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(54) **Shield machine**

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Machine à bouclier

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Description

[0001] The present invention relates to a shield machine capable of drilling a tunnel having an oval cross section.

[0002] Conventionally, a shield machine includes a shield machine main body having a body, a plurality of shield jacks which cause the shield machine main body to move, and a rotary cutter head which drills a natural ground on a front end side of the shield machine main body. Generally, the body of the shield machine main body is formed to have a cylindrical shape, and the cutter head, having the same diameter as the body is equipped with a plurality of cutter bits on a front surface thereof. The cutter head is mounted on a front end side portion of the shield machine main body so as to be rotatable around a central axis of the shield machine main body, and is rotated by, for example, a plurality of hydraulic motors to drill a tunnel having a circular cross section.

[0003] In recent years, shield machines capable of drilling tunnels having various cross sections, such as a rectangular cross section and an elliptical cross section, in addition to the circular cross section have been proposed and actually used.

[0004] In a free sectional shield machine disclosed in Japanese Unexamined Patent Application Publication No. 9-119288, a fixed gear is mounted on a fixed shaft having an axis concentric with the central axis of the shield machine main body, the fixed gear is in mesh with a planetary gear, and the planetary gear is in mesh with a first gear. A first casing is provided to be rotatable around the fixed shaft, the first casing houses the fixed gear, the planetary gear and the first gear, and the planetary gear is rotatably supported by the first casing. A second casing projects forward from a region of the first casing that is in the vicinity of an outer periphery thereof, a rear end portion of a hollow shaft portion of the second casing is rotatably internally fitted in the first casing, the hollow shaft portion is fixed to the first gear, and the second casing rotates integrally with the first gear.

[0005] A shaft member is rotatably inserted through the hollow shaft portion of the second casing, a second gear is mounted on a front end portion of the shaft member, and the second gear is in mesh with a third gear. A hollow arm portion of the second casing houses the second and third gears to rotatably support those gears, and the third gear is provided with a rotary cutter. The cutter is rotated by a casing drive motor around the fixed shaft via the first and second casings. In association with this rotation, the cutter is rotated around the fixed shaft via the fixed gear, the planetary gear, the first gear and the second casing. The cross section of the drilled tunnel changes depending on a ratio between the number of teeth of the fixed gear and the number of teeth of the first gear, and it is possible to drill a tunnel having an oval cross section when the ratio is 2 : 1. Since most part of the first casing projects into a chamber formed on a front end portion of the shield machine, drilling mud tends to

be adhered to the first casing.

[0006] A shield machine for a shallow cross section tunnel disclosed in Japanese Unexamined Patent Application Publication No. 2000-328872 includes a circular main cutter disc and a pair of right and left pivot cutters provided at slightly lower portions on both sides of the main cutter disk to be located behind and in close proximity to the main cutter disk. The pivot cutter is constructed to have a sector shape which includes a plurality of cutter spokes and whose open angle is about 220 degrees, and is capable of drilling a tunnel having a substantially D-shaped cross section. Moreover, outbreak small-diameter cutter disks (for example, eight sets) for covering the drilling of a boundary portion between the main cutter disk and the pivot cutters are provided at upper right and left side portions and lower left and right side portions.

[0007] In a shield machine in Japanese Unexamined Patent Application Publication No. 2001-55890, four radially extending spokes of a main cutter are provided with four extensible arms, each extensible arm is constructed to be radially extensible and retractable by a hydraulic jack, and each extensible arm is provided with a corner cutter and a hydraulic motor which rotates the corner cutter.

[0008] In a currently mainstream shield machine which drills the tunnel having the circular cross section, a vain drilled cross section is formed depending on the application of the tunnel. Especially, in the case of a multi-lane road, a double track railway tunnel, etc., the vain drilled cross section can be minimized by adopting the tunnel having the oval cross section.

[0009] Usually, an inner surface of the drilled tunnel is coated with a segment. By injecting mortar between the segment and the natural ground, the segment is fixed to the natural ground. In the case of, for example, a large shallow tunnel, such as a triple subway station, and a rectangular cross section tunnel, since the segment coating the inner surface of the tunnel does not become an arch structure, it is difficult to increase the strength of fixing the segment to the natural ground, thereby increasing the cost for coating the tunnel.

[0010] In the case of the tunnel having the oval cross section, since the segment coating the inner surface of the tunnel becomes the arch structure, it is easy to increase the strength of fixing the segment to the natural ground, the stability of the segment is high, and a segment which is substantially the same as a segment used for the circular cross section tunnel can be adopted as the segment of the tunnel having the oval cross section. Therefore, the tunnel having the oval cross section is advantageous in the cost for manufacturing the segment and the cost for carrying out coating using the segment.

[0011] In the shield machine disclosed in Japanese Unexamined Patent Application Publication No. 9-119288, the first casing housing the fixed gear, the planetary gear and the first gear is constructed to project into the chamber for stirring drilling mud. Therefore, the

first casing is more likely to be rotated with a large amount of sand adhered, and the power consumption increases due to an increase in the driving force for rotating the first casing. Moreover, since the hollow shaft portion of the second casing projects deep into the chamber, it is difficult to increase a supporting stiffness for supporting the rotary cutter. Therefore, the shield machine is disadvantageous in securing the durability of the cutter drive means.

[0012] In the shield machine disclosed in Japanese Unexamined Patent Application Publication No. 2000-328872, since eight sets of outbreak small-diameter cutter discs are provided, the structure of the shield machine becomes complex, and the manufacturing cost increases. Moreover, since the shield machine cannot drill the tunnel having the oval cross section, it is difficult to construct the segment coating the inner surface of the tunnel.

[0013] In the shield machine disclosed in Japanese Unexamined Patent Application Publication No. 2001-55890, the spoke type cutter head is included, and each spoke is equipped with the extensible arm which is radially extensible and retractable. Therefore, in the case of fully extending the extensible arm, such as the case of drilling the tunnel having the oval cross section, high rotational resistance is applied to the extensible arm. Therefore, the strength and durability of the extensible arm and a portion of connecting the extensible arm to the spoke may be low.

[0014] Objects of the present invention are to provide a shield machine capable of drilling a tunnel having an oval cross section, a shield machine which can reduce a power requirement and excels in durability, a shield machine whose production cost is lowered by simplifying a structure thereof, etc.

[0015] A shield machine according to a first aspect of the present invention comprises: a shield machine main body including a body and a separating wall defining a rear end of a chamber in a front end portion of the body; and a plurality of shield jacks for causing the shield machine main body to drill forward, the shield machine being arranged to drill a tunnel having an oval cross section, characterized in that the body is constructed to have an oval cross section similar to the cross section of the tunnel, and in that the shield machine further comprises: a circular plate member which is mounted on a front end-side portion of the shield machine main body so as to be rotatable around a first center axis that is a center of the shield machine main body and constitutes part of the separating wall; a first rotating means for rotating the circular plate member; a pair of pivot arms which are supported on a front surface side of the circular plate member such that base end portions of the pivot arms are rotatable around a pair of second center axes, respectively, which are in parallel with the first center axis and are rotationally symmetric with respect to the first center axis; a pair of second rotating means for rotating the pair of pivot arms around the second center axes, respectively;

a pair of head supporting members which are firmly fixed to tip end portions of the pair of pivot arms, respectively; a pair of rotary cutter heads which are mounted on the pair of head supporting members, respectively, so as to be rotatable around third center axes, respectively, which are in parallel with the second center axes, and each of which has a diameter that is half a short diameter of the oval cross section of the body; and a pair of third rotating means for rotating the pair of rotary cutter heads around the third center axes, respectively.

[0016] In accordance with the shield machine, when the first rotating means rotates the circular plate member around the first center axis, the base end portions of the pair of pivot arms move around the first center axis. When the pair of second rotating means rotate the base end portions of the pivot arms around the second center axes, the pair of pivot arms swing. Since the rotary cutter heads are mounted on the tip end portions of the pivot arms and rotated by the third rotating means, the pair of rotary cutter heads rotated by the pair of third rotating means move in a direction orthogonal to the first center axis so as to drill the natural ground. By appropriately controlling the driving of the first and second rotating means, it is possible to drill the tunnel having the oval cross section.

[0017] To be specific, in accordance with the shield machine, the following effects can be obtained. (a) Since the circular plate member constituting part of the separating wall defining the rear end of the chamber is rotated, and the base end portions of the pair of pivot arms are rotated via the circular plate member, the circular plate member does not project deep into the chamber, and the phenomenon of rotating the circular plate member with a large amount of drilling mud adhered does not occur, so that it is possible to reduce the power consumption of the first rotating means which rotates the circular plate member, and also possible to reduce the size of the first rotating means. (b) Since the load applied from the cutter heads and the pivot arms to the circular plate member can be supported by the separating wall supporting the circular plate member, it is possible to improve the supporting stiffness for supporting the cutter heads, the pivot arms and the circular plate member and secure the durability of the first rotating means. (c) It is possible to simplify the construction of a cutter head moving mechanism (the circular plate member, the pivot arms and the first and second rotating means) which causes the cutter heads to move in a direction orthogonal to a tunnel center axis (first center axis).

[0018] The shield machine may further comprise: a first rotation angle detecting means for detecting a rotation angle of the circular plate member rotated from a reference position; a pair of second rotation angle detecting means for detecting rotation angles of the pair of pivot arms rotated from reference positions around the second center axes; and a drilling control means for, based on outputs from the first and second rotation angle detecting means, controlling the first and second rotating means such that the pair of rotary cutter heads drill the tunnel

having the oval cross section. In accordance with this construction, the first rotation angle detecting means, the pair of second rotation angle detecting means and the drilling control means can control the first rotating means and the pair of second rotating means to drill the tunnel having the oval cross section.

[0019] A shield machine according to a second aspect of the present invention comprises: a shield machine main body including a body and a separating wall defining a rear end of a chamber in a front end portion of the body; and a plurality of shield jacks for causing the shield machine main body to drill forward, the shield machine being arranged to drill a tunnel having an oval cross section, characterized in that the body is constructed to have an oval cross section similar to the cross section of the tunnel, and in that the shield machine further comprises: a circular plate member which is mounted on a front end-side portion of the shield machine main body so as to be rotatable around a first center axis that is a center of the shield machine main body and constitutes part of the separating wall; a first rotating means for rotating the circular plate member; a pair of guide members which are mounted on a side of the circular plate member, which side is opposite the chamber side, so as to be rotationally symmetric with respect to the first center axis, and a pair of extensible arms which are slidably mounted on the pair of guide members so as to be rotationally symmetric with respect to the first center axis and are provided in parallel with the circular plate member; a pair of driving means for causing the pair of extensible arms to extend and retract, respectively; a pair of head supporting members which are firmly fixed to tip end portions of the pair of extensible arms, respectively; a pair of rotary cutter heads which are mounted on the pair of head supporting members, respectively, so as to be rotatable around second center axes, respectively, which are in parallel with the first center axis, and each of which has a diameter that is half a short diameter of the oval cross section of the body; and a pair of second rotating means for rotating the pair of rotary cutter heads around the second center axes, respectively.

[0020] In accordance with the shield machine, the pair of extensible arms are provided on the circular plate member, rotated by the first rotating means, via the pair of guide members so as to be rotationally symmetric with respect to the first center axis, the pair of driving means cause the pair of extensible arms to extend and retract, and the pair of rotary cutter heads provided on the tip end portions of the pair of extensible arms drill. By causing the pair of extensible arms to rotate around the tunnel center axis (first center axis) by the circular plate member and the first rotating means and causing the pair of extensible arms to extend and retract by the driving means, the cutter heads move in a direction orthogonal to the first center axis. By appropriately controlling the first rotating means and the pair of driving means, it is possible to drill the tunnel having the oval cross section.

[0021] To be specific, in accordance with the shield

machine, the following effects can be obtained in addition to an effect similar to the above effect (a). (d) Since the load applied from the cutter heads and the extensible arms to the circular plate member can be supported by the separating wall supporting the circular plate member, it is possible to improve the supporting stiffness for supporting the cutter heads, the extensible arms and the circular plate member and secure the durability of the first rotating means. (e) Since the pair of extensible arms are constructed to be slidably supported by the pair of guide members and to be driven by the pair of driving means, the construction of supporting the pair of extensible arms by the circular plate member and the construction of causing the cutter heads to move in a direction orthogonal to the first center axis are simplified significantly and can be manufactured at low cost.

[0022] Moreover, the shield machine may further comprise: a first rotation angle detecting means for detecting a rotation angle of the circular plate member rotated from a reference position; a pair of extended length detecting means for detecting extended lengths of the pair of extensible arms extended from a most retracted position, respectively; and a drilling control means for, based on outputs from the first rotation angle detecting means and the extended length detecting means, controlling the first rotating means and the driving means such that the pair of rotary cutter heads drill the tunnel having the oval cross section. In accordance with this construction, the first rotation angle detecting means, the pair of extended length detecting means and the drilling control means can control the first rotating means and the pair of driving means to drill the tunnel having the oval cross section.

[0023] A shield machine according to a third aspect of the present invention comprises: a shield machine main body including a body and a separating wall defining a rear end of a chamber in a front end portion of the body; and a plurality of shield jacks for causing the shield machine main body to drill forward, the shield machine being arranged to drill a tunnel having an oval cross section, characterized in that the body is constructed to have an oval cross section similar to the cross section of the tunnel, and in that the shield machine further comprises: a circular plate member which is mounted on a front end-side portion of the shield machine main body so as to be rotatable around a first center axis that is a center of the shield machine main body and constitutes part of the separating wall; a first rotating means for rotating the circular plate member; a pair of guide members which are mounted on a protruding portion so as to be mirror symmetric with respect to the first center axis, the protruding portion protruding forward of part of the separating wall other than the circular plate member and provided by the circular plate member, and a pair of extensible arms which are slidably mounted on the pair of guide members, respectively, such that extended lengths of the extensible arms are mirror symmetric with respect to the first center axis; one or a pair of driving means for causing the pair of extensible arms to extend and retract; a pair of head

supporting members which are firmly fixed to a pair of tip end portions of the pair of extensible arms, respectively; a pair of rotary cutter heads which are mounted on the pair of head supporting members, respectively, so as to be rotatable around second center axes, respectively, which are in parallel with the first center axis, and each of which has a diameter that is half a short diameter of the oval cross section of the body; and a pair of second rotating means for rotating the pair of rotary cutter heads around the second center axes, respectively.

[0024] In the shield machine, the pair of guide members are provided on the circular plate member, rotated by the first rotating means, so as to be substantially mirror symmetric with respect to the first center axis, the pair of extensible arms are slidably provided on the guide members such that extended lengths of the extensible arms are mirror symmetric with respect to the first center axis, one or a pair of driving means cause the pair of extensible arms to extend and retract, and the pair of rotary cutter heads provided on the tip end portions of the pair of extensible arms drill. By causing the pair of extensible arms to rotate around the tunnel center axis (first center axis) by the circular plate member and the first rotating means and causing the pair of extensible arms to extend and retract mirror-symmetrically by the driving means, the cutter heads move in a direction orthogonal to the first center axis. By appropriately controlling the first rotating means and the driving means, it is possible to drill the tunnel having the oval cross section.

[0025] To be specific, in accordance with the shield machine, effects similar to the above effects (a), (d) and (e) can be obtained.

[0026] Moreover, the shield machine may further comprise: a first rotation angle detecting means for detecting a rotation angle of the circular plate member rotated from a reference position; an extended length detecting means for detecting extended lengths of the extensible arms extended from a most retracted position; and a drilling control means for, based on outputs from the first rotation angle detecting means and the extended length detecting means, controlling the first rotating means and the driving means such that the pair of rotary cutter heads drill the tunnel having the oval cross section. In accordance with this construction, the first rotation angle detecting means, the extended length detecting means and the drilling control means can control the first rotating means and the pair of driving means to drill the tunnel having the oval cross section.

[0027] The above and further objects and features of the invention will more fully be apparent from the following detailed description with accompanying drawings.

[0028] Certain preferred embodiments will now be described by way of example only and with reference to the accompanying drawings.

Fig. 1 is a longitudinal sectional view of a shield machine of Embodiment 1 of the present invention.

Fig. 2 is a front view of the shield machine (reference

position) of Fig. 1.

Fig. 3 is a front view of the shield machine of Fig. 1.

Fig. 4 is a block diagram of a control system of the shield machine of Fig. 1.

Fig. 5 is a diagram for explaining a cutter head moving control of the shield machine of Fig. 1.

Fig. 6 is a schematic flow chart of a control for moving a cutter head.

Fig. 7 is a longitudinal sectional view of a shield machine of Embodiment 2 of the present invention.

Fig. 8 is a front view of the shield machine (reference position) of Fig. 7.

Fig. 9 is a front view of the shield machine of Fig. 7.

Fig. 10 is a block diagram of a control system of the shield machine of Fig. 7.

Fig. 11 is a diagram for explaining a cutter head moving control of the shield machine of Fig. 7.

Fig. 12 is a longitudinal sectional view of a shield machine of Embodiment 3 of the present invention.

Fig. 13 is a front view of the shield machine (reference position) of Fig. 12.

Fig. 14 is a front view of the shield machine of Fig. 12.

Fig. 15 is a block diagram of a control system of the shield machine of Fig. 12.

[0029] A shield machine according to the present invention is constructed to drill a tunnel having an oval cross section, and includes a body member having an oval cross section similar to a cross section of the tunnel and a circular plate member which constitutes part of a separating wall defining a rear end of a chamber and is rotated around a center of a shield machine main body. The circular plate member is equipped with a pair of rotary cutter heads each of whose position with respect to the above center is variable. The tunnel is drilled by the pair of rotary cutter heads. In the following explanation, a direction in which the shield machine drills is forward, and right and left directions when facing forward are right and left directions.

[0030] First, a shield machine of Embodiment 1 according to the present invention will be explained. As shown in Figs. 1 to 3, a shield machine SM includes: a shield machine main body 3 having a body 1 and a separating wall 2; a pair of rotary cutter heads 4 mounted on a front end portion of the shield machine main body 3; a cutter head moving mechanism 5 which causes the pair of cutter heads 4 to move in a direction orthogonal to a tunnel center axis; a plurality of shield jacks 6; an earth removing device 7; an earth removing conveyor (not shown) connected to the earth removing device 7; an erector device 8 which carries out coating using a segment S; and a rear carriage (not shown) equipped with a power source, a hydraulic source, a drill control unit 30 (see Fig. 4) and other necessary devices.

[0031] The shield machine main body 3 will be explained (see Figs. 1 to 3). The body 1 is constructed to have an oval cross section similar to a cross section of a tunnel T to be drilled, and is constituted of a steel plate

member. The body 1 includes a front body 1A and a rear body 1B fixed to a rear end of the front body 1A, and the rear body 1B has a tail seal 1a at a rear end portion thereof. In a front end portion of the body 1, a chamber 9 is formed, which receives sand drilled, and the separating wall 2 defining the rear end of the chamber 9 is provided at a front end-side portion of the shield machine main body 3.

[0032] A first oval ring portion 10 for reinforcement is provided inside an intermediate portion of the front body 1A of the body 1 in a forward and backward direction thereof, and a second oval ring portion 11 for reinforcement is provided inside a rear end portion of the front body 1A. At the position of the first ring portion 10, a pair of upper and lower roll restricting members 12 are provided, which project from the body 1 toward outside for a predetermined length to prevent the body 1 from rolling.

[0033] A plurality of the shield jacks 6 cause the shield machine main body 3 to move forward, and are connected to a hydraulic supply source mounted on the rear carriage. The plurality of the shield jacks 6 are provided on an inner surface of a rear half portion of the front body 1A so as to be circumferentially spaced apart from each other. A jack main body of the shield jack 6 is attached to the second ring portion 11 so as to penetrate therethrough and fixed to the first and second ring portions 10 and 11. Each of the shield jacks 6 has a rod capable of extending backward from the jack main body of the shield jack 6, and a spreader 6a is swingably connected to the tip end portion of the rod. The shield machine main body 3 is caused to move forward by the shield jacks 6 which support a reaction force of the drilling by causing the rods to extend backward and the spreaders 6a to contact a front end of the segment S coating the inner surface of the tunnel T.

[0034] The erector device 8 will be explained (see Fig. 1). A backwardly extending supporting frame 13 is fixed to the second ring portion 11 of the shield machine main body 3, and a rail member 14 for mounting the erector device 8 thereon is attached to the supporting frame 13. When viewed from a front surface, the rail member 14 is substantially oval which is spaced apart from the inner surface of the body 1 for a predetermined distance. For example, a pair of erectors 8A and 8B are mounted on the rail member 14 so as to be circumferentially movable and movable for a predetermined distance in the forward and backward direction. The pair of erectors 8A and 8B carry out coating using the segment S on the inner surface of the drilled tunnel T. Since the upper half portion, lower half portion, left half portion and right half portion of the coating segment S have the arch structures, these portions excel in strength and stability.

[0035] The earth removing device 7 will be explained (see Fig. 1). As the earth removing device 7, a pair of right and left earth removing devices 7 are provided. Each earth removing device 7 includes a screw conveyor constituted of a tubular case 15 and an auger 16 incorporated into the tubular case 15, and a belt conveyor (not shown)

which receives drilling mud from the screw conveyor and conveys backward in the tunnel. A front end portion of the auger 16 projects from an opening 2a of the separating wall 2 into the chamber 9.

[0036] The pair of rotary cutter heads 4 and the cutter head moving mechanism 5 which causes the cutter heads 4 to move in a direction orthogonal to a center axis of the tunnel T will be explained. The cutter head moving mechanism 5 includes: a circular plate member 17; a first rotating mechanism 18 which rotates the circular plate member 17; a pair of pivot arms 19; a pair of second rotating mechanisms 20 which rotate the pair of pivot arms 19, respectively; a pair of head supporting members 19a which are firmly fixed to tip end portions of the pair of pivot arms 19, respectively; sensors; and a control unit 30 as described below.

[0037] The circular plate member 17 will be explained (see Figs. 1 to 3). The circular plate member 17 is mounted on the front end-side portion of the shield machine main body 3 so as to be rotatable around a first center axis A1 that is a center of the shield machine main body 3, and constitutes part of the separating wall 2. The circular plate member 17 is disposed at a center portion of the separating wall 2. A cylindrical portion 10a is provided on an inner circumferential portion of the first ring portion 10 of the shield machine main body 3, and the circular plate member 17 is internally fitted in the cylindrical portion 10a so as to be rotatable. An annular portion 17a having an L-shaped cross section is provided at an outer circumferential portion of the circular plate member 17, a ring gear 18a is fixed to a rear portion of the annular portion 17a, and a bearing (not shown) is provided between the annular portion 17a and a member on the first ring portion 10 side. A plurality of annular sealing members (not shown) for liquid-tight sealing are provided between the cylindrical portion 10a and the annular portion 17a, and the annular portion 17a is constructed so as not to move in the forward or backward direction with respect to the cylindrical portion 10a.

[0038] The first rotating mechanism 18 which rotates the circular plate member 17 is constructed to be able to cause the ring gear 18a to rotate selectively in a forward direction or a reverse direction by a plurality of hydraulic motors 18m, mounted on the first ring portion 10 of the shield machine main body 3, via pinions 18p fixed to output shafts of the hydraulic motors 18m.

[0039] The pair of pivot arms 19 will be explained (see Figs. 1 to 3). The pair of pivot arms 19 are provided forward of the separating wall 2, and circular base end portions 19b of the pivot arms 19 are supported by the circular plate member 17 so as to be rotatable around a pair of second center axes A2, respectively, which are in parallel with the first center axis A1 and rotationally symmetric with respect to the first center axis A1. The second center axis A2 is located at an outer circumferential-side position which is about $(3/4) \times R$ away from the first center axis A1, where R is a radius of the circular plate member 17. Portions of the pivot arms 19 other than the circular

base end portions 19b project into the chamber 9, and portions of the circular base end portions 19b which portions protrude outside the circular plate member 17 also project into the chamber 9.

[0040] An annular portion 19c is formed at an outer circumferential portion of the circular base end portion 19b of each pivot arm 19. A ring gear 20a is fixed to the annular portion 19c, and slidably contacts or approaches a front surface of the separating wall 2 when protruding outside the circular plate member 17. A plurality of sealing members (not shown) for liquid-tight sealing are provided between the annular portion 19c and a partially annular portion 17b formed on the circular plate member 17 to prevent the annular portion 19c from moving in the forward or backward direction with respect to the partially annular portion 17b.

[0041] The pair of pivot arms 19 are controlled as follows so as to be rotationally symmetric with respect to the first center axis A1. Each pivot arm 19 includes an arm main body portion which extends from the circular base end portion 19b for a predetermined length, and the head supporting member 19a is provided on the tip end portion of the arm main body portion.

[0042] The second rotating mechanism 20 is provided, which rotates the circular base end portion 19b of the pivot arm 19 around the second center axis A2. The second rotating mechanism 20 is constructed to be able to cause the ring gear 20a to rotate selectively in a forward direction or a reverse direction by a plurality of hydraulic motors 20m, mounted on the partially annular portion 17b of the circular plate member 17, via pinions 20p fixed to output axes of the hydraulic motors 20m. Thus, the pair of pivot arms 19 are pivoted (rotated) around the second center axis A2 while moving (revolving) around the first center axis A1, and are controlled to be rotationally symmetric with respect to the first center axis A1.

[0043] The rotary cutter head 4 is mounted on the head supporting member 19a of the tip end portion of the pivot arm 19 so as to be rotatable around a third center axis A3 parallel to the second center axis A2. The pair of rotary cutter heads 4 are positioned in the forward and backward direction so as to correspond to the front end portion of the body 1. By causing the rotary cutter heads 4 to move to draw a substantially oval while holding the cutter heads 4 such that the cutter heads 4 are rotationally symmetric with respect to the first center axis A1, the tunnel T having an oval cross section similar to the body 1 is drilled. The rotary cutter head 4 has a diameter that is half a short diameter of the oval cross section of the body 1 (see Fig. 3).

[0044] The rotary cutter head 4 includes: a circular frame 4a; six spokes 4b which extend radially from the circular frame 4a; and a plurality of cutter bits 4c attached to a front surface and outer circumference-side surface of the spokes 4b (see Fig. 2). An annular portion 21c is formed on the head supporting member 19a, and the circular frame 4a of the rotary cutter head 4 is internally fitted in the annular portion 21c so as to be rotatable. A

plurality of sealing members (not shown) for liquid-tight sealing are provided between the annular portion 21c and the circular frame 4a to prevent the circular frame 4a from moving in the forward or backward direction with respect to the annular portion 21c.

[0045] A third rotating mechanism 21 which rotates the rotary cutter head 4 around the third center axis A3 is provided on the pivot arm 19. The third rotating mechanism 21 includes, for example, a ring gear 21a mounted on the circular frame 4a and a plurality of hydraulic motors 21m mounted on the annular portion 21c. The third rotating mechanism 21 is constructed to be able to cause the ring gear 21a to rotate selectively in a forward direction or a reverse direction by a plurality of hydraulic motors 21m via pinions 21p provided on output axes of the hydraulic motors 21m.

[0046] Next, a control system which controls the first, second and third rotating mechanisms 18, 20 and 21 will be explained. As shown in Fig. 4, a control panel 31, a control unit 30, a first rotation angle sensor 32 and a pair of second rotation angle sensors 33 are provided. The control unit 30 is constructed to control hydraulic control valves 34 and 35 of the first and second rotating mechanisms 18 and 20 based on detection signals from the first and second rotation angle sensors 32 and 33 such that the pair of rotary cutter heads 4 drill the tunnel T having the oval cross section. The control unit 30 includes a CPU 30a, a ROM 30b, a RAM 30c and an input/output interface (not shown).

[0047] The first rotation angle sensor 32 detects a rotation angle of the circular plate member 17 rotated from a reference position (position shown in Fig. 2 for example). The first rotation angle sensor 32 is constituted of an electromagnetic pickup which detects the gear teeth of the ring gear 18a, and is fixed to the first ring portion 10 of the shield machine main body 3. Among a large number of the gear teeth of the ring gear 18a, only the gear tooth at the reference position has a dividing small hole. The electromagnetic pickup detects two pulses (reference pulse) from the gear tooth at the reference position, and detects one pulse from each of a large number of other gear teeth. The control unit 30 detects the reference position from the reference pulse supplied from the first rotation angle sensor 32, and counts the number of pulses supplied at the time of and after the detection of the reference position so as to detect the rotation angle of the ring gear 18a (rotation angle of the circular plate member 17) rotated from the reference position toward a predetermined direction. By counting the number of pulses in consideration of the rotational direction of the hydraulic motor 18m, the rotation angle of the ring gear 18a rotated toward a direction opposite the predetermined direction is also detected.

[0048] The pair of second rotation angle detection sensors 33 detect the rotation angles of the pair of pivot arms 19 rotated from the reference positions (positions shown in Fig. 2 for example) of the pivot arms 19 with respect to the circular plate member 17 around the second center

axes A2, respectively. The second rotation angle detection sensor 33 is constituted of an electromagnetic pickup which detects the gear teeth of the ring gear 20a. The second rotation angle sensor 33 is fixed to the partially annular portion 17b of the circular plate member 17. Among a large number of the gear teeth of the ring gear 20a, only the gear tooth at the reference position has a dividing small hole. The electromagnetic pickup detects two pulses (reference pulse) from the gear tooth at the reference position, and detects one pulse from each of a large number of the gear teeth.

[0049] The control unit 30 detects the reference position from the reference pulse supplied from the electromagnetic pickup, and counts the number of pulses supplied at the time of and after the detection of the reference position so as to detect the rotation angle of the ring gear 20a (swinging rotation angle of the pivot arm 19) rotated from the reference position toward a predetermined direction. By counting the number of pulses in consideration of the rotational direction of the hydraulic motor 20m, the rotation angle of the ring gear 20a_rotated_toward a direction opposite the predetermined direction is also detected.

[0050] The first rotating mechanism 18 is constructed to include a hydraulic control valve 34 controlled by the control unit 30. The control unit 30 controls the rotation angles of a plurality of the hydraulic motors 18m by controlling the amount and pressure of oil supplied to the hydraulic motors 18m by the hydraulic control valve 34, and controls the rotation angle of the circular plate member 17. Similarly, the second rotating mechanism 20 is constructed to include a hydraulic control valve 35 controlled by the control unit 30. The control unit 30 controls the rotation angles of a plurality of the hydraulic motors 20m by controlling the amount and pressure of oil supplied to the hydraulic motors 20m by the hydraulic control valve 35, and controls the rotation angle (pivoting angle) of the pivot arm 19.

[0051] The third rotating mechanism 21 is constructed to include a hydraulic control valve 36 controlled by the control unit 30 to control the rotational direction and rotating speed of the rotary cutter head 4. The control unit 30 controls the rotational directions and rotating speeds of a plurality of the hydraulic motors 21 m by controlling the amount and pressure of oil supplied to the hydraulic motors 21m by the hydraulic control valve 36 and a direction in which the oil is supplied, and controls the rotational direction and rotating speed of the rotary cutter head 4. To reduce the rolling torque applied to the body 1, the pair of rotary cutter heads 4 are rotated in opposite directions.

[0052] The ROM 30b of the control unit 30 stores in advance a control program for drilling a tunnel having an oval cross section, and the first and second rotating mechanisms 18 and 20 are controlled based on the control program. First, the control logic of this control will be explained. As shown in Fig. 5, the first center axis A1 is the center of the body 1 of the shield machine SM, a circle

C is a trajectory formed by the second center axis A2, an oval E is an oval showing the external shape of the tunnel T to be drilled, an oval D is an oval or substantially oval which is inwardly spaced apart from the oval E by the radius R of the rotary cutter head 4, and the oval D is a trajectory formed by the movement of the third center axis A3.

[0053] One of the pivot arms 19 will be explained, and an explanation of the other pivot arm 19 is omitted. The pivot arm 19 is located at a reference position (the second center axis A2 is located at a point P0, and the third center axis A3 is located at a point Q0) shown in Fig. 5. Drilling is started from the reference position. When the third center axis A3 moves on the oval D in a counterclockwise direction, the second center axis A2 first moves on the circle C in a clockwise direction, and then moves in a counterclockwise direction. The movement speed V of the rotary cutter head 4 moving on the oval D, which is related to the drill speed, is set in advance depending on, for example, the type of soil of the natural ground.

[0054] Where the movement speed is V, and an elapsed time since the start of the drilling is t, the position of the second center axis A2 is the point P, and the position of the third center axis A3 is the point Q at the time t. These positions can be obtained by calculations. The rotation angle $-\theta_1$ of the circular plate member 17 and the rotation angle θ_2 of the pivot arm 19 at the time t can also be obtained by calculations. To be specific, the tunnel T having the oval cross section can be drilled by momentarily controlling the first and second rotating mechanisms 18 and 20 such that the rotation angle of the circular plate member 17 becomes $-\theta_1$ and the rotation angle of the pivot arm 19 becomes θ_2 at the time t after the start of the drilling.

[0055] A first method for drilling the entire tunnel using both rotary cutter heads 4 and a second method for drilling a left half of the tunnel using one of the rotary cutter heads 4 and drilling a right half of the tunnel using the other rotary cutter head 4 are adoptable. An example shown in the following flow chart shows the control carried out when the first method is adopted.

[0056] Next, explanations will be made based on the flow chart of Fig. 6. When the control is started, the detection signals, etc. from the first and second rotation angle sensors 32 and 33 are read (S1), and whether or not a start command which orders the start of the drilling is input from the control panel 31 is determined (S2). While the determination is No, the process returns to S1. When the determination is Yes, in S3, the circular plate member 17 and the pivot arms 19 are set to their reference positions. Here, by driving the hydraulic motors 18m and 20m, the circular plate member 17 and the pivot arms 19 are set to their reference positions based on the detection signals supplied from the first and second rotation angle sensors 32 and 33. Note that the hydraulic motor 21m starts being driven in response to the input of the start command, and the shield machine main body 3 moves forward by a plurality of the shield jacks 6.

[0057] Next, in S4, a timer T is started to start counting time. In S5, a counted time t of the timer T is read, and the detection signals supplied from the first and second rotation angle sensor 32 and 33 are read. In S6, the position of the third center axis A3 (position of the point Q) on the oval D is calculated based on the counted time t, the movement speed V of the cutter head 4 moving along the oval D, and the trajectory of the oval D. In S7, the position of the second center axis A2 (position of the point P) is calculated based on the position of the third center axis A3, the length of the pivot arm 19, and the trajectory of the circle C.

[0058] Next, in S8, the first rotation angle θ_1 that is the rotation angle of the circular plate member 17 and the second rotation angle θ_2 that is the rotation angle of the pivot arm 19 are calculated. In S9, the hydraulic control valves 34 and 35 of the first and second rotating mechanisms 18 and 20 are controlled such that the first and second rotation angles are $-\theta_1$ and θ_2 , respectively. In S10, whether or not the circular plate member 17 is located at the reference position is determined. When the determination is No, the process proceeds to S5, and S5 and the steps after S5 are executed. Therefore, the third center axis A3 that is the center of the cutter head 4 moves along the oval D, and thus the tunnel T having the oval cross section is drilled. When the cutter head 4 goes round once and reaches the reference position, the determination in S10 becomes Yes. In S11, whether or not a stop command is input from the control panel 31 is determined.

[0059] While the determination in S11 is No, the process returns to S3, and S3 and the steps after S3 are repeated. Therefore, the cutter head 4 goes round plural times. When the cutter head 4 moves a distance equal to the front-rear length of the segment S, the stop command is supplied from the control panel 31 to construct the segment S, the determination in S11 becomes Yes, the first and second rotating mechanisms 18 and 20 are stopped in S12, and the hydraulic motor 21m is also stopped. Then, the process proceeds to S1.

[0060] The operations and effects of the shield machine SM explained above will be explained. The tunnel T having the oval cross section is drilled in such a manner that the first rotating mechanism 18 rotates the circular plate member 17, the pair of second rotating mechanisms 20 hold the pair of pivot arms 19 such that the pivot arms 19 are rotationally symmetric with respect to the first center axis A1, the pair of third rotating mechanisms 21 rotate the pair of rotary cutter heads 4, and the center (third center axis A3) of the cutter head 4 is caused to move along the oval D shown in Fig. 5.

[0061] Since the circular plate member 17 constituting part of the separating wall 2 defining the rear end of the chamber 9 is rotated, and the circular base end portions 19b of the pair of pivot arms 19 are rotated via the circular plate member 17, the circular plate member 17 does not project deep into the chamber 9, and the phenomenon of rotating the circular plate member 17 with a large

amount of drilling mud adhered does not occur. Therefore, it is possible to reduce the power consumption of the first rotating mechanism 18 which rotates the circular plate member 17, and also possible to reduce the size of the first rotating mechanism 18. In addition, since part (about 1/3) of the circular base end portion 19b of the pivot arm 19 is constructed to protrude outside the circular plate member 17, it is possible to reduce the size of the circular plate member 17 and the size of the first rotating mechanism 18.

[0062] Since the circular plate member 17 is provided to be coplanar with the separating wall 2, the rotational resistance applied from the sand in the chamber 9 to the circular plate member 17 becomes very low. Therefore, it is possible to reduce the size of the first rotating mechanism 18. Since the diameter of the rotary cutter head 4 is set to half the short diameter of the oval cross section of the tunnel, the drilling performance of the shield machine SM can be improved by increasing the sizes of the pair of cutter heads 4 as much as possible while avoiding the mutual interference between the cutter heads 4.

[0063] Since the load applied from the cutter heads 4 and the pivot arms 18 to the circular plate member 17 can be supported by the separating wall 2 supporting the circular plate member 17, it is possible to improve the supporting stiffness for supporting the cutter heads 4, the pivot arms 19 and the circular plate member 17 and secure the durability of the first rotating mechanism 18. It is possible to simplify the construction of the cutter head moving mechanism 5 (the circular plate member 17, the pivot arms 19, and the first and second rotating mechanisms 18 and 20) which moves the cutter head 4 in a direction orthogonal to the tunnel center axis (first center axis A1).

[0064] Since the cross section of the tunnel T is oval, the segment S coating the inner surface of the tunnel has the arch structure at each portion. Therefore, it is possible to secure the strength and stability of the segment S such that the segment S is strongly fixed to the natural ground, and it is also possible to adopt as the segment S a normal segment or the like which is applied to the tunnel having the circular cross section. On this account, it is advantageous in light of the manufacturing and constructing of the segment S.

[0065] An example obtained by partially changing the above embodiment will be explained. First, the front body 1A and rear body 1B of the body 1 of the shield machine SM may be connected to each other so as to be bendable in the rightward and leftward directions, or the upward, downward, rightward and leftward directions, the bend angle may be adjusted by a plurality of broken-type jacks, and in this state a curved tunnel may be drilled. Secondly, although the shield machine SM is explained using as an example a shield machine including the earth removing device 7, a mud removing device may be provided instead of the earth removing device 7.

[0066] Next, a shield machine SM2 of Embodiment 2 according to the present invention will be explained (see

Figs. 7 to 9). Other than a cutter head moving mechanism 5A and a control system in the shield machine SM2, the shield machine SM2 is constructed in the same manner as the shield machine SM. Same reference numbers are used for the members that are the same as those of the shield machine SM, and explanations thereof are omitted. The cutter head moving mechanism 5A and the control system will be mainly explained.

[0067] As shown in Figs. 7 to 9, the cutter head moving mechanism 5A includes: a circular plate member 17A which is rotatable around the first center axis A1; the first rotating mechanism 18 which rotates the circular plate member 17A; a pair of guide members 40; a pair of extensible arms 41; a pair of arm drive mechanisms 42; a pair of head supporting members 43 which are firmly fixed to tip end portions of the pair of extensible arms 41, respectively; a pair of rotary cutter heads 4 which are supported by the pair of head supporting members 43; etc.

[0068] The circular plate member 17A includes a protruding portion 17a which protrudes forward of portions of the separating wall 2 other than the circular plate member 17A. The protruding portion 17a is provided with an extension and retraction space which allows the pair of extensible arms 41 to extend and retract. The structure of rotatably supporting the circular plate member 17A by the separating wall 2 is the same as that of Embodiment 1. On a side of the circular plate member 17A which side is opposite the chamber 9 side, the pair of guide members 40 are provided to be rotationally symmetric with respect to the first center axis A1. The pair of extensible arms 41 are slidably attached to the pair of guide members 40 so as to be rotationally symmetric with respect to the first center axis A1 and are provided to be in parallel with the separating wall 2.

[0069] The pair of arm drive mechanisms 42 are provided to cause the pair of extensible arms 41 to extend and retract, respectively. The arm drive mechanism 42 includes a hydraulic cylinder 42a. The hydraulic cylinder 42a is provided inside the extensible arm 41, its cylinder main body is pin-connected to a bracket 41b fixed to a wall portion of the protruding portion 17a, and a tip end portion of a rod 42b of the hydraulic cylinder 42a is pin-connected to a bracket fixed to a tip end member 41a of a tip end portion of the extensible arm 41. The hydraulic cylinder 42a is a double acting hydraulic cylinder and is connected to the hydraulic supply source mounted on the rear carriage.

[0070] A head supporting member 43 is fixedly provided on the tip end member 41a of the extensible arm 41, and a rotary cutter head 4 is rotatably provided on the head supporting member 43. The structure of rotatably supporting the rotary cutter head 4 by the head supporting member 43 is the same as that of Embodiment 1.

[0071] The pair of rotary cutter heads 4 are mounted on the pair of head supporting members 43, respectively, so as to be rotatable around the second center axes A2, respectively, which are in parallel with the first center axis A1. The rotary cutter head 4 is the same as that of Em-

bodiment 1. As with Embodiment 1, there is provided a pair of second rotating mechanisms 21A which rotate the pair of rotary cutter heads 4 around the second center axes A2, respectively. Note that the second center axis A2 and the second rotating mechanism 21A are the same as the third center axis A3 and the third rotating mechanism 21 of Embodiment 1, respectively.

[0072] The control system will be explained based on Fig. 10. The control panel 31, the first rotation angle sensor 32, and a pair of extended length detection sensors 44 are connected to a control unit 30A. The first rotation angle sensor 32 detects the rotation angle of the circular plate member 17A rotated from the reference position toward a predetermined direction, and is constructed in the same manner as Embodiment 1.

[0073] The extended length detection sensor 44 detects the extended length of the extensible arm 41 extended from a most retracted position shown in Figs. 7 and 8. For example, the extended length detection sensor 44 is constituted of a plurality of small holes which are formed at short intervals on a wall surface of the extensible arm 41 made of steel and are formed in a line parallel to an extension-retraction direction, and an electromagnetic pickup fixedly provided on the guide member 40 side. Note that the small holes are blocked liquid-tight on an inner surface side of the extensible arm 41. A wide small hole is also formed, from which a reference pulse whose pulse width detected by the electromagnetic pickup when the extensible arm 41 is at the most retracted position is especially wide is detected. Therefore, it is possible to detect the most retracted position based on the detection signal supplied from the electromagnetic pickup. Moreover, by counting the number of pulses detected at the time of and after the detection of the most retracted position, it is possible to detect the extended length of the extensible arm 41 extended from the most retracted position.

[0074] The first rotating mechanism 18 is the same as that of Embodiment 1. The arm drive mechanism 42 is constructed to cause the extensible arm 41 to extract and retract for a predetermined length according to the amount and pressure of oil supplied to the hydraulic cylinder 42a via the hydraulic control valve 42v. The hydraulic control valve 42v is controlled by the control unit 30A. The second rotating mechanism 21A is the same as the third rotating mechanism 21 of Embodiment 1. The control unit 30A receives outputs from the first rotation angle detection sensor 32 and the pair of extended length detection sensors 44 so as to control the first rotating mechanism 18 and the arm drive mechanisms 42 such that the pair of cutter heads 4 drill the tunnel T having the oval cross section.

[0075] The control unit 30A includes a CPU 30d, a ROM 30e, a RAM 30f and an input/output interface (not shown). The ROM 30e stores in advance a control program for the above control of causing the cutter head 4 to move in a direction orthogonal to the first center axis A1. The flow chart of the control program is omitted. The

control logic of one of the extensible arms 41 will be explained in brief. As shown in Fig. 11, an oval I is an oval showing the external shape of the tunnel to be drilled, an oval H is an oval or substantially oval which is inwardly spaced apart from the oval I by the radius R of the cutter head 4, a circle F is the circular plate member 17A, and a circle G is a virtual circle to which the extensible arm 41 which rotates integrally with the circular plate member 17A externally contacts.

[0076] When in the state shown in Fig. 8, the circular plate member 17A is located at the reference position, the extensible arm 41 is also located at the reference position (most retracted position). Therefore, in the case of the reference position shown in Fig. 11, the base end of the extensible arm 41 is located at the point M0, and the tip end of the extensible arm 41 is located at the point N0. At the time t after the start of the drilling, the tip end of the extensible arm 41 is located at the point N. As with Embodiment 1, the position of the point N can be calculated based on the preset movement speed V of the cutter head 4 moving along an oval and the time t.

[0077] Next, the position of the point M can be calculated based on the position of the point N and the circles F and G. The extensible arm 41 extends so as to change from a line segment M0N0 to a line segment MN, and the extended length of the extensible arm 41 extended from the most retracted position can be calculated by (Length of Line Segment MN - Length of Line Segment M0N0). To be specific, the tunnel T having the oval cross section can be drilled by momentarily controlling the arm drive mechanism 42 such that the extended length of the extensible arm 41 at the time t after the start of the drilling becomes the above value.

[0078] The operations and effects of the shield machine SM2 explained above will be explained. The tunnel T having the oval cross section is drilled in such a manner that the first rotating mechanism 18 rotates the circular plate member 17A, the pair of arm drive mechanisms 42 hold the pair of extensible arms 41 such that the extensible arms 41 are rotationally symmetric with respect to the first center axis A1, the pair of second rotating mechanisms 21 A rotate the pair of rotary cutter heads 4, and the center (third center axis A3) of the cutter head 4 is caused to move along the oval H shown in Fig. 11.

[0079] Since the circular plate member 17A constituting part of the separating wall 2 defining the rear end of the chamber 9 is rotated, and the pair of extensible arms 41 are rotated via the circular plate member 17A, the circular plate member 17A does not project deep into the chamber 9, and the phenomenon of rotating the circular plate member 17A with a large amount of drilling mud adhered does not substantially occur. Therefore, it is possible to reduce the power consumption of the first rotating mechanism 18 which rotates the circular plate member 17A, and also possible to reduce the size of the first rotating mechanism 18. Since the diameter of the rotary cutter head 4 is set to half of the short diameter of the oval cross section of the tunnel, the drilling performance

of the shield machine SM2 can be improved by increasing the size of the pair of cutter heads 4 as much as possible while avoiding the mutual interference between the cutter heads 4.

[0080] Since the load applied from the cutter heads 4 and the extensible arms 41 to the circular plate member 17A can be supported by the separating wall 2 supporting the circular plate member 17A, it is possible to improve the supporting stiffness for supporting the cutter heads 4, the extensible arms 41 and the circular plate member 17A and secure the durability of the first rotating mechanism 18.

[0081] It is possible to simplify the construction of the cutter head moving mechanism 5A (the circular plate member 17, the extensible arms 41, the first rotating mechanism 18, the arm drive mechanisms 42) which moves the cutter head 4 in a direction orthogonal to the tunnel center axis (first center axis A1).

[0082] Since the cross section of the tunnel T is oval, the segment S coating the inner surface of the tunnel has the arch structure. Therefore, it is possible to secure the strength and stability of the segment S such that the segment S is strongly fixed to the natural ground. Also, it is possible to adopt as the segment S a normal segment or the like which is applied to the tunnel having the circular cross section. On this account, it is advantageous in light of the manufacturing and constructing of the segment S.

[0083] Since the pair of extensible arms 41 are constructed to be slidably supported by the pair of guide members 40 and to be driven by the pair of arm drive mechanisms 42, the construction of supporting the pair of extensible arms 41 by the circular plate member 17A and the construction of causing the cutter heads 4 to move in a direction orthogonal to the first center axis A1 are simplified significantly and can be manufactured at low cost.

[0084] An example obtained by partially changing Embodiment 2 will be explained. First, the front body 1A and rear body 1B of the body 1 of the shield machine SM2 may be connected to each other so as to be bendable in the rightward and leftward directions or the upward, downward, rightward and leftward directions, and the bend angle may be adjusted by a plurality of broken-type jacks, and a curved tunnel may be drilled. Secondly, although the shield machine SM2 is explained using as an example a shield machine including the earth removing device 7, a mud removing device may be provided instead of the earth removing device 7.

[0085] Next, a shield machine SM3 of Embodiment 3 according to the present invention will be explained (see Figs. 12 to 14). Other than a cutter head moving mechanism 5B and a control system in the shield machine SM3, the shield machine SM3 is constructed in the same manner as the shield machine SM. Same reference numbers are used for the members that are the same as those of the shield machine SM, and explanations thereof are omitted. The cutter head moving mechanism 5B and the control system will be mainly explained.

[0086] As shown in Figs. 12 to 14, the cutter head moving mechanism 5B includes: a circular plate member 17B which is rotatable around the first center axis A1; the first rotating mechanism 18 which rotates the circular plate member 17B; a pair of guide members 50a and 50b; a pair of extensible arms 51a and 51b which are slidably attached to the pair of guide members 50a and 50b; an arm drive mechanism 52 which causes the pair of extensible arms 51a and 51b to extract and retract; and a pair of head supporting members 53 which are firmly fixed to tip end portions of the pair of extensible arms 51a and 51b, respectively.

[0087] The pair of rotary cutter heads 4 are mounted on a pair of head supporting members 53, respectively, so as to be rotatable around the second center axes A2, respectively, which are in parallel with the first center axis A1. The rotary cutter head 4 is the same as that of Embodiment 1. A pair of second rotating mechanisms 21 B which rotate the cutter heads 4 are the same as the third rotating mechanisms 21 of Embodiment 1.

[0088] The circular plate member 17B is mounted on a front end-side portion of a shield machine main body 3B so as to be rotatable around the first center axis A1 that is the center of the shield machine main body 3B, and the circular plate member 17B constitutes part of the separating wall 2. The circular plate member 17B includes a circular protruding portion 17b which is connected to the annular portion 17a and protrudes forward of portions of the separating wall 2 other than the circular plate member 17B. The pair of guide members 50a and 50b are provided inside the protruding portion 17b of the circular plate member 17B so as to be substantially mirror symmetric with respect to the first center axis A1. The pair of extensible arms 51a and 51b are slidably provided on the pair of guide members 50a and 50b such that the extended lengths are mirror symmetric with respect to the first center axis A1.

[0089] The pair of extensible arms 51a and 51b are constituted of an outside extensible arm 51a having a rectangular cross section and an inside extensible arm 51b which is internally fitted in the outside extensible arm 51a so as to be relatively slidable. An end portion of the outside extensible arm 51a is firmly fixed to the tip end member 53a which is firmly fixed to one of the head supporting members 53, and the end portion is slidably inserted through the guide member 50a on the tip end member 53a side. An end portion of the inside extensible arm 51b is firmly fixed to the tip end member 53b which is firmly fixed to the other head supporting member 53, and the end portion is slidably inserted through the guide member 50b on the tip end member 53b side.

[0090] The arm drive mechanism 52 is constituted of a two rod type extensible hydraulic cylinder provided in the pair of extensible arms 51a and 51b. The extensible hydraulic cylinder includes a separating wall at a lengthwisely intermediate portion inside a cylinder main body 52A thereof, includes piston portions in a pair of cylinder bore holes, respectively, which are formed on both sides

of the separating wall, and is constructed such that a pair of piston rods 52a and 52b extend and retract from both ends of the cylinder main body 52A, respectively. An end portion of one of the piston rods 52a is pin-connected to the tip end member 53a via a bracket, and an end portion of the other piston rod 52b is pin-connected to the tip end member 53b via a bracket.

[0091] Each of two hydraulic cylinders of the arm drive mechanism 52 is constructed as a double acting cylinder, and is connected to the hydraulic supply source of the rear carriage. By synchronizing the two hydraulic cylinders and causing them to operate to be mirror symmetric with respect to the first center axis A1, the extended lengths of the pair of extensible arms 51a and 51b become mirror symmetric with respect to the first center axis A1. By causing the pair of extensible arms 51a and 51b to extend and retract by the arm drive mechanism 52 while rotating the circular plate member 17B around the first center axis A1, the pair of cutter heads 4 can be made to be rotationally symmetric with respect to the first center axis A1. Thus, the tunnel T having the oval cross section can be drilled.

[0092] Next, the control system of the shield machine SM3 will be explained. As shown in Fig. 15, the control panel 31, the first rotation angle sensor 32, and a pair of extended length detection sensors 54a and 54b are connected to a control unit 30B. The first rotation angle sensor 32 detects the rotation angle of the circular plate member 17B rotated from the reference position toward a predetermined direction, and is constructed in the same manner as Embodiment 1.

[0093] The extended length detection sensor 54a detects the extended length of the outside extensible arm 51a extended from the most retracted position (reference position) shown in Figs. 12 and 13. For example, the extended length detection sensor 54a is constituted of a plurality of small holes which are formed at short intervals on a wall surface of the outside extensible arm 51a made of steel and are formed in a line parallel to an extension-retraction direction, and an electromagnetic pickup fixedly provided on the guide member 50a side. Note that the small holes are blocked watertight on an inner side of the outside extensible arm 51a. A wide small hole is also formed, from which a reference pulse whose pulse width detected by the electromagnetic pickup when the outside extensible arm 51a is at the most retracted position is especially wide is detected. Therefore, it is possible to detect the most retracted position based on the detection signal supplied from the electromagnetic pickup. Moreover, by counting the number of pulses detected at the time of and after the detection of the most retracted position, it is possible to detect the extended length of the outside extensible arm 51a extended from the most retracted position. Note that the extended length detection sensor 54b detects the extended length of the inside extensible arm 51b extended from the most retracted position, and is constructed in the same manner as the extended length detection sensor 54a.

[0094] The first rotating mechanism 18 is the same as that of Embodiment 1. The arm drive mechanism 52 is constructed to control the amount and pressure of oil supplied to the two hydraulic cylinders via a hydraulic control valve 52v and cause the outside extensible arm 51a and the inside extensible arm 51b to extend and retract mirror-symmetrically for a desired length. The hydraulic control valve 52v is controlled by the control unit 30B. The second rotating mechanism 21B is the same as the third rotating mechanism 21 of Embodiment 1. The control unit 30B receives outputs from the first rotation angle detection sensor 32 and the pair of extended length detection sensors 54a and 54b so as to control the first rotating mechanism 18 and the arm drive mechanism 52 such that the pair of cutter heads 4 drill the tunnel T having the oval cross section.

[0095] The control unit 30A includes a CPU 30g, a ROM 30h, a RAM 30i and an input/output interface (not shown). The ROM 30h stores in advance a control program for the above control of causing the cutter head 4 to move in a direction orthogonal to the first center axis A1 to drill the tunnel having the oval cross section. The flow chart and control logic of the control program are omitted.

[0096] The operations and effects of the shield machine SM3 are substantially the same as those of the shield machine SM2 of Embodiment 2, so that explanations thereof are omitted. An example obtained by partially changing Embodiment 3 will be explained. Two independent hydraulic cylinders may be provided to be opposite to each other instead of the hydraulic cylinders of the arm drive mechanism 52, and the hydraulic cylinders may be constructed to operate in sync with each other. The other modification examples are substantially the same as Embodiment 2.

[0097] As this invention may be embodied in several forms without departing from the essential characteristics thereof, the present embodiments are therefore illustrative and not restrictive, since the scope of the invention is defined by the appended claims rather than by the description preceding them, and all changes that fall within metes and bounds of the claims, or equivalence of such metes and bounds thereof are therefore intended to be embraced by the claims.

Claims

1. A shield machine (SM) comprising: a shield machine main body (3) including a body (1) and a separating wall (2) defining a rear end of a chamber (9) in a front end portion (1A) of the body; and a plurality of shield jacks (6) for causing the shield machine main body (3) to drill forward, the shield machine (SM) being arranged to drill a tunnel having an oval cross section, **characterized in that** the body (1) is constructed to have an oval cross section similar to the cross section of the tunnel, and

in that

the shield machine (SM) further comprises:

a circular plate member (17) which is mounted on a front end-side portion of the shield machine main body (3) so as to be rotatable around a first center axis (A1) that is a center of the shield machine main body (3) and constitutes part of the separating wall (2);
 a first rotating means (18) for rotating the circular plate member (17);
 a pair of pivot arms (19) which are supported on a front surface side of the circular plate member (17) such that base end portions (196) of the pivot arms are rotatable around a pair of second center axes (A2), respectively, which are in parallel with the first center axis (A1) and are rotationally symmetric with respect to the first center axis (A1);
 a pair of second rotating means (20) for rotating the pair of pivot arms (19) around the second center axes (A2), respectively;
 a pair of head supporting members (19a) which are firmly fixed to tip end portions of the pair of pivot arms (19), respectively;
 a pair of rotary cutter heads (4) which are mounted on the pair of head supporting members (19a), respectively, so as to be rotatable around third center axes (A3), respectively, which are in parallel with the second center axes (A2), and each of which has a diameter that is half a short diameter of the oval cross section of the body (3); and
 a pair of third rotating means (21) for rotating the pair of rotary cutter heads (4) around the third center axes (A3), respectively.

2. The shield machine (SM) according to claim 1, **characterized by** further comprising:

a first rotation angle detecting means (32) for detecting a rotation angle of the circular plate member (17) rotated from a reference position;
 a pair of second rotation angle detecting means for (33) detecting rotation angles of the pair of pivot arms (19) rotated from reference positions around the second center axes (A2); and
 a drilling control means (30) for, based on outputs from the first (32) and second (33) rotation angle detecting means, controlling the first (18) and second (20) rotating means such that the pair of rotary cutter heads (4) drill the tunnel having the oval cross section.

3. A shield machine (SM) comprising: a shield machine main body (3) including a body (1) and a separating wall (2) defining a rear end of a chamber (a) in a front end portion (19) of the body; and a plurality of shield

jacks (6) for causing the shield machine main body (3) to drill forward, the shield machine (SM) being arranged to drill a tunnel having an oval cross section, **characterized in that**

the body (1) is constructed to have an oval cross section similar to the cross section of the tunnel, and the shield machine further comprises:

a circular plate member (17a) which is mounted on a front end-side portion of the shield machine main body so as to be rotatable around a first center axis that is a center of the shield machine main body (3) and constitutes part of the separating wall (2);

a first rotating means (18) for rotating the circular plate member (17A);

a pair of guide members (40) which are mounted on a side of the circular plate member (17A), which side is opposite the chamber side, so as to be rotationally symmetric with respect to the first center axis (A1), and a pair of extensible arms (41) which are slidably mounted on the pair of guide members (40) so as to be rotationally symmetric with respect to the first center axis (A1) and are provided in parallel with the separating wall (2);

a pair of driving means (42) for causing the pair of extensible arms (41) to extend and retract, respectively;

a pair of head supporting members (43) which are firmly fixed to tip end portions (41a) of the pair of extensible arms (41), respectively;

a pair of rotary cutter heads (4) which are mounted on the pair of head supporting members (43), respectively, so as to be rotatable around second center axes (A2), respectively, which are in parallel with the first center axis (A1), and each of which has a diameter that is half a short diameter of the oval cross section of the body; and a pair of second rotating means (21a) for rotating the pair of rotary cutter heads around the second center axes (42), respectively.

4. The shield machine (SM) according to claim 3, characterized by further comprising:

a first rotation angle detecting means (32) for detecting a rotation angle of the circular plate member (17a) rotated from a reference position; a pair of extended length detecting means (44) for detecting extended lengths of the pair of extensible arms (41) extended from a most retracted position, respectively; and

a drilling control means (30A) for, based on outputs from the first rotation angle detecting means (32) and the extended length detecting means (44), controlling the first rotating means (18) and the driving means (42) such that the

pair of rotary cutter heads (4) drill the tunnel having the oval cross section.

5. A shield machine (SM) comprising: a shield machine main body (3B) including a body (1) and a separating wall (2) defining a rear end of a chamber (9) in a front end portion (1A) of the body; and a plurality of shield jacks (6) for causing the shield machine main body (3) to drill forward, the shield machine (SM) being arranged to drill a tunnel having an oval cross section, characterized in that

the body (1) is constructed to have an oval cross section similar to the cross section of the tunnel, and **in that**

the shield machine (SM) further comprises:

a circular plate member (17B) which is mounted on a front end-side portion of the shield machine main body (3) so as to be rotatable around a first center axis (A1) that is a center of the shield machine main body (3) and constitutes part of the separating wall (2);

a first rotating means (18) for rotating the circular plate member (17B);

a pair of guide members (50a, 50b) which are mounted on a protruding portion (17b) so as to be substantially mirror symmetric with respect to the first center axis (A1), the protruding portion (17b) protruding forward of part of the separating wall (2) other than the circular plate member (17B) and provided by the circular plate member, and a pair of extensible arms (51a, 51b) which are slidably mounted on the pair of guide members (50a, 50b), respectively, such that extended lengths of the extensible arms (51a, 51b) are mirror symmetric with respect to the first center axis (A1);

one or a pair of driving means (52) for causing the pair of extensible arms (51a, 51b) to extend and retract;

a pair of head supporting members (53) which are firmly fixed to a pair of tip end portions (53a) of the pair of extensible arms (51a, 51b), respectively;

a pair of rotary cutter heads (4) which are mounted on the pair of head supporting members (53), respectively, so as to be rotatable around second center axes (A2), respectively, which are in parallel with the first center axis (A1), and each of which has a diameter that is half a short diameter of the oval cross section of the body (3B); and

a pair of second rotating means (21B) for rotating the pair of rotary cutter heads (4) around the second center axes (A2), respectively.

6. The shield machine (SM) according to claim 5, characterized by further comprising:

a first rotation angle detecting means (32) for detecting a rotation angle of the circular plate member (17B) rotated from a reference position; an extended length detecting means (54a, 54b) for detecting extended lengths of the extensible arms (51a, 51b) extended from a most retracted position; and a drilling control means (30B) for, based on outputs from the first rotation angle detecting means (32) and the extended length detecting means (54a, 54b), controlling the first rotating means (18) and the driving means (52) such that the pair of rotary cutter heads (4) drill the tunnel having the oval cross section.

Patentansprüche

1. Schildmaschine (SM), die enthält: einen Schildmaschinen-Hauptkörper (3) mit einem Körper (1) und einer Trennwand (2), die ein hinteres Ende einer Kammer (9) in einem vorderen Endabschnitt (1A) des Körpers definiert; und mehrere Schildvorschubpressen (6) zum Bewirken, dass der Schildmaschinen-Hauptkörper (3) vorwärts bohrt, wobei die Schildmaschine (SM) angeordnet ist, um einen Tunnel mit einem ovalen Querschnitt zu bohren, **dadurch gekennzeichnet, dass** der Körper (1) so konstruiert ist, dass er einen ovalen Querschnitt ähnlich zum Querschnitt des Tunnels enthält, und dass die Schildmaschine (SM) außerdem enthält:

ein kreisförmiges Plattenelement (17), das an einem Seitenabschnitt des vorderen Endes des Schildmaschinen-Hauptkörpers (3) so angebracht ist, dass es um eine erste Mittelachse (A1) drehbar ist, die eine Mitte des Schildmaschinen-Hauptkörpers (3) ist, und einen Teil der Trennwand (2) bildet;
eine erste Dreheinrichtung (18) zum Drehen des kreisförmigen Plattenelements (17);
ein Paar Schwenkarme (19), die an einer Vorderoberflächen- seite des kreisförmigen Plattenelements (17) derart abgestützt sind, dass Basisendabschnitte (196) der Schwenkarme jeweils um ein Paar zweiter Mittelachsen (A2) drehbar sind, die zur ersten Mittelachse (A1) parallel sind und in Bezug auf die erste Mittelachse (A1) rotationssymmetrisch sind;
ein Paar zweiter Dreheinrichtungen (20) zum Drehen des Paares Schwenkarme (19) jeweils um die zweiten Mittelachsen (A2);
ein Paar Kopfstützelemente (19a), die an Spitzenendabschnitten des Paares Schwenkarme (19) jeweils stabil befestigt sind;
ein Paar Rotationsfräsköpfe (4), die jeweils an dem Paar Kopfstützelemente (19a) so ange-

bracht sind, dass sie jeweils um dritte Mittelachsen (A3) drehbar sind, die zu den zweiten Mittelachsen (A2) parallel sind, und wovon jeder einen Durchmesser aufweist, der ein halber kurzer Durchmesser des ovalen Querschnitts des Körpers (3) ist; und ein Paar dritter Dreheinrichtungen (21) zum Drehen des Paares Rotationsfräsköpfe (4) jeweils um die dritten Mittelachsen (A3).

2. Schildmaschine (SM) nach Anspruch 1, **dadurch gekennzeichnet, dass** sie außerdem enthält:

eine erste Drehwinkel-Detektionseinrichtung (32) zum Detektieren eines Drehwinkels des kreisförmigen Plattenelements (17), das aus einer Referenzposition gedreht ist;
ein Paar zweiter Drehwinkel-Detektionseinrichtungen (33) zum Detektieren von Drehwinkeln des Paares Schwenkarme (19), die aus Referenzpositionen um die zweiten Mittelachsen (A2) gedreht sind; und
eine Bohrsteuereinrichtung (30), um auf der Basis von Ausgaben aus den ersten (32) und zweiten (33) Drehwinkel-Detektionseinrichtungen die ersten (18) und zweiten (20) Dreheinrichtungen derart zu steuern, dass das Paar Rotationsfräsköpfe (4) den Tunnel mit dem ovalen Querschnitt bohrt.

3. Schildmaschine (SM), die enthält: einen Schildmaschinen-Hauptkörper (3) mit einem Körper (1) und einer Trennwand (2), die ein hinteres Ende einer Kammer (a) in einem vorderen Endabschnitt (19) des Körpers definiert; und mehrere Schildvorschubpressen (6) zum Bewirken, dass der Schildmaschinen-Hauptkörper (3) vorwärts bohrt, wobei die Schildmaschine (SM) angeordnet ist, um einen Tunnel mit einem ovalen Querschnitt zu bohren, **dadurch gekennzeichnet, dass** der Körper (1) so konstruiert ist, dass er einen ovalen Querschnitt ähnlich zum Querschnitt des Tunnels enthält, und die Schildmaschine außerdem enthält:

ein kreisförmiges Plattenelement (17a), das an einem Seitenabschnitt des vorderen Endes des Schildmaschinen-Hauptkörpers so angebracht ist, dass es um eine erste Mittelachse drehbar ist, die eine Mitte des Schildmaschinen-Hauptkörpers (3) ist, und einen Teil der Trennwand (2) bildet;
eine erste Dreheinrichtung (18) zum Drehen des kreisförmigen Plattenelements (17a);
ein Paar Führungselemente (40), die auf einer Seite des kreisförmigen Plattenelements (17a) angebracht sind, wobei die Seite zur Kammerseite entgegengesetzt ist, so dass sie in Bezug

- auf die erste Mittelachse (A1) rotationssymmetrisch sind, und ein Paar ausfahrbarer Arme (41), die an dem Paar Führungselemente (40) verschiebbar angebracht sind, so dass sie in Bezug auf die erste Mittelachse (A1) rotationssymmetrisch sind, und parallel zur Trennwand (2) vorgesehen sind;
- ein Paar Antriebseinrichtungen (42) zum Bewirken, dass das Paar ausfahrbarer Arme (41) ausfährt bzw. sich zurückzieht;
- ein Paar Kopfstützelemente (43), die an Spitzenendabschnitten (41a) des Paares ausfahrbarer Arme (41) jeweils stabil befestigt sind;
- ein Paar Rotationsfräsköpfe (4), die an dem Paar Kopfstützelemente (43) jeweils so angebracht sind, dass sie jeweils um zweite Mittelachsen (A2) drehbar sind, die zur ersten Mittelachse (A1) parallel sind, und wovon jeder einen Durchmesser aufweist, der ein halber kurzer Durchmesser des ovalen Querschnitts des Körpers ist; und
- ein Paar zweiter Dreheinrichtungen (21a) zum Drehen des Paares Rotationsfräsköpfe jeweils um die zweiten Mittelachsen (42).
4. Schildmaschine (SM) nach Anspruch 3, **dadurch gekennzeichnet, dass** sie außerdem enthält eine erste Drehwinkel-Detektionseinrichtung (32) zum Detektieren eines Drehwinkels des kreisförmigen Plattenelements (17a), das aus einer Referenzposition gedreht ist;
- ein Paar Detektionseinrichtungen (44) für eine ausgefahrene Länge zum Detektieren von ausgefahrenen Längen des Paares ausfahrbarer Arme (41), die jeweils aus einer ganz zurückgezogenen Position ausgefahren sind; und
- eine Bohrsteuereinrichtung (30A), um auf der Basis von Ausgaben aus der ersten Drehwinkel-Detektionseinrichtung (32) und den Detektionseinrichtungen (44) für eine ausgefahrene Länge die erste Dreheinrichtung (18) und die Antriebseinrichtungen (42) derart zu steuern, dass das Paar Rotationsfräsköpfe (4) den Tunnel mit dem ovalen Querschnitt bohrt.
5. Schildmaschine (SM), die enthält: einen Schildmaschinen-Hauptkörper (3B) mit einem Körper (1) und einer Trennwand (2), die ein hinteres Ende einer Kammer (9) in einem vorderen Endabschnitt (1A) des Körpers definiert; und mehrere Schildvortriebspressen (6) zum Bewirken, dass der Schildmaschinen-Hauptkörper (3) vorwärts bohrt, wobei die Schildmaschine (SM) angeordnet ist, um einen Tunnel mit einem ovalen Querschnitt zu bohren, **dadurch gekennzeichnet, dass** der Körper (1) so konstruiert ist, dass er einen ovalen Querschnitt ähnlich zum Querschnitt des Tunnels enthält, und

die Schildmaschine (SM) außerdem enthält:

ein kreisförmiges Plattenelement (17B), das an einem Seitenabschnitt des vorderen Endes des Schildmaschinen-Hauptkörpers (3) so angebracht ist, dass es um eine erste Mittelachse (A1) drehbar ist, die eine Mitte des Schildmaschinen-Hauptkörpers (3) ist, und einen Teil der Trennwand (2) bildet;

eine erste Dreheinrichtung (18) zum Drehen des kreisförmigen Plattenelements (17B);

ein Paar Führungselemente (50a, 50b), die an einem vorstehenden Abschnitt (17b) so angebracht sind, dass sie in Bezug auf die erste Mittelachse (41) im wesentlichen spiegelsymmetrisch sind, wobei der vorstehende Abschnitt (17b) von einem anderen Teil der Trennwand (2) als dem kreisförmigen Plattenelement (17B) nach vorn vorsteht und durch das kreisförmige Plattenelement vorgesehen ist, und ein Paar ausfahrbarer Arme (51a, 51b), die an dem Paar Führungselemente (50a, 50b) jeweils verschiebbar angebracht sind, so dass ausgefahrene Längen der ausfahrbaren Arme (51a, 51b) in Bezug auf die erste Mittelachse (A1) spiegelsymmetrisch sind;

eine oder ein Paar Antriebseinrichtungen (52) zum Bewirken, dass das Paar ausfahrbarer Arme (51a, 51b) ausfährt und sich zurückzieht;

ein Paar Kopfstützelemente (53), die an einem Paar Spitzenendabschnitte (53a) des Paares ausfahrbarer Arme (51a, 51b) jeweils stabil befestigt sind;

ein Paar Rotationsfräsköpfe (4), die an dem Paar Kopfstützelemente (53) jeweils so angebracht sind, dass sie jeweils um zweite Mittelachsen (A2) drehbar sind, die zur ersten Mittelachse (A1) parallel sind, und wovon jeder einen Durchmesser aufweist, der ein halber kurzer Durchmesser des ovalen Querschnitts des Körpers (3B) ist; und

ein Paar zweiter Dreheinrichtungen (21B) zum Drehen des Paares Rotationsfräsköpfe (4) jeweils um die zweiten Mittelachsen (A2).

6. Schildmaschine (SM) nach Anspruch 5, **dadurch gekennzeichnet, dass** sie außerdem enthält:

eine erste Drehwinkel-Detektionseinrichtung (32) zum Detektieren eines Drehwinkels des kreisförmigen Plattenelements (17B), das aus einer Referenzposition gedreht ist;

Detektionseinrichtungen (54a, 54b) für eine ausgefahrene Länge zum Detektieren von ausgefahrenen Längen der ausfahrbaren Arme (51a, 51b), die aus einer ganz zurückgezogenen Position ausgefahren sind; und

ein Bohrsteuereinrichtung (30B), um auf der Ba-

sis von Ausgaben aus der ersten Drehwinkel-Detektionseinrichtung (32) und den Detektionseinrichtungen (54a, 54b) für eine ausgefahrene Länge die erste Dreheinrichtung (18) und die Antriebseinrichtungen (52) derart zu steuern, dass das Paar Rotationsfräsköpfe (4) den Tunnel mit dem ovalen Querschnitt bohrt.

Revendications

1. Machine à bouclier (SM) comportant : un corps principal de machine à bouclier (3) incluant un corps (1) et une paroi de séparation (2) définissant une extrémité arrière d'une chambre (9) dans une partie d'extrémité avant (1A) du corps; et une pluralité de connecteurs de bouclier (6) pour amener le corps principal de machine à bouclier (3) à percer vers l'avant, la machine à bouclier (SM) étant conçue pour percer un tunnel ayant une section efficace ovale, **caractérisée en ce que** :

le corps (1) est construit de manière à avoir une section efficace ovale similaire à la section efficace du tunnel, et **en ce que** la machine à bouclier (SM) comporte en outre :

un élément de plaque circulaire (17) lequel est monté sur une partie latérale d'extrémité avant du corps principal de machine à bouclier (3) de manière à tourner autour d'un premier axe central (A1) qui est un centre du corps principal de machine à bouclier (3) et constitue une partie de la paroi de séparation (2) ;
des premiers moyens de rotation (18) pour mettre en rotation l'élément de plaque circulaire (17) ;
une paire de bras pivotants (19) lesquels sont supportés sur un côté de surface avant de l'élément de plaque circulaire (17) de sorte que des parties d'extrémité de base (196) des bras pivotants tournent autour d'une paire de deuxièmes axes centraux (A2), respectivement, lesquels sont parallèle au premier axe central (A1) et sont symétriques en rotation par rapport au premier axe central (A1) ;
une paire de deuxièmes moyens de rotation (20) pour mettre en rotation la paire de bras pivotants (19) autour des deuxièmes axes centraux (A2), respectivement ;
une paire d'éléments de support de tête (19a) lesquels sont fermement fixés à des parties d'extrémité de la paire de bras pivotants (19), respectivement ;
une paire de têtes de coupe rotatives (4) lesquelles sont montées sur la paire d'élé-

ments de support de tête (19a), respectivement, de manière à tourner autour de troisièmes axes centraux (A3), respectivement, lesquels sont parallèles aux deuxièmes axes centraux (A2), et chacun d'eux ayant un diamètre qui est égal à la moitié d'un petit diamètre de la section efficace ovale du corps (3) ; et
une paire de troisièmes moyens de rotation (21) pour mettre en rotation la paire de têtes de coupe rotatives (4) autour des troisièmes axes centraux (A3), respectivement.

2. Machine à bouclier (SM) selon la revendication 1, **caractérisée en ce qu'elle** comporte en outre ;

des premiers moyens de détection d'angle de rotation (32) pour détecter un angle de rotation de l'élément de plaque circulaire (17) mis en rotation à partir d'une position de référence ;
une paire de seconds moyens de détection d'angle de rotation (33) pour détecter des angles de rotation de la paire de bras pivotants (19) mis en rotation à partir de positions de référence autour des deuxièmes axes centraux (A2) ; et
des moyens de commande de perçage (30) pour, sur la base des sorties des premiers (32) et seconds (33) moyens de détection d'angle de rotation, commander les premiers (18) et deuxièmes (20) moyens de rotation de sorte que la paire de têtes de coupe rotatives (4) perce le tunnel ayant la section efficace ovale.

3. Machine à bouclier (SM) comportant : un corps principal de machine à bouclier (3) incluant un corps (1) et une paroi de séparation (2) définissant une extrémité arrière d'une chambre (a) dans une partie d'extrémité avant (19) du corps; et une pluralité de connecteurs de bouclier (6) pour amener le corps principal de machine à bouclier (3) à percer vers l'avant, la machine à bouclier (SM) étant conçue pour percer un tunnel ayant une section efficace ovale, **caractérisée en ce que**

le corps (1) est constitué pour avoir une section efficace ovale similaire à la section efficace du tunnel, et
la machine à bouclier comporte en outre :

un élément de plaque circulaire (17a) lequel est monté sur une partie latérale d'extrémité avant du corps principal de machine à bouclier de manière à tourner autour d'un premier axe central qui est un centre du corps principal de machine à bouclier (3) et constitue une partie de la paroi de séparation (2) ;
des premiers moyens de rotation (18) pour mettre en rotation l'élément de plaque circulaire (17A) ;

une paire d'éléments de guidage (40) lesquels sont montés sur un côté de l'élément de plaque circulaire (17A), lequel côté est opposé au côté de chambre, de manière à être symétriques en rotation par rapport au premier axe central (A1), et une paire de bras extensibles (41) lesquels sont montés en coulissement sur la paire d'éléments de guidage (40) de manière à être symétriques en rotation par rapport au premier axe central (A1) et sont agencés parallèlement à la paroi de séparation (2) ;

une paire de moyens d'entraînement (42) pour amener la paire de bras extensibles (41) à se déployer et à se rétracter, respectivement ;

une paire d'éléments de support de tête (43) lesquels sont fermement fixés à des parties d'extrémité (41a) de la paire de bras extensibles (41), respectivement ;

une paire de têtes de coupe rotatives (4) lesquelles sont montées sur la paire d'éléments de support de tête (43), respectivement, de manière à tourner autour des deuxièmes axes centraux (A2), respectivement, lesquels sont parallèles au premier axe central (A1), et chacun d'eux ayant un diamètre qui est égal à la moitié d'un petit diamètre de la section efficace ovale du corps ; et

une paire de deuxièmes moyens de rotation (21a) pour mettre en rotation la paire de têtes de coupe rotatives autour des deuxièmes axes centraux (42), respectivement.

4. Machine à bouclier (SM) selon la revendication 3, caractérisée en ce qu'elle comporte en outre :

des premiers moyens de détection d'angle de rotation (32) pour détecter un angle de rotation de l'élément de plaque circulaire (17) mis en rotation à partir d'une position de référence ;

une paire de moyens de détection de longueur déployée (44) pour détecter des longueurs déployées de la paire de bras extensibles (41) déployés depuis une position rétractée, respectivement ; et

des moyens de commande de perçage (30A) pour, sur la base des sorties des premiers moyens de détection d'angle de rotation (32) et des moyens de détection de longueur déployée (44), commander les premiers moyens de rotation (18) et les moyens d'entraînement (42) de sorte que la paire de têtes de coupe rotatives (4) percent le tunnel ayant la section efficace ovale.

5. Machine à bouclier (SM) comportant : un corps principal de machine à bouclier (3B) incluant un corps (1) et une paroi de séparation (2) définissant une extrémité arrière d'une chambre (9) dans une partie

d'extrémité avant (1A) du corps ; et une pluralité de connecteurs de bouclier (6) pour amener le corps principal de machine à bouclier (3) à percer vers l'avant, la machine à bouclier (SM) étant conçue pour percer un tunnel ayant une section efficace ovale, caractérisée en ce que :

le corps (1) est construit de manière à avoir une section efficace ovale similaire à la section efficace du tunnel, et en ce que la machine à bouclier (SM) comporte en outre :

un élément de plaque circulaire (17B) lequel est monté sur une partie latérale d'extrémité avant du corps principal de machine à bouclier (3) de manière à tourner autour d'un premier axe central (A1) qui est un centre du corps principal de machine à bouclier (3) et constitue une partie de la paroi de séparation (2) ;

des premiers moyens de rotation (18) pour mettre en rotation l'élément de plaque circulaire (17B) ;

une paire d'éléments de guidage (50a, 50b) lesquels sont montés sur une partie en saillie (17b) de manière à être sensiblement symétriques par rapport au premier axe central (41), la partie en saillie (17b) faisant saillie à l'avant d'une partie de la paroi de séparation (2) autre que l'élément de plaque circulaire (17B) et agencé par l'élément de plaque circulaire, et une paire de bras extensibles (51a, 51b) lesquels sont montés par coulissement sur la paire d'éléments de guidage (50a, 50b), respectivement, de sorte que les longueurs déployées des bras extensibles (51a, 51b) sont symétriques par rapport au premier axe central (A1) ;

des moyens ou une paire de moyens d'entraînement (52) pour amener la paire de bras extensibles (51a, 51b) à se déployer et à se rétracter ;

une paire d'éléments de support de tête (53) lesquels sont fermement fixés à une paire de parties d'extrémité (53a) de la paire de bras extensibles (51a, 51b), respectivement ;

une paire de têtes de coupe rotatives (4) lesquelles sont montées sur la paire d'éléments de support de tête (53), respectivement, de manière à tourner autour des deuxièmes axes centraux (A2), respectivement, lesquels sont parallèles au premier axe central (A1), et chacun d'eux ayant un diamètre qui est égal à la moitié d'un petit diamètre de la section efficace ovale du corps (3B) ; et

une paire de deuxièmes moyens de rotation

(21B) pour mettre en rotation la paire de têtes de coupe rotatives (4) autour des deuxièmes axes centraux (A2), respectivement.

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6. Machine à bouclier (SM) selon la revendication 5, caractérisée en ce qu'elle comporte en outre :

des premiers moyens de détection d'angle de rotation (32) pour détecter un angle de rotation de l'élément de plaque circulaire (17B) mis en rotation à partir d'une position de référence, des moyens de détection de longueur déployée (54a, 54b) pour détecter des longueurs déployées des bras extensibles (51a, 51b) déployés à partir de la position la plus rétractée ; et des moyens de commande de perçage (30B) pour, sur la base des sorties des premiers moyens de détection d'angle de rotation (32) et des moyens de détection de longueur déployée (54a, 54b), commander les premiers moyens de rotation (18) et les moyens d'entraînement (52) de sorte que la paire de têtes de coupe rotatives (4) percent le tunnel ayant la section efficace ovale.

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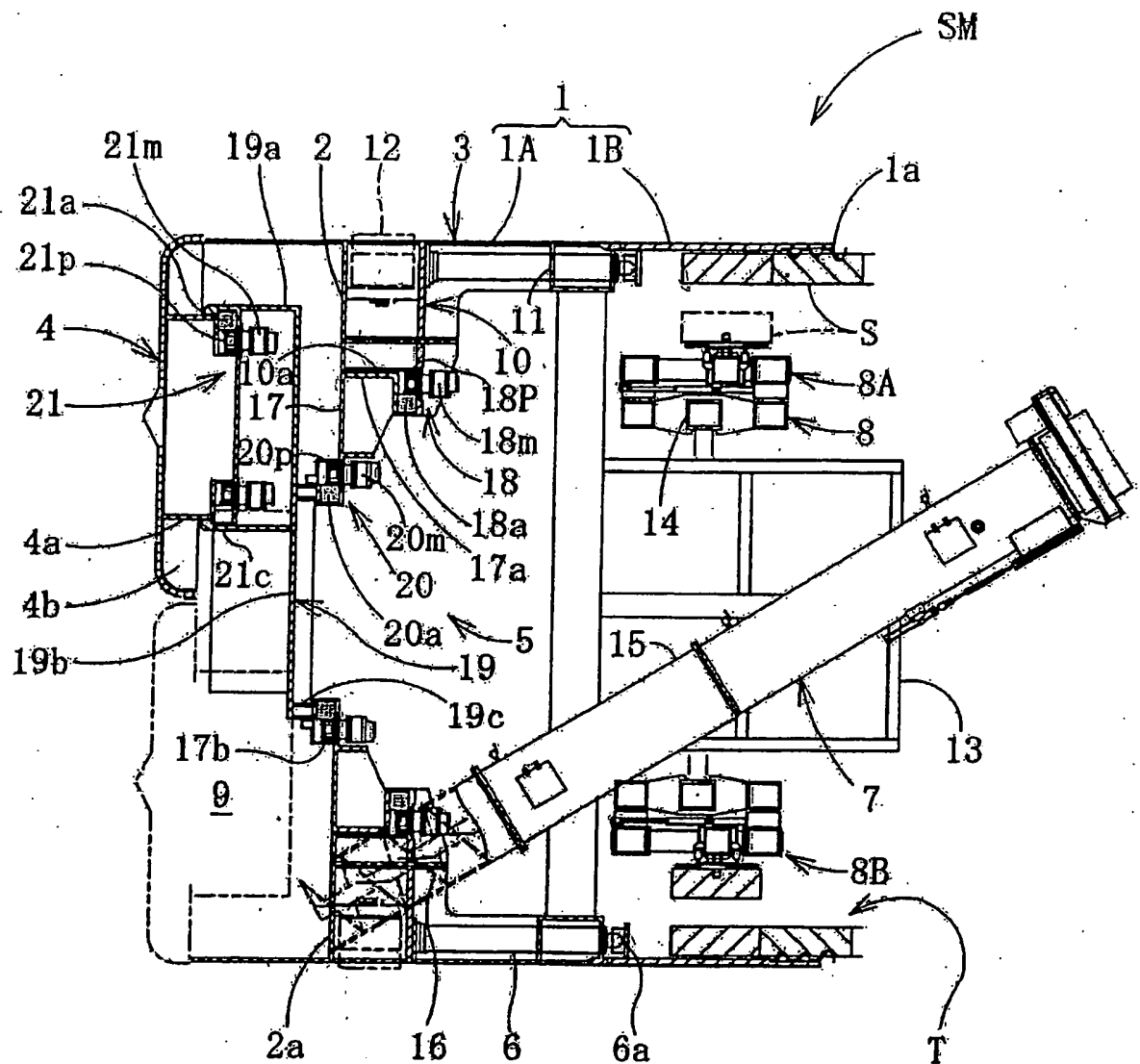


Fig. 1

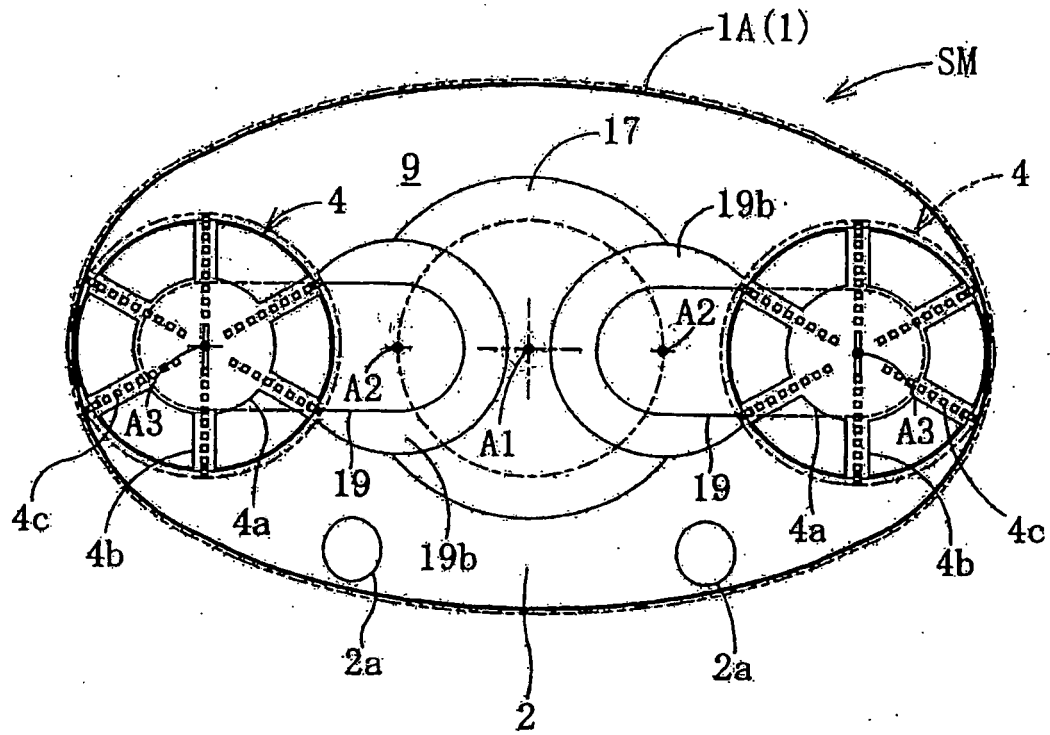


Fig. 2

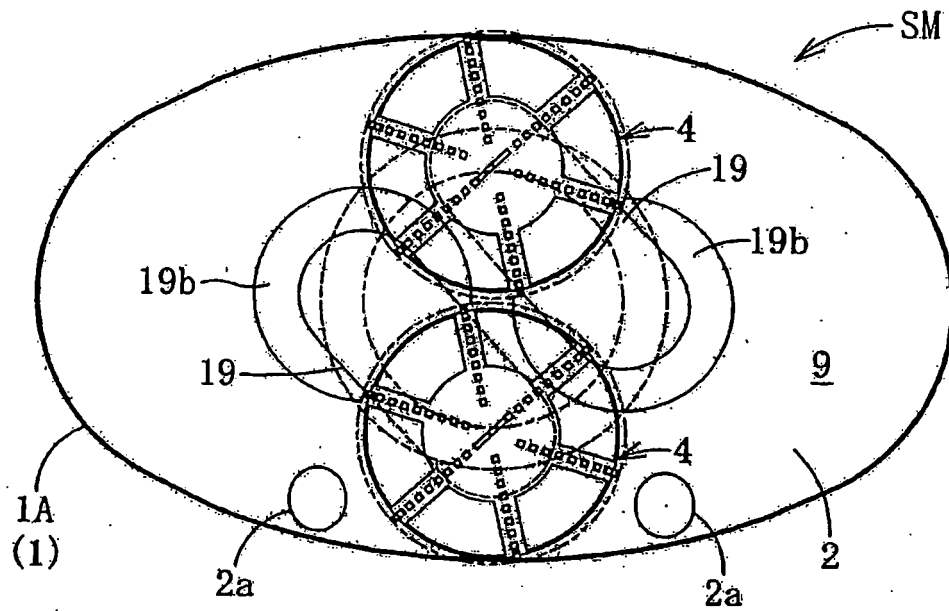


Fig. 3

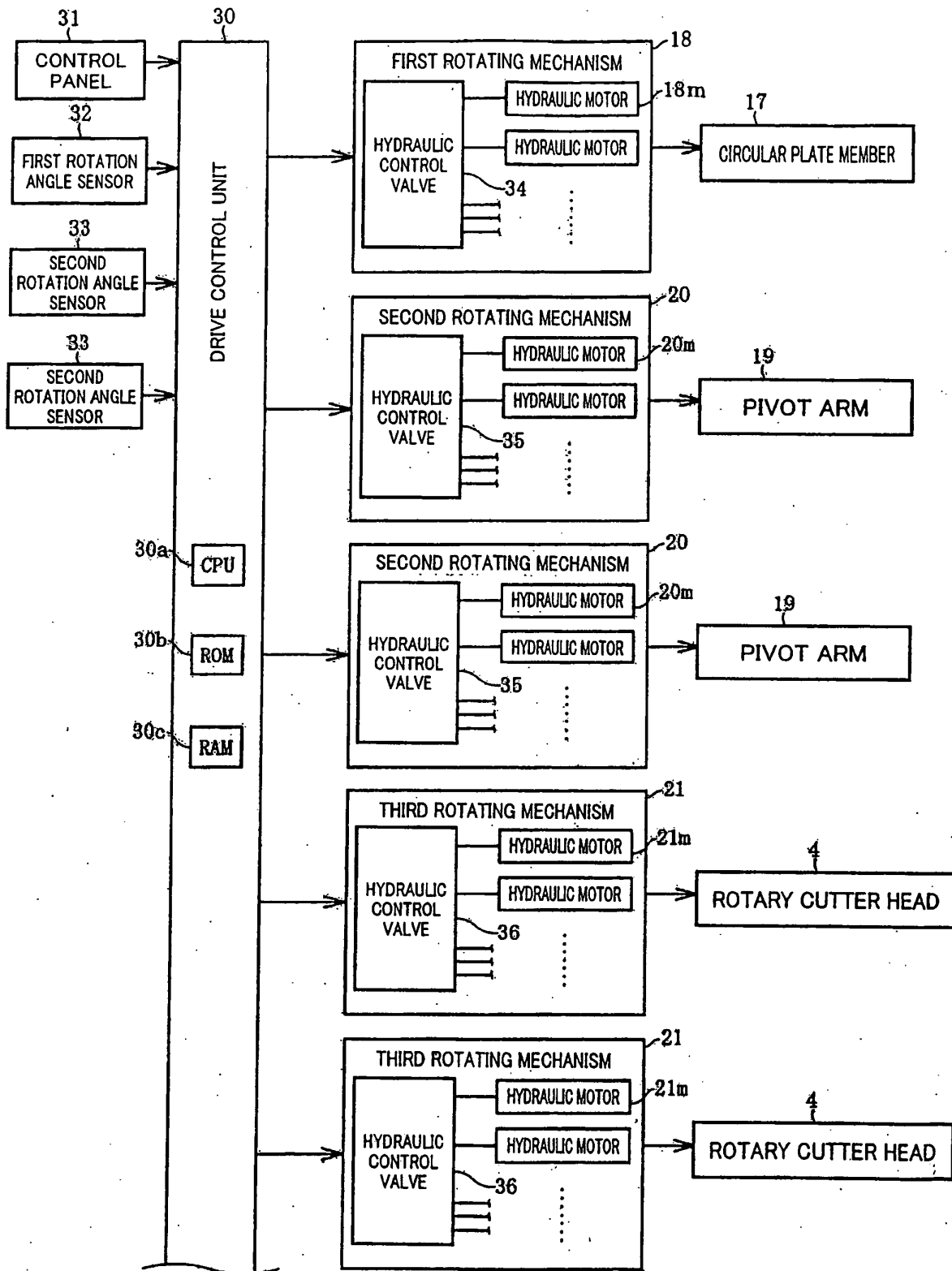


Fig. 4

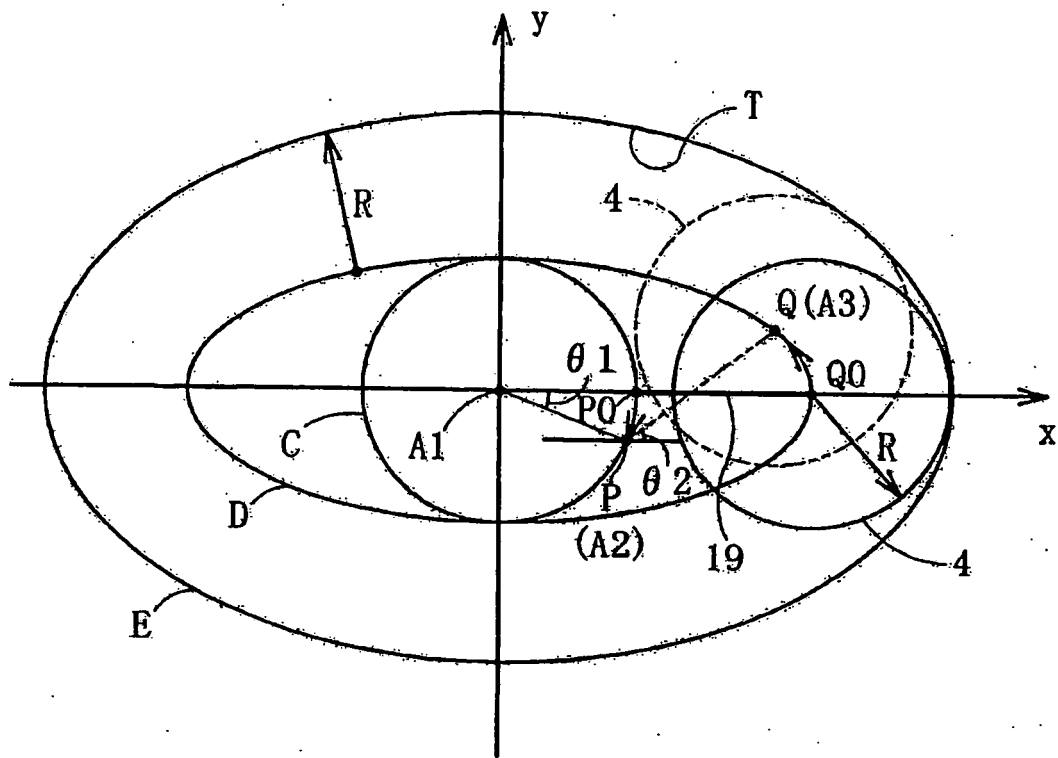


Fig. 5

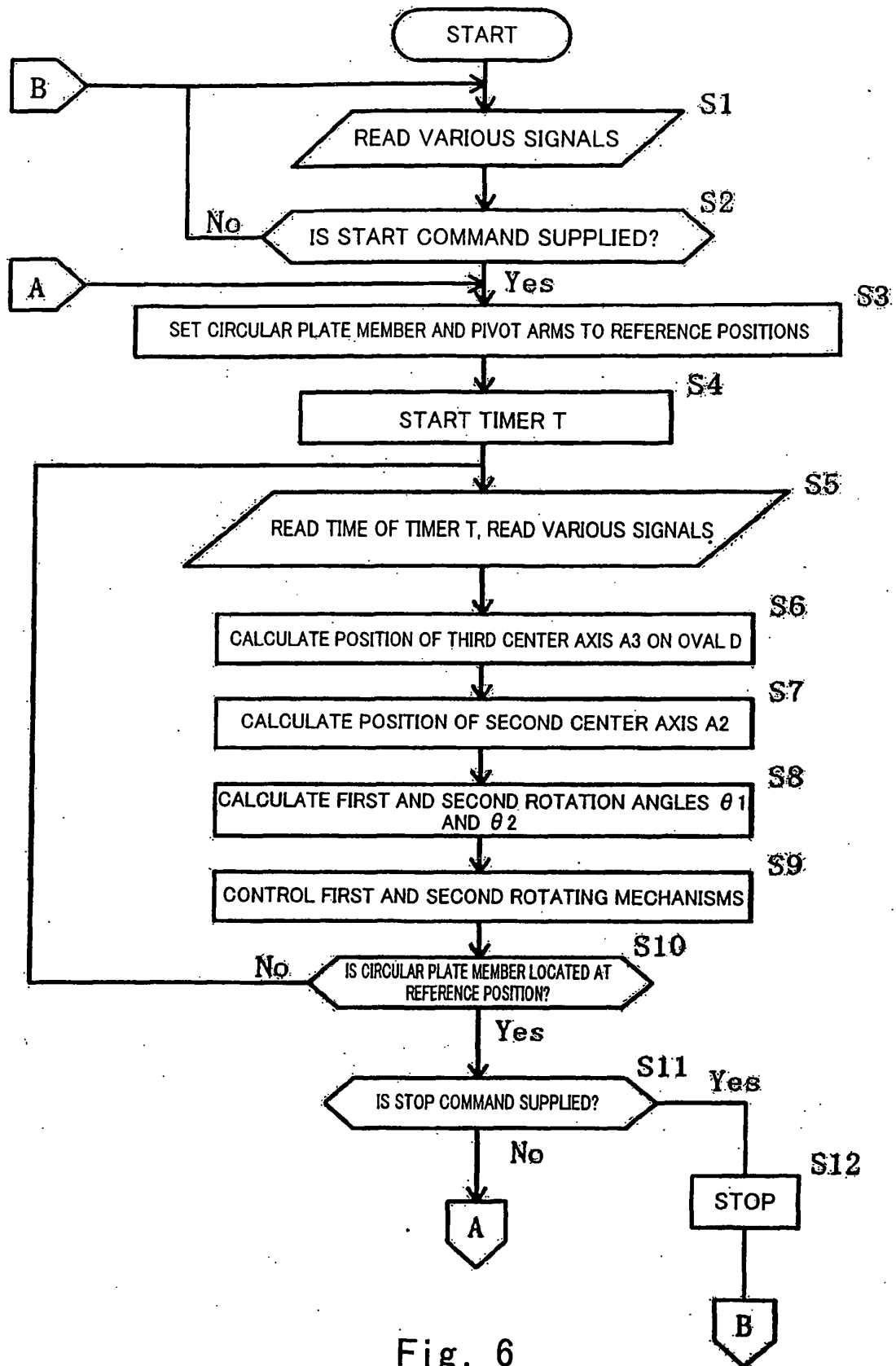


Fig. 6

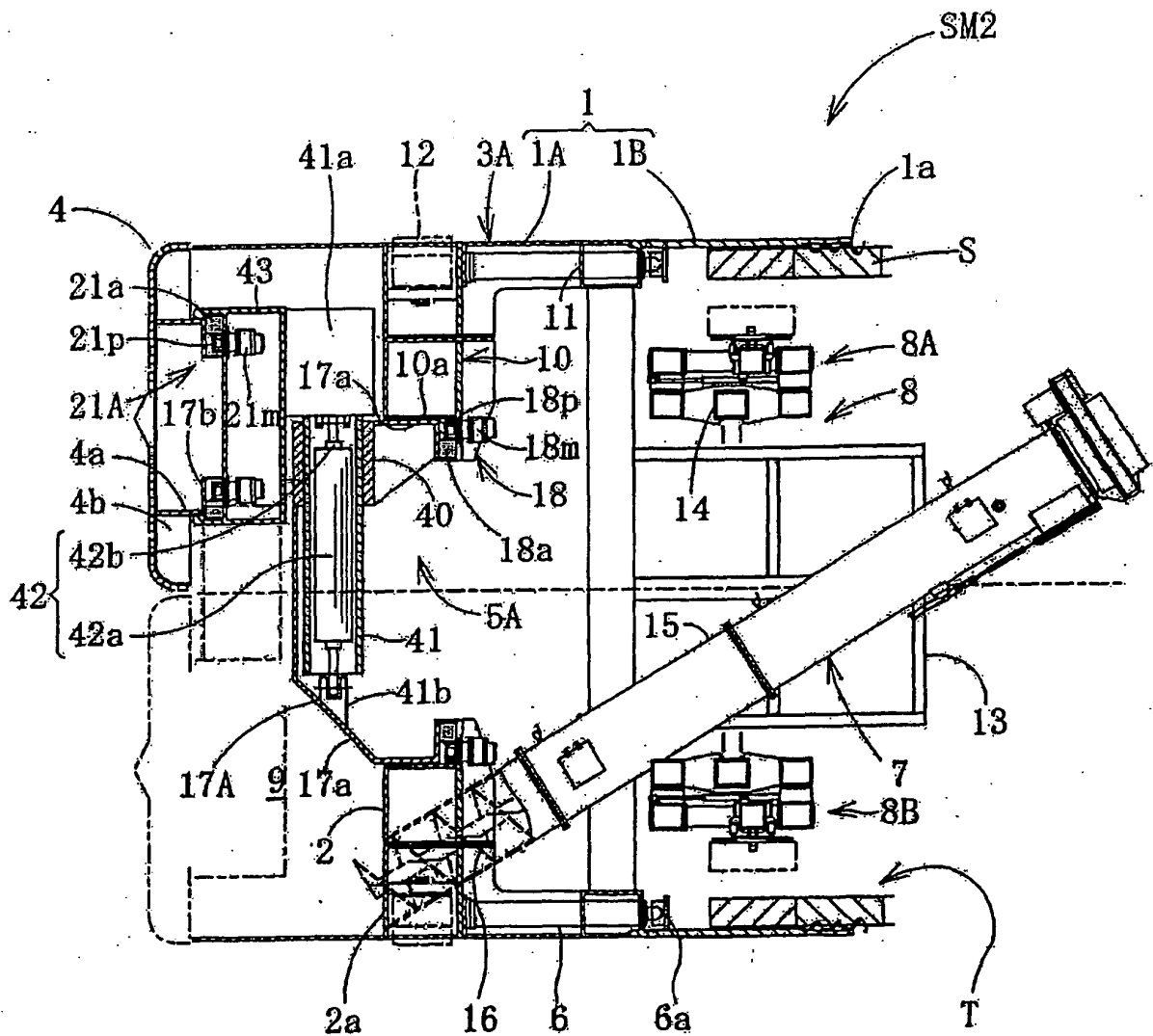


Fig. 7

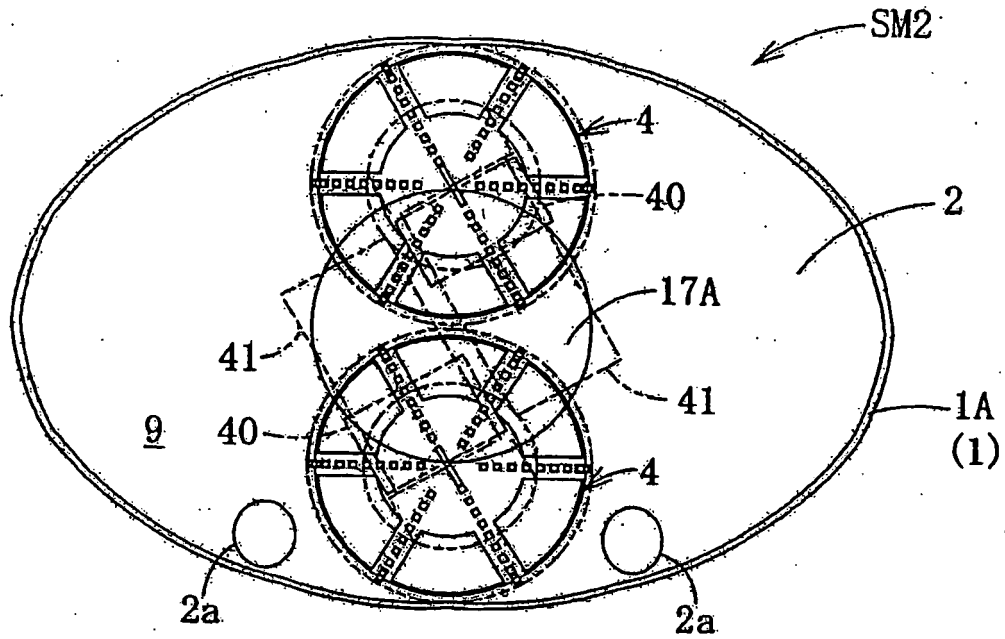


Fig. 8

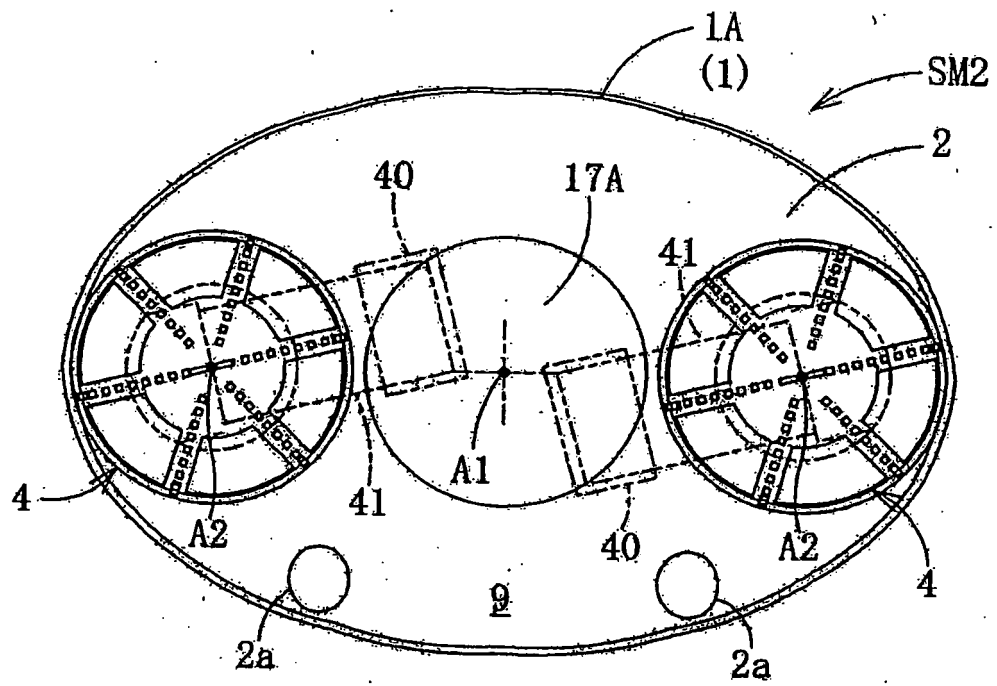


Fig. 9

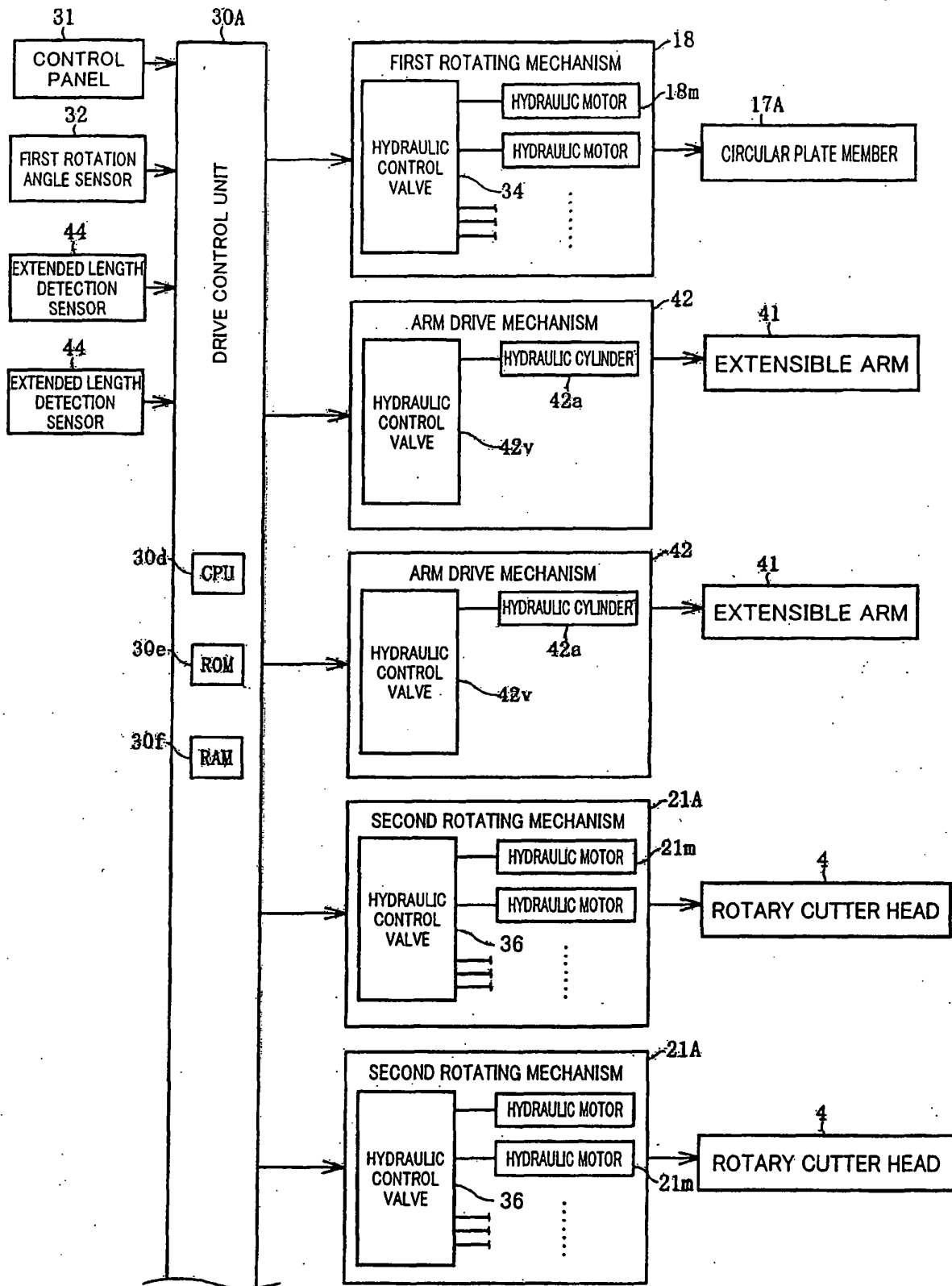


Fig. 10

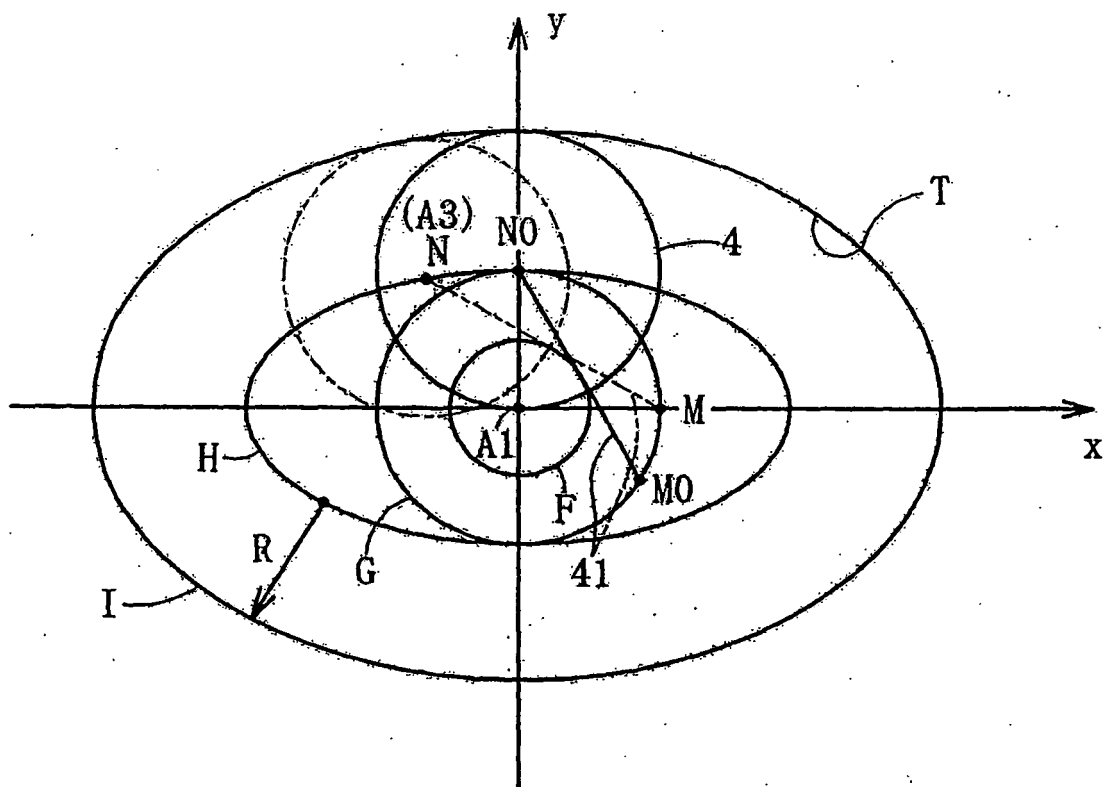


Fig. 11

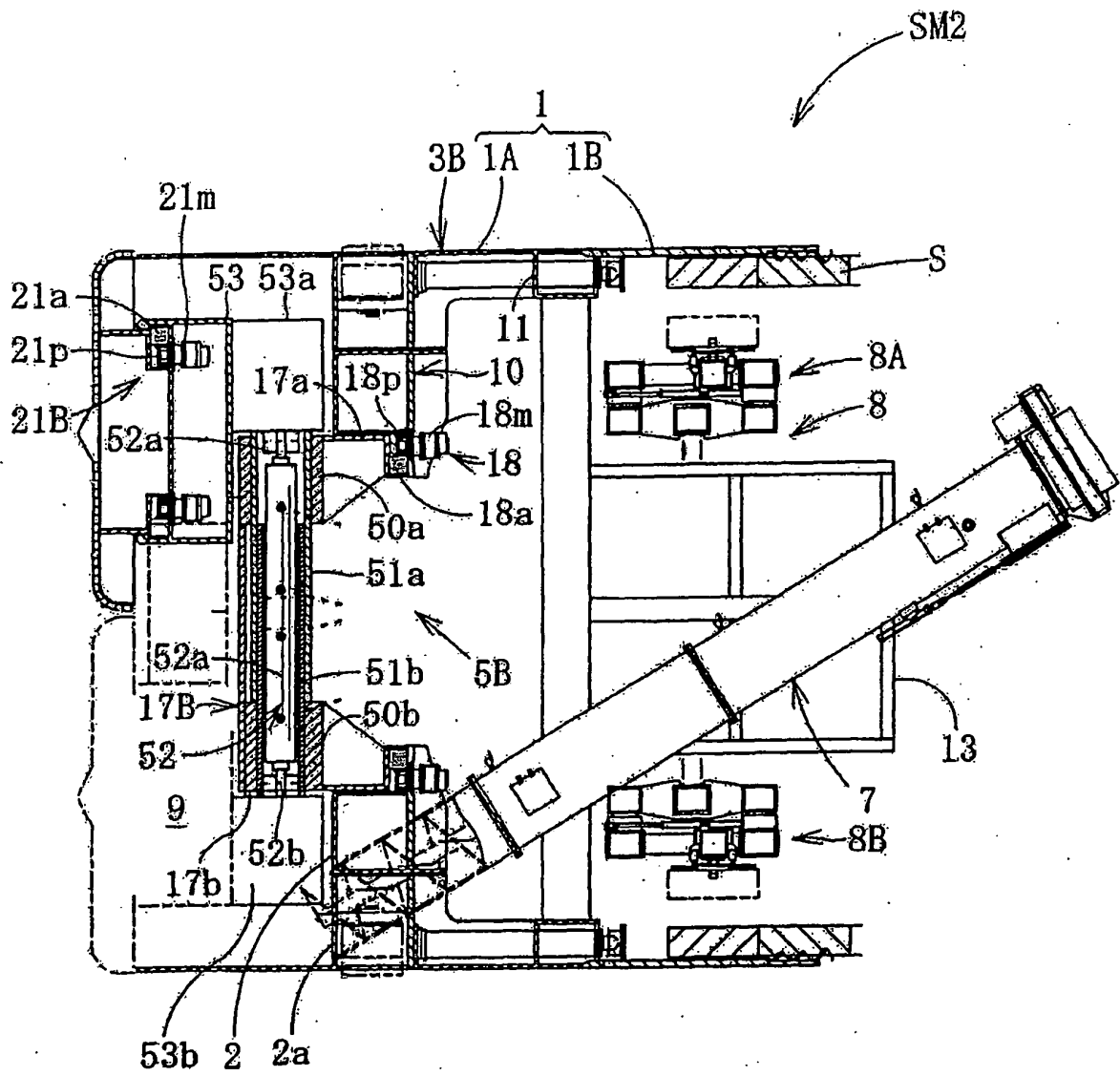


Fig. 12

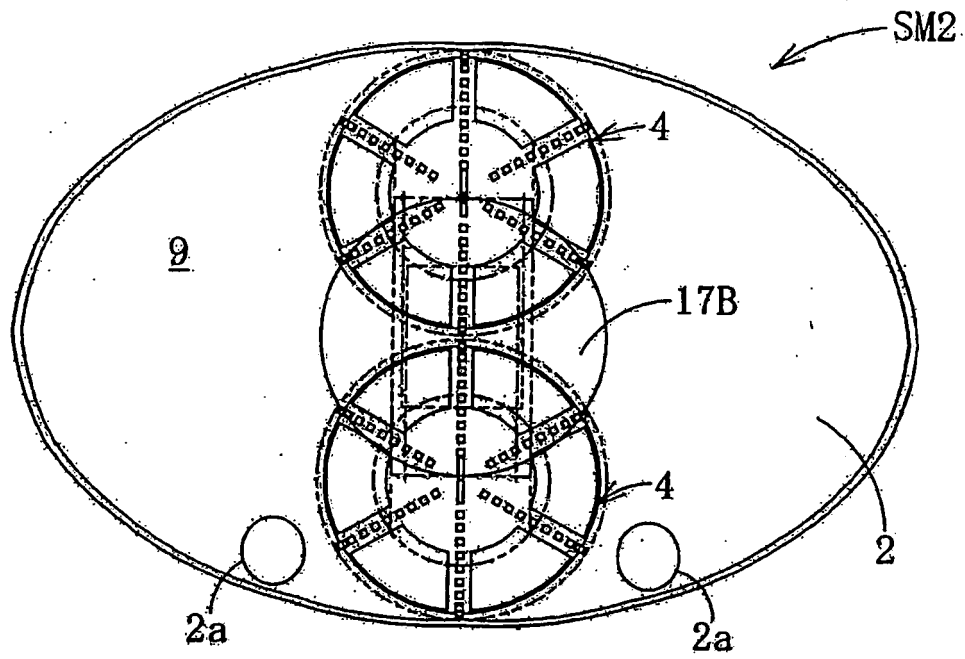


Fig. 13

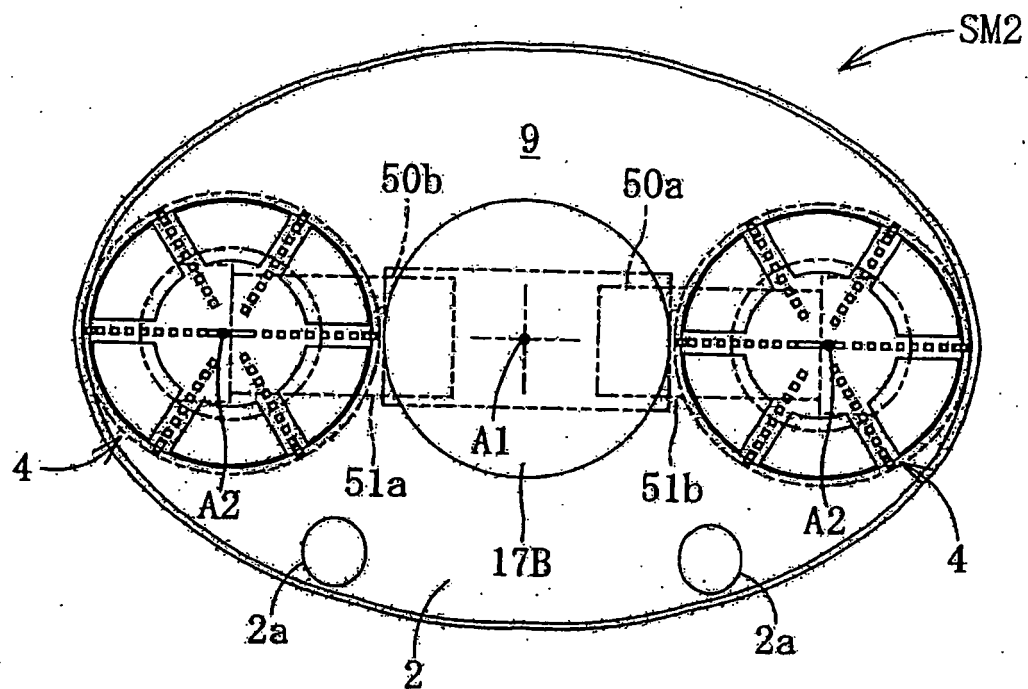


Fig. 14

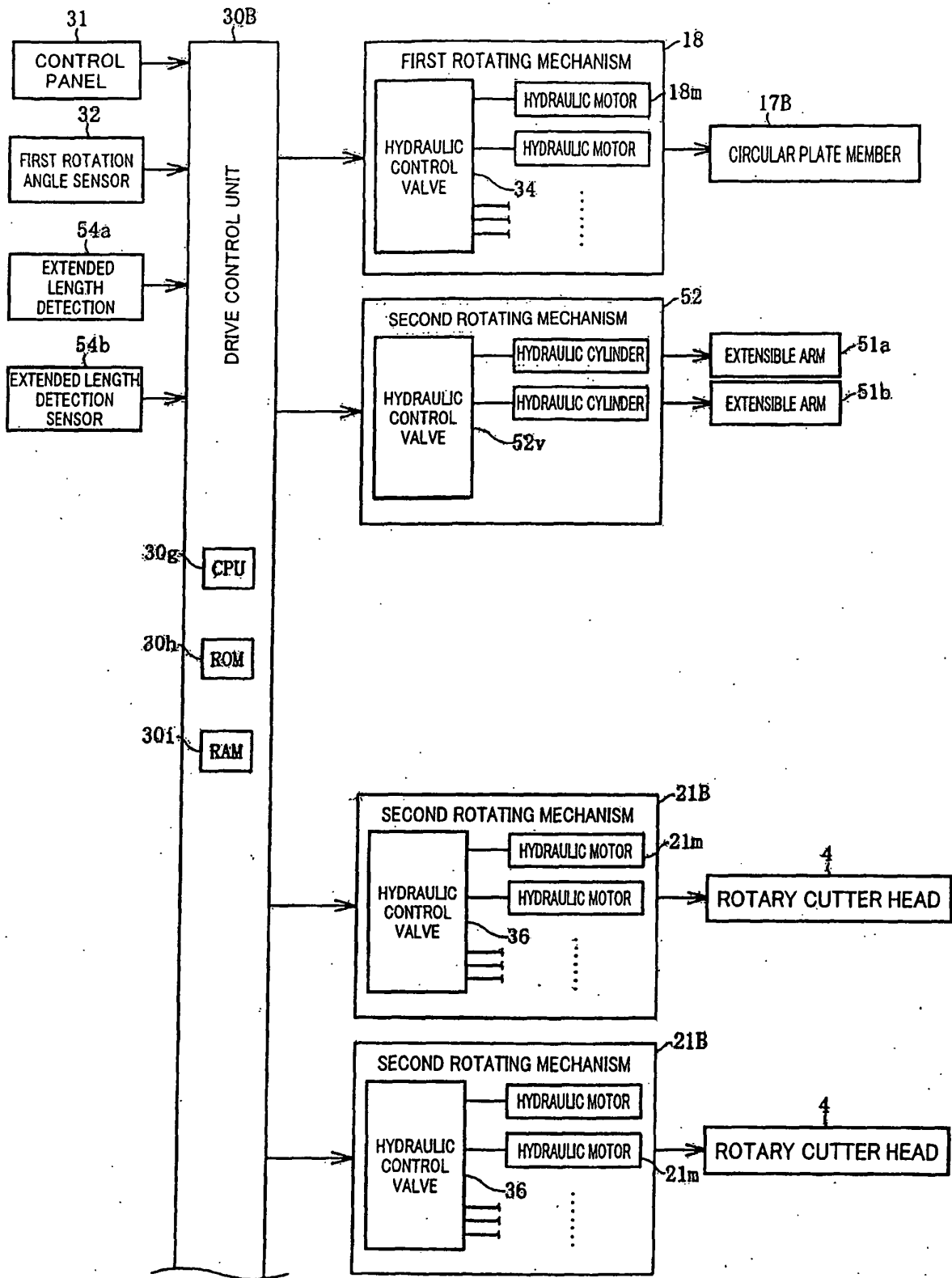


Fig. 15

REFERENCES CITED IN THE DESCRIPTION

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