



(11) **EP 2 163 671 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention
of the grant of the patent:
11.11.2015 Bulletin 2015/46

(51) Int Cl.:
D05B 3/06 (2006.01) **D05B 37/00** (2006.01)
G01L 1/00 (2006.01)

(21) Application number: **09169836.5**

(22) Date of filing: **09.09.2009**

(54) **Buttonholing machine**

Knopflochmaschine

Machine pour boutonsnières

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL
PT RO SE SI SK SM TR**

(30) Priority: **10.09.2008 JP 2008231695**

(43) Date of publication of application:
17.03.2010 Bulletin 2010/11

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Description

[0001] The present invention relates to a buttonholing machine which forms a buttonhole through a workpiece by cutting the workpiece by means of a knife and a hammer.

[0002] Buttonholing machines are capable of forming a buttonhole between right and left side stitching sections, before or after forming buttonhole stitches, including the right and left side stitching sections, on a workpiece.

[0003] For example, as shown in Fig. 8, a buttonholing machine 100 has a feed table 102 which is provided so as to be movable along an upper surface of a bed portion 101 of the buttonholing machine 100. A cloth presser 103 is provided on an upper surface of the feed table 102 to press a cloth. When forming overlock stitches on the cloth, the feed table 102 is moved while pressing the cloth pressed onto the feed table 102 by the cloth presser 103.

[0004] The buttonholing machine 100 includes a cloth cutting device 110 to forming a buttonhole through the cloth. The cloth cutting device 110 includes a knife 111 fixed to the bed portion 101, and a hammer 112 fixed to a support base 113 above the knife 111 so as to face the knife 111. The support base 113 is coupled to an output shaft 115a of an air cylinder 115 through a link mechanism 114. When the output shaft 115a of the air cylinder 115 is moved downward, the link mechanism 114 is rotated to move the support base 113 and the hammer 112 downward, whereby the cloth is pressed and cut between the hammer 112 and the knife 111 to form the buttonhole through the cloth (see, e.g., JP 2006-087813 A). Further examples of buttonholing machines related to the technical background of the present invention are known from JP 2000-005474 A, DE 100 22 238 A1 and JP 04-164229 A.

[0005] The knife is pressed against the hammer each time the buttonhole is formed. Therefore, fatigue is gradually accumulated. When the accumulated fatigue exceeds a threshold level, the knife is worn out or chipped. Because the wear-out or the breakage of the knife causes a cloth cutting failure, it is necessary to replace the knife beforehand.

[0006] However, it is unable to accurately determine the time for replacing the knife in the conventional buttonholing machines because a degree of fatigue accumulation varies depending on a thickness and a material of the cloth to be cut. Practically, for the purpose of replacing the knife, an operator has to visually check whether the knife worn out or chipped.

[0007] Accordingly, there has been a problem in that a working efficiency is reduced because the operator has to frequently check whether to replace the knife. Moreover, in the event that the visual check is neglected or when there is an oversight in the visual check, a cloth cutting failure is caused during a formation of a buttonhole, resulting in deterioration of commercial value. Further, if the knife is replaced while it can still be used, and

the knife is wasted to increase a maintenance cost.

[0008] It is an object of the invention to inform an operator of a replacement of a knife at an appropriate time before the knife is worn out or chipped, thereby preventing a cloth cutting failure.

[0009] According to a first aspect of the invention, a buttonholing machine includes a knife provided on a bed portion and formed with a cutting edge on an upper end thereof, a feed table provided on the bed portion and having an upper surface on which a workpiece is placed, a hammer provided on an arm portion to face the knife, wherein the knife and the hammer sandwiches the workpiece therebetween to cut the workpiece, an actuating mechanism which moves the hammer toward or away from the knife, a driving device coupled to the actuating mechanism, wherein the driving device drives the actuating mechanism when a current is applied thereto, and control means for controlling a driving operation of the driving device. Before or after forming, on the workpiece, buttonhole stitches including right and left side stitching sections, the control means controls the driving device to move the hammer toward the knife to form a buttonhole through the workpiece between the right and left side stitching sections. The buttonholing machine further includes stress detecting means for detecting a stress applied to the knife when forming the buttonhole, cumulating means for cumulating, each time the buttonhole is formed, the stress detected by the stress detecting means to calculate a cumulated stress, storing means for storing a threshold stress that causes a wear-out or a breakage of the knife, and informing means for informing a user of a replacement of the knife. When the cumulated stress reaches the threshold stress or before the cumulated stress reaches the threshold stress, the control means controls the informing means to inform the user of the replacement of the knife.

[0010] According to a second aspect of the invention, the stress detecting means includes load calculating means for calculating a workpiece cutting load based on the current applied to the driving device when forming of the buttonhole, and stress calculating means for calculating, from the cutting load, the stress applied to the knife. The cumulating means cumulates the stress calculated by the stress calculating means.

[0011] According to a third aspect of the invention, the stress calculating means calculates the stress from the cutting load and a contact area between the knife and the hammer.

[0012] According to a fourth aspect of the invention, the storing means stores a minimum stress that causes a fatigue accumulation in the knife. The cumulating means does not cumulate the stress which is smaller than the minimum stress.

[0013] According to a fifth aspect of the invention, the buttonholing machine further includes stress difference calculating means for calculating a difference between the cumulated stress and the threshold stress. The storing means stores a reference value for determining

whether the cumulated stress is close to the threshold stress. When the stress difference calculated by the stress difference calculating means becomes equal to or smaller than the reference value, the control means controls the informing means to inform the user of the replacement of the knife.

[0014] According to a sixth aspect of the invention, the load calculating means calculates the cutting load by using a maximum value or a mean value of the current within a specific region of a downward movement of the hammer.

[0015] According to a seventh aspect of the invention, the load calculating means calculates the cutting load by using a maximum value or a mean value of the current value after the hammer contacts the knife.

[0016] According to an eighth aspect of the invention, the control means controls the driving device to reduce a downward moving speed of the hammer before the hammer contacts the workpiece. The load calculating means calculates the cutting load by using a maximum value or a mean value of the current within a period from a start of a reduction of the downward moving speed of the hammer until the hammer contacts the knife.

[0017] According to a ninth aspect of the invention, the buttonholing machine further includes detecting means for detecting a driving amount of the driving device. The control means calculates a position of the hammer from the driving amount detected by the detecting means. When the control means calculates that the hammer is in a position at which the hammer contacts the workpiece, the load calculating means calculates the cutting load by using a maximum value or a mean value of the current within a period after the hammer contacts the workpiece and until the hammer contacts the knife.

[0018] According to the first aspect of the invention, the stress detecting means detects the stress applied to the knife from the workpiece cutting load during the formation of the buttonhole, and the cumulating means cumulates the stress detected by the stress detecting means each time the buttonhole is formed.

[0019] When or before the cumulated stress reaches the threshold stress after the repetitive formation of the buttonhole, a notice for prompting the replacement of the knife is given to the user by the informing means.

[0020] Since the fatigue applied to the knife is cumulated in each cloth cutting work, the operator can recognize an appropriate replacement time before the knife is worn out or chipped so that a commercial value of a sewn product can be prevented from being deteriorated due to a cloth cutting failure. Moreover, the operator does not need to carry out a work for checking the knife replacement time and can be devoted to a sewing work. Therefore, sewing work efficiency can be enhanced. Furthermore, because the knife can be prevented from being replaced too early, a maintenance cost can be reduced.

[0021] According to the second aspect of the invention, the load calculating means calculates the workpiece cutting load based on the current applied to the driving de-

vice in the formation of the buttonhole, and the stress calculating means calculates the stress applied to the knife from the workpiece cutting load calculated by the load calculating means.

[0022] Consequently, the fatigue applied to the knife can be accurately calculated and cumulated. Therefore, it is possible to reliably predict the time that the knife is worn out or chipped, and to accurately give a user a notice of the knife replacement time before the wear-out or the breakage of the knife, thereby preventing a cloth cutting failure.

[0023] According to the third aspect of the invention, the stress calculating means can accurately calculate the stress applied to the knife by dividing the cutting load by the contact area between the knife and the hammer.

[0024] According to the fourth aspect of the invention, the stress which is smaller than the minimum stress does not cause the fatigue of the knife. Therefore, by not cumulating such a small stress, it is possible to minimize an error between an actual fatigue of the knife and the cumulated stress.

[0025] According to the fifth aspect of the invention, by determining the knife replacement time depending on whether a difference between the cumulated stress and the threshold stress is equal to or smaller than the reference value, it is possible to give the user a notice of the replacement of the knife just before the cumulated stress reaches the threshold stress. Consequently, it is possible to decrease the number of the knife replacement works, thereby reducing a maintenance cost.

[0026] According to the sixth aspect of the invention, a current applied to the driving device also has an irregularity, and the load is also different depending on whether the hammer is in contact with the workpiece. By calculating the cutting load using of the current value in the specific region, however, it is possible to calculate the cutting load by using a current value under a condition desired by the user, each time the workpiece is cut.

[0027] According to the seventh aspect of the invention, the hammer presses the knife by a great force to cut the workpiece. However, after the hammer contacts the knife, a torque of the driving device is considerably increased. By using a current value at this time to calculate a cutting load, it is possible to calculate the cumulated stress during the time in which the stress is generated in the knife most greatly. Therefore, it is possible to enhance the effect of preventing the knife from being worn out or chipped.

[0028] According to the eighth aspect of the invention, when the downward movement of the hammer is decelerated by the control means, the hammer is close to the workpiece. In a section from this time to the contact of the hammer on the knife, the torque of the driving device is increased very greatly. By using a current value at this time to calculate a cutting load, it is possible to calculate the cumulated stress during the time in which the stress is generated in the knife most greatly. Therefore, it is possible to enhance the effect of preventing the knife

from being worn out or chipped.

[0029] According to the ninth aspect of the invention, the driving amount of the driving device is detected by the detecting means, and the position of the hammer is calculated from the driving amount detected by the control means. Thus, it is also possible to detect the time when the hammer contacts the workpiece. When it is calculated that the hammer is in a position at which it contacts the workpiece by the control means, the torque of the driving device is increased very greatly in a section from the contact of the hammer on the workpiece to the contact on the knife. By using a current value at this time to calculate a cutting load, it is possible to calculate the cumulated stress during the time in which the stress is generated in the knife most greatly. Therefore, it is possible to enhance the effect of preventing the knife from being worn out or chipped.

[0030] Other aspects and advantages of the present invention will be apparent from the following description, the drawings and the claims.

[0031] The following description of preferred embodiments of the invention serves to explain the invention in greater detail in conjunction with the drawings. These show:

- Fig. 1: a partially sectional side view of a buttonholing machine;
- Fig. 2: a side view of an actuating mechanism for a support member;
- Fig. 3: a block diagram of a control system of the buttonholing machine;
- Fig. 4: a block diagram illustrating data stored in an EEPROM;
- Fig. 5: a graph showing a relationship between a current value and a cutting load;
- Fig. 6: a block diagram illustrating programs stored in an ROM;
- Fig. 7: a flowchart of a control for prompting a replacement of a knife; and
- Fig. 8: a partially sectional side view of a conventional buttonholing machine.

Configuration of Buttonholing Machine

[0032] As shown in Figs. 1 and 2, a buttonholing machine 1 includes a bed portion 2, an arm portion 3 upwardly extending from the bed portion 2, a feed table 4 disposed on an upper surface of the bed portion 2 to move a cloth in a horizontal plane, a cloth presser 5 provided on an upper surface of the feed table 4 to press the cloth on the feed table 4 from above, a cloth cutting device 10 which forms a buttonhole, and a control device 20 (see Fig. 3) which controls an operation of the buttonholing machine 1.

[0033] The upper surface of the feed table 4, on which is the cloth is placed, is disposed substantially along the horizontal plane.

[0034] The cloth presser 5 includes a presser arm 52

which is rotatably provided on the upper surface of the feed table 4, and a presser plate 54 which is rotatably provided on a distal end of the presser arm 52 to press the cloth from above.

Cloth Cutting Device

[0035] The cloth cutting device 10 includes a knife 11 provided on the bed portion 2, and a hammer 12 provided on the arm portion 3 so as to face the knife 11. The knife 11 has a cutting edge along its upper end.

[0036] The knife 11 is detachably attached to a knife support base 13 which is fixed to the bed portion 2. The knife 11 according to this embodiment is configured to form an eyelet buttonhole. That is, the cutting edge of the knife 11 has an eyelet cutting portion for forming an eyelet portion of the buttonhole and a straight cutting portion for forming a straight portion of the buttonhole. The eyelet cutting portion and the straight cutting portion of the cutting edge are continuously formed.

[0037] The hammer 12 is detachably attached to a lower end of a support member 14 so as to face the knife 11 from above, and is downwardly movable to a position at which the cutting edge of the knife 11 is pressed.

[0038] An actuating mechanism 40 is coupled to the support member 14. The actuating mechanism 40 has a link mechanism including a first link 41 which is rotatably coupled to the support member 14, a second link 42 which is rotatably coupled to the first link 41, a third link 43 which is rotatably coupled to the second link 42, and a fourth link 44 which is rotatably coupled to the third link 43. Intermediate parts of the first link 41 and the third link 43 are rotatably attached to the arm portion 3, respectively.

[0039] The fourth link 44 is rotatably coupled to a moving member 46 which is engaged with a ball screw 45. The ball screw 45 is disposed such that its axis is oriented in a vertical direction of the buttonholing machine 1. In accordance with an axial rotation of the ball screw 45, the moving member 46 is moved in the vertical direction. A gear 47 is provided on an end of the ball screw 45, and is meshed with a gear 48 which is attached to an output shaft 50a of a cloth cutting motor 50. The cloth cutting motor 50 serves as a driving device for operating the actuating mechanism 40.

Control Device

[0040] As shown in Figs. 3 to 5, the control device 20 includes a CPU 21 which executes arithmetic processing related to operations of the buttonholing machine 1 to control respective driving sources, an ROM 22 in which data and parameters required for sewing and cloth cutting operations and programs to be executed by the CPU 21 to control a stitching motor 61, the cloth cutting motor 50 etc. are stored, an RAM 23 serving as a working area for the CPU 21, and an EEPROM 24 serving as storing means for storing data input by a user and calculated

data.

EEPROM

[0041] As shown in Fig. 4, a threshold stress σ_a is stored in the EEPROM 24. The threshold stress σ_a is a threshold of a stress at which the cutting edge of the knife 11 becomes worn out or chipped as a result of repetitive contact with the hammer 12 for cutting the cloth. The stress is a cumulated stress $\Sigma\sigma_n$ ($n = 1, 2, 3, \dots$) applied to the knife 11 through the cloth cutting operations. Each time the cloth is cut, the cumulated stress $\Sigma\sigma_n$ increases. "n" denotes the number of times a buttonhole is formed, i.e., the number of times the hammer 12 has contacted the knife 11.

[0042] A minimum stress σ_w that causes fatigue accumulation in the knife 12 is also stored in EEPROM 24. The minimum stress σ_w is a boundary between a stress that does not cause a wear-out or a breakage of the knife 11 after a certain number of (for example, 10^7 times) buttonhole cutting operations and a stress that causes the fatigue accumulation. The minimum stress σ_w is determined by a material, etc. of the knife 11 and the hammer 12.

[0043] A reference value X is also stored in the EEPROM 24. The reference value X is used to determine whether the cumulated stress $\Sigma\sigma_n$ to the knife 11 through the repetitive cloth cutting operations is close to the threshold stress σ_a . The reference value X is a desirable difference between the cumulated stress $\Sigma\sigma_n$ and the threshold stress σ_a . When the actual difference between the cumulated stress $\Sigma\sigma_n$ and the threshold stress σ_a becomes equal to or smaller than the reference value X, it implies that the cumulated stress $\Sigma\sigma_n$ is close to the threshold stress σ_a and the knife 11 will be worn out or chipped soon. The reference value X is set to prompt a user to replace the knife 11 before the cumulated stress $\Sigma\sigma_n$ reaches the threshold stress σ_a , thereby reliably preventing the knife 11 from being worn out or chipped.

[0044] In the EEPROM 24, a formula or a table representing a relation between a current applied to the cloth cutting motor 50 and a cutting load P at that time, as shown in the graph of Fig. 5. Accordingly, if the current applied to the cloth cutting motor 50 is given, it is possible to calculate a cutting load Pn. Here, as described above, "n" denotes the number of times a buttonhole is formed, i.e., the number of times the hammer 12 has contacted the knife 11.

ROM: Load Calculating Program

[0045] As shown in Fig. 6, a load calculating program 22a is stored in the ROM 22. When the load calculating program 22a is executed by the CPU 21, a cloth cutting load Pn is calculated based on a current applied to the cloth cutting motor 50 for forming a buttonhole. That is, when the CPU 21 executes the load calculating program 22a, the control device 20 functions as load calculating

means.

[0046] When calculating a load, the load calculating program 22a uses a maximum value of the current applied to the cloth cutting motor 50 within a specific region in the downward moving process of the hammer 12. The current value to be used in the load calculation is not restricted to the maximum value, and may be a mean value within the specific region.

[0047] The specific region is, for example, a region in which the hammer 12 is moved from a position at which the hammer 12 contacts the cloth to a position at which the hammer 12 contacts the knife 11 so that the cloth is cut. The position at which the hammer 12 contacts the upper surface of the cloth can be calculated in the control device 20 based on a detection of a rotating amount of the output shaft 50a of the cloth cutting motor 50 through an encoder 67.

ROM: Stress Calculating Program

[0048] As shown in Fig. 6, a stress calculating program 22b is also stored in the ROM 22. When the stress calculating program 22b is executed by the CPU 21, a stress σ_n applied to the knife 11 is calculated from the cloth cutting load Pn, which is calculated by executing the load calculating program 22a. That is, when the CPU 21 executes the stress calculating program 22b, the control device 20 functions as stress calculating means.

[0049] In the stress calculating program 22b, the cutting load Pn is divided by a contact area A between the knife 11 and the hammer 12 to calculate the stress σ_n applied to the knife 11. Because a width of the cutting edge of the knife 11 that contacts the hammer 12 is very small, the width of the knife 11 may be disregarded, and the stress σ_n may be calculated by dividing the cutting load Pn by a length of the knife 11.

[0050] The control device 20 functioning as the load calculating means and the stress calculating means constitutes stress detecting means for detecting the stress applied to the knife 11 in forming the buttonhole.

ROM: Cumulating Program

[0051] A cumulating program 22c is also stored in the ROM 22. When the cumulating program 22c is executed by the CPU 21, the stress σ_n calculated by executing the stress calculating program 22b is cumulated each time a buttonhole is formed. That is, when the CPU 21 executes the cumulating program 22c, the control device 20 functions as cumulating means, and cumulates a stress detected by the stress detecting means (a stress obtained through the execution of the load calculating program and the stress calculating program) each time a buttonhole is formed.

[0052] In the cumulating program 22c, the stress σ_n is regarded to be zero if the stress σ_n is smaller than the minimum stress σ_w stored in the EEPROM 24. That is, if the stress σ_n is smaller than the minimum stress σ_w ,

the stress σ_n is not cumulated. This is because a stress which is smaller than the minimum stress σ_w does not cause a wear-out or a breakage of the knife 11.

ROM : Stress Difference Calculating Program

[0053] A stress difference calculating program 22d is also stored in the ROM 22. When the stress difference calculating program 22d is executed by the CPU 21, a difference σ_d between the cumulated stress $\Sigma\sigma_n$ and the threshold stress σ_a stored in the EEPROM 24 is calculated. That is, when the CPU 21 executes the stress difference calculating program 22d, the control device 20 functions as stress difference calculating means.

ROM : Control Program

[0054] A control program 22e is also stored in the ROM 22. When the control program 22e is executed by the CPU 21, the CPU 21 controls the an operation panel 66 (informing means) to display a notice to prompt the replacement of the knife 11 if the stress difference σ_d between the cumulated stress $\Sigma\sigma_n$ and the threshold stress σ_a is equal to or smaller than the reference value X. That is, when the CPU 21 executes the control program 22e, the control device 20 functions as control means.

Control System

[0055] The cloth cutting motor 50 serving as a driving source in a cloth cutting operation, the stitching motor 61 for vertically moving a needle, an X-feed pulse motor 62 for moving the feed table 4 in an X direction, a Y-feed pulse motor 63 for moving the feed table 4 in a Y direction, a turning pulse motor 64 for rotating the needle and a looper, an S/S switch 65 from which a start or a stop of a sewing operation is input, the operation panel 66 serving as informing means for displaying information to be given to a user (e.g., a notice to prompt the user to replace the knife 11) and from which an instruction from the user's input, and the encoder 67 serving as detecting means for detecting a distance along which the support member 14 (the hammer 12) downwardly moved from an upper dead center of the support member 14 (the hammer 12), are coupled to the control device 20.

[0056] The threshold stress σ_a , the minimum stress σ_w , and the reference value X can be input from the operation panel 66. That is, the user can change the threshold stress σ_a , the minimum stress σ_w , and the reference value X in accordance with a condition of a cloth cutting operation.

[0057] The encoder 67 is coupled to the cloth cutting motor 50 (a pulse motor) and outputs two detection pulses, namely an A-phase pulse and a B-phase pulse (AB-phase pulses in combination) which have different phases from each other by 90 degrees, so as to correspond to a rotating position of the cloth cutting motor 50. The control device 20 can detect, in real time, the downward

moved position of the support member 14 (the hammer 12) with respect to an origin position, based on a phase relationship of the AB-phase pulses output from the encoder 67 and the numbers of the respective pulses. Consequently, it is possible to detect, in real time, a position at which the support member 14 (the hammer 12) is stopped.

Control for Informing and Prompting Knife Replacement

[0058] Next, description will be given to a driving operation of the cloth cutting motor 50 which is controlled by the CPU 21 when forming a buttonhole.

[0059] As shown in Fig. 7, first of all, stitches for buttonhole are formed (Step S1). When the stitching work is finished, the cloth cutting motor 50 moves the hammer 12 downward to sandwich and to cut a cloth between the knife 11 and the hammer 12, whereby a buttonhole is formed (Step S2).

[0060] The stitching work may be implemented after forming the buttonhole.

[0061] When the formation of the buttonhole is finished, the number of times a buttonhole is formed, i.e., the number of times "n" the hammer 12 has contacted the knife 11 is stored in the EEPROM 24 (Step S3). The number of times "n" is counted up until it is reset by an operation of the operation panel 66.

[0062] Subsequently, the load calculating program 22a is executed to calculate the cutting load P_n from the maximum value of the current applied to the cloth cutting motor 50 within the moving region of the hammer 12 from a position at which the hammer 12 contacts the cloth to a position at which the hammer 12 contacts the knife 11 and at which the cloth is cut (Step S4). The cutting load P_n is calculated each time the number of times the buttonhole is formed is counted.

[0063] Then, the stress calculating program 22b is executed to divide the cutting load P_n by the contact area A between the knife 11 and the hammer 12, thereby calculating the stress σ_n applied to the knife 11 (Step S5). The contact area A is calculated in advance depending on the knife 11 to be used and is stored in the EEPROM 24.

[0064] Thereafter, it is determined whether the stress σ_n calculated in Step S5 is equal to or greater than the minimum stress σ_w stored in the EEPROM 24 (Step S6).

[0065] If it is determined that the stress σ_n is equal to or greater than the minimum stress σ_w in Step S6 (Step S6 : YES), the cumulating program 22c is executed so that the stress σ_n is added to the previously cumulated stress (Step S7).

[0066] On the other hand, if it is determined that the stress σ_n is smaller than the minimum stress σ_w in Step S6 (Step S6 : NO), the stress σ_n is set to be zero (Step S8) and is added to the previously cumulated stress (Step S7). In other words, setting the stress σ_n to be zero implies that the stress σ_n is not cumulated.

[0067] Next, the stress difference calculating program

22d is executed to calculate a stress difference σ_d between the cumulated stress $\Sigma\sigma_n$ and the threshold stress σ_a stored in the EEPROM 24 (Step S9).

[0068] Subsequently, it is determined whether the stress difference σ_d calculated in Step S9 is equal to or smaller than the reference value X stored in the EEPROM 24 (Step S10).

[0069] If it is determined that the stress difference σ_d is equal to or smaller than the reference value X in Step S10 (Step S10 : YES), the control program 22e is executed so that a notice for prompting the replacement of the knife 11 is displayed on the operation panel 66 (Step S11).

[0070] On the other hand, if it is determined that the stress difference σ_d is greater than the reference value X in Step S10 (Step S10 : NO), the flow returns to Step S1.

[0071] In response to the notice for prompting the replacement of the knife 11 which is displayed in Step S11, the user replaces the knife 11 (Step S12). Because the knife 11 is replaced with a new knife 11, the user resets the number of times "n" the buttonhole is formed by operating the operation panel 66 (Step S13).

Advantages

[0072] According to the buttonholing machine 1, when a current is applied to the cloth cutting motor 50 by the control device 20, the cloth cutting motor 50 drives the actuating mechanism 40 to move the hammer 12 toward or away from the knife 11.

[0073] The CPU 21 executes the load calculating program 22a to calculate the cloth cutting load P_n based on the current applied to the cloth cutting motor 50 during the formation of the buttonhole.

[0074] Next, the CPU 21 executes the stress calculating program 22b to calculate the stress applied to the knife 11 from the cloth cutting load P_n and the contact area A between the knife 11 and the hammer 12.

[0075] Subsequently, the CPU 21 executes the cumulating program 22c to cumulate the stress each time the buttonhole is formed. The stress which is smaller than the minimum stress σ_w does not cause a fatigue of the knife 11. Therefore, by not cumulating such a small stress, it is possible to minimize an error between an actually cumulated fatigue of the knife 11 and the cumulated stress $\Sigma\sigma_n$. Accordingly, it is possible to inform the user of the replacement time of the knife 11 with high accuracy.

[0076] When the cumulated stress $\Sigma\sigma_n$ reaches the threshold stress σ_a after the repetitive formation of the buttonhole, the control device 20 displays, on the operation panel 66, the notice for prompting the user to replace the knife.

[0077] Because the fatigue applied to the knife 11 is cumulated in each cloth cutting work, it is possible to give the user the notice of the replacement time of the knife 11 before the knife 11 is worn out or chipped, thereby

preventing a cloth cutting failure.

[0078] Further, by determining the replacement time of the knife 11 depending on whether the difference between the cumulated stress $\Sigma\sigma_n$ and the threshold stress σ_a is equal to or smaller than the prestored reference value X, it is possible to give the user the notice of the replacement of the knife 11 before the cumulated stress $\Sigma\sigma_n$ reaches the threshold stress σ_a .

[0079] Accordingly, it is possible to give the user the notice of the replacement time of the knife 11 well in advance. Thus, it is possible to enhance an effect of preventing the knife 11 from being worn out or chipped.

[0080] Furthermore, the driving amount of the cloth cutting motor 50 is detected by the encoder 67, and the position of the hammer 12 is calculated from the driving amount detected by the control device 20. Therefore, it is possible to detect that the hammer 12 is in contact with the cloth. Once it is calculated by the control device 20 that the hammer 12 is in a position to contact the cloth, the torque of the cloth cutting motor 50 is greatly increased in the section from the position at which the hammer 12 contacts the cloth and to a position at which the hammer 12 contacts the knife 11. By using the current value during that time to calculate the cutting load, it is possible to calculate the cumulated stress $\Sigma\sigma_n$ during the time in which the stress σ_n is generated in the knife 11 most greatly. Therefore, it is possible to enhance the effect of preventing the knife 11 from being worn out or chipped.

Modifications

[0081] The present invention is not restricted to the embodiment described above. For example, in the load calculation of the load calculating program 22a, it is also possible to calculate the cutting load by using a maximum value or a mean value of the current after the hammer 12 contacts the knife 11. While the cloth is cut by pressing the hammer 12 onto the knife 11 with a large force, the torque of the cloth cutting motor 50 after the hammer 12 contacts the knife 11 is considerably increased. By using the current at this time to calculate the cutting load P_n , it is possible to calculate the cumulated stress $\Sigma\sigma_n$ during the time in which the stress σ_n is generated in the knife 11 most greatly. Therefore, it is possible to enhance the effect of preventing the knife 11 from being worn out or chipped.

[0082] In a case in which the encoder 67 is not provided, the position at which the hammer 12 contacts the cloth is not available. For this reason, the downward moving speed of the hammer 12 is often reduced slightly above the upper surface of the cloth. By utilizing this, it is also possible to calculate the cutting load P_n by using a maximum value or a mean value of the current within a period from a start of a reduction of the downward moving speed of the hammer 12 until the hammer 12 contacts the knife 11. When the downward movement of the hammer 12 is decelerated by the control device 20, the ham-

mer 12 is close to the cloth. In a section from that time until the hammer 12 contacts the knife 11, the torque of the cloth cutting motor 50 is greatly increased. By using the current at this time to calculate the cutting load P_n , it is possible to calculate the cumulated stress $\Sigma\sigma_n$ during the time in which the stress σ_n is generated in the knife 11 most greatly. Therefore, it is possible to enhance the effect of preventing the knife 11 from being worn out or chipped.

[0083] Furthermore, the informing means may inform the user of the replacement of the knife by generating a sound through a buzzer and/or emitting a light from a lamp, instead of or in addition to a display on the operation panel 66.

[0084] Furthermore, while the notice is given from the operation panel 66 before the cumulated stress $\Sigma\sigma_n$ reaches the threshold stress σ_a by using the reference value X in the embodiment described above, it is also possible to give a notice when the cumulated stress $\Sigma\sigma_n$ reaches the threshold stress σ_a . In other words, it is also possible to set the reference value X to be zero. Moreover, instead of comparing the stress difference between the threshold stress σ_a and the cumulated stress $\Sigma\sigma_n$ with the reference value X , the notice may be given when the cumulated stress $\Sigma\sigma_n$ reaches a certain ratio (%) of the threshold stress σ_a .

Claims

1. A buttonholing machine (1) comprising:

a knife (11) provided on a bed portion (2) and formed with a cutting edge on an upper end thereof;

a feed table (4) provided on the bed portion (2) and having an upper surface on which a workpiece is placed;

a hammer (12) provided on an arm portion (3) to face the knife (11), wherein the knife (11) and the hammer (12) sandwiches the workpiece therebetween to cut the workpiece;

an actuating mechanism (40) which moves the hammer (12) toward or away from the knife (11);

a driving device (50) coupled to the actuating mechanism (40), wherein the driving device (50) drives the actuating mechanism (40) when a current is applied thereto; and

control means (20) for controlling a driving operation of the driving device (50), wherein, before or after forming, on the workpiece, buttonhole stitches including right and left side stitching sections, the control means (20) controls the driving device (50) to move the hammer (12) toward the knife (11) to form a buttonhole through the workpiece between the right and left side stitching sections,

characterized by further comprising:

stress detecting means (20) for detecting a stress (σ_n) applied to the knife (11) when forming the buttonhole;

cumulating means (20) for cumulating, each time the buttonhole is formed, the stress (σ_n) detected by the stress detecting means (20) to calculate a cumulated stress ($\Sigma\sigma_n$);

storing means (24) for storing a threshold stress (σ_a) that causes a wear-out or a breakage of the knife (11); and

informing means (66) for informing a user of a replacement of the knife (11), wherein, when the cumulated stress ($\Sigma\sigma_n$) reaches the threshold stress (σ_a) or before the cumulated stress ($\Sigma\sigma_n$) reaches the threshold stress (σ_a), the control means (20) controls the informing means (66) to inform the user of the replacement of the knife (11).

2. The buttonholing machine (1) according to claim 1, wherein the stress detecting (20) means comprises:

load calculating means (20) for calculating a workpiece cutting load (P_n) based on the current applied to the driving device (50) when forming of the buttonhole; and

stress calculating means (20) for calculating, from the cutting load (P_n), the stress (σ_n) applied to the knife (11),

wherein the cumulating means (20) cumulates the stress (σ_n) calculated by the stress calculating means (20).

3. The buttonholing machine (1) according to claim 2, wherein the stress calculating means (20) calculates the stress (σ_n) from the cutting load (P_n) and a contact area (A) between the knife (11) and the hammer (12).

4. The buttonholing machine (1) according to any one of the preceding claims, wherein the storing means (24) stores a minimum stress (σ_w) that causes a fatigue accumulation in the knife (11), and the cumulating means (20) does not cumulate the stress (σ_n) which is smaller than the minimum stress (σ_w).

5. The buttonholing machine (1) according to any one of the preceding claims, further comprising stress difference calculating means (20) for calculating a difference (σ_d) between the cumulated stress ($\Sigma\sigma_n$) and the threshold stress (σ_a), wherein the storing means (24) stores a reference value (X) for determining whether the cumulated stress ($\Sigma\sigma_n$) is close to the threshold stress (σ_a), and when the stress difference (σ_d) calculated by the stress difference calculating means (20) becomes

equal to or smaller than the reference value (X), the control means (20) controls the informing means (66) to inform the user of the replacement of the knife (11).

6. The buttonholing machine (1) according to claim 2 or 3, wherein the load calculating means (20) calculates the cutting load (P_n) by using a maximum value or a mean value of the current within a specific region of a downward movement of the hammer (12). 5
7. The buttonholing machine (1) according to claim 6, wherein the load calculating means (20) calculates the cutting load (P_n) by using a maximum value or a mean value of the current value after the hammer (12) contacts the knife (11). 10
8. The buttonholing machine (1) according to claim 6, wherein the control means (20) controls the driving device (50) to reduce a downward moving speed of the hammer (12) before the hammer (12) contacts the workpiece, and 15
the load calculating means (20) calculates the cutting load (P_n) by using a maximum value or a mean value of the current within a period from a start of a reduction of the downward moving speed of the hammer (12) until the hammer (12) contacts the knife (11). 20
9. The buttonholing machine (1) according to claim 6, further comprising detecting means (67) for detecting a driving amount of the driving device (50), wherein the control means (20) calculates a position of the hammer (12) from the driving amount detected by the detecting means (67), and 25
when the control means (20) calculates that the hammer is in a position at which the hammer (12) contacts the workpiece, the load calculating means (20) calculates the cutting load (P_n) by using a maximum value or a mean value of the current within a period after the hammer (12) contacts the workpiece and until the hammer (12) contacts the knife (11). 30

Patentansprüche

1. Knopflochnähmaschine (1), umfassend: 45
ein Messer (11), welches an einem Bettbereich (2) bereitgestellt ist und an einem oberen Ende desselben mit einer Schneidkante ausgebildet ist; 50
einen Transporttisch (4), welcher an dem Bettbereich (2) bereitgestellt ist und eine obere Oberfläche aufweist, auf der ein Werkstück platziert ist;
einen Hammer (12), welcher an einem Armbereich (3) dem Messer (11) zugewandt bereitgestellt ist, wobei das Messer (11) und der Hammer (12) das Werkstück sandwichartig zwi- 55

schen sich anordnen, um das Werkstück zu schneiden;

einen Betätigungsmechanismus (40), welcher den Hammer (12) zu dem Messer (11) hin und von diesem weg bewegt;

eine Antriebseinrichtung (50), welche mit dem Betätigungsmechanismus (40) gekoppelt ist, wobei die Antriebseinrichtung (50) bei Beaufschlagung mit einem elektrischen Strom den Betätigungsmechanismus (40) antreibt; und ein Steuermittel (20) zum Steuern einer Antriebsoperation der Antriebseinrichtung (50), wobei vor oder nach Bildung von einen rechten und einen linken seitlichen Stichbildeabschnitt umfassenden Knopflochstichen an dem Werkstück das Steuermittel (20) die Antriebseinrichtung (50) steuert, um den Hammer (12) in Richtung zu dem Messer (11) hin zu bewegen, um zwischen dem rechten und dem linken seitlichen Stichbildeabschnitt ein Knopfloch durch das Werkstück hindurch zu bilden, 35

dadurch gekennzeichnet, dass sie ferner umfasst:

ein Spannungsdetektiermittel (20) zum Detektieren einer beim Bilden des Knopflochs auf das Messer (11) ausgeübten Spannung (σ_n);

ein Kumulierungsmittel (20) zum Kumulieren der von dem Spannungsdetektiermittel (20) detektierten Spannung (σ_n) bei jeder Knopflochbildung, um eine kumulierte Spannung ($\Sigma\sigma_n$) zu berechnen;

ein Speichermittel (24) zum Speichern einer Schwellenspannung (σ_a), welche einen Verschleiß oder Bruch des Messers (11) verursacht; und

ein Informationsmittel (66) zum Informieren eines Nutzers über einen Austausch des Messers (11),

wobei, wenn die kumulierte Spannung ($\Sigma\sigma_n$) die Schwellenspannung (σ_a) erreicht oder bevor die kumulierte Spannung ($\Sigma\sigma_n$) die Schwellenspannung (σ_a) erreicht, das Steuermittel (20) das Informationsmittel (66) steuert, um den Nutzer über den Austausch des Messers (11) zu informieren. 40

2. Knopflochnähmaschine (1) nach Anspruch 1, wobei das Spannungsdetektiermittel (20) umfasst: 50

ein Lastberechnungsmittel (20) zum Berechnen einer Werkstückschneidlast (P_n) basierend auf dem beim Bilden des Knopflochs an die Antriebseinrichtung (50) angelegten Strom; und ein Spannungsberechnungsmittel (20) zum Berechnen der auf das Messer (11) ausgeübten Spannung (σ_n) aus der Schneidlast (P_n), 55

wobei das Kumulierungsmittel (20) die von dem Spannungsberechnungsmittel (20) berechnete Spannung (σ_n) kumuliert.

3. Knopflochnähmaschine (1) nach Anspruch 2, wobei das Spannungsberechnungsmittel (20) die Spannung (σ_n) aus der Schneidlast (P_n) und einem Kontaktbereich (A) zwischen dem Messer (11) und dem Hammer (12) berechnet. 5
4. Knopflochnähmaschine (1) nach einem der voranstehenden Ansprüche, wobei das Speichermittel (24) eine minimale Spannung (σ_w) speichert, welche eine Ermüdungsakkumulation bei dem Messer (11) verursacht, und wobei das Kumulierungsmittel (20) eine Spannung (σ_n), die kleiner ist als die minimale Spannung (σ_w), nicht kumuliert. 10
5. Knopflochnähmaschine (1) nach einem der voranstehenden Ansprüche, ferner umfassend ein Spannungsdifferenz-Berechnungsmittel (20) zum Berechnen einer Differenz (σ_d) zwischen der kumulierten Spannung ($\Sigma\sigma_n$) und der Schwellenspannung (σ_a), wobei das Speichermittel (20) einen Referenzwert (X) zum Bestimmen, ob die kumulierte Spannung ($\Sigma\sigma_n$) nahe der Schwellenspannung (σ_a) liegt, speichert und wobei, wenn die von dem Spannungsdifferenz-Berechnungsmittel (20) berechnete Spannungsdifferenz (σ_d) gleich dem Referenzwert (X) oder kleiner als dieser wird, das Steuermittel (20) das Informationsmittel (66) steuert, um den Nutzer über den Austausch des Messers (11) zu informieren. 15 20
6. Knopflochnähmaschine (1) nach Anspruch 2 oder 3, wobei das Lastberechnungsmittel (20) die Schneidlast (P_n) berechnet unter Verwendung eines maximalen Wertes oder eines Mittelwerts des Stroms innerhalb eines spezifischen Bereichs einer Abwärtsbewegung des Hammers (12). 30
7. Knopflochnähmaschine (1) nach Anspruch 6, wobei das Lastberechnungsmittel (20) die Schneidlast (P_n) berechnet unter Verwendung eines maximalen Wertes oder eines Mittelwerts des Stromwertes nach Inkontaktkommen des Hammers (12) mit dem Messer (11). 35 40
8. Knopflochnähmaschine (1) nach Anspruch 6, wobei das Steuermittel (20) die Antriebseinrichtung (50) steuert, um eine Abwärtsbewegungsgeschwindigkeit des Hammers (12) zu reduzieren, bevor der Hammer (12) mit dem Werkstück in Kontakt kommt, und wobei das Lastberechnungsmittel (20) die Schneidlast (P_n) berechnet unter Verwendung eines maximalen Wertes oder eines Mittelwerts des Stroms in- 45 50

nerhalb eines Zeitraums von einem Start einer Reduzierung der Abwärtsbewegungsgeschwindigkeit des Hammers (12) bis zum Inkontaktkommen des Hammers (12) mit dem Messer (11).

9. Knopflochnähmaschine (1) nach Anspruch 6, ferner umfassend ein Detektiermittel (67) zum Detektieren eines Antriebsbetrags der Antriebseinrichtung (50), wobei das Steuermittel (20) eine Position des Hammers (12) aus dem von dem Detektiermittel (67) detektierten Antriebsbetrag berechnet, und wobei dann, wenn das Steuermittel (20) berechnet, dass sich der Hammer in einer Position befindet, in der der Hammer (12) das Werkstück kontaktiert, das Lastberechnungsmittel (20) die Schneidlast (P_n) berechnet unter Verwendung eines maximalen Wertes oder eines Mittelwerts des Stroms innerhalb eines Zeitraums nach dem Inkontaktkommen des Hammers (12) mit dem Werkstück bis zum Inkontaktkommen des Hammers (12) mit dem Messer (11). 55

Revendications

1. Machine pour faire des boutonnières (1) comprenant :
 - un couteau (11) prévu sur une partie de support (2) et comportant un bord de coupe sur une extrémité supérieure de celui-ci ;
 - une table d'avance (4) prévue sur la partie de support (2) et ayant une surface supérieure sur laquelle une pièce est placée ;
 - un marteau (12) prévu sur une partie de bras (3) de manière à être face au couteau (11), dans laquelle le couteau (11) et le marteau (12) prennent en sandwich la pièce entre eux pour couper la pièce ;
 - un mécanisme d'actionnement (40) qui rapproche ou éloigne le marteau (12) du couteau (11) ;
 - un dispositif d'entraînement (50) accouplé au mécanisme d'actionnement (40), dans laquelle le dispositif d'entraînement (50) entraîne le mécanisme d'actionnement (40) lorsqu'un courant est appliqué à celui-ci ; et
 - des moyens de commande (20) pour commander une opération d'entraînement du dispositif d'entraînement (50), dans laquelle, avant ou après avoir formé, sur la pièce, des points de boutonnière comprenant des sections de couture de côtés droit et gauche, les moyens de commande (20) commandent le dispositif d'entraînement (50) pour déplacer le marteau (12) vers le couteau (11) pour former une boutonnière à travers la pièce entre les sections de couture de côtés droit et gauche, **caractérisée en ce qu'elle comprend en outre :**

- des moyens de détection de contrainte (20) pour détecter une contrainte (σ_n) appliquée au couteau (11) lors de la formation de la boutonnière ;
- des moyens de cumul (20) pour cumuler, à 5 chaque fois que la boutonnière est formée, la contrainte (σ_n) détectée par les moyens de détection de contrainte (20) pour calculer une contrainte cumulée ($\Sigma\sigma_n$) ;
- des moyens de mémorisation (24) pour mé- 10 moriser une contrainte de seuil (σ_a) qui provoque une usure ou une rupture du couteau (11) ; et
- des moyens d'information (66) pour infor- 15 mer un utilisateur d'un remplacement du couteau (11),
- dans laquelle, lorsque la contrainte cumulée ($\Sigma\sigma_n$) atteint la contrainte de seuil (σ_a) ou avant que la contrainte cumulée ($\Sigma\sigma_n$) n'atteigne la contrainte de seuil (σ_a), les 20 moyens de commande (20) commandent les moyens d'information (66) pour informer l'utilisateur du remplacement du couteau (11).
2. Machine pour faire des boutonnières (1) selon la re- 25 vendication 1, dans laquelle les moyens de détection de contrainte (20) comprennent :
- des moyens de calcul de charge (20) pour cal- 30 culer une charge de coupe de pièce (P_n) sur la base du courant appliqué au dispositif d'entraînement (50) lors de la formation de la boutonnière ; et
- des moyens de calcul de contrainte (20) pour 35 calculer, à partir de la charge de coupe (P_n), la contrainte (σ_n) appliquée au couteau (11), dans laquelle les moyens de cumul (20) cumulent la contrainte (σ_n) calculée par les moyens de calcul de contrainte (20). 40
3. Machine pour faire des boutonnières (1) selon la re- 45 vendication 2, dans laquelle les moyens de calcul de contrainte (20) calculent la contrainte (σ_n) à partir de la charge de coupe (P_n) et d'une aire de contact (A) entre le couteau (11) et le marteau (12).
4. Machine pour faire des boutonnières (1) selon l'une 50 quelconque des revendications précédentes, dans laquelle les moyens de mémorisation (24) mémorisent une contrainte minimum (σ_w) qui provoque une accumulation de fatigue dans le couteau (11), et les moyens de cumul (20) ne cumulent pas la contrainte (σ_n) qui est inférieure à la contrainte minimum (σ_w). 55
5. Machine pour faire des boutonnières (1) selon l'une quelconque des revendications précédentes, com- 60
- prenant en outre des moyens de calcul de différence de contrainte (20) pour calculer une différence (σ_d) entre la contrainte cumulée ($\Sigma\sigma_n$) et la contrainte de seuil (σ_a), 65
- dans laquelle les moyens de mémorisation (24) mémorisent une valeur de référence (X) pour déterminer si la contrainte cumulée ($\Sigma\sigma_n$) est proche de la contrainte de seuil (σ_a), et 70
- lorsque la différence de contrainte (σ_d) calculée par les moyens de calcul de différence de contrainte (20) devient inférieure ou égale à la valeur de référence (X), les moyens de commande (20) commandent les 75
- moyens d'information (66) pour informer l'utilisateur du remplacement du couteau (11).
6. Machine pour faire des boutonnières (1) selon la re- 80 vendication 2 ou 3, dans laquelle les moyens de calcul de charge (20) calculent la charge de coupe (P_n) en utilisant une valeur maximum ou une valeur moyenne du courant dans une région spécifique d'un déplacement vers le bas du marteau (12).
7. Machine pour faire des boutonnières (1) selon la re- 85 vendication 6, dans laquelle les moyens de calcul de charge (20) calculent la charge de coupe (P_n) en utilisant une valeur maximum ou une valeur moyenne de la valeur de courant après que le marteau (12) est venu en contact avec le couteau (11).
8. Machine pour faire des boutonnières (1) selon la re- 90 vendication 6, dans laquelle les moyens de commande (20) commandent le dispositif d'entraînement (50) pour réduire une vitesse de déplacement vers le bas du marteau (12) avant que le marteau (12) soit venu en contact avec la pièce, et 95
- les moyens de calcul de charge (20) calculent la charge de coupe (P_n) en utilisant une valeur maximum ou une valeur moyenne du courant dans une période d'un début d'une réduction de la vitesse de déplacement vers le bas du marteau (12) jusqu'à ce 100
- que le marteau (12) vienne en contact avec le couteau (11).
9. Machine pour faire des boutonnières (1) selon la re- 105 vendication 6, comprenant en outre des moyens de détection (67) pour détecter une quantité d'entraînement du dispositif d'entraînement (50), dans laquelle les moyens de commande (20) calculent une position du marteau (12) à partir de la quantité d'entraînement détectée par les moyens de dé- 110
- téction (67), et
- lorsque les moyens de commande (20) calculent que le marteau est à une position à laquelle le marteau (12) est en contact avec la pièce, les moyens de calcul de charge (20) calculent la charge de coupe (P_n) en utilisant une valeur maximum ou une valeur 115
- moyenne du courant dans une période après que le marteau (12) est venu en contact avec la pièce et

jusqu'à ce que le marteau (12) vienne en contact avec le couteau (11).

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FIG. 1

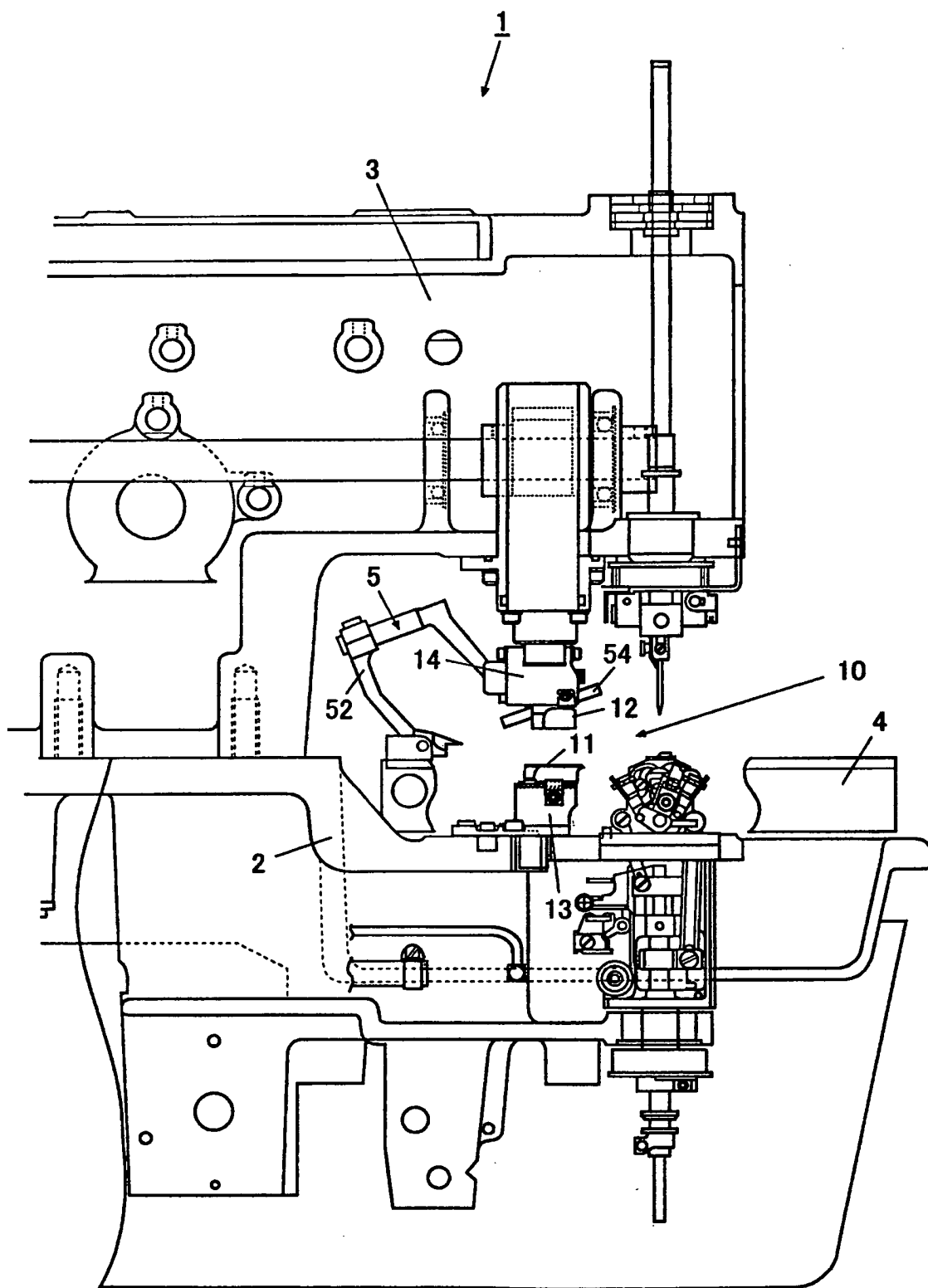


FIG. 2

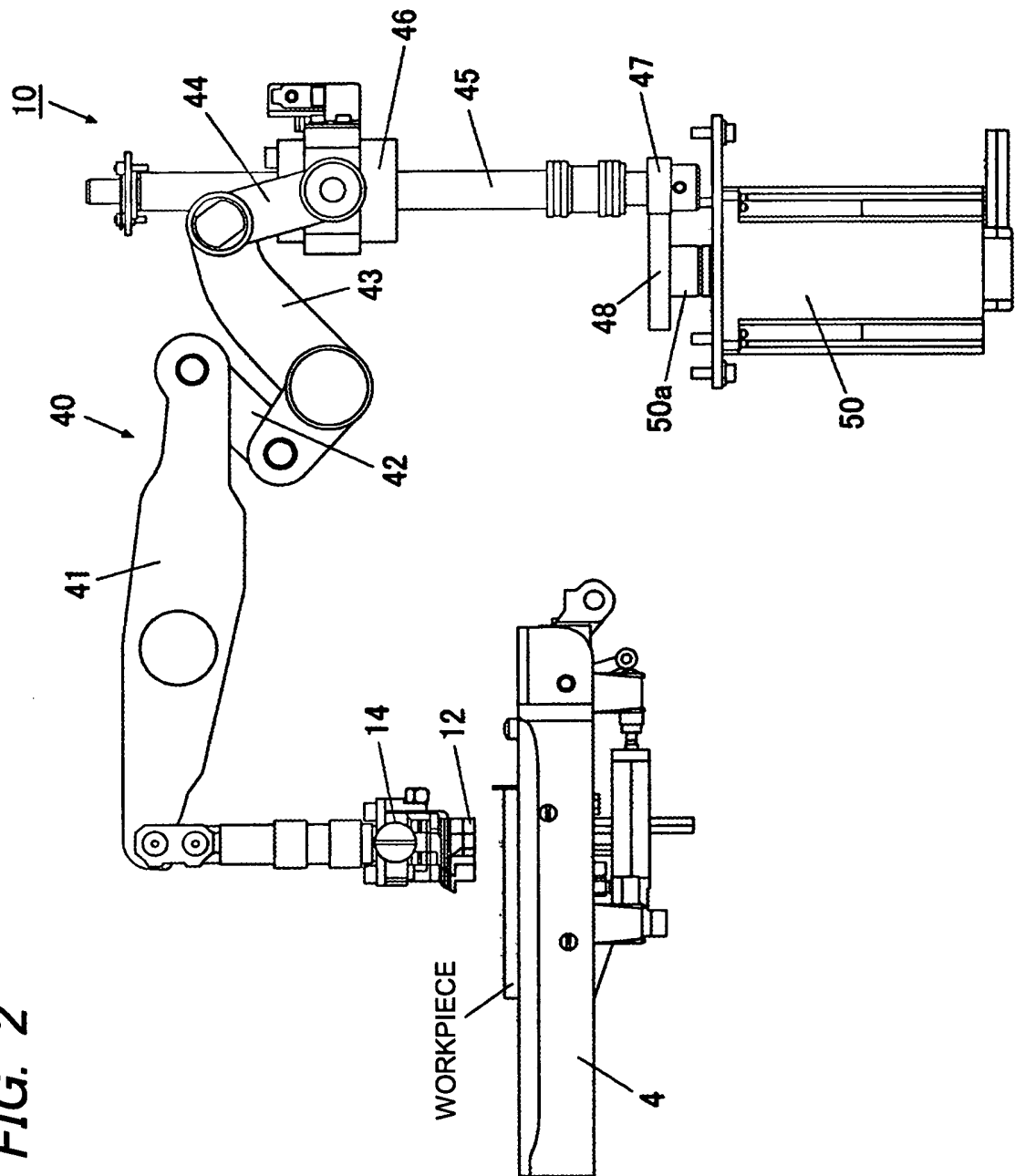


FIG. 3

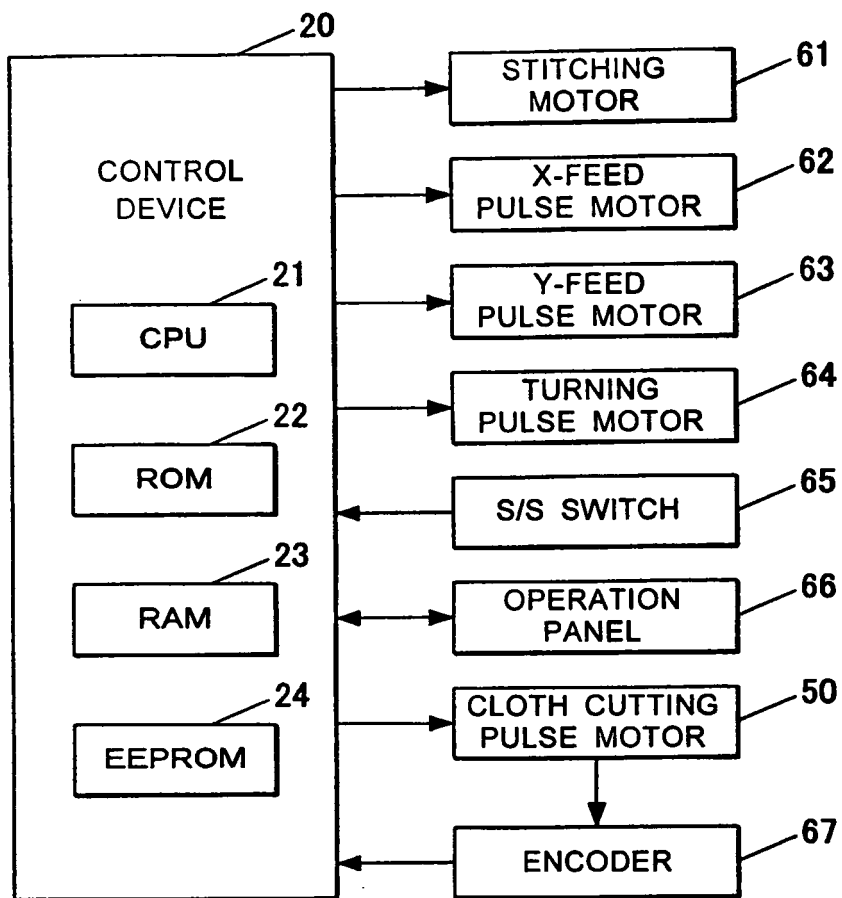


FIG. 4

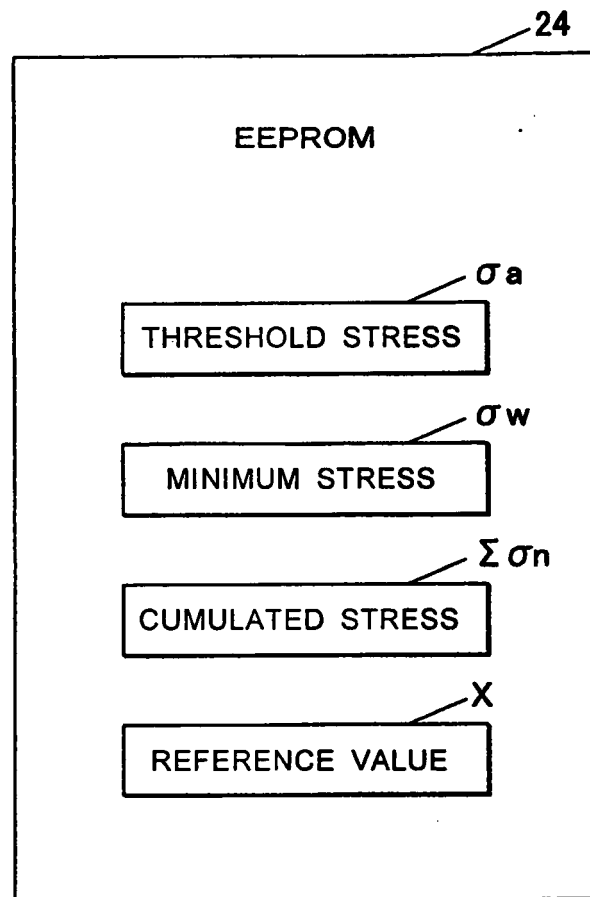


FIG. 5

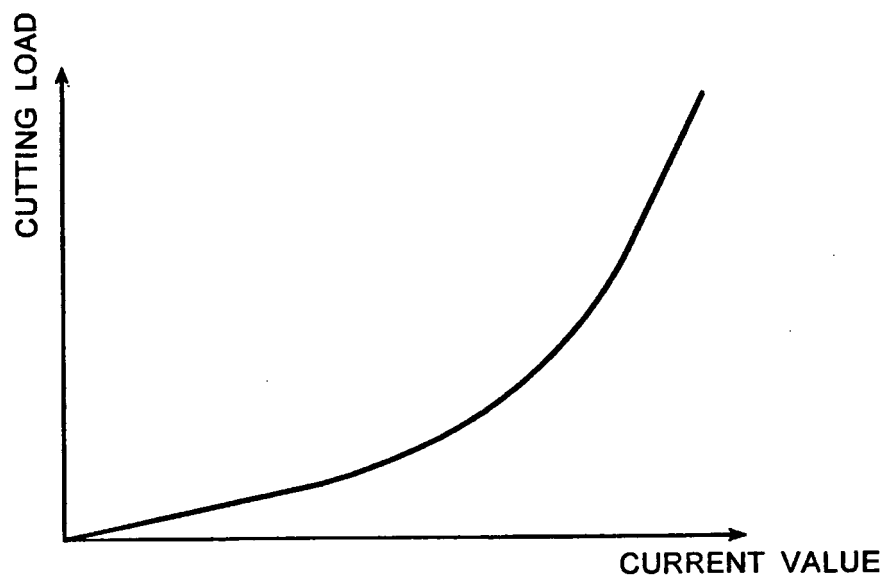


FIG. 6

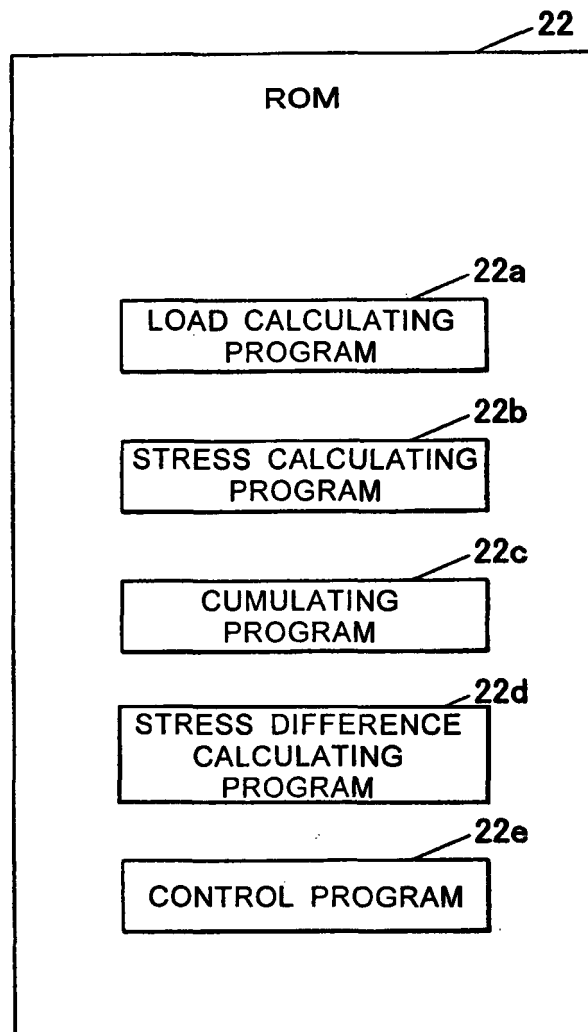


FIG. 7

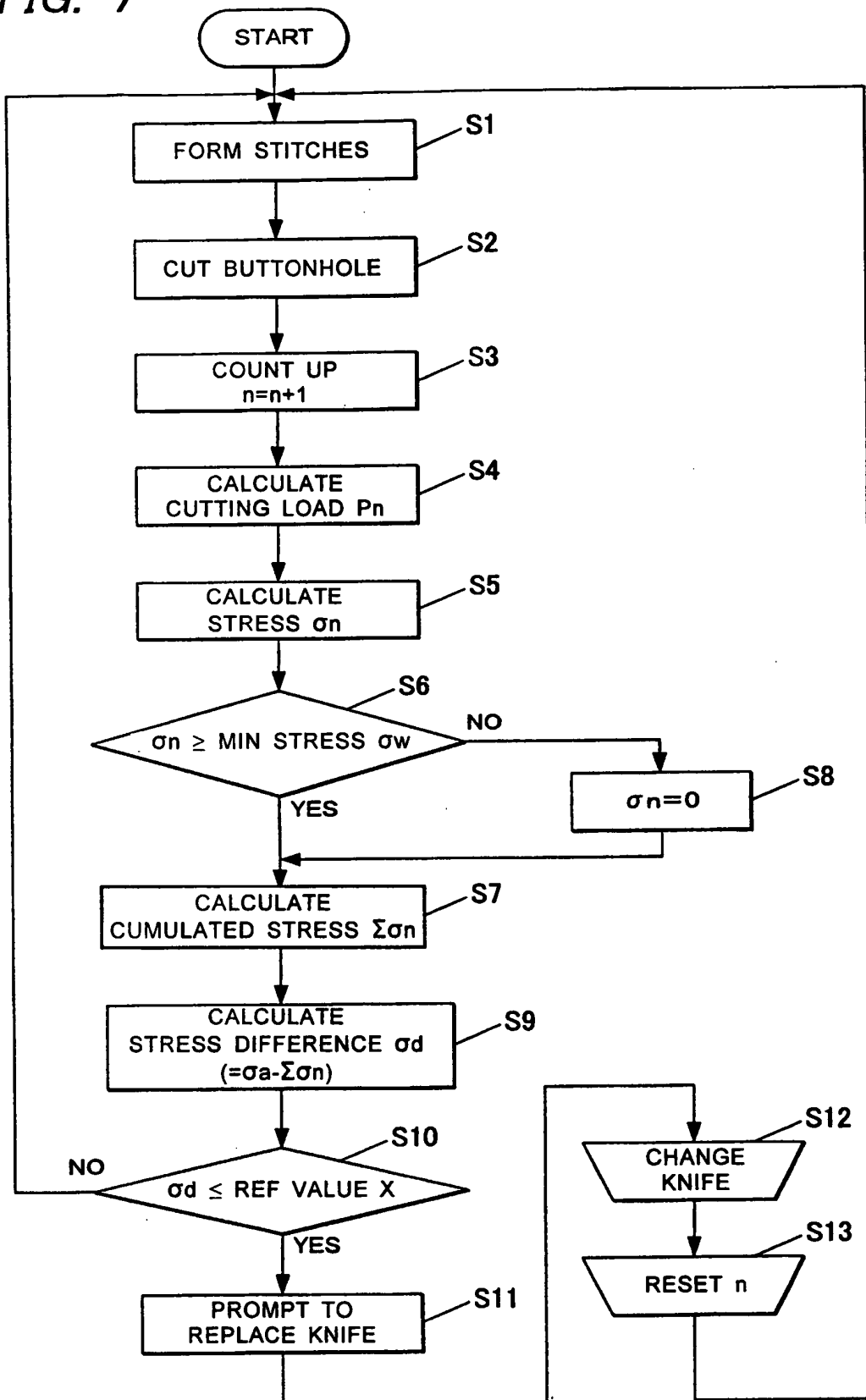
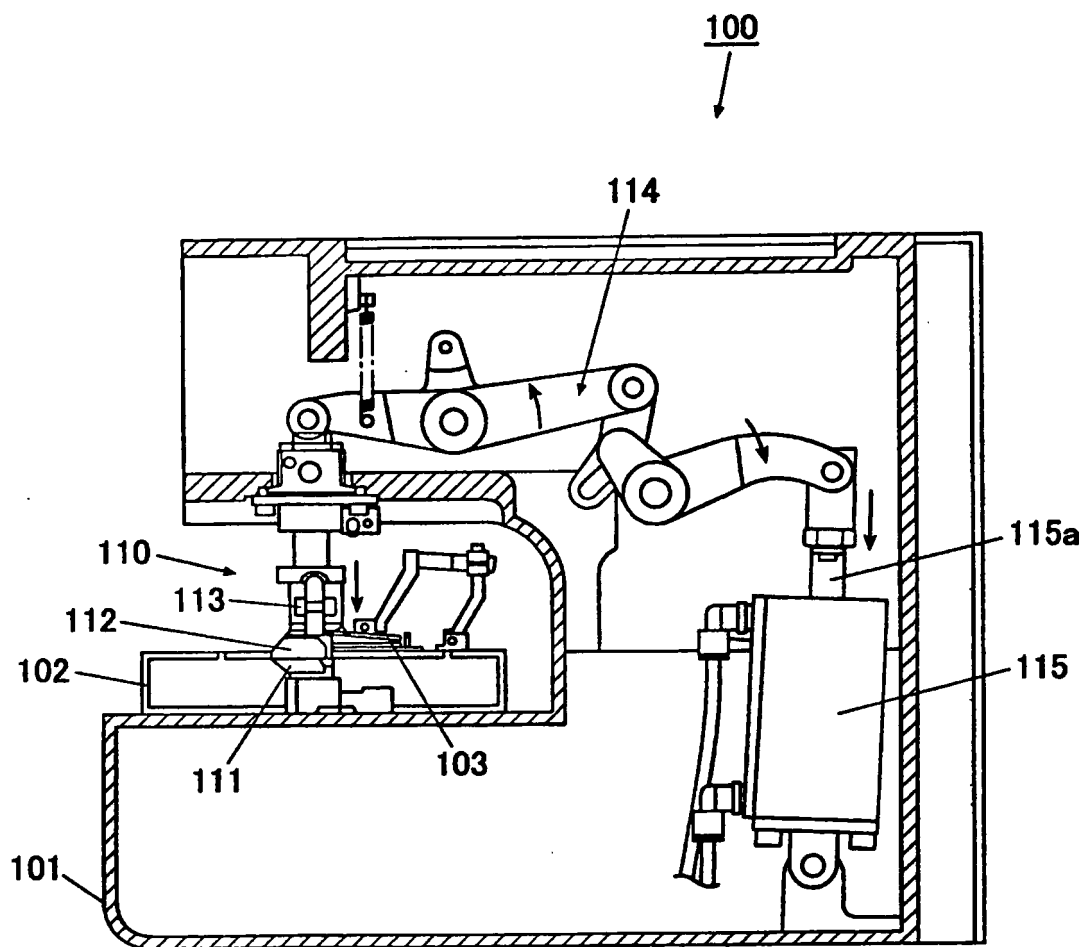


FIG. 8



REFERENCES CITED IN THE DESCRIPTION

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