

DESCRIPTION

TITLE OF THE INVENTION

FLAP GATE

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FIELD

[0001] The technique disclosed here relates to a flap gate.

BACKGROUND

10 [0002] A flap gate including: a door body that rotates between a lying state where the door body lies in water and a raised state where the door body is raised from the water; and a mooring that moors the door body in the lying state is known to date. The mooring includes a hook that is engaged with the door body. The hook is driven by an actuator. A driving force of the actuator is transferred from the actuator to the hook via a transfer. The actuator is located
15 above the water. The transfer is located from the actuator above the water to the hook in the water.

CITATION LIST

PATENT DOCUMENT

20 [0003] Patent Document 1: Japanese Patent Application Publication No. 2011-111722

SUMMARY

TECHNICAL PROBLEM

[0004] In the flap gate as described above, if the distance from the actuator to the hook is
25 long, the transfer is arranged along the long distance so that a transfer efficiency of the driving

force decreases. It is therefore difficult to place the hook at a location away from the actuator. Consequently, the size of the door body, arrangement of the door body, the number of door bodies in the case of using multiple door bodies, and other characteristics may also be restricted.

[0005] It is therefore an object of the technique disclosed here to reduce influence of the distance between a hook and an actuator on the configuration of a flap gate.

SOLUTION TO PROBLEMS

[0006] A flap gate disclosed here includes: a door body that rotates about a predetermined rotation axis between a lying state where the door body lies in water and a raised state where the door body is raised from the water; a mooring that moors the door body in the lying state; an air chamber located in the water and airtightly partitioned; and a connecting chamber adjacent to the air chamber with a partition interposed therebetween, the connecting chamber including a lower portion that is open in the water and an upper portion including an air pocket, wherein the mooring includes a hook that switches between an engaged state where the hook is engaged with the door body in the lying state and a disengaged state where the hook is disengaged from the door body, an actuator that generates a driving force, and a transfer that transfers the driving force of the actuator to the hook, the hook is located in the water, the actuator is located in the air chamber, and the transfer penetrates the partition from the air chamber to reach the hook through the air pocket.

ADVANTAGES OF INVENTION

[0007] The flap gate can reduce influence of the distance between the hook and the actuator on the configuration of the flap gate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] [FIG. 1] FIG. 1 is a schematic view of a port in which a flap gate is located.

[FIG. 2] FIG. 2 is a schematic cross-sectional view of the flap gate in a lying state.

[FIG. 3] FIG. 3 is a side view illustrating a schematic configuration of a mooring.

[FIG. 4] FIG. 4 is a plan view illustrating a schematic configuration of the mooring.

[FIG. 5] FIG. 5 is a longitudinal cross-sectional view of a shaft in a through hole.

[FIG. 6] FIG. 6 is a side view illustrating a schematic configuration of the mooring
5 in which a door body is disengaged.

[FIG. 7] FIG. 7 is a side view illustrating a schematic configuration of the mooring
in the middle of mooring of the door body.

[FIG. 8] FIG. 8 is a side view illustrating a schematic configuration of a mooring
according to a variation.

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DESCRIPTION OF EMBODIMENTS

[0009] An exemplary embodiment will be described in detail hereinafter with reference to the drawings. FIG. 1 is a schematic view of a port in which a flap gate 100 is located. FIG. 2 is a schematic cross-sectional view of the flap gate 100 in a lying state.

15 [0010] The flap gate 100 is a facility that blocks water. For example, the flap gate 100 is located in the ocean, more specifically in a harbor port, as a countermeasure against tsunami and storm surges. For example, the flap gate 100 is located in an opening 91 in an embankment 9. The flap gate 100 constitutes a breakwater together with the embankment 9.

[0011] As illustrated in FIG. 2, the flap gate 100 includes a door body 10 that rotates about
20 a predetermined rotation axis X between a lying state where the door body 10 lies in water and a raised state where the door body 10 is raised from the water, a mooring 1 that moors the door body 10 in the lying state, and a housing chamber 7 that houses the mooring 1.

[0012] The door body 10 has a plate shape expanding in a plane defined by a lateral direction that coincides with a direction of the rotation axis X and a longitudinal direction orthogonal to
25 the lateral direction. Specifically, the door body 10 has a substantially quadrangular plate

shape. The rotation axis X is located in a portion of the door body 10 corresponding to one side of a rectangle. In this example, as illustrated in FIG. 1, the flap gate 100 includes four door bodies 10. The four door bodies 10 are arranged such that the rotation axes X thereof are aligned in a straight line. The four door bodies 10 are located in the opening 91. The door
5 bodies 10 in the lying state are submerged in the water. The door bodies 10 in the raised state partially project above the water surface and close the opening 91. An air chamber (not shown) is defined inside the door bodies 10. Each door body 10 rotates from the lying state to the raised state by buoyancy received by the door body 10.

[0013] As illustrated in FIG. 2, the flap gate 100 includes a box body 8 including a storage
10 space 81 that stores the door bodies 10 in the lying state. The box body 8 is located in the water. The box body 8 has a box shape that is open upward. The internal space of the box body 8 serves as the storage space 81. The storage space 81 has a substantially rectangular planar shape that is slightly larger than the door body 10 in size. In this example, the four door bodies 10 share one common storage space 81.

15 [0014] An engager 13 is located at the edge of each door body 10 on the side opposite to the rotation axis X. A hook 2 of the mooring 1 described later is engaged with the engager 13 so that the door body 10 is thereby moored in the lying state.

[0015] FIG. 3 is a side view illustrating a schematic configuration of the mooring 1. FIG.
4 is a plan view illustrating a schematic configuration of the mooring 1. FIG. 5 is a
20 longitudinal cross-sectional view of a shaft 41 in a through hole 72. In FIG. 4, the door bodies 10 are not shown. The housing chamber 7 includes an air chamber 70 that houses a portion of the moorings 1, and a connecting chamber 73 that houses another portion of the moorings 1. The air chamber 70 and the connecting chamber 73 are located in the box body 8. Specifically, the air chamber 70 and the connecting chamber 73 are located on the inner side of one side wall
25 of the box body 8, The air chamber 70 and the connecting chamber 73 are located at a position

aligned with the door bodies 10 in the lying state in the longitudinal direction and a position facing the edges of the door bodies 10 on the side opposite to the rotation axis X.

[0016] The air chamber 70 is located in the water and airtightly partitioned. In the water, the air chamber 70 is located adjacent to the door bodies 10 in the lying state. Specifically, 5 the air chamber 70 is aligned with the door bodies 10 in the lying state and the longitudinal direction of the door bodies 10. The air chamber 70 is airtightly partitioned.

[0017] The air pressure of the air chamber 70 is controlled to a predetermined target pressure. The target pressure is a pressure higher than the atmospheric pressure, and is, for example, a pressure corresponding to the water depth of the air chamber 70. The water depth of the air 10 chamber 70 is set with reference to a standard water level of the water area in which the mooring 1 is located. Although not shown, the air chamber 70 is connected to an air supply source via an air pipe. The air pipe includes a pressure reducing valve. The air of the air supply source is supplied to the air chamber 70 with the pressure of the air supply source adjusted by the pressure reducing valve.

15 [0018] A buffer chamber 77 is located adjacent to the air chamber 70. A first hatch 78 is located between the air chamber 70 and the buffer chamber 77. In a case where the first hatch 78 is open, the air chamber 70 and the buffer chamber 77 communicate with each other. In a case where the first hatch 78 is closed, the air chamber 70 and the buffer chamber 77 are airtightly blocked from each other. The buffer chamber 77 also includes a second hatch 79.

20 In a case where the second hatch 79 is open, the buffer chamber 77 and the external space of the buffer chamber 77 communicate with each other. In a case where the second hatch 79 is closed, the buffer chamber 77 and the external space are airtightly blocked from each other.

[0019] The connecting chamber 73 is located adjacent to the air chamber 70 with a partition 71 interposed therebetween. The connecting chamber 73 is located adjacent to the air chamber 25 70 in the water. A wall partitioning the air chamber 70 is the partition 71 that separates the

air chamber 70 from the connecting chamber 73. In relation to each door body 10, the connecting chamber 73 is located adjacent to the door body 10 in the lying state. Specifically, the connecting chamber 73 is aligned with the door body 10 in the lying state in the longitudinal direction of the door body 10. The connecting chamber 73 includes a lower portion that is open in the water and an upper portion including an air pocket 74. That is, the lower portion of the connecting chamber 73 is water-sealed, and the air pocket 74 is present in the upper portion of the connecting chamber 73.

[0020] An air pressure of the air pocket 74 is controlled to a predetermined target pressure. The target pressure is a pressure higher than the atmospheric pressure, and is, for example, a pressure substantially equal to the pressure in the air chamber 70. Specifically, a first air pipe 75 is connected to the air pocket 74. The first air pipe 75 communicates with the air chamber 70 via a check valve 75b. The first air pipe 75 includes a electric actuator valve 75a. When the electric actuator valve 75a is opened, air is supplied from the air chamber 70 to the air pocket 74 in accordance with a differential pressure between the air chamber 70 and the air pocket 74. Specifically, in a case where the pressure of the air pocket 74 is lower than the pressure of the air chamber 70, air is supplied from the air chamber 70 to the air pocket 74 so that the pressure of the air pocket 74 becomes substantially equal to the pressure of the air chamber 70. For example, the target pressure of the air chamber 70 is set at a pressure corresponding to the standard water level of the water area in which the moorings 1 are located. With regard to the water level of the connecting chamber 73, the standard water level of the connecting chamber 73 is set to correspond to the standard water level of the water area in which the moorings 1 are located. The standard water level of the connecting chamber 73 is higher than an opening end of a lower portion of the connecting chamber 73 (i.e., the lower end of a side wall partitioning the connecting chamber 73 such that the connecting chamber 73 is open at the bottom) by a predetermined water level difference (hereinafter referred to as a “standard water level

difference”). If the water level of the water area where the mooring 1 is located is greater than or equal to a water level obtained by subtracting the standard water level difference of the connecting chamber 73 from the standard water level of this water area, the electric actuator valve 75a is opened. On the other hand, if the water level of the water level where the mooring 1 is located is less than the water level obtained by subtracting the standard water level difference of the connecting chamber 73 from the standard water level of this water area, the electric actuator valve 75a is closed. If the water level of the water area where the mooring 1 is located is the standard water level, the pressure of the air pocket 74 is a pressure corresponding to the water depth from the standard water level, in general. However, in a case where the air in the air pocket 74 has been reduced by leakage of the air from the air pocket 74 to the air chamber 70 due to fluctuations of the water level or other reasons, the water level in the connecting chamber 73 might rise so that the pressure of the air pocket 74 is not the pressure corresponding to the water depth from the standard water level. In such a case, since the electric actuator valve 75a is open, the air may be supplied from the air chamber 70 to the air pocket 74 via the check valve 75b.

[0021] The second air pipe 76 may be connected to the air chamber 70. The second air pipe 76 communicates with the air chamber 70. The second air pipe 76 includes a manual valve 76a. The manual valve 76a is manually operated by a user. When the manual valve 76a is opened, the air chamber 70 and the air pocket 74 thereby come to communicate with each other. In a case where the pressure of the air pocket 74 is lower than the pressure of the air chamber 70, air is supplied from the air chamber 70 to the air pocket 74 so that the pressure of the air pocket 74 becomes substantially equal to the pressure of the air chamber 70. When the manual valve 76a is closed, the second air pipe 76 is blocked.

[0022] The flap gate 100 includes moorings 1 in the same number as the number of the door bodies 10. In this example, the flap gate 100 includes four moorings 1. That is, one mooring

1 is used for one door body 10. The mooring 1 includes the hooks 2, an actuator 3 that generates a driving force, and a transfer 4 that transfers the driving force of the actuator 3 to the hooks 2. In this example, the mooring 1 includes two hooks 2. The mooring 1 is aligned with the door body 10 in the lying state in the longitudinal direction.

5 [0023] Each of the hooks 2 switches between an engaged state where the hook 2 is engaged with the door body 10 in the lying state and a disengaged state where the hook 2 is disengaged from the door body 10. The hooks 2 are located near the door body 10. Specifically, the hooks 2 are located in the water and near the engager 13 of the door body 10 in the lying state. The hooks 2 are located outside the air chamber 70 and the connecting chamber 73.

10 [0024] The hooks 2 are non-rotatably attached to the shaft 21. The shaft 21 is supported to be rotatable about a rotation axis A. The rotation axis A is substantially parallel to the rotation axis X. Each hook 2 extends from the shaft 21 in a radial direction of the rotation axis A. The shaft 21 is located in the water. The hook 2 is located above the engager 13 of the door body 10 in the lying state in a predetermined rotation position about the rotation axis A. In
15 this state, the hook 2 is engaged with the engager 13. This position will be referred to as an “engaged position.” A state where the hook 2 is engaged with the engager 13 will be referred to as an “engaged state.”

[0025] The shaft 21 includes a counter weight 23 that rotates the hook 2 in a circumferential direction about the rotation axis A. Specifically, the shaft 21 includes a first arm 21a and a
20 second arm 21b extending in the radial direction of the rotation axis A. The second arm 21b is located at a position different from the hook 2 by approximately 180 degrees about the rotation axis A. The counter weight 23 is suspended from the second arm 21b. The counter weight 23 generates a moment that rotates the hook 2 upward from the engaged position. The transfer 4 is coupled to the first arm 21a, which will be described later in detail.

25 [0026] The actuator 3 includes a hydraulic cylinder 31 and a sensor 35 that detects a stroke

amount of the hydraulic cylinder 31. The hydraulic cylinder 31 includes a cylinder tube 32 and a piston rod 33 that advances and retracts with respect to the cylinder tube 32. A hydraulic circuit is connected to the hydraulic cylinder 31 so that oil is supplied and discharged to/from the hydraulic cylinder 31 via the hydraulic circuit. The sensor 35 is a so-called stroke sensor and detects displacement of the piston rod 33 from the cylinder tube 32. For example, the sensor 35 is a magnetostrictive stroke sensor.

[0027] The actuator 3 (i.e., the hydraulic cylinder 31 and the sensor 35) is located in the air chamber 70. The cylinder tube 32 is supported to be rotatable about a rotation axis B. In this example, the hydraulic cylinder 31 is oriented such that the piston rod 33 projects downward from the cylinder tube 32.

[0028] The transfer 4 penetrates the partition 71 from the air chamber 70 and reaches the hook 2 through the air pocket 74. The transfer 4 includes the shaft 41 that is rotationally driven about a center axis C by the actuator 3. The shaft 41 passes through the partition 71 in the direction of the center axis C and extends in inner spaces of both the air chamber 70 and the air pocket 74. As illustrated in FIG. 5, the partition 71 has the through hole 72 through which the shaft 41 penetrates and which penetrates the partition 71 in the direction of the thickness of the partition 71. The center axis C extends in the direction of the rotation axis X of the door body. That is, the center axis C is substantially parallel to the rotation axis X.

[0029] The shaft 41 is supported by bearings 42 to be rotatable about the center axis C. In this example, the shaft 41 is supported by two bearings 42. One of the bearings 42 is located in the partition 71. The other bearings 42 is located in a side wall 710 included in side walls partitioning the connecting chamber 73 and facing the partition 71.

[0030] The shaft 41 is sealed to be rotatable in the through hole 72 of the partition 71. Specifically, as illustrated in FIG. 5, the partition 71 includes a rotation seal 43 that contacts the outer peripheral surface of the shaft 41. The rotation seal 43 is located at a side of the

connecting chamber 73 with respect to the bearings 42 in the partition 71. The shaft 41 is slidable with respect to the rotation seal 43.

[0031] This example additionally uses two rotation seals 43. Specifically, the rotation seals 43 are located at a side of the air chamber 70 with respect to the bearings 42 in the partition 71.

5 The rotation seal 43 is located at a side of the connecting chamber 73 with respect to the bearings 42 in the side wall 710.

[0032] The transfer 4 further includes a first transfer 5 coupling the actuator 3 and the shaft 41 to each other, and a second transfer 6 coupling the shaft 41 and the hook 2 to each other.

[0033] The first transfer 5 is located in the air chamber 70. The first transfer 5 includes a
10 lever 51 coupled to the actuator 3 and a first link rod 52 coupled to the lever 51. The lever 51 includes a first end portion 51a that is one end portion in the longitudinal direction and a second end portion 51b that is the other end portion in the longitudinal direction. The first link rod 52 includes a first end portion 52a that is one end portion in the longitudinal direction and a second end portion 52b that is the other end portion in the longitudinal direction.

15 [0034] The lever 51 is supported at the first end portion 51a to be rotatable about a rotation axis E in the air chamber 70. The first link rod 52 is coupled to the second end portion 51b of the lever 51 via a spring cylinder 53. Specifically, the second end portion 51b is coupled to a cylinder tube 53a of the spring cylinder 53 to be rotatable about a rotation axis F. The first end portion 52a of the first link rod 52 is coupled to a piston rod 53b of the spring cylinder 53.

20 [0035] The lever 51 is located below the rotation axis B. The actuator 3 is coupled to a portion of the lever 51 between the first end portion 51a and the second end portion 51b (hereinafter referred to as an “intermediate portion”). Specifically, a distal end of the piston rod 33 of the hydraulic cylinder 31 is coupled to the intermediate portion of the lever 51 to be rotatable about a rotation axis D.

25 [0036] The second end portion 52b of the first link rod 52 is coupled to the shaft 41.

Specifically, the shaft 41 includes a first arm 41a extending in the radial direction of the center axis C. The first arm 41a is located in the air chamber 70. The second end portion 52b is coupled to the first arm 41a to be rotatable about a rotation axis G.

[0037] The second transfer 6 is located in the connecting chamber 73 and in the water. The second transfer 6 includes links coupling the shaft 41 and the hook 2. Specifically, the second transfer 6 includes a second link rod 61 coupled to the shaft 41, a third link rod 63 coupled to the shaft 21 of the hook 2, and a rotation link 62 coupled to both the second link rod 61 and the third link rod 63. The second link rod 61 includes a first end portion 61a that is one end portion in the longitudinal direction and a second end portion 61b that is the other end portion in the longitudinal direction. The third link rod 63 includes a first end portion 63a that is one end portion in the longitudinal direction and a second end portion 63b that is the other end portion in the longitudinal direction. The second link rod 61, the rotation link 62, and the third link rod 63 are coupled to one another to be rotatable about an axis extending in the direction of the rotation axis X.

[0038] Specifically, the first end portion 61a of the second link rod 61 is coupled to the shaft 41. Specifically, the shaft 41 includes a second arm 41b extending in the radial direction of the center axis C. The second arm 41b is located in the air pocket 74 of the connecting chamber 73. The first end portion 61a is coupled to the second arm 41b to be rotatable about a rotation axis H.

[0039] The second end portion 61b of the second link rod 61 is coupled to the rotation link 62. Specifically, the rotating link 62 is non-rotatably attached to a shaft 64. The shaft 64 is supported to be rotatable about a rotation axis I. The rotation link 62 and the shaft 64 are located in the water. The rotation link 62 includes a first arm 62a and a second arm 62b extending in the radial direction of the rotation axis I. The second end portion 61b is coupled to the first arm 62a to be rotatable about a rotation axis J. A portion of the second link rod 61

is located in the air chamber 74, and the remaining portion of the second link rod 61 is located in the water.

[0040] The third link rod 63 is located in the water. The first end portion 63a of the third link rod 63 is coupled to the rotation link 62. Specifically, the first end portion 63a is coupled to the second arm 62b to be rotatable about a rotation axis K.

[0041] The second end portion 63b of the third link rod 63 is coupled to the shaft 21. Specifically, the second end portion 63b is coupled to the first arm 21a to be rotatable about a rotation axis L.

[0042] The rotation axis A, the rotation axis B, the center axis C, the rotation axis D, the rotation axis E, the rotation axis F, the rotation axis G, the rotation axis H, the rotation axis I, the rotation axis J, the rotation axis K, and the rotation axis L extend in the direction of the rotation axis X, that is, are substantially parallel to the rotation axis X.

[0043] Next, movement of the mooring 1 will be described. FIG. 6 is a side view illustrating a schematic configuration of the mooring 1 in which the door body 10 is disengaged.

FIG. 7 is a side view illustrating a schematic configuration of the mooring 1 in the middle of mooring of the door body 10. A controller controls the actuator 3. When the actuator 3 operates, a driving force of the actuator 3 is transferred to the hook 2 via the transfer 4 to rotate the hook 2. The controller controls the rotation position of the hook 2 by adjusting displacement of the piston rod 33 based on a detection result of the sensor 35.

[0044] First, movement of the mooring 1 in disengaging the hook 2 from the door body 10 will be described. In the mooring state, as illustrated in FIG. 3, the hook 2 is at an engaged position in an engaged state where the hook 2 is engaged with the engager 13 of the door body 10 in the lying state. From this state, the actuator 3 retracts the piston rod 33. The retraction, that is, upward movement, of the piston rod 33 rotates the lever 51 upward about the rotation axis E. The upward movement of the second end portion 51b of the lever 51 moves the first

link rod 52 upward. The upward movement of the first link rod 52 rotates the shaft 41 about the center axis C. The shaft 41 rotates counterclockwise in FIG. 6. For convenience of description, rotation of the shaft 41 in this direction, that is, counterclockwise rotation in FIG. 6 will be referred to as “reverse rotation.” When the shaft 41 rotates reversely, the second link rod 61 moves downward. The downward movement of the second link rod 61 rotates the rotation link 62 about the rotation axis I. The rotation link 62 rotates counterclockwise in FIG. 6. For convenience of description, rotation of the rotation link 62 in this direction, that is, counterclockwise rotation in FIG. 6 will be referred to as “reverse rotation.” When the rotation link 62 rotates reversely, the third link rod 63 moves upward. The upward movement of the third link rod 63 rotates the shaft 21 and the hook 2 about the rotation axis A. The shaft 21 and the hook 2 rotate counterclockwise in FIG. 6. For convenience of description, rotation of the shaft 21 and the hook 2 in this direction, that is, counterclockwise rotation in FIG. 6 will be referred to as “reverse direction.” The actuator 3 moves the hook 2 upward from the engaged position to a position that does not interfere with a trajectory of the engager 13 during rotation of the door body 10. Specifically, the controller controls the actuator 3 based on a detection result of the sensor 35 to move the hook 2 to a location outside the trajectory of the engager 13. Accordingly, the hook 2 is disengaged from the engager 13. At this time, the counter weight 23 facilitates the reverse rotation of the hook 2. When the hook 2 is disengaged from the engager 13, the door body 10 rotates to the raised state by buoyancy.

[0045] Next, movement of the mooring 1 in engaging the hook 2 with the door body 10 will be described. In a state where the door body 10 is not moored, the door body 10 is in the raised state. At this time, the hook 2 may be in any state. In this description, the hook 2 is located at a position above the engaged position and outside the trajectory of the engager 13 (see chain double-dashed lines in FIG. 7).

[0046] From this state, the actuator 3 advances the piston rod 33. The advancement, that

is, downward movement, of the piston rod 33 rotates the lever 51 downward about the rotation axis E. The downward movement of the second end portion 51b of the lever 51 moves the first link rod 52 downward. The downward movement of the first link rod 52 rotates the shaft 41 about the center axis C. The shaft 41 rotates clockwise in FIG. 7. For convenience of description, rotation of the shaft 41 in this direction, that is, clockwise rotation in FIG. 7 will be referred to as “forward rotation.” When the shaft 41 rotates forward, the second link rod 61 moves upward. The upward movement of the second link rod 61 rotates the rotation link 62 about the rotation axis I. The rotation link 62 rotates clockwise in FIG. 7. For convenience of description, rotation of the rotation link 62 in this direction, that is, clockwise rotation in FIG. 7 will be referred to as “forward rotation.” When the rotation link 62 rotates forward, the third link rod 63 moves downward. The downward movement of the third link rod 63 rotates the shaft 21 and the hook 2 about the rotation axis A. The shaft 21 and the hook 2 rotate clockwise in FIG. 7. For convenience of description, rotation of the shaft 21 and the hook 2 in this direction, that is, clockwise rotation in FIG. 7 will be referred to as “forward rotation.” At this time, the actuator 3 moves the hook 2 to a position below the engaged position and outside the trajectory of the engager 13. Specifically, the controller controls the actuator 3 based on a detection result of the sensor 35 to move the hook 2 to a location outside the trajectory of the engager 13. After that, the door body 10 is caused to lie. Since the hook 2 is located outside the trajectory of the engager 13, the engager 13 does not interfere with the hook 2. The door body 10 lies until the engager 13 reaches to a position below the hook 2. Specifically, the door body 10 is kept lying until the engager 13 moves out of the rotation trajectory of the hook 2.

[0047] When the engager 13 moves downward to a position below the hook 2, the actuator 3 retracts the piston rod 33. By movement similar to the disengagement of the hook 2 described above, the hook 2 rotates reversely. The actuator 3 moves the hook 2 to the engaged

position and maintains the hook 2 at the engaged position. In a state where the hook 2 is at the engaged position, the door body 10 is rotated upward. When the door body 10 rotates upward, the engager 13 engages with the hook 2 from below. In this manner, engagement between the engager 13 and the hook 2 is completed.

5 [0048] In the mooring 1, the lever 51 is suspended from the piston rod 33 of the actuator 3. Accordingly, the self-weight of the lever 51 acts to the advancing side of the piston rod 33. In other words, the self-weight of the lever 51 generates a moment of forward rotation to the hook 2, making it easier to return the hook 2 from the disengaged state to the engaged state.

[0049] In the thus-configured flap gate 100, the actuator 3 is located in the air chamber 70 in
10 the water. Since the air chamber 70 is airtightly configured, immersion of the actuator 3 is reduced. In addition, since the sensor 35 is also located in the air chamber 70, immersion of the sensor 35 is also reduced. This assures appropriate operation of the actuator 3 and the sensor 35.

[0050] Since the actuator 3 is located in the air chamber 70 in the water, the actuator 3 can
15 be placed near the door body 10 in the lying state in the water. Consequently, the distance from the actuator 3 to the hook 2 can be shortened. This can reduce influence, that is, restriction, on characteristics such as the size and arrangement of the door body 10 and the number of door bodies 10 in the case of using multiple door bodies 10, caused by the distance between the hook 2 and the actuator 3.

20 [0051] For example, in a case where the multiple door bodies 10 are arranged as illustrated in FIG. 1, door bodies 10 at both ends in the arrangement direction are located near a land structure such as the embankment 9, whereas door bodies 10 on the inner side in the arrangement direction have a longer distance from the land structure. In a case where the actuator 3 is placed on the land structure, the distance from the actuator 3 to the hook 2
25 corresponding to the door bodies 10 on the inner side in the arrangement direction becomes

longer. When the distance between the hook 2 and the actuator 3 is long, it can become difficult to arrange the transfer that transfers a driving force, and a loss in transfer of the driving force also increases. This problem is not limited to the case of arrangement of multiple door bodies 10. In a case where the lateral dimension of the door body 10 is large, the distance
5 from the land structure to the hook 2 becomes longer depending on the position of the hook 2, and consequently, the distance between the hook 2 and the actuator 3 increases.

[0052] However, in the flap gate 100, the actuator 3 is located in the air chamber 70 in the water. In the case of arranging multiple door bodies 10, the air chamber 70 is located near each of the door bodies 10 in the lying state in the water, and the actuator 3 corresponding to
10 each door body 10 can be located in the air chamber 70. Accordingly, the actuator 3 corresponding to each door body 10 can be placed near the door body 10, allowing reduction of the distance between the hook 2 and the actuator 3. In the case of a door body 10 with a large lateral dimension, the air chamber 70 is also located near the hook 2 in the water, allowing the actuator 3 to be located in the air chamber 70. As a result, the actuator 3 can be placed
15 near the door body 10, and the distance between the hook 2 and the actuator 3 can be shortened.

[0053] For example, the mooring 1 is located at a position aligned with the door body 10 in the lying state in the longitudinal direction. The door body 10 is typically arranged to block water flowing in a direction that intersects the rotation axis X. That is, in a water area where the door body 10 is located, water tends to flow along the longitudinal direction of the door
20 body 10. Even in a configuration where the mooring 1 and the door body 10 are aligned in the longitudinal direction, the mooring 1 is located below the water surface. Since structures on the water surface, such as a machinery room, are not aligned with the door body 10 in the longitudinal direction, the mooring 1 can be placed near the door body 10 in the lying state without obstructing flow of water or passage of ships and other vehicles.

25 [0054] In a case where the distance between the hook 2 and the actuator 3 is short, the link

length of each link included in the transfer 4 can be shortened. This can enhance strength against buckling of each link.

[0055] Further, the transfer 4 does not include a coupling element having flexibility and transmits both a pulling force and a pushing force. Accordingly, the actuator 3 can rotate the hook 2 to both sides in the circumferential direction about the rotation axis A. Consequently, the actuator 3 can control both the operation of engaging the hook 2 with the door body 10 and the operation of disengaging the hook 2 from the door body 10.

[0056] The connecting chamber 73 is defined adjacent to the air chamber 70 with the partition 71 interposed therebetween, and the shaft 41 of the transfer 4 penetrates the partition 71 and extends in both the air chamber 70 and the connecting chamber 73. A driving force of the actuator 3 is transferred from the air chamber 70 to the connecting chamber 73 via the shaft 41. The shaft 41 is sealed by the rotation seals 43 in the through hole 72 of the partition 71. The rotating seals 43 reduce entering of water into the air chamber 70 from the through hole 72. This ensures airtightness of the air chamber 70.

[0057] In addition, the air pocket 74 is present in an upper portion of the connecting chamber 73, and the shaft 41 is located in the air pocket 74 in the connecting chamber 73. This prevents submersion of the shaft 41. Further, the through hole 72 of the partition 71 is located at a position above the air chamber 74, that is, the water surface of the connecting chamber 73. Consequently, the possibility of entering of water into the air chamber 70 from the through hole 72 is further reduced.

[0058] Since the through hole 72 of the partition 71 is sealed by the rotation seals 43, an air flow between the air chamber 70 and the air pocket 74 is reduced. Even when the water pressure of the connecting chamber 73 fluctuates due to variations in the water level of the area where the air chamber 70 is located, the air pocket 74 can be maintained. In this manner, submersion of the shaft 41 and the through hole 72 in the connecting chamber 73 can be

avoided.

[0059] Furthermore, an air pressure of the air chamber 70 is managed to a pressure corresponding to the water depth relative to the standard water level of the water area where the air chamber 70 is located. This also reduces an airflow between the air chamber 70 and the air pocket 74.

[0060] In addition, an air pressure of the air pocket 74 is adjusted to a pressure higher than the atmospheric pressure, for example, the same pressure as the air chamber 70. In this manner, variations of the water surface in the connecting chamber 73 are reduced.

[0061] <Variation>

A mooring 201 according to a variation will now be described. FIG. 8 is a side view illustrating a schematic configuration of the mooring 20 according to the variation. The mooring 201 is different from the mooring 1 in that the self-weight of the lever 51 acts to the retracting side of the piston rod 33. The following description will be directed mainly to a part of the configuration of the mooring 201 different from the mooring 1. Components of the mooring 201 similar to those of the mooring 1 are denoted by the same reference characters and will not be described again.

[0062] Specifically, the configurations of an actuator 3 and a first transfer 205 of the mooring 201 are different from those of the mooring 1. The configuration of a second transfer 6 of the mooring 201 is similar to that of the mooring 1.

[0063] The actuator 3 is located in an air chamber 70. A cylinder tube 32 is supported to be rotatable about a rotation axis B. In the mooring 201, a hydraulic cylinder 31 is oriented such that a piston rod 33 projects obliquely upward from the cylinder tube 32.

[0064] The first transfer 205 is located in the air chamber 70. The first transfer 205 includes a lever 51 coupled to the actuator 3 and a first link rod 52 coupled to the lever 51. The lever 51 is supported at a first end portion 51a to be rotatable about a rotation axis E in the air chamber

70. The lever 51 is tilted and arranged such that a second end portion 51b is located obliquely above the first end portion 51a. The first link rod 52 is coupled to the second end portion 51b via a spring cylinder 53.

[0065] The actuator 3 is coupled to an intermediate portion of the lever 51. Specifically, a distal end of the piston rod 33 of the hydraulic cylinder 31 is coupled to the intermediate portion of the lever 51 to be rotatable about a rotation axis D. The actuator 3 is coupled to the lever 51 to support the tilted lever 51 from obliquely below.

[0066] First, movement of the mooring 201 in disengaging the hook 2 from the door body 10 will be described. From the engaged state of the hook 2, the actuator 3 retracts the piston rod 33. The retraction, that is, oblique downward movement, of the piston rod 33 rotates the lever 51 obliquely downward about the rotation axis E. The oblique downward movement of the second end portion 51b of the lever 51 moves the first link rod 52 obliquely downward. The oblique downward movement of the first link rod 52 causes the shaft 41 to rotate reversely about a center axis C, that is, to rotate counterclockwise in FIG. 8. Movement of the second transfer 6 when the shaft 41 rotates reversely is similar to that of the mooring 1. Consequently, the shaft 21 and the hook 2 rotate reversely about a rotation axis A, that is, rotate counterclockwise in FIG. 8, and the hook 2 is disengaged from the engager 13.

[0067] Next, movement of the mooring 201 in engaging the hook 2 with the door body 10 will be described. For example, from a state where the hook 2 is located at a position above the engaged position and outside a trajectory of the engager 13, the actuator 3 advances the piston rod 33. The advancement, that is, oblique upward movement, of the piston rod 33 rotates the lever 51 obliquely upward about the rotation axis E. The oblique upward movement of the second end portion 51b of the lever 51 moves the first link rod 52 obliquely upward. The oblique upward movement of the first link rod 52 causes the shaft 41 to rotate forward about the center axis C, that is, to rotate clockwise in FIG. 8. Movement of the second

transfer 6 when the shaft 41 rotates forward is similar to that of the mooring 1. Consequently, the shaft 21 and the hook 2 rotate forward about the rotation axis A, that is, rotate clockwise in FIG. 8, and the hook 2 moves to a position below the engaged position and outside the trajectory of the engager 13. Subsequently, the door body 10 is caused to lie until the engager 13 reaches to a position below the hook 2. Then, the actuator 3 retracts the piston rod 33. By movement similar to the disengagement of the hook 2 described above, the hook 2 rotates reversely. The actuator 3 moves the hook 2 to the engaged position and maintains the hook 2 at the engaged position. In the state where the hook 2 is at the engaged position, the door body 10 is rotated upward. When the door body 10 rotates upward, the engager 13 engages with the hook 2 from below. In this manner, engagement between the engager 13 and the hook 2 is completed.

[0068] In the mooring 201, the piston rod 33 supports the lever 51 from obliquely below. Accordingly, the self-weight of the lever 51 acts to the retracting side of the piston rod 33. In other words, the self-weight of the lever 51 generates a moment of reverse rotation with respect to the hook 2, making it easier to maintain the hook 2 in a position outside the trajectory of the engager 13 in the disengaged state.

[0069] <<Other Embodiments>>

As described above, the exemplary embodiment has been described as an example of the technique disclosed in this application. The technique disclosed here, however, is not limited to this embodiment, and is applicable to other embodiments obtained by changes, replacements, additions, and/or omissions as necessary. Components described in the above embodiment may be combined as a new exemplary embodiment. Components provided in the accompanying drawings and the detailed description can include components unnecessary for solving problems as well as components necessary for solving problems in order to exemplify the technique. Therefore, it should not be concluded that such unnecessary components are necessary only because these unnecessary components are included in the

accompanying drawings or the detailed description.

[0070] For example, the flap gate 100 is not limited to those located in harbor ports. The gate may be located in a river, an estuary, or other locations. The flap gate 100 may not constitute a gate-type breakwater together with the embankment 9. That is, the flap gate 100 is not necessarily located in an opening of the embankment and may be located in an opening partitioned by opposed side walls, such as the first side wall and the second side wall, in a river or an estuary.

[0071] The flap gate 100 includes the four door bodies 10, but the number of door bodies 10 is not limited to four. The number of door bodies 10 may be one, two, three, or five or more.

[0072] In a case where multiple door bodies 10 are used, the mooring 1 or 201 is used for each door body 10. In this case, air chambers 70 corresponding to the individual moorings 1 or 201 may be used, or a common air chamber 70 is used for the multiple moorings 1 or 201. However, in the case of using the common air chamber 70, the air reservoir 74, that is, the connecting chamber 73, is used for each of the multiple moorings 1 or 201.

[0073] Regarding the actuator 3, any configuration may be adopted as long as the actuator 3 generates a driving force of the hook 2. For example, the actuator 3 may be an electric motor or an air cylinder.

[0074] The transfer 4 is not limited to the configuration described above. Regarding the transfer 4, any configuration may be adopted as long as the transfer 4 penetrates the partition 71 from the air chamber 70 and reaches the hook 2 through the air pocket 74. For example, the transfer 4 may include transfer elements other than links. For example, the transfer 4 may include various transfer elements such as belts, chains, feed screws, and rack and pinions. The configuration, arrangement, and number of links included in the transfer 4 may be set arbitrarily.

[0075] The embodiment described above is a specific example of the following aspects.

[0076] [Aspect 1] A flap gate 100 includes: a door body 10 that rotates about a predetermined rotation axis X between a lying state where the door body 10 lies in water and a raised state where the door body 10 is raised from the water; a mooring 1, 201 that moors the door body 10 in the lying state; an air chamber 70 located in the water and airtightly partitioned; and a
5 connecting chamber 73 adjacent to the air chamber 70 with a partition 71 interposed therebetween, the connecting chamber 73 including a lower portion that is open in the water and an upper portion including an air pocket 74, the mooring 1, 201 includes a hook 2 that switches between an engaged state where the hook 2 is engaged with the door body 10 in the lying state and a disengaged state where the hook 2 is disengaged from the door body 10, an
10 actuator 3 that generates a driving force, and a transfer 4 that transfers the driving force of the actuator 3 to the hook 2, the hook 2 is located in the water, the actuator 3 is located in the air chamber 70, and the transfer 4 penetrates the partition 71 from the air chamber 70 to reach the hook 2 through the air pocket 74.

[0077] In this configuration, since the actuator 3 is located in the air chamber 70, submersion
15 of the actuator 3 is prevented. Accordingly, the actuator 3 can be located near the door body 10 in the lying state in the water, and further, the distance between the hook 2 and the actuator 3 can be reduced. Since the distance in which the transfer 4 transfers the driving force is shortened, the size of the transfer 4 is reduced, and a loss in transferring the driving force decreases.

[0078] [Aspect 2] In the flap gate 100 of Aspect 1, the transfer 4 includes a shaft 41 that is
20 rotationally driven about a center axis C by the actuator 3, and the shaft 41 penetrates the partition 71 in a direction of the center axis C and extends in inner spaces of both the air chamber 70 and the air pocket 74.

[0079] In this configuration, transfer of the driving force between the air chamber 70 and the
25 connecting chamber 73 is achieved via the shaft 41. The shaft 41 extends penetrates the

partition 71 from the air chamber 70 and extends in the air pocket 74 of the connecting chamber 73. That is, the shaft 41 is not submerged. This reduces entry of water into the through hole 72 of the partition 71. Consequently, entry of water into the air chamber 70 is reduced, and submersion of the actuator 3 is reduced.

5 [0080] [Aspect 3] In the flap gate 100 of Aspect 1 or 2, the shaft 41 is rotatably sealed in a through hole 72 of the partition 71.

[0081] In this configuration, even if water reaches the through hole 72 via the shaft 41 in the connecting chamber 73, entry of water into the air chamber 70 via the through hole 72 is reduced. This further reduces entry of water into the air chamber 70. In addition, since a
10 gap between the shaft 41 and the through hole 72 is sealed, airtightness of the air chamber 70 is further assured.

[0082] [Aspect 4] In the flap gate 100 of any one of Aspects 1 to 3, the center axis C of the shaft 41 extends in a direction of the rotation axis X of the door body 10, the transfer 4 includes links, for example, a second link rod 61, a rotation link 62, and a third link rod 63, coupling the
15 shaft 41 and the hook 2 to each other, and the links are coupled to one another to be rotatable about an axis extending in the direction of the rotation axis X.

[0083] In this configuration, the links of the transfer 4 are arranged parallel to a plane orthogonal to the rotation axis X. This simplifies arrangement of the links, allowing the distance in which the driving force is transferred through the links to be shortened, thereby
20 enhancing transfer efficiency of the driving force.

[0084] [Aspect 5] In the flap gate 100 of any one of Aspects 1 to 4, wherein the transfer 4 transfers both a pulling force and a pushing force.

[0085] In this configuration, the transfer 4 can appropriately transfer the driving force of the actuator 3 such that the hook 2 changes to any of the engaged state and the disengaged state.
25 As a result, the hook 2 can be controlled to the engaged state and the disengaged state

intentionally, not spontaneously.

[0086] [Aspect 6] In the flap gate 100 of any one of Aspects 1 to 5, the actuator 3 includes a hydraulic cylinder 31 and a sensor 35 that detects a stroke amount of the hydraulic cylinder 31.

[0087] In this configuration, the hydraulic cylinder 31 and the sensor 35 are located in the air chamber 70, and thus, are protected against submersion. As a result, appropriate operation of the hydraulic cylinder 31 and the sensor 35 is assured.

[0088] [Aspect 7] In the flap gate of any one of Aspects 1 to 6, the door body 10 has a plate shape expanding in a plane defined by a lateral direction that coincides with a direction of the rotation axis X and a longitudinal direction orthogonal to the lateral direction, and the mooring 1, 201 is located at a position aligned with the door body 10 in the lying state in the longitudinal direction.

[0089] The door body 10 is typically arranged to block water flowing in a direction that intersects the rotation axis X. That is, in a water area where the door body 10 is located, water tends to flow along the longitudinal direction of the door body 10. Even in a configuration where the mooring 1, 201 and the door body 10 are aligned in the longitudinal direction, the mooring 1, 201 is located below the water surface. Since structures on the water surface, such as a machinery room, are not aligned with the door body 10 in the longitudinal direction, the mooring 1, 201 can be placed near the door body 10 in the lying state without obstructing flow of water or passage of ships and other vehicles.

20

REFERENCE MARKS IN THE DRAWINGS

[0090] 100 flap gate

1, 201 mooring

2 hook

25 3 actuator

- 31 hydraulic cylinder
- 35 sensor
- 4 transfer
- 41 shaft
- 5 61 second link rod (link)
- 62 rotation link (link)
- 63 third link rod (link)
- 10 door body
- C center axis
- 10 X rotation axis

CLAIMS

1. A flap gate comprising:

5 a door body that rotates about a predetermined rotation axis between a lying state where the door body lies in water and a raised state where the door body is raised from the water;

a mooring that moors the door body in the lying state;

an air chamber located in the water and airtightly partitioned; and

10 a connecting chamber adjacent to the air chamber with a partition interposed therebetween, the connecting chamber including a lower portion that is open in the water and an upper portion including an air pocket, wherein

the mooring includes

15 a hook that switches between an engaged state where the hook is engaged with the door body in the lying state and a disengaged state where the hook is disengaged from the door body,

an actuator that generates a driving force, and

a transfer that transfers the driving force of the actuator to the hook,

the hook is located in the water,

the actuator is located in the air chamber, and

20 the transfer penetrates the partition from the air chamber to reach the hook through the air pocket.

2. The flap gate according to claim 1, wherein

25 the transfer includes a shaft that is rotationally driven about a center axis by the actuator, and

the shaft penetrates the partition in a direction of the center axis and extends in inner spaces of both the air chamber and the air pocket.

3. The flap gate according to claim 2, wherein
5 the shaft is rotatably sealed in a through hole of the partition.

4. The flap gate according to claim 2 or 3, wherein
the center axis of the shaft extends in a direction of the rotation axis of the door body,
the transfer includes links coupling the shaft and the hook to each other, and
10 the links are coupled to one another to be rotatable about an axis extending in the
direction of the rotation axis.

5. The flap gate according to any one of claims 1 to 3, wherein
the transfer transfers both a pulling force and a pushing force.
15

6. The flap gate according to any one of claims 1 to 3, wherein
the actuator includes a hydraulic cylinder and a sensor that detects a stroke amount
of the hydraulic cylinder.

7. The flap gate according to any one of claims 1 to 3, wherein
the door body has a plate shape expanding in a plane defined by a lateral direction
that coincides with a direction of the rotation axis and a longitudinal direction orthogonal to the
lateral direction, and
the mooring is located at a position aligned with the door body in the lying state in
25 the longitudinal direction.