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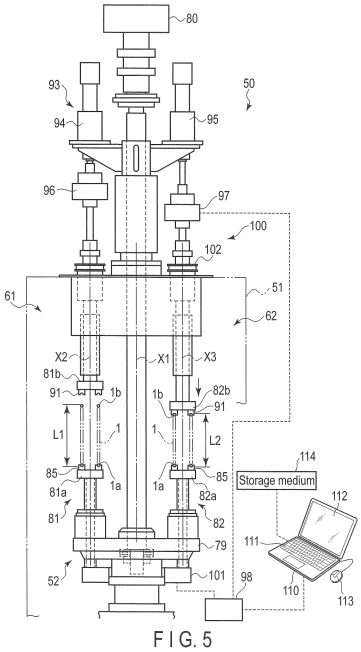
(54) SHOT PEENING DEVICE

(57) A shot peening device (50) includes a turntable (79) which rotates about a revolution axis (X1), holding mechanism (81, 82) which moves with the turntable (79), pressure mechanism (93) which compresses a coil spring (1), rotation mechanism (100) which rotates the coil spring (1), projection mechanism (57) which projects shots to the compressed coil spring (1), load cell (96, 97) which detects a load applied to the coil spring (1), and controller (98). A signal output from the load cell (96, 97) is input to the controller (98), and the controller (98) detects a chronological change of the load applied to the coil spring (1) during the shot peening.



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Description

Technical Field

[0001] The present invention described herein relate generally to a shot peening device which performs shot peening (stress shot peening) while a coil spring is being compressed.

Background Art

[0002] In order to increase durability of coil springs used in suspension springs of a suspension device of a vehicle, shot peening is well-known, which imparts a compressive residual stress to the coil spring. Patent Literature 1 discloses an example of a conventional shot peening device. The shot peening device thereof projects shots to the coil spring from a centrifugal accelerator (impeller) as the coil spring is conveyed. Patent Literature 2 discloses a conventional shot peening device. The shot peening device thereof compresses the coil spring and performs shot peening while the coil spring is stressed. That is, the shot peening device of the Patent Literature performs stress shot peening to impart a greater compressive residual stress to the coil spring. Furthermore, Patent Literature 3 discloses a shot peening device which performs shot peening on a rotating turntable in a state where the coil spring is compressed.

Citation List

Patent Literature

[0003]

Patent Literature 1: JP 2002-361558 A
Patent Literature 2: JP 2003-117830 A
Patent Literature 3: JP 2015-077638 A

Summary of Invention

Technical Problem

[0004] The shot peening device as in Patent Literature 1 simply hits shots to a coil spring, and thus, there is still a chance to increase the compressive residual stress of the coil spring. The shot peening device as in Patent Literatures 2 and 3 performs shot peening while a coil spring is compressed, and therein, the coil spring may be supported unstably depending on the shape of the coil spring (especially, on the shape of the end turn portion). Thus, stress shot peening may not be performed suitably because of the unstable coil spring.

[0005] Accordingly, an object of the present invention is to provide a shot peening device which can perform shot peening while a desired stress is applied to the coil spring.

Solution to Problem

[0006] According to an embodiment, a shot peening device includes: a turntable mechanism including a turntable which rotates around a revolution axis; a revolution mechanism which rotates the turntable mechanism; a holding mechanism which holds a lower end turn portion and an upper end turn portion of a coil spring while the coil spring is kept standing and moves around the revolution axis with the turntable; a rotation mechanism which rotates the holding mechanism around a rotation axis; a pressure mechanism which compresses the coil spring in a state where the coil spring is held by the holding mechanism; a load detector such as a load cell which detects a compressive load applied to the coil spring by the pressure mechanism; a projection mechanism which projects shots to the compressed coil spring; and a controller (for example, a personal computer) which detects a change in the load based on a signal output from the load detector.

[0007] For example, the load detector may be a load cell disposed in a load transfer path between the pressure mechanism and the holding mechanism. Furthermore, the controller may include means for storing a chronological change of the load. Or, the controller may include a display which displays a chronological change of the load.

[0008] The controller includes means for notifying that the load becomes out of an acceptable range while the projection mechanism projects shots to the coil spring. The controller may include a computer program which controls the pressure mechanism such that the load becomes a constant value while the projection mechanism projects shots to the coil spring.

Advantageous Effects of Invention

[0009] The present invention can perform shot peening (stress shot peening) in a state where a desired stress is applied to a coil spring in order to impart the compressive residual stress to the coil spring, and thus, the coil spring of stable quality can be obtained.

Brief Description of Drawings

[0010]

FIG. 1 is a perspective view of an example of a coil spring.
FIG. 2 is a flowchart of an example of the manufacturing process of the coil spring.
FIG. 3 is a schematic perspective view of a first shot peening device.
FIG. 4 is a perspective view of an example of a part of a conveyor and a transfer mechanism (robot).
FIG. 5 is a front view of a part of a second shot peening device of an embodiment.
FIG. 6 is a vertical cross-sectional view of the shot

peening device of FIG. 5.

FIG. 7 is a horizontal cross-sectional view of the shot peening device of FIG. 5.

FIG. 8 is a perspective view of a lower side holder of the shot peening device of FIG. 5.

FIG. 9 is a front view of the lower side holder of the shot peening device of FIG. 5 and an end turn portion of the coil spring.

FIG. 10 is a flowchart showing an operation of the shot peening device of FIG. 5.

FIG. 11 is a graph showing an example of chronological change in the load during the warm stress shot peening.

FIG. 12 is a graph showing another example of chronological change in the load during the warm stress shot peening.

[0011] Mode for Carrying Out the Invention Hereinafter, a coil spring processing device including a shot peening device 50 of an embodiment will be explained with reference to FIGS. 1 to 12.

[0012] FIG. 1 shows an example of a coil spring 1. The coil spring 1 is formed of an element wire 2 wound helically. The coil spring 1 includes an end turn portion 1a at its one end and an end turn portion 1b at its other end. A relative relationship between end 1c and other end 1d of the coil spring 1 is constant corresponding to the type of the coil spring 1.

[0013] In the present application, a position of the coil spring 1 from the end 1c around an axis C1 may be referred to as a position in a circumferential direction of the coil, or as a position in a winding direction. The coil spring 1 is, for example, a cylindrical coil spring; however, the coil spring 1 may be of various types such as a barrel-type coil spring, a hourglass-type coil spring, a tapered coil spring, an irregularly-pitched coil spring to conform to types of the suspension device. Furthermore, the end turn portions 1a and 1b may be formed in a negative pitch (negative pitch angle), or in a positive pitch (positive pitch angle).

[0014] FIG. 2 shows an example of a manufacturing process of the coil spring 1. In a forming process S1 of FIG. 2, the element wire 2 is formed helically by a coiling machine. In a heat treatment process S2, tempering and annealing of the wire 2 are performed to remove a distortion stress produced in the wire 2 by the forming process S1. For example, the wire 2 is heated to 400 to 450 °C and then is cooled slowly.

[0015] Furthermore, in a first shot peening process S3, first shot peening is performed in the warm using the remaining heat of the heat treatment process S2. In the first shot peening process S3, first shots are projected to the entire surface of the coil spring 1 in a process temperature of 250 to 300 °C by a first shot peening device 10 which is shown in FIG. 3. The first shot is, for example, a cut wire of which grain diameter is 1.1 mm. Note that a different shot peening device 10 may be used and a different shot size (for example, 0.87 to 1.2 mm) may be used. Through the first shot peening process S3, a compressive residual stress is produced to a relatively deep position from the surface of the coil spring 1. Furthermore, an oxide film (mill scale formed in the heat treatment) on the surface of the wire 2 is removed in the first shot peening process S3.

[0016] FIG. 3 shows a schematic example of the first shot peening device 10. The first shot peening device 10 includes a pair of rollers 11 and 12 and a shot projector (impeller) 13. Coil springs 1 are disposed on the rollers 11 and 12 in series in a position where the axis C1 is horizontal (laid horizontally). The coil spring 1 on the rollers 11 and 12 is rotated around the axis C1 to continuously move in the direction of arrow F1 in the figure. The shot projector 13 projects shots SH1 to the moving coil spring 1.

[0017] FIG. 4 shows a conveyor device 20 which is a part of the coil spring processing device and a robot 21 handling the coil spring 1. The conveyor device 20 continuously conveys the coil springs 1 in the direction of arrow F2. The robot 21 holds the coil spring 1 at both sides with an openable chuck 23 provided with the tip of an arm 22. The robot 21 is an example of a transfer mechanism used for moving the coil spring 1.

[0018] The robot 21 includes a function to store the positions of the ends 1c and 1d of the coil spring 1 held by the chuck 23 in a memory. The coil spring 1 held by the robot 21 is preliminarily maintained by means for positioning such as a jig such that the ends 1c and 1d are set to predetermined positions.

[0019] In a second shot peening process S4, second shot peening (warm stress shot peening) is performed by a shot peening device 50 of FIGS. 5 to 9. The second shot peening process S4 is performed in a temperature lower than that of the first shot peening process S3 (for example, warm zone of 200 to 250 °C) while the coil spring 1 is compressed. In the second shot peening process S4, second shots are projected to the entire surface of the coil spring 1. The size of second shot is less than that of the first shot used in the first shot peening process S3. The second shot is, for example, a cut wire of which grain diameter is 0.4 to 0.7 mm. Through the second shot peening process S4, the absolute value of the compressive residual stress in the proximity of the surface of wire 2 can be increased.

[0020] Then, a setting process S5 is performed if necessary. Furthermore, the coil spring 1 is coated in a coating process S6, and lastly, a quality inspection is performed in an inspection process S7 and the coil spring 1 is completed.

[0021] Now, the structure and operation of the second shot peening device 50 will be explained with reference to FIGS. 5 to 9. The second shot peening device 50 is a part of the coil spring processing device. The second shot peening device 50 performs shot peening in a warm zone between 200 and 250 °C, for example while the coil spring 1 is kept standing. "The position where the coil spring 1 is kept standing" means that the axis C1 of the coil spring

1 is substantially vertical.

[0022] FIG. 5 is a front view showing a part of the second shot peening device 50. FIG. 6 is a vertical cross-sectional view of the second shot peening device 50. FIG. 7 is a horizontal cross-sectional view of the second shot peening device 50. The second shot peening device 50 includes a housing 51, turntable mechanism 52, projection mechanism 57 (shown in FIG. 6), first elevator mechanism 58, and second elevator mechanism 59. The projection mechanism 57 includes a first projection unit 55 and a second projection unit 56. The first elevator mechanism 58 and the second elevator mechanism 59 move the projection units 55 and 56 vertically.

[0023] The first elevator mechanism 58 and the second elevator mechanism 59 include, for example, servo motors 58a and 59a (shown in FIG. 6) of which rotation is controlled by a controller and ball screws 58b and 59b. The elevator mechanisms 58 and 59 move the projection units 55 and 56 independently and vertically at constant strokes Y1 and Y2 based on the direction and amount of rotation of the servo motors 58a and 59a.

[0024] As shown in FIGS. 6 and 7, a first chamber 61, a second chamber 62, and middle chambers 63 and 64 which are disposed between the chambers 61 and 62 are formed inside the housing 51. A coil spring inlet/outlet port 65 is formed in the first chamber 61. The coil spring inlet/outlet port 65 is an opening through which the coil spring 1 is put in and out the first chamber 61 from the outside the housing 51. The second chamber 62 is provide with a projection port 55a of the first projection unit 55 and a projection port 56a of the second projection unit 56. Shots SH2 are projected to the coil spring 1 from the projection ports 55a and 56a.

[0025] As shown in FIG. 7, partition walls 70 and 71 are provided between the first chamber 61 and the middle chambers 63 and 64. Partition walls 72 and 73 are provided between the second chamber 62 and the middle chambers 63 and 64. Seal walls 74 and 75 are formed in the middle chambers 63 and 64. The seal walls 74 and 75 keep the shots SH2 projected in the second chamber 62 from going to the first chamber 61.

[0026] As shown in FIG. 5, the turntable mechanism 52 includes a turntable 79, revolution mechanism 80 (shown in FIG. 5), first holding mechanism 81, and second holding mechanism 82. The turntable 79 rotates around a revolution axis X1 extending in the vertical direction. The revolution mechanism 80 is provided with a motor. The motor intermittently rotates the turntable 79, 180° at a time around the revolution axis X1 in either first direction R1 or second direction R2 (shown in FIG. 7). The holding mechanisms 81 and 82 rotate around the revolution axis X1 together with the turntable 79. The first holding mechanism 81 includes a lower side holder 81a and an upper side holder 81b. The lower side holder 81a is disposed on the turntable 79. The upper side holder 81b is disposed above the lower side holder 81a to be opposed thereto. The second holding mechanism 82 also includes a lower side holder 82a and an upper side holder 82b. The lower side holder 82a is disposed on the turntable 79. The upper holder 82b is disposed above the lower side holder 82a to be opposed thereto.

[0027] The first and second holding mechanism 81 and 82 are positioned 180° symmetrically about the revolution axis X1. In the rear side of the first and second holding mechanisms 81 and 82 on the turntable 79, a pair of backup plates 83 and 84 (shown in FIG. 7) are disposed.

[0028] A shifting prevention jig 85 is provided with each of the lower side holder 81a of the first holding mechanism 81 and the lower side holder 82a of the second holding mechanism 82. A lower end turn portion 1a of the coil spring 1 can engage the shifting prevention jig 85. FIGS. 8 and 9 show the lower side holder 81a of the first holding mechanism 81. The structure of the lower side holder 82a of the second holding mechanism 82 is similar to that of the lower side holder 81a of the first holding mechanism 81. Thus, the lower side holder 81a of the first holding mechanism 81 will be explained with reference to FIGS. 8 and 9.

[0029] As shown in FIGS. 8 and 9, the shifting prevention jig 85 is provided with the lower side holder 81a. The shifting prevention jig 85 includes a plurality of pawls (for example, three pawls) 85a, 85b, and 85c. The pawls 85a, 85b, and 85c are arranged to conform to the shape, pitch angle, and the like of the end turn portion 1a such that the end turn portion 1a of the coil spring 1 can be stably supported. For example, the pawls 85a, 85b, and 85c are disposed on the lower side holder 81a in its peripheral direction at regular intervals (for example, 90°). Note that the number of pawls of the lower shifting prevention jig 85 and the number of pawls of an upper shifting prevention jig 91 may be other than three. Furthermore, the pawls may be disposed at intervals at an angle other than 90°.

[0030] Guide grooves 86a and 86b are formed in a base member 86 of circular plate shape. The pawls 85a, 85b, and 85c are movable along the guide grooves 86a and 86b. The pawls 85a, 85b, and 85c are adjusted to a position corresponding to the end turn portion 1a and the pawls 85a, 85b, and 85c are fixed to the base member 86 by blots 87 (shown in FIG. 9). Height adjustment members 88 and 89 are provided between the base member 86 and the pawls 85b and 85c. The height adjustment members 88 and 89 have thicknesses T1 and T2 which correspond to the pitch angles of the end turn portions of the coil spring. Thus, even an end turn portion of negative pitch can be stably mounted on the pawls 85a, 85b, and 85c. The pawls 85a, 85b, and 85c each include a V-shaped groove 90 into which the end turn portion 1a is inserted.

[0031] With the upper side holders 81b and 82b, a shifting prevention jig 91 corresponding to the upper end turn portion 1b is provided. As in the lower shifting prevention jig 85, the upper shifting prevention jig 91 includes a plurality of pawls (for example, three pawls) conforming to the shape, pitch angle, and the like of the end turn portion 1b. The upper end turn portion 1b is held stably by the

pawls. The upper shifting prevention jig 91 may be formed different from the lower shifting prevention jig 85 depending on the shape of the end turn portion 1b.

[0032] The revolution mechanism 80 (shown in FIG. 5) rotates the turntable 79 around the revolution axis X1. That is, the revolution mechanism 80 intermittently rotates the turntable 79, 180° at a time around the revolution axis X1 in either first direction R1 or second direction R2 (shown in FIG. 7). When the first holding mechanism 81 is positioned in the first chamber 61, the second holding mechanism 82 is positioned in the second chamber 62. When the second holding mechanism 82 is positioned in the first chamber 61, the first holding mechanism 81 is positioned in the second chamber 62.

[0033] Furthermore, the shot peening device 50 includes, as shown in FIG. 5, a pressure mechanism 93 which compresses the coil spring 1. The pressure mechanism 93 includes presser units 94 and 95 which move the upper side holders 81b and 82b vertically. The presser units 94 and 95 include, for example, ball screws and servo motors. The presser units 94 and 95 can change a compression load (stress) applied to the coil spring 1 depending on the vertical movement amount of the upper side holders 81b and 82b. The presser units 94 and 95 may use fluid pressure as their drive source such as a hydraulic cylinder.

[0034] First and second presser units 94 and 95 include load cells 96 and 97, respectively. The load cells 96 and 97 are examples of load detectors. The load cells (load detectors) 96 and 97 detect a compression load applied to the coil spring 1 during the shot peening, and input an electrical signal related to the detected compression load to a controller 98. The first load cell 96 is disposed in a load transfer path between the first presser unit 94 and the upper side holder 81b. The second load cell 97 is disposed in a load transfer path between the second presser unit 95 and the upper side holder 82b.

[0035] The controller 98 includes a function (computer program) to detect a change of the load based on the outputs from the load cells 96 and 97. Furthermore, the controller 98 includes a function to notify that the load becomes out of an acceptable range during the shot peening. Furthermore, the controller 98 compares the load value output from the load cells 96 and 97 to a certain load value preset in the controller 98. Furthermore, the controller 98 includes a function to feedback the signals to the first and second presser units 94 and 95 such that a different between the output load value and the certain load value reaches zero, that is, a certain load can be applied to the coil spring 1.

[0036] The shot peening device 50 includes a rotation mechanism 100. The rotation mechanism 100 rotates the coil spring 1 around the rotation axes X2 and X3. The rotation axes X2 and X3 each extend in a vertical direction. The rotation mechanism 100 includes a lower rotator 101 and an upper rotator 102. The lower rotator 101 rotates the lower side holders 81a and 82a around the rotation axes X2 and X3. The upper rotator 102 rotates the upper side holders 81b and 82b around the rotation axes X2 and X3.

[0037] The lower rotator 101 and the upper rotator 102 each include a drive source of a timing belt and a servo motor. The controller 98 which controls the drive source rotates the lower rotator 101 and the upper rotator 102 in the same direction in synchronization at the same revolution rate. That is, the lower side holders 81a and 82a and the upper side holders 81b and 82b rotate in the same direction in synchronization at the same revolution rate. Furthermore, the lower side holders 81a and 82a and the upper side holders 81b and 82b can stop at a preset first rotation stop position or a preset second rotation stop position on the basis of the data preliminarily input in the controller 98. The first rotation stop position is, for example, a position suitable for the robot 21 to hand the coil spring 1 to the holding mechanisms 81 and 82. The second rotation stop position is, for example, a position suitable for taking the coil spring 1 from the holding mechanisms 81 and 82.

[0038] An information processor 110 such as a personal computer is connected to the controller 98. The information processor 110 includes an input device 111 used to input various data such as serial number of coil spring, display 112, and pointing device 113 such as a mouse. For example, various data (coil diameter, turn number, length, and wire diameter) related to the coil spring and data related to a load applied to coil spring during shot peening and the like can be input through the input device 111 or a storage medium 114.

[0039] The information processor 110 such as a personal computer functions as means for storing a chronological change of a load applied to the coil spring 1 during the shot peening. Furthermore, the display 112 of the information processor 110 functions as means for displaying the chronological change of the load during the shot peening. Note that the information processor 110 may include the functions of the controller 98.

[0040] FIG. 7 is a horizontal cross-sectional view of the first projection unit 55 and the second projection unit 56, viewed from the above. The first projection unit 55 includes an impeller (wing wheel) 121 and a distributor 122. The impeller 121 is rotated by a motor 120. The distributor 122 supplies shots SH2 to the impeller 121. The second projection unit 56 includes an impeller 126 rotated by a motor 125 and a distributor 127 which supplies shots SH2 to the impeller 126.

[0041] The first projection unit 55 is supported by a guide member 130 extending vertically to be movable in the vertical direction. The guide member 130 is provided with the side part of the housing 51. The first projection unit 55 reciprocates by the first elevator mechanism 58 (shown in FIG. 6) from a neutral position N1 to go over an ascend position A1 and a descend position B1. The second projection unit 56 is supported by a guide member 131 extending vertically to be movable in the vertical direction. The guide member 131 is provided with the side part of the housing 51. The second projection unit 56

reciprocates by the second elevator mechanism 59 from neutral position N2 to go over an ascend position A2 and a descend position B2.

[0042] FIG. 10 is a flowchart showing the operation of the shot peening device 50 of the present embodiment.

[0043] In step S10 of FIG. 10, the lower side holder 81a of the first holding mechanism 81 is stopped in the first chamber 61. First coil spring 1 is set to (mounted on) the lower side holder 81a by the robot 21 (shown in FIG. 4). The end turn portion 1a mounted on the lower side holder 81a is stopped by the shifting prevention jig 91 (shown in FIGS. 8 and 9). When the upper side holder 81b descends, the coil spring 1 is compressed between the lower side holder 81a and the upper side holder 81b. At that time, the second holding mechanism 82 is positioned in the second chamber 62. The second holding mechanism 82 is in an empty state where no coil spring is mounted thereon. The coil spring 1 in the left of FIG. 5 is in a free state where no compression load is applied thereto. The length of the coil spring 1 in the free state (free length) is L1. The coil spring 1 in the right of FIG. 5 is in a state where it is compressed to length L2.

[0044] In step S11 of FIG. 10, the turntable 79 rotates 180° in a first direction. By the rotation, the coil spring 1 held by the first holding mechanism 81 is sent to the second chamber 62. At the same time, the second holding mechanism 82 is moved to the first chamber 61. In step S12, second coil spring 1 is set to the second holding mechanism 82.

[0045] In step S13, in the second chamber 62, the first coil spring 1 in the compressed state is rotated (turns on its axis) by the rotation mechanism 100 and shot peening is performed. That is, the first projection unit 55 and the second projection unit 56 moving vertically project shots SH2 to the first coil spring 1. The shot peening is performed while the stress is applied to the coil spring 1, and thus, a compressive residual stress which is effective to increase the durability of the coil spring 1 can be produced in a surface portion of the coil spring 1.

[0046] In step S14, the turntable 79 rotates 180° in a second direction. Thus, the coil spring 1 held by the first holding mechanism 81 is returned to the first chamber 61. Furthermore, the coil spring 1 held by the second holding mechanism 82 is sent to the second chamber 62.

[0047] In step S15, the upper side holder 81b of the first holding mechanism 81 rises, and the first coil spring 1 held by the first holding mechanism 81 is taken by the robot 21. The first holding mechanism 81 becomes empty, and the robot 21 sets third coil spring 1 thereto. The upper side holder 81b descends to compress the coil spring 1.

[0048] In step S16, in the second chamber 62, the second coil spring 1 in the compressed state is rotated (turns on its axis) by the rotation mechanism 100 and shot peening is performed. That is, the first projection unit 55 and the second projection unit 56 moving vertically project shots SH2 to the second coil spring 1.

[0049] In step S17, the turntable 79 rotates 180° again in the first direction. Thus, the coil spring 1 held by the first holding mechanism 81 is sent to the second chamber 62 and the second holding mechanism 82 is returned to the first chamber 61. The upper side holder 82b of the second holding mechanism 82 rises, and then, the coil spring 1 held by the second holding mechanism 82 is taken by the robot 21. Next coil spring 1 is set by the robot 21 into the second holding mechanism 82 in the empty state. After that, the upper side holder 82b descends to compress the coil spring 1. A series of steps S10 to S17 is repeated by the number of coil springs 1 (N times), and the shot peening of all coil springs 1 is completed.

[0050] FIG. 11 is a graph schematically showing an example of a chronological change of load (relationship between time and load) in warm stress shot peening performed by the shot peening device 50. For example, the shot peening device 50 performs the warm stress shot peening to the coil spring 1 held by the first holding mechanism 81, the coil spring 1 is compressed by the pressure mechanism 93. Between time t0 and t1 is an insensible zone of the load cell 96, and thus, the load is not detected. When the coil spring 1 is further compressed over the insensible zone, the load detected by the load cell 96 increases from Z1 to Z2. At time t2, the load reaches Z2 which is a target load, the pressure mechanism 93 is stopped. Then, the warm stress shot peening (projection of shots SH2) is started at time t3 while the compression (compression stroke) of the coil spring 1 is kept constant. The warm stress shot peening is performed until time t4 lapses.

[0051] When the compressive residual stress is produced in the coil spring 1 by the warm stress shot peening, the load tends to slightly increase by the compressive residual stress as shown in FIG. 11 with single-dotted line m1. However, a permanent set in fatigue occurs in the coil spring 1 which is compressed in the warm range, and thus, the load decreases as shown with dotted line m2 with some exaggeration. Thus, the load as a whole tends to slightly decrease as shown with solid line m3. The load as a whole (solid line m3) is determined a balance of the load increased by the occurrence of the compressive residual stress (line m1) and the load decreased by the permanent set in fatigue in the coil spring 1 (line m2). Thus, the load as a whole (line m3) may possibly be increased.

[0052] In the shot peening device 50 of the present embodiment, the load detected by the load cells 96 and 97 during the warm stress shot peening is constantly monitored by the controller 98. The information related to the detected load is displayed in the display 112. At the same time, the information is stored in a memory of the information processor 110 or in a storage medium 114. The information (a chronological change of load and the like) stored in the storage medium 114 or the like can be referred to anytime if necessary. If the detected change of the load is within an acceptable range, it is determined that the warm stress shot peening is per-

formed properly while a certain load is applied to the coil spring.

[0053] As explained above, the data related to chronological change of load are stored in the internal memory of the information processor 110 or the storage medium 114 during the warm stress shot peening is performed by the shot peening device 50. This process proves that the warm stress shot peening to the coil spring is performed properly, that is, the quality of coil spring.

[0054] A permanent set in fatigue of the coil spring during the shot peening may be a problem. In that case, as shown in FIG. 11 with two-dotted line m4, the signals output from the load cells 96 and 97 are sent back to the pressure mechanism 93 such that the load during the warm stress shot peening can be constant. Then, the presser units 94 and 95 are driven in the real time to change the stroke of compression, and thus, the warm stress shot peening can be substantially performed in the constant compression load.

[0055] FIG. 12 is a graph schematically showing another example of a change of load occurring during the warm stress shot peening. As shown in FIG. 12 with solid line m5, the load may suddenly drops at time t5 to be out of the acceptable range (threshold value). In that case, the coil spring 1 may possibly be dismounted from the first holding mechanism 81 or the second holding mechanism 82 during the shot peening. Thus, if such a steep drop of load is recognized, it is determined that the warm stress shot peening is not performed properly, and the coil spring is handled as a defective.

[0056] Furthermore, as shown in FIG. 12 with dotted line m6, if the load changes periodically during the shot peening, the coil spring 1 may possibly be held unstably. If such a change in load is recognized, it is determined that the warm stress shot peening is not performed properly, and the coil spring is handled as a defective.

Industrial Applicability

[0057] When the present invention is achieved, models, structures, and arrangement of the elements of the shot peening device can be arbitrarily changed. For example, the controller processing the signals output from the load cells may be a personal computer or may be an information processor storing computer program developed specifically for the shot peening device. Furthermore, a load detector other than the load cell may be used.

Reference Signs List

[0058] 1: Coil spring, 1a, 1b: End turn portion, 2: Wire, 10: First shot peening device, 50: Second shot peening device, 52: Turntable mechanism, 55: First projection unit, 56: Second projection unit, 57: Projection mechanism, 61: First chamber, 62: Second chamber, 79: Turntable, 80: Revolution mechanism, 81: First holding mechanism, 82: Second holding mechanism, 93: Pressure mechanism, 94, 95: Pressure unit, 96, 97: Load cell (load detector), 98: Controller, 100: Rotation mechanism, 110: Information processor, 111: Input device, 112: Display, X1: Revolution axis, X2, X3: Rotation axis

Claims

1. A shot peening device **characterized by** comprising:

   a turntable mechanism (52) including a turntable (79) which rotates around a revolution axis (X1);
   a revolution mechanism (80) which rotates the turntable mechanism (52);
   a holding mechanism (81, 82) which holds a lower end turn portion (la) and an upper end turn portion (1b) of a coil spring (1) while the coil spring (1) is kept standing and moves around the revolution axis (X1) with the turntable (79);
   a rotation mechanism (100) which rotates the holding mechanism (81, 82) around a rotation axis (X2, X3) ;
   a pressure mechanism (93) which compresses the coil spring (1) in a state where the coil spring (1) is held by the holding mechanism (81, 82);
   a load detector which detects a load applied to the coil spring (1) by the pressure mechanism (93);
   a projection mechanism (57) which projects a shot to the compressed coil spring (1); and
   a controller (98) which detects a change in the load based on a signal output from the load detector.

2. The shot peening device of Claim 1, **characterized in that** the load detector is a load cell (96, 97) disposed in a load transfer path between the pressure mechanism (93) and the holding mechanism (81, 82) .

3. The shot peening device of Claim 1 or 2, **characterized in that** the controller (98) includes means for storing a chronological change of the load.

4. The shot peening device of Claim 1, **characterized in that** the controller (98) includes a display (112) which displays a chronological change of the load.

5. The shot peening device of Claim 2, **characterized in that** the controller (98) includes a display (112) which displays a chronological change of the load.

6. The shot peening device of Claim 3 according to any one of Claims 1 to 3, **characterized in that** the controller (98) includes a display (112) which displays a

chronological change of the load.

7. The shot peening device of Claim 1 or 2, wherein the controller (98) includes means for notifying that the load becomes out of an acceptable range while the projection mechanism (57) projects shots to the coil spring (1).

8. The shot peening device of Claim 1 or 2, **characterized in that** the controller (98) controls the pressure mechanism (93) such that the load becomes a constant value while the projection mechanism (57) projects shots to the coil spring (1).

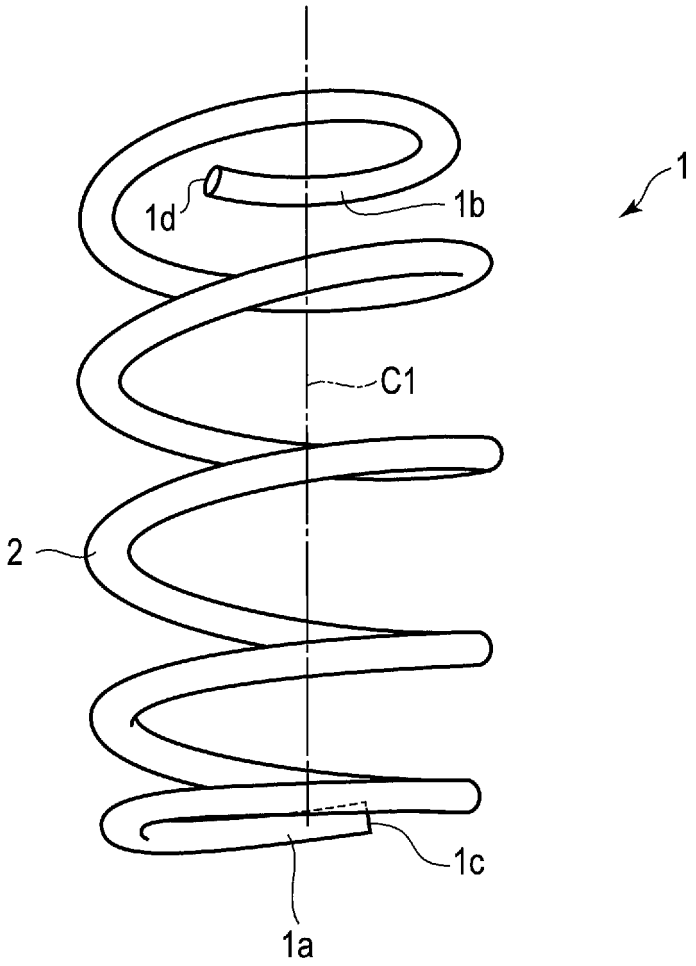

FIG. 1

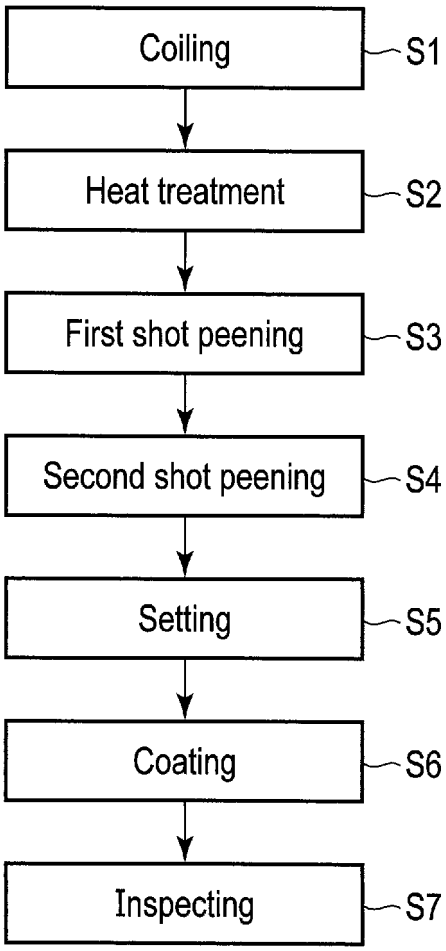
Coiling
S1
Heat treatment
S2
First shot peening
S3
Second shot peening
S4
Setting
S5
Coating
S6
Inspecting
S7

FIG. 2

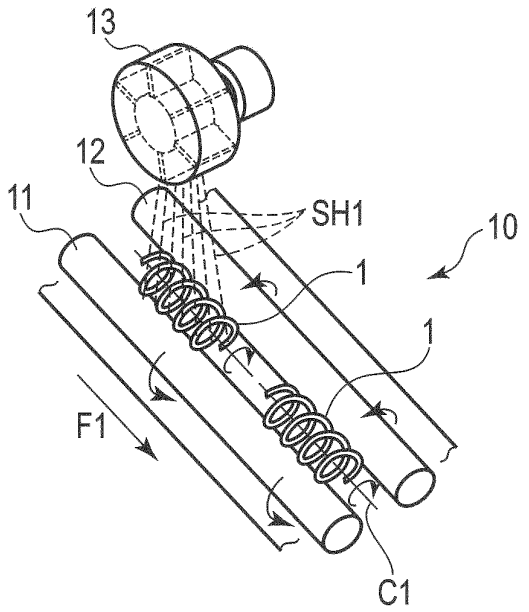

FIG. 3

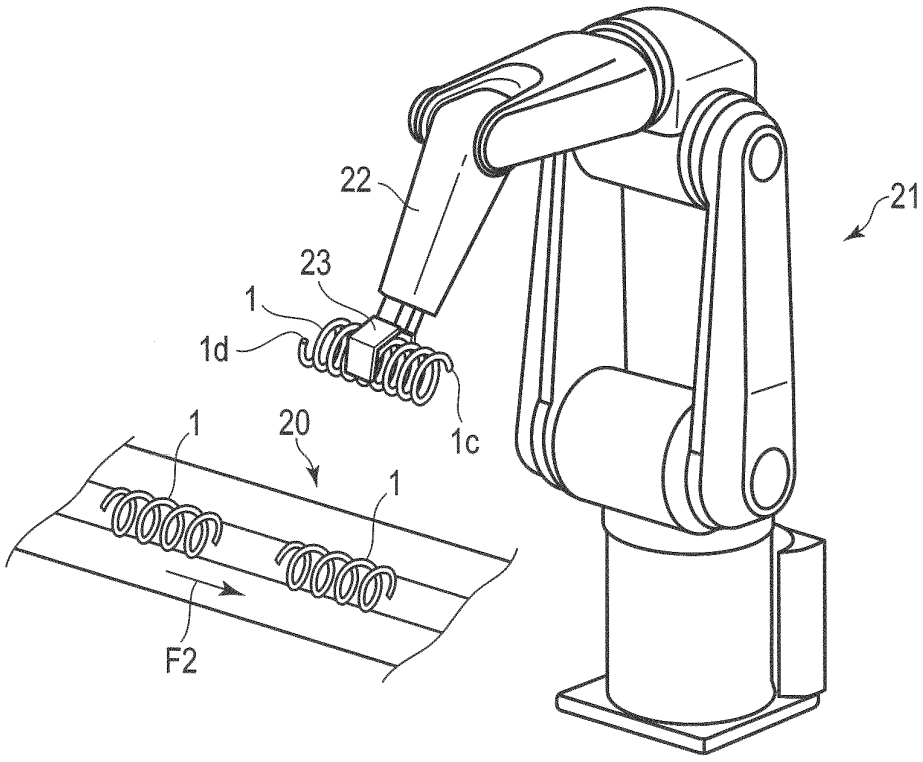

FIG. 4

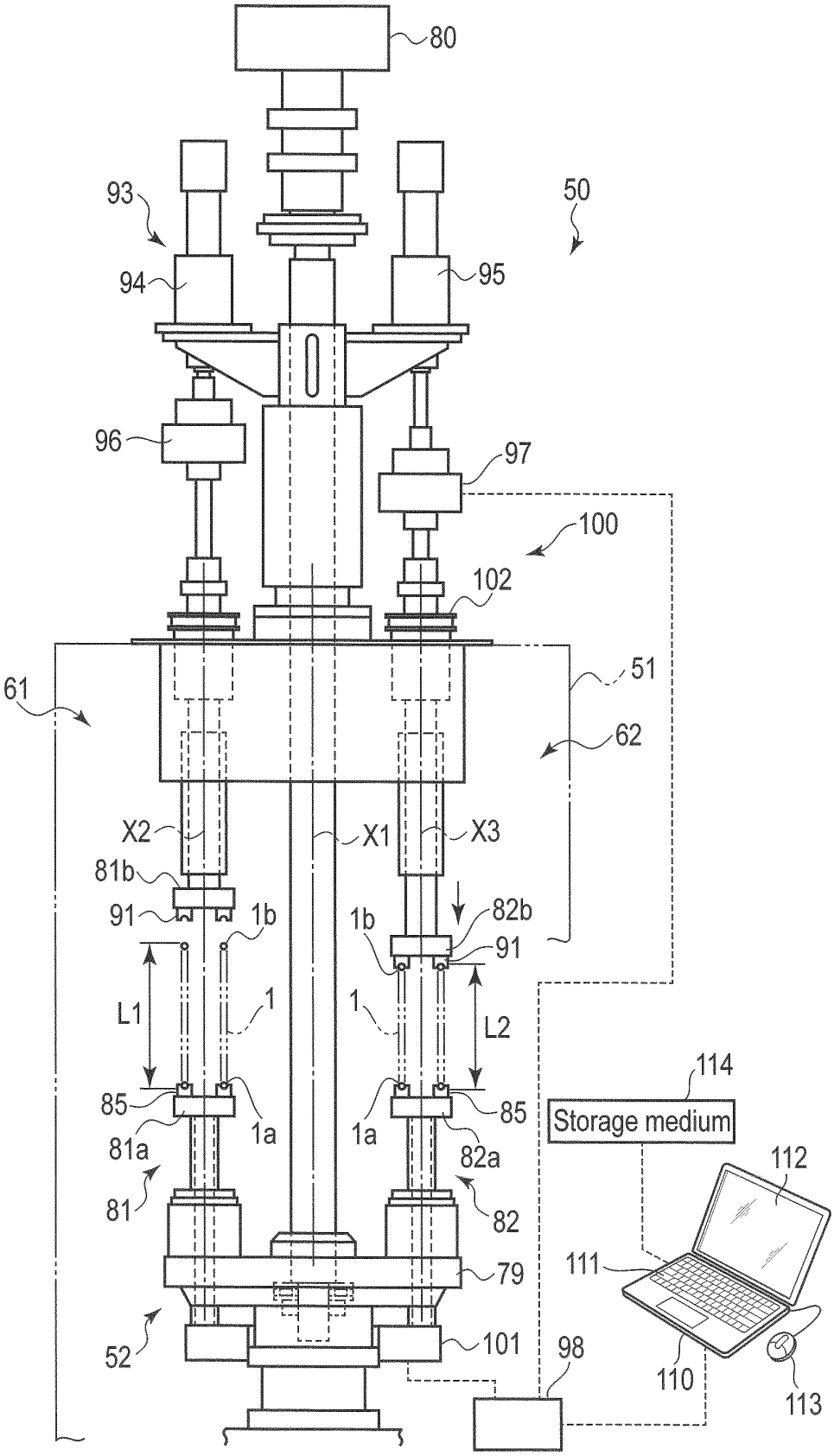
80
93
50
94
95
96
97
100
102
51
61
62
X2
X1
X3
81b
91
1b
1b
82b
91
L1
1
1
L2
85
1a
1a
85
81a
82a
81
82
79
52
101
98
114
Storage medium
112
111
110
113

FIG. 5

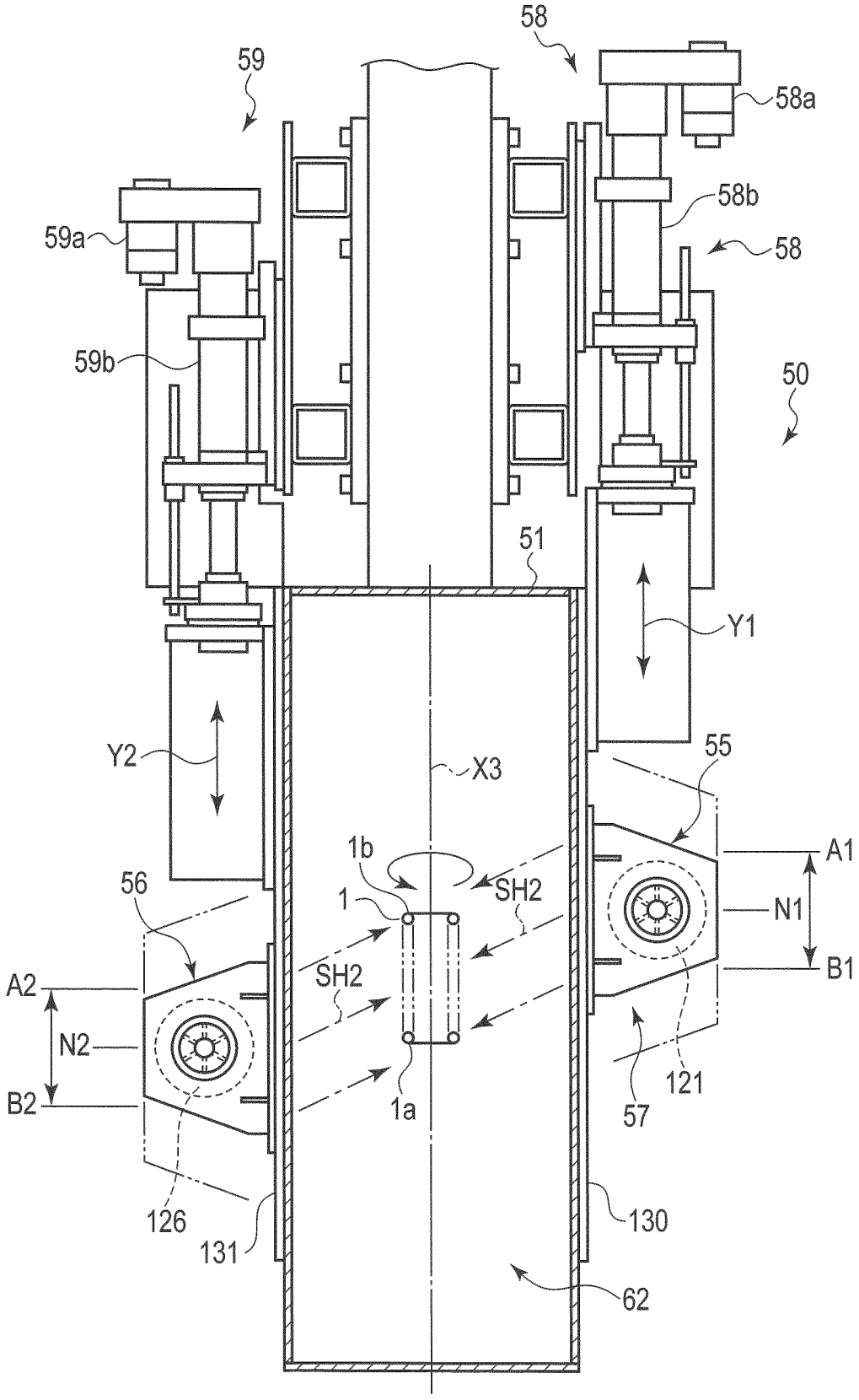
58
59
58a
58b
59a
58
59b
50
51
Y1
Y2
X3
55
A1
1b
56
1
SH2
N1
B1
SH2
A2
N2
B2
1a
121
57
126
131
130
62

FIG. 6

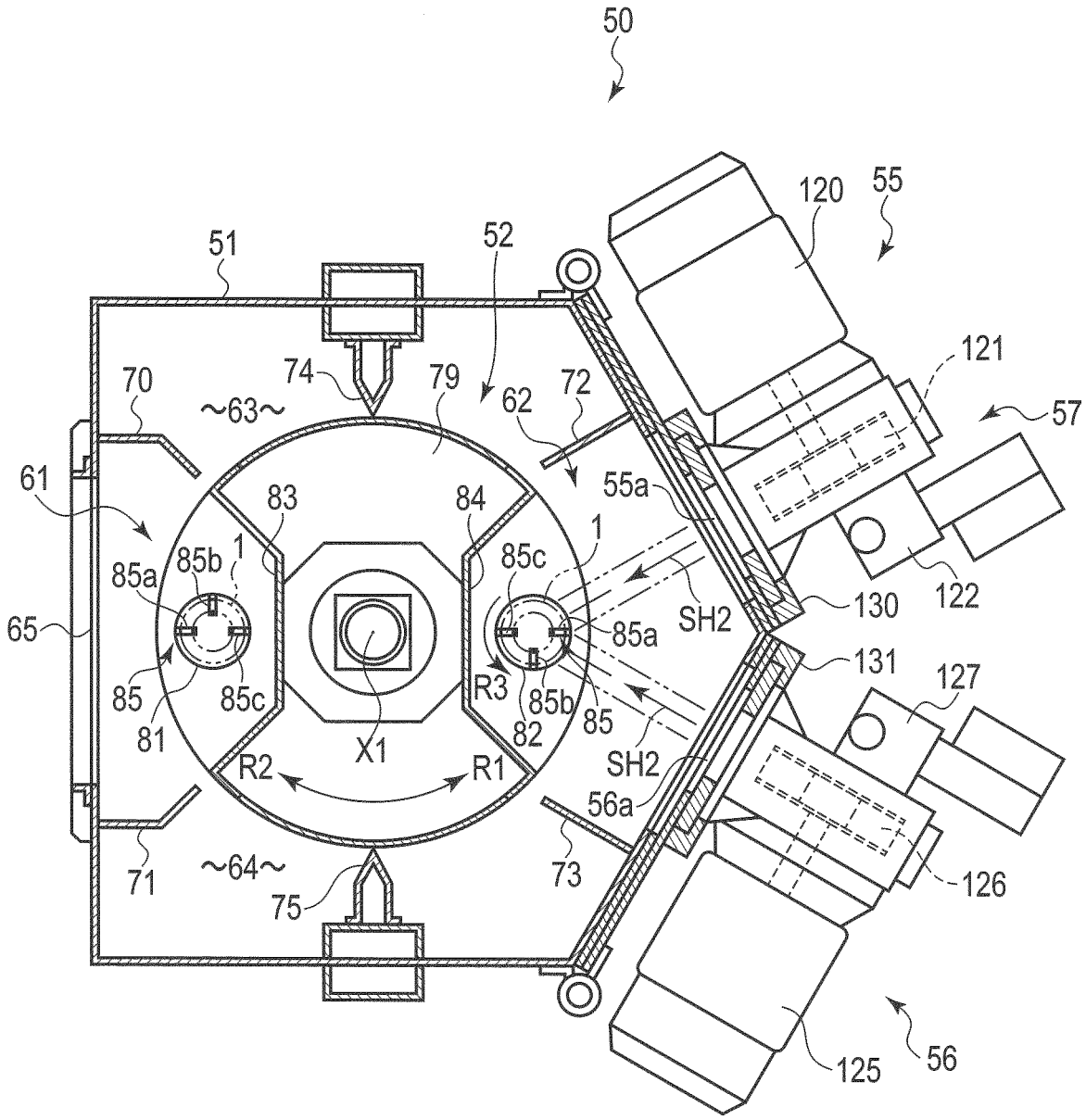
50
120
55
51
52
121
57
70
74
79
62
72
~63~
61
83
84
55a
1
85a
85b
1
85c
SH2
130
122
65
85a
131
127
85
85c
R3
85b
85
81
82
SH2
X1
R2
R1
56a
71
~64~
75
73
126
125
56

FIG. 7

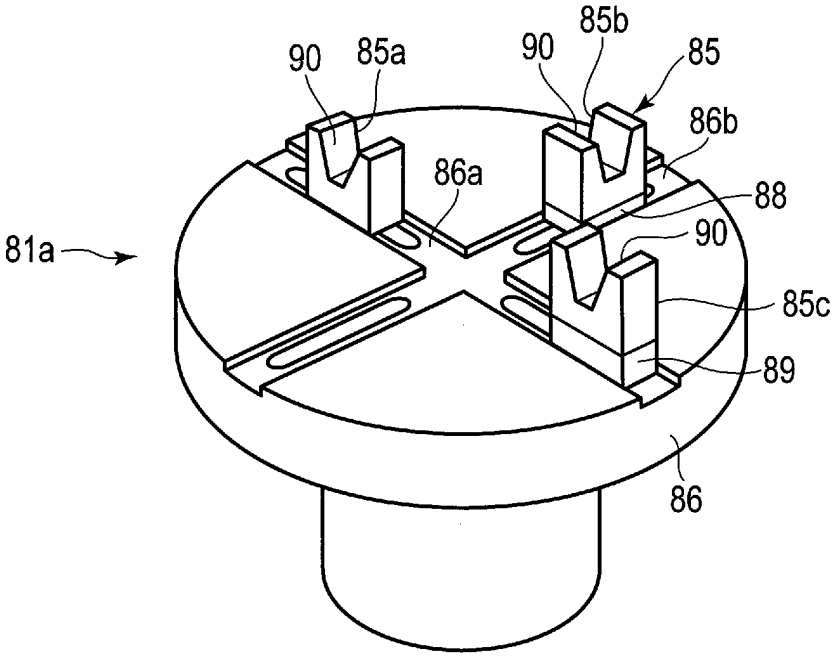
90
85a
90
85b
85
86b
86a
88
81a
90
85c
89
86

FIG. 8

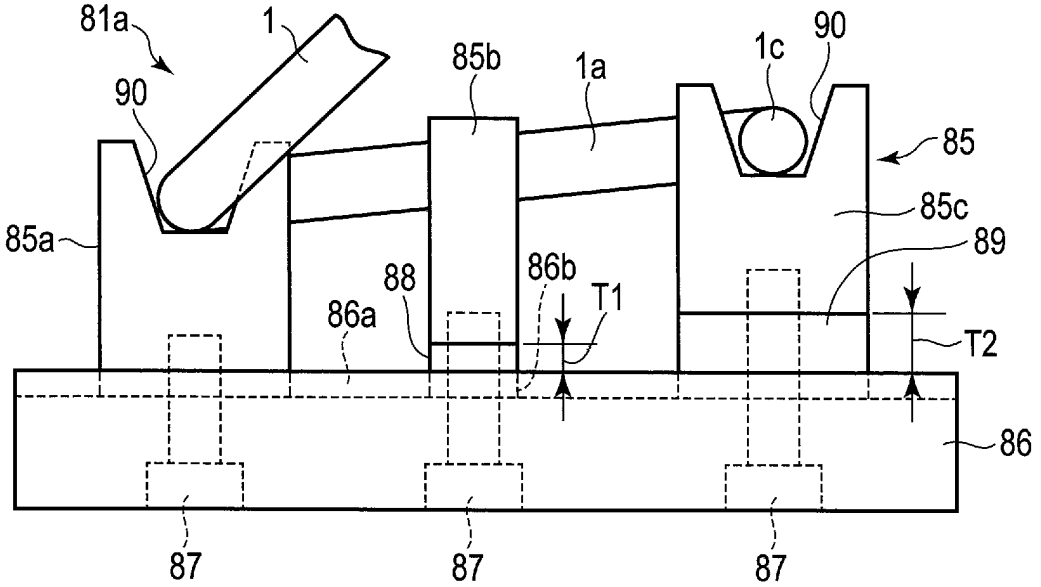
81a
1
85b
1a
1c
90
90
85
85c
85a
89
88
86b
T1
86a
T2
86
87
87
87

FIG. 9

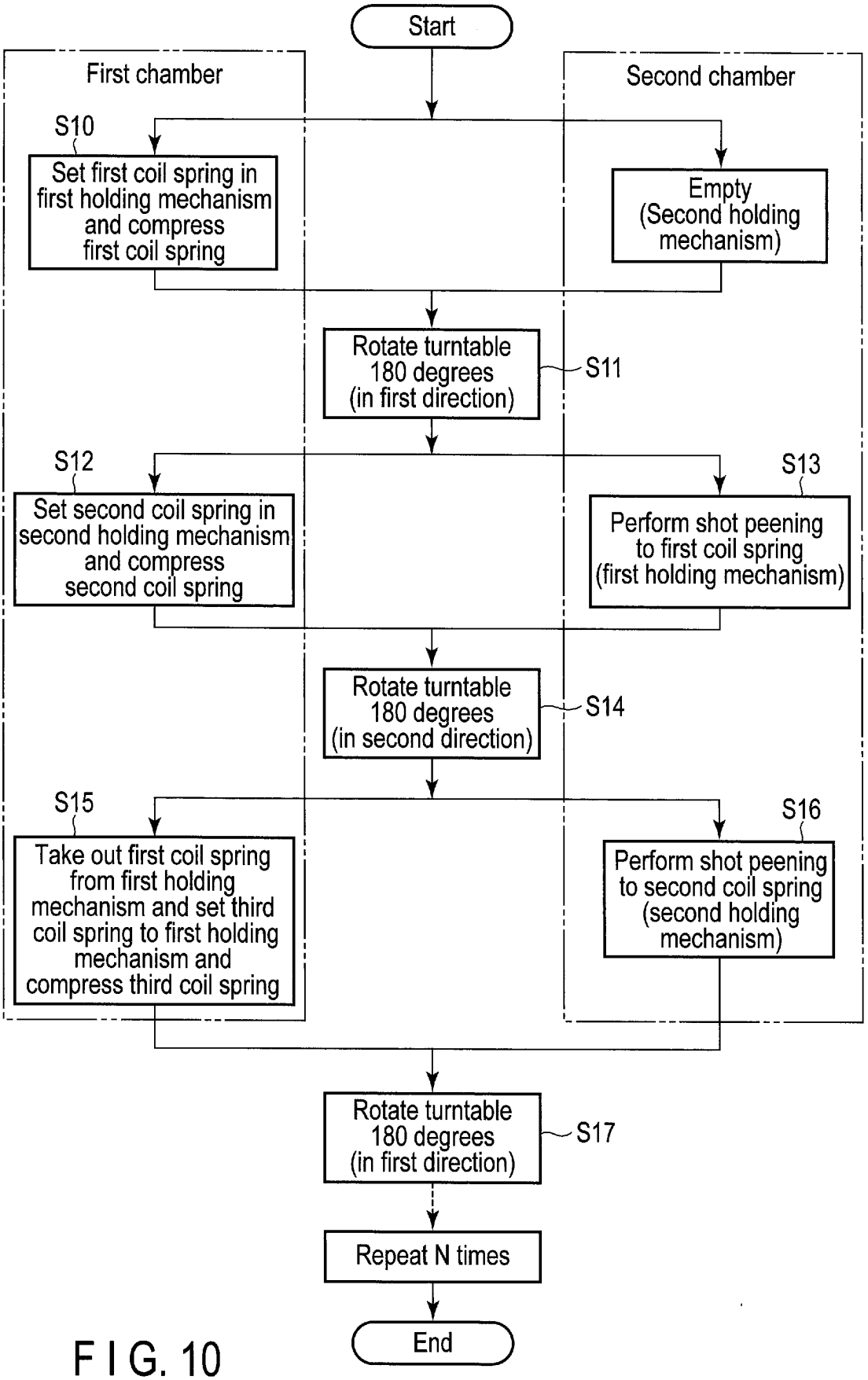
Start
First chamber
Second chamber
S10
Set first coil spring in first holding mechanism and compress first coil spring
Empty (Second holding mechanism)
Rotate turntable 180 degrees (in first direction)
S11
S12
Set second coil spring in second holding mechanism and compress second coil spring
S13
Perform shot peening to first coil spring (first holding mechanism)
Rotate turntable 180 degrees (in second direction)
S14
S15
Take out first coil spring from first holding mechanism and set third coil spring to first holding mechanism and compress third coil spring
S16
Perform shot peening to second coil spring (second holding mechanism)
Rotate turntable 180 degrees (in first direction)
S17
Repeat N times
End

FIG. 10

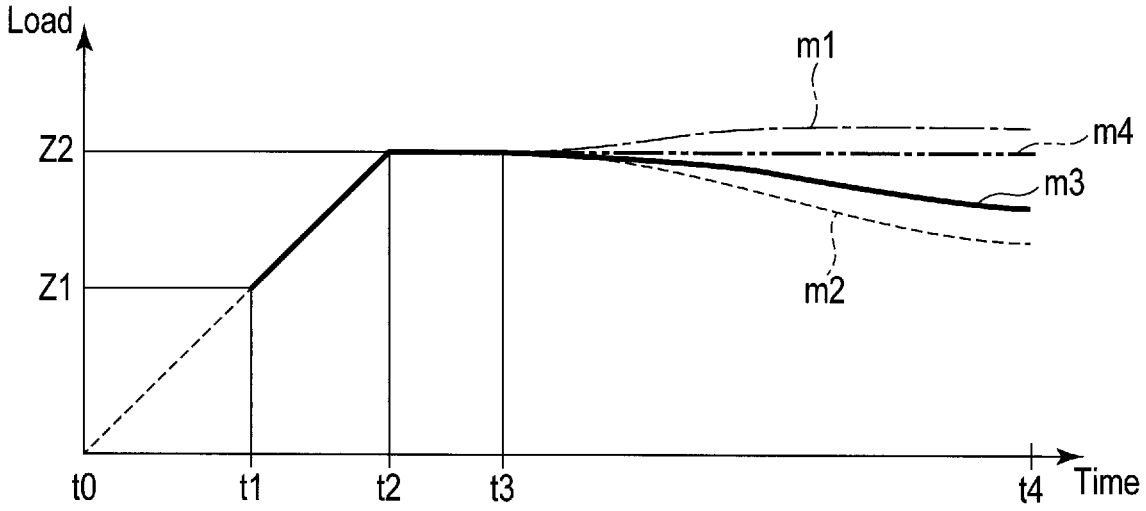
Load
m1
m4
Z2
m3
Z1
m2
t0
t1
t2
t3
t4
Time

FIG. 11

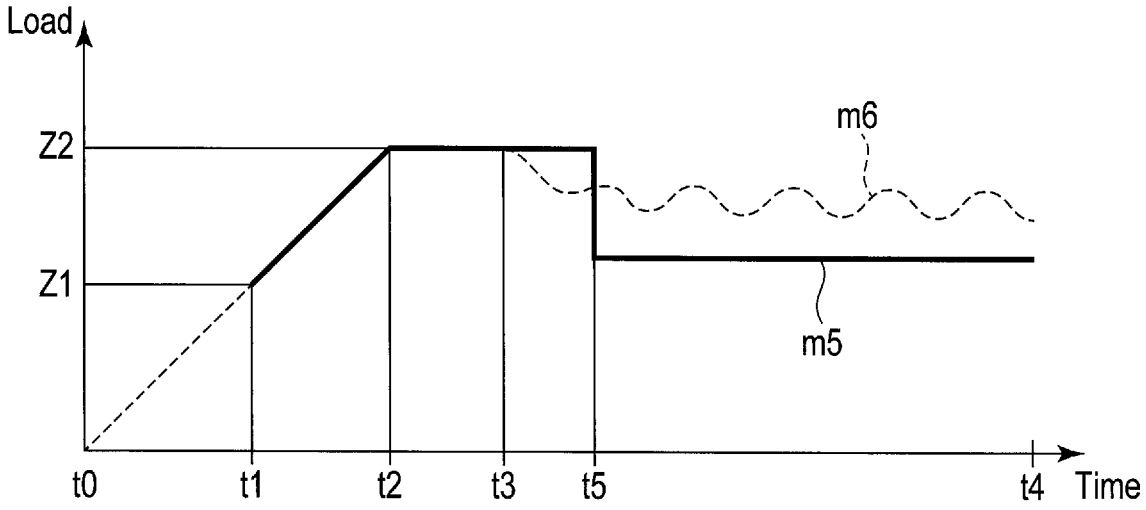
Load
m6
Z2
Z1
m5
t0
t1
t2
t3
t5
t4
Time

FIG. 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2017/006931

A. CLASSIFICATION OF SUBJECT MATTER
B24C1/10(2006.01)i, *B24C3/24*(2006.01)i, *B24C3/32*(2006.01)i, *B24C9/00*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B24C1/10, B24C3/24, B24C3/32, B24C9/00, C21D7/06, F16F1/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2017
Kokai Jitsuyo Shinan Koho 1971-2017 Toroku Jitsuyo Shinan Koho 1994-2017

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2015/136737 A1 (Sinto Kogyo Ltd.), 17 September 2015 (17.09.2015), paragraphs [0039] to [0081]; fig. 4 to 11 & JP 5780371 B1 & EP 3088131 A1 paragraphs [0039] to [0081]; fig. 4 to 11 & CN 105377508 A & KR 10-2016-0132369 A	1-8
A	DE 4419208 C1 (FRIED. KRUPP AG HOESCH-KRUPP), 03 August 1995 (03.08.1995), column 1, lines 46 to 51; fig. 1 to 2 (Family: none)	1-8
A	DE 4408643 C1 (FRIED. KRUPP AG HOESCH-KRUPP), 22 June 1995 (22.06.1995), column 2, lines 10 to 42; fig. 1 to 4 (Family: none)	1-8

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 May 2017 (10.05.17)	23 May 2017 (23.05.17)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

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Patent documents cited in the description

- JP 2002361558 A **[0003]**
- JP 2003117830 A **[0003]**
- JP 2015077638 A **[0003]**