each sub-nozzle is set suitably for the actual weft travel status.

[0011] To set the jetting mode of each sub-nozzle in the initial setting phase before the weaving is started, when the weft travel information is set on the basis of the precedent invention, in the precedent application, the start point (first bend point) and the end point (second bend point) of the second partial travel line are obtained on the basis of a predicted value for a release timing that is obtained by using, for example, data of weaving in the past, the configuration (status) of a weft-insertion device, and weft-insertion conditions.

[0012] However, with the studies made by the inventors of the present application, it has been found that the third partial travel line obtained in a form connecting the end point and an arrival point corresponding to a target arrival timing may be plotted substantially in parallel to the second partial travel line as the result of obtaining the start point and the end point in the initial setting phase as described above, depending on the weaving conditions such as a weaving width.

[0013] Specifically, to obtain the predicted value for the release timing, if data in a case where weaving (or test weaving) is performed under the same conditions (the same loom (or a loom with similar specifications)) and under the same weaving conditions (weaving width, weft-insertion conditions, etc.) is present, the weft travel information can be obtained in a manner suitable for the actual

weft travel status. However, such data obtained under the same conditions (data under the same conditions) may not be always present. Such data under the same conditions may not be obtained due to certain circumstances. In particular, with a large-width loom (for example, a loom having a weaving width larger than 250 cm), the data under the same conditions mentioned above may not be obtained in many cases because such looms are relatively less manufactured.

[0014] If the data under the same conditions is not obtained, the predicted value is obtained by using calculation or the like, on the basis of data obtained during weaving under different conditions. As the result of obtaining the predicted value in this way, the third partial travel line and the second partial travel line may be plotted to be substantially parallel to each other as described above depending on the weaving conditions or the like. In this case, the travel line is not bent at the second bend point, and is plotted as a line extending straight from the first bend point to the arrival point.

[0015] As described in the precedent application, the travel line plotted in the form corresponding to the actual weft travel status is supposed to have a shape bent at the second bend point. However, in the aforementioned case, since the weft travel information is set in the travel line form not bent at the second bend point, the weft travel information is not proper as the information corresponding to the actual weft travel status. Thus, in this case, the jetting mode determined on the basis of such weft travel information is not suitable for the actual weft travel status, and a problem such as improper weft insertion may occur.

SUMMARY OF THE INVENTION

[0016] A method of setting weft travel information according to the present invention is made in light of the above-described situations. An object of the invention relates to weft travel information that is obtained for setting a jetting mode of a sub-nozzle in an initial setting phase for an air jet loom like one described above, and the object is, if the weft travel information is not information suitable for an actual weft travel status when the weft travel information is obtained on the basis of the predicted value, to make the weft travel information be information suitable for the actual weft travel status as far as possible.

[0017] The present invention presupposes an air jet loom, in which a jetting mode of each sub-nozzle is determined on the basis of weft travel information that is information about an expected weft travel status and that is 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. Also, with the presupposed air jet loom, weft insertion is executed under weft-insertion conditions including the jetting mode of each sub-nozzle and a target weft arrival timing.

[0018] 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.

[0019] 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 a plurality of corresponding sub-nozzles.

[0020] The present invention is a method of setting the weft travel information for the air jet loom. The method includes setting a first position determined on a weft supply side and a second position determined on a side opposite to the weft supply side in a weft travel passage from the weft-insertion start position to a weft arrival position in the weaving-width direction; determining that the travel line expressed by the weft travel information is plotted in a form that is bent at a first bend point set at the first position and a second bend point set at the second position; and setting the second bend point by using the rotational angle of the loom main shaft that is obtained on the basis of the target weft arrival timing, and the second position.

[0021] With the present invention, the weft travel information 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 information more suitable for the actual weft travel status. In particular, when the weft travel information is obtained on the basis of data or the like that can be previously obtained, the weft travel information may not be information suitable for the actual weft travel status depending on the weaving conditions or the like of the loom. Even in this case, with the present invention, since the second bend point is set on the basis of the target weft arrival timing used for weaving (weft insertion) with the loom, the obtained weft travel information can be information suitable for the actual weft travel status as far as possible. 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

[0022]

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

[0023] 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.

[0024] 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.

[0025] 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.

[0026] 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.

[0027] 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 aux-

iliary main nozzle 6 and the main nozzle 7.

[0028] 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.

[0029] 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 the weft-insertion control unit 8.

[0030] 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.

[0031] 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.

[0032] 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 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.

[0033] 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 located on the side near the compressed-air supply source 21, 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.

[0034] 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.

[0035] 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 (hereinafter, the position referred to as "arrival position") (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.

[0036] 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 also 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.

[0037] 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.

[0038] An encoder EN that detects a rotational angle (crank angle) of a loom main shaft 15 is electrically connected 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.

[0039] 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 timing detector 8c of the weft-insertion control unit 8 obtains a crank angle (release timing) $R\theta$ at the time point of gen-

eration of the release signal RS on the basis of both the signals every time when the release signal RS is generated.

[0040] The timing detector 8c is also electrically connected to the memory 8b of the weft-insertion control unit 8. The release timing $R\theta$ 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 $R\theta$ is obtained four times every weft insertion, that is, from a 1st-turn release timing $R\theta 1$ to a 4th-turn release timing $R\theta 4$. The memory 8b stores the four release timings $R\theta 1$ to $R\theta 4$ every weft insertion as data for one-time weft insertion relating to the release timing $R\theta$.

[0041] 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) $A\theta$ 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 $A\theta$ obtained by the timing detector 8c is output to the memory 8b.

[0042] 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 (braking start time point). Specifically, the driving of the actuator is controlled as follows.

[0043] 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.

[0044] 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 R0 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 R0 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.

[0045] 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.

[0046] The controller 8a starts the driving of the actuator 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.

[0047] 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.

[0048] 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 R0 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.

[0049] With the weft-insertion device for the air jet loom, to set the jetting mode of a sub-nozzle in an initial setting phase before weaving is started, the method of setting the jetting mode of the sub-nozzle on the basis of weft travel information being information about an expected weft travel status 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. Based on this, the invention provides a method of setting weft travel information to be obtained for setting the jetting mode of the sub-nozzle in the initial setting phase as described above. An example of the method of setting the weft travel information is described below. This embodiment presupposes the following.

[0050] 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.

[0051] The weft-insertion length (from the weft-insertion start position to the arrival position) is substituted by the weaving width, which is 260 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 0s (in the illustrated example, corresponding to a crank angle of 80°). The set value of the target weft arrival timing (hereinafter, referred to as "target arrival timing") is 0e

(in the illustrated example, corresponding to a crank angle of 246°), and is stored in the memory via the input-and-setting unit. 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 260 (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 (260, θ_e), and indicated by reference sign "b" in Fig. 3).

[0052] Further, the set value of the distance set as the braking start time point of the weft brake device to the arrival position is L_r (cm). That is, setting 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 $(260 - L_r)$ 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 presupposition.

[0053] 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 a test or the like and finding out a suitable position.

[0054] 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 (decreased) 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 L_2 of the second position from the weft-insertion start position (a position of L_2 along the vertical axis) is $L_2 = 260 - L_r$ (cm).

[0055] With the setting of the first position and the second position as described above, the set value L_1 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 (L_r) at the braking start time point and the set value of the weaving width (260 (cm)) stored in the memory is set as the set value L_2 (and stored in the memory).

[0056] Since the first position of L_1 and the second position of L_2 are set as described above, for the setting, the section of the weaving width in the weaving-width direction (weaving-width position: 0 to 260 (cm)) is divid-

ed 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 L_1 ; a second section in which the weaving-width position is from the first position of L_1 to the second position of L_2 ; and a third section in which the weaving-width position is from the second position of L_2 to the arrival position.

[0057] 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.

[0058] Under the presupposition described above, according to the invention, the weft travel information is obtained as information that can be plotted in a form such that the travel line g is bent at the first position L_1 and the second position L_2 . That is, the travel line g expressed by the weft travel information can be plotted in a form such that the first partial travel line g1 and the third partial travel line g3 are not parallel to (are not at the same angle as the angle of) the second partial travel line g2. Specifically, when the travel line g is to be plotted in the graph region, the first to third partial travel lines g1 to g3 continuous on the travel line g are plotted such that, regarding an angle (acute angle) formed with respect to the X axis or a straight line parallel to the X axis, the angle of the second partial travel line g2 is larger than the angle of the first partial travel line g1 and the angle of the third partial travel line g3 is smaller than the angle of the second partial travel line g2.

[0059] Thus, the travel line g includes two bend points K1 and K2. The bend point K1 that is one of the two bend points K1 and K2 and that is closer to the start point a of the travel line g than the other one (hereinafter, the point referred to as "first bend point") is set at the first position L_1 in the weaving-width direction, and the other bend point K2 that is closer to the arrival position b of the travel line g (hereinafter, the point referred to as "second bend point") is set at the second position L_2 in the weaving-width direction.

[0060] Then, with regard to that the travel line g can be plotted as the line graph extending from the start point a to the arrival point b and that the first to third partial travel lines g1 to g3 are continuous, the first partial travel line g1 is a partial straight line having a start point thereof at the start point a and an end point thereof at the first bend point K1; and the second partial travel line g2 is a partial straight line having a start point thereof at the first bend point K1 and an end point thereof at the second bend point K2. Also, the third partial travel line g3 is a partial straight line having a start point thereof at the second bend point K2 and an end point thereof at the arrival

point b. With regard to that the start point a and the arrival point b are known information, information about the respective partial travel lines g1 to g3 (the information are information that allow the respective partial travel lines g1 to g3 to be plotted in the graph region and are linear expressions expressing the start points, end points, and partial straight lines) can be obtained when the first bend point K1 and the second bend point K2 are determined.

[0061] The weft travel information is information that allows the travel status in the form of the travel line g. The travel line is configured of the first to third partial travel lines g1 to g3 as described above. Thus, the weft travel information is set as information including information about the respective partial travel lines g1 to g3, and to obtain the information about the respective partial travel lines g1 to g3, the first bend point K1 and the second bend point K2 are determined (set). The method of setting the first bend point K1 and the second bend point K2 is described below in detail.

[0062] This embodiment provides an example in which a linear expression expressing a temporary second partial travel line is obtained on the basis of previously obtained information, and then a first bend point K1 is obtained by using the linear expression and the first position.

[0063] As described in the precedent application, the linear expression expressing the second partial travel line can be obtained on the basis of the release timing of a weft obtained with weft insertion (in this embodiment, four release timings obtained every time when the weft is released at 1st to 4th turns). However, since the present invention relates to setting of the weft travel information in the initial setting phase, each release timing that is used for obtaining the second partial travel line (the first bend point K1) is not an actually measured value during weaving, but is a previously obtained predicted value. That is, the predicted values for the respective release timings expected for initial weft insertion during main weaving are previously obtained, and the second partial travel line (consequently, the first bend point K1) is obtained on the basis of the predicted values.

[0064] The predicted values for the respective release timings can be obtained if a test or the like is previously performed for the loom before main weaving. However, it is difficult to perform such a time-consuming test on a subject loom in a fabric factory of a customer (a customer for a loom manufacturer). Hence, the loom manufacturer basically performs the work of performing the test and obtaining the first bend point. Note that, with the test performed by the loom manufacturer, the test may not be performed on a loom under the same conditions (with the same specifications and under the same weaving conditions) as those of the subject loom. Particularly if the subject loom is a large-width loom having a weaving width larger than 250 cm as shown in Fig. 3, in many cases, the test for the loom with the same specifications may not be performed.

[0065] In such a case, a test is performed for a loom

with different specifications, such as the weaving width. Then, the respective release timings (average value) obtained through the test or the like are corrected with regard to the difference in specifications and the difference in weaving conditions (weft-insertion conditions) between the subject loom and the loom on which the test has been performed, and thus the predicted values for the respective release timings are obtained. It is assumed that, also in this embodiment, the predicted values for the respective release timings are obtained in this way. Note that the predicted values thus obtained may not serve as the respective release timings corresponding to the actual weft travel status of the subject loom. Hence, the second partial travel line expressed by the linear expression obtained by using the predicted values is a temporary second partial line and is used only for determining the first bend point.

[0066] Note that the respective release timings correspond to crank angles during weft insertion at time points when the weft end arrives at weaving-width positions corresponding to the lengths of the weft for the numbers of release turns (1st to 4th turns). The lengths of the weft for the numbers of release turns (the weaving-width positions corresponding to the lengths) are known information, and are previously stored in the memory via the input-and-setting unit. Since the predicted values for the respective release timings for the 1st to 4th turns are obtained as described above, four coordinates which may be plotted in the graph region are obtained.

[0067] 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 is obtained. 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 $Y = aX + b$, and a and b are obtained) is stored in the arithmetic element, and the approximate linear expression is obtained by the arithmetic element. The approximate linear expression obtained as described above serves as the linear expression expressing the temporary second partial travel line.

[0068] The second partial travel line expresses the weft travel status in the second section, and is plotted in the graph region while the first position L1 serves as the start point in the weaving-width direction. Hence, by using the approximate linear expression ($Y = aX + b$) obtained as described above and an expression ($Y = L1$) expressing the first position in terms of the weaving-width position, the coordinates in the graph region of the start point of the temporary second partial travel line, which is an intersection point between the straight lines expressed by both expressions, that is, the coordinates in the graph region of the first bend point K1 are obtained.

[0069] The second bend point K2 is the end point of the second partial travel line g2. Also as described in the precedent application, the end point (the second bend

point K2) can be obtained by using the linear expression expressing the second partial travel line g2 and an expression ($Y = L2$) expressing the second position in terms of the weaving-width position. However, as described above, the above-described predicted values may not be the release timings corresponding to the actual weft travel status. The second partial travel line g2 obtained on the basis of such predicted values may be deviated from the travel line expressing the actual weft travel status as the second partial travel line g2 extends toward the side opposite to the weft supply side. Owing to this, a proper second bend point K2 may not be obtained by the method of setting the second bend point K2 on the basis of the second partial travel line obtained using the predicted values for the respective release timings.

[0070] The present invention employs a method of setting a second bend point K2 on the basis of a target arrival timing which is known information. The details on the setting method are as follows.

[0071] First, a target arrival timing that serves as a reference (hereinafter, also referred to as "reference timing") is determined. The reference timing is set at a proper timing by the loom manufacturer on the basis of experimental values and so forth. After the reference timing is determined, a crank angle of a second bend point K2 optimal for a situation in which weft insertion is performed at the reference timing (hereinafter, also referred to as "reference crank angle") is determined through a test or the like in accordance with the specifications and weaving conditions of a subject loom. Since the reference crank angle is the crank angle of the second bend point (the end point of the second partial travel line) K2, the reference crank angle is smaller than the reference timing (the crank angle of the end point of the travel line g) and is larger than the crank angle of the first bend point (the start point of the second partial travel line) K1.

[0072] It is presupposed that a test under the same conditions (with the same specifications and under the same weaving conditions) as those of the subject loom cannot be performed as described above. For example, the reference crank angle is determined by performing a test under a plurality of weaving conditions, and recognizing and analyzing the tendency. If the test and tendency analysis are performed every time when the weaving conditions are determined for the loom, the second bend point K2 can be set accordingly. However, with such a setting method, since the second bend point K2 is set every time when the weaving conditions are changed, the setting method takes a time and is troublesome.

[0073] Owing to this, according to the present invention, the reference timing is previously determined and the reference crank angle for weft insertion at the reference timing is obtained as described above. Then, a correction expression that corrects the reference crank angle is previously obtained on the basis of the large-and-small relationship between the reference timing and the target arrival timing. Thus, the crank angle of the second bend point K2 is obtained on the basis of the set target

arrival timing.

[0074] Specifically, when θ_{e0} is a reference timing, θ_{x0} is a reference crank angle, θ_e is a target arrival timing to be set, θ_x is a crank angle of a second bend point K2 to be obtained, and a and b are correction coefficients based on the large-and-small relationship, correction expressions are obtained as follows.

If

$$\theta_e < \theta_{e0}, \theta_x = \theta_{x0} - \{(\theta_{e0} - \theta_e) \times a\}$$

If

$$\theta_e > \theta_{e0}, \theta_x = \theta_{x0} + \{(\theta_e - \theta_{e0}) \times b\}$$

[0075] Regarding the correction expression, if $\theta_e < \theta_{e0}$, the crank angle θ_x of the second bend point K2 is smaller than the reference crank angle θ_{x0} . The crank angle θ_x of the second bend point K2 is a value obtained by subtracting a correction value corresponding to the target arrival timing from the reference crank angle θ_{x0} . The correction value (subtraction value) is a value obtained by multiplying the difference between the reference timing θ_{e0} and the target arrival timing θ_e by the correction coefficient a. If $\theta_e > \theta_{e0}$, the crank angle θ_x of the second bend point K2 is larger than the reference crank angle θ_{x0} . The crank angle θ_x of the second bend point K2 is a value obtained by adding a correction value corresponding to the target arrival timing to the reference crank angle θ_{x0} . The correction value (addition value) is a value obtained by multiplying the difference between the target arrival timing θ_e and the reference timing θ_{e0} by the correction coefficient b.

[0076] The correction coefficients a and b are obtained, for example, by performing a test with different target arrival timings under a plurality of weaving conditions, and analyzing the tendency based on the results. Note that the value a is a positive number smaller than 1 and the value b is a positive value larger than 1. The values a and b can be values corresponding to the weaving conditions, such as the weaving width. However, the values a and b may be the same value if the conditions are close to each other.

[0077] For example, for the loom with the weaving width of 260 cm exemplified in this embodiment, in a case where the reference timing θ_{e0} is 236° and the reference crank angle θ_{x0} is 196° , if $a = 0.8$ and $b = 1.1$, the crank angle θ_x of the second bend point K2 when the target arrival timing θ_e is 246° in this embodiment is expressed as follows.

$$\theta_x = 196 + \{(246 - 236) \times 1.1\} = 207(^\circ)$$

In contrast, if the target arrival timing θ_e is 230° ,

$$\theta x = 196 - \{(236 - 230) \times 0.8\} = 191(^{\circ})$$

However, in either case, if the result obtained by multiplying the difference between the reference timing and the target arrival timing by the correction coefficient includes the number of decimal places, the number of decimal places of the multiplication result is dropped, and then addition or subtraction is performed with respect to the reference timing.

[0078] With the above-described setting method, merely by setting the target arrival timing which is one of the weaving conditions, the crank angle of the second bend point K2 is calculated on the basis of the target arrival timing. Since the crank angle is obtained, the coordinates (θx , L2) in the graph region of the second bend point K2 are obtained.

[0079] While the respective cases of $\theta e < \theta e0$ and $\theta e > \theta e0$ have been described above, if the target arrival timing is the same as the reference timing ($\theta e = \theta e0$), as the matter of course, the crank angle θx of the second bend point K2 in this case is the same as the reference crank angle $\theta x0$ ($\theta x = \theta x0$).

[0080] Since the first bend point K1 and the second bend point K2 are obtained as described above, for the second partial travel line g2 using the first bend point K1 and the second bend point K2 as the start point and the end point thereof, information about the second partial travel line g2 (information required for plotting the partial straight line in the graph region, that is, an expression expressing the straight line, and the start point and end point of the straight line). Also, as described above, the first partial travel line g1 uses the start point a as the start point thereof and uses the first bend point K1 as the end point thereof; the third partial travel line g3 uses the second bend point K2 as the start point thereof and uses the arrival point b as the end point thereof; and the start point a and the arrival point b are known information. Thus, information about the partial travel lines g1 and g3 are obtained by obtaining the first bend point K1 and the second bend point K2. The information about the obtained first to third partial travel lines g1 to g3 are output to the memory, and stored as the weft travel information.

[0081] 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 line g 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 g1 to g3) 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 g1 to g3 in a manner overlapping on the graph region (see Fig. 3).

[0082] The graphic display such as the travel line g 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 line, 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 etc.

[0083] 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 θs . 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 θs , and the weft insertion is started at a time point when the hook of the weft by the hook pin is released.

[0084] 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 No. 63-92754, 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 260 cm, the pitch of the sub-nozzles is set to 65 mm, and the weft-insertion device includes 40 sub-nozzles S. Also, in the following description, when the 40 sub-nozzles S are distinguished from one another, a 1st sub-nozzle of the sub-nozzles S 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 S40.

[0085] Regarding the weaving-width positions of the 40 sub-nozzles S1 to S40 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.

[0086] 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 36th sub-nozzle S36 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.

[0087] Then, the jetting modes of the sub-nozzles S3 to S36 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 36) 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.

[0088] 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.

[0089] 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 experiential values of 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.

[0090] 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.

[0091] Information about jetting modes (jetting start timings, jetting end timings) for the sub-nozzles located in the first section (sub-nozzles S1, S2 of the first group) and the sub-nozzles located in the third section (sub-nozzles S37 to S40 of the third group) in terms of the weaving-width position are set as follows.

[0092] For the sub-nozzle S1 of the sub-nozzles S1 and S2 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 S1 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 S1 is also changed.

[0093] The jetting start timing of the sub-nozzle S2 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 g1 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 S2 in the expected travel status is obtained on the basis of the linear expression and the weaving-width position of the sub-nozzle S2. 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 S2.

[0094] The jetting end timings of the sub-nozzles S1 and S2 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 S1 and S2 of the first group set as described above are 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 S1 and S2.

[0095] For the sub-nozzles S37 to S40 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 g3. Specifically, as the result that the jetting start timing of each 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 θd in terms of the crank angle, the jetting start timing of the sub-nozzle S37 nearest to the weft-insertion start position among the sub-nozzles S37 to S40 of the third group is set to start jetting at a timing after the jetting start timing of the sub-nozzle S36 (the sub-nozzle nearest to the arrival position) of the second group only by the crank angle θd . Similarly for the sub-nozzles S38 to S40, the jetting start timings of the sub-nozzles S38 to S40 are set on the basis of the jetting start timings of the sub-nozzles S37 to S39 near the weft-insertion start position. In this case, the lead angles (lead jetting periods) in the jetting modes of the sub-nozzles S37 to S40 are larger than the lead angle in the jetting mode of each sub-nozzle S_m of the second group.

[0096] The jetting end timings of the sub-nozzles S37 to S40 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 S37 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 S37 (the sub-nozzle S36 of the second group). In contrast, the jetting end timings of the sub-nozzles S38 to S40 are set at desirable crank angles. The jetting end timings of the sub-nozzles S38 to S40 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 S40 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 S37 to S40 of the third group set as described above are 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 S37 to S40.

[0097] The information about the jetting modes of the sub-nozzles are 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 g 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.

[0098] 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 S_m 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 16th sub-nozzle S16 and the 17th sub-nozzle S17 counted from the weft-insertion start position.

[0099] Referring to Fig. 4, the relationship between the jetting modes according to the present invention (the jetting modes based on the travel line g nearer to the actual weft travel status) and the jetting modes of related art (the jetting modes suggested in Japanese Unexamined Patent Application Publication No. 63-92754) can be understood as follows. In the jetting modes of related art, the jetting modes of the sub-nozzles (sub-nozzles S3 to S16) nearer to the weft-insertion start position than the sub-nozzle S17 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. Also, in the jetting modes of related art, the jetting modes of the sub-nozzles (sub-nozzles S17 to S36) nearer to the arrival position than the sub-nozzle S16 are set to have shorter lead jetting periods as compared with the jetting modes according to the present invention. Hence, in the jetting modes of related art, 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 g 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 g are more suitable for the actual weft travel status.

[0100] 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 (8).

(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 may not travel at the constant speed from the first position described in the embodiment to the arrival position (the travel speed may not be 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 a test 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, and for example, may be obtained on the basis of experiential values of the past weaving, prediction, and so forth.

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 positions of the sub-nozzles, the weft travel status starts being influenced by the compressed air jetted from the sub-nozzles, 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 3rd or 4th 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 a test or the like similarly to the case of the first position of the embodiment and finding a proper position, or by using experiential values of the past weaving, prediction, and so forth.

(5) For the first bend point, in the embodiment, the predicted values for the respective release timings (more specifically, the values of the respective release timings expected for the initial weft insertion of the main weaving with the subject loom) are obtained through a test or the like, and the linear expression (approximate linear expression) expressing the temporary second partial travel line is obtained by using the predicted values, and then the coordinates of the first bend point are determined by using the linear expression and the expression expressing the first position in terms of the weaving-width position. That is, in this embodiment, the first bend point is set on the basis of the predicted values for the respective release timings, by using the predicted values and the known information.

However, to set the first bend point, the setting method is not limited to the method of setting the first bend point on the basis of the predicted values for the respective release timings as described in the embodiment. For example, the first bend point that is actually used in another loom may be referenced, and the first bend point for the subject loom may be determined with regard to the weaving conditions and so forth of the reference loom.

(6) A test may be performed in a loom with different specifications and different weaving conditions as described in the embodiment, a proper first bend point may be obtained for the loom on which the test

has been performed, and then a first bend point may be determined for a subject loom with regard to the obtained first bend point, and the specifications and weaving conditions of the loom on which the test has been performed. Further, when the first bend point is obtained for the loom on which the test is performed, the first bend point does not have to be obtained on the basis of the respective release timings (detection values) obtained through the test. The weft travel status may be observed by using a stroboscope or the like, and the crank angle of the first bend point may be obtained on the basis of the observation result.

(7) For the second bend point, in this embodiment, the correction expression is previously obtained by using the reference timing and the reference crank angle. By substituting the target arrival timing, which is set as one of the weaving conditions, into the correction expression, the crank angle of the second bend point is calculated. By obtaining the crank angle of the second bend point in this way, the coordinates of the second bend point are set.

However, the method of obtaining the crank angle of the second bend point is not limited to the calculation using the correction expression like the embodiment. For example, by using the correction expression or the like, crank angles of second bend points corresponding to a plurality of expected target arrival timings are previously obtained. Then, a database in which the target arrival timings and the crank angles of the corresponding second bend points are associated with one another is created, and the database is stored in the memory. When a target arrival timing is input and set with the input-and-setting unit (stored in the memory), the crank angle of the second bend point corresponding to the input and set target arrival timing may be selected and thus the crank angle of the second bend point may be obtained.

(8) In the setting method exemplarily described in the embodiment, the jetting start timing of the sub-nozzle S1 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. However, the jetting start timing of each of such sub-nozzles may be also set on the basis of the weft travel information obtained similarly to the sub-nozzles of the second group.

[0101] 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, in which a jetting mode of each sub-nozzle (S) is determined on the basis of weft travel information that is information about an expected weft travel status and that is 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 (15) and a distance from a weft-insertion start position in a weaving-width direction and whose vertical axis indicates the other one, and in which weft insertion is executed under weft-insertion conditions including the jetting mode of each sub-nozzle and a target weft arrival timing, the method of setting the weft travel information for the air jet loom comprising:

setting a first position determined on a weft supply side and a second position determined on a side opposite to the weft supply side in a weft travel passage from the weft-insertion start position to a weft arrival position in the weaving-width direction;

determining that the travel line expressed by the weft travel information is plotted in a form that is bent at a first bend point set at the first position and a second bend point set at the second position; and

setting the second bend point by using the rotational angle of the loom main shaft that is obtained on the basis of the target weft arrival timing, and the second position.

FIG. 1

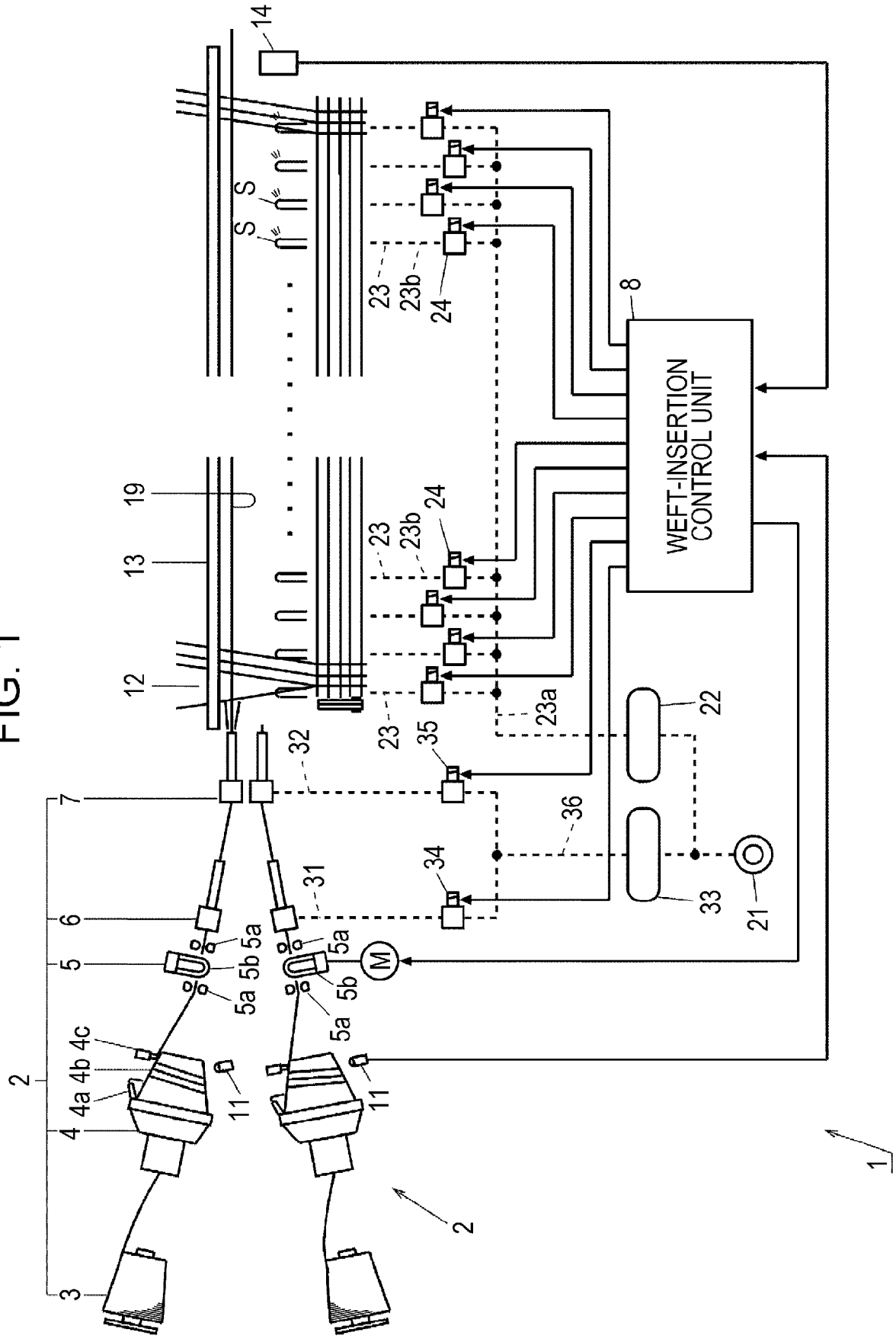


FIG. 2

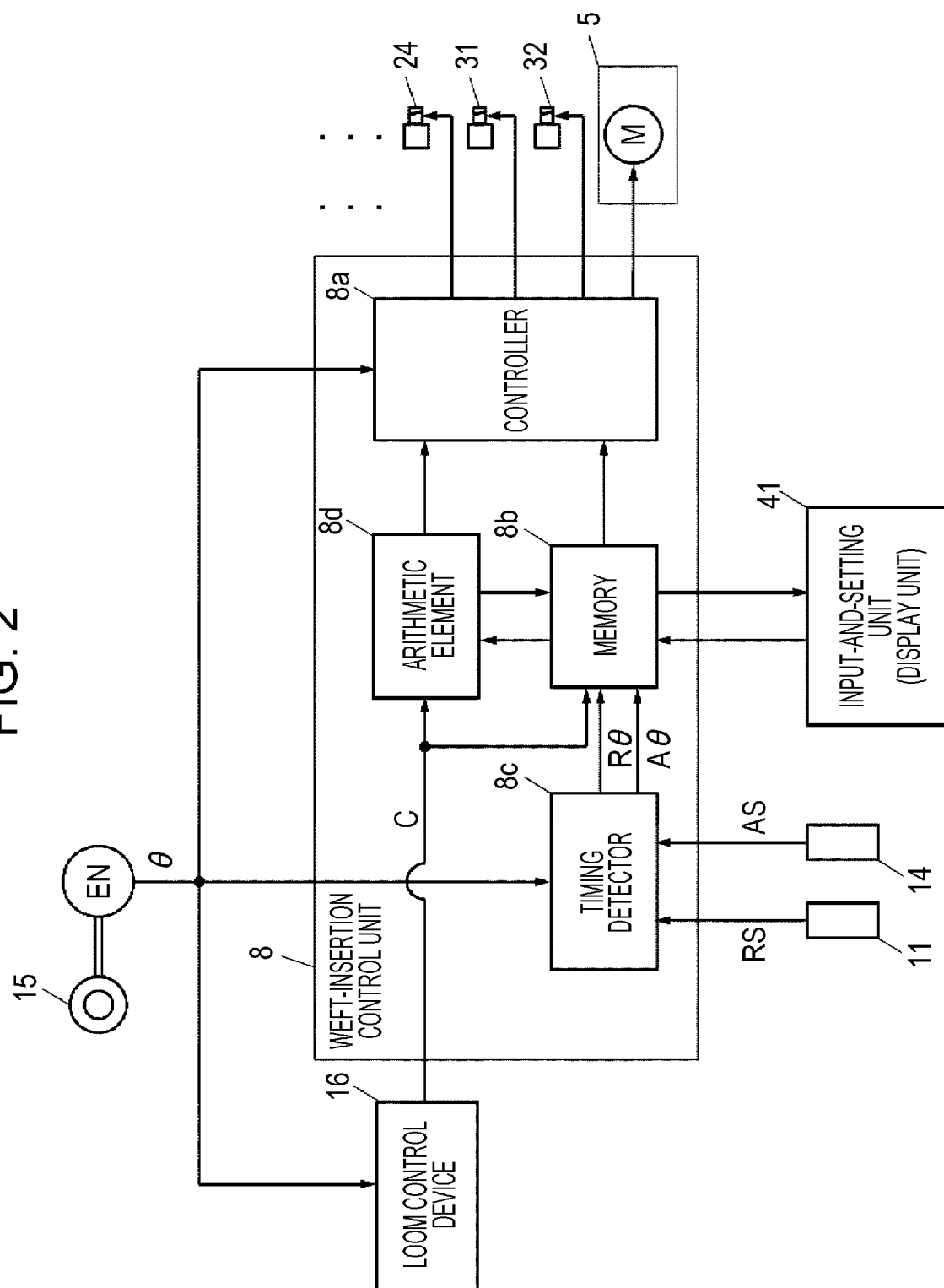


FIG. 3

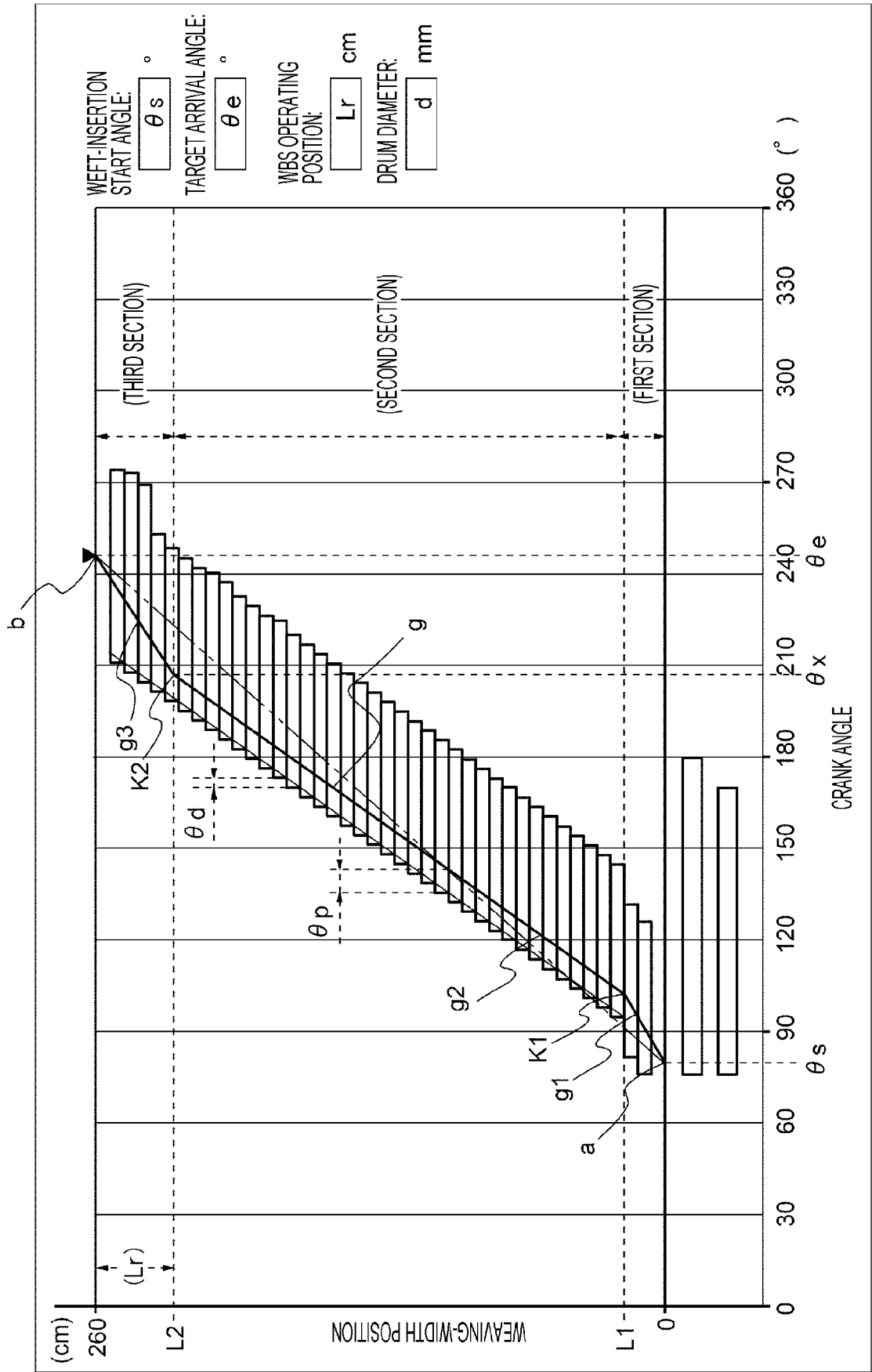
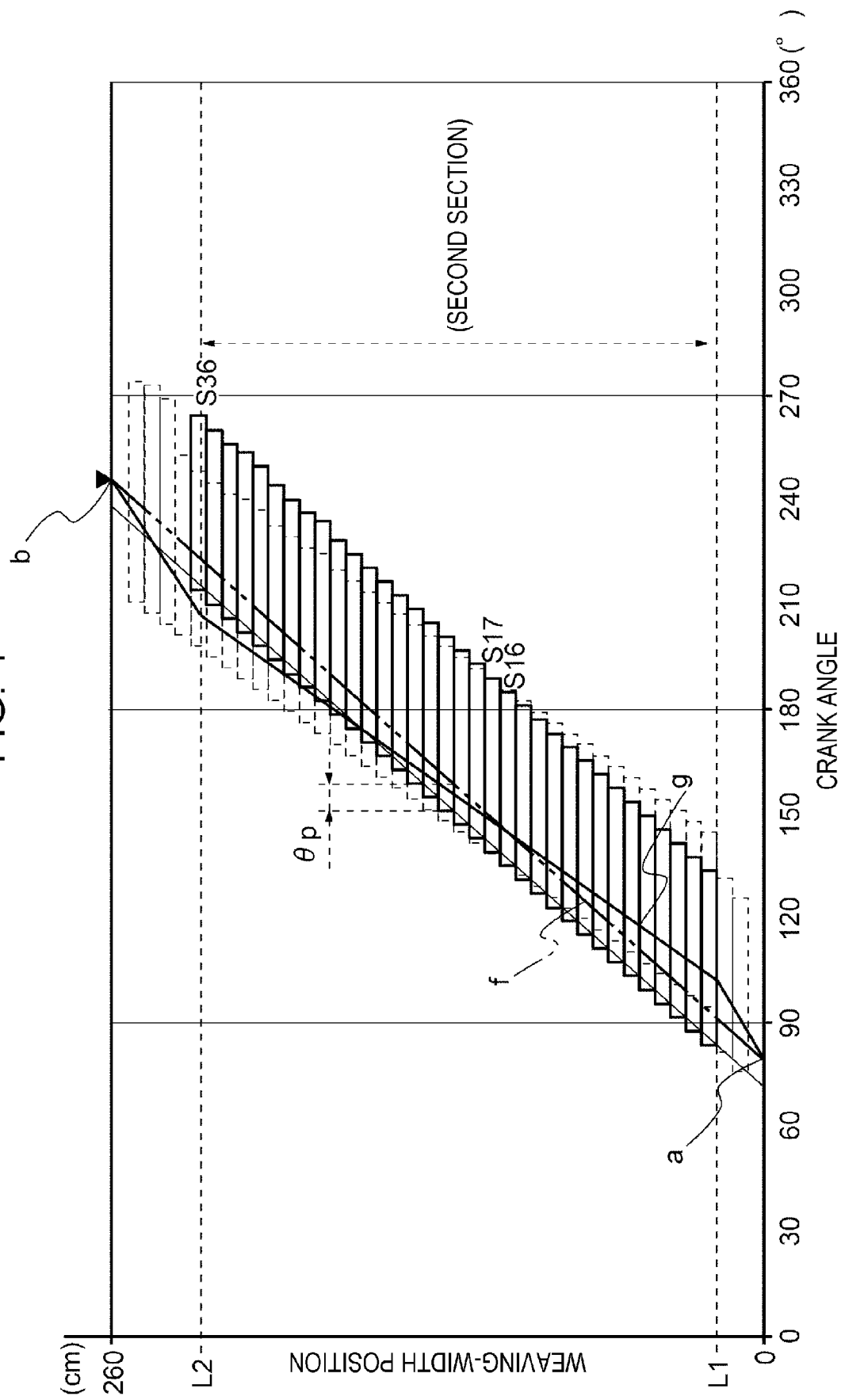


FIG. 4





EUROPEAN SEARCH REPORT

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Place of search Munich		Date of completion of the search 21 February 2019	Examiner Heinzelmann, Eric
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