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VEHICLE PUMP ASSEMBLY AND OFF-ROAD VEHICLE

Abstract

A vehicle pump assembly **13** includes a pump **30** having a mechanical seal **35** sealing a cooling medium and a drain hose **50** attached to the pump **30**. The pump **30** includes an introduction chamber **40** separated by the mechanical seal **35** and configured such that the cooling medium having leaked from the mechanical seal **35** is introduced thereinto, and the drain hose **50** communicates with the introduction chamber **40**. The internal volume of the drain hose **50** is three times the volume of the introduction chamber **40** or more.

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Background/Summary

FIELD
[0001] The technique disclosed here relates to a vehicle pump assembly and an off-road vehicle.
BACKGROUND
[0002] U.S. Patent Application Publication No. 2006/0278451 discloses a vehicle pump assembly. The vehicle pump assembly has a pump that supplies coolant water to an engine.
SUMMARY
[0003] The pump of the vehicle pump assembly as described above has a mechanical seal that seals the coolant water. The pump has an introduction chamber into which the coolant water having leaked from the mechanical seal is introduced. The introduction chamber communicates with the outside through a water drain hole. The coolant water introduced into the introduction chamber is discharged to the outside through the water drain hole.
[0004] For example, when a user drives a vehicle and the pump is exposed to outside water accumulated on the ground, such as muddy water, there is a probability that the outside water is sucked through the water drain hole and the sucked outside water enters the introduction chamber of the pump.
[0005] The technique disclosed here has been made in view of the above-described point, and an object thereof is to reduce entrance of the outside water into the introduction chamber of the pump.
[0006] A vehicle pump assembly disclosed here includes a pump having a mechanical seal sealing a cooling medium and a drain hose attached to the pump. The pump includes an introduction chamber separated by the mechanical seal and configured such that the cooling medium having leaked from the mechanical seal is introduced thereinto, and the drain hose communicates with the introduction chamber. The internal volume of the drain hose is three times the volume of the introduction chamber or more.
[0007] An off-road vehicle disclosed here includes an engine and a vehicle pump assembly that supplies a cooling medium to the engine. The vehicle pump assembly includes a pump having a mechanical seal sealing the cooling medium and attached to the engine, and a drain hose attached to the pump. The pump includes an introduction chamber separated by the mechanical seal and configured such that the cooling medium having leaked from the mechanical seal is introduced thereinto, and the drain hose communicates with the introduction chamber. The internal volume of the drain hose is three times the volume of the introduction chamber or more.
[0008] The above-described vehicle pump assembly can be configured such that entrance of outside water into the introduction chamber of the pump is reduced.
[0009] The above-described off-road vehicle can be configured such that entrance of outside water into the introduction chamber of the pump is reduced.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0010] FIG. **1** is a left side view of a utility vehicle according to an embodiment.
[0011] FIG. **2** is a bottom view of the utility vehicle from below.
[0012] FIG. **3** is a perspective view showing, from below, an engine, a vehicle pump assembly, and an oil pan.
[0013] FIG. **4** is a bottom view showing, from below, a support attached to the oil pan with a bolt.
[0014] FIG. **5** is a sectional view of the vehicle pump assembly attached to the engine.
[0015] FIG. **6** is a sectional view of a drain hose and a joint.
[0016] FIG. **7** is a sectional view showing such a model that an introduction chamber of a pump and an internal space of the drain hose are simulatively reproduced.
[0017] FIG. **8** is a graph showing a relationship between the ratio (B/A) of the volume B of an internal space of a hose to the volume A of an internal space of a case and the ratio (C/B) of the

amount C of water sucked into the hose to the volume B of the internal space of the hose.
[0018] FIG. **9** is a schematic side view showing an engine, a vehicle pump assembly, and a vehicle body frame in a utility vehicle according to a modification.

DESCRIPTION OF EMBODIMENTS

[0019] Hereinafter, an exemplary embodiment will be described in detail with reference to the drawings. FIG. **1** is a left side view of a utility vehicle **100**. The utility vehicle **100** can travel off road. The utility vehicle **100** is one example of an off-road vehicle. Hereinafter, the utility vehicle **100** will also be merely referred to as a "vehicle **100**."
[0020] In the present disclosure, each component of the vehicle **100** will be described using a direction with respect to the vehicle **100**. Specifically, a "front" means the front of the vehicle **100** in a vehicle front-rear direction, and a "rear" means the rear of the vehicle **100** in the vehicle front-rear direction. A "left" means the left when facing the front of the vehicle **100**, and a "right" means the right when facing the front of the vehicle **100**. A "width direction" means the vehicle width direction of the vehicle **100**, and in other words, means the right-left direction of the vehicle **100** and will also be referred to as a "right-left direction." A "vehicle-width inside" means a vehicle interior side in the width direction, and a "vehicle-width outside" means a vehicle outer side in the width direction. Each direction with respect to a vehicle pump assembly **13** is coincident with a corresponding direction with respect to the vehicle **100** when the vehicle pump assembly **13** is incorporated into the vehicle **100**. For example, the front-rear direction of the vehicle pump assembly **13** is coincident with the front-rear direction of the vehicle **100** when the vehicle pump assembly **13** is incorporated into the vehicle **100**.
[0021] The vehicle **100** includes a vehicle body frame **2**, right and left front wheels **3** supporting a front portion of the vehicle body frame **2**, and right and left rear wheels **4** supporting a rear portion of the vehicle body frame **2**. That is, the vehicle **100** is a four-wheeled automobile. A space between the right and left front wheels **3** is covered with a hood **5** from above. Right and left seats **6** supported on the vehicle body frame **2** are located on the rear side of the hood **5**.
[0022] The vehicle body frame **2** includes hollow pipes **20**, and the pipes **20** are connected into the frame. The vehicle body frame **2** has a cabin frame **2***a* defining a vehicle interior **7** in which the seats **6** are located. Entrances are opened on both right and left sides of the vehicle interior **7**, and are closed with doors **8**. A dashboard **9** is located in front of the seats **6** in the vehicle interior **7**. A steering wheel **10** is attached to the dashboard **9**. A cargo bed **11** is located in rear of the cabin frame **2***a*. The cargo bed **11** includes a recessed loading space opened upward.
[0023] The vehicle **100** has an engine **12** and the vehicle pump assembly **13**. The engine **12** is located in rear of the seats **6** and below the cargo bed **11**. That is, the engine **12** is positioned between the front wheels **3** and the rear wheels **4**. The vehicle pump assembly **13** is attached to the engine **12** to supply a cooling medium to the engine **12**. The vehicle **100** further has an oil pan **14**, and the oil pan **14** is attached to the engine **12** to store engine oil. The oil pan **14** is attached to a lower portion of the engine **12**, specifically the bottom of the engine **12**. A transmission that changes an output engine speed is attached to the engine **12**. A radiator that cools the cooling medium is coupled to the engine **12**. The cooling medium is, for example, coolant water, but may be other cooling media.
[0024] FIG. **2** is a bottom view of the vehicle **100** from below. FIG. **2** mainly shows the vehicle body frame **2**, the rear wheels **4**, the engine **12**, the vehicle pump assembly **13**, and the oil pan **14**. FIG. **3** is a perspective view of the engine **12**, the vehicle pump assembly **13**, and the oil pan **14** from below.
[0025] The vehicle pump assembly **13** has a pump **30** attached to the engine **12** and a drain hose **50** attached to the pump **30**.
[0026] The pump **30** is attached to an engine case **121** of the engine **12**. The engine case **121** is, for example, a crankcase. The pump **30** is, for example, a centrifugal pump, and circulates the cooling medium between the engine **12** and the radiator. For the sake of convenience, a pipe connecting the

pump **30** and the engine **12** to each other and a pump connecting the pump **30** and the radiator to each other are not shown in FIGS. **2** and **3**.

[0027] The drain hose **50** discharges the cooling medium having leaked from the pump **30** to the outside. The material of the drain hose **50** is, for example, a rubber material such as ethylene propylene diene methylene linkage (EPDM). The drain hose **50** has flexibility, for example. The drain hose **50** has an inlet **51** and an outlet **52**. The inlet **51** is connected to the pump **30**, and the outlet **52** is opened to the outside. The drain hose **50** causes the cooling medium to flow from the inlet **51** to the outlet **52**.

[0028] The outlet **52** of the drain hose **50** faces the rear of the vehicle. Specifically, the drain hose **50** extends in the front-rear direction such that the inlet **51** is positioned in front and the outlet **52** is positioned in rear.

[0029] The drain hose **50** is continuously inclined so as to be positioned lower as extending to the outlet **52**. Specifically, a portion of the drain hose **50** in the vicinity of the inlet **51** extends substantially in the vertical direction. A portion of the drain hose **50** between the portion in the vicinity of the inlet **51** and the outlet **52** is inclined with a substantially constant inclination. Note that the inclination may be changed in the middle in the portion of the drain hose **50** between the portion in the vicinity of the inlet **51** and the outlet **52**.

[0030] The outlet **52** of the drain hose **50** is positioned, as viewed from below, between the rear end of the engine **12** and the front ends of the rear wheels **4**. Specifically, as viewed from below, the outlet **52** is positioned in rear with respect to the rear end of the engine **12** and in front with respect to the front ends of the rear wheels **4**. Note that the outlet **52** may be positioned, as viewed from below, in front with respect to axles **4***a* of the rear wheels **4**.

[0031] The drain hose **50** is supported by a support **60**. The support **60** is, for example, a clamp. Specifically, the support **60** supports the drain hose **50** on the side closer to the inlet **51** with respect to an intermediate portion **53** of the drain hose **50**. The support **60** is attached to the oil pan **14**.

[0032] A peripheral wall **141** of the oil pan **14** includes a recess **141***a*, and the support **60** is attached to the recess **141***a*. Specifically, the recess **141***a* is opened to the front and the left as viewed from below. That is, the peripheral wall **141** is, as viewed from below, in such a shape that one corner portion of a substantially rectangular shape is cut out.

[0033] The support **60** is fixed to the oil pan **14** with a bolt **15**. The bolt **15** also serves as, for example, a bolt for attaching the oil pan **14** to the engine case **121**. Note that the bolt **15** may be a bolt only for attaching the support **60** to the oil pan **14**.

[0034] The support **60** is obtained in such a manner that a metal plate is bent. The support **60** has an attachment **61** fastened to the oil pan **14** with the bolt **15** and a support **62** supporting the drain hose **50**. The support **62** is bent in a U-shape. The drain hose **50** penetrates the support **62**, and is hooked on the support **62**.

[0035] FIG. **4** is a bottom view showing, from below, the support **60** attached to the oil pan **14** with the bolt **15**. The peripheral wall **141** has a stepped portion **141***b* expanding in the horizontal direction, and the bolt **15** is attached to the stepped portion **141***b*. The axis **15***a* of the bolt **15** is coincident with the vertical direction, i.e., an up-down direction. As viewed in the direction of the axis **15***a*, the support **60** has an end portion **65** (hereinafter also referred to as a fastening-side end portion **65**) positioned in a fastening direction F of the bolt **15**. The fastening-side end portion **65** contacts the inner surface of the recess **141***a* as viewed in the direction of the axis **15***a*. In this example, the fastening-side end portion **65** is equivalent to an end portion of the support **62**.

[0036] FIG. **5** is a sectional view of the vehicle pump assembly **13** attached to the engine **12**. The pump **30** has a pump housing **31** and a pump cover **32**. The pump housing **31** is attached to the engine case **121**. A boss **310** of the pump housing **31** is inserted into a hole of the engine case **121**. The pump cover **32** is attached to the pump housing **31**. The pump cover **32** includes a suction port **321** and a discharge port **322**. The suction port **321** communicates with the radiator, and the cooling medium is sucked into the suction port **321** from the radiator. The discharge port **322**

communicates with a jacket (not shown) of the engine **12**, and the cooling medium is discharged to the engine **12** from the discharge port **322**.

[0037] The pump housing **31** includes a shaft insertion hole **311** through which the boss **310** penetrates. A pump shaft **33** is inserted into the shaft insertion hole **311**. A bearing **37** is located between the pump shaft **33** and the boss **310** of the pump housing **31**. That is, the pump shaft **33** is rotatably supported on the boss **310** of the pump housing **31** through the bearing **37**.

[0038] A first end portion of the pump shaft **33** protrudes into the pump cover **32**. Specifically, in the pump cover **32**, the first end portion of the pump shaft **33** is located in a region where the cooling medium is housed. On the other hand, a second end portion of the pump shaft **33** protrudes into the engine case **121**. Specifically, in the engine case **121**, the second end portion of the pump shaft **33** is located in a region where the engine oil is housed.

[0039] An impeller **34** is fixed to the first end portion of the pump shaft **33**. The impeller **34** is located in the pump cover **32**. The impeller **34** rotates together with the pump shaft **33**.

[0040] A transmission shaft **39** is coupled to the second end portion of the pump shaft **33**. The transmission shaft **39** is coupled to a crankshaft, for example, through a gear. With this configuration, rotation of the crankshaft is transmitted to the pump shaft **33** through the gear and the transmission shaft **39**, and the impeller **34** rotates along with rotation of the pump shaft **33**.

[0041] The pump **30** has a mechanical seal **35** and an oil seal **36**. The mechanical seal **35** and the oil seal **36** are located between the pump housing **31** and the pump shaft **33**. The mechanical seal **35** is located on the side closer to the first end portion of the pump shaft **33** with respect to the oil seal **36**. The mechanical seal **35** seals the cooling medium in the pump cover **32**. The oil seal **36** seals the engine oil in the engine case **121**.

[0042] The mechanical seal **35** has a rotary seal **351** and a fixed seal **352**. The rotary seal **351** is fixed to the impeller **34**, and rotates together with the pump shaft **33** and the impeller **34**. The fixed seal **352** is fixed to the pump housing **31**, and does not rotate together with the pump shaft **33**. The fixed seal **352** elastically contacts the rotary seal **351** by biasing of a spring included in the fixed seal **352**. Contact between the rotary seal **351** and the fixed seal **352** prevents the cooling medium in the pump cover **32** from leaking to the side closer to the second end portion of the pump shaft **33**.

[0043] The oil seal **36** is fixed to the pump housing **31**, and does not rotate together with the pump shaft **33**. The oil seal **36** elastically contacts the pump shaft **33**. Contact between the oil seal **36** and the pump shaft **33** prevents the engine oil in the engine case **121** from leaking to the side closer to the first end portion of the pump shaft **33**.

[0044] The pump **30** includes an introduction chamber **40**. For the sake of simple illustration of the introduction chamber **40**, the introduction chamber **40** is hatched with dots in FIG. **5**. The introduction chamber **40** is separated by the mechanical seal **35** and the oil seal **36**, and the cooling medium having leaked from the mechanical seal **35** is introduced into the introduction chamber **40**. The cooling medium introduced into the introduction chamber **40** is not limited to a liquid cooling medium (for example, coolant water), and includes a vaporized cooling medium (for example, vapor). The introduction chamber **40** discharges the introduced cooling medium to the outside of the pump **30**.

[0045] Specifically, the pump housing **31** includes an introduction space **312** separated by the mechanical seal **35** and the oil seal **36** and configured such that the cooling medium having leaked from the mechanical seal **35** is introduced thereinto. The introduction space **312** is a space defined by the pump housing **31**, the pump shaft **33**, the mechanical seal **35**, the oil seal **36**, and the impeller **34**.

[0046] The pump **30** has a joint **38**. The joint **38** is inserted into the pump housing **31**, and communicates with the introduction space **312**. The joint **38** is in a tubular shape, and includes an internal space **381**. The drain hose **50** is connected to the joint **38**. The drain hose **50** communicates with the internal space **381**. The inlet **51** of the drain hose **50** is inserted into the joint **38**. The drain

hose **50** is fixed to the joint **38**, for example, with a retaining ring.
[0047] The introduction chamber **40** includes the introduction space **312** of the pump housing **31** and the internal space **381** of the joint **38**. The introduction chamber **40** communicates with the drain hose **50**. With this configuration, the cooling medium introduced into the introduction chamber **40** is discharged to the outside of the vehicle pump assembly **13** through the drain hose **50**.
[0048] Subsequently, operation of the pump **30** will be described.
[0049] When the pump shaft **33** is rotationally driven through the transmission shaft **39**, the impeller **34** rotates together with the pump shaft **33**. Accordingly, the cooling medium is sucked into the pump cover **32** from the suction port **321** communicating with the radiator. The cooling medium having flowed into the pump cover **32** is supplied with pressure by the impeller **34**, and is discharged from the discharge port **322** to the engine **12**. In this manner, the pump **30** circulates the cooling medium between the radiator and the engine **12**.
[0050] At this time, the mechanical seal **35** seals the cooling medium in the pump cover **32**. Even in this state, in a case where the cooling medium in the pump cover **32** has leaked from the mechanical seal **35**, the leaked cooling medium is discharged from the drain hose **50** through the introduction chamber **40**.
[0051] FIG. **6** is a sectional view of the drain hose **50** and the joint **38**. The drain hose **50** includes an internal space **54**. For the sake of simple illustration of the internal space **54**, the internal space **54** is hatched with dots in FIG. **6**. The internal space **54** of the drain hose **50** communicates with the internal space **381** of the joint **38**. The internal space **54** of the drain hose **50** is a region of a through-hole extending across the entire length of the drain hose **50** other than a region into which the joint **38** is inserted. That is, the internal space **54** of the drain hose **50** is a region from the tip end of the joint **38** to the outlet **52**.
[0052] The internal volume of the drain hose **50** is three times the volume of the introduction chamber **40** or more, preferably 3.5 times or more. The internal volume of the drain hose **50** is the volume of the internal space **54**. Hereinafter, the internal volume of the drain hose **50** will also be referred to as the volume of the internal space **54**. The volume of the internal space **54** of the drain hose **50** is preferably 5.5 times the volume of the introduction chamber **40** or less, more preferably five times or less.
[0053] The sectional area of the internal space **54** of the drain hose **50** is preferably 28.3 mm.sup.2 or more and 50.3 mm.sup.2 or less. In other words, the equivalent circle diameter of the section of the internal space **54** is preferably 6 mm or more and 8 mm or less. The section of the internal space **54** is a section perpendicular to the long axis of the drain hose **50**. For example, the section of the internal space **54** is in a circular shape, and the diameter of the section of the internal space **54** is 7.5 mm.
[0054] The sectional area of the internal space **54** is preferably substantially uniform across the long axis of the drain hose **50**. Even if the sectional area of the internal space **54** is non-uniform across the long axis, the sectional area of the internal space **54** at least at the outlet **52** may preferably be 28.3 mm.sup.2 or more and 50.3 mm.sup.2 or less.
[0055] According to the above-described vehicle pump assembly **13**, the volume of the internal space **54** of the drain hose **50** is three times the volume of the introduction chamber **40** or more. Thus, in a case where the vehicle pump assembly **13** is exposed to water from the outside, even if the outside water is sucked through the drain hose **50**, the sucked outside water is less likely to enter the introduction chamber **40** of the pump **30**.
[0056] The inventor(s) of the present application has newly conducted study on the phenomenon in which the water is sucked through the drain hose **50** in a case where the vehicle pump assembly **13** is exposed to the water. Specifically, the mechanical seal **35** has the rotary seal **351** rotating together with the pump shaft **33** and the fixed seal **352** fixed to the pump housing **31**. The cooling medium in the pump **30** turns into vapor due to friction at a contact surface between the rotary seal

351 and the fixed seal **352**, and a slight amount of vapor leaks to the introduction chamber **40** through the contact surface. In this state, when the pump **30** is exposed to the outside water such as muddy water, the vapor introduced into the introduction chamber **40** is rapidly cooled, and the introduction chamber **40** is brought into a negative pressure due to contraction of the vapor. Accordingly, the outside water is sucked through the drain hose **50** communicating with the introduction chamber **40** under the negative pressure. Thus, from this study on the phenomenon, the inventor(s) of the present application has newly focused on a relationship between the volume of the introduction chamber **40** and the volume of the internal space **54** of the drain hose **50**, and as a result of intensive study, has found a relative relationship between the volume of the introduction chamber **40** and the volume of the internal space **54** of the drain hose **50**.

[0057] Thus, for example, when a user drives the vehicle **100** and the pump **30** is exposed to the outside water accumulated on the ground, such as muddy water, even if the outside water is sucked through the drain hose **50**, the sucked outside water is less likely to enter the introduction chamber **40** of the pump **30**.

[0058] The outlet **52** of the drain hose **50** faces the rear of the vehicle, and therefore, the outside water is less likely to enter the drain hose **50** from the front of the vehicle when the vehicle travels forward.

[0059] The drain hose **50** is continuously inclined so as to be positioned lower as extending to the outlet **52** of the drain hose **50**, and therefore, the outside water sucked into the drain hose **50** is easily discharged to the outside.

[0060] The volume of the internal space **54** of the drain hose **50** is 5.5 times the volume of the introduction chamber **40** or less, and therefore, the length of the drain hose **50** can be reduced. Thus, the cost of the drain hose **50** can be reduced. Moreover, an increase in an installation space for the drain hose **50** can be suppressed. Further, contact of the drain hose **50** with other components can be reduced. In addition, the inclination of the drain hose **50** can be ensured. Moreover, the number of supports **60** supporting the drain hose **50** can be reduced.

[0061] The sectional area of the internal space **54** of the drain hose **50** is 28.3 mm.sup.2 or more and 50.3 mm.sup.2 or less. Since the sectional area of the internal space **54** is 28.3 mm.sup.2 or more, the sectional area of the internal space **54** can be increased, influence of surface tension in the drain hose **50** can be decreased, and the outside water sucked into the drain hose **50** can be smoothly discharged. Moreover, the sectional area of the internal space **54** can be increased, and the length of the drain hose **50** necessary for ensuring the volume of the internal space **54** can be decreased. On the other hand, since the sectional area of the internal space **54** is 50.3 mm.sup.2 or less, the thickness of the drain hose **50** can be decreased.

[0062] According to the above-described vehicle **100**, the volume of the internal space **54** of the drain hose **50** is three times the volume of the introduction chamber **40** or more. Thus, in a case where the vehicle pump assembly **13** is exposed to the water from the outside, even if the outside water is sucked through the drain hose **50**, the sucked outside water is less likely to enter the introduction chamber **40** of the pump **30**.

[0063] The vehicle **100** further includes the support **60** supporting the drain hose **50** on the side closer to the inlet **51** of the drain hose **50** with respect to the intermediate portion **53** of the drain hose **50**, and therefore, the drain hose **50** can be easily continuously inclined so as to be positioned lower as extending to the outlet **52** of the drain hose **50**. With this configuration, the outside water sucked into the drain hose **50** is easily discharged to the outside. Specifically, in a case where the drain hose **50** has the flexibility, the inclined posture of the drain hose **50** can be effectively ensured.

[0064] The support **60** is attached to the oil pan **14**, and therefore, can be located near the pump **30**. With this configuration, the drain hose **50** can be supported on the side closer to the inlet **51** of the drain hose **50** with respect to the intermediate portion **53** of the drain hose **50** without increasing the size of the support **60**.

[0065] Specifically, in a case where the support **60** is located far from the pump **30**, the support **60** extends long to the side closer to the inlet **51** with respect to the intermediate portion **53** of the drain hose **50** to support the drain hose **50**, and for this reason, the support **60** is large. On the other hand, the support **60** is located near the pump **30** so that the drain hose **50** can be supported on the side closer to the inlet **51** with respect to the intermediate portion **53** of the drain hose **50** without increasing the length of the support **60**. Thus, the support **60** can be small.

[0066] The support **60** is attached to the recess **141***a* of the peripheral wall **141** of the oil pan **14**, and therefore, the support **60** can be attached to a dead space of the oil pan **14**. With this configuration, an increase in an installation space for the support **60** can be suppressed.

[0067] The fastening-side end portion **65** of the support **60** positioned in the fastening direction F of the bolt **15** contacts the inner surface of the recess **141***a* as viewed in the direction of the axis **15***a* of the bolt **15**. Thus, when the bolt **15** is fastened, even if the support **60** rotates together with the bolt **15**, the fastening-side end portion **65** of the support **60** contacts the inner surface of the recess **141***a* so that co-rotation of the support **60** can be prevented. With this configuration, the support **60** can be reliably fixed to the oil pan **14**.

[0068] The outlet **52** of the drain hose **50** is positioned, as viewed from below, between the rear end of the engine **12** and the front ends of the rear wheels **4**. Since the outlet **52** of the drain hose **50** is positioned, as viewed from below, in rear with respect to the rear end of the engine **12**, the outlet **52** of the drain hose **50** can be separated from the pump **30** attached to the engine **12** and the vapor introduced into the introduction chamber **40** of the pump **30** is less likely to reach the outlet **52** of the drain hose **50**. Thus, the percentage of the volume of the vapor contracted by rapid cooling with respect to the volume of the internal space **54** of the drain hose **50** can be further reduced, and the amount of outside water sucked through the drain hose **50** can be further reduced. Moreover, since the outlet **52** of the drain hose **50** is positioned, as viewed from below, in front with respect to the front ends of the rear wheels **4**, the length of the drain hose **50** can be reduced and exposure of the outlet **52** of the drain hose **50** to water splashed by the rear wheels **4** can be reduced.

Example

[0069] Next, an example will be described. Study was conducted on whether or not the water sucked through the drain hose **50** enters the introduction chamber **40** while changing the ratio of the volume of the internal space **54** of the drain hose **50** to the volume of the introduction chamber **40** of the pump **30**.

[0070] FIG. **7** is a sectional view showing such a model that the introduction chamber **40** of the pump **30** and the internal space **54** of the drain hose **50** are simulatively reproduced. A case **101** including the simulatively-reproduced introduction chamber **40** of the pump **30** was prepared. An internal space **101***a* of the case **101** was hatched with dots, and the volume of the internal space **101***a* of the case **101** was A. That is, the internal space **101***a* of the case **101** is equivalent to the introduction chamber **40**, and the volume A of the internal space **101***a* of the case **101** is equivalent to the volume of the introduction chamber **40**.

[0071] A hose **102** including the simulatively-reproduced internal space **54** of the drain hose **50** was prepared. An internal space **102***a* of the hose **102** was hatched with dots, and the volume of the internal space **102***a* of the hose **102** was B. That is, the internal space **102***a* of the hose **102** is equivalent to the internal space **54**, and the volume B of the internal space **102***a* of the hose **102** is equivalent to the volume of the internal space **54**.

[0072] A predetermined amount, e.g., several drops, of coolant water was supplied into the case **101**, and by heating of the case **101**, was changed into vapor. At this time, the tip end of the hose **102** was dipped in water stored in a container. Thereafter, the case **101** was rapidly cooled such that the internal space **101***a* of the case **101** is brought into a negative pressure, and the amount of water sucked from the container through the tip end of the hose **102** was measured. The amount of water sucked into the hose **102** was C.

[0073] While the ratio (B/A) of the volume B of the internal space **102***a* of the hose **102** to the

volume A of the internal space **101***a* of the case **101** was changed to various ratios, the ratio (C/B) of the amount C of water sucked into the hose **102** to the volume B of the internal space **102***a* of the hose **102** was obtained. The unit of the volumes A, B, C was cm.sup.3.

[0074] Here, a ratio (C/B) of greater than 1 means that the amount C of water sucked into the hose **102** is greater than the volume B of the internal space **102***a* of the hose **102** and the water sucked into the hose **102** enters the case **101**. That is, this means that the water sucked through the drain hose **50** enters the introduction chamber **40**.

[0075] On the other hand, a ratio (C/B) of less than 1 means that the amount C of water sucked into the hose **102** is less than the volume B of the internal space **102***a* of the hose **102** and the water sucked into the hose **102** does not enter the case **101**. That is, this means that the water sucked through the drain hose **50** does not enter the introduction chamber **40**.

[0076] FIG. **8** is a graph showing a relationship between the ratio (B/A) and the ratio (C/B). In FIG. **8**, the horizontal axis represents the ratio (B/A), and the vertical axis represents the ratio (C/B). In FIG. **8**, a variation range for each plot is indicated by an error bar.

[0077] As seen from FIG. **8**, in a case where the ratio (B/A) was less than 3, the ratio (C/B) exceeded 1 in some cases. That is, in a case where the volume B of the internal space **102***a* of the hose **102** was less than three times the volume A of the internal space **101***a* of the case **101**, the water sucked into the hose **102** entered the case **101** in some cases. Thus, it can be said that when the volume of the internal space **54** of the drain hose **50** is less than three times the volume of the introduction chamber **40** of the pump **30**, the water sucked through the drain hose **50** enters the introduction chamber **40** in some cases.

[0078] On the other hand, in a case where the ratio (B/A) was 3 or more, the ratio (C/B) was less than 1. That is, in a case where the volume B of the internal space **102***a* of the hose **102** was three times the volume A of the internal space **101***a* of the case **101** or more, the water sucked into the hose **102** did not enter the case **101**. Thus, it can be said that when the volume of the internal space **54** of the drain hose **50** is three times the volume of the introduction chamber **40** of the pump **30** or more, the water sucked through the drain hose **50** does not enter the introduction chamber **40**.

[0079] Particularly, in a case where the ratio (B/A) was 3.5 or more, the ratio (C/B) was more reliably less than 1. That is, it can be said that when the volume of the internal space **54** of the drain hose **50** is 3.5 times the volume of the introduction chamber **40** of the pump **30** or more, entrance of the water sucked through the drain hose **50** into the introduction chamber **40** is more reliably prevented.

[0080] In a case where the ratio (B/A) was 3 or more, the ratio (C/B) gradually decreased. In this case, as the ratio (B/A) increased, the rate of change in the decrease in the ratio (C/B) decreased. That is, even in a case where the ratio (B/A) increased, there was no significant difference in the amount of water sucked into the hose **102**.

[0081] The increase in the ratio (B/A) means that the volume B of the internal space **102***a* of the hose **102** increases and, e.g., the length of the hose **102** increases. That is, even in a case where the length of the hose **102** increases, there is no significant difference in the amount of water sucked into the hose **102**. Thus, when the ratio (B/A) was 5.5 or less, i.e., the volume B of the internal space **102***a* of the hose **102** was 5.5 times the volume A of the internal space **101***a* of the case **101** or less, the length of the hose **102** could be reduced and entrance of the water sucked into the hose **102** into the hose **102** could be prevented. Consequently, it can be said that when the volume of the internal space **54** of the drain hose **50** is 5.5 times the volume of the introduction chamber **40** of the pump **30** or less, the length of the drain hose **50** can be reduced and entrance of the water sucked through the drain hose **50** into the introduction chamber **40** can be prevented.

[0082] Particularly, in a case where the ratio (B/A) was 5 or less, the length of the hose **102** could be further reduced. That is, it can be said that when the volume of the internal space **54** of the drain hose **50** is five times the volume of the introduction chamber **40** of the pump **30** or less, the length of the drain hose **50** can be further reduced.

<<Modification>>

[0083] FIG. **9** is a schematic side view showing an engine **12**, a vehicle pump assembly **13**, and a vehicle body frame **2** in a vehicle **100**A according to a modification. Hereinafter, a different configuration of the vehicle **100**A according to the modification from that of the vehicle **100** according to the embodiment will be mainly described. Note that in the vehicle **100**A according to the modification, the same reference numerals as those of the vehicle **100** according to the embodiment represent the same components as those of the vehicle **100** according to the embodiment, and therefore, description thereof will be omitted.

[0084] In the vehicle **100**A according to the modification, the outlet-**52**-side end portion of the drain hose **50** is inserted into the hollow pipe **20** of the vehicle body frame **2**. Specifically, the pipe **20** has a hole **20***a* allowing communication between the outside and inside of the pipe **20**. The outlet-**52**-side end portion of the drain hose **50** is inserted into the hole **20***a* of the pipe **20**, and the outlet **52** of the drain hose **50** is positioned inside the pipe **20**.

[0085] According to the vehicle **100**A of the modification, the outlet-**52**-side end portion of the drain hose **50** is inserted into the pipe **20**, and therefore, exposure of the outlet **52** of the drain hose **50** to outside water can be reduced and suction of the outside water through the drain hose **50** can be reduced.

[0086] Note that although description of other configurations, features, and effects will be omitted, description of the vehicle **100** according to the embodiment can be used in description of the vehicle **100**A according to the modification.

Other Embodiments

[0087] The embodiment has been described above as an example of the technique disclosed in the present application. However, the technique in the present disclosure is not limited to above, and is also applicable to embodiments to which changes, replacements, additions, omissions, etc. are made as necessary. The components described above in the embodiment may be combined to form a new embodiment. The components shown in the attached drawings and described in detail may include not only components essential for solving the problems, but also components that are provided for describing an example of the above-described technique and are not essential for solving the problems. Thus, description of these non-essential components in detail and illustration of these components in the attached drawings shall not be interpreted that these non-essential components are essential.

[0088] In the above-described embodiment, the outlet **52** of the drain hose **50** faces the rear of the vehicle, but may face the front of the vehicle or face the right and left of the vehicle.

[0089] In the above-described embodiment, the drain hose **50** is continuously inclined so as to be positioned lower as extending to the outlet **52**, but may be inclined in a stepwise manner so as to be positioned lower as extending to the outlet **52**. Alternatively, the drain hose **50** may extend in the vertical direction, or may extend in the horizontal direction.

[0090] In the above-described embodiment, the outlet **52** of the drain hose **50** is positioned, as viewed from below, between the rear end of the engine **12** and the front ends of the rear wheels **4**, but may overlap with the engine **12** as viewed from below.

[0091] In the above-described embodiment, the drain hose **50** is supported by the support **60**, but a component for supporting the drain hose **50**, such as the support **60**, is not necessarily disposed.

[0092] In the above-described embodiment, the support **60** is attached to the oil pan **14**, but may be attached to another component such as the engine case **121**.

[0093] In the above-described embodiment, the peripheral wall **141** of the oil pan **14** includes the recess **141***a*, but does not necessarily include the recess **141***a*.

[0094] In the above-described embodiment, the support **60** is attached to the recess **141***a*, but may be attached to the bottom of the oil pan **14**.

[0095] In the above-described embodiment, the fastening-side end portion **65** of the support **60** contacts the inner surface of the recess **141***a* as viewed in the direction of the axis **15***a* of the bolt

15, but may be separated from the inner surface of the recess **141***a*.
[0096] In the above-described embodiment, the pump **30** has the mechanical seal **35** and the oil seal **36**, but may have only the mechanical seal **35** without the oil seal **36**. In this case, the introduction chamber **40** is a space separated by the mechanical seal **35**.
[0097] In the above-described embodiment, the pump **30** has the joint **38**, and the introduction chamber **40** includes the introduction space **312** of the pump housing **31** and the internal space **381** of the joint **38**. However, instead of the joint **38**, a connection portion for connecting the drain hose **50** to the pump housing **31** may be integrated, and in this case, the introduction chamber **40** includes the introduction space **312** of the pump housing **31**.
[0098] In the above-described embodiment, the upper limit of the internal volume (volume of the internal space **54**) of the drain hose **50** is 5.5 times the volume of the introduction chamber **40**, but may be a numerical value greater than 5.5 times.
[0099] The technique disclosed here may be applied to an off-road vehicle other than the utility vehicle **100**.
[Aspects]
[0100] The above-described embodiment is a specific example of the following aspects.
(First Aspect)
[0101] The vehicle pump assembly **13** includes the pump **30** having the mechanical seal **35** sealing the cooling medium, and the drain hose **50** attached to the pump **30**. The pump **30** includes the introduction chamber **40** separated by the mechanical seal **35** and configured such that the cooling medium having leaked from the mechanical seal **35** is introduced thereinto, and the drain hose **50** communicates with the introduction chamber **40**. The internal volume of the drain hose **50** is three times the volume of the introduction chamber **40** or more.
[0102] According to this configuration, the internal volume of the drain hose **50** is three times the volume of the introduction chamber **40** or more. Thus, in a case where the vehicle pump assembly **13** is exposed to water from the outside, even if the outside water is sucked through the drain hose **50**, the sucked outside water is less likely to enter the introduction chamber **40** of the pump **30**.
(Second Aspect)
[0103] In the vehicle pump assembly **13** of the first aspect, the outlet **52** of the drain hose **50** faces the rear of the vehicle.
[0104] According to this configuration, the outlet **52** of the drain hose **50** faces the rear of the vehicle, and therefore, the outside water is less likely to enter the drain hose **50** from the front of the vehicle when the vehicle travels forward.
(Third Aspect)
[0105] In the vehicle pump assembly **13** of the first or second aspect, the drain hose **50** is continuously inclined so as to be positioned lower as extending to the outlet **52** of the drain hose **50**.
[0106] According to this configuration, the drain hose **50** is continuously inclined so as to be positioned lower as extending to the outlet **52** of the drain hose **50**, and therefore, the outside water sucked into the drain hose **50** is easily discharged to the outside.
(Fourth Aspect)
[0107] In the vehicle pump assembly **13** of any one of the first to third aspects, the internal volume of the drain hose **50** is 5.5 times the volume of the introduction chamber **40** or less.
[0108] According to this configuration, the internal volume of the drain hose **50** is 5.5 times the volume of the introduction chamber **40** or less, and therefore, the length of the drain hose **50** can be reduced.
(Fifth Aspect)
[0109] The utility vehicle **100** (off-road vehicle) includes the engine **12** and the vehicle pump assembly **13** that supplies the cooling medium to the engine **12**. The vehicle pump assembly **13** includes the pump **30** having the mechanical seal **35** sealing the cooling medium and attached to

the engine **12**, and the drain hose **50** attached to the pump **30**. The pump **30** includes the introduction chamber **40** separated by the mechanical seal **35** and configured such that the cooling medium having leaked from the mechanical seal **35** is introduced thereinto, and the drain hose **50** communicates with the introduction chamber **40**. The internal volume of the drain hose **50** is three times the volume of the introduction chamber **40** or more.

[0110] According to this configuration, the internal volume of the drain hose **50** is three times the volume of the introduction chamber **40** or more. Thus, in a case where the vehicle pump assembly **13** is exposed to water from the outside, even if the outside water is sucked through the drain hose **50**, the sucked outside water is less likely to enter the introduction chamber **40** of the pump **30**.

(Sixth Aspect)

[0111] The utility vehicle **100** of the fifth aspect further includes the support **60** supporting the drain hose **50** on the side closer to the inlet **51** of the drain hose **50** with respect to the intermediate portion **53** of the drain hose **50**.

[0112] According to this configuration, the utility vehicle **100** further includes the support **60** supporting the drain hose **50** on the side closer to the inlet **51** of the drain hose **50** with respect to the intermediate portion **53** of the drain hose **50**, and therefore, the drain hose **50** can be easily continuously inclined so as to be positioned lower as extending to the outlet **52** of the drain hose **50** from the inlet **51** of the drain hose **50**. With this configuration, the outside water sucked into the drain hose **50** is easily discharged to the outside.

(Seventh Aspect)

[0113] The utility vehicle **100** of the fifth or sixth aspect further includes the oil pan **14** attached to the engine **12**. The support **60** is attached to the oil pan **14**.

[0114] According to this configuration, the support **60** is attached to the oil pan **14**, and therefore, can be located near the pump **30**. With this configuration, the drain hose **50** can be supported on the side closer to the inlet **51** of the drain hose **50** with respect to the intermediate portion **53** of the drain hose **50** without increasing the size of the support **60**. Thus, the drain hose **50** can be easily continuously inclined so as to be positioned lower as extending to the outlet **52** of the drain hose **50** from the inlet **51** of the drain hose **50**, and the outside water sucked into the drain hose **50** can be easily discharged to the outside.

(Eighth Aspect)

[0115] In the utility vehicle **100** of any one of the fifth to seventh aspects, the peripheral wall **141** of the oil pan **14** includes the recess **141***a*, and the support **60** is attached to the recess **141***a*.

[0116] According to this configuration, the support **60** is attached to the recess **141***a* of the peripheral wall **141** of the oil pan **14**, and therefore, the support **60** can be attached to the dead space of the oil pan **14**. With this configuration, an increase in the installation space for the support **60** can be suppressed.

(Ninth Aspect)

[0117] The utility vehicle **100** of any one of the fifth to eighth aspects further includes the bolt **15** (fastener) fixing the support **60** to the oil pan **14**. As viewed in the direction of the axis **15***a* of the bolt **15**, the end portion **65** of the support **60** positioned in the fastening direction F of the bolt **15** contacts the inner surface of the recess **141***a*.

[0118] According to this configuration, the fastening-side end portion **65** of the support **60** positioned in the fastening direction F of the bolt **15** contacts the inner surface of the recess **141***a* as viewed in the direction of the axis **15***a* of the bolt **15**. Thus, when the bolt **15** is fastened, even if the support **60** rotates together with the bolt **15**, the fastening-side end portion **65** of the support **60** contacts the inner surface of the recess **141***a* so that co-rotation of the support **60** can be prevented. With this configuration, the support **60** can be reliably fixed to the oil pan **14**.

(Tenth Aspect)

[0119] The utility vehicle **100** of any one of the fifth to ninth aspects further includes the front wheels **3** and the rear wheels **4**. The engine **12** is positioned between the front wheels **3** and the rear

wheels **4**, and the outlet **52** of the drain hose **50** is positioned, as viewed from below, between the rear end of the engine **12** and the front ends of the rear wheels **4**.
[0120] According to this configuration, the outlet **52** of the drain hose **50** is positioned, as viewed from below, between the rear end of the engine **12** and the front ends of the rear wheels **4**. Since the outlet **52** of the drain hose **50** is positioned, as viewed from below, in rear with respect to the rear end of the engine **12**, the outlet **52** of the drain hose **50** can be separated from the pump **30** attached to the engine **12** and the vapor introduced into the introduction chamber **40** of the pump **30** is less likely to reach the outlet **52** of the drain hose **50**. Thus, the percentage of the volume of the vapor contracted by rapid cooling with respect to the volume of the internal space **54** of the drain hose **50** can be further reduced, and the amount of outside water sucked through the drain hose **50** can be further reduced. Moreover, since the outlet **52** of the drain hose **50** is positioned, as viewed from below, in front with respect to the front ends of the rear wheels **4**, the length of the drain hose **50** can be reduced and exposure of the outlet **52** of the drain hose **50** to the water splashed by the rear wheels **4** can be reduced.
(Eleventh Aspect)
[0121] The utility vehicle **100**A of any one of the fifth to tenth aspects further includes the vehicle body frame **2** including the hollow pipe **20**. The outlet-**52**-side end portion of the drain hose **50** is inserted into the pipe **20**.
[0122] According to this configuration, the outlet-**52**-side end portion of the drain hose **50** is inserted into the pipe **20**, and therefore, exposure of the outlet **52** of the drain hose **50** to the outside water can be reduced and suction of the outside water through the drain hose **50** can be reduced.

Claims

1. A vehicle pump assembly comprising: a pump having a mechanical seal sealing a cooling medium; and a drain hose attached to the pump, wherein the pump includes an introduction chamber separated by the mechanical seal and configured such that the cooling medium having leaked from the mechanical seal is introduced thereinto, and the drain hose communicates with the introduction chamber, and an internal volume of the drain hose is three times a volume of the introduction chamber or more.
2. The vehicle pump assembly of claim 1, wherein an outlet of the drain hose faces a rear of a vehicle.
3. The vehicle pump assembly of claim 1, wherein the drain hose is continuously inclined so as to be positioned lower as extending to an outlet of the drain hose.
4. The vehicle pump assembly of claim 1, wherein the internal volume of the drain hose is 5.5 times the volume of the introduction chamber or less.
5. An off-road vehicle comprising: an engine; and a vehicle pump assembly that supplies a cooling medium to the engine, wherein the vehicle pump assembly includes a pump having a mechanical seal sealing the cooling medium and attached to the engine, and a drain hose attached to the pump, the pump includes an introduction chamber separated by the mechanical seal and configured such that the cooling medium having leaked from the mechanical seal is introduced thereinto, and the drain hose communicates with the introduction chamber, and an internal volume of the drain hose is three times a volume of the introduction chamber or more.
6. The off-road vehicle of claim 5, further comprising: a support supporting the drain hose on a side closer to an inlet of the drain hose with respect to an intermediate portion of the drain hose.
7. The off-road vehicle of claim 6, further comprising: an oil pan attached to the engine, wherein the support is attached to the oil pan.
8. The off-road vehicle of claim 7, wherein a peripheral wall of the oil pan includes a recess, and the support is attached to the recess.
9. The off-road vehicle of claim 8, further comprising: a fastener fixing the support to the oil pan,

wherein as viewed in an axial direction of the fastener, an end portion of the support positioned in a fastening direction of the fastener contacts an inner surface of the recess.

10. The off-road vehicle of claim 5, further comprising: a front wheel and a rear wheel, wherein the engine is positioned between the front wheel and the rear wheel, and an outlet of the drain hose is positioned, as viewed from below, between a rear end of the engine and a front end of the rear wheel.

11. The off-road vehicle of claim 5, further comprising: a vehicle body frame including a hollow pipe, wherein an outlet-side end portion of the drain hose is inserted into the pipe.