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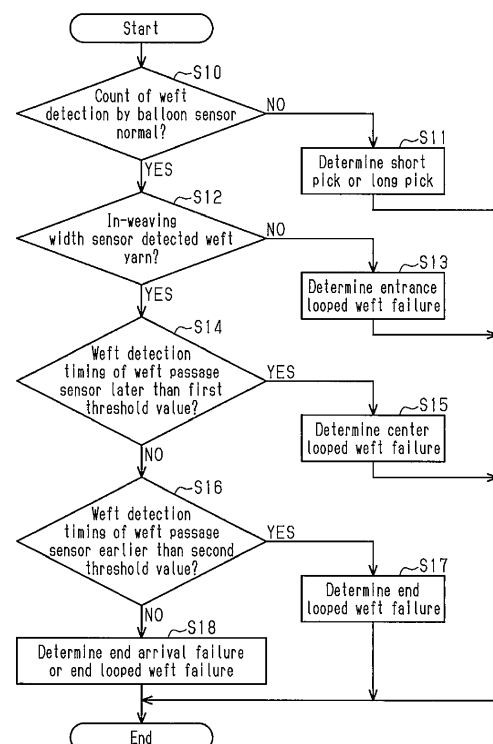
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(54) **METHOD FOR DIAGNOSING WEFT INSERTION IN AIR-JET LOOM**

(57) If a count of unwinding detected by a balloon sensor is normal, and a weft yarn is detected by an in-weaving width sensor but not by an end sensor, a controller compares a weft detection timing of the in-weaving width sensor with a previously set threshold value of the weft detection timing of the in-weaving width sensor to estimate the location of a weft loop failure that is a weft insertion failure that has occurred.

Fig.7



Description

BACKGROUND

[0001] The present disclosure relates to a method for diagnosing weft insertion in an air-jet loom.

[0002] In an air-jet loom, a weft yarn is inserted through a weft yarn flight path by jet of air from a main nozzle and sub-nozzles. For example, Japanese Laid-Open Patent Publication No. 4-257347 discloses a weft insertion control apparatus that includes a weft insertion diagnosis device. The weft insertion diagnosis device determines whether weft insertion of a weft yarn is normal or abnormal. The weft insertion diagnosis device includes a weft unwinding detector (balloon sensor), which detects unwinding of the weft yarn from a weft measuring and storing device, a weft arrival detector (end sensor), which detects the arrival of the leading end of the weft yarn, and weft yarn flight detectors (weft passage sensors), which are arranged at equal intervals within a weaving width. In the air-jet loom, the flight condition of the weft yarn may deteriorate due to a change in the injection pressure or the injection timing of the sub-nozzles. In this case, the weft yarn slackens, and an end arrival failure may possibly occur, in which the leading end of the weft yarn does not arrive at the detection position of the weft arrival detector. Although the injection pressure and the injection timing of the sub-nozzles are appropriate, if the warp yarn tension is reduced and the condition of the shed deteriorates, the weft yarn injected from the main nozzle may hit a warp yarn at the entrance of the shed. In this case, an entrance looped weft failure may possibly occur, in which a loop of the weft yarn is formed at a position past the entrance of the shed and in the vicinity of the entrance. The weft insertion control apparatus of Japanese Laid-Open Patent Publication No. 4-257347 identifies the end arrival failure and the entrance looped weft failure based on flight detection information detected by the weft yarn flight detectors.

[0003] In the air-jet loom, a center looped weft failure or an end looped weft failure may occur besides the entrance looped weft failure. The center looped weft failure is a weft insertion failure in which a loop of a weft yarn is formed when the weft yarn hits a warp yarn at a position in the vicinity of the center of the weaving width in the weft yarn flight path. The end looped weft failure is a weft insertion failure in which a loop of the weft yarn is formed when the weft yarn hits a warp yarn at a position in the weft yarn flight path farther than the center of the weaving width from the main nozzle. According to the weft insertion control apparatus of Japanese Laid-Open Patent Publication No. 4-257347, it is difficult to estimate the location of the looped weft failure other than the entrance looped weft failure.

SUMMARY

[0004] Accordingly, it is an objective of the present dis-

closure to provide a method for diagnosing weft insertion in an air-jet loom that estimates the location of a looped weft failure when there is a looped weft failure other than an entrance looped weft failure.

[0005] In accordance with one aspect of the present disclosure, a method for diagnosing weft insertion in an air-jet loom is provided. The air jet loom includes a main nozzle and a sub-nozzle, which insert a weft yarn in a weft yarn flight path, a balloon sensor, which detects unwinding of the weft yarn from a weft measuring and storing device, an end sensor located on an opposite end of the weft yarn flight path from the main nozzle and outside of a weaving width, and an in-weaving width sensor located at a position in the weft yarn flight path farther from the main nozzle than a center of the weaving width and within the weaving width. If a count of unwinding detected by the balloon sensor is normal, and the weft yarn is detected by the in-weaving width sensor but not by the end sensor, a weft detection timing of the in-weaving width sensor is compared with a previously set threshold value of the weft detection timing of the in-weaving width sensor to estimate the location of a looped weft failure that is a weft insertion failure that has occurred.

[0006] Other aspects and advantages of the present disclosure will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating exemplary embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The disclosure may be understood by reference to the following description together with the accompanying drawings:

Fig. 1 is a diagrammatic view of a weft insertion device of an air-jet loom according to one embodiment of the present disclosure;

Fig. 2 is a schematic diagram illustrating a state in which weft insertion of a weft yarn is performed normally;

Fig. 3A is a schematic diagram illustrating a state in which there is an end arrival failure;

Fig. 3B is a schematic diagram illustrating a state in which there is an entrance looped weft failure;

Fig. 3C is a schematic diagram illustrating a state in which there is a center looped weft failure;

Fig. 3D is a schematic diagram illustrating a state in which there is an end looped weft failure;

Fig. 4 is a table showing data of weft insertion failure stored in the controller;

Fig. 5 is a graph showing the relationship between a machine angle at the weft detection timing of the weft passage sensor with respect to the center looped weft failure and the end arrival failure;

Figs. 6A to 6D are diagrams each showing the type of a weft insertion failure and the adjustment method corresponding to the type of the weft insertion failure indicated on the display; and

Fig. 7 is a flowchart of the method for diagnosing weft insertion.

DETAILED DESCRIPTION

[0008] A method for diagnosing weft insertion in an air-jet loom according to one embodiment will be described with reference to Figs. 1 to 7. In the following description, a direction in which a weft yarn is inserted in a shed and conveyed will be referred to as a weft insertion direction.

[0009] As shown in Fig. 1, a weft insertion device 10 includes a weft insertion nozzle 11, a yarn supply package 12, a weft measuring and storing device 13, a reed 14, sub-nozzles 15, and a controller 16. The controller 16 is connected to a display 16a, which has a display function and an input function.

[0010] The yarn supply package 12 is located upstream of the weft insertion nozzle 11. A weft yarn Y is drawn out from the yarn supply package 12 by rotation of a winding arm (not shown) of the weft measuring and storing device 13 and is wound around a storage drum 17.

[0011] The weft measuring and storing device 13 includes a weft stopper pin 18 and a balloon sensor 19, which detects unwinding of the weft yarn Y from the weft measuring and storing device 13. The weft stopper pin 18 and the balloon sensor 19 are located on the circumference of the storage drum 17. The weft stopper pin 18 is electrically connected to the controller 16. The weft stopper pin 18 unwinds the weft yarn Y stored on the storage drum 17 at a loom rotational angle previously set in the controller 16. The timing at which the weft yarn Y is unwound by the weft stopper pin 18 is referred to as a weft insertion start timing.

[0012] The balloon sensor 19 is electrically connected to the controller 16. The balloon sensor 19 detects the weft yarn Y unwound from the storage drum 17 during the weft insertion and transmits weft unwinding signals to the controller 16. Upon reception of the weft unwinding signals by a predetermined number of times (four times in the present embodiment), the controller 16 operates the weft stopper pin 18. The weft stopper pin 18 stops the weft yarn Y unwound from the storage drum 17 and ends the weft insertion.

[0013] The timing at which the weft stopper pin 18 is operated to stop the weft yarn Y is set in accordance with the number of coils required to store a length of the weft yarn Y corresponding to the weaving width TL on the storage drum 17. Upon receipt of the weft unwinding signals four times from the balloon sensor 19, the controller 16 transmits an operation signal to the weft stopper pin 18 to stop the weft yarn Y. Thus, the weft insertion device 10 inserts the weft yarn Y having a length corresponding to four coils of the weft yarn stored on the storage drum 17.

[0014] A weft detection signal of the balloon sensor 19 corresponds to an unwinding signal of the weft yarn Y from the storage drum 17. The controller 16 recognizes the weft detection signal of the balloon sensor 19 as a

weft unwinding timing based on a loom rotational angle signal from an encoder 20.

[0015] The weft insertion nozzle 11 includes a tandem nozzle 21, which draws out the weft yarn Y on the storage drum 17, and a main nozzle 22, which performs weft insertion of the weft yarn Y into a weft yarn flight path 14a of the reed 14. A brake 23 is provided upstream of the tandem nozzle 21. The brake 23 brakes the flying weft yarn Y before the weft insertion is finished.

[0016] The main nozzle 22, the sub-nozzles 15, and the reed 14 are located on a sley (not shown) and swing to-and-fro of the air-jet loom. The tandem nozzle 21, the brake 23, the weft measuring and storing device 13, and the yarn supply package 12 are fixed on, for example, a bracket (not shown) mounted on a frame (not shown) of the air-jet loom or the floor (not shown).

[0017] An end sensor 24 and a double end sensor 25 are located downstream of the weft yarn flight path 14a. The end sensor 24 and the double end sensor 25 are located downstream of the weaving width TL. Thus, the end sensor 24 and the double end sensor 25 are located on the opposite end of the weft yarn flight path 14a from the main nozzle 22 and are located outside of the weaving width TL. The double end sensor 25 is located at a position farther than the end sensor 24 from the main nozzle 22.

[0018] As shown in Fig. 2, the end sensor 24 is located at a position where the leading end of the weft yarn Y having a length corresponding to four coils of the weft yarn stored on the storage drum 17 arrives when the weft insertion of the weft yarn Y is performed normally. Thus, when the weft insertion of the weft yarn Y is performed normally, the double end sensor 25 does not detect the weft yarn Y. As shown in Fig. 1, the end sensor 24 and the double end sensor 25 are electrically connected to the controller 16. The weft detection signal of the end sensor 24 corresponds to an arrival signal of the weft yarn Y. The controller 16 recognizes the weft detection signal of the end sensor 24 as a weft leading end arrival timing TW at which the leading end of the inserted weft yarn Y arrives at the detection position of the end sensor 24 based on the loom rotational angle signal from the encoder 20.

[0019] In the weft yarn flight path 14a, an in-weaving width sensor 45 is located within the weaving width TL upstream of the end sensor 24. The in-weaving width sensor 45 is located at a position in the weft yarn flight path 14a farther than the center of the weaving width TL from the main nozzle 22. The in-weaving width sensor 45 is located at a position where the leading end of the weft yarn Y having a length corresponding to three coils of the weft yarn stored on the storage drum 17 arrives when the weft insertion of the weft yarn Y is performed normally. The in-weaving width sensor 45 is electrically connected to the controller 16. The controller 16 recognizes the weft detection signal of the in-weaving width sensor 45 as a weft intermediate position arrival timing IS at which the leading end of the inserted weft yarn Y

arrives at the detection position of the in-weaving width sensor 45 based on the loom rotational angle signal from the encoder 20. That is, the weft intermediate position arrival timing IS corresponds to a weft detection timing of the in-weaving width sensor 45.

[0020] The in-weaving width sensor 45 includes a light emitting optical fiber and a light receiving optical fiber. During operation of the air-jet loom, light is emitted from the light emitting optical fiber of the in-weaving width sensor 45 toward the weft yarn flight path 14a, and the light reflected by the reed 14 and the weft yarn Y is received by the light receiving optical fiber. The light received by the light receiving optical fiber is input to a filler amplifier (not shown). The filler amplifier receives the input light with a receiver, which is a photodiode in this embodiment, and converts the light to an electrical signal. The filler amplifier amplifies the converted electrical signal and then outputs the signal to the controller 16.

[0021] The main nozzle 22 is connected to a main valve 22v through a pipe 22a. The main valve 22v is connected to a main air tank 26 through a pipe 22b. The tandem nozzle 21 is connected to a tandem valve 21v through a pipe 21a. The tandem valve 21v is connected to the main air tank 26 through a pipe 21b. The main valve 22v and the tandem valve 21v are connected to the common main air tank 26.

[0022] The main air tank 26 is connected to a common air compressor 31 installed in a textile factory via a main pressure gage 27, a main regulator 28, a source pressure gage 29, and a filter 30. The compressed air supplied from the air compressor 31 is adjusted to a predetermined pressure by the main regulator 28 and stored in the main air tank 26. The main pressure gage 27 constantly detects the pressure of the compressed air supplied to the main air tank 26.

[0023] The sub-nozzles 15 are divided into six groups. Each group includes four sub-nozzles 15. The weft insertion device 10 includes six sub-valves 32 each corresponding to one of the groups. The sub-nozzles 15 of each group are connected to the associated sub-valve 32 via pipes 33. The sub-valves 32 are connected to a common sub-air tank 34.

[0024] The sub-air tank 34 is connected to a sub-regulator 36 via a sub-pressure gage 35. The sub-regulator 36 is connected to a pipe 28a, which connects the main pressure gage 27 to the main regulator 28, via a pipe 36a. The compressed air supplied from the air compressor 31 is adjusted to a predetermined pressure by the sub-regulator 36 and is stored in the sub-air tank 34. The sub-pressure gage 35 constantly detects the pressure of the compressed air supplied from the sub-air tank 34.

[0025] The main valve 22v, the tandem valve 21v, the sub-valves 32, the source pressure gage 29, the main pressure gage 27, the sub-pressure gage 35, and the brake 23 are electrically connected to the controller 16. The controller 16 previously sets the timing and the period of time for operating the main valve 22v, the tandem valve 21v, the sub-valves 32, and the brake 23. The controller

16 also receives detection signals from the source pressure gage 29, the main pressure gage 27, and the sub-pressure gage 35.

[0026] The controller 16 outputs an operation command signal to the main valve 22v and the tandem valve 21v at a point in time earlier than the weft insertion start timing, at which the weft stopper pin 18 is operated. Thus, the main nozzle 22 and the tandem nozzle 21 inject compressed air. The controller 16 outputs an operation command signal to the brake 23 at a point in time earlier than the weft leading end arrival point in time TW at which the weft stopper pin 18 operates to stop the weft yarn Y on the storage drum 17. The brake 23 brakes the weft yarn Y flying at a high-speed and decreases the flight speed of the weft yarn Y. This reduces the impact on the weft yarn Y caused at the weft leading end arrival timing TW.

[0027] The controller 16 stores various fabric conditions and weaving conditions. The fabric conditions include, for example, the types of the weft yarn such as the material and the counts of the thread used for the weft yarn Y, the weft yarn density, the types of the warp yarn such as the material and the counts of the thread used for the warp yarn, the warp yarn density, the weaving width, and the fabric structure. The weaving conditions include, for example, the rotational speed of the loom, the pressure of the compressed air in the main air tank 26 and the sub-air tank 34, the opening degree of the main valve 22v and the tandem valve 21v, the weft insertion start timing, and a target weft leading end arrival timing.

[0028] As shown in Fig. 3A, if the injection pressure or the injection timing of the sub-nozzles 15 is changed, and the flight condition of the weft yarn Y deteriorates, the weft yarn Y may slacken. This may possibly cause an end arrival failure in which the leading end of the weft yarn Y does not arrive at the detection position of the end sensor 24.

[0029] As shown in Fig. 3B, an entrance looped weft failure may occur as the weft insertion failure. The entrance looped weft failure is a weft insertion failure in which a loop of the weft yarn Y is formed in the vicinity of the entrance of the shed. Although the injection pressure and the injection timing of the sub-nozzles 15 are appropriate, if the warp yarn tension is reduced and the condition of the shed deteriorates, the weft yarn Y injected from the main nozzle 22 hits a warp yarn at the entrance of the shed. When the entrance looped weft failure occurs, the weft yarn Y arrives only at a position in the vicinity of the center of the weaving width TL. Thus, neither the in-weaving width sensor 45 nor the end sensor 24 detects the weft yarn Y.

[0030] Furthermore, a looped weft failure other than the entrance looped weft failure may occur as the weft insertion failure. Other looped weft failures include, for example, a center looped weft failure shown in Fig. 3C and an end looped weft failure, which is the weft insertion failure shown in Fig. 3D. The center looped weft failure is a weft insertion failure in which a loop of the weft yarn

Y is formed when the weft yarn Y hits a warp yarn in the vicinity of the center of the weaving width TL in the weft yarn flight path 14a. The end looped weft failure is a weft insertion failure in which a loop of the weft yarn Y is formed when the weft yarn Y hits a warp yarn at a position in the weft yarn flight path 14a farther than the center of the weaving width TL from the main nozzle 22.

[0031] When a center looped weft failure or an end looped weft failure occurs, the end sensor 24 does not detect the weft yarn Y as in the case of the entrance looped weft failure. In the center looped weft failure or the end looped weft failure, a loop is mostly formed after the leading end of the weft yarn Y arrives at the detection position of the in-weaving width sensor 45. Thus, the in-weaving width sensor 45 detects the weft yarn Y that causes the center looped weft failure or the end looped weft failure.

[0032] Fig. 4 shows data such as the number of pulses of the end sensor 24 when an entrance looped weft failure, a center looped weft failure, an end looped weft failure, or an end arrival failure occurs, the machine angle at the weft leading end arrival timing TW, the machine angle at the weft intermediate position arrival timing IS, and the count of the unwinding detected by the balloon sensor 19. The controller 16 stores these data. The display 16a shows the data stored in the controller 16 in a list.

[0033] As shown in Fig. 4, when the entrance looped weft failure occurs, the count of unwinding detected by the balloon sensor 19 is four, which is the count of detected unwinding when the weft yarn Y is inserted normally. In this case, neither the end sensor 24 nor the in-weaving width sensor 45 detects the weft yarn Y.

[0034] When the center looped weft failure occurs, the count of unwinding detected by the balloon sensor 19 is four, which is the count of detected unwinding when the weft insertion of the weft yarn Y is performed normally. In this case, the weft yarn Y is not detected by the end sensor 24, but is detected by the in-weaving width sensor 45. As described above, the center looped weft failure is the weft insertion failure in which a loop of the weft yarn Y is formed when the weft yarn Y hits a warp yarn in the vicinity of the center of the weaving width TL in the weft yarn flight path 14a. Thus, the weft detection timing of the in-weaving width sensor 45 is far later than that when the weft insertion of the weft yarn Y is performed normally.

[0035] When the end looped weft failure occurs, the count of unwinding detected by the balloon sensor 19 is four, which is the count of detected unwinding when the weft insertion of the weft yarn Y is performed normally. In this case, the weft yarn Y is not detected by the end sensor 24, but is detected by the in-weaving width sensor 45. As described above, the end looped weft failure is the weft insertion failure in which a loop of the weft yarn Y is formed when the weft yarn Y hits a warp yarn at a position in the weft yarn flight path 14a farther than the center of the weaving width TL from the main nozzle 22. Thus, the weft detection timing of the in-weaving width sensor 45 is substantially the same as that when the weft

insertion of the weft yarn Y is performed normally.

[0036] When the end arrival failure occurs, the count of unwinding detected by the balloon sensor 19 is four, which is the count of detected unwinding when the weft insertion of the weft yarn Y is performed normally. In this case, the number of pulses of the end sensor 24 may be zero or a numerical value that is less than the number of pulses of the end sensor 24 when the weft insertion of the weft yarn Y is performed normally (for example, 15). Furthermore, as shown in Fig. 3A, in the case of the end arrival failure, the slackening of the weft yarn Y mostly occurs only at the leading end of the weft yarn Y. Thus, the in-weaving width sensor 45 detects the weft yarn Y. Additionally, at this time, the leading end of the weft yarn Y arrives at the detection position of the in-weaving width sensor 45 with the leading end of the weft yarn Y being slackened. Thus, the weft detection timing of the in-weaving width sensor 45 is slightly later than that when the weft insertion of the weft yarn Y is performed normally.

[0037] Fig. 5 shows the relationship between the machine angle at the weft detection timing of the in-weaving width sensor 45 with respect to the center looped weft failure and the end arrival failure. As shown in Fig. 5, the controller 16 obtains a minimum value ISmin and a maximum value ISmax of the machine angle at the weft detection timing of the in-weaving width sensor 45 within a range of a predetermined number of picks (for example, every 30 picks) when the weft insertion of the weft yarn Y is performed normally. Furthermore, the controller 16 stores a value obtained by adding a predetermined value (for example, 10 degrees) to the maximum value ISmax as a first threshold value ISx1.

[0038] When the count of unwinding detected by the balloon sensor 19 is normal, and the weft yarn Y is detected by the in-weaving width sensor 45, but not by the end sensor 24, the controller 16 compares the machine angle at the weft detection timing of the in-weaving width sensor 45 with the first threshold value ISx1. If the machine angle at the weft detection timing of the in-weaving width sensor 45 is later than the first threshold value ISx1, the controller 16 determines that the weft insertion failure that has occurred is the center looped weft failure. Thus, the first threshold value ISx1 is used to determine that the type of the weft insertion failure that has occurred is the center looped weft failure. In this manner, the controller 16 presumes that the looped weft failure other than the entrance looped weft failure is the center looped weft failure.

[0039] Furthermore, the controller 16 calculates the mean value of the machine angles at the weft detection timing of the in-weaving width sensor 45 within the range of the predetermined number of picks when the weft insertion of the weft yarn Y is performed normally and stores the mean value as a second threshold value ISx2.

[0040] When the count of unwinding detected by the balloon sensor 19 is normal, and the weft yarn Y is detected by the in-weaving width sensor 45, but not by the end sensor 24, the controller 16 compares the machine

angle at the weft detection timing of the in-weaving width sensor 45 with the second threshold value ISx2. When the machine angle at the weft detection timing of the in-weaving width sensor 45 is earlier than the second threshold value ISx2, the controller 16 determines that the weft insertion failure that has occurred is the end looped weft failure. Thus, the second threshold value ISx2 is used to determine that the type of the weft insertion failure that has occurred is the end looped weft failure. In this manner, when the looped weft failure other than the entrance looped weft failure, which is the end looped weft failure in this case, occurs, the controller 16 presumes that the location of the looped weft failure corresponds to the location of the end looped weft failure.

[0041] In this manner, when the count of unwinding detected by the balloon sensor 19 is normal, and the weft yarn Y is detected by the in-weaving width sensor 45, but not by the end sensor 24, the controller 16 compares the weft detection timing of the in-weaving width sensor 45 with the previously set first threshold value ISx1 and the second threshold value ISx2 of the weft detection timing of the in-weaving width sensor 45 to estimate the location where the looped weft failure has occurred.

[0042] When the machine angle at the weft detection timing of the in-weaving width sensor 45 is earlier than the first threshold value ISx1 and later than the second threshold value ISx2, the controller 16 determines that the type of the weft insertion failure that has occurred is the end arrival failure or the end looped weft failure. At this time, the type of the weft insertion failure that is actually occurring is more likely to be an end arrival failure than an end looped weft failure. This is because, while the weft detection timing of the in-weaving width sensor 45 in the case of an end looped weft failure is substantially the same as that when the weft insertion of the weft yarn Y is performed normally, the weft detection timing of the in-weaving width sensor 45 in the case of an end arrival failure is slightly later than that when the weft insertion of the weft yarn Y is performed normally.

[0043] As shown in Fig. 6A, when it is determined that the type of the weft insertion failure that has occurred is the end arrival failure, the controller 16 controls the display 16a to show the type of the weft insertion failure on the display 16a. The display 16a shows, as the type of the weft insertion failure, "End arrival failure occurred due to change in condition of injection pressure or injection timing of sub-nozzles or change in flight condition of weft yarn." The display 16a also shows, as an adjustment method corresponding to the end arrival failure, "Recommendation to adjust injection pressure of sub-nozzles."

[0044] As shown in Fig. 6B, if it is determined that the type of the weft insertion failure that has occurred is the entrance looped weft failure, the controller 16 controls the display 16a to show the type of the weft insertion failure on the display 16a. The display 16a shows, as the type of the weft insertion failure, "Entrance looped weft failure occurred due to change in warp yarn condition." The display 16a also shows, as an adjustment method

corresponding to the entrance looped weft failure, "Recommendation to check warp yarn tension, to check shed condition, and to adjust weft insertion start timing."

[0045] As shown in Fig. 6C, if it is determined that the type of the weft insertion failure that has occurred is the center looped weft failure, the controller 16 controls the display 16a to show the type of the weft insertion failure on the display 16a. The display 16a shows, as the type of the weft insertion failure, "Center looped weft failure occurred due to change in warp yarn condition, or some kind of trouble." The display 16a also shows, as an adjustment method corresponding to the center looped weft failure, "Recommendation to check warp yarn tension, to check shed condition, and to check whether sub-nozzle tube has fallen off in vicinity of center of weaving width in weft yarn flight path."

[0046] As shown in Fig. 6D, if it is determined that the type of the weft insertion failure that has occurred is the end looped weft failure, the controller 16 controls the display 16a to show the type of the weft insertion failure on the display 16a. The display 16a shows, as the type of the weft insertion failure, "End looped weft failure occurred due to change in warp yarn condition, or some kind of trouble." The display 16a also shows, as an adjustment method corresponding to the end looped weft failure, "Recommendation to check warp yarn tension, to check shed condition, and to check whether sub-nozzle tube has fallen off in vicinity of end of weft yarn flight path farther than center of weaving width from main nozzle."

[0047] Next, a method for diagnosing weft insertion performed by the weft insertion diagnosis device and operation of the present embodiment will be described.

[0048] As shown in Fig. 7, in step S10, the controller 16 first determines whether the count of unwinding detected by the balloon sensor 19 is normal. If the count of unwinding detected by the balloon sensor 19 is abnormal, the controller 16 proceeds to step S11 and determines the type of the weft insertion failure that has occurred to be a short pick or a long pick. The short pick refers to a case in which the weft insertion is terminated with the weft yarn Y having a length corresponding to three coils of the weft yarn around the storage drum 17 is inserted or a case in which the weft insertion is terminated with the weft yarn Y having a length corresponding to two coils of the weft yarn around the storage drum 17 is inserted. The long pick refers to a case in which the weft insertion is terminated with the weft yarn Y having a length corresponding to five coils of the weft yarn around the storage drum 17 is inserted.

[0049] If the count of unwinding detected by the balloon sensor 19 is normal, the controller 16 proceeds to step S12. In step S12, the controller 16 determines whether the in-weaving width sensor 45 detected the weft yarn Y. If the in-weaving width sensor 45 did not detect the weft yarn Y, the controller 16 proceeds to step S13 and determines that the type of the weft insertion failure that has occurred is the entrance looped weft failure. If the

in-weaving width sensor 45 detected the weft yarn Y, the controller 16 proceeds to step S14.

[0050] In step S14, the controller 16 compares the machine angle at the weft detection timing of the in-weaving width sensor 45 with the first threshold value ISx1 to determine whether the machine angle at the weft detection timing of the in-weaving width sensor 45 is later than the first threshold value ISx1. If the machine angle at the weft detection timing of the in-weaving width sensor 45 is later than the first threshold value ISx1, the controller 16 proceeds to step S15 and determines that the type of the weft insertion failure that has occurred is the center looped weft failure. If the machine angle at the weft detection timing of the in-weaving width sensor 45 is not later than the first threshold value ISx1, the controller 16 proceeds to step S16.

[0051] In step S16, the controller 16 determines whether the machine angle at the weft detection timing of the in-weaving width sensor 45 is earlier than the second threshold value ISx2. If the machine angle at the weft detection timing of the in-weaving width sensor 45 is earlier than the second threshold value ISx2, the controller 16 proceeds to step S17 and determines that the type of the weft insertion failure that has occurred is the end looped weft failure. If the machine angle at the weft detection timing of the in-weaving width sensor 45 is not earlier than the second threshold value ISx2, the controller 16 proceeds to step S18 and determines that the type of the weft insertion failure that has occurred is the end arrival failure or the end looped weft failure. The weft insertion diagnosis device determines the type of the weft insertion failure that has occurred by the method for diagnosing weft insertion as described above.

[0052] The above-described embodiment has the following advantages.

(1) When the count of unwinding detected by the balloon sensor 19 is normal, and the weft yarn Y is detected by the in-weaving width sensor 45, but not by the end sensor 24, the controller 16 compares the weft detection timing of the in-weaving width sensor 45 with the previously set threshold values of the weft detection timing of the in-weaving width sensor 45 to estimate the location of the looped weft failure, which is the weft insertion failure that has occurred. If the looped weft failure different from the entrance looped weft failure has occurred, the end sensor 24 does not detect the weft yarn Y as in the case of the entrance looped weft failure. In the looped weft failure other than the entrance looped weft failure, a loop is mostly formed after the leading end of the weft yarn Y arrives at the detection position of the in-weaving width sensor 45. Thus, the in-weaving width sensor 45 detects the weft yarn Y that causes the looped weft failure other than the entrance looped weft failure.

[0053] Furthermore, the controller 16 compares the

weft detection timing of the in-weaving width sensor 45 with the previously set threshold values of the weft detection timing of the in-weaving width sensor 45 to estimate the location of the looped weft failure, which is the weft insertion failure that has occurred. In this manner, the controller 16 estimates the location of the looped weft failure when the looped weft failure other than the entrance looped weft failure occurs.

(2) In the center looped weft failure, a loop of the weft yarn Y is formed when the weft yarn Y hits a warp yarn in the vicinity of the center of the weaving width TL in the weft yarn flight path 14a. Thus, the weft detection timing of the in-weaving width sensor 45 is far later than that when, for example, the weft insertion of the weft yarn Y is performed normally. For this reason, when the weft detection timing of the in-weaving width sensor 45 is later than the first threshold value ISx1, the controller 16 determines that the type of the weft insertion failure that has occurred is the center looped weft failure. In this manner, the controller 16 presumes that the looped weft failure other than the entrance looped weft failure is the center looped weft failure.

(3) The first threshold value ISx1 is a value obtained by adding a predetermined value to the maximum value ISmax of the weft detection timing of the in-weaving width sensor 45 within the range of the predetermined number of picks when the weft insertion of the weft yarn Y is performed normally. Thus, the type of the weft insertion failure that has occurred is accurately determined as the center looped weft failure.

(4) In the end looped weft failure, a loop of the weft yarn Y is formed when the weft yarn Y hits a warp yarn at a position farther than the center of the weaving width TL from the main nozzle 22 in the weft yarn flight path 14a. Thus, the weft detection timing of the in-weaving width sensor 45 is substantially the same as that when the weft insertion of the weft yarn Y is performed normally. For this reason, when the weft detection timing of the in-weaving width sensor 45 is earlier than the second threshold value ISx2, the controller 16 determines that the type of the weft insertion failure that has occurred is the end looped weft failure. In this manner, the controller 16 presumes that the looped weft failure other than the entrance looped weft failure is the end looped weft failure.

(5) The second threshold value ISx2 is the mean value of the weft detection timing of the in-weaving width sensor 45 within the range of the predetermined number of picks when the weft insertion of the weft yarn Y is performed normally. Thus, the type of the weft insertion failure that has occurred is easily determined as the end looped weft failure.

(6) The display 16a shows the adjustment method corresponding to the type of the weft insertion failure.

Thus, the operator can see the adjustment method shown on the display 16a and deal smoothly in accordance with the type of the weft insertion failure. (7) The display 16a shows the data of the weft insertion failure stored in the controller 16 in a list. Thus, the operator can easily check what type of the weft insertion failure has occurred by checking the data shown on the display 16a.

[0054] The above-described embodiment may be modified as follows.

[0055] The first threshold value $ISx1$ may be set based on multiples of a standard deviation $IS\sigma$ of the weft detection timing of the in-weaving width sensor 45. For example, when the standard deviation $IS\sigma$ is 3, $6IS\sigma$ equals 18 degrees. Furthermore, when the mean value of the machine angles at the weft detection timing of the in-weaving width sensor 45 within the range of the predetermined number of picks when the weft insertion of the weft yarn Y is performed normally is 188 degrees, a value obtained by adding 18 degrees to 188 degrees, which is 206 degrees, may be the first threshold value $ISx1$.

[0056] In step S18, if it is determined that the type of the weft insertion failure that has occurred is either the end arrival failure or the end looped weft failure, the controller 16 may control the display 16a to indicate, for example, "Probability that end arrival failure has occurred is 70%" and "Probability that end looped weft failure has occurred is 30%."

[0057] The controller 16 may calculate the moving average within the range of the predetermined number of picks (for example, 30 picks) when the weft insertion of the weft yarn Y is performed normally to obtain the minimum value $ISmin$ and the maximum value $ISmax$ of the machine angle at the weft detection timing of the in-weaving width sensor 45.

[0058] The controller 16 may calculate the moving average within the range of the predetermined number of picks when the weft insertion of the weft yarn Y is performed normally to calculate the mean value of the machine angle at the weft detection timing of the in-weaving width sensor 45.

[0059] The controller 16 does not need to store the second threshold value $ISx2$, that is, the controller 16 may store only the first threshold value $ISx1$. Thus, the controller 16 does not necessarily have to determine the type of the weft insertion failure to be the end looped weft failure using the second threshold value $ISx2$.

[0060] The controller 16 does not need to store the first threshold value $ISx1$, that is, the controller 16 may store only the second threshold value $ISx2$. Thus, the controller 16 does not necessarily have to determine the type of the weft insertion failure to be the center looped weft failure using the first threshold value $ISx1$.

[0061] If the number of times the weft insertion failure is detected per unit time exceeds a predetermined number of times, the operator may be warned. For example, the display 16a may indicate a warning, or an

alarm lamp may be turned on.

[0062] The controller 16 may indicate the type of the weft insertion failure by symbols or colors. Alternatively, the controller 16 may inform the operator of the type of the weft insertion failure by a sound.

[0063] The display 16a does not necessarily have to indicate the data of the weft insertion failure stored in the controller 16 in a list.

[0064] A device that indicates the data of the weft insertion failure stored in the controller 16 in a list may be provided separately from the display 16a.

[0065] The display 16a does not necessarily have to indicate the adjustment method corresponding to the type of the weft insertion failure. A device that indicates the adjustment method may be provided separately from the display 16a.

[0066] The controller 16 does not necessarily have to have the function of storing the data of the weft insertion failure.

[0067] If a count of unwinding detected by a balloon sensor is normal, and a weft yarn is detected by an in-weaving width sensor but not by an end sensor, a controller compares a weft detection timing of the in-weaving width sensor with a previously set threshold value of the weft detection timing of the in-weaving width sensor to estimate the location of a weft loop failure that is a weft insertion failure that has occurred.

Claims

1. A method for diagnosing weft insertion in an air-jet loom, wherein the air jet loom includes

a main nozzle (22) and a sub-nozzle (15), which insert a weft yarn (Y) in a weft yarn flight path (14a),
a balloon sensor (19), which detects unwinding of the weft yarn (Y) from a weft measuring and storing device (13),
an end sensor (24) located on an opposite end of the weft yarn flight path (14a) from the main nozzle (22) and outside of a weaving width (TL), and
an in-weaving width sensor (45) located at a position in the weft yarn flight path (14a) farther from the main nozzle (22) than a center of the weaving width (TL) and within the weaving width (TL), and

if a count of unwinding detected by the balloon sensor (19) is normal, and the weft yarn (Y) is detected by the in-weaving width sensor (45) but not by the end sensor (24), a weft detection timing of the in-weaving width sensor (45) is compared with a previously set threshold value ($ISx1$, $ISx2$) of the weft detection timing of the in-weaving width sensor (45)

to estimate the location of a looped weft failure that is a weft insertion failure that has occurred.

2. The method for diagnosing weft insertion in an air-jet loom according to claim 1, wherein
the threshold value includes a first threshold value (ISx1) used to determine a type of the weft insertion failure that has occurred to be a center looped weft failure that is the looped weft failure other than an entrance looped weft failure, and
if the weft detection timing of the in-weaving width sensor (45) is later than the first threshold value (ISx1), the type of the weft insertion failure that has occurred is determined to be the center looped weft failure.
3. The method for diagnosing weft insertion in an air-jet loom according to claim 2, wherein the first threshold value (ISx1) is a value obtained by adding a predetermined value to a maximum value of the weft detection timing of the in-weaving width sensor (45) within a range of a predetermined number of picks when the weft insertion of the weft yarn (Y) is performed normally.
4. The method for diagnosing weft insertion in an air-jet loom according to any one of claims 1 to 3, wherein
the threshold value includes a second threshold value (ISx2) used to determine the type of the weft insertion failure that has occurred to be an end looped weft failure that is the looped weft failure other than the entrance looped weft failure, and
if the weft detection timing of the in-weaving width sensor (45) is earlier than the second threshold value (ISx2), the type of the weft insertion failure that has occurred is determined to be the end looped weft failure.
5. The method for diagnosing weft insertion in an air-jet loom according to claim 4, wherein the second threshold value (ISx2) is a mean value of the weft detection timing of the in-weaving width sensor within a range of a predetermined number of picks when the weft insertion of the weft yarn (Y) is performed normally.

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Fig.1

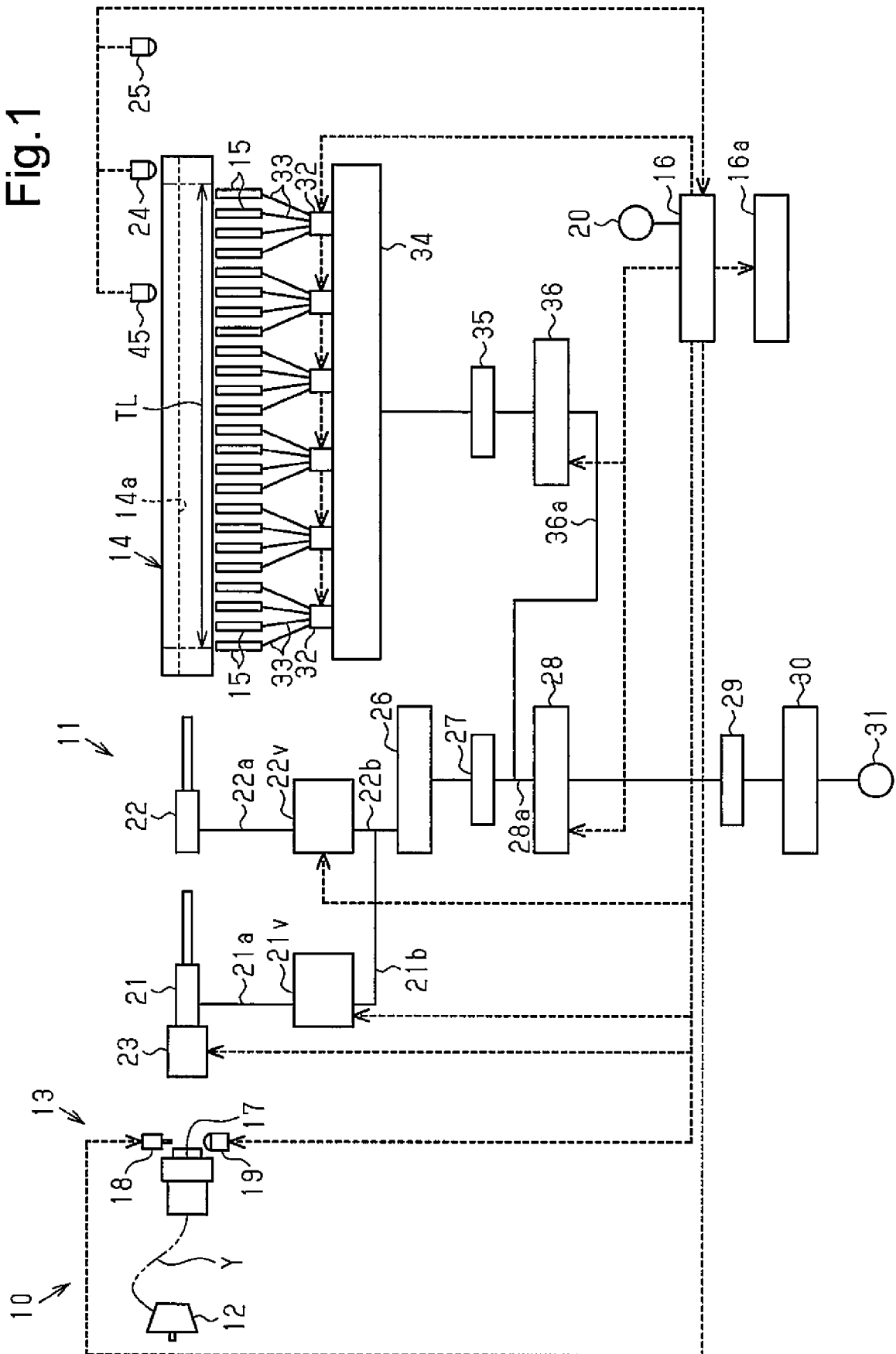


Fig.2

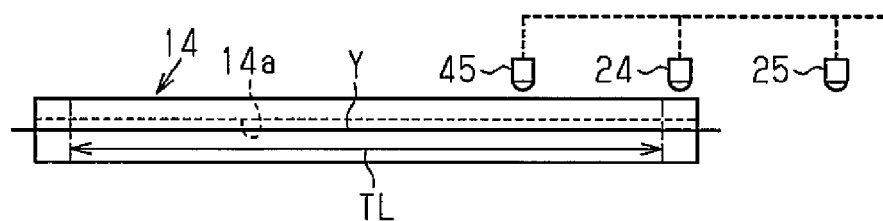


Fig.3A

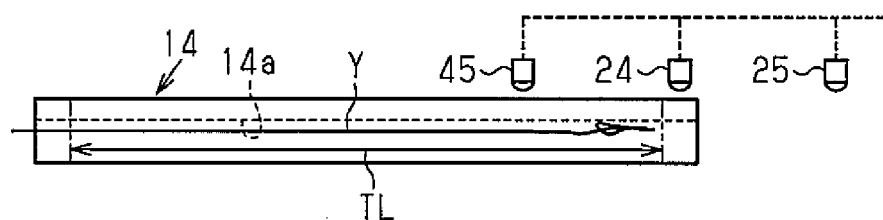


Fig.3B

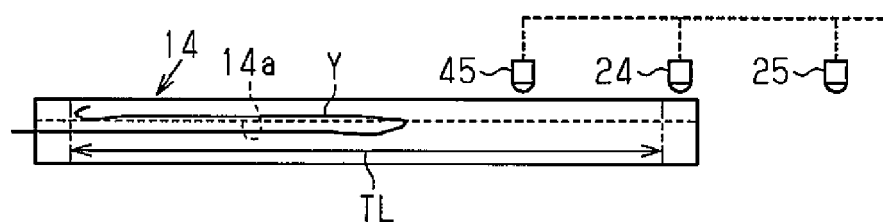


Fig.3C

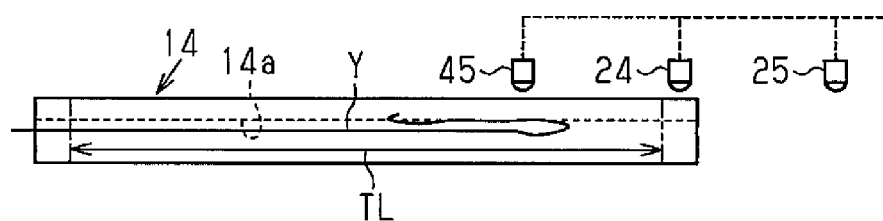


Fig.3D

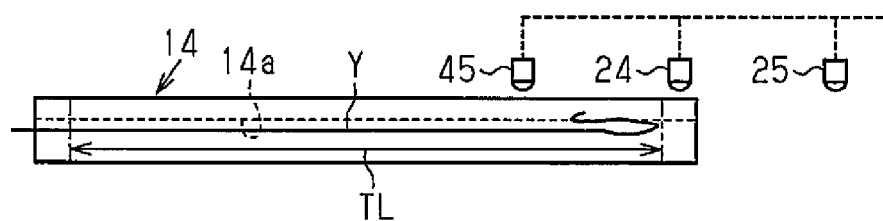


Fig.4

Time	Category of Failure	Detail of Weft Failure	Number of Pulses of End Sensor	TW	IS	Count of Unwinding Detected by Balloon Sensor
2016/10/21 10:01	WF MISS	Entrance Looped Weft Failure	0	0	0	4
2016/10/21 12:06	WF MISS	Center Looped Weft Failure	0	0	220	4
2016/10/21 12:22	WF MISS	End Looped Weft Failure	0	0	180	4
2016/10/21 13:05	WF MISS	End Arrival Failure (80%)	0	0	190	4

Fig.5

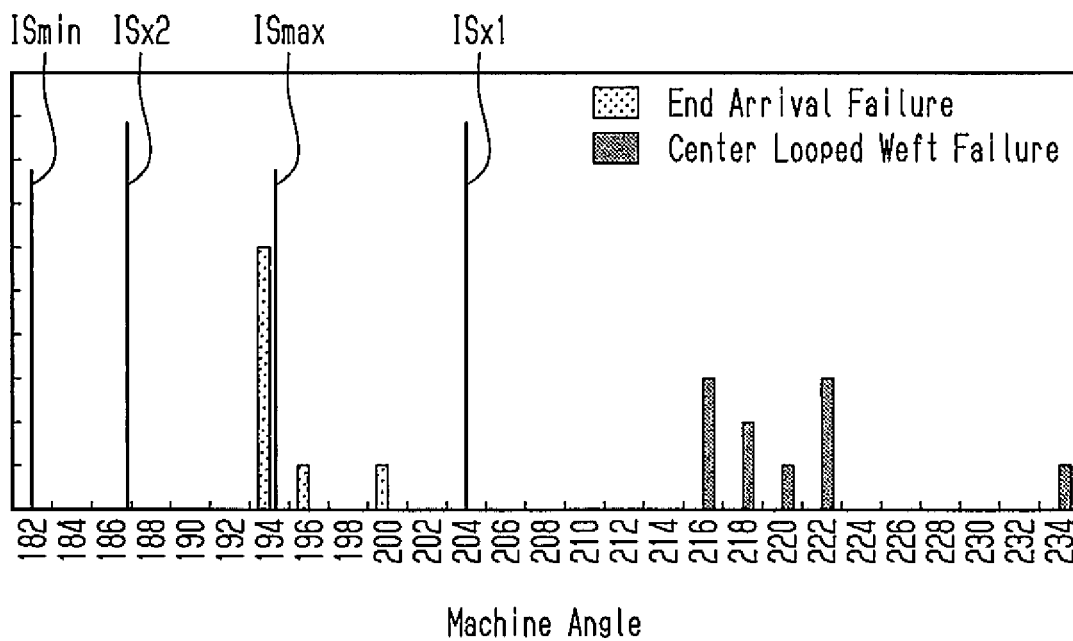


Fig.6A

16a

End arrival failure occurred due to change in condition of injection pressure or injection timing of sub-nozzles or change in flight condition of weft yarn.
Recommendation to adjust injection pressure of sub-nozzles.

Fig.6B

16a

Entrance looped weft failure occurred due to change in warp yarn condition.
Recommendation to check warp yarn tension, check shed condition, and adjust weft insertion start timing.

Fig.6C

16a

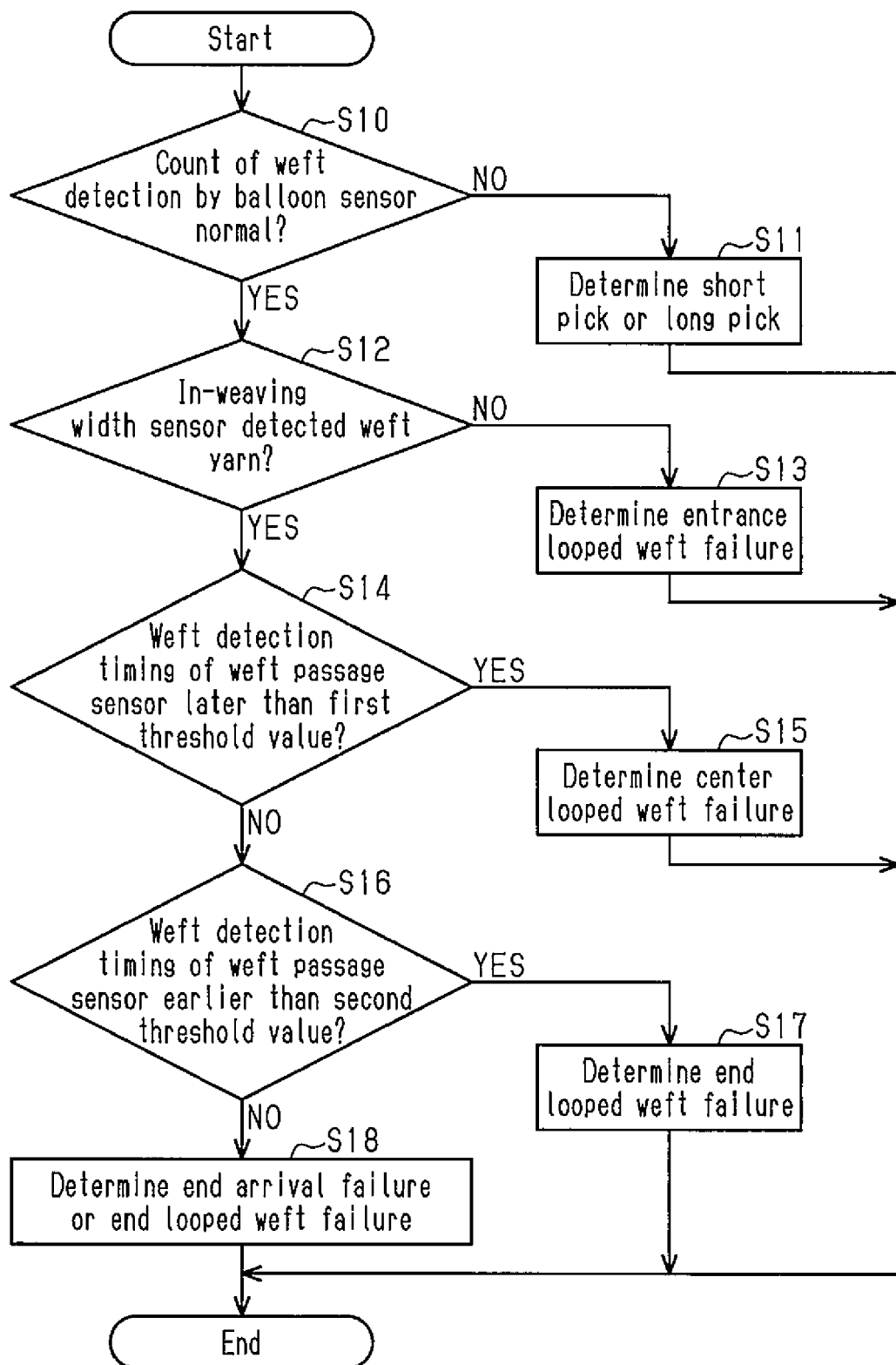
Center looped weft failure occurred due to change in warp yarn condition or some kind of trouble.
Recommendation to check warp yarn tension, check shed condition, and check whether sub-nozzle tube has fallen off in vicinity of center of weaving width in weft yarn flight path.

Fig.6D

16a

End looped weft failure occurred due to change in warp yarn condition or some kind of trouble.
Recommendation to check warp yarn tension, check shed condition, and check whether sub-nozzle tube has fallen off in vicinity of end of weft yarn flight path farther than center of weaving width from main nozzle.

Fig.7





EUROPEAN SEARCH REPORT

Application Number
EP 18 21 0644

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A,D	EP 0 498 773 A1 (TOYODA AUTOMATIC LOOM WORKS [JP]) 12 August 1992 (1992-08-12) * abstract; figures 1-16 * * column 9, lines 35-48 * -----	1-5	
			TECHNICAL FIELDS SEARCHED (IPC)
			D03D
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 4 April 2019	Examiner Louter, Petrus
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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