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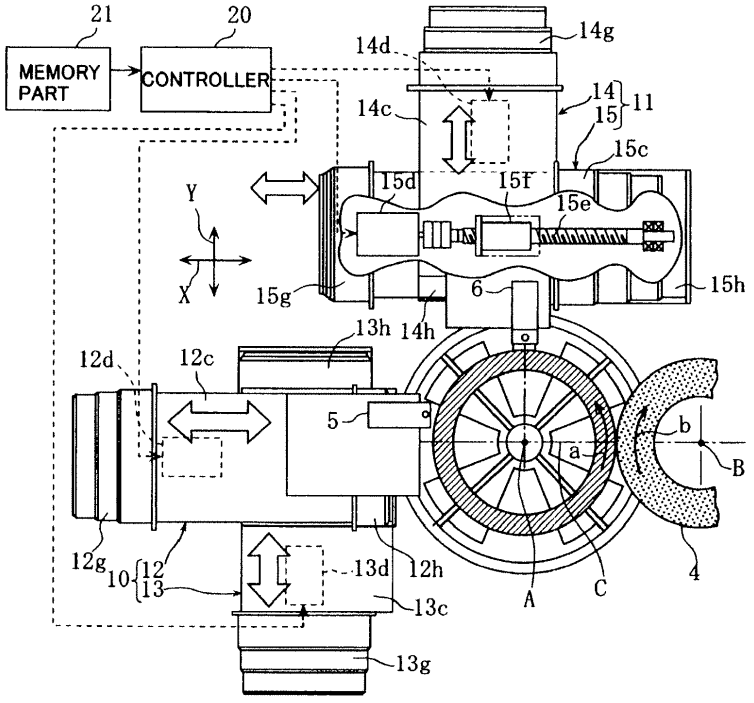
(54) Grinding machine

(57) In a grinding machine 1 which is provided with: a grinding wheel 4 grinding an outer peripheral surface or an inner peripheral surface of a workpiece W in a substantially cylindrical shape; a worktable 3 supporting the workpiece W in a rotationally drivable manner and having a rotation axis directed in a vertical direction; and a first and a second shoe 5, 6 abutting on the workpiece W to support the workpiece W, there are provided: a moving mechanism capable of moving the first and second shoes 5, 6 in X-axis and Y-axis directions in a horizontal plane; and a controller 20 controlling the moving mechanism so that positions in the two-axial directions of the first and second shoes 5, 6 become predetermined positions.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

[0001] The present invention relates to a grinding machine grinding an outer peripheral surface and an inner peripheral surface of a workpiece requiring high circularity, such as, for example, an inner race and an outer race of a bearing.

2. DESCRIPTION OF THE RELATED ART

[0002] As a grinding machine of this type, there is a grinding machine including: a grinding wheel grinding the outer peripheral surface or the inner peripheral surface of the workpiece; a worktable supporting the workpiece in a rotationally drivable manner; and shoes abutting on the workpiece to support the workpiece (see, for example, Japanese Examined Patent Publication No. Hei 3-79151).

SUMMARY OF THE INVENTION

[0003] In the grinding machine of this type, because of a great influence that arrangement positions of the shoes has on finishing accuracy of a workpiece, it is necessary to adjust the arrangement positions of the shoes depending on each size of the workpiece or depending on each process. For example, the arrangement positions of the shoes need to be finely adjusted according to the diameter, height, and thickness of the workpiece, and further the arrangement positions of the shoes need to be greatly adjusted depending on whether a current process is outside diameter grinding or inside diameter grinding. Such adjustment of the arrangement positions of the shoes requires a high level of skill, and as a result, the adjustment of the arrangement positions of the shoes is time-consuming, which gives rise to a problem that productivity lowers.

[0004] It is an object of the present invention to provide a grinding machine that does not require a high level of skill for position adjustment of shoes and accordingly is capable of shortening the setup time for workpiece grinding and can achieve improved productivity.

[0005] The present invention is a grinding machine comprising : a grinding wheel grinding an outer peripheral surface or an inner peripheral surface of an object to be machined (hereinafter, referred to as a workpiece) in a substantially cylindrical shape; a worktable supporting the workpiece in a rotationally drivable manner and having a rotation axis directed in a vertical direction; and a shoe abutting on the workpiece to support the workpiece, the grinding machine including: a moving mechanism capable of moving the shoe in two axial directions in a horizontal plane; and a controller controlling the moving mechanism so that positions in the two-axial directions of the shoe become predetermined positions.

[0006] According to the present invention, the moving mechanism capable of moving the shoe in the two axial directions in the horizontal plane; and the controller controlling the moving mechanism so that positions in the two-axial directions of the shoe become predetermined positions are provided. Therefore, by the control for reproducing the two-axial direction positions, for example, stored in a memory part, it is possible to easily and surely decide the position of the shoe without any adjustment by a skilled person which has conventionally been needed, and to improve productivity.

[0007] In a preferable embodiment of the present invention, the controller uses an orthogonal coordinate system or a polar coordinate system as a movement coordinate system of the shoe when controlling the moving mechanism.

[0008] According to the above preferable example, the moving mechanism may be controlled with the use of the orthogonal coordinate system or the polar coordinate system as the movement coordinate system of the shoe. Therefore, it is possible to optimally control the position of the shoe according to workpiece conditions or the like.

[0009] In another preferable embodiment of the present invention, the controller has a memory part storing preset two-axial direction positions of the shoe, and controls the moving mechanism so as to reproduce the stored two-axial direction positions.

[0010] According to the above another preferable embodiment, the memory part storing the two-axial direction positions of the shoe is provided. Therefore, by finding the optimum positions of the shoe according to workpiece conditions and the like in advance based on actual grinding or the like, storing data on the found two-axial direction positions in the memory part, and reproducing the stored two-axial direction positions, it is possible to easily and surely decide the position of the shoe.

[0011] In still another preferable embodiment of the present invention, the controller has a memory part storing two-axial direction positions of the shoe corresponding to machining condition information, and controls the moving mechanism so as to reproduce the two-axial direction positions called from the memory part according to the machining condition information.

[0012] According to the above still another embodiment, since the two-axial direction positions of the shoe corresponding to the machining condition information are stored, it is possible to reproduce the two-axial direction positions according to the machining condition information, which enables higher-accuracy control of the position of the shoe.

[0013] In yet another preferable embodiment of the present invention, the controller controls the moving mechanism so as to cause the shoe to move in accordance with a change in a diameter of the workpiece.

[0014] According to the above yet another embodiment, since the controller controls the moving mechanism so as to cause the shoe to move in accordance with

the change in the diameter of the workpiece, it is possible to ensure the optimum position of the shoe even when a grinding amount increases, which can enhance grinding accuracy.

[0015] According to yet another preferable embodiment of the present invention, the controller controls the moving mechanism so as to make a pressing force that the shoe gives to the workpiece a predetermined pressure.

[0016] According to the above yet another preferable embodiment, since the controller controls the moving mechanism so as to make the pressing force that the shoe gives to the workpiece a predetermined pressure, it is possible to control the pressing force according to rigidity of the workpiece, and in this respect as well, it is possible to enhance grinding accuracy.

[0017] In a yet another preferable embodiment of the present invention, the moving mechanism includes: a first moving mechanism including: a first moving table disposed to be movable in an X-axis direction parallel to a cutting direction of the grinding wheel and in a Y-axis direction perpendicular to the X-axis direction and having a first shoe fixed thereto; a ball screw moving the first moving table; and a servo motor rotationally driving the ball screw; and a second moving mechanism including: a second moving table disposed to be movable in the X-axis and Y-axis directions and having a second shoe fixed thereto; a ball screw moving the second moving table; and a servo motor rotationally driving the ball screw.

[0018] According to the above yet another preferable embodiment, the moving mechanism includes: the first moving mechanism in which the first shoe is fixed to the first moving table moving in the X-axis direction and the Y-axis direction; and the second moving mechanism in which the second shoe is fixed to the second moving table moving in the X-axis direction and the Y-axis directions. Therefore, it is possible to provide a concrete structure that can realize the X-axis and Y-axis direction movements of the first shoe and the X-axis and Y-axis direction movements of the second shoe which are described in claim 1.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

FIG. 1 is a plane view of a grinding machine according to an embodiment 1 of the present invention;

FIG. 2 is a front view of the grinding machine partly in section;

FIG. 3 is an explanatory view of states of outside diameter grinding and inside diameter grinding by the grinding machine;

FIG. 4 is a plane view explaining positions of shoes during the outside diameter grinding by the grinding machine; and

FIG. 5 is a plane view explaining positions of the shoes during the inside diameter grinding by the grinding machine.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0020] Hereinafter, an embodiment of the present invention will be described based on the attached drawings.

[0021] In the drawings, reference numeral 1 denotes a vertical grinding machine, which grinds an outer peripheral surface Wo and an inner peripheral surface Wi of a workpiece W in a cylindrical shape such as an outer race, an inner race, or the like of a bearing. The vertical grinding machine 1 includes: a worktable 3 mounted on top of a bed 2 so as to be rotationally drivable, with its rotation axis A directed in a vertical direction; a grinding wheel 4 grinding the outer peripheral surface Wo of the workpiece W; and a first shoe 5 and a second shoe 6 abutting on the workpiece W to support the workpiece W in a diameter direction.

[0022] The worktable 3 is attached to an upper end portion of a workpiece spindle (not shown) and is rotationally driven by the workpiece spindle anticlockwise (arrow a direction) in FIG. 1. An electromagnetic chuck 7 is fixed on top of the worktable 3.

[0023] On the electromagnetic chuck 7, the workpiece W is placed via a work rest (workpiece receiver) 8 with its rotation axis being coaxial with the rotation axis A of the worktable 3, and is suction-held by the electromagnetic chuck 7. Therefore, the workpiece W rotates with the workpiece spindle.

[0024] The grinding wheel 4 is disposed, with its rotation axis B being parallel to the rotation axis A of the workpiece spindle and is fixed to a lower end surface of a grinding wheel driving shaft 9. The grinding wheel 4 is rotationally driven clockwise (arrow b direction) in FIG. 1. Incidentally, as shown in FIG. 3, outside diameter grinding and inside diameter grinding are possible by using the grinding wheel 4.

[0025] In the embodiment 1, the first shoe 5 is disposed at a position slightly deviated to a rotation-direction upstream side from a position that is right opposite the rotation axis B of the grinding wheel 4 across the rotation axis A. The second shoe 6 is disposed on a 90-degree rotation-direction upstream side from a straight line C connecting the rotation axes A and B.

[0026] The grinding machine 1 of this embodiment 1 includes a moving mechanism moving the first and second shoes 5, 6 in an X-axis direction and a Y-axis direction, and the moving mechanism includes: a first moving mechanism 10 moving the first shoe 5 in the X-axis direction and the Y-axis direction; and a second moving mechanism 11 moving the second shoe 6 in the X-axis direction and the Y-axis direction.

[0027] The first moving mechanism 10 includes: a first slide table 12 disposed to be movable in the X-axis direction parallel to a cutting direction of the grinding wheel 4 and having the first shoe 5 fixed to its upper surface;

and a first driving table 13 on which the first slide table 12 is placed and which moves the first slide table 12 in the Y-axis direction perpendicular to the X-axis direction.

[0028] The first driving table 13 includes: a support member 13a fixed on top of the bed 2; and a driving table main body 13c supported on top of the support member 13a via slide rails 13b so as to be movable in the Y-axis direction.

[0029] Further, in a concave portion 13a' of the support member 13a, a first Y-axis motor 13d, a first Y-axis ball screw 13e coupled to an output shaft of the first Y-axis motor 13d, and a first Y-axis nut 13f screwed to the first Y-axis ball screw 13e are disposed.

[0030] The first Y-axis motor 13d is fixed to the concave portion 13a', the Y-axis ball screw 13e is supported by the concave portion 13a' via a bearing, and the first Y-axis nut 13f is fixed to the driving table main body 13c.

[0031] The first slide table 12 includes: a support member 12a fixed on top of the driving table main body 13c of the first driving table 13; and a slide table main body 12c supported on top of the support member 12a via slide rails to be movable in the X-axis direction.

[0032] In a concave portion 12a' of the support member 12a, a first X-axis motor 12d, a first X-axis ball screw 12e coupled to an output shaft of the first X-axis motor 12d, and a first X-axis nut 12f screwed to the first X-axis ball screw 12e are disposed.

[0033] The first X-axis motor 12d is fixed to the concave portion 12a', the first X-axis ball screw 12e is supported by the concave portion 12a' via a bearing, and the first X-axis nut 12f is fixed to the slide table main body 12c.

[0034] Note that 12g, 12h, 13g, and 13h denote slide covers of telescopic type for preventing grinding powder from falling on the ball screws and so on.

[0035] When the first Y-axis motor 13d rotationally drives the first Y-axis ball screw 13e, the driving table main body 13c moves the entire first slide table 12 in the Y-axis direction, and accordingly, the first shoe 5 moves in the Y-axis direction.

[0036] When the first X-axis motor 12d rotationally drives the first X-axis ball screw 12e, the slide table main body 12c moves in the X-axis direction, and accordingly the first shoe 5 moves in the X-axis direction.

[0037] The second moving mechanism 11 has the same structure as that of the first moving mechanism 10. That is, the second moving mechanism 11 includes a second slide table 14 disposed to be movable in the Y-axis direction and having the second shoe 6 fixed to its upper surface; and a second driving table 15 on which the second slide table 14 is placed and which moves the second slide table 14 in the X-axis direction.

[0038] The second driving table 15 includes: a driving table main body 15c disposed to be movable in the X-axis direction relative to the bed 2; a second X-axis motor 15d driving the driving table main body 15c so that the driving table main body 15c reciprocates in the X-axis direction; a second X-axis ball screw 15e; and a second X-axis nut 15f.

[0039] The second slide table 14 is disposed on top of the driving table main body 15c and has: a slide table main body 14c disposed to be movable in the Y-axis direction relative to the driving table main body 15c; a second Y-axis motor 14d; and a second Y-axis ball screw and a second Y-axis nut which are not shown.

[0040] Note that 14g, 14h, 15g, and 15h denote slide covers of telescopic type for preventing the grinding powder from falling on the ball screws and so on.

[0041] When the second X-axis motor 15d rotationally drives the second X-axis ball screw 15e, the driving table main body 15c moves the entire second slide table 14 in the X-axis direction and accordingly the second shoe 6 moves in the X-axis direction.

[0042] When the second Y-axis motor 14d rotationally drives the second Y-axis ball screw, the slide table main body 14c moves in the Y-axis direction and accordingly the second shoe 6 moves in the Y-axis direction.

[0043] The grinding machine 1 of this embodiment 1 has a controller 20 controlling the first moving mechanism 10 and the second moving mechanism 11 so that the X-axis direction and Y-axis direction positions of the first shoe 5 and the second shoe 6 become predetermined positions. The controller 20 has a memory part 21 storing preset X-axis and Y-axis direction positions of the first and second shoes 5, 6. The controller 20 controls various kinds of motors of the first and second moving mechanisms 10, 11 so that the X-axis and Y-axis direction positions read from the memory part 21 according to work information or the like are reproduced as the X-axis and Y-axis direction positions of the first and second shoes 5, 6.

Furthermore, the controller 20 controls the first and second moving mechanisms 10, 11 so that the first and second shoes 5, 6 move in accordance with a change in a diameter of the workpiece, and further controls the first and second moving mechanisms 10, 11 so that pressing forces that the shoes 5, 6 give to the workpiece become predetermined pressures.

[0044] Here, the X-axis and Y-axis direction positions of the first shoe 5 and the second shoe 6 which are stored in the memory part 21 are found in the following manner.

[0045] For example, the optimum X-axis and Y-axis direction positions that can ensure machining accuracy such as circularity satisfying a demand are found in advance for each workpiece condition such as diameter, height, thickness, material of the workpiece, based on the results of grinding that a skilled person performs while fine-adjusting the positions of the shoes. Further, in this case, the X-axis and Y-axis direction positions are found for each machining condition such as a cutting amount and a pressing force by the grinding wheel 4 and outside diameter grinding, inside diameter grinding and the found X-axis and Y-axis direction positions are stored as data in the memory part 21.

[0046] In this embodiment 1, the controller 20 gives a command regarding the positions of the first and second shoes 5, 6 by using an orthogonal coordinate system

whose origin is the rotation axis A of the workpiece spindle. For example, the controller 20 commands that the X-axis and Y-axis direction positions of the first shoe 5 be (x1, y1) and the X-axis and Y-axis direction positions of the second shoe 6 be (x2, y2).

[0047] Incidentally, in giving the command regarding the positions of the first and second shoes 5, 6, a polar coordinate system whose origin is the rotation axis A of the workpiece spindle may be used. For example, commands such as the first shoe 5 = (r1, θ1) and the second shoe 6 = (r2, θ2) are given.

[0048] In the grinding machine 1 according to this embodiment 1, the workpiece W is fixed on top of the electromagnetic chuck 7 via the work rest 8 and is rotationally driven in the arrow "a" direction by the workpiece spindle, and the grinding wheel 4 is rotationally driven in the arrow "b "direction at a higher rotation speed than that of the workpiece W. At this time, the controller 20 controls the rotations of the motors of the first moving mechanism 10 and the second moving mechanism 11 so that the X-axis direction and Y-axis direction positions of the first and second shoes 5, 6 read from the memory part 21 are reproduced.

[0049] As described above, in this embodiment 1, the first moving mechanism 10 and the second moving mechanism 11 moving the first shoe 5 and the second shoe 6 in the X-axis direction and the Y-axis direction in a horizontal plane are provided, and these moving mechanisms 10, 11 are controlled so that the X-axis direction positions and the Y-axis direction positions of the first and second shoes 5, 6 stored in the memory part 21 are reproduced. This makes it possible to easily and surely control the positions of the shoes at ideal positions without any adjustment by a skilled person which has conventionally been required, and to improve productivity.

[0050] Further, since the memory part 21 storing the X-axis direction positions and the Y-axis direction positions of the first and second shoes 5, 6 are provided, it is possible to easily and surely decide the positions of the shoes by finding the optimum positions of the shoes depending on the workpiece condition and the like in advance based on the results of actual grinding or the like, and storing the found positions in the memory part 21, and reproducing the stored X-axis and Y-axis direction positions.

[0051] Further, since the two-axial direction positions of the first and second shoes 5, 6 corresponding to the machining condition information are stored in the memory part 21, it is possible to reproduce the two-axial direction positions according to the machining condition information, which enables higher-accuracy control of the positions of the shoes.

[0052] Furthermore, since the controller 20 controls the first and second moving mechanisms 10, 11 so that the first and second shoes 5, 6 move in accordance with a change in the diameter of the workpiece W, it is possible to ensure the optimum positions of the shoes even when a grinding amount increases, which can enhance grinding accuracy.

[0053] Further, the controllert 20 controls the first and second moving mechanisms 10, 11 so that the pressing forces that the first and second shoes 5, 6 give to the workpiece W become predetermined pressures, it is possible to control the pressing forces according to rigidity of the workpiece W, and in this respect as well, it is possible to enhance grinding accuracy.

[0054] Further, in a conventional grinding machine, when the outside diameter grinding and the inside diameter grinding are performed, setup is necessary before each of four processes, that is, outside diameter rough machining t1, inside diameter rough machining t2, outside diameter finish machining t3, and inside diameter finish machining t4. On the other hand, in this embodiment, since the positions of the first and second shoes 5, 6 can be automatically adjusted, the setup has to be done only once and then the four processes t1 to t4 can be continuously executed as shown in FIG. 3, which can improve productivity.

[0055] In the embodiment 1, as shown in FIG. 1, the first shoe 5 is set on a slightly upstream side of the straight line C in terms of the rotation direction and the second shoe 6 is set on a 980-degree rotation-direction upstream side from the straight line C. However, the optimum positions of the first and second shoes in the present invention are not limited to the positions in FIG. 1, and as shown in FIG. 4, for instance, the second shoe 6 may be set on a further upstream side. Further, in the case of the inside diameter grinding, the first shoe 5 may be disposed at a position facing a grinding wheel 4' as shown in FIG. 5.

[0056] Furthermore, the above embodiment describes the case where the first and second shoes 5, 6 are both moved, but the position of only one of the shoes may be adjusted with the other shoe being fixedly disposed.

[0057] In addition, in the above embodiment, 12g, 12h, 13g, 13h, 14g, 14h, 15g, 15h are described as the slide covers of telescopic type, but some of them may be sheet metal covers of fixed type.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof.

The present embodiments are therefore to be considered in all respects as illustrative and no restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

Claims

1. A grinding machine comprising:

a grinding wheel grinding an outer peripheral surface or an inner peripheral surface of an object to be machined (hereinafter, referred to as

a workpiece) in a substantially cylindrical shape;
a worktable supporting the workpiece in a rotationally drivable manner and having a rotation axis directed in a vertical direction;
a shoe abutting on the workpiece to support the workpiece,
a moving mechanism capable of moving the shoe in two axial directions in a horizontal plane; and
a controller controlling said moving mechanism so that positions in the two-axial directions of the shoe become predetermined positions.

2. The grinding machine according to claim 1, wherein said controller uses an orthogonal coordinate system or a polar coordinate system as a movement coordinate system of the shoe when controlling said moving mechanism.

3. The grinding machine according to claim 2, wherein said controller has a memory part storing preset two-axial direction positions of the shoe, and controls said moving mechanism so as to reproduce the stored two-axial direction positions.

4. The grinding machine according to claim 2, wherein said controller has a memory part storing two-axial direction positions of the shoe corresponding to machining condition information, and controls said moving mechanism so as to reproduce the two-axial direction positions called from the memory part according to the machining condition information.

5. The grinding machine according to claim 4, wherein said controller controls said moving mechanism so as to cause the shoe to move in accordance with a change in a diameter of the workpiece.

6. The grinding machine according to claim 4, wherein said controller controls said moving mechanism so as to make a pressing force that the shoe gives to the workpiece a predetermined pressure.

7. The grinding machine according to claim 1, wherein said moving mechanism includes:

a first moving mechanism including: a first moving table disposed to be movable in an X-axis direction parallel to a cutting direction of the grinding wheel and in a Y-axis direction perpendicular to the X-axis direction and having a first shoe fixed thereto; a ball screw moving the first moving table; and a servo motor rotationally driving the ball screw; and
a second moving mechanism including: a second moving table disposed to be movable in the X-axis and Y-axis directions and having a second shoe fixed thereto; a ball screw moving the second moving table; and a servo motor rotationally driving the ball screw.

FIG. 1

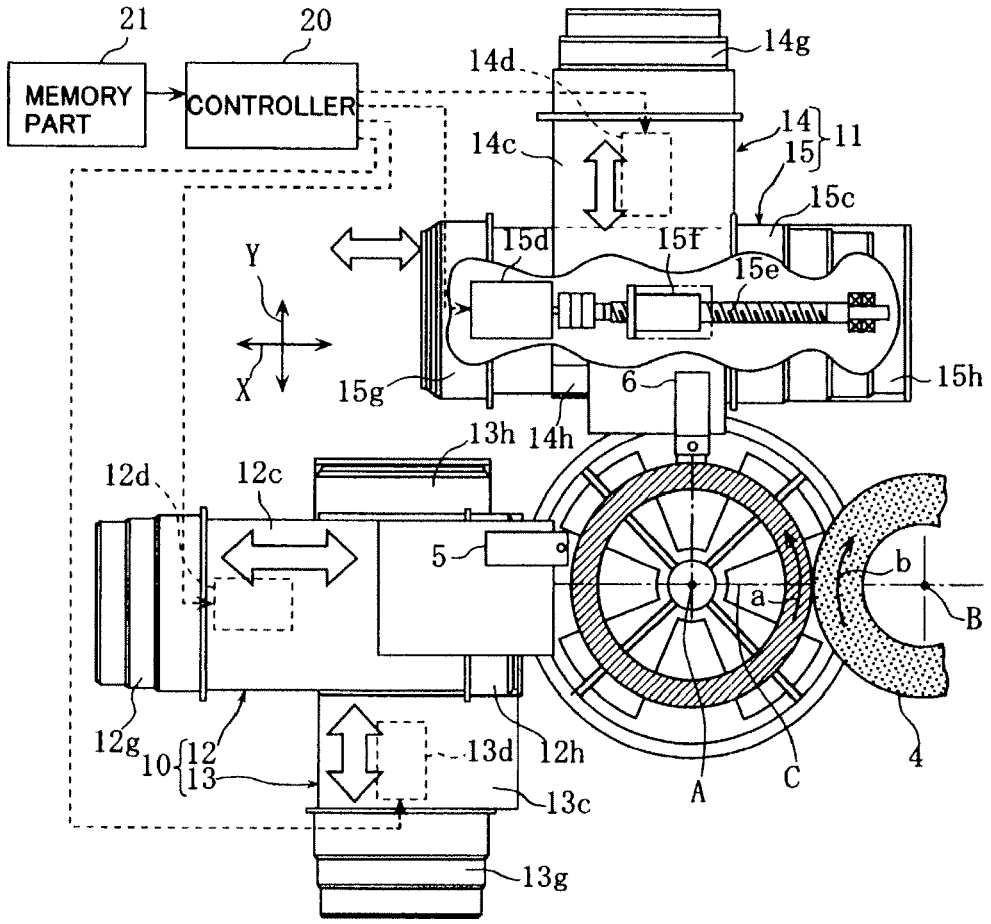
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FIG. 2

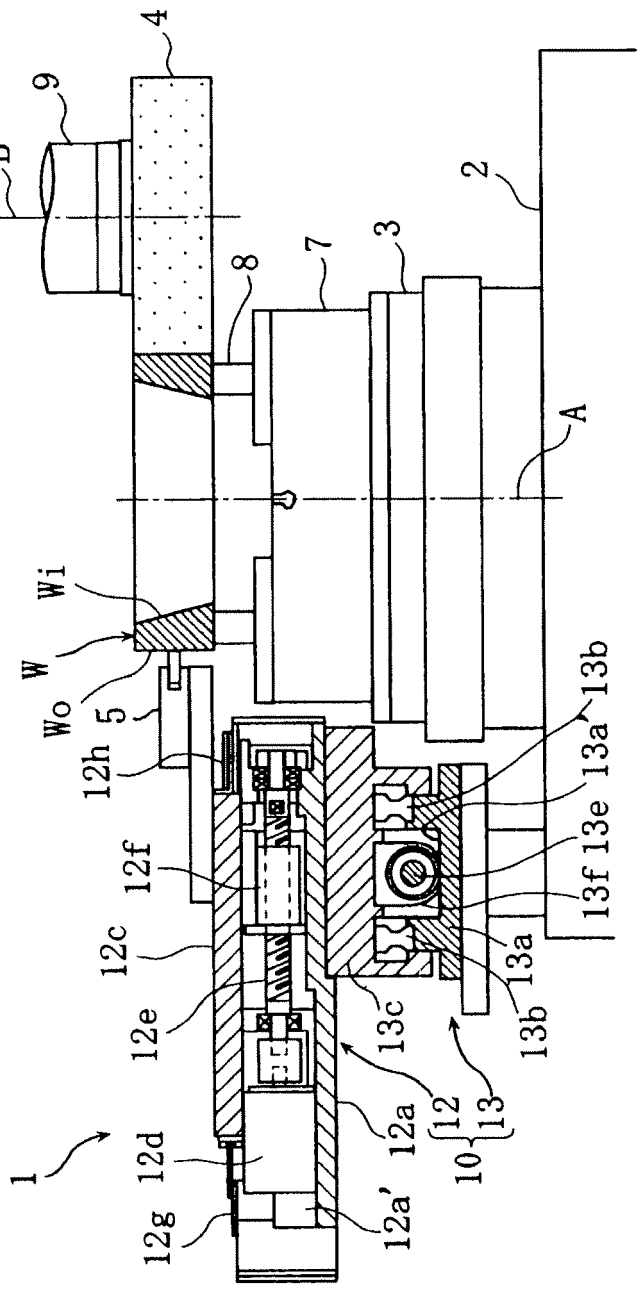
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FIG. 3

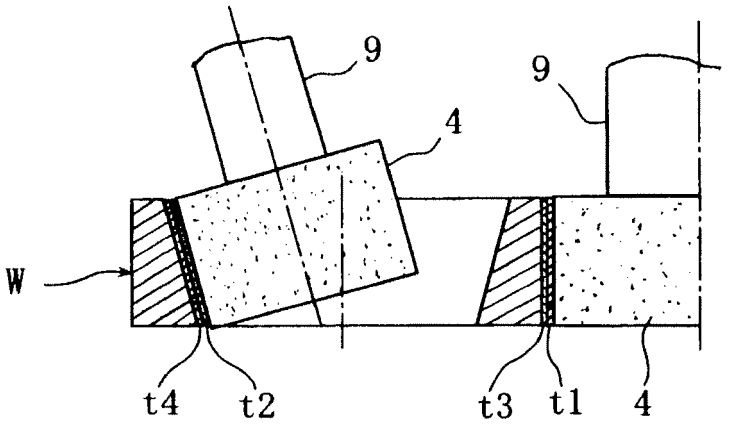


FIG. 4

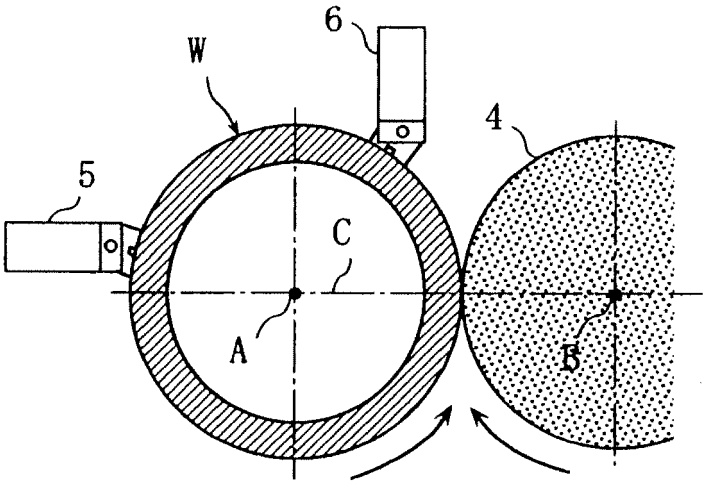
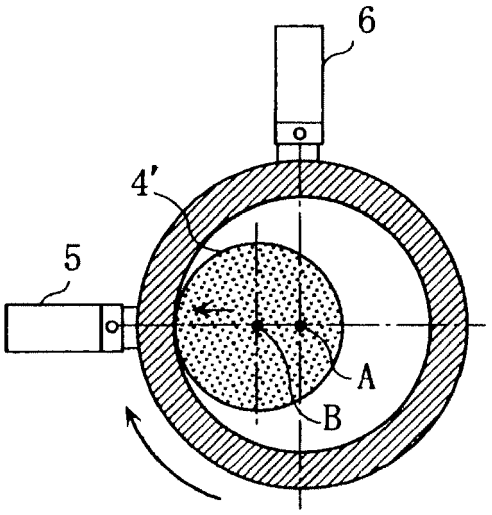


FIG. 5



REFERENCES CITED IN THE DESCRIPTION

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