(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 889 334 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
06.10.2021 Bulletin 2021/40

(51) Int Cl.:
D05B 69/36 *(2006.01)*

(21) Application number: **21165662.4**

(22) Date of filing: **29.03.2021**

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

(30) Priority: **30.03.2020 JP 2020059293**

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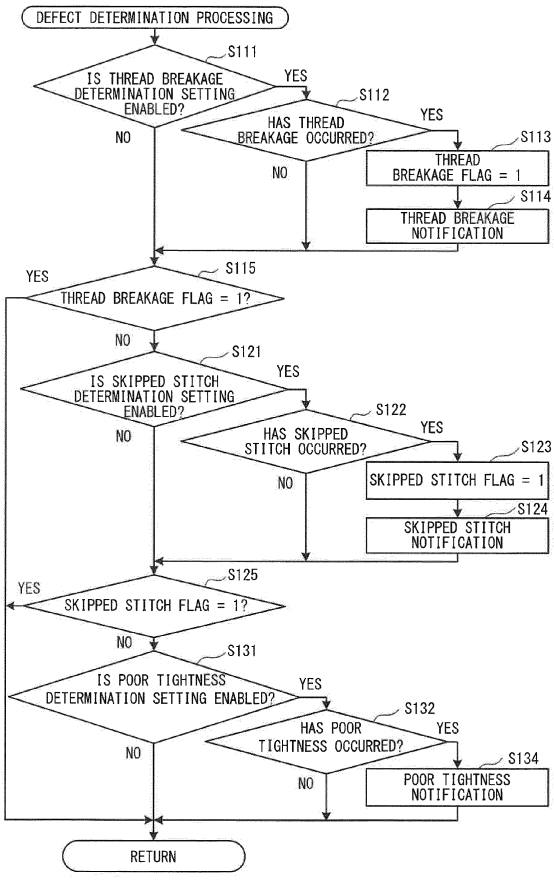
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(54) DEFECT DETERMINATION DEVICE

(57) The present invention relates to a defect determination device capable of more reliably distinguishing and determining the type of sewing defect that has occurred. A sewing machine 1 determines whether a sewing defect has occurred during the sewing of cloth. The sewing defect includes thread breakage in which an upper thread breaks, and a skipped stitch in which a shuttle 49 fails to pick up the upper thread 66. The sewing machine 1 has a detection threshold value for each of the thread breakage and the skipped stitch, and distinguishes and determines the occurrence of thread breakage and a skipped stitch. If it has been determined that thread breakage has occurred (YES at step S112), the sewing machine 1 will not determine whether a skipped stitch has occurred (YES at step S115).

FIG. 11



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Description

[0001] The present invention relates to a defect determination device.

[0002] Japanese Laid-Open Patent Publication No. 2019-201741 discloses a seam inspection device that detects an abnormality (skipped stitch, thread breakage, etc.) of a seam of an object to be sewn by a sewing machine. The seam inspection device includes a tension sensor that detects the tension of an upper thread, and calculates a detection characteristic amount and a reference characteristic amount from a detection value of the tension sensor. The detection characteristic amount indicates the actual characteristic amount of tension of the upper thread. The reference characteristic amount indicates the characteristic amount of tension of the upper thread when the seam of the object to be sewn is normal. When the rotation angle of a motor is between 270° and 360°, inclusive, the seam inspection device determines that a skipped stitch has occurred on the basis of the fact that the actual tension of the upper thread is smaller than the tension of the upper thread when the seam is normal. Also, when the rotation angle of the motor is between 0° and 90°, inclusive, the seam inspection device determines that thread breakage has occurred on the basis of the fact that the actual tension of the upper thread is smaller than the tension of the upper thread when the seam is normal.

SUMMARY

[0003] In the seam inspection device described above, when thread breakage has occurred, the actual tension of the upper thread is not generated over one cycle of rotation of the motor. That is, when thread breakage has occurred, the actual tension of the upper thread is smaller than the tension of the upper thread when a seam is normal, when the rotation angle of the motor is between 270° and 360°, inclusive. Therefore, there are times when the seam inspection device erroneously determines that a skipped stitch has occurred when thread breakage has occurred.

[0004] The present invention aims to provide a defect determination device capable of more reliably distinguishing and determining the type of sewing defect that has occurred.

[0005] One embodiment provides a defect determination device which includes a determination portion that is configured to determine an occurrence of a sewing defect including thread breakage and a skipped stitch, when sewing a cloth in a sewing machine provided with a needle bar and a shuttle. The needle bar moves up and down and has a sewing needle through which an upper thread is inserted attached thereto. The shuttle is provided below the needle bar and picks up the upper thread inserted through the sewing needle, forms a loop, and interlaces the looped upper thread with a lower thread, in synchronization with the up and down movement of the needle bar. The thread breakage is a defect in which the upper thread breaks, and the skipped stitch is a defect in which the shuttle fails to pick up the upper thread. The determination portion determines, for each type of sewing defect, whether the sewing defect has occurred, and does not determine whether the skipped stitch has occurred when it has been determined that the thread breakage has occurred. When the defect determination device has determined that thread breakage has occurred, the detect determination device will not determine whether a skipped stitch has occurred, so it is possible to inhibit the defect determination device from erroneously determining that a skipped stitch has occurred. Therefore, the defect determination device is able to more reliably distinguish and determine the type of sewing defect that has occurred.

[0006] In the defect determination device of the present invention, the determination portion may determine whether the thread breakage and the skipped stitch, in that order, have occurred. When thread breakage in which the upper thread breaks has occurred, a skipped stitch wherein the shuttle fails to pick up the upper thread will not occur. The defect determination device determines whether thread breakage or a skipped stitch, in that order, has occurred, so the defect determination device is able to more reliably distinguish and determine the type of sewing defect that has occurred.

[0007] In the defect determination device of the present invention, the determination portion may further determine whether poor tightness has occurred, and may not determine whether the poor tightness has occurred when it has been determined that the skipped stitch has occurred. The poor tightness is a defect in the balance between the upper thread and the lower thread that form a stitch. When the defect determination device has determined that a skipped stitch has occurred, the defect determination device will not determine whether poor tightness has occurred, so it is possible to inhibit the defect determination device from erroneously determining that poor tightness has occurred. Therefore, the defect determination device is able to more reliably distinguish and determine the type of sewing defect that has occurred.

[0008] In the defect determination device of the present invention, the determination portion may determine whether the thread breakage, the skipped stitch, and the poor tightness, in that order, have occurred. When thread breakage in which the upper thread breaks has occurred, the shuttle will not pick up the upper thread and form a seam, so a skipped stitch will not occur. Also, when a skipped stitch in which a seam is not formed due to the shuttle not picking up the upper thread occurs, poor tightness that occurs when a seam is formed will not occur. The defect determination device determines whether thread breakage, a skipped stitch, or poor tightness, in that order, has occurred, so the defect determination device is able to more reliably distinguish and determine the type of sewing defect that has occurred.

[0009] The defect determination device of the present

invention may further include an upper shaft angle acquisition portion and a tension acquisition portion. The upper shaft angle acquisition portion is configured to acquire an upper shaft angle that is a rotation angle phase of an upper shaft, and the tension acquisition portion is configured to acquire the tension of the upper thread. The sewing machine further includes a thread take-up lever that is configured to pull up the upper thread that the shuttle has interlaced with the lower thread and an upper shaft that is configured to move the needle bar and the thread take-up lever up and down by rotating. The determination portion may determine whether a sewing defect has occurred on the basis of the tension in a predetermined range of the upper shaft angle acquired by the upper shaft angle acquisition portion and the tension acquisition portion, at a predetermined timing from the end of a period during which the thread take-up lever pulls up the upper thread until the start of a period during which the shuttle picks up the upper thread. The defect determination device determines whether a defect has occurred on the basis of the tension of the upper thread in a predetermined range of the upper shaft angle, for both thread breakage and a skipped stitch. The timing at which a determination is made regarding thread breakage or a skipped stitch is after the end of the period when the thread take-up lever pulls up the upper thread, so it is possible to inhibit the defect determination device from erroneously determining that thread breakage or a skipped stitch has occurred. Therefore, the defect determination device is able to more reliably distinguish and determine the type of sewing defect that has occurred.

[0010] In the defect determination device of the present invention, the determination portion may further determine, at the predetermined timing, whether poor tightness has occurred, and may not determine whether the poor tightness has occurred if it has been determined that the skipped stitch has occurred. The poor tightness is a defect in the balance between the upper thread and the lower thread that forms a stitch. The defect determination device determines whether poor tightness has occurred on the basis of the tension of the upper thread in a predetermined range of the upper shaft angle. The predetermined timing is after the end of the period when the thread take-up lever pulls up the upper thread, so it is possible to inhibit the defect determination device from erroneously determining that thread breakage, a skipped stitch, or poor tightness has occurred. Therefore, the defect determination device is able to more reliably distinguish and determine the type of sewing defect that has occurred.

[0011] In the defect determination device of the present invention, the determination portion may determine, at the predetermined timing, whether the thread breakage, the skipped stitch, and the poor tightness defect, in that order, have occurred. When thread breakage has occurred, the shuttle will not pick up the upper thread and form a seam, so a skipped seam will not occur. Also, when a skipped seam has occurred, poor tightness will not occur. The defect determination device determines whether thread breakage, a skipped stitch, or poor tightness, in that order, has occurred, so the defect determination device is able to more reliably distinguish and determine the type of sewing defect that has occurred.

[0012] In the defect determination device of the present invention, when the up and down movement of the needle bar stops during a penetration period in which the sewing needle pierces the cloth and the sewing machine stops sewing, the predetermined timing may be a timing from the end of a period during which the thread take-up lever pulls up the upper thread until either the start of a period during which the shuttle picks up the upper thread or the sewing needle stops, whichever is earlier. When the sewing machine stops sewing during a penetration period, the defect determination device determines whether a sewing defect has occurred at a predetermined timing from the end of the period when the thread take-up lever pulls up the upper thread until either the start of the period when the shuttle picks up the upper thread or the sewing needle stops, whichever is earlier. Therefore, it is possible to inhibit the defect determination device from determining that a sewing defect has occurred, immediately after resuming sewing with the sewing machine, on the basis of the tension of the upper thread up until the previous sewing stopped.

[0013] The defect determination device of the present invention may be provided with a setting portion that individually sets whether the determination portion is to determine whether each type of sewing defect has occurred. The defect determination device can be set so as to not make a determination regarding a sewing defect deemed to be less important by the operator. The operator does not have to pay attention to less important sewing defects, so the defect determination device can suppress annoyance felt by the operator.

[0014] The defect determination device of the present invention may be provided with a notification portion that issues a notification that the sewing defect has occurred when it has been determined by the determination portion that the sewing defect has occurred. When the determination portion has determined that a sewing defect has occurred, the defect determination device issues, with the notification unit, a notification that a sewing defect has occurred. Therefore, the operator can easily understand that a sewing defect has occurred, and can quickly respond to the sewing defect.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Exemplary embodiments of the present invention will be described below in detail with reference to the accompanying drawings in which:

FIG. 1 is a perspective view of a sewing machine 1;
FIG. 2 is a partial enlarged view of a head portion 5;
FIG. 3 is a perspective view of a tension detection mechanism 18;

FIG. 4 is an electrical block diagram of the sewing machine 1;
FIG. 5 is a conceptual diagram illustrating the flow of a shuttle 49 picking up an upper thread 66;
FIG. 6 is a graph showing the relationship between upper thread tension, the vertical position of a needle tip, and upper shaft angle;
FIG. 7 is a graph showing the relationship between the upper thread tension, the vertical position of the needle tip, and the upper shaft angle when a skipped stitch occurs;
FIG. 8 is a graph showing the relationship between the upper thread tension, the vertical position of the needle tip, and the upper shaft angle when poor tightness occurs;
FIG. 9 is a flowchart of sewing processing;
FIG. 10 is a flowchart of sewing processing continuing from FIG. 9; and
FIG. 11 is a flowchart of defect determination processing.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

[0016] A sewing machine 1 according to one embodiment of the present invention will be described with reference to the drawings. In the description below, the left-right direction, front-rear direction, and up-down direction shown by the arrows in the drawings will be used.

[0017] The configuration of the sewing machine 1 will be described with reference to FIG. 1 to FIG. 3. As shown in FIG. 1, the sewing machine 1 includes a bed portion 2, a pillar portion 3, and an arm portion 4. The bed portion 2 includes a needle plate 7 on the upper surface thereof. The needle plate 7 has a needle hole 8 and feed dog holes 14 in generally the center. The feed dog holes 14 are provided to the left, rear, right, and front of the needle hole 8.

[0018] The pillar portion 3 extends upward from the right end of the bed portion 2. The arm portion 4 extends to the left from the upper end of the pillar portion 3, and faces the bed portion 2. The front surface of the arm portion 4 includes an input portion 24 and a display portion 25 in generally the center in the left-right direction. The input portion 24 is three buttons lined up in the up-down direction. The display portion 25 displays various information. An operator inputs various instructions by operating the input portion 24 while looking at the display portion 25. The arm portion 4 includes a spool pin 20 that protrudes upward on the left side of the upper surface. A thread spool from which the upper thread 66 (refer to FIG. 2) is reeled out is fitted on the spool pin 20.

[0019] The arm portion 4 includes therein an upper shaft 15 and a main motor 27 (refer to FIG. 4). The upper shaft 15 extends in the left-right direction and is connected to an output shaft of the main motor 27 via an upper shaft pulley. The upper shaft pulley is fixed to the right end portion of the upper shaft 15. The upper shaft 15 rotates under the power of the main motor 27. The left end portion of the arm portion 4 includes a head portion 5. The head portion 5 protrudes downward from the arm portion 4 and faces the needle plate 7 from above. The head portion 5 supports a needle bar 11 in a manner enabling the needle bar 11 to move up and down. The lower end portion of the needle bar 11 protrudes downward from the head portion 5. The needle bar 11 is connected to the upper shaft 15 via an up-down movement mechanism. The needle bar 11 moves up and down with the rotation of the upper shaft 15. A sewing needle 10 is mounted on the lower end of the needle bar 11. The sewing needle 10 holds the upper thread 66 that has been inserted through an eye 10A (refer to FIG. 5) of the sewing needle 10. The sewing needle 10 moves up and down together with the needle bar 11. The sewing needle 10 can pass through the needle hole 8. The upper end of the movable range of the sewing needle 10 is top dead center and the lower end of the movable range of the sewing needle 10 is bottom dead center.

[0020] The bed portion 2 includes therein a shuttle 49 (refer to FIG. 5), a thread cutting mechanism 17 (refer to FIG. 4), and a feed mechanism. The shuttle 49 is provided below the needle plate 7, and houses a bobbin around which a lower thread 67 (refer to FIG. 5) is wound. The shuttle 49 includes a hook 46 (refer to FIG. 5). The shuttle 49 rotates under the power of the main motor 27, and picks up, with the hook 46, the upper thread 66 that is inserted through the sewing needle 10, and interlaces the upper thread 66 with the lower thread 67.

[0021] The thread cutting mechanism 17 includes a fixed blade, a movable blade, and a solenoid 17A (refer to FIG. 4). The movable blade is connected to the solenoid 17A. The movable blade moves with respect to the fixed blade by the driving of the solenoid 17A. The thread cutting mechanism 17 cuts the upper thread 66 and the lower thread 67 with the combination of the movable blade and the fixed blade.

[0022] The feed mechanism includes a feed dog 13 and a feed motor 28 (refer to FIG. 4). The feed dog 13 is provided below the needle plate 7. The feed dog 13 moves in the front-rear direction under the power of the feed motor 28, and moves in the up-down direction under the power of the main motor 27. At this time, the feed dog 13 appears in the feed dog holes 14. The feed dog 13 feeds cloth 69 by moving in the front-rear direction while protruding upwards from the feed dog holes 14.

[0023] As shown in FIG. 2, the head portion 5 includes, in order from the upstream side of the supply path of the upper thread 66 that runs from the thread spool to the sewing needle 10, an auxiliary thread tensioner 26, a main thread tensioner 22, a thread guide 21, a tension detection mechanism 18, a thread take-up lever 23, and a guide hook 29.

[0024] The auxiliary thread tensioner 26 is provided on the upper right portion of the front surface of the head portion 5. The main thread tensioner 22 is provided below the auxiliary thread tensioner 26. Both the auxiliary

thread tensioner 26 and the main thread tensioner 22 apply tension to the upper thread 66. The main thread tensioner 22 is provided with a thread tensioning motor 16 (refer to FIG. 4), and applies tension to the upper thread 66 by driving the thread tensioning motor 16. The main thread tensioner 22 optimizes the tension (hereinafter, referred to as the "upper thread tension") applied to the upper thread 66 in accordance with the sewing by the sewing machine 1. The thread guide 21 is provided to the left of the main thread tensioner 22. The thread guide 21 guides the upper thread 66 via the main thread tensioner 22 by folding the upper thread 66 back toward the tension detection mechanism 18 and the thread take-up lever 23.

[0025] The tension detection mechanism 18 is provided in a recess 5A that is recessed toward the rear from the front surface of the head portion 5. The tension detection mechanism 18 is located at a vertical position between the auxiliary thread tensioner 26 and the main thread tensioner 22. The tension detection mechanism 18 can detect the upper thread tension. The tension detection mechanism 18 will be described later. The thread take-up lever 23 is provided to the left of the auxiliary thread tensioner 26. The thread take-up lever 23 has an insertion hole 23A through which the upper thread 66 is inserted. The thread take-up lever 23 moves up and down with the driving of the main motor 27. The guide hook 29 is provided to the left of the tension detection mechanism 18. The guide hook 29 guides the upper thread 66 that has passed through the insertion hole 23A of the thread take-up lever 23 toward the needle bar 11.

[0026] As shown in FIG. 3, the tension detection mechanism 18 includes an attachment base 51, a holding portion 52, a magnetic sensor 53, a plate 54, a guide member 55, and a magnet 56. The attachment base 51 has an attaching portion 57 and a base portion 59. The attaching portion 57 and the base portion 59 are integrally formed. The attaching portion 57 has a long hole 58 through which a screw is inserted. The screw that is inserted through the long hole 58 is fastened to a screw hole provided in the recess 5A. The base portion 59 is on the left side of the attachment base 51. The base portion 59 includes a left protruding portion 60 and a right protruding portion 61. Both the left protruding portion 60 and the right protruding portion 61 have a rectangular parallelepiped shape that extends in the front-rear direction.

[0027] The holding portion 52 is formed in a substantially rectangular parallelepiped shape, and is attached to the base portion 59 between the left protruding portion 60 and the right protruding portion 61. The holding portion 52 is a non-magnetic body. The magnetic sensor 53 is held on the front surface of the holding portion 52. The magnetic sensor 53 is a Hall element. The magnetic sensor 53 is located to farther to the rear than the front ends of both the left protruding portion 60 and the right protruding portion 61.

[0028] The plate 54 has a plate shape having a thickness in the front-rear direction, and extends between the left protruding portion 60 and the right protruding portion 61. The guide member 55 is attached to the left protruding portion 60 and the right protruding portion 61. The left end portion of the plate 54 is sandwiched between the guide member 55 and the left protruding portion 60, and the right end portion of the plate 54 is sandwiched between the guide member 55 and the right protruding portion 61. There is a gap between the center portion, in the right-left-right direction, of the plate 54 and the front surface of the holding portion 52. Therefore, the plate 54 flexes in the front-rear direction with both end portions in the left-right direction as fulcrums.

[0029] The magnet 56 is formed in a cylindrical shape that extends in the front-rear direction. The magnet 56 is fixed to the rear surface of the center portion of the plate 54 in the left-right direction. When the plate 54 flexes in the front-rear direction, the magnet 56 moves back and forth such that the distance between the magnet 56 and the magnetic sensor 53 changes. The magnetic sensor 53 detects the change in the magnetic flux density from the magnet 56, and outputs a voltage corresponding to the magnetic flux density.

[0030] The guide member 55 includes an upper guide groove 63 and a lower guide groove 65. The upper guide groove 63 and the lower guide groove 65 are arranged in the vertical direction with the plate 54 in between. The upper guide groove 63 and the lower guide groove 65 are both open in the up-down direction and are formed a hook shape. The upper guide groove 63 has an upper retaining hole 62 and the lower guide groove 65 has a lower retaining hole 64. The upper retaining hole 62 and the lower retaining hole 64 are both through-holes that are open in the up-down direction. The upper thread 66 is inserted through both the upper retaining hole 62 and the lower retaining hole 64. The upper thread 66 that is between the upper retaining hole 62 and the lower retaining hole 64 contacts the plate 54 from the front. As the upper thread tension increases, the upper thread 66 urges the plate 54 rearward. The magnetic sensor 53 outputs a voltage corresponding to the front-rear position of the plate 54 that flexes in the front-rear direction from the upper thread tension. The sewing machine 1 can acquire the upper thread tension from the output voltage of the magnetic sensor 53.

[0031] As shown in FIG. 2, the head portion 5 further includes a head portion amp 70. The head portion amp 70 is provided on the upper surface of the rear portion of the head portion 5. A thread breakage LED 71, a skipped stitch LED 72, and a poor tightness LED 73 are provided, in order from the right, on the front surface of the upper portion of the head portion amp 70. The thread breakage LED 71, the skipped stitch LED 72, and the poor tightness LED 73 can each emit light. The thread breakage LED 71 emits light when thread breakage has occurred. The skipped stitch LED 71 emits light when a skipped stitch has occurred. The poor tightness LED 71 emits light when poor tightness has occurred. Thread breakage, a skipped stitch, and poor tightness are each a type of sewing de-

fect. These sewing defects will be described in detail later.

[0032] The electrical configuration of the sewing machine 1 will be described with reference to FIG. 4. A control device 90 of the sewing machine 1 includes a CPU 91, ROM 92, RAM 93, a storage device 94, an I/O interface (hereinafter, referred to as "I/O") 95, and drive circuits 81 to 86. The CPU 91 is connected to each of the ROM 92, the RAM 93, the storage device 94, and the I/O 95. The CPU 91 controls the sewing machine 1. The CPU 91 executes processing such as sewing processing (refer to FIG. 9), which will be described later, and various calculations, in accordance with various programs. The ROM 92 stores various programs, various initial setting parameters, and detection threshold values that will be described later, etc. The RAM 93 temporarily stores the calculation results from the CPU 91 and a counter, etc. The storage device 94 stores various setting information and the like that has been input by an operator.

[0033] The I/O 95 is connected to each of the drive circuits 81 to 86, the input portion 24, a pedal 38, and the magnetic sensor 53. The drive circuit 81 is connected to the main motor 27. The main motor 27 includes an encoder 27A. The encoder 27A detects the rotational position of the output shaft of the main motor 27. That is, the detection result of the encoder 27A indicates the upper shaft angle that is the rotation angle phase of the upper shaft 15. The encoder 27A transmits the detection result to the CPU 91 via the I/O 95. The drive circuit 82 is connected to the feed motor 28. The drive circuit 83 is connected to the thread tensioning motor 16. Hereinafter, the main motor 27, the feed motor 28, and the thread tensioning motor 16 will collectively be referred to as "drive portions". The CPU 91 controls the drive portions via the drive circuits 81 to 83.

[0034] The drive circuit 84 is connected to the thread cutting mechanism 17. The CPU 91 controls the solenoid 17A of the thread cutting mechanism 17 via the drive circuit 84. The drive circuit 85 is connected to the display unit 25. The CPU 91 controls the display unit 25 via the drive circuit 85. The drive circuit 86 is connected to the head portion amp 70. The CPU 91 controls each of the thread breakage LED 71, the skipped stitch LED 72, and the poor tightness LED 73 via the drive circuit 86.

[0035] The input portion 24 outputs various instructions input by the operator to the CPU 91. The pedal 38 outputs, to the CPU 91, the detection results for both the operating direction and the operating amount from an operation of the pedal 38 by the operator. The magnetic sensor 53 outputs an output voltage indicative of the upper thread tension to the CPU 91.

[0036] An outline of the operation of the sewing machine 1 will be described with reference to FIG. 1 and FIG. 5. The operator places the cloth 69 on the needle plate 7. The main motor 27 is driven by the operator operating the pedal 38 in a predetermined direction. The upper shaft 15 rotates, thereby moving the needle bar 11 and the thread take-up lever 23 up and down, with the driving of the main motor 27. The shuttle 49 rotates in synchronization with the rotation of the upper shaft 15.

[0037] The sewing needle 10 that descends together with the needle bar 11 penetrates the cloth 69 and passes through the needle hole 8. The upper thread 66 that is near the eye 10A that has descended below the needle hole 8 forms a loop (refer to FIG. 5A). As the shuttle 49 rotates clockwise in a front view, the hook 46 picks up the looped upper thread 66 (refer to FIG. 5B). Hereinafter, the period during which the hook 46 picks up the looped upper thread 66 will be referred to as the "shuttle pick-up period". The sewing needle 10 rises toward above the cloth 69 and the shuttle 49 rotates again in the clockwise direction in a front view. The hook 46 pulls the looped upper thread 66 in the direction of rotation such that the loop of the looped upper thread 66 expands in diameter.

[0038] When the looped upper thread 66 passes through the shuttle 49 (refer to FIG. 5C), the upper thread 66 becomes interlaced with the lower thread 67. The rotational direction of the shuttle 49 then switches to counterclockwise in a front view. At this time, the thread take-up lever 23 pulls up the upper thread 66 that is interlaced with the lower thread 67 (refer to FIG. 5D. Hereinafter, the period during which the thread take-up lever 23 pulls up the upper thread 66 will be referred to as the "thread take-up lever pull-up period". The diameter of the loop of the looped upper thread 66 is thereby reduced, and the sewing machine 1 completes the sewing of one stitch. In the present embodiment, the sewing machine 1 sews one stitch each time the upper shaft 15 rotates once. The sewing machine 1 forms a plurality of stitches 68 in the cloth 69 by repeating this operation.

[0039] The main motor 27 stops being driven when the operator stops operating the pedal 38 in the predetermined direction. At this time, the sewing needle 10 stops at bottom dead center and thus has penetrated through the cloth 69.

[0040] The sewing defects of the sewing machine 1 will now be described. A sewing defect indicates that a proper stitch 68 was not able to be formed during a sewing operation. Sewing defects include thread breakage, a skipped stitch, and poor tightness. Thread breakage is a defect wherein the upper thread 66 breaks during sewing, such that a stitch 68 cannot be formed in the cloth 69. A skipped stitch is a defect wherein the shuttle 49 fails to pick up the upper thread 66 during sewing, and as a result, the upper thread 66 does not become interlaced with the lower thread 67 such that a proper stitch 68 cannot be formed in the cloth 69. Poor tightness is a defect in the balance between the upper thread 66 and the lower thread 67 that form the stitch 68 in the cloth 69 when the thread take-up lever 23 pulls up the upper thread 66. For example, if the upper thread 66 becomes interlaced too tightly with the lower thread 67, the cloth 69 near the stitch 68 will pucker. The sewing machine 1 stores detection references corresponding to each of thread breakage, a skipped stitch, and poor tightness as detection threshold values in the storage device 94. Therefore,

the sewing machine 1 can identify the type of sewing defect.

[0041] A change in the upper thread tension when a sewing defect has occurred will now be described with reference to FIG. 6 to FIG. 8. The CPU 91 acquires the upper thread tension by the detection result of the magnetic sensor 53 and the upper shaft angle by the detection result of the encoder 27A. As shown in FIG. 6, during sewing, the upper thread tension and the height of the lower end (needle tip) of the sewing needle 10 change periodically, with a sewing period as the unit cycle, in accordance with the upper shaft angle. The sewing period is the period for sewing one stitch. Hereinafter, the upper thread tension that changes periodically will be referred to as variable tension.

[0042] During the sewing period for one stitch (one cycle) with top dead center of the sewing needle 10 as the reference (upper shaft angle of 0°), the thread take-up lever pull-up period, the determination period, and the shuttle pick-up period occur in this order. During the thread take-up lever pull-up period, the first peak of the variable tension during the sewing period occurs. During the shuttle pick-up period, the second peak of the variable tension during the sewing period occurs. The determination period is a period from the end of the thread take-up lever pull-up period until the start of the shuttle pick-up period. The CPU 91 determines the thread take-up lever pull-up period, the determination period, and the shuttle pick-up period from the upper shaft angle by the detection result of the encoder 27A.

[0043] The variable tension when thread breakage has occurred will now be described. Although not shown in the drawings, when thread breakage has occurred, the upper thread tension becomes extremely small over the sewing period for one cycle. The storage device 94 stores the detection threshold value for thread breakage. If the upper thread tension during the thread take-up lever pull-up period falls equal to or below the thread breakage detection threshold value, the CPU 91 determines that thread breakage has occurred.

[0044] The variable tension when a skipped stitch has occurred will now be described. As shown in FIG. 7, when a skipped stitch has occurred, the variable tension during the thread take-up lever pull-up period does not change significantly from what it is normally, but the variable tension during the shuttle pick-up period becomes much smaller than it is normally. The storage device 94 stores the detection threshold value for a skipped stitch. If the upper thread tension during the shuttle pick-up period falls equal to or below the skipped stitch detection threshold value, the CPU 91 determines that a skipped stitch has occurred.

[0045] The variable tension when poor tightness has occurred will now be described. As shown in FIG. 8, when poor tightness has occurred, the variable tension during the thread take-up lever pull-up period is different from what it was in the previous cycle. The phase and magnitude of the upper thread tension during the thread take-up lever pull-up period during an Nth cycle of sewing (where N is an integer of 2 or more) when poor tightness has occurred change with respect to the phase and magnitude of the upper thread tension during the thread take-up lever pull-up period during an N-1 cycle of sewing where poor tightness has not occurred. The storage device 94 stores the detection threshold value for poor tightness. If the difference between a phase G1 and a phase G2 during the thread take-up lever pull-up period becomes equal to or greater than the poor tightness detection threshold value, the CPU 91 determines that poor tightness has occurred. The phase G1 is a phase where the upper thread tension during the Nth cycle of sewing starts to increase. The phase G2 is a phase where the upper thread tension during the N-1 cycle of sewing starts to increase.

[0046] The vertical axis on the right side in FIG. 6 indicates the height of the lower end of the sewing needle 10 with the upper surface of the needle plate 7 as the reference. When the upper shaft angle is H1 and H2, the lower end of the sewing needle 10 is at a position that is at the same height as the upper surface of the cloth 69 placed on the upper surface of the needle plate 7. That is, the period when the upper shaft angle is from H1 to H2 is a penetration period during which the sewing needle 10 pierces the cloth 69. The period during which the upper shaft angle is less than H1 and the period during which the upper shaft angle is greater than H2 are non-penetration periods where the sewing needle 10 is above the cloth 69.

[0047] The determination of an occurrence of a sewing defect by the CPU 91 will now be described. The CPU 91 determines whether thread breakage, a skipped stitch, or poor tightness has occurred at a predetermined timing during the determination period. In the present embodiment, the predetermined timing is a timing when the upper shaft angle is 200°. Hereinafter, the upper shaft angle of 200° will be referred to as the "determination angle". The CPU 91 constantly acquires the variable tension during sewing, and determines, when the upper shaft angle has reached the determination angle, whether thread breakage, a skipped stitch, or poor tightness, in that order, has occurred.

[0048] When the sewing machine 1 stops sewing, the sewing needle 10 stops at bottom dead center (upper shaft angle of 180°). At this time, the CPU 91 determines whether there is thread breakage, a skipped stitch, or poor tightness, in that order, at a timing when the upper shaft angle is 170° which is before the sewing machine 1 stops sewing, within the determination period. Hereinafter, the upper shaft angle of 170° will be referred to as the "end determination angle".

[0049] When the CPU 91 has determined that thread breakage has occurred, the CPU 91 will not determine whether a skipped stitch or poor tightness has occurred. When the CPU 91 has determined that a skipped stitch has occurred, the CPU 91 will not determine whether poor tightness has occurred.

[0050] The sewing processing of the sewing machine 1 will be described with reference to FIG. 9 to FIG. 11. When the operator turns the power supply of the sewing machine 1 on, the CPU 91 reads a program from the ROM 92 and starts sewing processing.

[0051] Flags used by the CPU 91 in the sewing processing will now be described.

[0052] The RAM 93 stores a thread breakage flag and a skipped stitch flag, and the like. When the CPU 91 has determined that thread breakage has occurred, the thread breakage flag is set to a value of 1. When the CPU 91 has determined that a skipped stitch has occurred, the skipped stitch flag is set to a value of 1.

[0053] As shown in FIG. 9, the CPU 91 executes initialization processing (step S1). The CPU 91 sets both the thread breakage flag and the skipped stitch flag stored in the RAM 93 to 0. The CPU 91 sets each of a thread breakage determination setting, a skipped stitch determination setting, and a poor tightness determination setting, which will be described later, to enabled. If any of a thread breakage notification, a skipped stitch notification, or a poor tightness notification, which will be described later, is being issued, the CPU 91 ends the notification.

[0054] The CPU 91 determines whether a thread breakage setting signal has been received from the input portion 24 (step S11). The thread breakage determination setting can be set to either enabled or disabled. When the thread breakage determination setting is enabled, the CPU 91 determines whether thread breakage has occurred. When the thread breakage determination setting is disabled, the CPU 91 will not determine whether thread breakage has occurred. The operator operates the input portion 24 when setting the thread breakage determination setting. At this time, the input portion 24 outputs a thread breakage determination setting signal to the CPU 91. If the CPU 91 determines that a thread breakage determination setting signal has not been received from the input portion 24 (NO at step S11), the processing moves on to step S21. If the CPU 91 determines that a thread breakage determination setting signal has been received from the input portion 24 (YES at step S11), the CPU 91 determines whether the thread breakage determination setting is enabled (step S12). If the thread breakage determination setting is enabled (YES at step S12), the CPU 91 sets the thread breakage determination setting to enabled (step S13), and the processing moves on to step S21. If the thread breakage determination setting is disabled (NO at step S12), the CPU 91 sets the thread breakage determination setting to disabled (step S14), and the processing moves on to step S21.

[0055] The CPU 91 determines whether a skipped stitch determination setting signal has been received from the input portion 24 (step S21). The skipped stitch determination setting can be set to either enabled or disabled. When the skipped stitch determination setting is enabled, the CPU 91 determines whether a skipped stitch has occurred. When the skipped stitch determination setting is disabled, the CPU 91 will not determine whether a skipped stitch has occurred. The operator operates the input portion 24 when setting the skipped stitch determination setting. At this time, the input portion 24 outputs a skipped stitch determination setting signal to the CPU 91. If the CPU 91 determines that a skipped stitch determination setting signal has not been received from the input portion 24 (NO at step S21), the processing moves on to step S31. If the CPU 91 determines that a skipped stitch determination setting signal has been received from the input portion 24 (YES at step S21), the CPU 91 determines whether the skipped stitch determination setting is enabled (step S22). If the skipped stitch determination setting is enabled (YES at step S22), the CPU 91 sets the skipped stitch determination setting to enabled (step S23), and the processing moves on to step S31. If the skipped stitch determination setting is disabled (NO at step S22), the CPU 91 sets the skipped stitch determination setting to disabled (step S24), and the processing moves on to step S31.

[0056] The CPU 91 determines whether a poor tightness determination setting signal has been received from the input portion 24 (step S31). The poor tightness determination setting can be set to either enabled or disabled. When the poor tightness determination setting is enabled, the CPU 91 determines whether poor tightness has occurred. When the poor tightness determination setting is disabled, the CPU 91 will not determine whether poor tightness has occurred. The operator operates the input portion 24 when setting the poor tightness determination setting. At this time, the input portion 24 outputs a poor tightness determination setting signal to the CPU 91. If the CPU 91 determines that a poor tightness determination setting signal has not been received from the input portion 24 (NO at step S31), the processing moves on to step S41. If the CPU 91 determines that a poor tightness determination setting signal has been received from the input portion 24 (YES at step S31), the CPU 91 determines whether the poor tightness determination setting is enabled (step S32). If the poor tightness determination setting is enabled (YES at step S32), the CPU 91 sets the poor tightness determination setting to enabled (step S33), and the processing moves on to step S41. If the poor tightness determination setting is disabled (NO at step S32), the CPU 91 sets the poor tightness determination setting to disabled (step S34), and the processing moves on to step S41.

[0057] The CPU 91 determines whether to start sewing on the basis of the detection result of the pedal 38 (step S41). When the operator is not operating the pedal 38 in a predetermined direction, the pedal 38 outputs an OFF signal. When the CPU 91 receives an OFF signal from the pedal 38, the CPU 91 determines that sewing will not start (NO in step S41), and the processing returns to step S11. The operator places the cloth 69 on the needle plate 7. When the operator operates the pedal 38 in the predetermined direction after placing the cloth 69 on the nee-

dle plate 7, the pedal 38 outputs an ON signal. When the CPU 91 receives the ON signal from the pedal 38, the CPU 91 determines that a sewing operation will start (YES at step S41), and the processing moves on to step S42 (refer to FIG. 10).

[0058] As shown in FIG. 10, the CPU 91 starts driving the drive portions (step S42). The sewing machine 1 forms the stitches 68 in the cloth 69 by the sewing needle 10 moving up and down together with the needle bar 11, and the shuttle 49 rotating in synchronization with the up-and-down movement of the needle bar 11. The CPU 91 acquires the upper shaft angle on the basis of the detection result of the encoder 27A. The CPU 91 acquires the upper thread tension on the basis of the detection result of the magnetic sensor 53. The CPU 91 then associates the acquired upper shaft angle with the upper thread tension and stores them in the RAM 93 as the variable tension (step S51).

[0059] The CPU 91 determines whether the upper shaft angle is the determination angle on the basis of the detection result of the encoder 27A (step S61). If the upper shaft angle is not the determination angle (NO at step S61), the CPU 91 determines whether to end sewing on the basis of the detection result of the pedal 38 (step S71). When the CPU 91 receives an ON signal from the pedal 38, the CPU 91 makes a determination not to end sewing (NO at step S71) and the processing returns to step S51.

[0060] The CPU 91 repeatedly executes steps S51 to S71. If the upper shaft angle is the determination angle (YES at step S61), the CPU 91 executes defect determination processing (step S62).

[0061] The defect determination processing will now be described with reference to FIG. 11. The CPU 91 determines whether the thread breakage determination setting is enabled (step S111). When the thread breakage determination setting is enabled (YES at step S111), the CPU 91 determines whether thread breakage has occurred (step S112). The CPU 91 determines that thread breakage has occurred when the upper thread tension during the thread take-up lever pull-up period becomes equal to or less than the thread breakage detection threshold value stored in the storage device 94. If the CPU 91 determines that thread breakage has not occurred (NO at step S112), the CPU 91 moves the processing to step S115. If the CPU 91 determines that thread breakage has occurred (YES at step S112), the CPU91 sets the value of the thread breakage flag to 1 (step S113), issues a thread breakage notification by illuminating the thread breakage LED 71 (S114), and moves the processing to step S115. When the thread breakage determination setting is disabled (NO at step S111), the CPU 91 will not determine whether thread breakage has occurred, and the processing moves on to step S115.

[0062] The CPU 91 determines whether the value of the thread breakage flag is 1 (step S115). If thread breakage has occurred such that the value of the thread breakage flag is 1 (YES at step S115), the CPU 91 returns the processing to the sewing processing without determining whether a skipped stitch or poor tightness has occurred (refer to FIG. 10).

[0063] If thread breakage has not occurred such that the value of the thread breakage flag is 0 (NO at step S115), the CPU 91 determines whether the skipped stitch determination setting is enabled (step S121). If the skipped stitch determination setting is enabled (YES at step S121), the CPU 91 determines whether a skipped stitch has occurred (step S122). The CPU 91 determines that a skipped stitch has occurred when the upper thread tension during the shuttle pick-up period becomes equal to or less than the skipped stitch detection threshold value stored in the storage device 94. If the CPU 91 determines that a skipped stitch has not occurred (NO at step S122), the CPU 91 moves the processing to step S125. If the CPU 91 determines that a skipped stitch has occurred (YES at step S122), the CPU 91 sets the value of the skipped stitch flag to 1 (step S123), issues a skipped stitch notification by illuminating the skipped stitch LED 72 (step S124), and moves the processing on to step S125. If the skipped stitch determination setting is disabled (NO at step S121), the CPU 91 moves the processing on to step S125 without determining whether a skipped stitch has occurred.

[0064] The CPU 91 determines whether the value of the skipped stitch flag is 1 (step S125). If a skipped stitch has occurred such that the value of the skipped stitch flag is 1 (YES at step S125), the CPU 91 returns the processing to the sewing processing without determining whether poor tightness has occurred.

[0065] If a skipped stich has not occurred such that the value of the skipped stitch flag is 0 (NO at step S125), the CPU 91 determines whether the poor tightness determination setting is enabled (step S131). If the poor tightness determination setting is enabled (YES at step S131), the CPU 91 determines whether poor tightness has occurred (step S132). If the difference between a phase G1 and a phase G2 during the thread take-up lever pull-up period is equal to or greater than the poor tightness detection threshold value, the CPU 91 determines that the poor tightness stored in the storage device 94 has occurred. The phase G1 is a phase where the upper thread tension during the Nth cycle of sewing starts to increase. The phase G2 is a phase where the upper thread tension during the N-1 cycle of sewing starts to increase. If the CPU 91 determines that poor tightness has not occurred (NO at step S132), the CPU 91 returns the processing to the sewing processing. If the CPU 91 determines that poor tightness has occurred (YES at step S132), the CPU 91 issues a poor tightness notification by illuminating the poor tightness LED 73 (step S134), and returns the processing to the sewing processing. If the poor tightness determination setting is disabled (NO at step S131), the CPU 91 returns the processing to the sewing processing without determining whether poor tightness has occurred.

[0066] As shown in FIG. 10, when the CPU 91 receives an OFF signal from the pedal 38, the CPU 91 determines that sewing will end (YES at step S71). The sewing machine 1 drives the drive portions until the sewing needle 10 moves to bottom dead center. The CPU 91 associates the upper shaft angle with the upper thread tension and stores them in the RAM 93 as the variable tension (step S81), just as in step S51. The CPU 91 determines whether the upper shaft angle is the end determination angle (step S91). If the upper shaft angle is not the end determination angle (NO at step S91), the CPU 91 returns the processing to step S81, and repeats the execution of steps S81 and S91. If the upper shaft angle is the end determination angle (YES at step S91), the CPU 91 executes defect determination processing (step S92). The defect determination processing executed by the CPU 91 at step S92 is the same processing as the defect determination processing executed by the CPU 91 at step S62, so a description thereof will be omitted.

[0067] The CPU 91 determines whether the sewing needle 10 has moved to bottom dead center (step S101). Before the sewing needle 10 moves to bottom dead center (NO at step S101), the CPU 91 is on stand-by. When the sewing needle 10 has moved to bottom dead center (YES at step S101), the CPU 91 controls the solenoid 17A to cut the thread (step S102). The CPU 91 stops driving the drive portions (step S103). The sewing machine 1 ends sewing.

[0068] The CPU 91 determines whether there is an operation to turn the power supply of the sewing machine 1 off (step S104). If the CPU 91 determines that there is no operation to turn the power supply of the sewing machine 1 off (NO at step S104), the CPU 91 returns the processing to step S 1 (refer to FIG. 9). The operator places an unsewn cloth 69 on the sewing plate 7 in place of the sewn cloth 69, and operates the pedal 38 (YES at step S41). If the CPU 91 determines that there is an operation to turn the power supply of the sewing machine 1 off (YES at step S104), the CPU 91 ends the sewing processing.

[0069] As described above, in the sewing machine 1 that determines whether thread breakage or a skipped stitch has occurred, the CPU 91 distinguishes and determines whether thread breakage or a skipped stitch has occurred from the detection threshold value stored in the storage device 94. If the CPU 91 determines that thread breakage has occurred (YES at step S112), the CPU 91 will not determine whether a skipped stitch has occurred (YES at step S 115). When it is determined that a skipped stitch has occurred, the determination of whether a skipped stitch has occurred will not be made, so the sewing machine 1 is able to inhibit an erroneous determination that a skipped stitch has occurred from being made. Therefore, the sewing machine 1 is able to more reliably distinguish and determine the type of sewing defect that has occurred.

[0070] The CPU 91 determines whether thread breakage (step S 112) or a skipped stitch (step S 122), in this order, has occurred. When thread breakage in which the upper thread 66 breaks occurs, a skipped stitch in which the shuttle 49 fails to pick up the upper thread 66 will not occur. The sewing machine 1 determines whether thread breakage or a skipped stitch, in this order, occurs, and thus is able to inhibit an erroneous determination that a skipped stitch has occurred from being made. Therefore, the sewing machine 1 is able to more reliably distinguish and determine the type of sewing defect that has occurred.

[0071] The CPU 91 further distinguishes and determines whether poor tightness has occurred from the detection threshold value stored in the storage device 94. If the CPU 91 determines that a skipped stitch has occurred (YES at step S122), the CPU 91 will not determine whether poor tightness has occurred (YES at step S 125). When it has been determined that a skipped stitch has occurred, the sewing machine 1 will not determine whether poor tightness has occurred, and is thus able to inhibit an erroneous determination that poor tightness has occurred from being made. Therefore, the sewing machine 1 is able to more reliably distinguish and determine the type of sewing defect that has occurred.

[0072] The CPU 91 determines whether thread breakage (step S 112), a skipped stitch (step S122), or poor tightness (step S132), in that order, has occurred. When thread breakage has occurred, a skipped stitch will not occur. Also, when a skipped stitch in which the stitch 68 is not formed due to the upper thread 66 not becoming interlaced with the lower thread 67 occurs, poor tightness that occurs when the stitch 68 is formed will not occur. The sewing machine 1 determines whether thread breakage, a skipped stitch, or poor tightness, in that order, has occurred, so the sewing machine 1 is able to more reliably distinguish and determine the type of sewing defect that has occurred.

[0073] The sewing machine 1 includes the encoder 27A and the magnetic sensor 53. The CPU 91 acquires the upper shaft angle on the basis of the detection result of the encoder 27A. The CPU 91 acquires the upper thread tension on the basis of the detection result of the magnetic sensor 53. The CPU 91 associates the upper shaft angle with the upper thread tension and stores them as the variable tension in the RAM 93 (steps S51 and S81). The CPU 91 determines whether thread breakage or a skipped stitch has occurred on the basis of the variable tension in a predetermined range of the upper shaft angle (for example, in the case of thread breakage, on the basis of the upper thread tension during the thread take-up lever pull-up period). The CPU 91 determines whether thread breakage or a skipped stitch has occurred, at the timing when the upper shaft angle reaches the determination angle (upper shaft angle of 200°) during the determination period. The sewing machine 1 determines whether thread breakage or a skipped stitch has occurred on the basis of the variable tension in a predetermined range of the upper shaft angle. The sewing machine 1 determines that thread breakage or a

skipped stitch has occurred, at a predetermined timing during the determination period from the end of the thread take-up lever pull-up period until the start of the shuttle pick-up period. The sewing machine 1 makes the determination after the thread take-up lever pull-up period has ended, so it is possible to inhibit an erroneous determination that thread breakage or a skipped stitch has occurred from being made. Therefore, the sewing machine 1 is able to more reliably distinguish and determine the type of sewing defect that has occurred.

[0074] The CPU 91 further determines whether poor tightness has occurred on the basis of the variable tension in a predetermined range of the upper shaft angle, at the timing when the upper shaft angle reaches a determination angle. When the CPU 91 determines whether a skipped stitch has occurred (YES at step S122), the CPU 91 will not determine that poor tightness has occurred (YES at step S125). The sewing machine 1 determines whether poor tightness has occurred on the basis of the upper thread tension in a predetermined range of the upper shaft angle. The sewing machine 1 further determines that poor tightness has occurred at a predetermined timing during the determination period from the end of the thread take-up lever pull-up period until the start of the shuttle pick-up period. The sewing machine 1 makes the determination after the end of the thread take-up lever pull-up period, so the sewing machine 1 can inhibit an erroneous determination that thread breakage, a skipped stitch, or poor tightness has occurred from being made. Therefore, the sewing machine 1 is able to more reliably distinguish and determine the type of sewing defect that has occurred.

[0075] The CPU 91 determines whether thread breakage (step S112), a skipped stitch (step S122), or poor tightness (step S132), in this order, have occurred at the timing when the upper shaft angle reaches the determination angle. If thread breakage has occurred, a skipped stitch will not occur. Also, if a skipped stitch has occurred, poor tightness will not occur. The sewing machine 1 determines whether thread breakage, a skipped stitch, or poor tightness, in this order, has occurred, so the sewing machine 1 can more reliably distinguish and determine the type of sewing defect that has occurred.

[0076] When sewing ends, the sewing needle 10 stops at bottom dead center (upper shaft angle of 180°) which is during the penetration period, so the sewing needle 10 has penetrated through the cloth 69. When sewing ends, the CPU 91 determines whether a sewing defect has occurred at the timing when the upper shaft angle reaches the end determination angle (upper shaft angle of 170°). The end determination angle is the upper shaft angle before the sewing needle 10 stops during the determination period. Therefore, the sewing machine 1 is able to inhibit a determination that a sewing defect has occurred from being made, immediately after resuming sewing, on the basis of the variable tension up until the previous sewing stopped.

[0077] The sewing machine 1 individually sets whether to determine whether each of thread breakage (steps S13 and S14), a skipped stitch (steps S23 and S24), and poor tightness (steps S33 and S34) has occurred. The sewing machine 1 can be set so as to not make a determination regarding a sewing defect deemed to be less important by the operator. Because the operator does not have to pay attention to less important sewing defects, the sewing machine 1 can suppress annoyance felt by the operator.

[0078] When thread breakage has occurred (YES at step S112), the CPU 91 executes thread breakage notification by illuminating the thread breakage LED 71 of the head portion amp 70 (step S114). When a skipped stitch has occurred (YES at step S122), the CPU 91 executes skipped thread notification by illuminating the skipped thread LED 72 of the head portion amp 70 (step S124). When poor tightness has occurred (YES at step S132), the CPU 91 executes poor tightness notification by illuminating the poor tightness LED 73 of the head portion amp 70 (step S134). When the sewing machine 1 has determined that a sewing defect has occurred, the sewing machine 1 issues a notification that a sewing defect has occurred using the head portion amp 70. Therefore, the operator can easily understand that a sewing defect has occurred, and can quickly respond to the sewing defect.

[0079] In the embodiment described above, the sewing machine 1 is one example of the sewing machine and the defect determination device of the present invention. The CPU 91 is one example of the determination portion of the present invention. The CPU 91 that acquires the defect result from the encoder 27A at steps S51 and S81 is one example of the upper shaft angle acquisition portion of the present invention. The CPU 91 that acquires the detection result from the magnetic sensor 53 at steps S51 and S81 is one example of the tension acquisition portion of the present invention. The determination angle and the end determination angle are examples of the predetermined timing of the present invention. The thread take-up lever pull-up period and the shuttle pick-up period are examples of the predetermined range. The CPU 91 that executes steps S13, S14, S23, S24, S33, and S34 is one example of the setting portion of the present invention. The CPU 91 that executes steps S114, S124, and S134 is one example of the notification portion of the present invention.

[0080] Aside from the foregoing embodiment, the present invention may be modified as follows, for example. The CPU 91 that determines a sewing defect may be provided in a separate device from the sewing machine 1, and the determination of whether a sewing defect of the sewing machine 1 has occurred may be determined by this device. At this time, the device including the CPU 91 that determines a sewing defect is one example of the defect determination device of the present invention.

[0081] The CPU 91 may determine whether a sewing defect has occurred by the movement amount of the upper thread 66. At this time, an encoder for detecting the

rotational position of an output shaft of the thread tensioning motor 16 is preferably provided for the CPU 91 to acquire the movement amount of the upper thread 66.

[0082] The CPU 91 may determine whether a sewing defect has occurred, at a predetermined timing during the determination period, which is different from the determination angle. The CPU 91 may determine whether a sewing defect has occurred, at a plurality of timings during the determination period. When it has been determined that a sewing defect has occurred, the CPU 91 may stop the drive portions and end sewing in accordance with the type of sewing defect that has occurred.

[0083] The sewing needle 10 does not have to be at bottom dead center when sewing ends. If the sewing needle 10 stops during a period when the penetration period and the shuttle pick-up period overlap, the CPU 91 determines whether a sewing defect has occurred, before the shuttle pick-up period starts. When sewing will end, the CPU 91 does not have to determine whether a sewing defect has occurred after it has been determined that sewing will end (YES at step S71). At this time, steps S81 to S92 of the sewing processing may be omitted.

[0084] The structure and number of devices of the sewing machine 1 may be modified as appropriate. The sewing machine 1 need not be provided with the thread cutting mechanism 17, the input portion 24, the display portion 25, the pedal 38, or the head portion amp 70, etc. If the pedal 38 is not provided, the sewing machine 1 may start or stop sewing in accordance with the operation of a switch, for example. The CPU 91 may issue a notification that a sewing defect has occurred using a speaker. The sewing machine 1 may feed the cloth 69 by a feed device that sandwiches the cloth 69 and moves in a horizontal direction, instead of by the feed mechanism that includes the feed dog 13 and the feed motor 28. The upper shaft angle and the upper thread tension may be detected by an optical sensor or the like.

[0085] A program that includes instructions for the CPU 91 to execute the processing shown in FIG. 9 to FIG. 11 need simply be stored in a storage device of the sewing machine 1 until the CPU 91 executes the program. Therefore, the program acquisition method, acquisition path, and device that stores the program may be changed as appropriate. The program executed by the CPU 91 may be received from another device via a cable or wireless communication, and be stored in a storage device such as nonvolatile memory. The other device is, for example, a PC or a server that connects to the sewing machine 1 via a network, for example.

[0086] The steps in the processing shown in FIG. 9 to FIG. 11 are not limited to the example in which they are executed by the CPU 91; another device (an ASIC, for example) may execute some or all of these steps. The steps in the processing shown in FIG. 9 to FIG. 11 may be divided up and processed by a plurality of electronic devices (a plurality of CPUs, for example). The order of the steps in the processing shown in FIG. 9 to FIG. 11 may be modified, as appropriate, or steps may be omitted or added, as appropriate. Some or all of the steps in the processing shown in FIG. 9 to FIG. 11 may be performed by an operating system (OS) or the like running on the sewing machine 1 in accordance with instructions from the CPU 91.

[0087] The CPU 91 may omit some or all of steps S11 to S34. When an operator cuts the thread, the CPU 91 may omit step S102. The CPU 91 may also omit some or all of steps S114, S124, and S134. The various numerical values given in the embodiment are merely examples and may be changed as appropriate.

Claims

1. A defect determination device (1) comprising:

   a determination portion (91) configured to determine an occurrence of a sewing defect including thread breakage and a skipped stitch, when sewing a cloth in a sewing machine (1) provided with a needle bar (11) and a shuttle (49),
   the needle bar moving up and down and having a sewing needle (10) through which an upper thread (66) is inserted attached thereto;
   the shuttle being provided below the needle bar (11) and picking up the upper thread (66) inserted through the sewing needle (10) and forming a loop, and interlacing the looped upper thread (66) with a lower thread (67), in synchronization with the up and down movement of the needle bar (11);
   the thread breakage being a defect in which the upper thread (66) breaks;
   the skipped stitch being a defect in which the shuttle (49) fails to pick up the upper thread (66); and
   the determination portion (91) determining, for each type of sewing defect, whether the sewing defect has occurred, and not determining whether the skipped stitch has occurred when it has been determined that the thread breakage has occurred.

2. The defect determination device (1) according to claim 1, wherein
   the determination portion (91) determines whether the thread breakage and the skipped stitch, in that order, have occurred.

3. The defect determination device (1) according to claim 1 or 2, wherein
   the determination portion (91) further determines whether poor tightness has occurred, and does not determine whether the poor tightness has occurred when it has been determined that the skipped stitch has occurred, the poor tightness being a defect in the balance between the upper thread (66) and the

lower thread (67) that form a stitch.

4. The defect determination device (1) according to claim 3, wherein
the determination portion (91) determines whether the thread breakage, the skipped stitch, and the poor tightness, in that order, have occurred.

5. The defect determination device (1) according to claim 1 or 2, further comprising:

an upper shaft angle acquisition portion configured to acquire an upper shaft angle that is a rotation angle phase of an upper shaft (15); and
a tension acquisition portion (91) configured to acquire the tension of the upper thread (66), wherein
the sewing machine (1) further includes a thread take-up lever (23) configured to pull up the upper thread (66) that the shuttle (49) has interlaced with the lower thread (67), and an upper shaft (15) configured to move the needle bar (11) and the thread take-up lever (23) up and down by rotating; and
the determination portion (91)

determines whether a sewing defect has occurred on the basis of the tension in a predetermined range of the upper shaft angle acquired by the upper shaft angle acquisition portion (91) and the tension acquisition portion (91),
at a predetermined timing from the end of a period during which the thread take-up lever (23) pulls up the upper thread (66) until the start of a period during which the shuttle (49) picks up the upper thread (66).

6. The defect determination device (1) according to claim 5, wherein
the determination portion (91) further determines, at the predetermined timing, whether poor tightness, which is a defect in the balance between the upper thread (66) and the lower thread (67) that forms a stitch, has occurred, and does not determine whether the poor tightness has occurred if it has been determined that the skipped stitch has occurred.

7. The detect determination device (1) according to claim 6, wherein
the determination portion (91) determines, at the predetermined timing, whether the thread breakage, the skipped stitch, and the poor tightness defect, in that order, have occurred.

8. The defect determination device (1) according to any one of claims 5 to 7, wherein
when the up and down movement of the needle bar (11) stops during a penetration period in which the sewing needle (10) pierces the cloth and the sewing machine (1) stops sewing,
the predetermined timing is a timing from the end of a period during which the thread take-up lever (23) pulls up the upper thread (66) until either the start of a period during which the shuttle (49) picks up the upper thread (66) or the sewing needle (10) stops, whichever is earlier.

9. The defect determination device (1) according to any one of claims 1 to 8, further comprising:
a setting portion (91) that individually sets whether the determination portion is to determine whether each type of sewing defect has occurred.

10. The defect determination device (1) according to any one of claims 1 to 9, further comprising:
a notification portion (91) that issues a notification that the sewing defect has occurred when it has been determined by the determination portion that the sewing defect has occurred.

FIG. 1

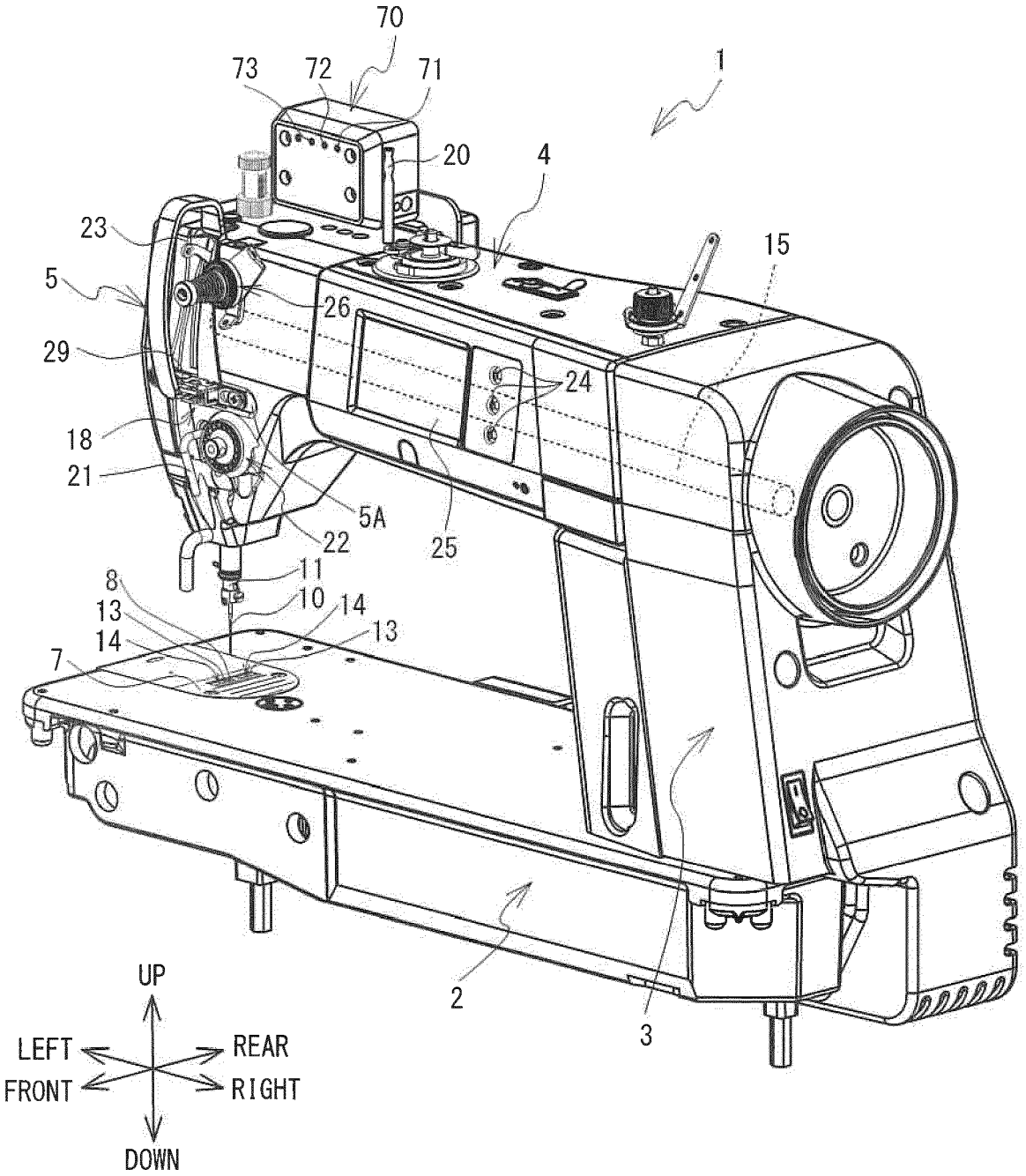

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FIG. 2

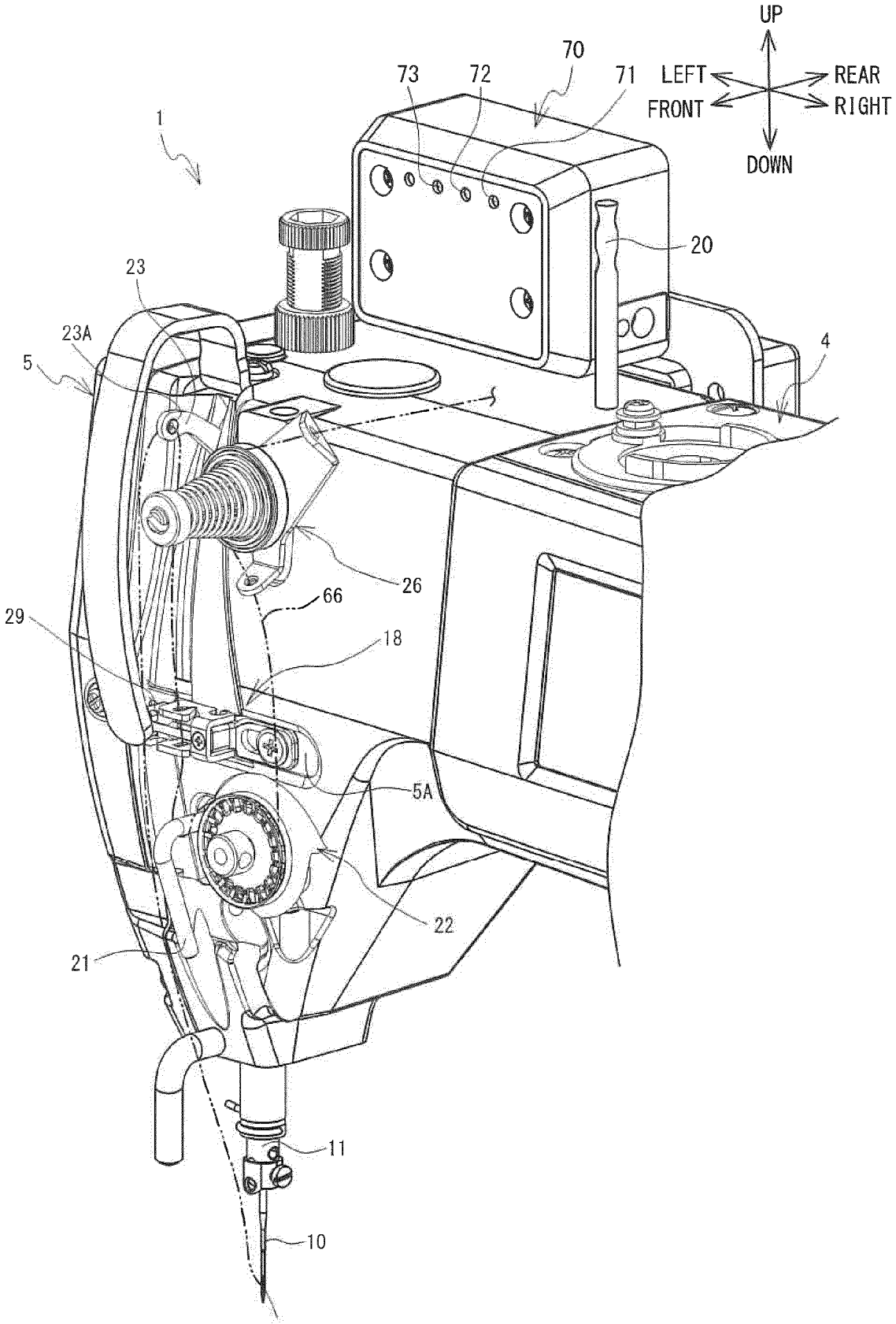

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FIG. 3

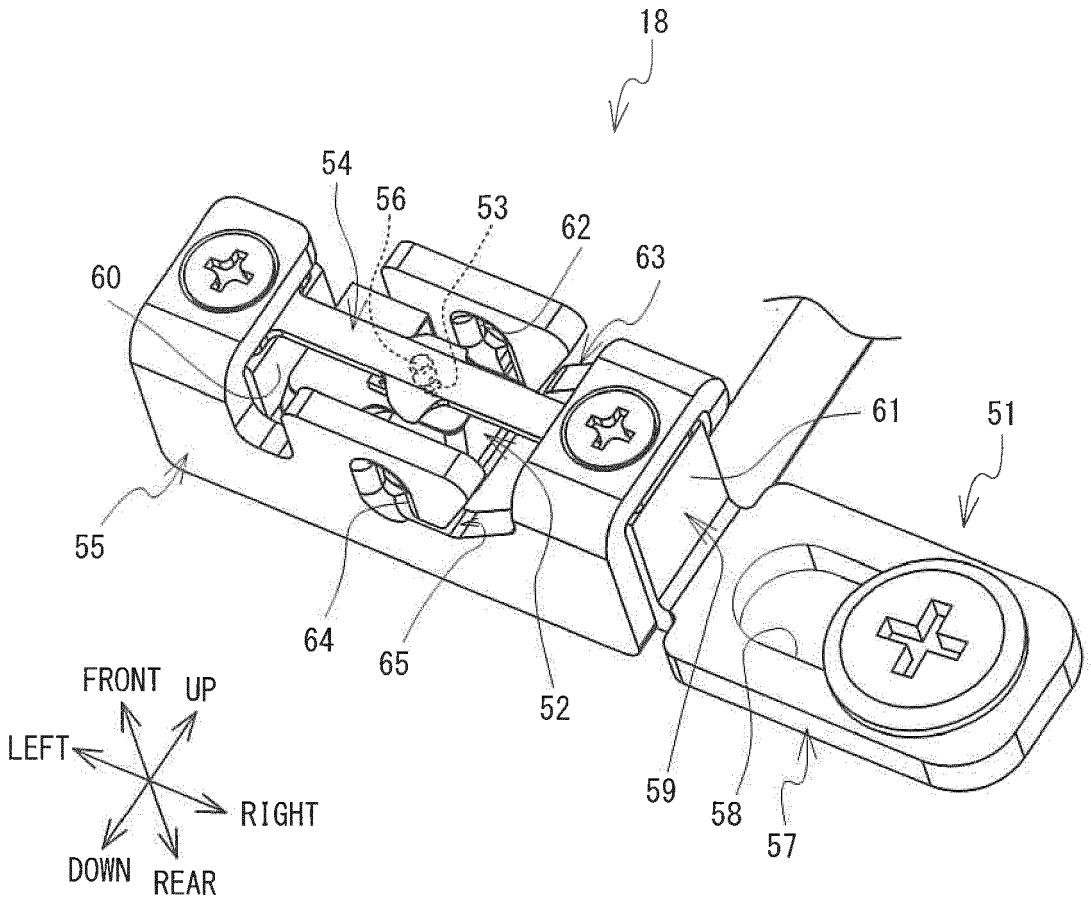

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REAR

FIG. 4

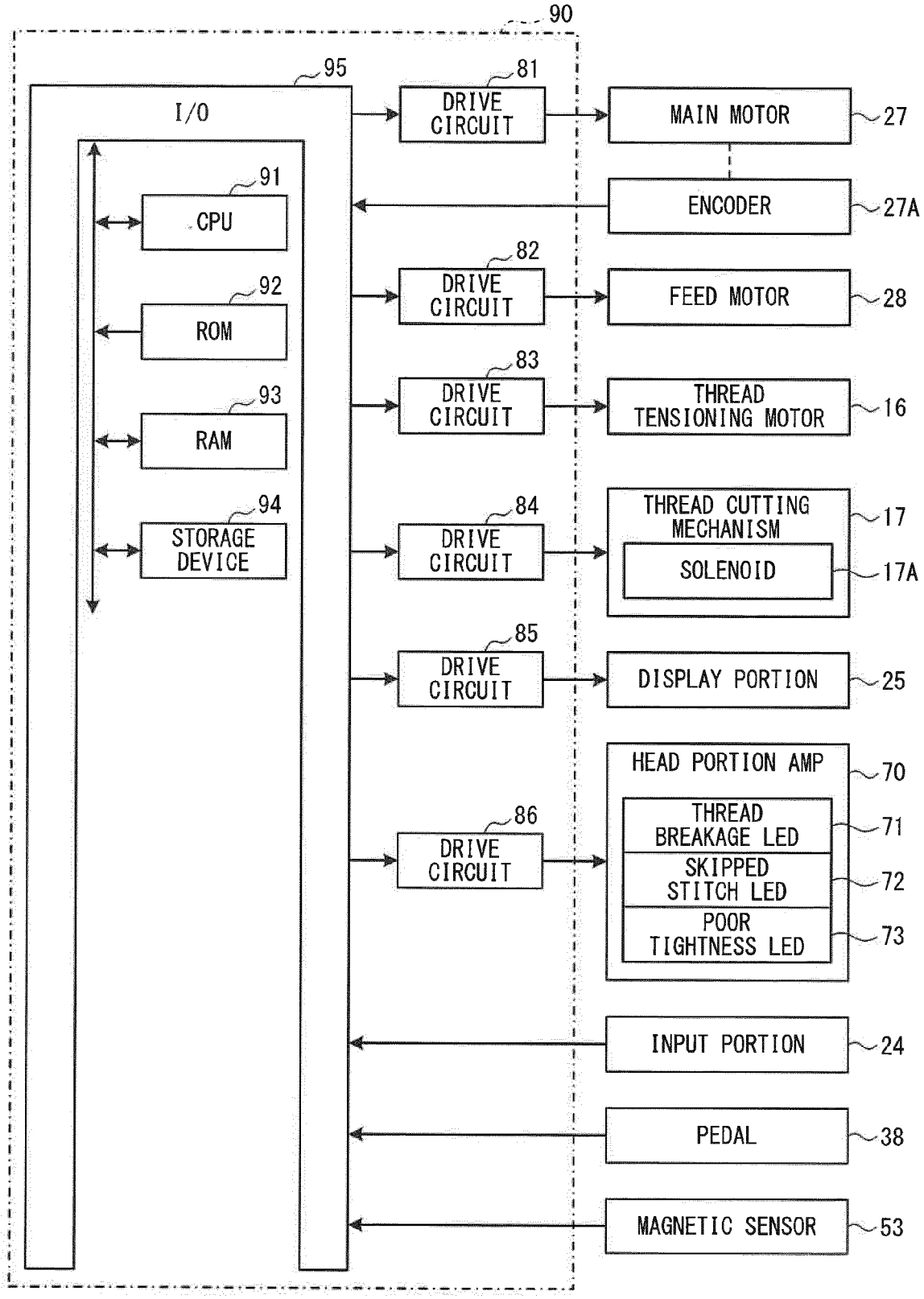

90
95
I/O
91
CPU
92
ROM
93
RAM
94
STORAGE DEVICE
81
DRIVE CIRCUIT
MAIN MOTOR
27
ENCODER
27A
82
DRIVE CIRCUIT
FEED MOTOR
28
83
DRIVE CIRCUIT
THREAD TENSIONING MOTOR
16
84
DRIVE CIRCUIT
THREAD CUTTING MECHANISM
17
SOLENOID
17A
85
DRIVE CIRCUIT
DISPLAY PORTION
25
HEAD PORTION AMP
70
86
DRIVE CIRCUIT
THREAD BREAKAGE LED
71
SKIPPED STITCH LED
72
POOR TIGHTNESS LED
73
INPUT PORTION
24
PEDAL
38
MAGNETIC SENSOR
53

FIG. 5A

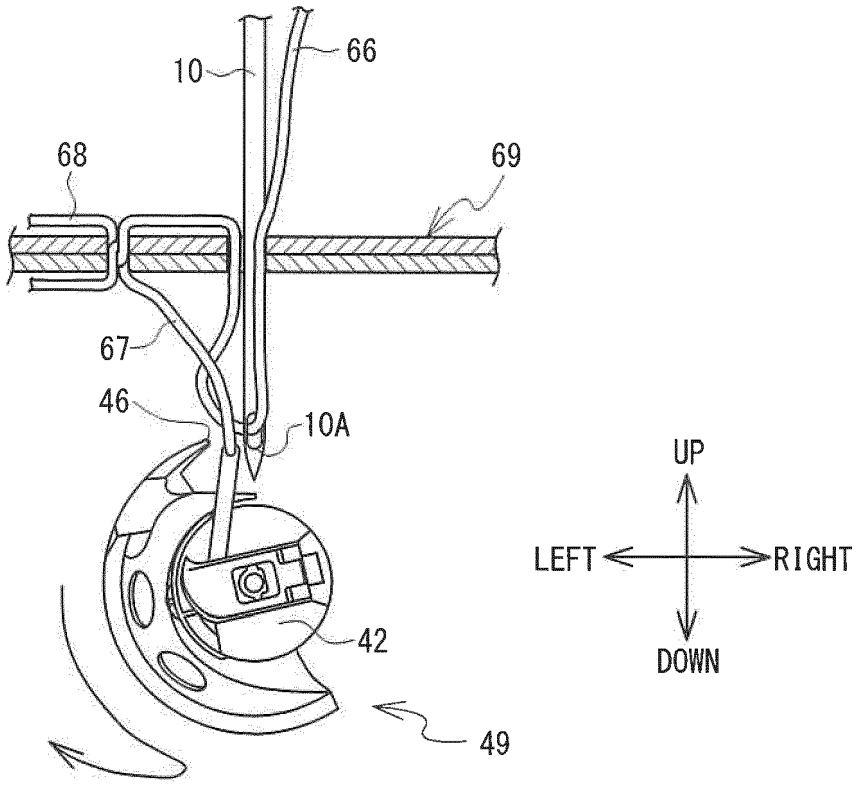


FIG. 5B

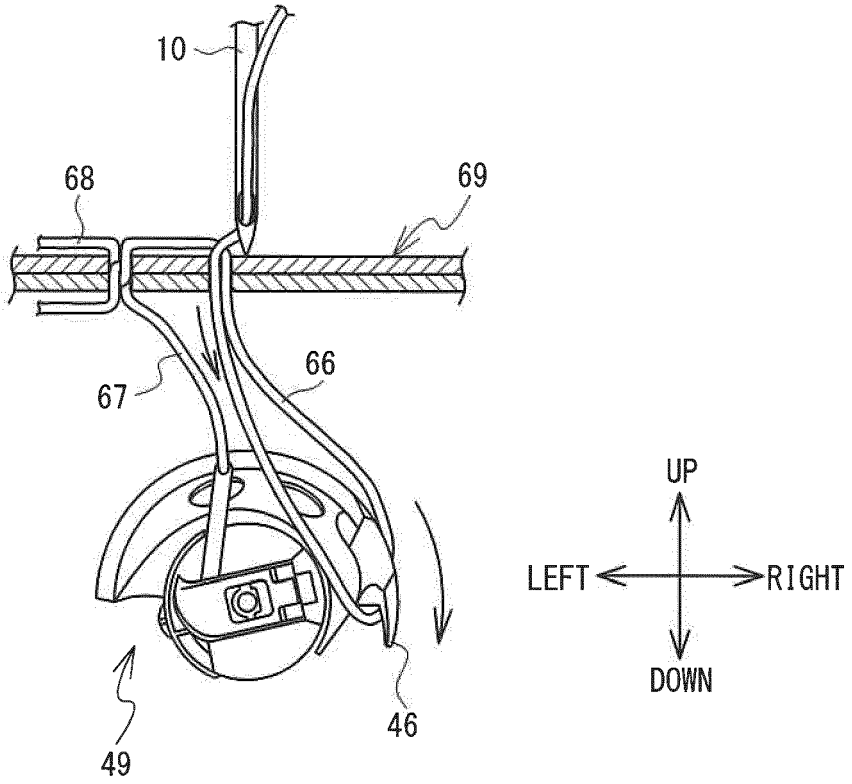


FIG. 5C

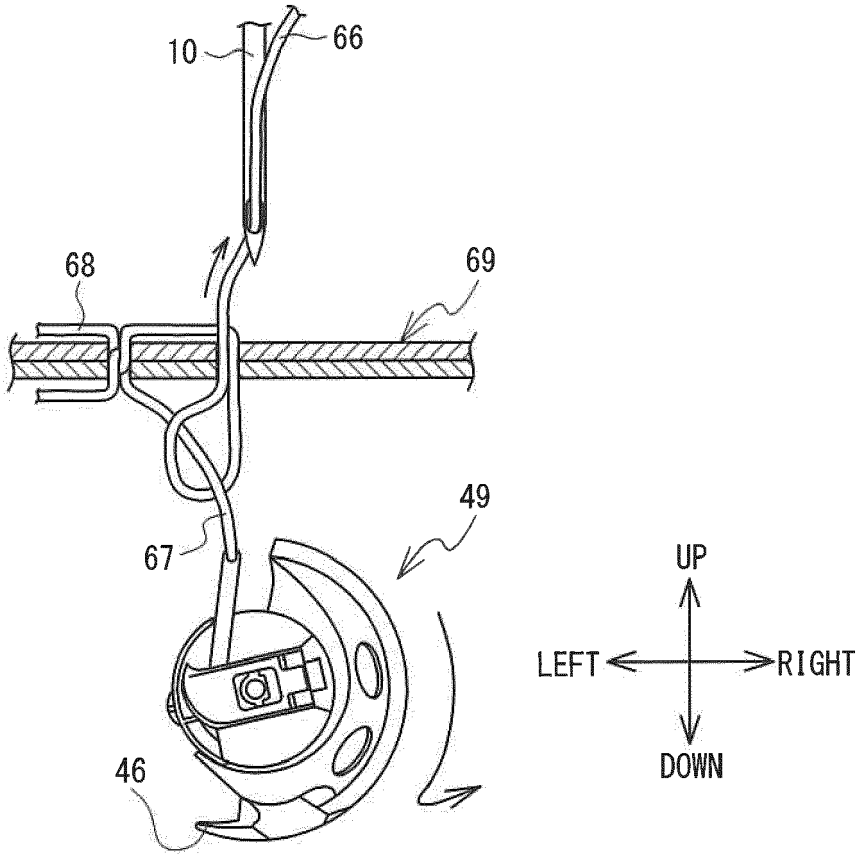


FIG. 5D

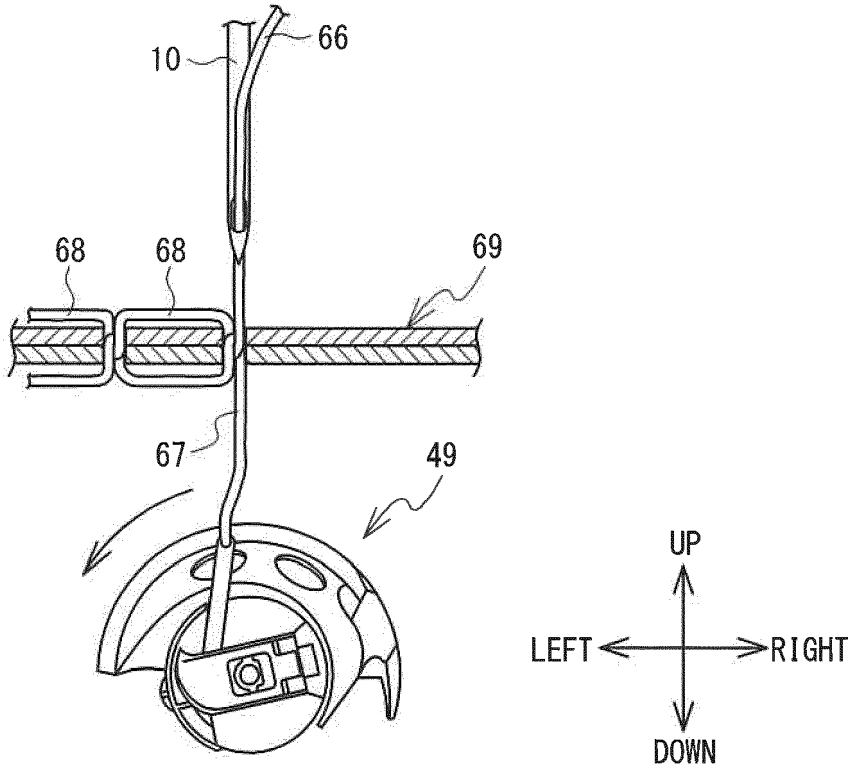


FIG. 6

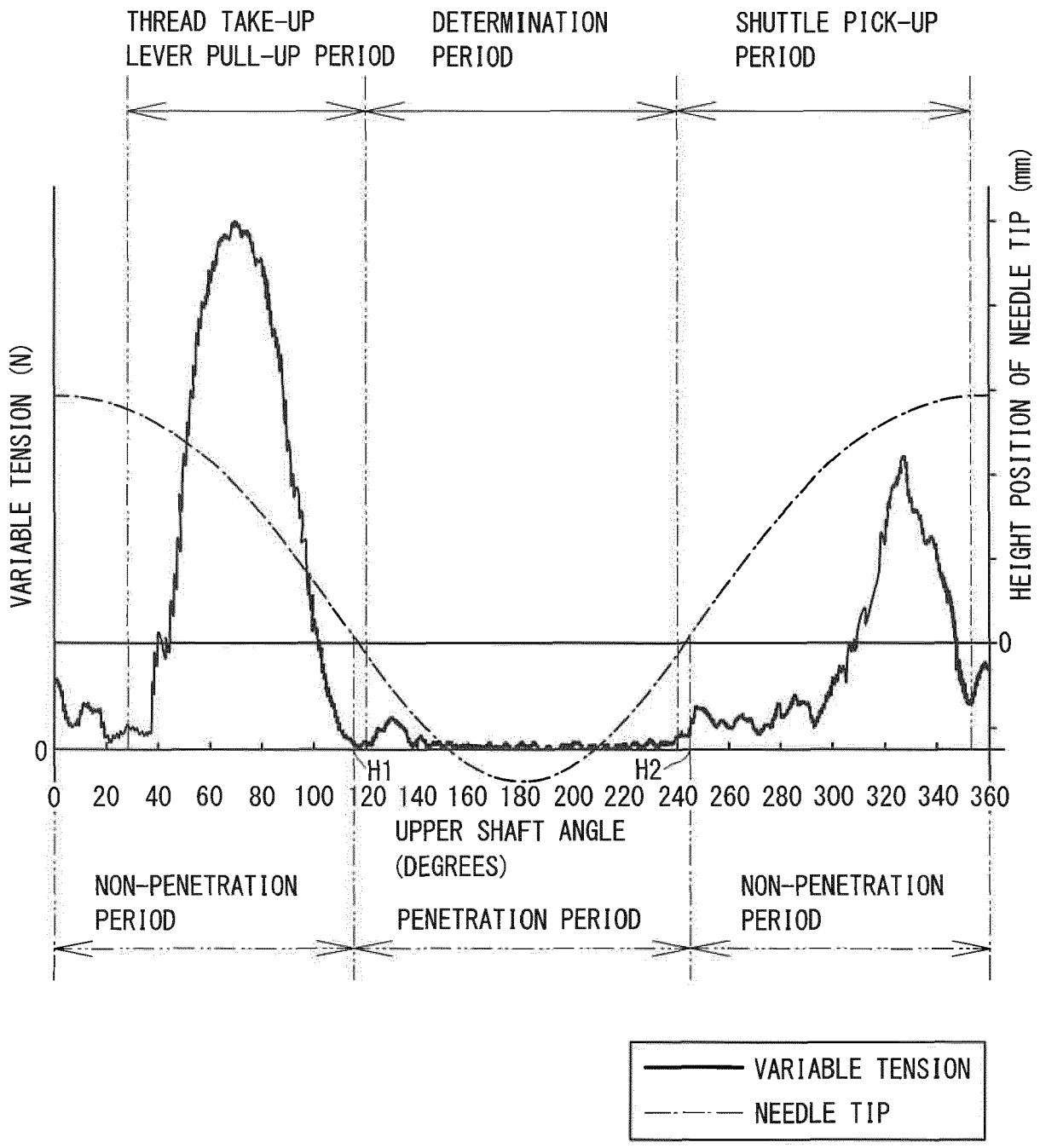

THREAD TAKE-UP LEVER PULL-UP PERIOD
DETERMINATION PERIOD
SHUTTLE PICK-UP PERIOD
VARIABLE TENSION (N)
HEIGHT POSITION OF NEEDLE TIP (mm)
0
0
H1
H2
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360
UPPER SHAFT ANGLE (DEGREES)
NON-PENETRATION PERIOD
PENETRATION PERIOD
NON-PENETRATION PERIOD
VARIABLE TENSION
NEEDLE TIP

FIG. 7

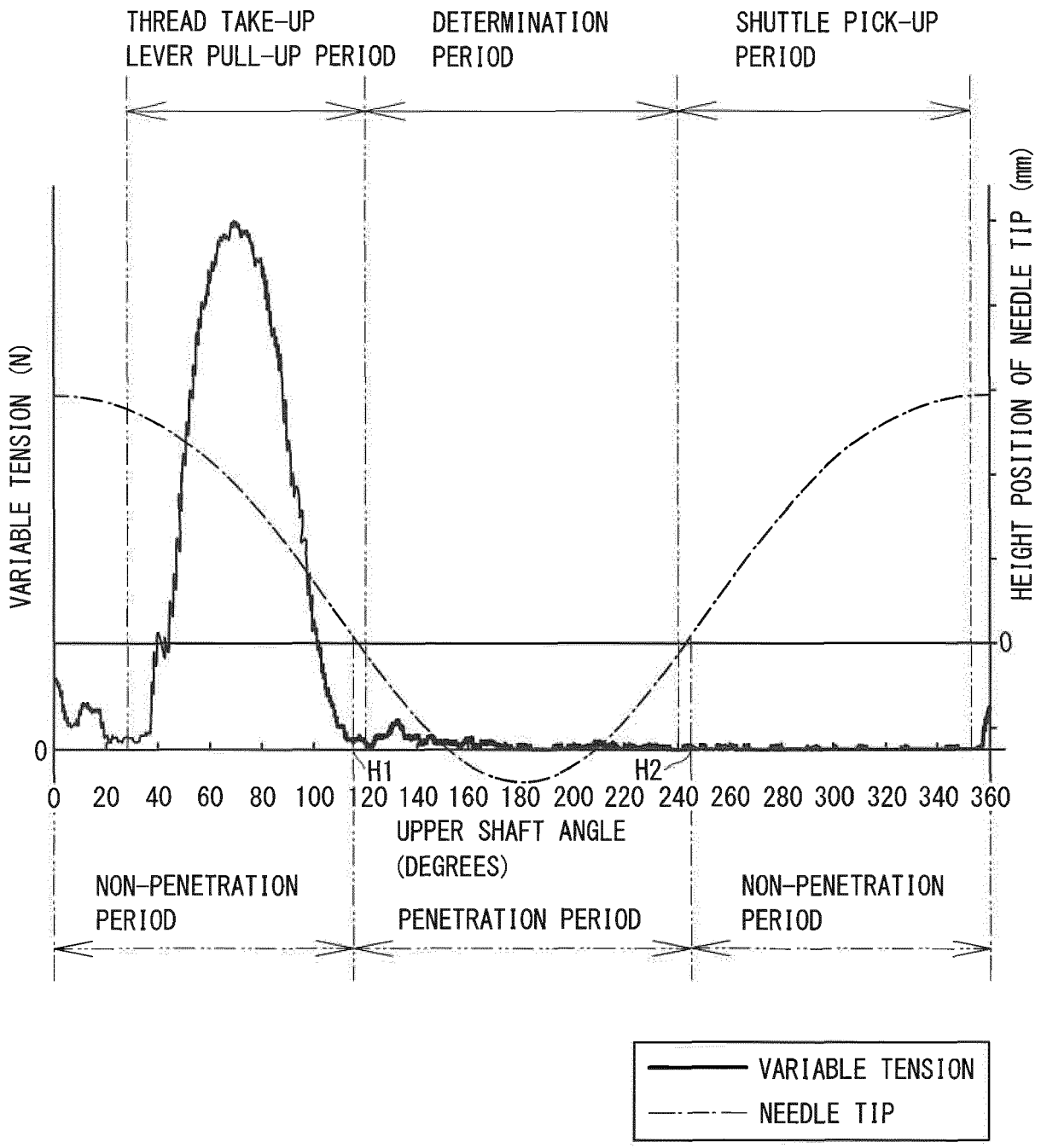

THREAD TAKE-UP LEVER PULL-UP PERIOD
DETERMINATION PERIOD
SHUTTLE PICK-UP PERIOD
VARIABLE TENSION (N)
HEIGHT POSITION OF NEEDLE TIP (mm)
0
0
H1
H2
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360
UPPER SHAFT ANGLE (DEGREES)
NON-PENETRATION PERIOD
PENETRATION PERIOD
NON-PENETRATION PERIOD
VARIABLE TENSION
NEEDLE TIP

FIG. 8

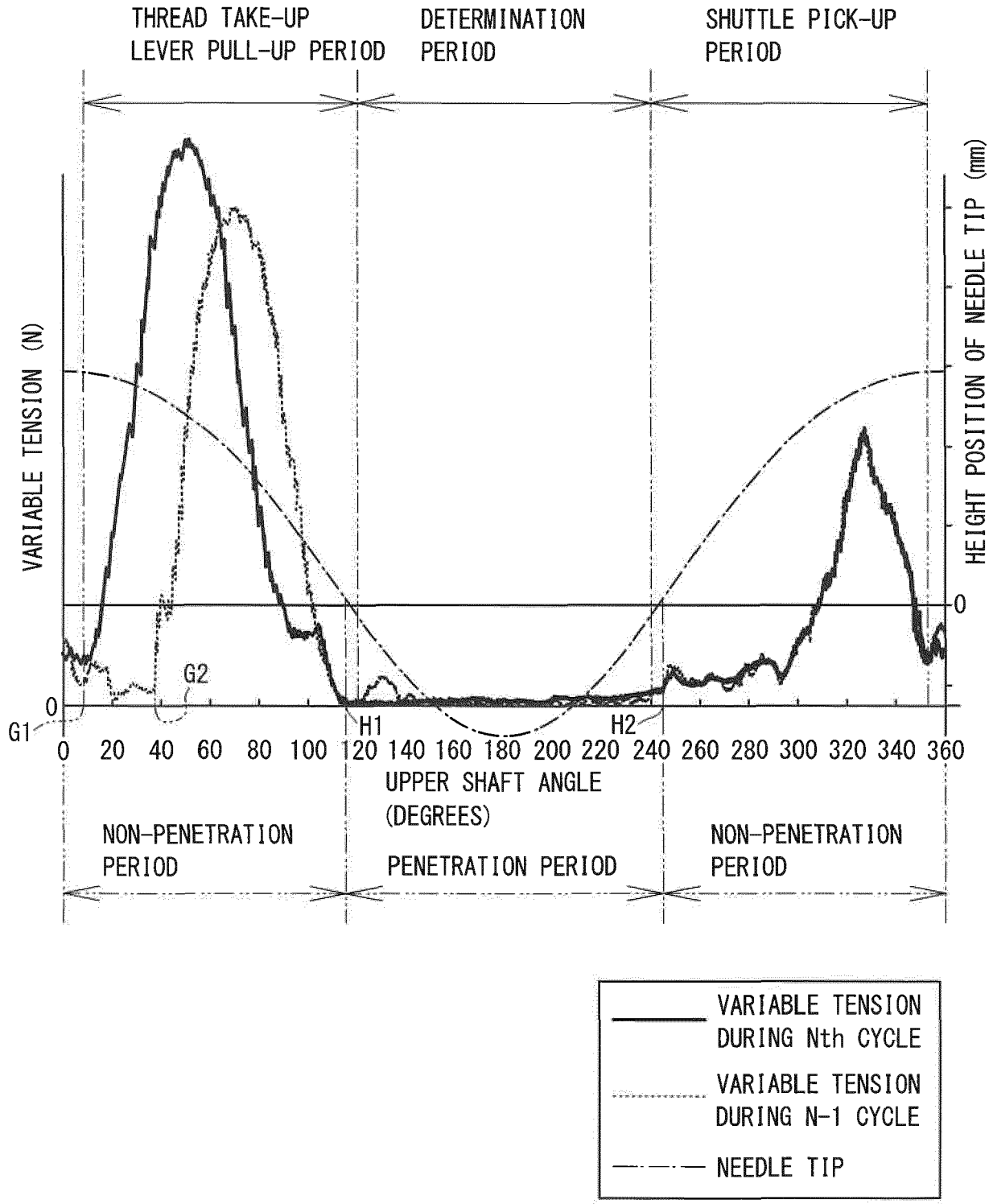

THREAD TAKE-UP LEVER PULL-UP PERIOD
DETERMINATION PERIOD
SHUTTLE PICK-UP PERIOD
VARIABLE TENSION (N)
HEIGHT POSITION OF NEEDLE TIP (mm)
0
G1
G2
H1
H2
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360
UPPER SHAFT ANGLE (DEGREES)
NON-PENETRATION PERIOD
PENETRATION PERIOD
NON-PENETRATION PERIOD
VARIABLE TENSION DURING Nth CYCLE
VARIABLE TENSION DURING N-1 CYCLE
NEEDLE TIP

FIG. 9

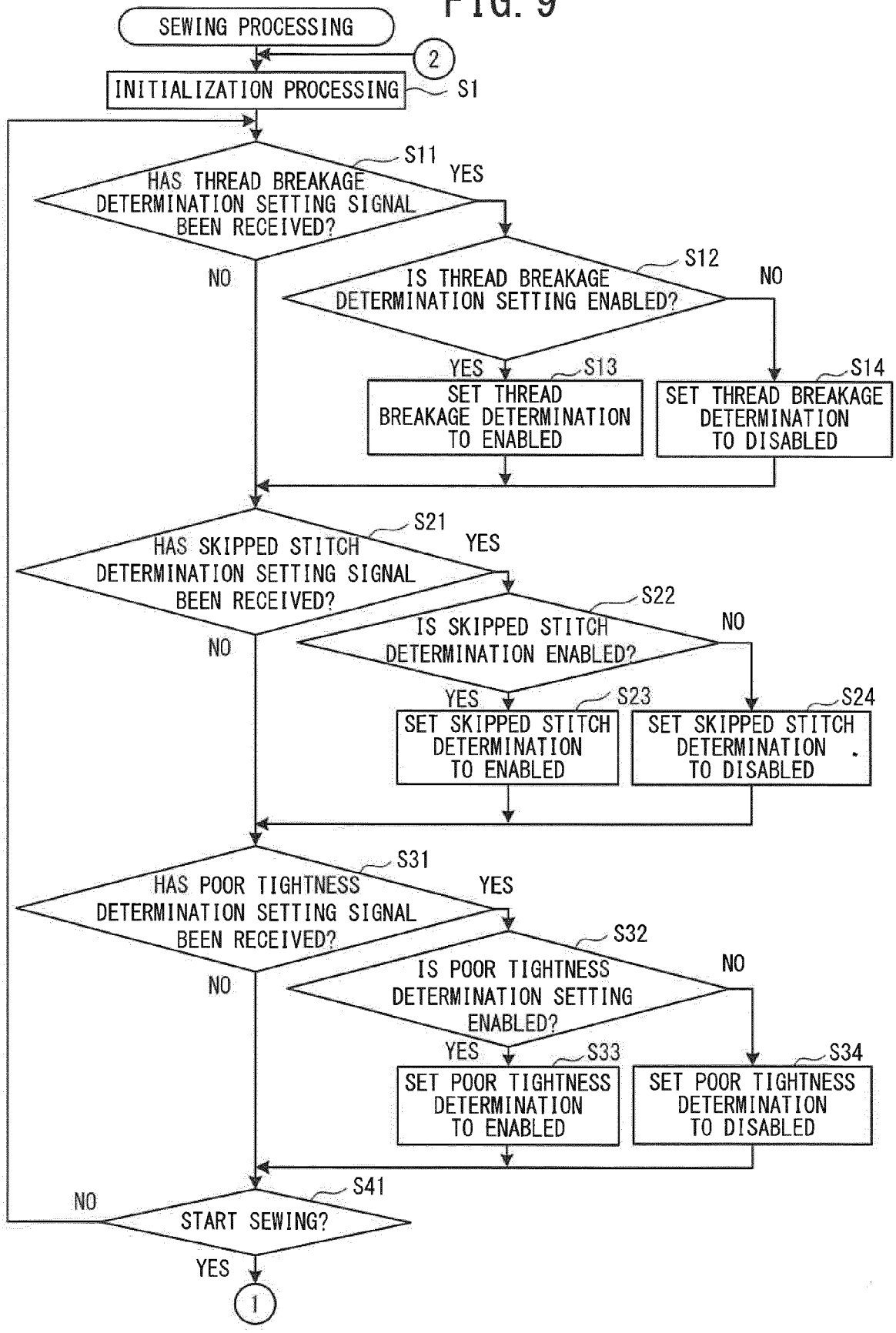

SEWING PROCESSING
2
INITIALIZATION PROCESSING
S1
S11
HAS THREAD BREAKAGE DETERMINATION SETTING SIGNAL BEEN RECEIVED?
YES
NO
S12
IS THREAD BREAKAGE DETERMINATION SETTING ENABLED?
NO
YES
S13
SET THREAD BREAKAGE DETERMINATION TO ENABLED
S14
SET THREAD BREAKAGE DETERMINATION TO DISABLED
S21
HAS SKIPPED STITCH DETERMINATION SETTING SIGNAL BEEN RECEIVED?
YES
NO
S22
IS SKIPPED STITCH DETERMINATION ENABLED?
NO
YES
S23
SET SKIPPED STITCH DETERMINATION TO ENABLED
S24
SET SKIPPED STITCH DETERMINATION TO DISABLED
S31
HAS POOR TIGHTNESS DETERMINATION SETTING SIGNAL BEEN RECEIVED?
YES
NO
S32
IS POOR TIGHTNESS DETERMINATION SETTING ENABLED?
NO
YES
S33
SET POOR TIGHTNESS DETERMINATION TO ENABLED
S34
SET POOR TIGHTNESS DETERMINATION TO DISABLED
S41
NO
START SEWING?
YES
1

FIG. 10

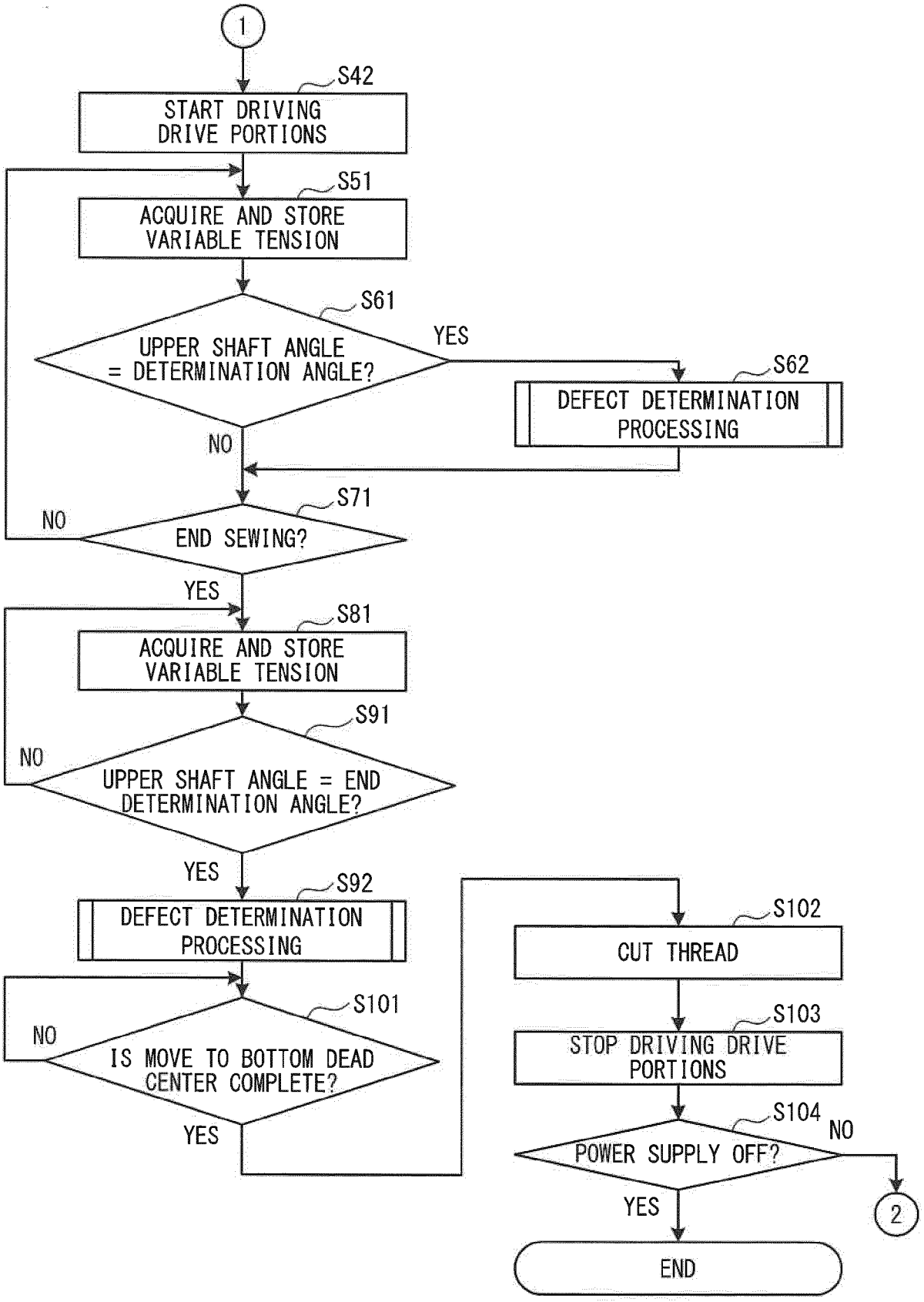
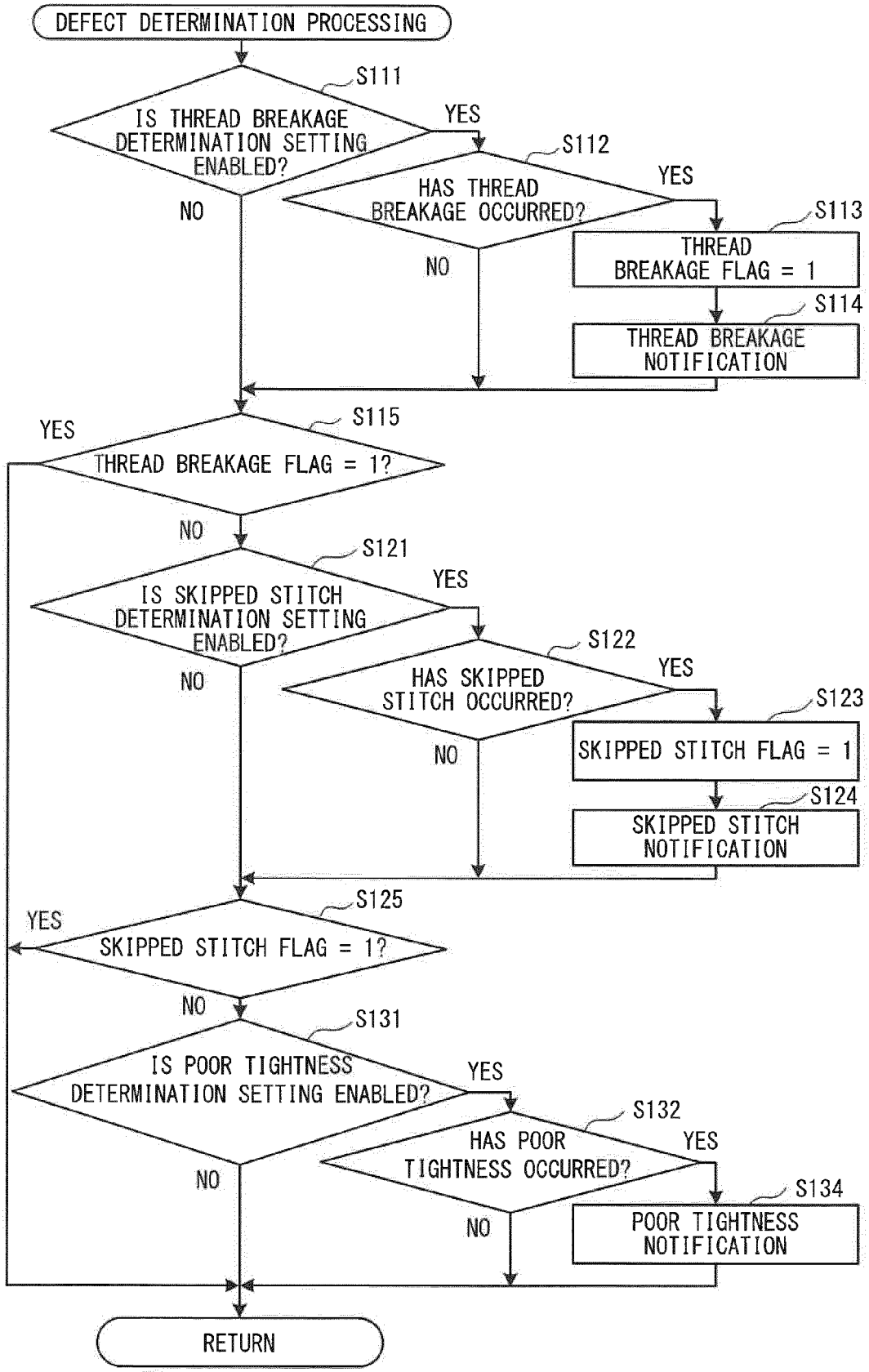

1
S42
START DRIVING DRIVE PORTIONS
S51
ACQUIRE AND STORE VARIABLE TENSION
S61
UPPER SHAFT ANGLE = DETERMINATION ANGLE?
YES
S62
DEFECT DETERMINATION PROCESSING
NO
S71
END SEWING?
NO
YES
S81
ACQUIRE AND STORE VARIABLE TENSION
S91
UPPER SHAFT ANGLE = END DETERMINATION ANGLE?
NO
YES
S92
DEFECT DETERMINATION PROCESSING
S101
IS MOVE TO BOTTOM DEAD CENTER COMPLETE?
NO
YES
S102
CUT THREAD
S103
STOP DRIVING DRIVE PORTIONS
S104
POWER SUPPLY OFF?
NO
YES
2
END

FIG. 11


DEFECT DETERMINATION PROCESSING
S111
IS THREAD BREAKAGE DETERMINATION SETTING ENABLED?
YES
NO
S112
HAS THREAD BREAKAGE OCCURRED?
YES
NO
S113
THREAD BREAKAGE FLAG = 1
S114
THREAD BREAKAGE NOTIFICATION
S115
YES
THREAD BREAKAGE FLAG = 1?
NO
S121
IS SKIPPED STITCH DETERMINATION SETTING ENABLED?
YES
NO
S122
HAS SKIPPED STITCH OCCURRED?
YES
NO
S123
SKIPPED STITCH FLAG = 1
S124
SKIPPED STITCH NOTIFICATION
S125
YES
SKIPPED STITCH FLAG = 1?
NO
S131
IS POOR TIGHTNESS DETERMINATION SETTING ENABLED?
YES
NO
S132
HAS POOR TIGHTNESS OCCURRED?
YES
NO
S134
POOR TIGHTNESS NOTIFICATION
RETURN

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EUROPEAN SEARCH REPORT

Application Number
EP 21 16 5662

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X,D	JP 2019 201741 A (JUKI KK) 28 November 2019 (2019-11-28) * paragraph [0040] - paragraph [0082]; figures 1-11 *	1-3,9,10	INV. D05B69/36
X	CN 108 978 062 A (JACK SEWING MACHINE CO LTD) 11 December 2018 (2018-12-11) * paragraph [0045] - paragraph [0050]; figures 2, 3, 5 *	1,2,10	
X	JP 2019 005502 A (BROTHER IND LTD) 17 January 2019 (2019-01-17) * paragraphs [0051], [0075], [0079]; figures 7, 9 *	1-4,10	
X	DE 10 2016 107262 A1 (JUKI KK [JP]) 20 October 2016 (2016-10-20) * paragraphs [0006], [0007], [0041] *	1,2,10	

TECHNICAL FIELDS SEARCHED (IPC)

D05B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	29 July 2021	Braun, Stefanie

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