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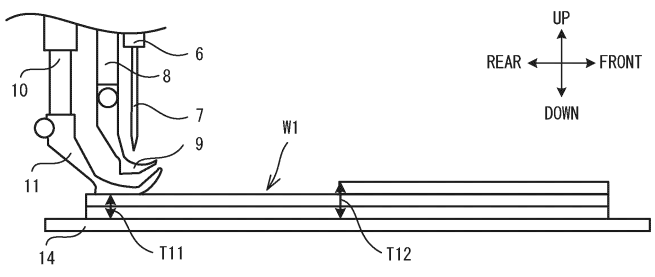
(54) SEWING DEVICE

(57) A sewing device includes a needle plate, a needle bar, a needle bar mechanism, a drive shaft motor, a presser bar, a detector, a processor, and a memory. The detector is configured to detect a detected thickness, the detected thickness being a thickness of the sewing object pressed by the presser foot. The memory is configured to store computer-readable instructions that, when executed by the processor, instruct the processor to perform processes. The processes include detection processing of acquiring the detected thickness detected by the detector, acquisition processing of acquiring a reference thickness, the reference thickness being a thickness of one of one layer of the sewing object and a plurality of layers of the sewing object used as a reference, comparison processing of comparing the detected thickness and the reference thickness, and notification control processing of notifying a comparison result of the comparison processing.

FIG. 10



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Description

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to Japanese Patent Application No. 2020-060891 filed March 30, 2020, the content of which is hereby incorporated herein by reference in its entirety.

BACKGROUND

[0002] The present disclosure relates to a sewing device.

[0003] A known sewing device is provided with a presser foot that presses a cloth in the vicinity of a stitch formation position. The presser foot is mounted on the lower end of a presser bar, and the presser bar can move between a raised position in which the presser foot releases the cloth, and a pressing position in which the presser foot presses the cloth. When the presser foot moves, a distance between a part of the presser bar and a reference changes in a stable manner. A position sensor detects a position of the presser foot in the pressing position. Based on an output value of the position sensor, the sewing device sets sewing conditions of the sewing device in accordance with a cloth thickness.

SUMMARY

[0004] The above-described sewing device automatically calculates the sewing conditions of the sewing device depending on the cloth thickness, and performs sewing. Also, when a sewing object of a cloth thickness that is not intended by an operator is sewn, the sewing device automatically sets the sewing conditions depending on the cloth thickness, and thus the operator does not notice that the sewing object of the unintended thickness is being sewn.

[0005] Embodiments of the broad principles derived herein provide a sewing device that improves convenience for an operator when performing sewing in accordance with a thickness of a sewing object.

[0006] Embodiments provide a sewing device that includes a needle plate, a needle bar, a needle bar mechanism, a drive shaft motor, a presser bar, a detector, a processor, and a memory. The needle plate is a plate on which a sewing object is to be placed. The needle bar extends in an up-down direction and on a lower end of which a sewing needle is mountable. The needle bar mechanism is configured to move the needle bar up and down. The drive shaft motor is configured to drive the needle bar mechanism. The presser bar is a bar on a lower end of which a presser foot is mountable, and the presser bar configured to press, using the presser foot, the sewing object placed on the needle plate, from above. The detector is configured to detect a detected thickness, the detected thickness being a thickness of the sewing object pressed by the presser foot. Thea memory is configured to store computer-readable instructions that, when executed by the processor, instruct the processor to perform processes. The processes include detection processing of acquiring the detected thickness detected by the detector, acquisition processing of acquiring a reference thickness, the reference thickness being a thickness of one of one layer of the sewing object and a plurality of layers of the sewing object used as a reference, comparison processing of comparing the detected thickness and the reference thickness, and notification control processing of notifying a comparison result of the comparison processing. The operator can refer to the comparison result notified by the sewing device, and, using the comparison result, can verify whether or not the sewing object placed on the needle plate and pressed by the presser foot is the sewing object intended by the operator. Thus, compared to known art, the sewing device can improve convenience for the operator when performing sewing in accordance with the thickness of the sewing object.

[0007] In this aspect of the sewing device, the computer-readable instructions may further instruct the processor to perform a process that includes warning threshold value acquisition processing of acquiring a warning threshold value to be compared with a difference between the detected thickness and the reference thickness. The notification control processing may include issuing a warning when the difference between the detected thickness and the reference thickness is equal to or greater than the warning threshold value. By setting the warning threshold value as appropriate, the sewing device can notify the operator that the sewing object of the thickness not intended by the operator is placed on the needle plate. By referring to the warning, the operator can avoid sewing the sewing object that is not intended by the operator, for example.

[0008] In this aspect of the sewing device, the computer-readable instructions may further instruct the processor to perform processes that include change threshold value acquisition processing of acquiring a change threshold value smaller than the warning threshold value, and condition changing processing of changing sewing conditions in accordance with the detected thickness when the difference between the reference thickness and the detected thickness is smaller than the warning threshold value and is equal to or greater than the change threshold value. By setting the warning threshold value and the change threshold value as appropriate, the sewing device can automatically change the sewing conditions in accordance with the detected thickness, when the difference between the reference thickness and the detected thickness is not large enough to issue the warning but it is not appropriate for the operator to perform the sewing using the sewing conditions set based on the reference thickness. The sewing device can reduce an amount of time and effort required for the operator to change the sewing conditions during the sewing.

[0009] In this aspect of the sewing device, the compu-

ter-readable instructions may further instruct the processor to perform processes that include enabling threshold value acquisition processing of acquiring an enabling threshold value smaller than the warning threshold value, and enabling setting processing of enabling a penetration improvement function for improving penetration of the sewing object by the sewing needle, by driving the drive shaft motor using an conduction pattern different from when sewing the sewing object of the reference thickness, when the difference between the reference thickness and the detected thickness is smaller than the warning threshold value, and a value obtained by subtracting the reference thickness from the detected thickness is smaller than the enabling threshold value. By setting the warning threshold value and the enabling threshold value as appropriate, the sewing device can automatically enable the penetration improvement function, when the difference between the reference thickness and the detected thickness is not large enough for the operator to cancel the sewing, but it is difficult for the sewing needle to penetrate the sewing object when sewing using the sewing conditions set based on the reference thickness. The sewing device can reduce an amount of time and effort required for the operator to enable the penetration improvement function during the sewing.

[0010] In this aspect of the sewing device, the computer-readable instructions may further instruct the processor to perform a process that includes sewing stop processing of stopping the driving of the drive shaft motor when the different between the reference thickness and the detected thickness acquired during the driving of the drive shaft motor is equal to or greater than the warning threshold value. By setting the warning threshold value as appropriate, the sewing device can avoid continuing the sewing of the sewing object of the thickness not intended by the operator.

[0011] In this aspect of the sewing device, the detection processing may include detecting the detected thickness before a start of the driving of the drive shaft motor, and the notification control processing may include performing the notification of the comparison result between the reference thickness and the detected thickness detected before the start of the driving of the drive shaft motor. The operator can refer to the comparison result notified by the sewing device, and, using the comparison result, can verify before performing the sewing whether or not the sewing object placed on the needle plate and pressed by the presser foot is the sewing object intended by the operator. Thus, compared to known art, the sewing device can further improve convenience for the operator when performing the sewing in accordance with the thickness of the sewing obj ect.

[0012] In this aspect of the sewing device, the detection processing may include detecting the detected thickness during driving of the drive shaft motor, and the notification control processing may include issuing a warning when the detected thickness detected during the driving of the drive shaft motor changes. When the detected thickness detected during the driving of the drive shaft motor changes, the sewing device can notify the operator using a notification. The operator can refer to the notification and can respond appropriately in accordance with whether or not the change in thickness is intended by the operator.

[0013] In this aspect of the sewing device, the detection processing may include detecting the detected thickness during the driving of the drive shaft motor, and the computer-readable instructions may further instruct the processor to perform a process that includes condition changing processing of changing sewing conditions in accordance with the detected thickness when the detected thickness detected during the driving of the drive shaft motor changes. When the detected thickness detected during the driving of the drive shaft motor changes, the sewing device can automatically change the sewing conditions in accordance with the detected thickness. The sewing device can reduce an amount of time and effort required for the operator to change the sewing conditions during the sewing.

[0014] In this aspect of the sewing device, the detection processing may include detecting the detected thickness during the driving of the drive shaft motor, and the notification control processing may include performing notification that the sewing object is not present between the needle plate and the presser foot when the detected thickness detected during the driving of the drive shaft motor is smaller than a predetermined value. The computer-readable instructions may further instruct the processor to perform a process that includes sewing stop processing of stopping the driving of the drive shaft motor when the detected thickness detected during the driving of the drive shaft motor is smaller than the predetermined value. The sewing device can perform the notification that the sewing object is not present between the needle plate and the presser foot, and can stop the driving of the drive shaft motor. The sewing device can avoid continuation of the driving of the drive shaft motor after sewing to the end of the sewing object.

[0015] In this aspect of the sewing device, the computer-readable instructions may further instruct the processor to perform a process that includes warning threshold value acquisition processing of acquiring a warning threshold value used in comparing a difference between the detected thickness and the reference thickness, and the acquisition processing includes acquiring a plurality of reference thicknesses during the driving of the drive shaft motor in a setting order. The comparison processing may include comparing the detected thickness and the reference thickness that is next in the setting order when the detected thickness detected during the driving of the drive shaft motor changes, and the notification control processing may include issuing a warning when the difference between the detected thickness and the reference thickness that is next in the setting order is equal to or greater than the warning threshold value. When sewing the sewing object for which the thickness changes during the sewing, the sewing device can prevent a

location at which the thickness changes from being detected as an abnormality. When the sewing device has detected the change in the detected thickness, the sewing device compares the reference thickness that is next in the setting order with the detected thickness, and thus can also appropriately compare the reference thickness and the detected thickness during the sewing of the sewing object for which the thickness changes during the sewing.

[0016] In this aspect of the sewing device, the memory may store a plurality of combinations of the reference thickness during the driving of the drive shaft motor and the setting order, and the acquisition processing may include acquiring, in the setting order, the plurality of combinations stored in the memory. When sewing the sewing object for which the thickness changes during the sewing, the sewing device can prevent a location at which the thickness changes from being detected as an abnormality. When the sewing device has detected the change in the detected thickness, the sewing device compares the reference thickness that is next in the setting order with the detected thickness, and thus can also appropriately compare the reference thickness and the detected thickness during the sewing of the sewing object for which the thickness changes during the sewing.

[0017] In this aspect of the sewing device, the computer-readable instructions may further instruct the processor to perform a process that includes storage control processing of setting the detected thickness detected by the detector as the reference thickness, and storing the plurality of combinations of the reference thickness and the setting order in the memory. The sewing device can store the plurality of combinations of the reference thickness and the setting order, using the detected thickness detected by the detector as the reference thickness. Compared to a device that acquires combinations of the reference thickness and the setting order from another device, the sewing device can reduce an impact of a mounting error of the detector with respect to the sewing device or the like.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] Embodiments will be described below in detail with reference to the accompanying drawings in which:

FIG. 1 is a perspective view of a sewing device;
FIG. 2 is a perspective view of part of an internal structure of the sewing device;
FIG. 3 is a front view of part of the internal structure of the sewing device;
FIG. 4A is a left side view of part of the internal structure of the sewing device when a presser mechanism is in a needle lowered position, and FIG. 4B is a left side view of part of the internal structure of the sewing device when the presser mechanism is in a needle raised position;
FIG. 5 is a block diagram of an electrical configuration of the sewing device;
FIG. 6 is a flowchart of sewing processing;
FIG. 7 is a flowchart of setting processing;
FIG. 8 is a flowchart of pre-sewing detection processing;
FIG. 9 is a flowchart of during sewing detection processing;
FIG. 10 is an explanatory diagram of a thickness of a sewing object of a first specific example; and
FIG. 11 is an explanatory diagram of the sewing object of a second specific example.

DETAILED DESCRIPTION

[0019] A physical configuration of a sewing device 1 according to the present invention will be explained. In the following explanation, left and right, front and rear, and up and down directions indicated by arrows in the diagrams are used. As shown in FIG. 1 and FIG. 2, the sewing device 1 is a union-feed sewing machine, and is provided with a bed portion 2, a pillar 3, an arm portion 4, and a head portion 5. The bed portion 2 includes a needle plate 14 in an upper surface thereof, and houses a shuttle mechanism, a feed mechanism 36, and a feed adjustment mechanism 37. The shuttle mechanism is driven by the rotation of a lower shaft 40, and causes a lower thread and an upper thread to be entwined below the needle plate 14. The lower shaft 40 rotates in synchronization with a drive shaft 31, due to a belt 35 stretched between the drive shaft 31 and the lower shaft 40. As shown in FIG. 2 to FIG. 4A, and FIG. 4B, the feed mechanism 36 is provided with an up-down feed shaft 38, an eccentric link 69, an eccentric rod (not shown in the drawings), a converter 66, a horizontal feed shaft 39, a link mechanism 53, and a feed dog 17. The feed mechanism 36 drives the feed dog 17 in synchronization with the lower shaft 40 and moves a sewing object in a conveyance direction by a predetermined feed amount. The conveyance direction is a rearward direction and a frontward direction. The lower shaft 40, the up-down feed shaft 38, and the horizontal feed shaft 39 extend in the left-right direction. The up-down feed shaft 38 is positioned in front of the horizontal feed shaft 39. The up-down feed shaft 38 is coupled to the lower shaft 40 via the eccentric link 69 that is eccentric with respect to a shaft center of the lower shaft 40. The eccentric rod is provided so as to be eccentric with respect to the lower shaft 40, to the right of the eccentric link 69. The converter 66 is coupled to a rear end portion of the eccentric rod that is provided so as to be eccentric with respect to the lower shaft 40, and transmits the rotation of the lower shaft 40, which is generated by the rotation of the drive shaft 31, to the horizontal feed shaft 39. The left end of the up-down feed shaft 38, and the left end of the horizontal feed shaft 39 are coupled to the feed dog 17, via the link mechanism 53. The feed adjustment mechanism 37 is provided with a feed adjustment motor 24, an intermediate shaft 28, the converter 66, a cam lever 67, a

cam disk 65, and the horizontal feed shaft 39. The intermediate shaft 28 extends in the left-right direction, and is coupled to the horizontal feed shaft 39 via the converter 66. The intermediate shaft 28 includes the cam lever 67 on a right end portion thereof, and the cam lever 67 is coupled to the cam disk 65 provided on an output shaft of the feed adjustment motor 24. The feed adjustment motor 24 is a pulse motor. By rotating the output shaft, the feed adjustment motor 24 changes a rotation amount of the horizontal feed shaft 39 via the cam disk 65, the cam lever 67, the intermediate shaft 28, and the converter 66, and adjusts a feed amount in the front-rear direction of the sewing object by the feed mechanism 36. When the lower shaft 40 rotates in synchronization with the rotation of the drive shaft 31, the up-down feed shaft 38 and the horizontal feed shaft 39 swing, and the feed dog 17 rotates while drawing an elliptical trajectory in the counterclockwise direction or the clockwise direction in a left side view.

[0020] As shown in FIG. 1 and FIG. 2, the pillar 3 extends upward from the right end portion of the bed portion 2, and houses a drive shaft motor 21, a presser motor 22, the belt 35, and a drive link 41. The drive shaft motor 21 rotates the drive shaft 31. The presser motor 22 is a pulse motor provided to the left and to the rear of the drive shaft motor 21, and adjusts a downward pressing pressure applied to the sewing object by an outer presser foot 11 mounted on the lower end of an outer presser bar 10. The presser motor 22 can also move the outer presser foot 11 up and down. The drive link 41 is coupled to the horizontal feed shaft 39 and a needle bar rocking shaft 42.

[0021] The arm portion 4 extends to the left from the upper end portion of the pillar 3. The front face of the arm portion 4 is provided with a display portion 15, input portions 16 and 19, and a tensioner 13. The display portion 15 is a liquid crystal display that displays an image, and the input portion 16 is a touch panel provided in the front face of the display portion 15 that can input various commands to a control portion 90 (refer to FIG. 5). The input portion 19 is provided to the right of the display portion 15, and is a switch that inputs various commands to the control portion 90. The tensioner 13 includes a thread tension solenoid 25 (refer to FIG. 5), and a predetermined tension is imparted to the upper thread by the driving of the thread tension solenoid 25. The arm portion 4 houses the thread tension solenoid 25, an alternating vertical movement amount adjustment motor 23, the drive shaft 31, a presser shaft 26, the needle bar rocking shaft 42, an intermediate shaft 27, a rocking shaft 45, and an alternating vertical movement amount adjustment mechanism 50. The thread tension solenoid 25 is a proportional solenoid, and the sewing device 1 can adjust the tension imparted to the upper thread by adjusting a drive voltage supplied to the thread tension solenoid 25. The alternating vertical movement amount adjustment motor 23 is a pulse motor provided to the left of the drive shaft motor 21 and the presser motor 22. The drive shaft 31, the presser shaft 26, the needle bar rocking shaft 42, the intermediate shaft 27, and the rocking shaft 45 extend in the left-right direction. The right end portion of the drive shaft 31 is connected to the drive shaft motor 21, and the left end portion of the drive shaft 31 is connected to a needle bar mechanism 32. The presser shaft 26 is positioned to the rear of the drive shaft 31, and a fan gear 64 is included on the right end portion of the presser shaft 26. The fan gear 64 meshes with a pinion 61 provided on an output shaft of the presser motor 22, and is rotated by the driving of the presser motor 22. Thus, the presser shaft 26 is rotated by the driving of the presser motor 22. The left end portion of the presser shaft 26 is connected to a presser mechanism 44. The right end portion of the needle bar rocking shaft 42 is connected to the drive link 41, and the left end portion of the needle bar rocking shaft 42 is connected to a swinging mechanism 34. The alternating vertical movement amount adjustment mechanism 50 is provided with the alternating vertical movement amount adjustment motor 23, a cam mechanism 62, the intermediate shaft 27, a converter 63, and the rocking shaft 45. An output shaft of the alternating vertical movement amount adjustment motor 23 is coupled to the intermediate shaft 27 via the cam mechanism 62. The intermediate shaft 27 is coupled to the rocking shaft 45 via the converter 63. By rotating the output shaft, the alternating vertical movement amount adjustment motor 23 changes a swing amount of the rocking shaft 45 via the cam mechanism 62, the intermediate shaft 27, and the converter 63, and adjusts an alternating vertical movement amount. The alternating vertical movement amount is an amount of a vertical movement, from the needle plate 14, when a center presser bar 8 and the outer presser bar 10 alternately move up and down in synchronization with the rotation of the drive shaft 31.

[0022] The head portion 5 is provided on the left end portion of the arm portion 4, and a thread take-up lever 12 is provided in the front face thereof. The thread take-up lever 12 pulls up the upper thread, and creates a knot with the lower thread. The head portion 5 houses the needle bar mechanism 32, a thread take-up lever mechanism 33, the presser mechanism 44, the swinging mechanism 34, and a detector 49. The needle bar mechanism 32 is coupled to the drive shaft 31 and moves a needle bar 6 up and down. The thread take-up lever mechanism 33 moves the thread take-up lever 12 up and down in synchronization with the rotation of the drive shaft 31.

[0023] As shown in FIG. 2 to FIG. 4A and FIG. 4B, the presser mechanism 44 is coupled to the left end portion of the presser shaft 26, and is provided with the outer presser bar 10, the center presser bar 8, the rocking shaft 45, links 46, 47, and 70, a triangular lever 48, an urging member 51, an adjustment member 52, the converter 63, and an eccentric rod 68. The outer presser bar 10 extends in the up-down direction, and the outer presser foot 11 can be mounted on or detached from the lower end thereof. The center presser bar 8 extends in the up-down direction to the front of the outer presser bar 10. A

center presser foot 9 can be mounted on or detached from the lower end of the center presser bar 8. The left end of the rocking shaft 45 is coupled to the link 46 that extends in the up-down direction. The lower end of the link 46 is coupled to the rear end of the link 47 that extends in the front-rear direction. The triangular lever 48 has a triangular shape in a left side view, and one of the three corner portions thereof is coupled to the front end of the link 47. Of the three corner portions of the triangular lever 48, the remaining two corner portions are coupled to the outer presser bar 10 and the link 70. One end portion of the link 70 is coupled to the triangular lever 48, and the other end portion is coupled to the center presser bar 8. The urging member 51 is a coil-shaped compression spring, is placed around the outer presser bar 10, and presses the outer presser bar 10 downward. The adjustment member 52 is cylindrically shaped, and the urging member 51 is inserted through the inside of the adjustment member 52 such that the adjustment member 52 can move up and down. The adjustment member 52 is driven up and down by the driving of the presser motor 22, and adjusts a downward pressing pressure applied to the outer presser bar 10 by the urging member 51. The converter 63 is coupled to the rear end portion of the eccentric rod 68 provided so as to be eccentric with respect to the drive shaft 31. The converter 63 transmits the rotation of the drive shaft 31 by the driving of the drive shaft motor 21 to the rocking shaft 45, and swings the rocking shaft 45. When the rocking shaft 45 swings due to the rotation of the drive shaft 31, the link 46 swings around the rocking shaft 45. The link 47 operates in the front-rear direction in accordance with the swinging of the link 46, and causes the outer presser bar 10 and the center presser bar 8 to operate in the up-down direction via the triangular lever 48. As shown in FIG. 4A, when the link 47 has moved to the front, the outer presser bar 10 rises, and the center presser bar 8 descends. As shown in FIG. 4B, when the link 47 has moved to the rear, the outer presser bar 10 descends and the center presser bar 8 rises. In synchronization with the rotation of the drive shaft 31, the presser mechanism 44 moves the outer presser bar 10 and the center presser bar 8 in an opposite phase, namely, moves the outer presser bar 10 and the center presser bar 8 alternately up and down, and presses the sewing object from above toward the needle plate 14 using the outer presser foot 11 and the center presser foot 9 alternately.

[0024] The swinging mechanism 34 is coupled to the needle bar rocking shaft 42, and, in synchronization with the rotation of the drive shaft 31, the swinging mechanism 34 swings the needle bar 6 and the center presser bar 8 in the conveyance direction of the sewing object, by an amount corresponding to a swinging amount of the needle bar rocking shaft 42. As shown in FIG. 4A, a state in which the lower end of a sewing needle 7 is below the needle plate 14, the outer presser foot 11 is in a position above and separated from the needle plate 14, and the center presser foot 9 is in a position closer to the feed dog 17, is referred to as the presser mechanism 44 being in a needle lowered position. During a period in which the presser mechanism 44 is in the needle lowered position, the sewing device 1 swings the needle bar 6, the center presser bar 8, and the feed dog 17 to the rear in a state in which the sewing needle 7 is piercing the sewing object. As shown in FIG. 4B, a state in which the lower end of the sewing needle 7 is above the needle plate 14, the outer presser foot 11 is in a position closer to the needle plate 14, and the center presser foot 9 is in a position above and separated from the needle plate 14, is referred to as the presser mechanism 44 being in a needle raised position. During a period in which the presser mechanism 44 is in the needle raised position, the sewing device 1 swings the needle bar 6, the center presser bar 8, and the feed dog 17 to the front in a state in which the sewing needle 7 is not piercing the sewing object.

[0025] The detector 49 is configured to output, to the control portion 90, a detection result corresponding to the thickness of the sewing object. The detector 49 is a magnetic sensor provided on the head portion 5, for example, and is configured to detect a vertical position of a magnetic body 71 provided on a presser bar holder 60. The presser bar holder 60 supports the outer presser bar 10 so as to be movable in the up-down direction. On the lower portion of the head portion 5, the sewing device 1 is provided with the needle bar 6 that is moved up and down by the driving of the drive shaft motor 21, the outer presser bar 10, and the center presser bar 8. The needle bar 6 extends in the up-down direction to the front of the center presser bar 8, and the sewing needle 7 can be mounted on and detached from the lower end of the needle bar 6. A thread spool supplies the upper thread to an eye of the sewing needle 7.

[0026] An electrical configuration of the sewing device 1 will be explained with reference to FIG. 5. The control portion 90 of the sewing device 1 includes a CPU 91, a ROM 92, a RAM 93, a, an input/output interface (I/O) 95, drive circuits 81 to 86, and the like. The CPU 91 performs overall control of operation of the sewing device 1. The ROM 92 stores, in advance, programs and the like for executing various processing. The RAM 93 temporarily stores various pieces of information generated during the execution of the various processing. The storage device 94 is non-volatile, and stores various setting values. The storage device 94 stores a number of layers table 96, a setting table 97, and a threshold value table 98. The number of layers table 96 stores correspondences between a reference thickness, a number of layers, the feed amount, the thread tension, the pressing pressure, the alternating vertical movement amount, and a number of revolutions. The reference thickness is a thickness that is used as a reference of the sewing object in which a number of layers are overlaid, as indicated by the number of layers. The feed amount is an amount by which the sewing object is transported by the feed mechanism 36 during a period in which the drive shaft 31 rotates once,

and is adjusted by the driving of the feed adjustment motor 24. The thread tension is an amount indicating the pressure applied to the upper thread, and is adjusted by the driving of the thread tension solenoid 25. The pressing pressure is an amount corresponding to a pressure applied downward on the sewing object by the outer presser foot 11 mounted on the lower end of the outer presser bar 10, and is adjusted by the driving of the presser motor 22. The alternate rising amount is an amount corresponding to a height, from the needle plate 14, when the outer presser bar 10 and the center presser bar 8 are alternately moved up and down by the presser mechanism 44, and is adjusted by the driving of the alternating vertical movement amount adjustment motor 23. The number of revolutions is a number of revolutions of an output shaft of the drive shaft motor 21. The setting table 97 stores correspondences between a setting order and the reference thicknesses. The setting order corresponds to an order of sewing of the sewing objects of the reference thicknesses. The threshold value table 98 stores various threshold values. The tables 96 to 98 may be stored in a peripheral device connected to the sewing device 1, in another of the sewing devices 1, or in a cloud. The tables 96 to 98 may be configured such that the tables 96 to 98 can be viewed, changed, or set using the sewing device 1, or a PC, smartphone or the like connected to the sewing device 1.

[0027] Each of the drive circuits 81 to 86 is connected to the I/O 95. The drive circuit 81 is connected to the drive shaft motor 21 and drives the drive shaft motor 21 using a control command from the CPU 91. The drive circuit 82 is connected to the feed adjustment motor 24 and drives the feed adjustment motor 24 using a control command from the CPU 91. The drive circuit 83 is connected to the alternating vertical movement amount adjustment motor 23 and drives the alternating vertical movement amount adjustment motor 23 using a control command from the CPU 91. The drive circuit 84 is connected to the presser motor 22 and drives the presser motor 22 using a control command from the CPU 91. The drive circuit 85 is connected to the thread tension solenoid 25 and drives the thread tension solenoid 25 using a control command from the CPU 91. The drive circuit 86 is connected to the display portion 15 and drives the display portion 15 using a control command from the CPU 91.

[0028] Encoders 56 to 59, the input portions 16 and 19, a pedal 18, and the detector 49 are connected to the I/O 95. The encoder 56 detects a rotation position and a rotation speed of the drive shaft 31 that is connected to the output shaft of the drive shaft motor 21, and inputs detection results to the I/O 95. The encoder 57 detects a rotation position and a rotation speed of the output shaft of the feed adjustment motor 24 and inputs detection results to the I/O 95. The encoder 58 detects a rotation position and a rotation speed of the output shaft of the alternating vertical movement amount adjustment motor 23 and inputs detection results to the I/O 95. The encoder 59 detects a rotation position and a rotation speed of the output shaft of the presser motor 22 and inputs detection results to the I/O 95. The input portions 16 and 19 detect various commands and input detection results to the I/O 95. The pedal 18 detects an operation direction and an operation amount of the pedal 18 and inputs detection results to the I/O 95. The detector 49 inputs the detection result corresponding to the thickness of the sewing object to the I/O 95.

[0029] Sewing processing will be explained with reference to FIG. 6 to FIG. 11, and using two specific examples shown in FIG. 10 and FIG. 11. In the sewing processing, the CPU 91 compares the detection result of the detector 49 with the reference thickness stored in the storage device 94, and performs processing in accordance with a comparison result. A first specific example shown in FIG. 10 is an example in which the number of layers of a sewing object W1 during the sewing changes, in order, from two layers to three layers, and then to four layers. In the sewing processing of the first specific example, when the CPU 91 detects the changes in the detected thickness during the sewing, the CPU 91 reads the reference thickness that is next in the setting order from among the reference thicknesses stored in the setting table 97, and performs processing to compare the detected thickness with the reference thickness. The detected thickness is the thickness, detected by the detector 49, of the sewing object pressed by the outer presser foot 11. A second specific example shown in FIG. 11 is an example in which the number of layers of a sewing object W2 does not change during the sewing, but the thickness of the sewing object W2 changes. In the sewing processing of the second specific example, the CPU 91 uses the reference thickness corresponding to the detected thickness or to currently set sewing conditions, and performs processing to compare the detected thickness with the reference thickness. The sewing processing is started when a power supply to the sewing device 1 is turned on. The CPU 91 reads out a sewing processing program from the ROM 92 to the RAM 93, and performs the sewing processing. The CPU 91 performs the sewing processing of the two specific examples on mutually different occasions, but in order to simplify the explanation, the sewing processing of the two specific examples is explained in parallel.

[0030] As shown in FIG. 6, the CPU 91 performs initialization processing (step S1). Based on the detection result of the input portion 16, the CPU 91 determines whether or not a sewing command has been detected (step S2). When an operator performs sewing using the sewing device 1, the operator operates the input portion 16 and inputs the sewing command. When the sewing command has not been detected (no at step S2), the CPU 91 determines whether or not a setting command has been detected, based on the detection result of the input portion 16 (step S5). When the operator sets at least one of a setting of the number of layers table 96, a setting of the setting table 97, or a setting of the threshold value table 98, the operator operates the input portion 16 and inputs the setting command. When the setting

command has not been detected (no at step S5), the CPU 91 performs processing at step S14. When the setting command has been detected (yes at step S5), the CPU 91 performs setting processing (step S6). In the setting processing, the CPU 91 performs the setting of the number of layers table 96, the setting of the setting table 97, or the setting of the threshold value table 98 in accordance with the command of the operator. The operator operates the input portion 16 and inputs the command to perform at least one of the setting of the number of layers table 96, the setting of the setting table 97, or the setting of the threshold value table 98.

[0031] As shown in FIG. 7, in the setting processing, based on the detection result of the input portion 16, the CPU 91 determines whether or not the command has been detected to set the number of layers table 96 (step S21). The thickness of the sewing obj ect detected by the detector 49 becomes larger the greater the number of sewing obj ects overlaid on each other. For example, the operator inputs the command to set the number of layers table 96 when the operator wishes to store, in the number of layers table 96, a correspondence between the thickness of the sewing object detected by the detector 49 and the number of layers overlaid in the sewing object. When the command to set the number of layers table 96 has been detected (yes at step S21), the CPU 91 determines whether or not the presser mechanism 44 is in the needle raised position, based on the detection result of the input portion 16 (step S22). When the presser mechanism 44 is in the needle raised position, the outer presser bar 10 on which the outer presser foot 11 is mounted is in a lowered position close to the needle plate 14. The operator places the single sewing object or a predetermined number of overlaid sewing objects on the needle plate 14 as a reference, disposes the presser mechanism 44 in the needle raised position, and operates the input portion 16 to input a signal indicating that the presser mechanism 44 is disposed in the needle raised position. The CPU 91 continues the determination at step S22 until it is detected that the presser mechanism 44 is in the needle raised position (no at step S22). When it has been detected that the presser mechanism 44 is in the needle raised position (yes at step S22), the CPU 91 sets the detected thickness, which is the detection result of the detector 49, as the reference thickness (step S23). Based on the detection result of the input portion 16, the CPU 91 acquires the number of layers of the sewing object specified by the operator (step S24). The CPU 91 associates the reference thickness set at step S23 with the number of layers acquired at step S24 and stores the associated data in the number of layers table 96 (step S25). The detected thickness detected at step S23 changes due to the settings of the sewing device 1 at the time of detection, and thus, the CPU 91 may store the settings of the sewing device 1 at the time of detection in association with the reference thickness and the number of layers. The CPU 91 determines whether or not a command to end the setting of the number of layers table 96 has been detected, based on the detection result of the input portion 16 (step S26). When the command to end the setting of the number of layers table 96 has not been detected (no at step S26), the CPU 91 returns the processing to step S22. When the command to end the setting of the number of layers table 96 has been detected (yes at step S26), the CPU 91 performs processing at step S48.

[0032] When the command to set the number of layers table 96 has not been detected (no at step S21), the CPU 91 determines whether or not the command to set the setting table 97 has been detected, based on the detection result of the input portion 16 (step S31). When the operator, for example, tries to sew the sewing object for which the number of layers of the sewing object changes during the sewing, or the sewing object for which the thickness of the sewing object changes during the sewing, the operator operates the input portion 16 to input the command to set the setting table 97. When the command to set the setting table 97 has been detected (yes at step S31), the CPU 91 sets a variable N, which indicates the setting order, to zero (step S32). The CPU 91 adds one to the variable N and updates the variable N (step S33). In the same manner as at step S22, the CPU 91 determines whether or not the presser mechanism 44 is in the needle raised position (step S34), and continues the determination at step S34 until it is detected that the presser mechanism 44 is in the needle raised position (no at step S34). When it is detected that the presser mechanism 44 is in the needle raised position (yes at step S34), the CPU 91 sets the detected thickness, which is the thickness detected by the detector 49, as the reference thickness (step S35). The CPU 91 takes the variable N as the setting order, and stores the correspondence between the setting order and the reference thickness set at step S35 in the setting table 97 (step S36). The CPU 91 determines whether or not a command has been detected to end the setting of the setting table 97, based on the detection result of the input portion 16 (step S37). When the command to end the setting of the setting table 97 has not been detected (no at step S37), the CPU 91 returns the processing to step S33. When the command to end the setting of the setting table 97 has been detected (yes at step S37), the CPU 91 performs processing at step S48.

[0033] When the command to set the setting table 97 has not been detected (no at step S31), the CPU 91 determines whether or not the command to set the threshold value table 98 has been detected, based on the detection result of the input portion 16 (step S41). When the command to set the threshold value table 98 has not been detected (no at step S41), the CPU 91 performs the processing at step S48. When the command to set the threshold value table 98 has been detected (yes at step S41), the CPU 91 determines whether or not a command to set a warning threshold value has been detected, based on the detection result of the input portion 16. (step S42). The warning threshold value is used in processing

to determine whether or not to issue a warning in accordance with the comparison result between the thickness of the sewing object detected by the detector 49 before the start of sewing or during the sewing and the reference thickness. When the command to set the warning threshold value has been detected (yes at step S42), the CPU 91 sets the warning threshold value based on the detection result of the input portion 16, and stores the warning threshold value in the threshold value table 98 (step S43). When the command to set the warning threshold value has not been detected (no at step S42), or after step S43, the CPU 91 determines whether or not a command to set a change threshold value has been detected, based on the detection result of the input portion 16 (step S44). The change threshold value is used in processing to determine whether or not the sewing condition is to be changed in accordance with a comparison result between the thickness of the sewing object detected by the detector 49 before the start of sewing or during the sewing and the reference thickness. When the command to set the change threshold value has been detected (yes at step S42), the CPU 91 sets the change threshold value based on the detection result of the input portion 16, and stores the change threshold value in the threshold value table 98 (step S45).

[0034] When the command to set the change threshold value has not been detected (no at step S44), or after step S45, the CPU 91 determines whether or not a command to set an enabling threshold value has been detected, based on the detection result of the input portion 16. (step S46). The enabling threshold value is used in processing to determine whether or not to enable a penetration improvement function in accordance with the comparison result between the thickness of the sewing object detected by the detector 49 before the start of sewing or during the sewing, and the reference thickness. The CPU 91 of the present example improves the penetration of the sewing object by the sewing needle 7 by driving the drive shaft motor 21 using a specific conduction pattern that is different from when sewing the sewing object of the reference thickness. A known conduction pattern may be employed as appropriate as the specific conduction pattern, and the specific conduction pattern may include conduction and a conduction interruption, for example. During the conduction, a current that is larger than a current conducted to the drive shaft motor 21 when the number of revolutions of the drive shaft motor 21 is higher than a predetermined number of revolutions is supplied for a longer period of time than a period of time from a timing at which the sewing needle 7 is stopped to a timing at which the sewing needle 7 is moved forward by starting the conduction to the drive shaft motor 21. During the conduction interruption, the supply of the current is cut off for a predetermined time period after the conduction. The specific conduction pattern may be a pattern in which a predetermined cycle in a rotation direction of the drive shaft motor 21 is reversed within a range before the sewing needle 7 reaches a top dead center or a bottom dead center at which an operation direction of the sewing needle 7 is reversed.

[0035] When the command to set the enabling threshold value has been detected (yes at step S46), the CPU 91 sets the enabling threshold value based on the detection result of the input portion 16, and stores the enabling threshold value in the threshold value table 98 (step S47). When the command to set the enabling threshold value has not been detected (no at step S46), or after step S47, the CPU 91 determines whether or not a command has been detected to end the setting processing, based on the detection result of the input portion 16 (step S48). When the command to end the setting processing has not been detected (no at step S48), the CPU 91 returns the processing to step S21. When the command to end the setting processing has been detected (yes at step S48), the CPU 91 ends the setting processing and returns the processing to the sewing processing shown in FIG. 6.

[0036] When the setting command has not been detected (no at step S5), or after step S6, the CPU 91 performs the processing at step S14. When the sewing command has been detected (yes at step S2), in the same manner as at step S22, the CPU 91 determines whether or not the presser mechanism 44 is in the needle raised position (step S3), and continues the determination at step S3 until it is detected that the presser mechanism 44 is in the needle raised position (no at step S3). When it is detected that the presser mechanism 44 is in the needle raised position (yes at step S3), the CPU 91 performs pre-sewing detection processing (step S4). In the pre-sewing detection processing, the CPU 91 performs processing in accordance with a comparison result between the detected thickness of the sewing object based on the detection result of the detector 49 before the start of the sewing and the reference thickness stored in the storage device 94.

[0037] As shown in FIG. 8, the CPU 91 detects the detection result of the detector 49 as the detected thickness and stores the detected thickness in the RAM 93 (step S51). The CPU 91 detects a detected thickness T11 for the sewing object W1 of the first specific example, and stores the detected thickness T11 in the RAM 93. The CPU 91 detects a detected thickness T21 for the sewing object W2 of the second specific example, and stores the detected thickness T21 in the RAM 93. The CPU 91 acquires the reference thickness (step S62). In the first specific example, the CPU 91 acquires a reference thickness T2 that corresponds to 1 in the setting order. In the second specific example, of the reference thicknesses stored in the number of layers table 96, the CPU 91 acquires the reference thickness T2 when the number of layers is two layers, which is closest to the detected thickness T21 detected at step S51. The CPU 91 compares the detected thickness acquired at step S51 and the reference thickness acquired at step S62 (step S63). A method of comparing the detected thickness and the reference thickness may be set as appropriate. The

CPU 91 of the present example calculates a difference obtained by subtracting the reference thickness acquired at step S62 from the detected thickness acquired at step S51. The CPU 91 may compare the detected thickness with the reference thickness, for example, and may calculate the number of layers of the sewing object placed on the needle plate 14. The CPU 91 may calculate, as the thickness of the sewing object, a value obtained by subtracting the detected thickness when the needle plate 14 is in contact with the outer presser foot 11 from the detected thickness when the sewing object placed on the needle plate 14 is pressed by the outer presser foot 11. The CPU 91 refers to the threshold value table 98 and acquires a warning threshold value H1 (step S64). The CPU 91 may acquire the warning threshold value H1 store in the threshold value table 98 of the storage device 94, may acquire the warning threshold value H1 input by the operator based on the detection result of the input portion 16, or may acquire the warning threshold value H1 from another device (another sewing device, for example). The CPU 91 determines whether or not an absolute value of the difference calculated at step S63 is equal to or greater than the warning threshold value H1 acquired at step S64 (step S65). When the absolute value of the difference is equal to or greater than the warning threshold value H1 (yes at step S65), the CPU 91 issues the warning (step S66). For example, the CPU 91 displays, on the display portion 15, an error message reading "Fabric thickness abnormality warning." The CPU 91 stores, in the RAM 93, a disable sewing setting that does not allow the sewing to be started (step S67).

[0038] When the absolute value of the different is not equal to or greater than the warning threshold value H1 (no at step S65), the CPU 91 refers to the threshold value table 98 and acquires a change threshold value H2 (step S71). In a similar manner to step S64, a method of acquiring the change threshold value H2 may be changed as appropriate. The change threshold value H2 of the present example is a value smaller than the warning threshold value H1. The CPU 91 determines whether or not the absolute value of the difference calculated at step S63 is equal to or greater than the change threshold value H2 acquired at step S71 (step S72). When the absolute value of the difference is equal to or greater than the change threshold value H2 (yes at step S72), the CPU 91 refers to the number of layers table 96 and sets the sewing conditions in accordance with the detected thickness detected at step S51 (step S73). As the sewing conditions, the CPU 91 of the present example sets the feed amount, the thread tension, the pressing pressure, the alternating vertical movement amount, and the number of revolutions to conditions in accordance with the detected thickness. When the absolute value of the difference is not equal to or greater than the change threshold value H2 (no at step S72), or after step S73, the CPU 91 refers to the threshold value table 98 and acquires an enabling threshold value H3 (step S74). In a similar manner to step S64, a method of acquiring the enabling threshold value H3 may be changed as appropriate. The enabling threshold value H3 of the present example is a value smaller than the warning threshold value H1. The enabling threshold value H3 may be the same as the change threshold value H2 or may be a value different from the change threshold value H2.

[0039] The CPU 91 determines whether or not the difference calculated at step S63 is equal to or greater than the enabling threshold value H3 acquired at step S74 (step S75). When the difference is equal to or greater than the enabling threshold value H3 (yes at step S75), the CPU 91 enables the penetration improvement function (step S76). When the difference is not equal to or greater than the enabling threshold value H3 (no at step S75), or after step S76, the CPU 91 performs notification of the comparison result at step S63 between the detected thickness and the reference thickness (step S77). For example, the CPU 91 may display, on the display portion 15, the number of layers of the sewing object placed on the needle plate 14, may display the difference calculated at step S63 on the display portion 15, or may be display the thickness of the sewing object on the display portion 15. When the CPU 91 changes the sewing conditions at step S73, the CPU 91 may perform notification of the sewing conditions after the change. The CPU 91 may perform notification of a setting status of the penetration improvement function. The detected thickness detected at step S51 changes based on the settings of the sewing device 1 at the time of detection, such as the pressing pressure, positions of the feed dog 17 and the outer presser foot 11, and the like, and thus, a comparison content may be displayed along with the settings at the time of detection. The CPU 91 may display the difference between the detected thickness and the reference thickness using a numerical value, a ratio, or the like, or may display the detected thickness and the reference thickness together. The CPU 91 may display the comparison result using characters, or using a graphic. The CPU 91 stores, in the RAM 93, a sewing permission setting that allows the start of the sewing (step S78). After step S67 or step S78, the CPU 91 ends the pre-sewing detection processing, and returns the processing to the sewing processing shown in FIG. 6.

[0040] After step S4, the CPU 91 refers to the RAM 93 and determines whether or not the sewing permission setting is stored in the RAM 93 (step S7). When the disable sewing setting is stored in the RAM 93 (no at step S7), the CPU 91 performs the processing at step S14. When the sewing permission setting is stored in the RAM 93 (yes at step S7), the CPU 91 determines whether or not the sewing start command has been detected (step S8). At the start of the sewing, the operator depresses the pedal 18, and the pedal 18 inputs the sewing start command to the control portion 90. When the sewing start command has not been detected (no at step S8), the CPU 91 determines whether or not a cancel command has been detected that cancels the sewing processing based on the detection result of the input por-

tion 16 (step S15). For example, when the operator takes into account a notification result at step S77 and re-positions the sewing object, the operator operates the input portion 16 and inputs the cancel command. When the cancel command has not been detected (no at step S15), the CPU 91 returns the processing to step S8. When the cancel command has been detected (yes at step S15), the CPU 91 performs the processing at step S14.

[0041] When the sewing start command has been detected (yes at step S8), the CPU 91 starts the sewing using the sewing conditions in accordance with the detected thickness (step S9). In the first and second specific examples, the CPU 91 refers to the number of layers table 96 and acquires the sewing conditions corresponding to the reference thickness T2. When the CPU 91 has changed the sewing conditions at step S4, the CPU 91 acquires the sewing conditions after the change. The CPU 91 drives the thread tension solenoid 25 in accordance with the sewing conditions and adjusts the thread tension. The CPU 91 drives the feed adjustment motor 24 in accordance with the sewing conditions and adjusts the feed amount. The CPU 91 drives the alternating vertical movement amount adjustment motor 23 in accordance with the sewing conditions and adjusts the alternating vertical movement amount. The CPU 91 drives the presser motor 22 in accordance with the sewing conditions and adjusts the pressing pressure. The CPU 91 drives the drive shaft motor 21 in accordance with the sewing conditions, adjusts the number of revolutions, and, when the penetration improvement function is enabled, controls the conduction pattern of the drive shaft motor 21.

[0042] The CPU 91 determines whether or not a sewing stop command has been detected (step S10). When stopping the sewing, the operator releases the depression of the pedal 18, and the pedal 18 inputs the sewing stop command to the control portion 90. The CPU 91 also detects the sewing stop command when a sewing stop setting is stored in the RAM 93. When the sewing stop command has been detected (yes at step S10), the CPU 91 stops the driving of the thread tension solenoid 25 and the drive shaft motor 21, and stops the sewing using the sewing conditions in accordance with the detected thickness (step S11). When the sewing stop command has not been detected (no at step S10), the CPU 91 determines whether or not it is a detection timing, based on the detection result of the encoder 56 (step S12). The CPU 91 of the present example performs during-sewing detection processing taking a time at which a rotation angle of the drive shaft 31 is a predetermined angle as the detection timing. The predetermined angle is, for example, an angle when the presser mechanism 44 is in the needle raised position. When it is not the detection timing (no at step S12), the CPU 91 returns the processing to step S10. When it is the detection timing (yes at step S12), the CPU 91 performs the during-sewing detection processing (step S13). In the during-sewing detection processing, the CPU 91 performs processing in accordance with the comparison result between the detected thickness of the sewing object based on the detection result of the detector 49 during the sewing, and the reference thickness stored in the storage device 94.

[0043] In the during-sewing detection processing shown in FIG. 9, the same step numbers are assigned to the processing that is the same as that of the pre-sewing detection processing shown in FIG. 8, and an explanation thereof will be omitted or simplified. The CPU 91 detects the detection result of the detector 49 as the detected thickness (step S51). The CPU 91 refers to the threshold value table 98 of the storage device 94 and acquires a thickness threshold value (step S52). The thickness threshold value is a threshold value for detecting that the sewing object is not present between the needle plate 14 and the outer presser foot 11, and is set while taking into account a detection accuracy of the detector 49 and the like. The CPU 91 determines whether or not the detected thickness detected at step S51 is equal to or greater than the thickness threshold value (step S53). When the detected thickness is not equal to or greater than the thickness threshold value (no at step S53), the CPU 91 performs notification that the thickness of the sewing object is zero (step S54). For example, the CPU 91 displays, on the display portion 15, an error message reading "There is no fabric between the needle plate and the outer presser foot." The CPU 91 stores the sewing stop setting in the RAM 93 (step S55), ends the during-sewing detection processing, and returns the processing to the sewing processing shown in FIG. 6.

[0044] When the detected thickness is equal to or greater than the thickness threshold value (yes at step S53), the CPU 91 determines whether or not the detected thickness has changed (step S56). For example, the CPU 91 determines that the detected thickness has changed when an absolute value of a difference between the detected thickness detected in the preceding during-sewing detection processing or pre-sewing processing and stored in the RAM 93, and the detected thickness detected in the current during-sewing detection processing and stored in the RAM 93 is equal to or greater than a thickness change threshold value stored in the threshold value table 98. The thickness change threshold value may be set as appropriate taking into account the detection accuracy of the detector 49, and is a value smaller than the warning threshold value H1, the change threshold value H2, and the enabling threshold value H3, for example.

[0045] When the CPU 91 has acquired the detected thickness T12 in the first specific example (step S51, yes at step S53), the CPU 91 determines that the detected thickness has changed (yes at step S56), and issues a warning (step S57). For example, the CPU 91 displays, on the display portion 15, a message reading "Thickness change detected." The CPU 91 refers to the setting table 97 and determines whether the next setting order is stored in the setting table 97 (step S58). In the first specific example, the CPU 91 determines that the next set-

ting order is stored (yes at step S58), sets the sewing conditions to the sewing conditions corresponding to 2 that is next in the setting order (step S59), and acquires a reference thickness T3 that corresponds to 2 in the setting order (step S60). The CPU 91 compares the detected thickness T12 detected at step S51 with the reference thickness T3 acquired at step S60, and calculates the difference between the detected thickness T12 and the reference thickness T3 (step S63). The CPU 91 refers to the threshold value table 98, acquires the warning threshold value H1 (step S64), and determines that the absolute value of the difference calculated at step S63 is not equal to or greater than the warning threshold value H1 (no at step S65). The CPU 91 refers to the threshold value table 98, acquires the change threshold value H2 (step S71), and determines that the absolute value of the difference calculated at step S63 is not equal to or greater than the change threshold value H2 (no at step S72). The CPU 91 refers to the threshold value table 98, acquires the enabling threshold value H3 (step S74), and determines that the difference calculated at step S63 is not equal to or greater than the enabling threshold value H3 (no at step S75). The CPU 91 performs notification of a comparison result at step S63 (step S77), ends the during-sewing detection processing, and returns the processing to the sewing processing shown in FIG. 6.

[0046] When the CPU 91 has acquired the detected thickness T13 in the first specific example (step S51, yes at step S53), the CPU 91 determines that the detected thickness has changed (yes at step S56), and issues the warning (step S57). The CPU 91 refers to the setting table 97 and determines that the next setting order is stored in the setting table 97 (yes at step S58), sets the sewing conditions to the sewing conditions corresponding to 3 that is next in the setting order (step S59), and acquires a reference thickness T1 that corresponds to 3 in the setting order (step S60). The CPU 91 compares the detected thickness T13 detected at step S51 with the reference thickness T1 acquired at step S60, and calculates the difference between the detected thickness T13 and the reference thickness T1 (step S63). The CPU 91 refers to the threshold value table 98, acquires the warning threshold value H1 (step S64), and determines that the absolute value of the difference calculated at step S63 is equal to or greater than the warning threshold value H1 (yes at step S65). The CPU 91 issues the warning (step S66), and stores the sewing stop setting in the RAM 93 (step S68). The CPU 91 ends the during-sewing detection processing, and returns the processing to the sewing processing shown in FIG. 6.

[0047] When the CPU 91 has acquired a detected thickness T22 in the second specific example (step S51, yes at step S53), the CPU 91 determines that the detected thickness has not changed (no at step S56), ends the during-sewing detection processing, and returns the processing to the sewing processing shown in FIG. 6. When the CPU 91 has acquired a detected thickness T23 in the second specific example (step S51, yes at step S53), the CPU 91 determines that the detected thickness has changed (yes at step S56), and issues the warning (step S57). The CPU 91 refers to the setting table 97 and determines that the next setting order is not stored in the setting table 97 (no at step S58). The CPU 91 acquires the detected thickness T2 corresponding to the current sewing conditions (step S62). The CPU 91 compares the detected thickness T23 detected at step S51 with the reference thickness T2, and calculates the difference between the detected thickness T23 and the reference thickness T2 (step S63). The CPU 91 refers to the threshold value table 98, acquires the warning threshold value H1 (step S54), and determines that the absolute value of the difference calculated at step S63 is not equal to or greater than the warning threshold value H1 (no at step S65). The CPU 91 refers to the threshold value table 98, acquires the change threshold value H2 (step S71), and determines that the absolute value of the difference calculated at step S63 is equal to or greater than the change threshold value H2 (yes at step S72). As the sewing conditions corresponding to the detected thickness T23 detected at step S51, the CPU 91 changes to the sewing conditions corresponding to the reference thickness T3 that is closest to the detected thickness T23, in the number of layers table 96 (step S73). The CPU 91 refers to the threshold value table 98, acquires the enabling threshold value H3 (step S74), and determines that the difference calculated at step S63 is equal to or greater than the enabling threshold value H3 (yes at step S75). The CPU 91 enables the penetration improvement function (step S76). When the difference calculated at step S63 is not equal to or greater than the enabling threshold value H3 (no at step S75), the CPU 91 may disable the penetration improvement function. The CPU 91 performs the notification of the comparison result at step S63 (step S77), ends the during-sewing detection processing, and returns the processing to the sewing processing shown in FIG. 6.

[0048] After step S13, the CPU 91 returns the processing to step S10. The CPU 91 determines whether or not an operation to turn off the power supply to the sewing device 1 has been detected (step S14). When the operation to turn off the power supply has not been detected (no at step S14), the CPU 91 returns the processing to step S2. When the operation to turn off the power supply has been detected (yes at step S14), the CPU 91 ends the sewing processing.

[0049] In the sewing device 1 of the above-described embodiment, each of the sewing device 1, the needle bar 6, the sewing needle 7, the outer presser bar 10, the outer presser foot 11, the needle plate 14, the drive shaft motor 21, the needle bar mechanism 32, the detector 49, and the storage device 94 is, respectively, an example of a sewing device, a needle bar, a sewing needle, an outer presser bar, an outer presser foot, a needle plate, a drive shaft motor, a needle bar mechanism, a detector, and a storage portion of the present invention. Step S62 is an example of acquisition processing of the present

invention. Step S63 is an example of comparison processing of the present invention. Step S57, step S66, and step S77 are an example of notification control processing of the present invention. Step S64 is an example of warning threshold value acquisition processing of the present invention. Step S71 is an example of change threshold value acquisition processing of the present invention. Step S59 and step S73 are an example of condition changing processing of the present invention. Step S74 is an example of enabling threshold value acquisition processing of the present invention. Step S76 is an example of enabling setting processing of the present invention. Step S68, step S10, and step S11 are an example of sewing stop processing of the present invention. The Step S55 is an example of the sewing stop portion of the present invention. Step S36 is an example of storage control processing of the present invention.

[0050] The sewing device 1 is provided with the needle plate 14, the needle bar 6, the needle bar mechanism 32, the drive shaft motor 21, the outer presser bar 10, the detector 49, and the CPU 91. The sewing object is placed on the needle plate 14. The needle bar 6 extends in the up-down direction, and the sewing needle 7 can be mounted on the lower end thereof. The needle bar mechanism 32 moves the needle bar 6 up and down. The drive shaft motor 21 drives the needle bar mechanism 32. The outer presser foot 11 can be mounted on the lower end of the outer presser bar 10, and the sewing object placed on the needle plate 14 is pressed, from above, by the outer presser foot 11. The detector 49 is configured to detect the detected thickness, which is the thickness of the sewing object pressed by the outer presser foot 11. The CPU 91 acquires the detected thickness detected by the detector 49 (step S51). The CPU 91 acquires the reference thickness, which is the thickness of the one layer or the plurality of layers of the sewing object and which is used as the reference (step S62, step S60). The CPU 91 compares the detected thickness with the reference thickness (step S63). The CPU 91 performs the notification of the comparison result (step S77). Since the sewing device 1 performs the notification of the comparison result between the detected thickness and the reference thickness, the operator can refer to the comparison result notified by the sewing device 1, and, using the comparison result, can verify whether or not the sewing object placed on the needle plate 14 and pressed by the outer presser foot 11 is the sewing object intended by the operator. Thus, compared to known art, the sewing device 1 can improve convenience for the operator when performing the sewing in accordance with the thickness of the sewing object.

[0051] The CPU 91 acquires the warning threshold value H1 to be compared with the difference between the detected thickness and the reference thickness (step S64). When the difference between the detected thickness and the reference thickness is equal to or greater than the warning threshold value H1 (yes at step S65), the CPU 91 issues the warning (step S66). By setting the warning threshold value H1 as appropriate, the sewing device 1 can notify the operator that the sewing object of a thickness not intended by the operator is placed on the needle plate 14. By referring to the warning, the operator can avoid sewing the sewing object that is not intended by the operator.

[0052] The CPU 91 acquires the change threshold value H2 that is smaller than the warning threshold value H1 (step S71). When the difference between the detected thickness and the reference thickness is smaller than the warning threshold value H1 (no at step S65), and is equal to or greater than the change threshold value H2 (yes at step S72), the CPU 91 changes the sewing conditions in accordance with the detected thickness (step S73). By setting the warning threshold value H1 and the change threshold value H2 as appropriate, the sewing device 1 can automatically change the sewing conditions in accordance with the detected thickness, when the difference between the reference thickness and the detected thickness is not large enough to issue the warning but it is not appropriate for the operator to perform the sewing using the sewing conditions set based on the reference thickness. The sewing device 1 can reduce an amount of time and effort required for the operator to change the sewing conditions during the sewing. The sewing device 1 can set the thread tension in accordance with the detected thickness, and thus, can perform the sewing while taking into account a degree of friction between the sewing obj ect and the upper thread that accords with the thickness of the sewing obj ect. The sewing device 1 sets the pressing pressure in accordance with the detected thickness and can thus perform the sewing while appropriately pressing the sewing object. The sewing device 1 sets the alternating vertical movement amount in accordance with the detected thickness and can thus reduce the possibility of not being able to surmount a stepped portion, and can suppress the occurrence of noise resulting from an impact between the stepped portion and the outer presser foot 11. The sewing device 1 adjusts the number of revolutions of the drive shaft motor 21 in accordance with the detected thickness and can thus increase the possibility that the sewing is completed in an assumed operation time.

[0053] The sewing device 1 acquires the enabling threshold value H3 that is smaller than the warning threshold value H1 (step S74). When the difference between the reference thickness and the detected thickness is smaller than the warning threshold value H1 (no at step S65) and the difference that is the value obtained by subtracting the reference thickness from the detected thickness is equal to or greater than the enabling threshold value H3 (yes at step S75), the sewing device 1 enables the penetration improvement function, which improves the penetration of the sewing object by the sewing needle 7 (step S76), by driving the drive shaft motor 21 using the conduction pattern that is different to when sewing the sewing object of the reference thickness. In general, when the penetration of the needle bar 6 with respect

to the sewing object is insufficient, the sewing needle 7 cannot penetrate the sewing object and a sewing defect occurs. When the penetration of the needle bar 6 with respect to the sewing order is excessive, noise increases, which is unpleasant for the operator. By setting the warning threshold value H1 and the enabling threshold value H3 as appropriate, the sewing device 1 can automatically enable the penetration improvement function when the difference between the reference thickness and the detected thickness is not large enough to issue the warning, but it is difficult for the sewing needle 7 to penetrate the sewing object when the sewing is performed using the sewing conditions set based on the reference thickness. The sewing device 1 can reduce an amount of time and effort required for the operator to enable the penetration improvement function during the sewing. The sewing device 1 can suppress a deterioration in sewing quality caused by a lack of penetration of the needle bar 6.

[0054] When the difference between the reference thickness and the detected thickness acquired during the driving of the drive shaft motor 21 is equal to or greater than the warning threshold value H1, the sewing device 1 stops the driving of the drive shaft motor 21 (step S68, yes at step S10, step S11). By setting the warning threshold value H1 as appropriate, the sewing device 1 can avoid continuing to sew the sewing object of the thickness that is not intended by the operator.

[0055] The CPU 91 of the sewing device 1 detects the detected thickness before starting the driving of the drive shaft motor 21 based on the detection result of the detector 49 (step S51 in FIG. 8), and performs notification of the comparison result of the reference thickness with the detected thickness detected before the start of the driving of the drive shaft motor 21 (step S77 in FIG. 8). The operator can refer to the comparison result notified by the sewing device 1, and, using the comparison result by the sewing device 1, can verify before performing the sewing whether or not the sewing object placed on the needle plate 14 and pressed by the outer presser foot 11 is the sewing object intended by the operator. Thus, compared to known art, the sewing device 1 can further improve convenience for the operator when performing the sewing in accordance with the thickness of the sewing object.

[0056] The CPU 91 of the sewing device 1 detects the detected thickness during the driving of the drive shaft motor 21 based on the detection result of the detector 49 (step S51 in FIG. 9), and issues the warning when the detected thickness detected during the driving of the drive shaft motor 21 has changed (yes at step S56, step S57). When the detected thickness detected during the driving of the drive shaft motor 21 has changed, the sewing device 1 can let the operator know through the notification. The operator can refer to the notification by the sewing device 1 and can respond appropriately in accordance with whether or not the change in the detected thickness is intended by the operator. For example, as a result of the warning issued by the sewing device 1, the operator can ascertain that the sewing object has unintentionally been removed from between the needle plate 14 and the outer presser foot 11. For example, as a result of the warning issued by the sewing device 1, the operator can notice that the sewing object is being sewn while being unintentionally folded over.

[0057] The CPU 91 of the sewing device 1 detects the detected thickness during the driving of the drive shaft motor 21 based on the detection result of the detector 49 (step S51 in FIG. 9), and, when the detected thickness detected during the driving of the drive shaft motor 21 has changed (yes at step S56), the CPU 91 changes the sewing conditions in accordance with the detected thickness (step S59, step S73). When the detected thickness has changed during the driving of the drive shaft motor 21, the sewing device 1 can automatically change the sewing conditions in accordance with the detected thickness. The sewing device 1 can reduce an amount of time and effort required for the operator to change the sewing conditions during the sewing.

[0058] The CPU 91 of the sewing device 1 detects the detected thickness during the driving of the drive shaft motor 21 based on the detection result of the detector 49 (step S51 in FIG. 9), and, when the detected thickness detected during the driving of the drive shaft motor 21 is smaller than a predetermined value (no at step S53), the CPU 91 performs the notification that the sewing object is not present between the needle plate 14 and the outer presser foot 11 (step S54). Further, when the detected thickness detected during the driving of the drive shaft motor 21 is smaller than the predetermined value, the CPU 91 stops the driving of the drive shaft motor 21 (step S55). The sewing device 1 can perform the notification that the sewing object is not present between the needle plate 14 and the outer presser foot 11 and stop the driving of the drive shaft motor 21. The sewing device 1 can avoid continuation of the driving of the drive shaft motor 21 after sewing to the end of the sewing object.

[0059] The CPU 91 of the sewing device 1 acquires the plurality of reference thicknesses of the setting order during the driving of the drive shaft motor 21 (step S60), and, when the detected thickness detected during the driving of the drive shaft motor 21 has changed, the CPU 91 compares the detected thickness with the reference thickness that is next in the setting order (step S63). When the difference between the detected thickness and the reference thickness that is next in the setting order is equal to or greater than the warning threshold value H1 (yes at step S65), the CPU 91 issues the warning (step S66). When sewing the sewing object for which the thickness changes during the sewing, the sewing device 1 can prevent a location at which the thickness changes from being detected as an abnormality. When the sewing device 1 has detected the change in the detected thickness, the sewing device 1 compares the reference thickness that is next in the setting order with the detected thickness, and can thus also appropriately compare the reference thickness and the detected thickness during

the sewing of the sewing object for which the thickness changes during the sewing. By referring to the notification result of the sewing device 1, the operator can notice, even when repeatedly sewing the same sewing pattern many times, for example, that the sewing object has been removed from between the needle plate 14 and the outer presser foot 11, that the sewing has been performed in a state in which the sewing object is folded over unintentionally, that the sewing has been performed erroneously using a plurality of layers of the sewing object, that the type of the sewing object is wrong, or the like.

[0060] The sewing device 1 is provided with the storage device 94 that stores a plurality of combinations of the reference thickness during the driving of the drive shaft motor 21 and the setting order. The CPU 91 acquires the plurality of combinations stored in the setting table 97 of the storage device 94, in the setting order (step S60). When sewing the sewing object for which the thickness changes during the sewing, as in the first specific example shown in FIG. 10, the sewing device 1 can avoid detecting the location at which the thickness changes as an abnormality. When the sewing device 1 detects the change in the detected thickness, the sewing device 1 compares the reference thickness that is next in the setting order with the detected thickness, and thus can also appropriately compare the reference thickness with the detected thickness when sewing the sewing object for which the thickness changes during the sewing.

[0061] The CPU 91 of the sewing device 1 sets the detected thickness detected by the detector 49 as the reference thickness (step S23), and stores the plurality of combinations of the reference thickness and the setting order in the storage device 94 (step S25). The sewing device 1 can store the plurality of combinations of the reference thickness and the setting order, using the detected thickness detected by the detector 49 as the reference thickness. Compared to a device that acquires combinations of the reference thickness and the setting order from another device, the sewing device 1 can reduce an impact of a mounting error of the detector 49 with respect to the sewing device 1 or the like.

[0062] The present invention is not limited to the above-described embodiment. The type of the sewing device 1 may be changed as appropriate, such as a lock stitch sewing machine, a vertical feed sewing machine, or the like. The sewing device 1 need not necessarily be provided with the center presser bar and the center presser foot. The method of detecting the thickness of the sewing object by the detector 49 may be changed as appropriate, and the detector 49 may be a proximity displacement sensor that is one of an optical type, an eddy-current type, an ultrasonic type, or a contact type, for example. The placement of the detector 49 and the detection timing may be changed as appropriate.

[0063] The program including the instructions to cause the sewing processing, to be executed may be stored in the storage device 94 of the sewing device 1 until the CPU 91 executes the program. Therefore, an acquisition method of the program, an acquisition route, and the device that stores the program may each be changed as appropriate. The program to be executed by the CPU 91 may be received from another device via a cable or wireless communication, and may be stored in a storage device, such as a flash memory. Examples of the other device include a PC and a server connected via a network.

[0064] A part or all of the respective steps of the main processing performed by the sewing device 1 may be performed by another electronic device (an ASIC, for example). The respective steps may be performed through distributed processing by a plurality of electronic devices (a plurality of CPUs, for example). The respective steps performed by the sewing device 1 can be changed in order, omitted or added, as necessary. An aspect in which an operating system (OS) or the like operating on the sewing device 1 performs a part or all of the main processing on the basis of a command from the CPU 91 is also included in the scope of the present disclosure. For example, the following modifications may be added to the main processing, as appropriate.

[0065] The sewing device 1 may or may not change the sewing conditions in accordance with the detected thickness of the sewing object. The sewing device 1 may enable the penetration improvement function in accordance with the detected thickness of the sewing object, may disable the penetration improvement function, or may not change the setting. When the sewing device 1 changes the sewing conditions in accordance with the detected thickness of the sewing object, the sewing conditions that are the target of the change may be changed as appropriate in accordance with the configuration of the sewing device 1. The sewing device 1 may issue the comparison result and the warning using a desired method, such as a voice output, a warning illumination, or the like. The method of setting at least one of the number of layers table 96, the setting table 97, and the threshold value table 98 may be changed as appropriate. The sewing device 1 may change or omit the processing using at least one of the warning threshold value H1, the change threshold value H2, the enabling threshold value H3, the thickness threshold value, and the thickness change threshold value. The sewing device 1 may omit the processing at step S68 shown in FIG. 9, for example, and when the absolute value of the difference between the detected thickness and the reference thickness is equal to or greater than the warning threshold value H1 (yes at step S65), the sewing device 1 may issue the warning only (step S66) and need not necessarily stop the sewing. The method of setting at least one of the warning threshold value H1, the change threshold value H2, the enabling threshold value H3, the thickness threshold value, and the thickness change threshold value may be changed as appropriate. At least one of the warning threshold value H1, the change threshold value H2, the enabling threshold value H3, and the thickness change threshold value may be a value that changes in accordance with the detected thickness or the reference

thickness, may be a value represented by a mathematical formula, may be a value stored in advance in a table, or may be a value input by the operator.

[0066] The sewing device 1 may omit the processing at step S55 shown in FIG. 9, for example, and when the detected thickness is not equal to or greater than the thickness threshold value (no at step S53), the sewing device 1 may issue the warning only (step S54) and need not necessarily stop the sewing. The sewing device 1 may acquire the detected thickness at one of only before the sewing and during the sewing, and may compare the detected thickness with the reference thickness. The sewing device 1 may omit the processing at step S56 and need not necessarily detect whether or not the detected thickness has changed during the sewing. The sewing device 1 may omit the processing at step S53 to step S55, and need not necessarily detect that the sewing object is not present between the needle plate 14 and the outer presser foot 11, nor perform the notification. The sewing device 1 need not necessarily store the setting table 97, and may omit the processing at step S58 to step S60. The sewing device 1 need not necessarily perform some or all of the setting processing shown in FIG. 7, and may, for example, set the reference thickness as the detection result of the input portion 16. The sewing device 1 may detect the detected thickness during the sewing of the sewing object at a predetermined timing at at least one of step S23 and step S35. At this time, since the detected thickness changes in accordance with the sewing conditions of the sewing device 1, the CPU 91 may store the sewing conditions together with the detected thickness at step S25 and step S36. The sewing conditions may be selected as appropriate, for example, from among the following conditions: a number of needles, the presence or absence of a temporary stop, the presence or absence of a thread breakage, a change in a feed amount, the presence or absence of a reverse rotation of the rotation direction of the drive shaft 31, a change in the thread tension, a change in the pressing pressure, a change in the alternating vertical movement amount, and a change in the number of revolutions.

Claims

1. A sewing device (1) comprising:

a needle plate (14) on which a sewing object is to be placed;
a needle bar (6) extending in an up-down direction and on a lower end of which a sewing needle is mountable;
a needle bar mechanism (32) configured to move the needle bar up and down;
a drive shaft motor (21) configured to drive the needle bar mechanism;
a presser bar (8) on a lower end of which a presser foot is mountable, and configured to press, using the presser foot, the sewing object placed on the needle plate, from above;
a detector (49) configured to detect a detected thickness, the detected thickness being a thickness of the sewing object pressed by the presser foot;
a processor (91); and
a memory (94) configured to store computer-readable instructions that, when executed by the processor, instruct the processor to perform processes comprising:

detection processing (S51) of acquiring the detected thickness detected by the detector;
acquisition processing (S62) of acquiring a reference thickness, the reference thickness being a thickness of one of one layer of the sewing object and a plurality of layers of the sewing object used as a reference;
comparison processing (S63) of comparing the detected thickness and the reference thickness; and
notification control processing (S57, S66, S77) of notifying a comparison result of the comparison processing.

2. The sewing device according to claim 1, wherein
the computer-readable instructions further instruct the processor to perform a process comprising:
warning threshold value acquisition processing (S64) of acquiring a warning threshold value to be compared with a difference between the detected thickness and the reference thickness, and
the notification control processing includes issuing a warning when the difference between the detected thickness and the reference thickness is equal to or greater than the warning threshold value.

3. The sewing device according to claim 2, wherein
the computer-readable instructions further instruct the processor to perform processes comprising:

change threshold value acquisition processing (S71) of acquiring a change threshold value smaller than the warning threshold value; and
condition changing processing (S73) of changing sewing conditions in accordance with the detected thickness when the difference between the reference thickness and the detected thickness is smaller than the warning threshold value and is equal to or greater than the change threshold value.

4. The sewing device according to claim 2 or 3, wherein
the computer-readable instructions further instruct the processor to perform processes comprising:

enabling threshold value acquisition processing (S74) of acquiring an enabling threshold value smaller than the warning threshold value; and
enabling setting processing (S76) of enabling a penetration improvement function for improving penetration of the sewing object by the sewing needle, by driving the drive shaft motor using an conduction pattern different from when sewing the sewing object of the reference thickness, when the difference between the reference thickness and the detected thickness is smaller than the warning threshold value, and a value obtained by subtracting the reference thickness from the detected thickness is smaller than the enabling threshold value.

5. The sewing device according to any one of claims 2 through 4, wherein
the computer-readable instructions further instruct the processor to perform a process comprising:
sewing stop processing (S68, S10, S11) of stopping the driving of the drive shaft motor when the different between the reference thickness and the detected thickness acquired during the driving of the drive shaft motor is equal to or greater than the warning threshold value.

6. The sewing device according to claim 1, wherein
the detection processing includes detecting the detected thickness before a start of the driving of the drive shaft motor, and
the notification control processing includes performing the notification of the comparison result between the reference thickness and the detected thickness detected before the start of the driving of the drive shaft motor.

7. The sewing device according to claim 6, wherein
the detection processing includes detecting the detected thickness during driving of the drive shaft motor, and
the notification control processing includes issuing a warning when the detected thickness detected during the driving of the drive shaft motor changes.

8. The sewing device according to claim 6 or 7, wherein
the detection processing includes detecting the detected thickness during the driving of the drive shaft motor, and
the computer-readable instructions further instruct the processor to perform a process comprising:
condition changing processing (S59) of changing sewing conditions in accordance with the detected thickness when the detected thickness detected during the driving of the drive shaft motor changes.

9. The sewing device according to any one of claims 6 through 8, wherein
the detection processing includes detecting the detected thickness during the driving of the drive shaft motor,
the notification control processing includes performing notification that the sewing object is not present between the needle plate and the presser foot when the detected thickness detected during the driving of the drive shaft motor is smaller than a predetermined value, and
the computer-readable instructions further instruct the processor to perform a process comprising:
sewing stop processing (S55) of stopping the driving of the drive shaft motor when the detected thickness detected during the driving of the drive shaft motor is smaller than the predetermined value.

10. The sewing device according to claim 1, wherein
the computer-readable instructions further instruct the processor to perform a process comprising:
warning threshold value acquisition processing (S64) of acquiring a warning threshold value used in comparing a difference between the detected thickness and the reference thickness,
the acquisition processing includes acquiring a plurality of reference thicknesses during the driving of the drive shaft motor in a setting order,
the comparison processing includes comparing the detected thickness and the reference thickness that is next in the setting order when the detected thickness detected during the driving of the drive shaft motor changes, and
the notification control processing includes issuing a warning when the difference between the detected thickness and the reference thickness that is next in the setting order is equal to or greater than the warning threshold value.

11. The sewing device according to claim 10, wherein
the memory stores a plurality of combinations of the reference thickness during the driving of the drive shaft motor and the setting order, and
the acquisition processing includes acquiring, in the setting order, the plurality of combinations stored in the memory.

12. The sewing device according to claim 11, wherein
the computer-readable instructions further instruct the processor to perform a process comprising:
storage control processing (S36) of setting the detected thickness detected by the detector as the reference thickness, and storing the plurality of combinations of the reference thickness and the setting order in the memory.

FIG. 1

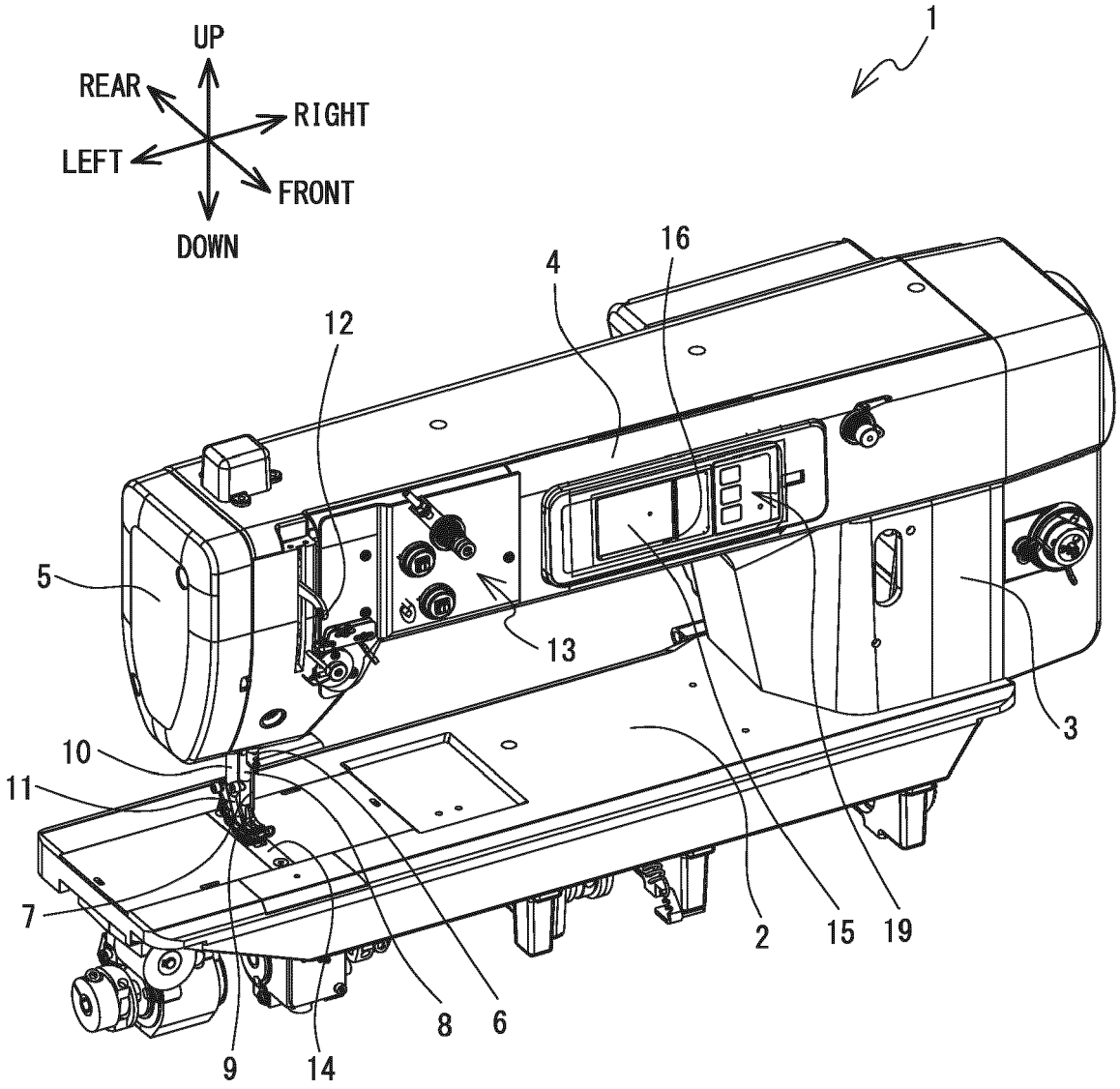
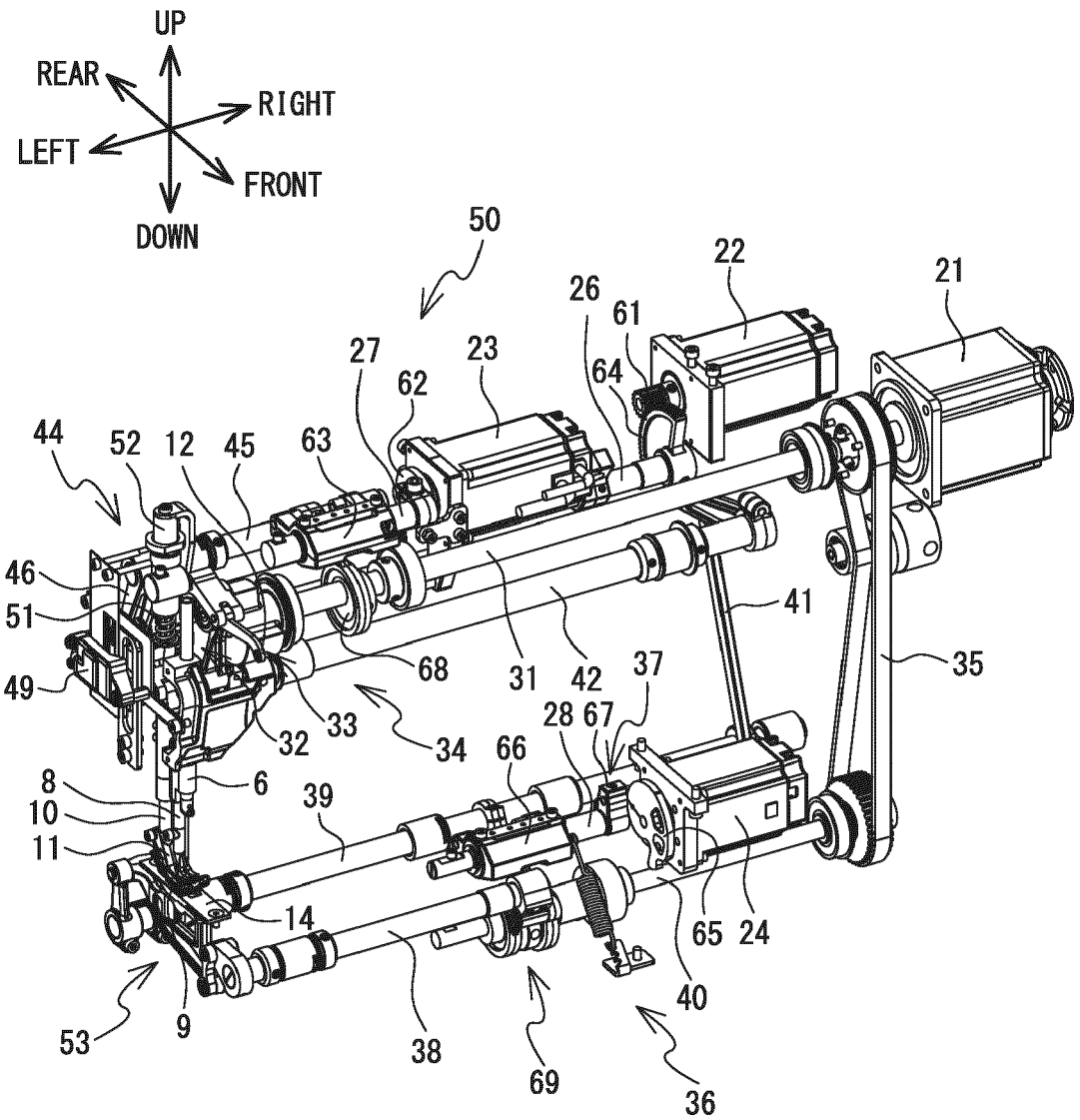


FIG. 2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62
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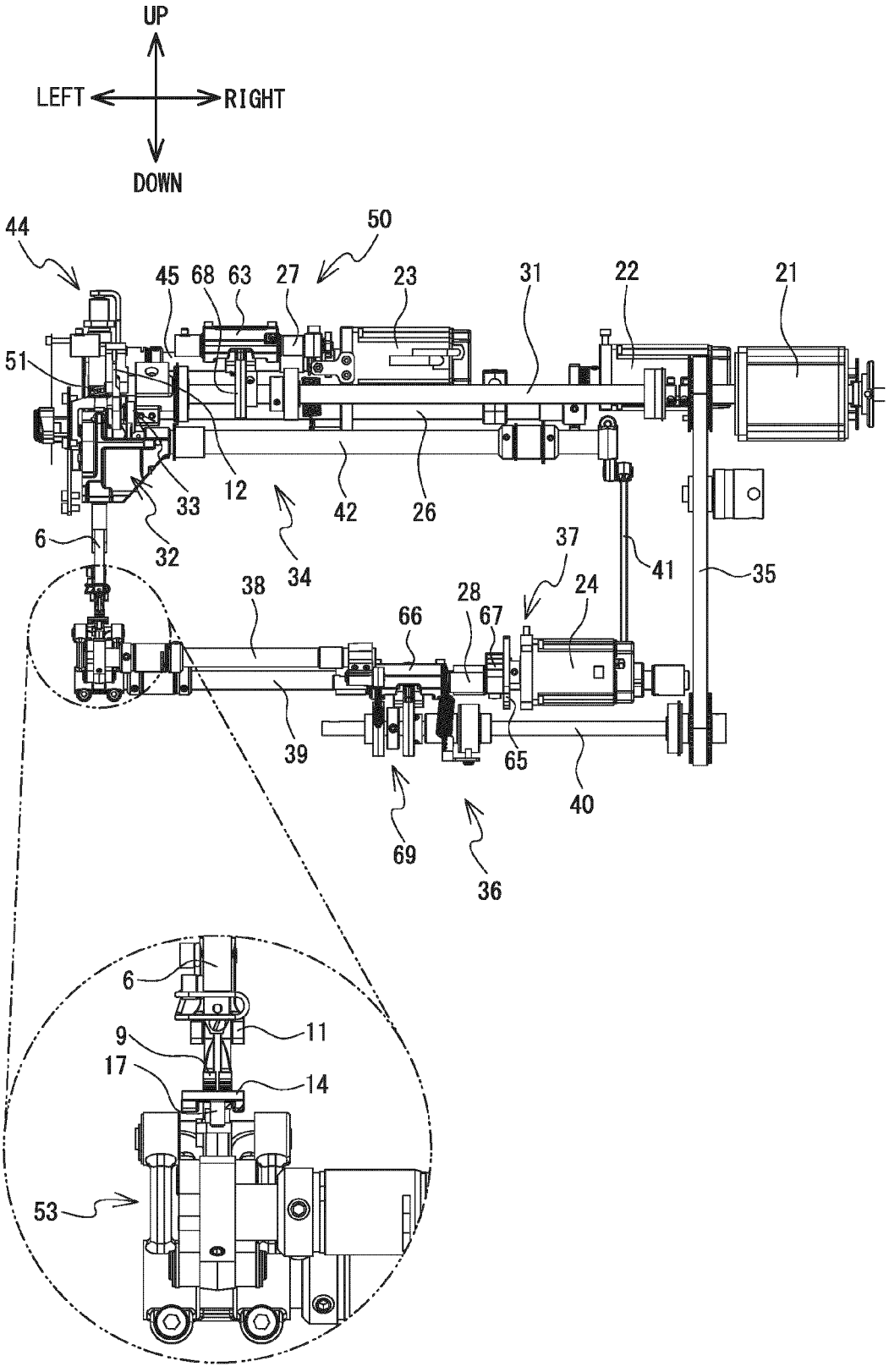
63
46
51
41
49
68
31
42
37
35
28
67
32
33
34
66
8
6
39
10
11
14
65
24
40
53
9
38
69
36

FIG. 3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37
41
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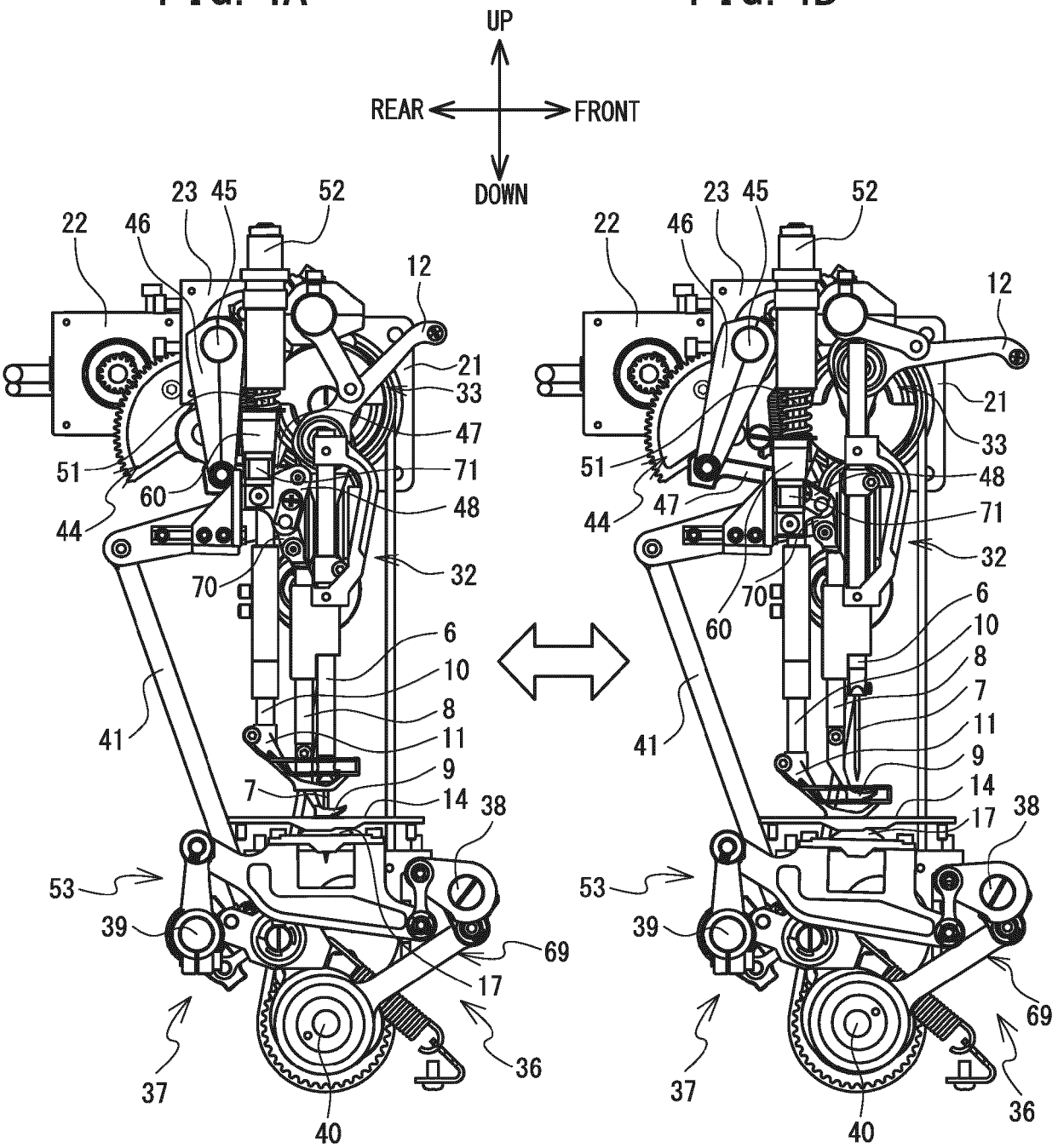
17
14
53

FIG. 4A

FIG. 4B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40

FIG. 5

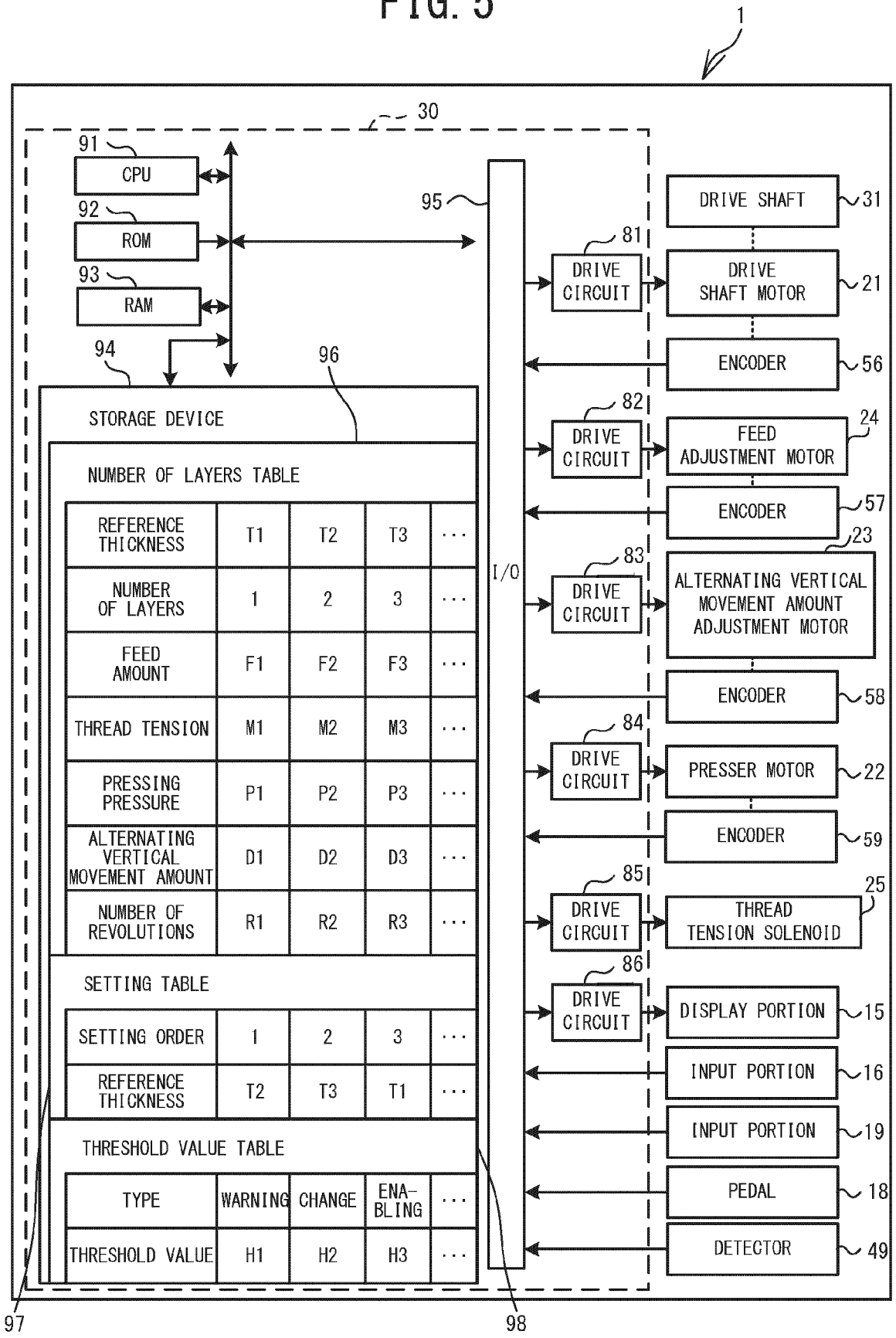

1
30
91
CPU
92
ROM
93
RAM
94
95
96
STORAGE DEVICE
NUMBER OF LAYERS TABLE
REFERENCE THICKNESS
T1
T2
T3
NUMBER OF LAYERS
1
2
3
FEED AMOUNT
F1
F2
F3
THREAD TENSION
M1
M2
M3
PRESSING PRESSURE
P1
P2
P3
ALTERNATING VERTICAL MOVEMENT AMOUNT
D1
D2
D3
NUMBER OF REVOLUTIONS
R1
R2
R3
SETTING TABLE
SETTING ORDER
1
2
3
REFERENCE THICKNESS
T2
T3
T1
THRESHOLD VALUE TABLE
TYPE
WARNING
CHANGE
ENA-BLING
THRESHOLD VALUE
H1
H2
H3
I/O
81
DRIVE CIRCUIT
DRIVE SHAFT
31
DRIVE SHAFT MOTOR
21
ENCODER
56
82
DRIVE CIRCUIT
FEED ADJUSTMENT MOTOR
24
ENCODER
57
83
DRIVE CIRCUIT
23
ALTERNATING VERTICAL MOVEMENT AMOUNT ADJUSTMENT MOTOR
ENCODER
58
84
DRIVE CIRCUIT
PRESSER MOTOR
22
ENCODER
59
85
DRIVE CIRCUIT
25
THREAD TENSION SOLENOID
86
DRIVE CIRCUIT
DISPLAY PORTION
15
INPUT PORTION
16
INPUT PORTION
19
PEDAL
18
DETECTOR
49
97
98

FIG. 6

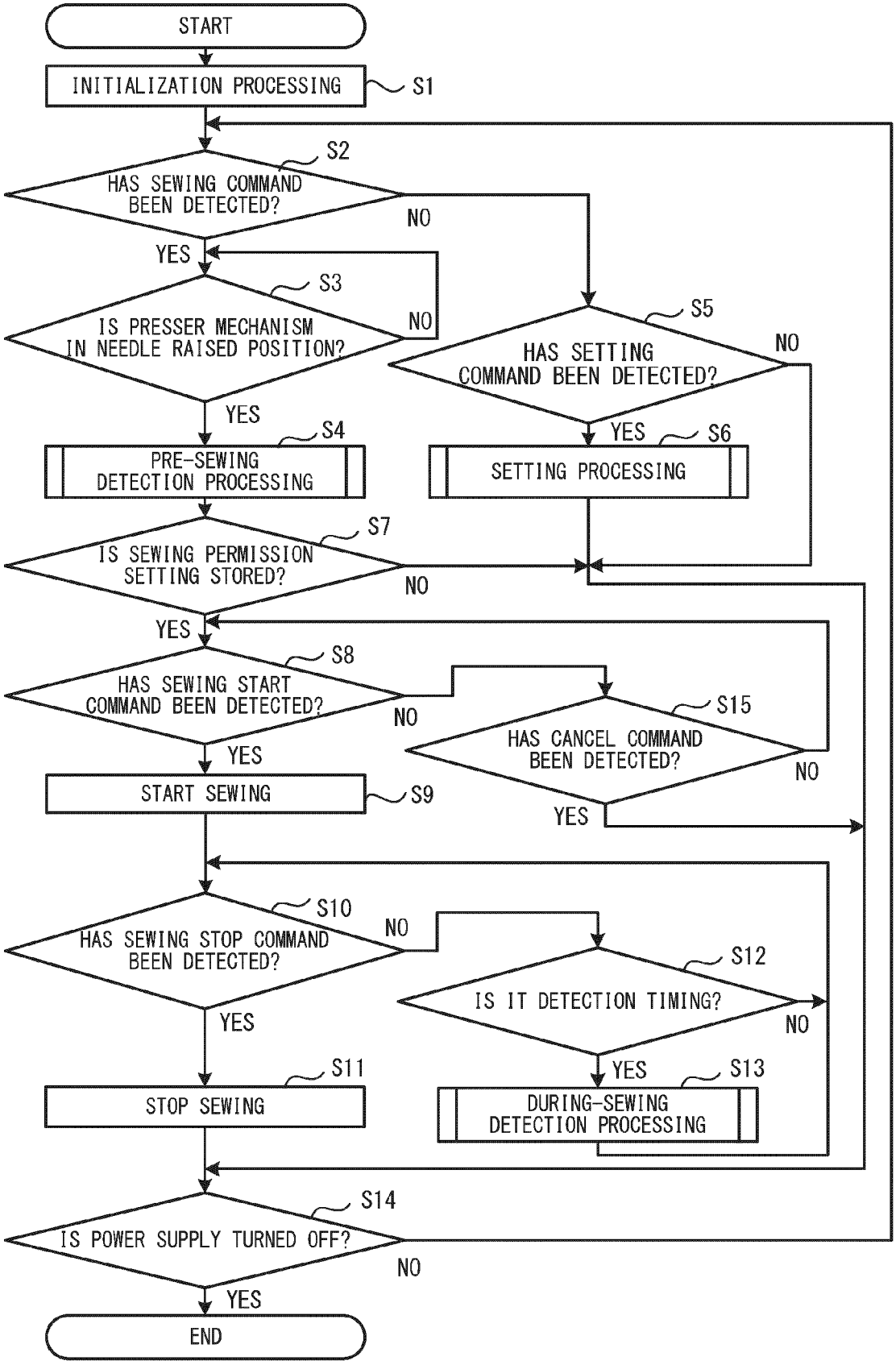

START
INITIALIZATION PROCESSING
S1
S2
HAS SEWING COMMAND BEEN DETECTED?
NO
YES
S3
IS PRESSER MECHANISM IN NEEDLE RAISED POSITION?
NO
YES
S4
PRE-SEWING DETECTION PROCESSING
S5
HAS SETTING COMMAND BEEN DETECTED?
NO
YES
S6
SETTING PROCESSING
S7
IS SEWING PERMISSION SETTING STORED?
NO
YES
S8
HAS SEWING START COMMAND BEEN DETECTED?
NO
YES
S15
HAS CANCEL COMMAND BEEN DETECTED?
NO
YES
START SEWING
S9
S10
HAS SEWING STOP COMMAND BEEN DETECTED?
NO
YES
S12
IS IT DETECTION TIMING?
NO
YES
S11
STOP SEWING
S13
DURING-SEWING DETECTION PROCESSING
S14
IS POWER SUPPLY TURNED OFF?
NO
YES
END

FIG. 7

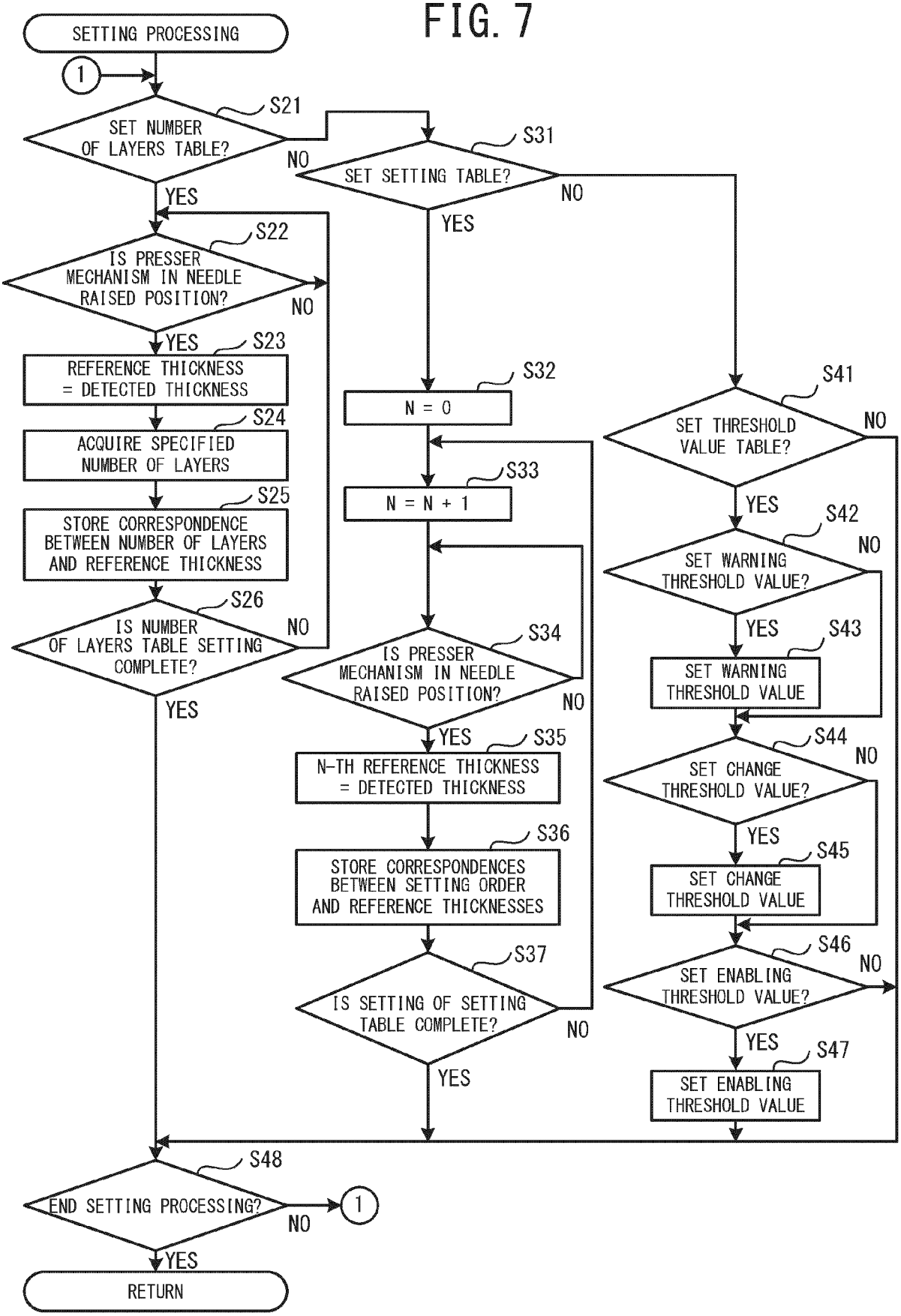

SETTING PROCESSING
1
S21
SET NUMBER OF LAYERS TABLE?
NO
YES
S31
SET SETTING TABLE?
NO
YES
S22
IS PRESSER MECHANISM IN NEEDLE RAISED POSITION?
NO
YES
S23
REFERENCE THICKNESS = DETECTED THICKNESS
S24
ACQUIRE SPECIFIED NUMBER OF LAYERS
S25
STORE CORRESPONDENCE BETWEEN NUMBER OF LAYERS AND REFERENCE THICKNESS
S26
IS NUMBER OF LAYERS TABLE SETTING COMPLETE?
NO
YES
S32
N = 0
S33
N = N + 1
S34
IS PRESSER MECHANISM IN NEEDLE RAISED POSITION?
NO
YES
S35
N-TH REFERENCE THICKNESS = DETECTED THICKNESS
S36
STORE CORRESPONDENCES BETWEEN SETTING ORDER AND REFERENCE THICKNESSES
S37
IS SETTING OF SETTING TABLE COMPLETE?
NO
YES
S41
SET THRESHOLD VALUE TABLE?
NO
YES
S42
SET WARNING THRESHOLD VALUE?
NO
YES
S43
SET WARNING THRESHOLD VALUE
S44
SET CHANGE THRESHOLD VALUE?
NO
YES
S45
SET CHANGE THRESHOLD VALUE
S46
SET ENABLING THRESHOLD VALUE?
NO
YES
S47
SET ENABLING THRESHOLD VALUE
S48
END SETTING PROCESSING?
NO
1
YES
RETURN

FIG. 8

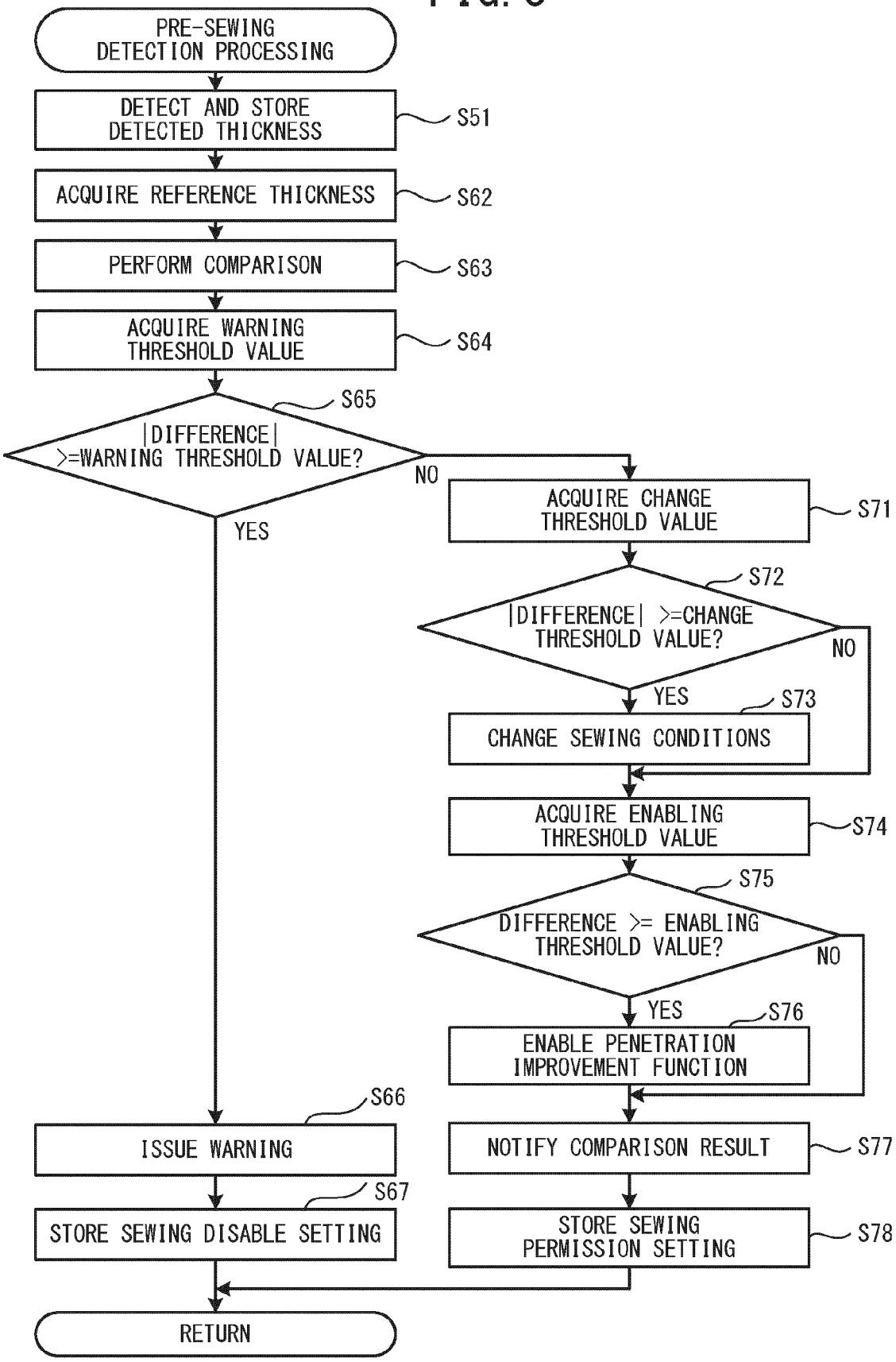

PRE-SEWING DETECTION PROCESSING
DETECT AND STORE DETECTED THICKNESS
S51
ACQUIRE REFERENCE THICKNESS
S62
PERFORM COMPARISON
S63
ACQUIRE WARNING THRESHOLD VALUE
S64
S65
|DIFFERENCE| >=WARNING THRESHOLD VALUE?
NO
YES
ACQUIRE CHANGE THRESHOLD VALUE
S71
S72
|DIFFERENCE| >=CHANGE THRESHOLD VALUE?
NO
YES
S73
CHANGE SEWING CONDITIONS
ACQUIRE ENABLING THRESHOLD VALUE
S74
S75
DIFFERENCE >= ENABLING THRESHOLD VALUE?
NO
YES
S76
ENABLE PENETRATION IMPROVEMENT FUNCTION
S66
ISSUE WARNING
NOTIFY COMPARISON RESULT
S77
S67
STORE SEWING DISABLE SETTING
STORE SEWING PERMISSION SETTING
S78
RETURN

FIG. 9

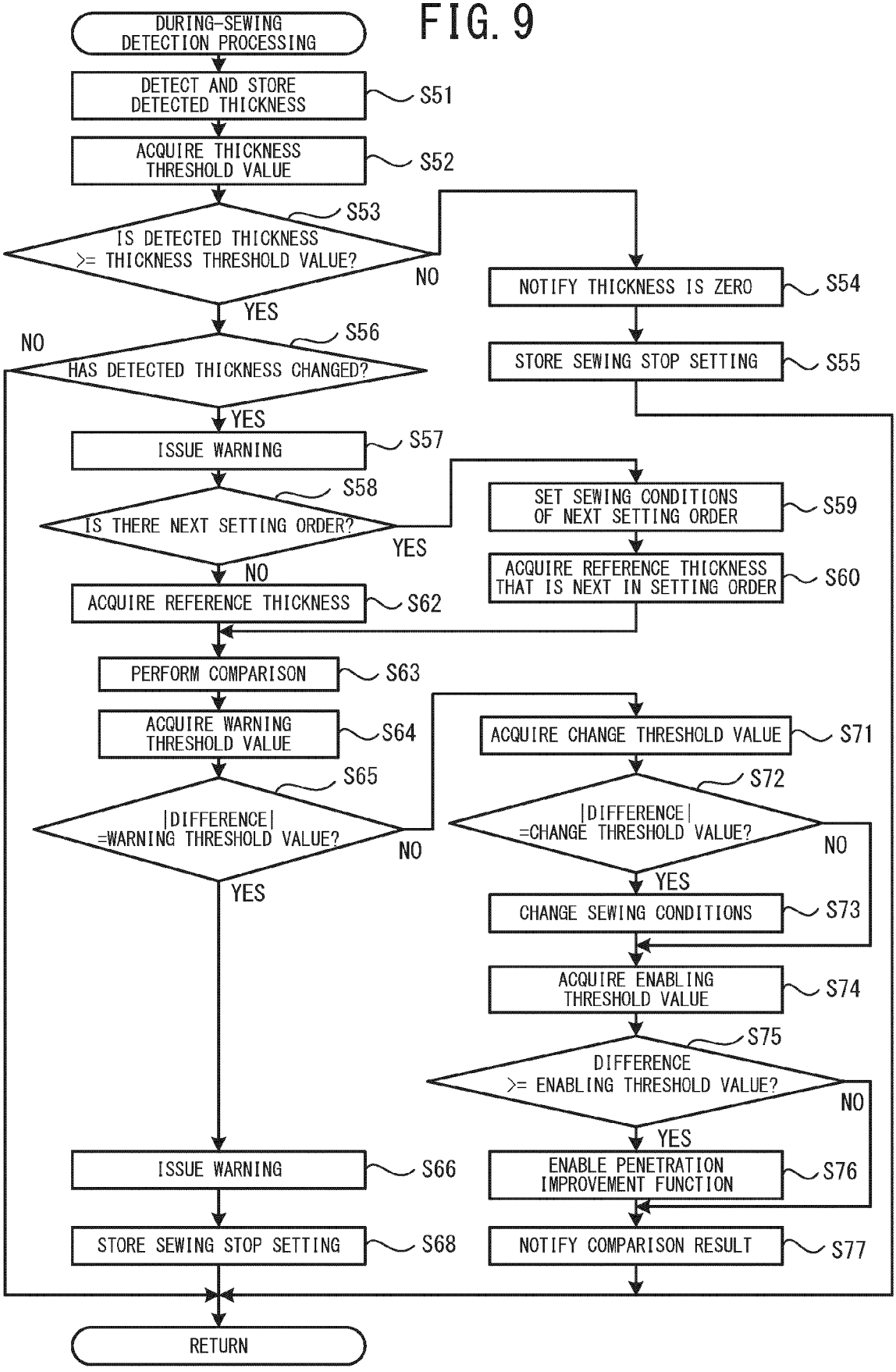

DURING-SEWING DETECTION PROCESSING
DETECT AND STORE DETECTED THICKNESS
S51
ACQUIRE THICKNESS THRESHOLD VALUE
S52
S53
IS DETECTED THICKNESS >= THICKNESS THRESHOLD VALUE?
NO
YES
NOTIFY THICKNESS IS ZERO
S54
STORE SEWING STOP SETTING
S55
NO
S56
HAS DETECTED THICKNESS CHANGED?
YES
ISSUE WARNING
S57
S58
IS THERE NEXT SETTING ORDER?
YES
NO
SET SEWING CONDITIONS OF NEXT SETTING ORDER
S59
ACQUIRE REFERENCE THICKNESS THAT IS NEXT IN SETTING ORDER
S60
ACQUIRE REFERENCE THICKNESS
S62
PERFORM COMPARISON
S63
ACQUIRE WARNING THRESHOLD VALUE
S64
S65
|DIFFERENCE| =WARNING THRESHOLD VALUE?
NO
YES
ACQUIRE CHANGE THRESHOLD VALUE
S71
S72
|DIFFERENCE| =CHANGE THRESHOLD VALUE?
NO
YES
CHANGE SEWING CONDITIONS
S73
ACQUIRE ENABLING THRESHOLD VALUE
S74
S75
DIFFERENCE >= ENABLING THRESHOLD VALUE?
NO
YES
ISSUE WARNING
S66
ENABLE PENETRATION IMPROVEMENT FUNCTION
S76
STORE SEWING STOP SETTING
S68
NOTIFY COMPARISON RESULT
S77
RETURN

FIG. 10

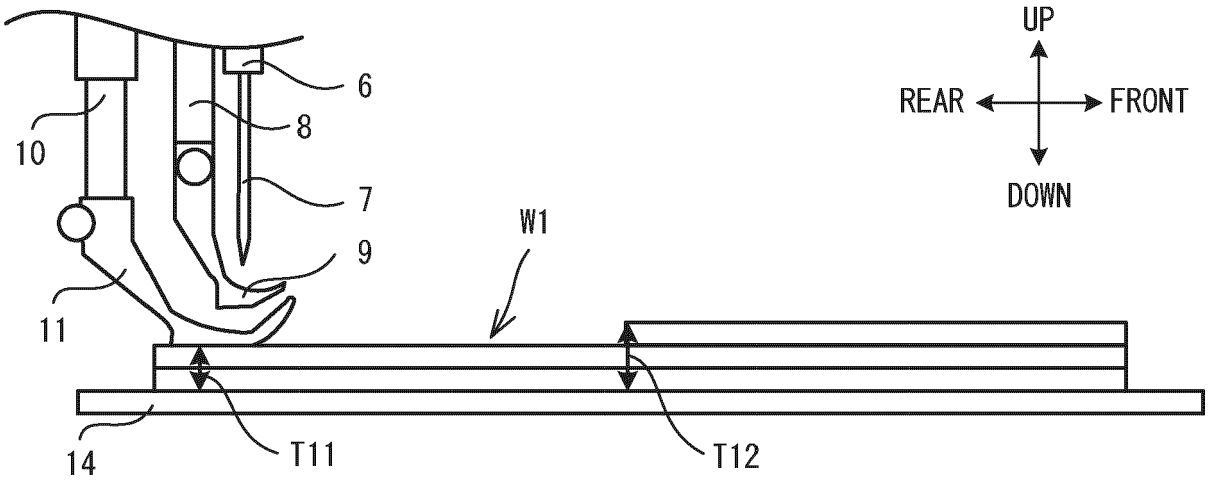
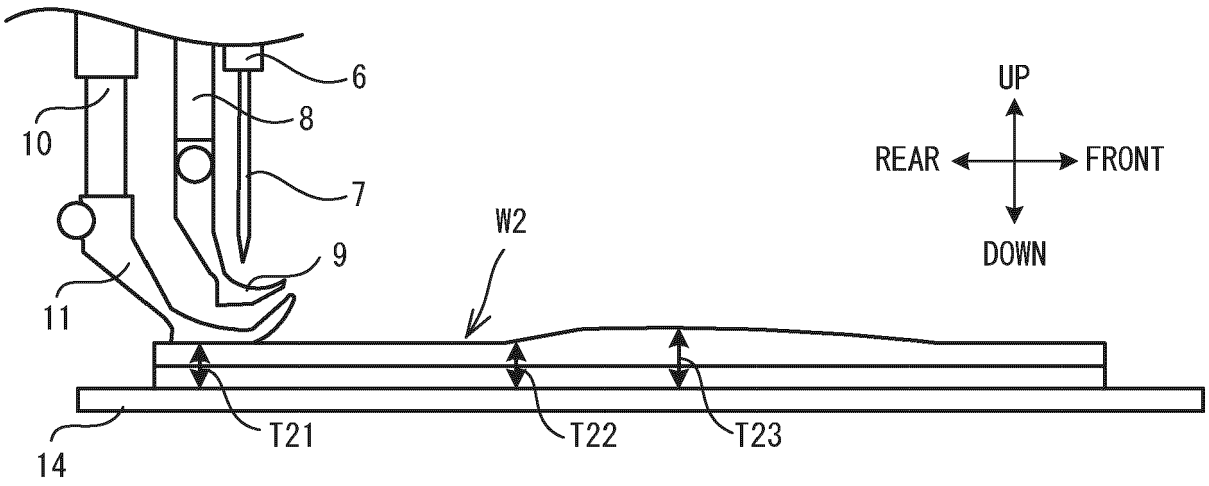


FIG. 11



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EUROPEAN SEARCH REPORT

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X	US 2019/352823 A1 (TACHIKAWA MITSUHIRO [JP] ET AL) 21 November 2019 (2019-11-21) * abstract * * claims 1-5 * * figures 1-4,8-10 * * paragraph [0001] - paragraph [0020] * * paragraph [0021] - paragraph [0024] * * paragraph [0029] * * paragraph [0030] * * paragraph [0043] - paragraph [0047] * * paragraph [0105] - paragraph [0107] * * paragraph [0117] * * paragraph [0123] - paragraph [0126] * * paragraph [0144] - paragraph [0160] * * paragraph [0168] - paragraph [0171] * * paragraph [0162] - paragraph [0164] * -----	1,6-12	TECHNICAL FIELDS SEARCHED (IPC) D05B

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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	Heinzelmann, Eric

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DOCUMENTS CONSIDERED TO BE RELEVANT

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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	Heinzelmann, Eric

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