DESCRIPTION

Title of the Invention: Submersible Pump

Technical Field

[0001] The present invention relates to a submersible pump.

Background Art

[0002] In general, a submersible pump that cools a motor with a cooling fluid is known. Such a submersible pump is disclosed in Japanese Patent No. 5552402, for example.

[0003] In Japanese Patent No. 5552402, there is disclosed a submersible pump including a motor, a cooling fluid circulation flow path for a cooling fluid that cools the motor, and a mechanical seal provided on the cooling fluid circulation flow path. The submersible pump also uses the cooling fluid for the motor as a lubricating fluid for the mechanical seal.

Prior Art

Patent Document

[0004] Patent Document 1: Japanese Patent No. 5552402

Summary of the Invention

Problems to be Solved by the Invention

[0005] In the submersible pump described in Japanese Patent No. 5552402, however, the fluid that flows through the cooling fluid circulation flow path is used for

cooling and lubrication, and thus it is impossible to select a fluid optimum for each application. Furthermore, when a fluid in a pump chamber enters the cooling fluid circulation flow path via the mechanical seal, there is a problem that the cooling fluid is immediately contaminated. When the cooling fluid is contaminated, a scum or the like contained in the entering fluid may unpreferably block the flow path and stop circulation of the cooling fluid. That is, a function of cooling the motor is unpreferably hindered.

[0006] The present invention has been proposed in order to solve the aforementioned problems, and an object of the present invention is to provide a submersible pump capable of selecting an optimum fluid as each of a fluid for cooling a motor and a fluid for lubricating a mechanical seal and capable of significantly reducing or preventing contamination of a cooling fluid.

Means for Solving the Problems

[0007] A submersible pump according to an aspect of the present invention includes a motor including a drive shaft, a pump chamber in which an impeller driven by the motor is disposed, and including a suction port and a discharge port, an oil chamber including a mechanical seal that includes a slider and disposed between the motor and the pump chamber, a motor cooling chamber disposed adjacent to

the motor and that cools the motor with a cooling fluid, a heat exchange chamber disposed adjacent to the pump chamber and that performs heat exchange between the cooling fluid and a fluid in the pump chamber by allowing the cooling fluid to flow therethrough, a first flow path provided outside the oil chamber in a radial direction of the drive shaft, that connects the heat exchange chamber and the motor cooling chamber, and through which the cooling fluid flows from one of the heat exchange chamber and the motor cooling chamber to the other, and a second flow path provided outside the oil chamber in the radial direction, that connects the heat exchange chamber and the motor cooling chamber, and through which the cooling fluid flows in a direction opposite to that of the first flow path.

[0008] As described above, the submersible pump according to this aspect of the present invention includes the first flow path, the second flow path, the motor cooling chamber, and the heat exchange chamber through which the cooling fluid flows separately from the oil chamber such that cooling of the motor and lubrication of the mechanical seal can be performed with separate fluids, and thus it is possible to select an optimum fluid as each of a fluid for cooling the motor and a fluid for lubricating the mechanical seal. In addition, even when

the fluid in the pump chamber enters through the mechanical seal, the fluid (oil) in the oil chamber can be contaminated first, and thus contamination of the cooling fluid can be prevented. Therefore, it is possible to select an optimum fluid as each of a fluid for cooling the motor and a fluid for lubricating the mechanical seal, and to significantly reduce or prevent contamination of the cooling fluid. Further, it is possible to dispose the cooling fluid circulation pump chamber further from the pump chamber than the oil chamber along the drive shaft, and thus in the event of fluid immersion, the infiltration destination of sewage water can be set to the oil chamber. Consequently, contamination of the cooling fluid can be further significantly reduced or prevented.

[0009] In the aforementioned submersible pump according to this aspect, wherein in the heat exchange chamber, a watertight seal structure to an outside is preferably provided. According to this structure, the seal structure effectively prevents the entry of a fluid and air from the outside of the heat exchange chamber, such as the pump chamber side, the atmospheric side, and the oil chamber side, to the heat exchange chamber. Consequently, contamination of the cooling fluid can be further significantly reduced or prevented.

~~[0010] The aforementioned submersible pump according to~~

~~this aspect preferably further includes a cooling fluid circulation pump chamber, in which a cooling fluid circulation impeller for the cooling fluid driven by the motor is disposed, and provided in the second flow path between the motor and the oil chamber. According to this structure, it is possible to dispose the cooling fluid circulation pump chamber further from the pump chamber than the oil chamber along the drive shaft, and thus in the event of fluid immersion, the infiltration destination of sewage water can be set to the oil chamber. Consequently, contamination of the cooling fluid can be further significantly reduced or prevented.~~

[0010] In the aforementioned submersible pump according to this aspect, the first flow path and the second flow path preferably extend in an axial direction of the drive shaft along an outer circumference of the oil chamber outside the oil chamber in the radial direction. According to this structure, as compared with the case in which the first flow path and the second flow path extend in a direction that intersects with the axial direction of the drive shaft around the oil chamber, the lengths of the first flow path and the second flow path can be reduced, and thus it is possible to efficiently cool the motor by reducing energy losses in the flow paths.

[0011] In the aforementioned submersible pump according

to this aspect, at least one of the first flow path and the second flow path preferably surrounds substantially an entire circumference of the oil chamber. According to this structure, the cooling fluid can flow from substantially the entire circumference of the oil chamber into the heat exchange chamber, and thus it is possible to ensure a large heat transfer area between the cooling fluid in the heat exchange chamber and the fluid in the pump chamber. Consequently, it is possible to effectively perform heat exchange between the cooling fluid and the fluid in the pump chamber.

[0012] In the aforementioned ~~structure including the cooling fluid circulation pump chamber~~ submersible pump according to this aspect, the second flow path is preferably disposed inside the first flow path in the radial direction of the drive shaft, and the cooling fluid circulation impeller preferably causes the cooling fluid from the heat exchange chamber to flow into the cooling fluid circulation pump chamber and causes the cooling fluid that has flowed out of the cooling fluid circulation pump chamber to flow to the motor cooling chamber. According to this structure, the cooling fluid cooled in the heat exchange chamber can flow through the second flow path closer to the motor than the first flow path in the radial direction of the drive shaft, and thus it is

possible to effectively cool the motor.

[0013] In the aforementioned ~~structure including the cooling fluid circulation pump chamber~~ submersible pump according to this aspect, the second flow path is preferably disposed inside the first flow path in the radial direction, and the cooling fluid circulation impeller preferably causes the cooling fluid from the motor cooling chamber to flow into the cooling fluid circulation pump chamber and causes the cooling fluid that has flowed out of the cooling fluid circulation pump chamber to flow to the heat exchange chamber. According to this structure, the cooling fluid can be caused to flow toward the heat exchange chamber side opposite to the motor (excluding the drive shaft) by the cooling fluid circulation impeller, and thus it is possible to set the motor side to a negative pressure and effectively significantly reduce or prevent fluid immersion into the motor.

[0014] The aforementioned submersible pump according to this aspect preferably further includes a single first housing including an oil change hole through which the atmosphere communicates with the oil chamber, and provided with the oil chamber. According to this structure, it is possible to save time and effort to assemble a plurality of housings, as compared with the case in which the oil

change hole is provided across the plurality of housings. In addition, it is possible to reduce the number of seals required to prevent oil leakage.

[0015] In this case, in the first housing, the oil change hole preferably does not overlap with the first flow path and the second flow path provided in the first housing in a plan view. According to this structure, it is possible to prevent the flow of the cooling fluid in the first flow path and the second flow path from being obstructed by the oil change hole, and to prevent the complicated structure of the first housing.

[0016] In the aforementioned submersible pump according to this aspect, the first flow path preferably includes at least one first flow path, is disposed outside the second flow path in the radial direction, and has an arcuate shape that surrounds a periphery of the drive shaft in a plan view. According to this structure, the first flow path can be shaped to conform to the outer circumference of the motor.

[0017] The aforementioned structure in which the seal structure is provided in the heat exchange chamber preferably further includes a first housing opened on the heat exchange chamber side and provided with the oil chamber, a second housing opened on the first housing side and provided with the heat exchange chamber, and a

partition disposed between the first housing and the second housing and that partitions the oil chamber and the heat exchange chamber, and the seal structure is preferably provided between the first housing and the partition and preferably includes a seal that provides a watertight seal between the oil chamber and the heat exchange chamber. According to this structure, the seal can provide a watertight seal between the oil chamber and the heat exchange chamber so as to prevent contamination of the cooling fluid by the oil.

[0018] The aforementioned structure in which the seal structure is provided in the heat exchange chamber preferably further includes a first housing opened on the heat exchange chamber side and provided with the oil chamber, a second housing opened on the first housing side and provided with the heat exchange chamber, and a partition disposed between the first housing and the second housing and that partitions the oil chamber and the heat exchange chamber, and the seal structure preferably includes an integral structure in which the second housing and the partition are integrally formed. According to this structure, it is possible to improve the watertightness of the heat exchange chamber by reducing the number of portions that require seals. Consequently, the apparatus configuration can be further simplified.

[0019] The aforementioned ~~structure including the cooling fluid circulation pump chamber~~ submersible pump according to this aspect preferably further includes a first housing provided with the oil chamber, a second housing provided with the heat exchange chamber, a third housing provided with the cooling fluid circulation pump chamber, and a fourth housing provided between the third housing and the motor, and the first flow path and the second flow path are preferably formed by stacking the second housing, the first housing, the third housing, and the fourth housing in this order on the pump chamber. According to this structure, it is possible to easily assemble a pump body simply by stacking the second housing, the first housing, the third housing, and the fourth housing in this order.

[0020] In this case, the fourth housing preferably includes a motor-side first opening through which the first flow path communicates with the motor cooling chamber and a motor-side second opening through which the second flow path communicates with the motor cooling chamber, and the motor-side first opening and the motor-side second opening are preferably shifted from each other in a circumferential direction of the drive shaft. According to this structure, the motor-side first opening and the motor-side second opening can be used as an

opening through which the cooling fluid flows to the motor cooling chamber and as an opening through which the cooling fluid flows to the heat exchange chamber.

[0021] In the aforementioned structure in which the second housing, the first housing, the third housing, and the fourth housing are stacked in this order, the fourth housing preferably extends along a lower surface of the motor, and the second flow path preferably includes a motor lower flow path that extends in the radial direction of the drive shaft along the lower surface of the motor between the third housing and the fourth housing and including a first end and a second end connected to the cooling fluid circulation pump chamber and the motor cooling chamber, respectively. According to this structure, the motor can also be cooled from the lower side by the cooling fluid that flows through the motor lower flow path.

[0022] In the aforementioned structure in which the second housing, the first housing, the third housing, and the fourth housing are stacked in this order, the second housing is preferably formed such that a position of the heat exchange chamber in an axial direction of the drive shaft overlaps with a position of the oil chamber in the axial direction of the drive shaft. According to this structure, as compared with the case in which the heat

exchange chamber and the oil chamber do not overlap with each other in the axial direction of the drive shaft and are disposed along the drive shaft, the length of the drive shaft can be reduced. That is, the apparatus can be downsized in the axial direction.

[0023] In the aforementioned submersible pump according to this aspect, the heat exchange chamber preferably includes a guide that restricts a flow of the cooling fluid that has flowed in from an outer side in the radial direction of the drive shaft such that the cooling fluid flows along the drive shaft and flows out from the outer side in the radial direction. According to this structure, the guide restricts the flow of the cooling fluid such that the cooling fluid can flow along the drive shaft (the circumferential direction of the drive shaft) during driving and flow along the pump chamber, and thus the flow of the cooling fluid in the heat exchange chamber can be rectified.

[0024] In this case, the guide preferably includes a plurality of ribs each including a gap, which serves as a portion of a flow path for the cooling fluid, at an inner end in the radial direction of the drive shaft, and each extending radially in the radial direction. According to this structure, due to the ribs, the flow path for the cooling fluid in the heat exchange chamber can be formed

into a shape including folding, and thus it is possible to increase the length of the flow path for the cooling fluid in the heat exchange chamber, and more effectively perform heat exchange between the cooling fluid and the fluid in the pump chamber.

[0025] The aforementioned submersible pump according to this aspect preferably further includes a storage chamber disposed between the motor and the oil chamber, and a fluid level sensor that detects a predetermined fluid level of a fluid that has flowed into and has been stored in the storage chamber. According to this structure, the storage chamber can significantly reduce or prevent rising of the fluids to the motor side. In addition, the fluid level sensor can detect oil rising and fluid immersion into the storage chamber. Accordingly, the maintenance work can be reliably performed before oil rising and fluid immersion into the motor occurs.

[0026] In the aforementioned submersible pump according to this aspect, the heat exchange chamber is preferably provided outside the pump chamber in the radial direction. According to this structure, it is possible to ensure a large heat transfer area between the heat exchange chamber and the pump chamber, using substantially the entire outer circumference of a pump casing, and thus heat exchange can be effectively performed. In addition, it is possible to

effectively perform heat exchange between the cooling fluid in the heat exchange chamber and a fluid outside the submersible pump. Furthermore, even in the case of an upright submersible pump, the heat exchange chamber can be disposed at a relatively low position, and thus even when the fluid level outside the submersible pump is lower, it is possible to perform heat exchange more effectively between the cooling fluid in the heat exchange chamber and the fluid outside the submersible pump. Furthermore, as compared with the case in which the heat exchange chamber and the pump chamber do not overlap with each other in the axial direction of the drive shaft and are disposed along the drive shaft, the length of the drive shaft can be reduced. That is, the apparatus can be downsized in the axial direction.

Effect of the Invention

[0027] According to the present invention, as described above, it is possible to provide the submersible pump capable of selecting an optimum fluid as each of the fluid for cooling the motor and the fluid for lubricating the mechanical seal and capable of significantly reducing or preventing contamination of the cooling fluid.

Brief Description of the Drawings

[0028] [FIG. 1] A schematic view showing a submersible pump according to a first embodiment of the present

invention.

[FIG. 2] An exploded perspective view showing the cross-section of a housing of the submersible pump according to the first embodiment of the present invention.

[FIG. 3] A side view showing an oil housing of the submersible pump according to the first embodiment of the present invention.

[FIG. 4] A sectional view taken along the line 1000-1000 in FIG. 3.

[FIG. 5] A plan view showing a cooling housing of the submersible pump according to the first embodiment of the present invention.

[FIG. 6] A schematic view showing a submersible pump according to a second embodiment of the present invention.

[FIG. 7] A schematic view showing a submersible pump according to a third embodiment of the present invention.

[FIG. 8] A schematic view showing a submersible pump according to a fourth embodiment of the present invention.

[FIG. 9] A sectional view of an oil housing of the submersible pump according to the third embodiment of the present invention, corresponding to FIG. 4.

[FIG. 10] A schematic view showing a submersible pump according to a fifth embodiment of the present invention.

[FIG. 11] A schematic partial enlarged view showing a submersible pump according to a sixth embodiment of the

present invention.

[FIG. 12] A schematic view showing a submersible pump according to a seventh embodiment of the present invention.

[FIG. 13] A plan view of a cooling casing of the submersible pump according to the seventh embodiment of the present invention, corresponding to FIG. 5.

[FIG. 14] A schematic view showing a submersible pump according to an eighth embodiment of the present invention.

[FIG. 15] A plan view of a cooling casing of the submersible pump according to the eighth embodiment of the present invention, corresponding to FIG. 5.

[FIG. 16] A schematic view showing a submersible pump according to a ninth embodiment of the present invention.

[FIG. 17] A sectional view taken along the line 1100-1100 in FIG. 16.

[FIG. 18] A sectional view taken along the line 1200-1200 in FIG. 16.

Modes for Carrying Out the Invention

[0029] Embodiments of the present invention are hereinafter described on the basis of the drawings.

[0030] [First Embodiment]

(Configuration of Submersible Pump)

A first embodiment of the present invention is now described with reference to FIGS. 1 to 5. As shown in FIG. 1, a submersible pump 100 according to the first

embodiment includes a motor 10, a head cover 11, a pump chamber 12, a pump casing 13, an impeller 14, an oil chamber 15, a housing 2, a cooling fluid circulator 3 provided in the housing 2, and a seal 4.

[0031] The seal 4 is provided in a heat exchange chamber 31 (described below) of the cooling fluid circulator 3. The seal 4 has a watertight structure with respect to the outside, and prevents a fluid from entering from the pump chamber 12 side. That is, the seal 4 prevents a cooling fluid from being contaminated by fluid immersion from the pump chamber 12 side.

[0032] The submersible pump 100 is an internal cooling pump. Specifically, the submersible pump 100 cools the motor 10 with the cooling fluid circulated by the cooling fluid circulator 3. The submersible pump 100 performs heat exchange between the cooling fluid and the fluid in the pump chamber 12 in the heat exchange chamber 31. That is, the submersible pump 100 cools the cooling fluid in the heat exchange chamber 31. The cooling fluid is water to which glycol is added, for example.

[0033] Therefore, the submersible pump 100 can be used even in an environment in which the level of a fluid around the submersible pump 100 is lowered depending on the situation, and the submersible pump 100 is exposed. In addition, the submersible pump 100 can be used even in

the same environment as that in which a land pump, which is always exposed, is used. The submersible pump 100 is a vertical pump in which a drive shaft 10a of the motor 10 extends in an upward-downward direction.

[0034] In the following description, the axial direction of the drive shaft 10a of the motor 10 is defined as a Z direction (upward-downward direction). In the Z direction, an upward direction is defined as a Z1 direction, and a downward direction is defined as a Z2 direction. Furthermore, the radial direction of the drive shaft 10a is defined as an A direction. In the A direction, an outward direction in the radial direction of the drive shaft 10a is defined as an A1 direction, and a direction opposite to the A1 direction is defined as an A2 direction.

[0035] The motor 10 is hermetically sealed such that a fluid does not enter the motor 10 from the outside. The motor 10 includes the drive shaft 10a, a stator 10b, a rotor 10c, and a motor frame 10d. The motor 10 rotationally drives the impeller 14 connected to the drive shaft 10a via the drive shaft 10a. Specifically, the motor 10 is an inner rotor motor in which the stator 10b is disposed outside (on the A1 direction side) in the radial direction of the rotor 10c and is attached to the inner side of the motor frame 10d. The rotor 10c is

attached to the drive shaft 10a and rotates together with the drive shaft 10a due to a magnetic field from the stator 10b. The rotor 10c rotationally drives the impeller 14 via the drive shaft 10a.

[0036] The drive shaft 10a is rotatably supported by bearings 16a and 16b. The bearing 16a is supported by the head cover 11 (described below) of the housing 2 on the Z1 direction side of the motor 10. The bearing 16b is supported by a bearing cover 21 (described below) of the housing 2 on the Z2 direction side of the motor 10. Note that the motor 10, a cooling fluid circulation pump chamber 34 (described below) of the cooling fluid circulator 3, the oil chamber 15, the heat exchange chamber 31, and the pump chamber 12 are disposed in this order from the Z1 direction side along the drive shaft 10a (Z direction).

[0037] In the pump chamber 12, the impeller 14 driven by the motor 10 is disposed. The pump chamber 12 is provided in the pump casing 13. The pump casing 13 includes a suction port 13a and a discharge port 13b for a fluid (such as sewage water). The pump casing 13 is disposed on the lower side (Z2 direction side) relative to the housing 2.

[0038] The impeller 14 rotates to suction water in a drainage region in which the submersible pump 100 is

disposed via the suction port 13a into the pump casing 13 (pump chamber 12) and discharge the suctioned water to the discharge port 13b (basically in the A1 direction).

[0039] The oil chamber 15 is disposed between the motor 10 and the pump chamber 12, and is filled with oil. The oil chamber 15 includes a mechanical seal 15a and an electrode sensor 15b.

[0040] The mechanical seal 15a includes a slider on the load side (pump chamber 12 side, i.e. the Z2 direction side) and a slider on the counter load side (the side opposite to the pump chamber 12, i.e. the Z1 direction side). The slider on the load side has a function of significantly reducing or preventing flowing of pressure water in the pump chamber 12 into the oil chamber 15. The slider on the counter load side has a function of significantly reducing or preventing flowing of a fluid containing the oil in the oil chamber 15 into the cooling fluid circulation pump chamber 34. The sliders are lubricated by the oil with which the oil chamber 15 is filled, and are cooled so as not to be burned. Note that a slight gap is formed between a stationary ring and a rotary ring of the mechanical seal 15a, and thus even when the mechanical seal 15a functions normally, a fluid enters the oil chamber 15 from the pump chamber 12 little by little.

[0041] The electrode sensor 15b can detect the entry of the fluid from the pump chamber 12 into the oil chamber 15. An electric current is transferred between the electrode sensor 15b and an oil housing 23 due to the fluid that has entered the oil chamber 15 such that the electrode sensor 15b detects the entry of the fluid.

[0042] (Configurations of Cooling Fluid Circulator and Housing)

As shown in FIG. 1, the cooling fluid circulator 3 circulates the cooling fluid in a pump body between the pump chamber 12 and the head cover 11 in order to cool the motor 10. The cooling fluid circulator 3 prevents the oil in the oil chamber 15 from being mixed into the cooling fluid.

[0043] The cooling fluid circulator 3 includes a motor cooling chamber 30, the heat exchange chamber 31 (a space in which the cooling fluid is cooled), a first flow path 32, a second flow path 33, and the cooling fluid circulation pump chamber 34 provided in the second flow path 33.

[0044] The cooling fluid circulator 3 circulates the cooling fluid through the cooling fluid circulation pump chamber 34, a downstream flow path (motor lower flow path 33b described below) of the cooling fluid circulation pump chamber 34 of the second flow path 33, the motor cooling

chamber 30, the first flow path 32, the heat exchange chamber 31, and an upstream flow path (flow path 33a described below) of the cooling fluid circulation pump chamber 34 of the second flow path 33 in this order, and returns the cooling fluid to cooling fluid circulation pump chamber 34.

[0045] The housing 2 includes a water jacket 20, the bearing cover 21, a cooling housing 22, the oil housing 23, an oil casing 24, and a cooling casing 25. The bearing cover 21 is an example of a "fourth housing" in the claims. The cooling housing 22 is an example of a "third housing" in the claims. The oil casing 24 is an example of a "partition" in the claims. The oil housing 23 is an example of a "first housing" in the claims. The cooling casing 25 is an example of a "second housing" in the claims.

[0046] The first flow path 32 and the second flow path 33 are formed by stacking the cooling casing 25, the oil casing 24, the oil housing 23, the cooling housing 22, and the bearing cover 21 in this order from the Z2 direction side to the Z1 direction side on the pump chamber 12 (pump casing 13). Note that the housing 2 includes a seal (such as an O-ring) in each portion such that the cooling fluid, the oil in the oil chamber 15, and the atmosphere and the fluid in the pump chamber 12 do not mix with each other.

[0047] The portions (the water jacket 20, the bearing cover 21, the cooling housing 22, the oil housing 23, and the cooling casing 25) of the housing 2 excluding the oil casing 24 generally have substantially the same outer diameters (sizes in the A direction) as each other. The bearing cover 21 extends in the radial direction (A direction) of the drive shaft 10a along the lower surface of the motor 10 (excluding the drive shaft 10a).

[0048] The oil housing 23 is opened on the heat exchange chamber 31 side (Z2 direction side), and the oil chamber 15 is provided therein. The cooling casing 25 is opened on the oil housing 23 side (Z1 direction side), and the heat exchange chamber 31 is provided therein. The oil casing 24 is disposed between the oil housing 23 and the cooling casing 25, and partitions the oil housing 23 and the cooling casing 25. That is, the oil casing 24 prevents the oil in the oil chamber 15 and the cooling fluid in the heat exchange chamber 31 from mixing with each other.

[0049] The motor cooling chamber 30 is provided in the water jacket 20 and is disposed adjacent to the motor 10 so as to cover the motor 10 from the outer circumferential side (A1 direction side). That is, the motor cooling chamber 30 is a cylindrical space.

[0050] The motor cooling chamber 30 includes a

partition wall 30a, an inner cooling chamber 30b, and an outer cooling chamber 30c.

[0051] The partition wall 30a has a cylindrical shape that extends upward from the lower end (the end on the Z2 direction side) and is a plate-shaped wall that partitions the motor cooling chamber 30 into the inner cooling chamber 30b and the outer cooling chamber 30c. The partition wall 30a includes a gap at the upper end (the end on the Z1 direction side). The inner cooling chamber 30b is disposed inside (A2 direction side) the partition wall 30a. The outer cooling chamber 30c is disposed outside (A1 direction side) the partition wall 30a. The inner cooling chamber 30b and the outer cooling chamber 30c communicate with each other through the gap at the upper end of the partition wall 30a. The upper end of the partition wall 30a is located on the Z1 direction side relative to the stator 10b and the rotor 10c of the motor 10.

[0052] The inner cooling chamber 30b communicates with the second flow path 33 (the motor lower flow path 33b described below) (inflow port 21a (described below) provided in the bearing cover 21) at the lower end (the end on the Z2 direction side). Therefore, the inner cooling chamber 30b can effectively cool the motor 10 by allowing the cooling fluid from the heat exchange chamber

31 to flow along the motor 10.

[0053] The outer cooling chamber 30c communicates with the first flow path 32 (outflow port 21b (described below) provided in the bearing cover 21) at the lower end. Therefore, the outer cooling chamber 30c can effectively cool the cooling fluid heated by taking away heat from the motor 10 with the fluid or the atmosphere that surrounds the submersible pump 100 before sending the cooling fluid to the heat exchange chamber 31.

[0054] A plurality of (three) inflow ports 21a and a plurality of (three) outflow ports 21b are provided in the bearing cover 21 disposed adjacent to the Z2 direction side of the water jacket 20. The inflow ports 21a are examples of a "motor-side first opening" in the claims. The outlets 21b are examples of a "motor-side second opening" in the claims.

[0055] The second flow path 33 communicates with the motor cooling chamber 30 (inner cooling chamber 30b) through the inflow ports 21a such that the cooling fluid flows from the second flow path 33 into the motor cooling chamber 30 (inner cooling chamber 30b). The first flow path 32 communicates with the motor cooling chamber 30 (outer cooling chamber 30c) through the outflow ports 21b such that the cooling fluid flows out of the motor cooling chamber 30 (outer cooling chamber 30c) to the first flow

path 32.

[0056] As shown in FIG. 2, the inflow ports 21a and the outflow ports 21b each have an arcuate shape, and are shifted from each other in the A direction. That is, the inflow ports 21a are disposed on the A2 direction side relative to the outflow ports 21b. The plurality of inflow ports 21a and the plurality of outflow ports 21b are alternately disposed at substantially equal angular intervals in the circumferential direction of the drive shaft 10a (see FIG. 1) in a state in which the same are shifted from each other in the A direction. That is, in the motor cooling chamber 30 (see FIG. 1), the motor 10 (see FIG. 1) is evenly cooled by the cooling fluid that flows in and out via the plurality of inflow ports 21a and the plurality of outflow ports 21b in the circumferential direction of the drive shaft 10a. In FIG. 2, only one-side configurations of the longitudinal sectional shapes of the cooling fluid circulator 3 and the housing 2 are shown, but the other-side configurations (not shown) of the longitudinal sectional shapes have the same shapes (shapes symmetrical with respect to the sections) as those of the one-side configurations.

[0057] The heat exchange chamber 31 is provided in the cooling casing 25. The heat exchange chamber 31 is disposed adjacent to the Z1 direction side of the pump

chamber 12. The heat exchange chamber 31 is disposed adjacent to the Z2 direction side of the oil chamber 15. The heat exchange chamber 31 performs heat exchange between the cooling fluid and the fluid in the pump chamber 12 by allowing the cooling fluid to flow therethrough.

[0058] As shown in FIGS. 4 and 5, a plurality of (three) inflow ports 23a and a plurality of (three) outflow ports 23b are provided in the oil housing 23.

[0059] The first flow path 32 communicates with the heat exchange chamber 31 through the inflow ports 23a such that the cooling fluid flows from the first flow path 32 into the heat exchange chamber 31 (see FIG. 1). The second flow path 33 communicates with the heat exchange chamber 31 through the outflow ports 23b such that the cooling fluid flows out of the heat exchange chamber 31 to the second flow path 33.

[0060] The inflow ports 23a and the outflow ports 23b each have an arcuate shape, and are disposed at positions corresponding to each other in the A direction without being shifted from each other in the A direction. The inflow ports 23a and the outflow ports 23b are disposed in the vicinity of the outer end of the heat exchange chamber 31 in the A1 direction. The plurality of inflow ports 23a and the plurality of outflow ports 23b are alternately

disposed at substantially equal angular intervals in the circumferential direction of the drive shaft 10a.

[0061] As shown in FIGS. 2 and 5, the heat exchange chamber 31 includes a plurality of ribs 31a.

[0062] The plurality of ribs 31a restrict the flow of the cooling fluid that has flowed in via the inflow ports 23a on the outer side in the radial direction (A direction) such that the cooling fluid flows along the drive shaft 10a (the circumferential direction of the drive shaft 10a) and flows out via the outflow ports 23b on the outer side in the radial direction.

[0063] Specifically, the plurality of ribs 31a each include a gap, which serves as a portion of a flow path for the cooling fluid in the heat exchange chamber 31, at the inner end in the radial direction, and extend radially in the radial direction. That is, the plurality of ribs 31a partition the heat exchange chamber 31 into a plurality of spaces aligned in the circumferential direction such that the heat exchange chamber 31 has a fan shape in a plan view. As a result, the cooling fluid that has flowed into the heat exchange chamber 31 via the inflow ports 23a (first flow path 32) flows toward the inner side (A2 direction side) in the radial direction inside the fan-shaped spaces, passes through the gaps of the ribs 31a at the inner ends, flows to other adjacent

fan-shaped spaces, and flows toward the outer side (A1 direction side) in the radial direction so as to flow out via the outflow ports 23b to the second flow path 33. The plurality of ribs 31a can efficiently circulate the cooling fluid by rectifying (restricting) the flow of the cooling fluid in the heat exchange chamber 31. As a result, the heat exchange chamber 31 can effectively cool the cooling fluid.

[0064] As shown in FIG. 2, a plurality of (three) first flow paths 32 are provided outside the oil chamber 15 in the radial direction (A direction) of the drive shaft 10a (see FIG. 1). The first flow paths 32 connect the heat exchange chamber 31 and the motor cooling chamber 30 (see FIG. 1). Specifically, first ends (ends on the Z2 direction side) of the first flow paths 32 communicate with the heat exchange chamber 31 through the inflow ports 23a, and second ends (ends on the Z1 direction side) communicate with the motor cooling chamber 30 through the outflow ports 21b. As a result, the first flow paths 32 allow the cooling fluid to flow from the motor cooling chamber 30 to the heat exchange chamber 31.

[0065] The first flow paths 32 extend in the axial direction (Z direction) of the drive shaft 10a along the outer circumference of the oil chamber 15 outside the oil chamber 15 in the radial direction. The first flow paths

32 are provided across the bearing cover 21, the cooling housing 22, and the oil housing 23. The first flow paths 32 linearly extend along the axial direction (Z direction) of the drive shaft 10a.

[0066] Therefore, although not shown, the first flow paths 32, the outflow ports 21b, and the inflow ports 23a are disposed at positions corresponding to each other in the plan view. The plurality of first flow paths 32 are each disposed in the vicinity of outer ends of the bearing cover 21, the cooling housing 22, and the oil housing 23 in the A1 direction, and are aligned at substantially equal angular intervals in the circumferential direction of the drive shaft 10a.

[0067] A plurality of (three) second flow paths 33 are provided outside the oil chamber 15 in the radial direction (A direction) of the drive shaft 10a (see FIG. 4). The second flow paths 33 are disposed inside the first flow path 32 in the radial direction (A direction). The second flow paths 33 connect the heat exchange chamber 31 and the motor cooling chamber 30. Specifically, first ends (ends on the Z2 direction side) of the second flow paths 33 communicate with the heat exchange chamber 31 through the outflow ports 23b, and second ends (ends on the Z1 direction side) of the second flow paths 33 communicate with the motor cooling chamber 30 through the

outflow ports 21a. As a result, the second flow paths 33 allow the cooling fluid to flow in a direction (from the heat exchange chamber 31 to the motor cooling chamber 30) opposite to that of the first flow paths 32.

[0068] Similarly to the first flow paths 32, the second flow paths 33 extend in the axial direction (Z direction) of the drive shaft 10a along the outer circumference of the oil chamber 15 outside (A1 direction side) the oil chamber 15 in the radial direction.

[0069] The cooling fluid circulation pump chamber 34 in which a cooling fluid circulation impeller 34a that generates the flow of the cooling fluid in the cooling fluid circulator 3 is disposed is provided in the second flow paths 33.

[0070] The cooling fluid circulation impeller 34a is attached to the drive shaft 10a of the motor 10 (see FIG. 1), and is driven (rotated) by the motor 10. The cooling fluid circulation impeller 34a is driven to generate a flow in the Z1 direction along the drive shaft 10a. The cooling fluid circulation pump chamber 34 (cooling fluid circulation impeller 34a) is disposed between the motor 10 (excluding the drive shaft 10a) and the oil chamber 15. The cooling fluid circulation impeller 34a is an axial flow impeller that allows the cooling fluid to flow in and out along the axial direction (Z direction) of the drive

shaft 10a.

[0071] As shown in FIG. 1, the second flow paths 33 each include the flow path 33a provided on the upstream side of the cooling fluid circulation pump chamber 34 and a motor lower flow path 33b provided on the downstream side of the cooling fluid circulation pump chamber 34.

[0072] The second flow paths 33 each allow the cooling fluid to flow through the flow path 33a, the cooling fluid circulation pump chamber 34, and the motor lower flow path 33b in this order such that the cooling fluid is sent from the heat exchange chamber 31 to the motor cooling chamber 30.

[0073] The flow path 33a includes a first portion 133a that extends in the axial direction (Z direction) of the drive shaft 10a and a second portion 133b that extends inward (A2 direction side) in the radial direction of the drive shaft 10a from the end of the first portion 133a on the Z1 direction side. The first portion 133a is provided in the form of a through-hole in the oil housing 23. The second portion 133b is provided between the oil housing 23 and the cooling housing 22.

[0074] The motor lower flow path 33b extends outward (A1 direction side) in the radial direction of the drive shaft 10a along the lower surface of the motor 10 (a portion excluding the drive shaft 10a). The motor lower

flow path 33b is provided between the bearing cover 21 and the cooling housing 22. A first end of the motor lower flow path 33b on the upstream side is connected to the cooling fluid circulation pump chamber 34. A second end of the motor lower flow path 33b on the downstream side is connected to the motor cooling chamber 30 (inner cooling chamber 30b).

[0075] The second flow paths 33 allow the cooling fluid from the heat exchange chamber 31 to flow inward (A2 direction side) in the radial direction of the drive shaft 10a along the oil chamber 15 (an upper portion of the oil chamber 15) through the second portion 133b and flow into the cooling fluid circulation pump chamber 34. In addition, the second flow paths 33 allow the cooling fluid, which has been caused to flow out of the cooling fluid circulation pump chamber 34 by the cooling fluid circulation impeller 34a, to flow outward (A1 direction side) in the radial direction of the drive shaft 10a along the lower surface of the motor 10 (the portion excluding the drive shaft 10a).

[0076] Consequently, the cooling fluid flows into the motor cooling chamber 30. In other words, the second flow paths 33 allow the cooling fluid to flow in opposite directions in the radial direction (A direction) on the upstream side and the downstream side of the cooling fluid

circulation impeller 34a.

[0077] (Configuration of Oil Change Hole)

As shown in FIGS. 3 and 4, the oil housing 23 includes oil change holes 23c through which oil is changed.

[0078] The atmosphere (the outside of the submersible pump 100) communicates with the oil chamber 15 through the oil change holes 23c. Specifically, in the oil housing 23, the oil change holes 23c do not overlap with the first flow paths 32 and the second flow paths 33 provided in the oil housing 23 in the plan view (viewed in the Z direction). The oil change holes 23c extend in a direction (A direction) orthogonal to the axial direction of the drive shaft 10a. The oil change holes 23c are disposed at substantially intermediate positions of the oil housing 23 in the Z direction. The oil change holes 23c are respectively provided on both sides of the drive shaft 10a with the drive shaft 10a interposed therebetween.

[0079] (Configuration of Seal)

As shown in FIGS. 1 and 2, the oil casing 24 includes a cylindrical protrusion 24a that protrudes in the Z2 direction along the drive shaft 10a (see FIG. 1). The protrusion 24a includes an annular groove 24b recessed inward (A2 direction side) in the radial direction and that surrounds the periphery of the drive shaft 10a. The seal 4 is attached to the groove 24b. The heat exchange

chamber 31 (cooling fluid) is disposed on a first side of the seal 4, and the pump chamber 12 (fluid such as sewage water) is disposed on a second side of the seal 4. The seal 4 includes an O-ring, for example.

[0080] The cooling casing 25 includes an annular recess 25a that engages with the protrusion 24a of the oil casing 24 from the Z2 direction side and surrounds the periphery of the drive shaft 10a. The seal 4 is in contact with the inner surface of the protrusion 24a in a state in which the same is attached to the groove 24b so as to provide a watertight seal between the pump chamber 12 and the heat exchange chamber 31.

[0081] The seal 4 is provided between the cooling casing 25 and the oil casing 24, both of which are stationary with respect to each other, and thus unlike the mechanical seal 15a provided on the drive shaft 10a that is rotationally driven, it is possible to substantially reliably prevent a fluid from entering the heat exchange chamber 31 from the pump chamber 12.

[0082] A seal 4a is provided between the oil housing 23 and the oil casing 24. The seal 4a provides a watertight seal between the oil chamber 15 and the heat exchange chamber 31. Thus, the seal 4a prevents the oil in the oil chamber 15 from entering the heat exchange chamber 31. The seal 4a includes an O-ring, for example. The seal 4a

is an example of a "seal structure" in the claims.

[0083] A seal 4b is provided between the oil housing 23 and the cooling casing 25. The seal 4b provides a watertight seal between the atmosphere and the heat exchange chamber 31. The seal 4b includes an O-ring, for example. The seal 4b is an example of a "seal structure" in the claims.

[0084] An oil seal (not shown) may be provided on the top of the pump chamber 12 on the Z1 direction side along the drive shaft 10a and the lower surface of the cooling casing 25 in the Z2 direction. The oil seal can significantly reduce or prevent the fluid from rising from the pump chamber 12 toward the Z1 direction side.

[0085] (Advantageous Effects of First Embodiment)

The advantageous effects of the first embodiment are now described.

[0086] According to the first embodiment, as described above, the submersible pump 100 includes the first flow paths 32, the second flow paths 33, the motor cooling chamber 30, and the heat exchange chamber 31 through which the cooling fluid flows separately from the oil chamber 15 such that cooling of the motor 10 and lubrication of the mechanical seal 15a can be performed with separate fluids, and thus it is possible to select an optimum fluid as each of a fluid for cooling the motor 10 and a fluid for

lubricating the mechanical seal 15a. In addition, even when the fluid in the pump chamber 12 enters through the mechanical seal 15a, the fluid (oil) in the oil chamber 15 can be contaminated first, and thus contamination of the cooling fluid can be prevented. Therefore, it is possible to select an optimum fluid as each of a fluid for cooling the motor 10 and a fluid for lubricating the mechanical seal 15a, and to significantly reduce or prevent contamination of the cooling fluid.

[0087] According to the first embodiment, as described above, in the heat exchange chamber 31, the watertight seal structures (seals 4, 4a, and 4b) to the outside are provided. Accordingly, the seal structures (seals 4, 4a, and 4b) effectively prevent the entry of a fluid and air from the outside of the heat exchange chamber 31, such as the pump chamber 12 side, the atmospheric side, and the oil chamber 15 side, to the heat exchange chamber 31. Consequently, contamination of the cooling fluid can be further significantly reduced or prevented.

[0088] According to the first embodiment, as described above, the submersible pump 100 further includes the cooling fluid circulation pump chamber 34, in which the cooling fluid circulation impeller 34a for the cooling fluid driven by the motor 10 is disposed, and provided in the second flow paths 33 between the motor 10 and the oil

chamber 15. Accordingly, it is possible to dispose the cooling fluid circulation pump chamber 34 further from the pump chamber 12 than the oil chamber 15 along the drive shaft 10a, and thus in the event of fluid immersion, the infiltration destination of sewage water can be set to the oil chamber 15. Consequently, contamination of the cooling fluid can be further significantly reduced or prevented.

[0089] According to the first embodiment, as described above, the first flow paths 32 and the second flow paths 33 extend in the axial direction of the drive shaft 10a along the outer circumference of the oil chamber 15 outside the oil chamber 15 in the radial direction of the drive shaft 10a. Accordingly, as compared with the case in which the first flow paths 32 and the second flow paths 33 extend in a direction that intersects with the axial direction of the drive shaft 10a around the oil chamber 15, the lengths of the first flow paths 32 and the second flow paths 33 can be reduced, and thus it is possible to efficiently cool the motor 10 by reducing energy losses in the flow paths.

[0090] According to the first embodiment, as described above, the second flow paths 33 are disposed inside the first flow paths 32 in the radial direction of the drive shaft 10a, and the cooling fluid circulation impeller 34a

causes the cooling fluid from the heat exchange chamber 31 to flow into the cooling fluid circulation pump chamber 34 and causes the cooling fluid that has flowed out of the cooling fluid circulation pump chamber 34 to flow to the motor cooling chamber 30. Accordingly, the cooling fluid cooled in the heat exchange chamber 31 can flow through the second flow paths 33 closer to the motor 10 than the first flow paths 32 in the radial direction of the drive shaft 10a, and thus it is possible to effectively cool the motor 10.

[0091] According to the first embodiment, as described above, the submersible pump 100 further includes the oil chamber 15 including the oil change holes 23c through which the atmosphere communicates with the oil chamber 15 and provided with the oil chamber 15. Accordingly, it is possible to save time and effort to assemble a plurality of housings, as compared with the case in which the oil change holes are provided across the plurality of housings. In addition, it is possible to reduce the number of seals required to prevent oil leakage.

[0092] According to the first embodiment, as described above, in the oil housing 23, the oil change holes 23c do not overlap with the first flow paths 32 and the second flow paths 33 provided in the oil housing 23 in the plan view. Accordingly, it is possible to prevent the flow of

the cooling fluid in the first flow paths 32 and the second flow paths 33 from being obstructed by the oil change holes 23c, and to prevent the complicated structure of the oil housing 23.

[0093] According to the first embodiment, as described above, at least one first flow path 32 is provided, is disposed outside the second flow paths 33 in the radial direction of the drive shaft 10a, and has an arcuate shape that surrounds the periphery of the drive shaft 10a in the plan view. Accordingly, the first flow path 32 can be shaped to conform to the outer circumference of the motor 10.

[0094] According to the first embodiment, as described above, the submersible pump 100 further includes the oil housing 23 opened on the heat exchange chamber 31 side and provided with the oil chamber 15, the cooling casing 25 opened on the oil housing 23 side and provided with the heat exchange chamber 31, and the oil casing 24 disposed between the oil housing 23 and the cooling casing 25 and that partitions the oil chamber 15 and the heat exchange chamber 31, and the seal structure is provided between the oil casing 24 and the oil housing 23 and includes the seal 4a that provides a watertight seal between the oil chamber 15 and the heat exchange chamber 31. Accordingly, the seal 4a can provide a watertight seal between the oil

chamber 15 and the heat exchange chamber 31 so as to prevent contamination of the cooling fluid by the oil.

[0095] According to the first embodiment, as described above, the submersible pump 100 further includes the oil housing 23 provided with the oil chamber 15, the cooling casing 25 provided with the heat exchange chamber 31, the cooling housing 22 provided with the cooling fluid circulation pump chamber 34, and the bearing cover 21 provided between the cooling housing 22 and the motor 10, and the first flow paths 32 and the second flow paths 33 are formed by stacking the cooling casing 25, the oil housing 23 to which the oil casing 24 is attached, the cooling housing 22, and the bearing cover 21 in this order on the pump chamber 12. Accordingly, it is possible to easily assemble the pump body simply by stacking the cooling casing 25, the oil housing 23, the cooling housing 22, and the bearing cover 21 in this order.

[0096] According to the first embodiment, as described above, the bearing cover 21 includes the inflow ports 21a through which the second flow paths 33 communicate with the motor cooling chamber 30 and the outflow ports 21b through which the first flow paths 32 communicate with the motor cooling chamber 30, and the inflow ports 21a and the outflow ports 21b are shifted from each other in the circumferential direction of the drive shaft 10a.

Accordingly, the inflow ports 21a and the outflow ports 21b can be used as openings through which the cooling fluid flows to the motor cooling chamber 30 and as openings through which the cooling fluid flows to the heat exchange chamber 31.

[0097] According to the first embodiment, as described above, the bearing cover 21 extends along the lower surface of the motor 10, and the second flow paths 33 each include the motor lower flow path 33b that extends in the radial direction of the drive shaft 10a along the lower surface of the motor 10 between the cooling housing 22 and the bearing cover 21 and including the first end and the second end connected to the cooling fluid circulation pump chamber 34 and the motor cooling chamber 30, respectively. Accordingly, the motor 10 can also be cooled from the lower side by the cooling fluid that flows through the motor lower flow path 33b.

[0098] According to the first embodiment, as described above, the heat exchange chamber 31 includes the ribs 31a that restrict the flow of the cooling fluid that has flowed in from the outer side in the radial direction of the drive shaft 10a such that the cooling fluid flows along the drive shaft 10a and flows out from the outer side in the radial direction. The ribs 31a restrict the flow of the cooling fluid such that the cooling fluid can

flow along the drive shaft 10a (the circumferential direction of the drive shaft 10a) during driving and flow along the pump chamber 12, and thus the flow of the cooling fluid in the heat exchange chamber 31 can be rectified.

[0099] According to the first embodiment, as described above, the plurality of ribs 31a each include the gap, which serves as a portion of a flow path for the cooling fluid, at the inner end in the radial direction of the drive shaft 10a, and extend radially in the radial direction. Due to the ribs 31a, the flow path for the cooling fluid in the heat exchange chamber 31 can be formed into a shape including folding, and thus it is possible to increase the length of the flow path for the cooling fluid in the heat exchange chamber 31, and more effectively perform heat exchange between the cooling fluid and the fluid in the pump chamber 12.

[0100] [Second Embodiment]

A second embodiment is now described with reference to FIG. 6. In the second embodiment, a submersible pump 200 further includes a storage chamber 51 disposed between a cooling fluid circulation pump chamber 34 and an oil chamber 15 in addition to the configurations of the first embodiment. The same configurations as those of the first embodiment are denoted by the same reference numerals, and

description thereof is omitted.

[0101] As shown in FIG. 6, the submersible pump 200 according to the second embodiment includes the storage chamber 51 and a fluid level sensor 52 provided in the storage chamber 51.

[0102] The storage chamber 51 is disposed between a motor 10 (excluding a drive shaft 10a) and the oil chamber 15. Specifically, the storage chamber 51 is disposed between the cooling fluid circulation pump chamber 34 and the oil chamber 15. Note that the submersible pump 200 includes a lid 53 attached to an oil housing 23 from above in order to form the storage chamber 51.

[0103] The fluid level sensor 52 is a float sensor that detects a predetermined fluid level of fluids (oil and a fluid from a pump chamber 12) that have flowed into and have been stored in the storage chamber 51. A second portion 133b of a flow path 33a of each of second flow paths 33 is disposed adjacent to the storage chamber 51 on the Z1 direction side.

[0104] When the fluid level sensor 52 detects the predetermined fluid level in the storage chamber 51, the submersible pump 200 can stop the motor 10 and notify a user, for example. Thus, the submersible pump 200 can significantly reduce or prevent mixing of another fluid into a cooling fluid in a cooling fluid circulator 3.

[0105] The remaining configurations of the second embodiment are similar to those of the first embodiment.

[0106] (Advantageous Effects of Second Embodiment)

The advantageous effects of the second embodiment are now described.

[0107] According to the second embodiment, as described above, the submersible pump 200 further includes the storage chamber 51 disposed between the motor 10 and the oil chamber 15, and the fluid level sensor 52 that detects the predetermined fluid level of the fluids that have flowed into and have been stored in the storage chamber 51. Accordingly, the storage chamber 51 can significantly reduce or prevent rising of the fluids to the motor 10 side. In addition, the fluid level sensor 52 can detect oil rising and fluid immersion into the storage chamber 51. Accordingly, the maintenance work can be reliably performed before oil rising and fluid immersion into the motor 10 occurs. In addition, the fluid level sensor 52 is provided on the upper side of the oil chamber 15 such that it is possible to detect not only fluid immersion from the pump chamber 12 into the oil chamber 15 but also oil rising from the oil chamber 15 into the upper portion at an early stage.

[0108] The remaining advantageous effects of the second embodiment are similar to those of the first embodiment.

[0109] [Third Embodiment]

A third embodiment is now described with reference to FIG. 7. In the third embodiment, a submersible pump 300 includes a storage chamber 351 disposed between a cooling fluid circulation pump chamber 34 and a motor 10 (excluding a drive shaft 10a), unlike the second embodiment. The same configurations as those of the second embodiment are denoted by the same reference numerals, and description thereof is omitted.

[0110] As shown in FIG. 7, the submersible pump 300 according to the third embodiment includes the storage chamber 351 and a fluid level sensor 352 provided in the storage chamber 351.

[0111] The storage chamber 351 is disposed between the motor 10 (excluding the drive shaft 10a) and the oil chamber 15. Specifically, the storage chamber 351 is disposed between the motor 10 (excluding the drive shaft 10a) and the cooling fluid circulation pump chamber 34. The submersible pump 300 includes a lid 353 attached to a bearing cover 21 from below in order to form the storage chamber 351.

[0112] The fluid level sensor 352 is a float sensor that detects a predetermined fluid level of fluids (a cooling fluid, oil, and a fluid from a pump chamber 12) that have flowed into and have been stored in the storage

chamber 351. A motor lower flow path 33b of each of second flow paths 33 is disposed adjacent to the storage chamber 351 on the Z2 direction side.

[0113] When the fluid level sensor 352 detects the predetermined fluid level in the storage chamber 351, the submersible pump 300 can stop the motor 10 and notify a user, for example. Thus, the submersible pump 300 can significantly reduce or prevent the entry of the fluids into the motor 10 (the inside of a motor frame 10d).

[0114] The remaining configurations of the third embodiment are similar to those of the second embodiment.

[0115] (Advantageous Effects of Third Embodiment)

The advantageous effects of the third embodiment are now described.

[0116] According to the third embodiment, as described above, the storage chamber 351 and the fluid level sensor 352 are provided immediately below the motor 10 (excluding the drive shaft 10a). Accordingly, it is possible to detect oil rising and fluid immersion into the most important motor 10 immediately before.

[0117] The remaining advantageous effects of the third embodiment are similar to those of the second embodiment.

[0118] [Fourth Embodiment]

A fourth embodiment is now described with reference to FIGS. 8 and 9. In the fourth embodiment, a submersible

pump 400 includes one first flow path 432, unlike the first embodiment in which the submersible pump 100 includes the plurality of first flow paths 32. The same configurations as those of the first embodiment are denoted by the same reference numerals, and description thereof is omitted.

[0119] As shown in FIG. 8, the submersible pump 400 according to the fourth embodiment includes one first flow path 432, one second flow path 433, a heat exchange chamber 431, and an oil housing 423.

[0120] The first flow path 432 is disposed outside (A1 direction side) the second flow path 433 in the radial direction of a drive shaft 10a. The first flow path 432 has an arcuate shape (C-shape) that surrounds the periphery of the drive shaft 10a in a plan view (viewed from the Z1 direction side) (see FIG. 9). An oil change hole 23c is disposed in a C-shaped open portion of the first flow path 432. The second flow path 433 also has an arcuate shape (C-shape) similar to that of the first flow path 432 in the plan view (viewed from the Z1 direction side) (see FIG. 9). Therefore, the first flow path 432 and the second flow path 433 surround substantially the entire circumference of an oil chamber 15.

[0121] The heat exchange chamber 431 includes a flat plate-shaped horizontal rib 431a that extends in a

direction (horizontal direction) that intersects with the axial direction (Z direction) of the drive shaft 10a. The horizontal rib 431a has a gap at the end on the A2 direction side, and forms a flow path for a cooling fluid folded in an upward-downward direction at the end on the A2 direction side. The horizontal rib 431a is an example of a "guide" in the claims.

[0122] The remaining configurations of the fourth embodiment are similar to those of the first embodiment.

[0123] (Advantageous Effects of Fourth Embodiment)

The advantageous effects of the fourth embodiment are now described.

[0124] According to the fourth embodiment, as described above, the first flow path 432 and the second flow path 433 surround substantially the entire circumference of the oil chamber 15. Accordingly, the cooling fluid can flow from substantially the entire circumference of the oil chamber 15 into the heat exchange chamber 431, and thus it is possible to ensure a large heat transfer area between the cooling fluid in the heat exchange chamber 431 and a fluid in a pump chamber 12. Consequently, it is possible to effectively perform heat exchange between the cooling fluid and the fluid in the pump chamber 12.

[0125] According to the fourth embodiment, as described above, at least one first flow path 432 is disposed

outside the second flow path 433 in the radial direction of the drive shaft 10a, and has an arcuate shape (C-shape) that surrounds the periphery of the drive shaft 10a in the plan view. Accordingly, the configuration of the first flow path 432 can be simplified.

[0126] The remaining advantageous effects of the fourth embodiment are similar to those of the first embodiment.

[0127] [Fifth Embodiment]

A fifth embodiment is now described with reference to FIG. 10. In the fifth embodiment, a submersible pump 500 includes an oil casing 24 and a cooling casing 25 integrally formed, unlike the first embodiment in which the submersible pump 100 includes one oil casing 24 and one cooling casing 25 separately from each other (i.e. the oil casing 24 and the cooling casing 25 are separate bodies). The same configurations as those of the first embodiment are denoted by the same reference numerals, and description thereof is omitted.

[0128] As shown in FIG. 10, the submersible pump 500 according to the fifth embodiment includes a casing 525 formed by integrally forming (a portion of) the oil casing 24 and (a portion of) the cooling casing 25. The casing 525 is an example of a "seal structure" or an "integral structure" in the claims.

[0129] The submersible pump 500 includes no gap between

(the portion of) the oil casing 24 and (the portion of) the cooling casing 25 or includes no seal 4, unlike the submersible pump 100 according to the first embodiment.

[0130] The remaining configurations of the fifth embodiment are similar to those of the first embodiment.

[0131] (Advantageous Effects of Fifth Embodiment)

The advantageous effects of the fifth embodiment are now described.

[0132] According to the fifth embodiment, as described above, the submersible pump 500 further includes an oil housing 23 opened on the heat exchange chamber 31 side and provided with an oil chamber 15, a cooling casing 25 opened on the oil housing 23 side and provided with the heat exchange chamber 31, and the oil casing 24 disposed between the oil housing 23 and the cooling casing 25 and that partitions the oil chamber 15 and the heat exchange chamber 31, and the seal structure includes a casing 525 in which the cooling casing 25 and the oil casing 24 are integrally formed. Accordingly, it is possible to improve the watertightness of the heat exchange chamber 31 by reducing the number of portions that require seals. Consequently, the apparatus configuration can be further simplified.

[0133] The remaining advantageous effects of the fifth embodiment are similar to those of the first embodiment.

[0134] [Sixth Embodiment]

A sixth embodiment is now described with reference to FIG. 11. In the sixth embodiment, a cooling fluid flows in a direction opposite to that in the first embodiment. The same configurations as those of the first embodiment are denoted by the same reference numerals, and description thereof is omitted.

[0135] As shown in FIG. 11, a submersible pump 600 according to the sixth embodiment includes a cooling fluid circulation impeller 634a.

[0136] The cooling fluid circulation impeller 634a is attached to a drive shaft 10a of a motor 10, and is driven (rotated) by the motor 10. The cooling fluid circulation impeller 634a has the same shape as that of the cooling fluid circulation impeller 34a (see FIG. 1) according to the first embodiment and is disposed at the same position as that of the cooling fluid circulation impeller 34a (see FIG. 1) according to the first embodiment, but the cooling fluid circulation impeller 634a is attached upside down to the drive shaft 10a. Therefore, the cooling fluid circulation impeller 634a is driven to generate a flow toward a Z2 direction (oil chamber 15) along the drive shaft 10a.

[0137] The remaining configurations of the sixth embodiment are similar to those of the first embodiment.

[0138] (Advantageous Effects of Sixth Embodiment)

The advantageous effects of the sixth embodiment are now described.

[0139] According to the sixth embodiment, as described above, second flow paths 33 are disposed inside first flow paths 32 in the radial direction of the drive shaft 10a, and the cooling fluid circulation impeller 634a causes the cooling fluid from a motor cooling chamber 30 to flow into the cooling fluid circulation pump chamber 34 and causes the cooling fluid that has flowed out of the cooling fluid circulation pump chamber 34 to flow to a heat exchange chamber 31. Accordingly, the cooling fluid can be caused to flow toward the heat exchange chamber 31 side opposite to the motor 10 (excluding the drive shaft 10a) by the cooling fluid circulation impeller 634a, and thus it is possible to set the motor 10 side to a negative pressure and effectively significantly reduce or prevent fluid immersion into the motor 10.

[0140] The remaining advantageous effects of the sixth embodiment are similar to those of the first embodiment.

[0141] [Seventh Embodiment]

A seventh embodiment is now described with reference to FIGS. 12 and 13. In the seventh embodiment, an oil chamber 15 and a heat exchange chamber 731 are aligned in the radial direction (A direction) of a drive shaft 10a,

unlike the first embodiment in which the oil chamber 15 and the heat exchange chamber 31 are aligned in the axial direction (Z direction) of the drive shaft 10a. The same configurations as those of the first embodiment are denoted by the same reference numerals, and description thereof is omitted.

[0142] As shown in FIG. 12, a submersible pump 700 according to the seventh embodiment includes a cooling casing 725 and the heat exchange chamber 731.

[0143] The cooling casing 725 includes a circular opening 725a on the inner side (A2 direction side) in the radial direction of a drive shaft 10a, and an oil casing 24 is fitted in the opening. Therefore, the heat exchange chamber 731 is disposed on the outer side (A1 direction side) in the radial direction of the drive shaft 10a. The cooling casing 725 is formed such that the position of the heat exchange chamber 731 in the axial direction (Z direction) of the drive shaft 10a overlaps with the position of the oil chamber 15 in the axial direction of the drive shaft 10a. That is, the heat exchange chamber 731 and the oil chamber 15 are disposed side by side in a transverse direction.

[0144] The remaining configurations of the seventh embodiment are similar to those of the first embodiment.

[0145] (Advantageous Effects of Seventh Embodiment)

The Advantageous effects of the seventh embodiment are now described.

[0146] According to the seventh embodiment, as described above, the cooling casing 725 is formed such that the position of the heat exchange chamber 731 in the axial direction overlaps with the position of the oil chamber 15 in the axial direction. Accordingly, as compared with the case in which the heat exchange chamber 731 and the oil chamber 15 do not overlap with each other in the axial direction of the drive shaft 10a and are disposed along the drive shaft 10a, the length of the drive shaft 10a can be reduced. That is, the apparatus can be downsized in the axial direction.

[0147] The remaining advantageous effects of the seventh embodiment are similar to those of the first embodiment.

[0148] [Eighth Embodiment]

An eighth embodiment is now described with reference to FIGS. 14 and 15. In the eighth embodiment, a submersible pump 800 includes one first flow path 832, similarly to the fourth embodiment but unlike the seventh embodiment. The same configurations as those of the seventh embodiment are denoted by the same reference numerals, and description thereof is omitted.

[0149] As shown in FIG. 14, the submersible pump 800

according to the eighth embodiment includes one first flow path 832, a heat exchange chamber 831, and a cooling casing 825.

[0150] The first flow path 832 is disposed outside (A1 direction side) a second flow path 833 in the radial direction of a drive shaft 10a. The first flow path 832 has an arcuate shape (C-shape) that surrounds the periphery of the drive shaft 10a in a plan view (viewed from the Z1 direction side) (see FIG. 9). Note that an oil change hole 23c (see FIG. 9) is disposed in a C-shaped open portion of the first flow path 832.

[0151] The heat exchange chamber 831 includes a flat plate-shaped horizontal rib 831a that extends in a direction (horizontal direction) that intersects with the axial direction (Z direction) of the drive shaft 10a. The horizontal rib 831a includes a gap at the end on the A2 direction side and forms a flow path for a cooling fluid folded in an upward-downward direction at the end on the A2 direction side. The horizontal rib 831a is an example of a "guide" in the claims.

[0152] As shown in FIG. 15, a plurality of (six) openings 825a aligned in the circumferential direction of the drive shaft 10a and connected to the first flow path 832 are provided on an upper portion of the cooling casing 825. Furthermore, the cooling casing 825 and an oil

casing 24 are combined such that a plurality of (six) openings 826 aligned in the circumferential direction of the drive shaft 10a and connected to the second flow path 833 are formed on the upper portion of the cooling casing 825 inside (A2 direction side) the openings 825a in the radial direction. In a flow path that forms the heat exchange chamber 831, an opening 825b disposed on the downstream side of the openings 825a and that communicates with the opening 825a is provided.

[0153] The remaining configurations of the eighth embodiment are similar to those of the first embodiment.

[0154] (Advantageous Effects of Eighth Embodiment)

The advantageous effects of the eighth embodiment are similar to those of the fourth and seventh embodiments.

[0155] [Ninth Embodiment]

A ninth embodiment is now described with reference to FIGS. 16 to 18. In the ninth embodiment, a heat exchange chamber 931 is disposed radially outside (A1 direction side) a pump chamber 12, unlike the first embodiment in which the heat exchange chamber 31 is disposed between the pump chamber 12 and the oil chamber 15 in the Z direction. The same configurations as those of the first embodiment are denoted by the same reference numerals, and description thereof is omitted.

[0156] As shown in FIG. 16, a submersible pump 900

according to the ninth embodiment includes a cooling casing 925, the heat exchange chamber 931, and a pump casing 913.

[0157] The cooling casing 925 includes an upper cooling casing 925a and a lower cooling casing 925b.

[0158] The upper cooling casing 925a is disposed radially outside (A1 direction side) the pump casing 913 and surrounds an upper portion of the pump casing 913. The lower cooling casing 925b is disposed radially outside (A1 direction side) the pump casing 913 and surrounds a lower portion of the pump casing 913. Note that the pump casing 913 includes two members of a main body 913a that surrounds an impeller 14 and a pipe 913b that forms a fluid discharge flow path.

[0159] The heat exchange chamber 931 surrounds substantially the entire circumference of the periphery of a pump chamber 12 radially outside (A1 direction side) the pump chamber 12. Specifically, the heat exchange chamber 931 is provided between the pump casing 913 and the cooling casing 925. In FIG. 17, illustration of the impeller 14 is omitted.

[0160] As shown in FIG. 18, the heat exchange chamber 931 includes a plurality of ribs 931a that radially extend in a plan view and a plurality of (six) regions circumferentially aligned. Specifically, the heat

exchange chamber 931 includes a plurality of (three) regions 931b and a plurality of (three) regions 931c. The ribs 931a are examples of a "guide" in the claims.

[0161] In the regions 931b, a cooling fluid flows in from first flow paths 32 and flows downward (Z2 direction). In the regions 931c, the cooling fluid flows in from the regions 931b at the end in the Z2 direction, flows upward (Z1 direction), and flows out to second flow paths 33. The regions 931b and the regions 931c are partitioned by the ribs 931a and are circumferentially alternately disposed. The ribs 931a are provided on the outer circumference of each of the pump casing 913 and an oil casing 24.

[0162] As shown in FIG. 16, a plurality of (two) seals 4c are provided between the pump casing 913 and the cooling casing 925. A seal 4c provides a watertight seal between the atmosphere and the heat exchange chamber 931. The seal 4c includes an O-ring, for example. The seal 4c is an example of a "seal structure" in the claims.

[0163] A seal 4d is provided between the pump casing 913 and the oil casing 24. The seal 4d provides a watertight seal between the pump chamber 12 and the heat exchange chamber 931. The seal 4d includes an O-ring, for example. The seal 4d is an example of a "seal structure" in the claims.

[0164] A seal 4e is provided between the main body 913a and the pipe 913b. The seal 4e provides a watertight seal between the pump chamber 12 and the heat exchange chamber 931. The seal 4e includes an O-ring, for example. The seal 4e is an example of a "seal structure" in the claims.

[0165] A seal 4f is provided between the upper cooling casing 925a and the lower cooling casing 925b. The seal 4f provides a watertight seal between the atmosphere and the heat exchange chamber 931. The seal 4f includes a packing, for example. The seal 4f is an example of a "seal structure" in the claims.

[0166] The remaining configurations of the eighth embodiment are similar to those of the first embodiment.

[0167] (Advantageous Effects of Ninth Embodiment)

The advantageous effects of the ninth embodiment are now described.

[0168] According to the ninth embodiment, as described above, the heat exchange chamber 931 surrounds the pump chamber 12 radially outside (A1 direction side) the pump chamber 12. Accordingly, it is possible to ensure a large heat transfer area between the heat exchange chamber 931 and the pump chamber 12, using substantially the entire outer circumference of the pump casing 913, and thus heat exchange can be effectively performed. In addition, it is possible to effectively perform heat exchange between the

cooling fluid in the heat exchange chamber 931 and a fluid outside the submersible pump 900. Furthermore, the heat exchange chamber 931 can be disposed at a relatively low position, and thus even when the fluid level outside the submersible pump 900 is lower, it is possible to perform heat exchange more effectively between the cooling fluid in the heat exchange chamber 931 and the fluid outside the submersible pump 900. Furthermore, as compared with the case in which the heat exchange chamber 931 and the pump chamber 12 do not overlap with each other in the axial direction of a drive shaft 10a and are disposed along the drive shaft, the length of the drive shaft 10a can be reduced. That is, the apparatus can be downsized in the axial direction.

[0169] The remaining advantageous effects of the ninth embodiment are similar to those of the first embodiment.

[0170] [Modified Examples]

The embodiments disclosed this time must be considered as illustrative in all points and not restrictive. The scope of the present invention is not shown by the above description of the embodiments but by the scope of claims for patent, and all modifications (modified examples) within the meaning and scope equivalent to the scope of claims for patent are further included.

[0171] For example, while the example in which the submersible pump is a vertical pump has been shown in each of the aforementioned first to ninth embodiments, the present invention is not restricted to this. According to the present invention, the submersible pump may be a horizontal pump.

[0172] While the example in which the number of first flow paths (second flow paths) is one or three has been shown in each of the aforementioned first to ninth embodiments, the present invention is not restricted to this. According to the present invention, the number of first flow paths (second flow paths) may be two, four or more.

[0173] While the example in which the cooling fluid circulation pump chamber (cooling fluid circulation impeller) is provided between the motor (excluding the drive shaft) and the oil chamber has been shown in each of the aforementioned first to ninth embodiments, the present invention is not restricted to this. According to the present invention, the cooling fluid circulation pump chamber (cooling fluid circulation impeller) may be provided between the oil chamber and the pump chamber, for example.

[0174] While the example in which the first flow path(s) linearly extends in the axial direction of the

drive shaft has been shown in each of the aforementioned first to ninth embodiments, the present invention is not restricted to this. According to the present invention, the first flow path(s) may not linearly extend in the axial direction of the drive shaft but may be bent between the heat exchange chamber and the motor cooling chamber.

[0175] While the example in which the cooling fluid flows out of the inside of the motor cooling chamber has been shown in each of the aforementioned first to fifth and seventh to ninth embodiments, the present invention is not restricted to this. According to the present invention, the cooling fluid may flow in from the outside of the motor cooling chamber.

[0176] While the example in which the submersible pump includes all of the configurations corresponding to the first housing, the second housing, the third housing, and the fourth housing according to the present invention has been shown in each of the aforementioned first to eighth embodiments, the present invention is not restricted to this. According to the present invention, the submersible pump may include only some of the first housing, the second housing, the third housing, and the fourth housing according to the present invention.

[0177] While the example in which the submersible pump includes the electrode sensor in the oil chamber has been

shown in each of the aforementioned first to ninth embodiments, the present invention is not restricted to this. According to the present invention, the submersible pump may not include the electrode sensor in the oil chamber. Alternatively, according to the present invention, the submersible pump may include an electrode sensor or a float fluid level sensor in the motor, and detect fluid immersion into the motor.

[0178] While the example in which the submersible pump includes the axial flow impeller as a cooling fluid circulation impeller has been shown in each of the aforementioned first to ninth embodiments, the present invention is not restricted to this. According to the present invention, the submersible pump may include an impeller of a type different from the axial flow sensor, such as a centrifugal impeller, as a cooling fluid circulation impeller.

[0179] While the example in which the ribs are radially formed in the plan view has been shown in each of the aforementioned first to third and fifth to seventh embodiments, the present invention is not restricted to this. According to the present invention, the ribs may be meanderingly or arcuately formed in the plan view, for example.

[0180] While the example in which the O-ring is used as

a seal has been shown in each of the aforementioned first to ninth embodiments, the present invention is not restricted to this. According to the present invention, an elastic member other than the O-ring may be used as a seal, for example.

[0181] While the example in which the heat exchange chamber is disposed above the pump chamber has been shown in each of the aforementioned first to eighth embodiments, and the example in which the heat exchange chamber is disposed radially outside the pump chamber has been shown in the ninth embodiment, the present invention is not restricted to this. According to the present invention, the heat exchange chamber may be disposed both above the pump chamber and radially outside the pump chamber.

[0182] While the example in which the heat exchange chamber is provided on substantially the entire outer circumference of the pump casing has been shown in the aforementioned ninth embodiment, the present invention is not restricted to this. According to the present invention, the heat exchange chamber may partially overlap with the outer circumference of the pump casing.

[0183] While the example in which the pump casing includes two members of the main body that surrounds the impeller and the pipe that forms the fluid discharge flow path has been shown in the aforementioned ninth embodiment,

the present invention is not restricted to this.

According to the present invention, the main body that surrounds the impeller and the pipe that forms the fluid discharge flow path may be integral and unitary with each other.

Description of Reference Numerals

[0184]

4, 4a, 4b, 4c, 4d, 4e, 4f: seal (seal structure)

10: motor

10a: drive shaft

12: pump chamber

13a: suction port

13b: discharge port

14: impeller

15: oil chamber

15a: mechanical seal

21: bearing cover (fourth housing)

21a: inflow port (motor-side first opening)

21b: outflow port (motor-side second opening)

22: cooling housing (third housing)

23, 423: oil housing (first housing)

24: oil casing (partition)

25, 725, 825, 925: cooling casing (second housing)

30: motor cooling chamber

31, 431, 731, 831, 931: heat exchange chamber

31a: rib (guide)

32, 432, 832: first flow path

33, 433, 833: second flow path

33b: motor lower flow path

34: cooling fluid circulation pump chamber

34a, 634a: cooling fluid circulation impeller

51, 351: storage chamber

52, 352: fluid level sensor

100, 200, 300, 400, 500, 600, 700, 800, 900: submersible pump

431a, 831a: horizontal rib (guide)

525: casing (seal structure, integral structure)

931a: rib (guide)

CLAIMS

[Claim 1] A submersible pump (100, 200, 300, 400, 500, 600, 700, 800, 900) comprising:

a motor (10) including a drive shaft (10a);

a pump chamber (12) in which an impeller (14) driven by the motor is disposed, and including a suction port (13a) and a discharge port (13b);

an oil chamber (15) including a mechanical seal (15a) that includes a slider and disposed between the motor and the pump chamber;

a motor cooling chamber (30) disposed adjacent to the motor and that cools the motor with a cooling fluid;

a heat exchange chamber (31, 431, 731, 831, 931) disposed adjacent to the pump chamber and that performs heat exchange between the cooling fluid and a fluid in the pump chamber by allowing the cooling fluid to flow therethrough;

a first flow path (32, 432, 832) provided outside the oil chamber in a radial direction of the drive shaft, that connects the heat exchange chamber and the motor cooling chamber, and through which the cooling fluid flows from one of the heat exchange chamber and the motor cooling chamber to the other; ~~and~~

a second flow path (33, 433, 833) provided outside

the oil chamber in the radial direction, that connects the heat exchange chamber and the motor cooling chamber, and through which the cooling fluid flows in a direction opposite to that of the first flow path; and

a cooling fluid circulation pump chamber (34), in which a cooling fluid circulation impeller (34a, 634a) for the cooling fluid driven by the motor is disposed, and provided in the second flow path between the motor and the oil chamber.

[Claim 2] The submersible pump according to claim 1, wherein in the heat exchange chamber, a watertight seal structure to an outside is provided.

~~[Claim 3] The submersible pump according to claim 1, further comprising a cooling fluid circulation pump chamber (34), in which a cooling fluid circulation impeller (34a, 634a) for the cooling fluid driven by the motor is disposed, and provided in the second flow path between the motor and the oil chamber.~~

[Claim ~~4~~ 3] The submersible pump according to claim 1 or 2, wherein the first flow path and the second flow path extend in an axial direction of the drive shaft along an outer circumference of the oil chamber outside

the oil chamber in the radial direction.

[Claim ~~5~~ 4] The submersible pump according to ~~claim 1~~ any one of claims 1 to 3, wherein at least one of the first flow path and the second flow path surrounds substantially an entire circumference of the oil chamber.

[Claim ~~6~~ 5] The submersible pump according to ~~claim 3~~ any one of claims 1 to 4, wherein

the second flow path is disposed inside the first flow path in the radial direction, and

the cooling fluid circulation impeller causes the cooling fluid from the heat exchange chamber to flow into the cooling fluid circulation pump chamber and causes the cooling fluid that has flowed out of the cooling fluid circulation pump chamber to flow to the motor cooling chamber.

[Claim ~~7~~ 6] The submersible pump according to ~~claim 3~~ any one of claims 1 to 4, wherein

the second flow path is disposed inside the first flow path in the radial direction, and

the cooling fluid circulation impeller causes the cooling fluid from the motor cooling chamber to flow into the cooling fluid circulation pump chamber and causes the

cooling fluid that has flowed out of the cooling fluid circulation pump chamber to flow to the heat exchange chamber.

[Claim ~~8~~ 7] The submersible pump according to ~~claim 1~~ any one of claims 1 to 6, further comprising a single first housing (23, 423) including an oil change hole through which the atmosphere communicates with the oil chamber, and provided with the oil chamber.

[Claim ~~9~~ 8] The submersible pump according to claim ~~8~~ 7, wherein in the first housing, the oil change hole does not overlap with the first flow path and the second flow path provided in the first housing in a plan view.

[Claim ~~10~~ 9] The submersible pump according to ~~claim 1~~ any one of claims 1 to 8, wherein the first flow path includes at least one first flow path, is disposed outside the second flow path in the radial direction, and has an arcuate shape that surrounds a periphery of the drive shaft in a plan view.

[Claim ~~11~~ 10] The submersible pump according to claim 2, further comprising:

a first housing (23, 423) opened on the heat exchange chamber side and provided with the oil chamber;

a second housing (25, 725, 825, 925) opened on the first housing side and provided with the heat exchange chamber; and

a partition (24) disposed between the first housing and the second housing and that partitions the oil chamber and the heat exchange chamber, wherein

the seal structure is provided between the first housing and the partition and includes a seal that provides a watertight seal between the oil chamber and the heat exchange chamber.

[Claim ~~12~~ 11] The submersible pump according to claim 2, further comprising:

a first housing (23, 423) opened on the heat exchange chamber side and provided with the oil chamber;

a second housing (25, 725, 825, 925) opened on the first housing side and provided with the heat exchange chamber; and

a partition (24) disposed between the first housing and the second housing and that partitions the oil chamber and the heat exchange chamber, wherein

the seal structure includes an integral structure in which the second housing and the partition are integrally

formed.

[Claim ~~13~~ 12] The submersible pump according to ~~claim 3~~ any one of claims 1 to 11, further comprising:

a first housing (23, 423) provided with the oil chamber;

a second housing (25, 725, 825, 925) provided with the heat exchange chamber;

a third housing (22) provided with the cooling fluid circulation pump chamber; and

a fourth housing (21) provided between the third housing and the motor, wherein

the first flow path and the second flow path are formed by stacking the second housing, the first housing, the third housing, and the fourth housing in this order on the pump chamber.

[Claim ~~14~~ 13] The submersible pump according to claim ~~13~~ 12, wherein

the fourth housing includes a motor-side first opening (21a) through which the first flow path communicates with the motor cooling chamber and a motor-side second opening (21b) through which the second flow path communicates with the motor cooling chamber, and

the motor-side first opening and the motor-side

second opening are shifted from each other in a circumferential direction of the drive shaft.

[Claim ~~15~~ 14] The submersible pump according to claim 12 or 13, wherein

the fourth housing extends along a lower surface of the motor, and

the second flow path includes a motor lower flow path (33b) that extends in the radial direction along the lower surface of the motor between the third housing and the fourth housing and including a first end and a second end connected to the cooling fluid circulation pump chamber and the motor cooling chamber, respectively.

[Claim ~~16~~ 15] The submersible pump according to ~~claim 13~~ any one of claims 12 to 14, wherein the second housing is formed such that a position of the heat exchange chamber in an axial direction of the drive shaft overlaps with a position of the oil chamber in the axial direction.

[Claim ~~17~~ 16] The submersible pump according to ~~claim 1~~ any one of claims 1 to 15, wherein the heat exchange chamber includes a guide (31a, 431a, 831a, 931a) that restricts a flow of the cooling fluid that has flowed in from an outer side in the radial direction such that the

cooling fluid flows along the drive shaft and flows out from the outer side in the radial direction.

[Claim ~~18~~ 17] The submersible pump according to claim ~~17~~ 16, wherein the guide includes a plurality of ribs (31a) each including a gap, which serves as a portion of a flow path for the cooling fluid, at an inner end in the radial direction, and each extending radially in the radial direction.

[Claim ~~19~~ 18] The submersible pump according to ~~claim 1~~ any one of claims 1 to 17, further comprising:

a storage chamber (51, 351) disposed between the motor and the oil chamber; and

a fluid level sensor (52, 352) that detects a predetermined fluid level of a fluid that has flowed into and has been stored in the storage chamber.

[Claim ~~20~~ 19] The submersible pump according to ~~claim 1~~ any one of claims 1 to 18, wherein the heat exchange chamber is provided outside the pump chamber in the radial direction.