(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 009 626 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
20.04.2016 Bulletin 2016/16

(51) Int Cl.:
F01P 11/04 *(2006.01)*

(21) Application number: **15183179.9**

(22) Date of filing: **31.08.2015**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA

(30) Priority: **16.10.2014 JP 2014211469**
11.11.2014 JP 2014229141

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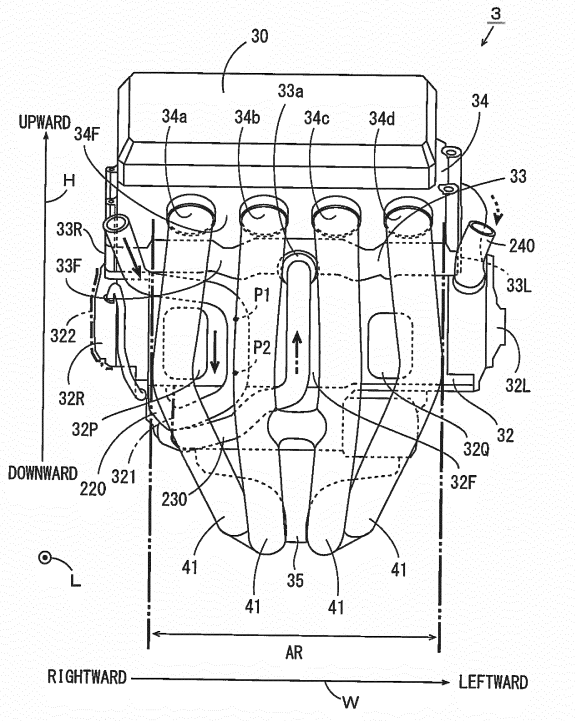
(54) MOTORCYCLE

(57) A plurality of exhaust pipes are respectively connected to a plurality of exhaust ports of a cylinder head. The plurality of exhaust pipes are arranged in a left-and-right direction to be spaced apart from one another and pass in front of and below a crankcase from the cylinder head to extend rearward. A first pipe that connects a water pump to a radiator extends forward at the right of a right side surface portion to a front surface portion of the crankcase and is curved leftward from the right of the right side surface portion in a front view of a motorcycle. Further, the first pipe passes through an inner region between a left end and a right end of the plurality of exhaust pipes to be connected to the radiator in the front view of the motorcycle.

FIG. 3



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Description

[0001] The present invention relates to a motorcycle.

[0002] In a motorcycle including a water-cooled engine, cooling water circulates between the engine and a radiator. For example, in a motorcycle described in JP 2009-255627 A, a circulation circuit for the cooling water is provided. The circulation circuit includes a water pump, a head cylinder, a radiator, a first pipe, a second pipe and a circulation path.

[0003] The water pump and the head cylinder are connected to each other by the circulation path. The head cylinder and the radiator are connected to each other by the second pipe. The radiator and the water pump are connected to each other by the first pipe.

[0004] Each member that constitutes the circulation circuit for the cooling liquid is preferably provided at a position spaced apart from a member that generates heat during an operation of an engine such as an exhaust pipe such that cooling efficiency of the engine does not decrease. In the above-mentioned motorcycle, the first pipe extends forward at one side of the crankcase and further extends upward while being curved outward at the front end of the crankcase. In this case, the first pipe does not pass in front of the crankcase and the head cylinder. Therefore, even when the exhaust pipe is arranged in front of the crankcase and the head cylinder, the first pipe is spaced apart from the exhaust pipe.

[0005] A vehicle body tilts sideward during turning of the motorcycle. In a motorcycle used for races and the like, it is required that an allowable bank angle is more largely ensured in order to realize stable turning during travelling at a high speed.

[0006] However, when a pipe for circulating the cooling liquid is curved outward at the front end of the crankcase, the bank angle may be limited by the pipe.

[0007] An object of the present invention is to provide a motorcycle that can travel at a larger bank angle while a decrease in cooling efficiency of a multi-cylinder engine is inhibited.

[0008] According to the present invention said object is solved by a motorcycle having the features of independent claim 1. Preferred embodiments are laid down in the dependent claims.

[0009] During an operation of the multi-cylinder engine, a plurality of cylinders and a plurality of exhaust pipes generate heat. In this case, it is estimated that a temperature of a space between the crankcase and the plurality of exhaust pipes becomes extremely high during the operation of the multi-cylinder engine. Therefore, conventionally, there was technical knowledge that a cooling liquid pipe is not to be arranged in the vicinity of the plurality of exhaust pipes in order to prevent a decrease in cooling efficiency of the multi-cylinder engine.

[0010] Regardless of such conventional technical knowledge, the temperature of the space between the crankcase and the plurality of exhaust pipes during the operation of the multi-cylinder engine was lower than a conventionally estimated temperature. Thus, it was found that the cooling efficiency of the multi-cylinder engine did not markedly decrease even when part of the cooling liquid pipe is arranged in the space between the crankcase and the plurality of exhaust pipes.

[0011] (1) A motorcycle according to one aspect includes a multi-cylinder engine having a crankcase and a cylinder head, a plurality of exhaust pipes connected to the cylinder head, a radiator, a pump, and a cooling liquid pipe that leads a cooling liquid between the radiator and the pump, wherein the crankcase has a front surface portion facing forward of the motorcycle and a pair of side surface portions facing leftward and rightward, the plurality of exhaust pipes extend downward and are arranged in a left-and-right direction of the motorcycle in front of the front surface portion of the crankcase, the radiator is provided at a position further forward than the plurality of exhaust pipes, and the cooling liquid pipe extends forward outside of one side surface portion of the pair of side surface portions to the front surface portion of the crankcase, is curved inward from outside of the one side surface portion in a front view of the motorcycle, and passes through a region between a left end and a right end of the plurality of exhaust pipes in the front view of the motorcycle to be connected to the radiator.

[0012] In the motorcycle, the cooling liquid pipe that connects the radiator to the pump is curved inward from the outside of the one side surface portion in the front view of the motorcycle and passes through a region between the left end and the right end of the plurality of exhaust pipes in the front view of the motorcycle to be connected to the radiator. Thus, the cooling liquid pipe does not project outward from the side surface portion in the vicinity of the front end of the crankcase, so that the limit of the bank angle by the cooling liquid pipe is eased.

[0013] Further, the above-mentioned configuration enables the center of gravity of the cooling liquid pipe to be brought close to the center of the engine. Therefore, centralization of the mass in the motorcycle becomes possible. In this case, the temperature of the region close to the plurality of exhaust pipes in front of the front surface portion of the crankcase does not increase to a degree at which the cooling efficiency of the radiator decreases. As a result, the motorcycle can travel at a larger bank angle while a decrease in cooling efficiency of the multi-cylinder engine is inhibited.

[0014] (2) The one side surface portion of the crankcase may have a first portion located below a crankshaft supported by the crankcase, and a second portion located above the first portion, the first portion is located at a position further inward than the second portion in the left-and-right direction of the motorcycle in the front view of the motorcycle, and the cooling liquid pipe may extend forward outside of the first portion to the front surface portion of the crankcase.

[0015] In this case, the cooling liquid pipe can be arranged more inward in the left-and-right direction of the motorcycle. Thus, the limit of the bank angle by the cool-

ing liquid pipe is more sufficiently eased.

[0016] (3) Part of the cooling liquid pipe may extend to intersect with at least one of the plurality of exhaust pipes in the front view of the motorcycle.

[0017] In this case, the cooling liquid pipe is exposed from a space between the two adjacent exhaust pipes. Thus, during the travelling of the motorcycle, the cooling liquid pipe is cooled by air flowing through a space among the plurality of exhaust pipes. Therefore, the cooling efficiency of the multi-cylinder engine is improved.

[0018] (4) The cooling liquid pipe may be formed of resin.

[0019] In this case, the temperature of the space between the front surface portion of the crankcase and the plurality of exhaust pipes does not increase to be higher than the conventionally estimated temperature, so that it is possible to decrease the weight of the motorcycle by using the cooling liquid pipe formed of resin.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

[0020]

Fig. 1 is a side view of one side of a motorcycle according to one preferred embodiment;
Fig. 2 is a block diagram showing a schematic configuration of a cooling liquid circulation system provided at an engine unit of Fig. 1;
Fig. 3 is a front view of the engine unit of Fig. 1;
Fig. 4 is a right side view of the engine unit of Fig. 1;
Fig. 5 is a left side view of the engine unit of Fig. 1;
Fig. 6 is a front view of an engine unit of a comparative example;
Fig. 7 is a right side view of the engine unit of the comparative example; and
Fig. 8 is a front view of an engine unit showing a result of comparison between a first pipe according to the one embodiment and a first pipe of the comparative example.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

(1) Schematic Configuration of Motorcycle

[0021] Fig. 1 is a side view of one side of the motorcycle according to one preferred embodiment. Fig. 1 shows the motorcycle 100 being stood up to be vertical to a road surface. In Figs. 1, 3 and the subsequent diagrams, a front-and-rear direction L, a left-and-right direction W and a top-and-bottom direction H of the motorcycle 100 are indicated by arrows.

[0022] In the following description, a direction in which the arrow is directed in the front- and-rear direction L is referred to as forward, and the opposite direction is referred to as rearward. Further, a direction in which the arrow is directed in the left-and-right direction W is referred to as leftward and the opposite direction is referred to as rightward. Further, a direction in which the arrow is directed in the top-and-bottom direction H is referred to as upward, and the opposite direction is referred to as downward.

[0023] As shown in Fig. 1, the motorcycle 100 includes a vehicle body frame 1. The vehicle body frame 1 includes a head pipe 11, a main frame 12 and a sub-frame 13. The main frame 12 obliquely extends rearward and downward from the head pipe 11. The rear end of the main frame 12 is curved downward. The sub-frame 13 extends rearward from upper portions of the rear ends of the main frames 12.

[0024] A front fork 2 is provided at the head pipe 11 to be swingable in the left-and-right direction W. A front wheel 21 is rotatably supported at the lower end of the front fork 2. A pair of left and right handles 22 is provided at the upper end of the front fork 2.

[0025] A vehicle body cover 23 is provided to cover the head pipe 11 from the front and to cover part of the front fork 2 from the left and the right. The vehicle body cover 23 is attached to the vehicle body frame 1.

[0026] An engine unit 3 is provided below the main frame 12. The engine unit 3 includes a water-cooled multi-cylinder engine 30, a radiator 40, and a cooling liquid circulation system 200 (see Fig. 2) that is described below. The multi-cylinder engine 30 includes a crankshaft 31, a crankcase 32, a cylinder body 33, a cylinder head 34 and an oil pan 35 and is supported at the main frame 12. The multi-cylinder engine 30 of the present example is a water-cooled straight four-cylinder engine.

[0027] Upstream ends of a plurality (four in the present example) of exhaust pipes 41 are connected to the cylinder head 34. Each of the plurality of exhaust pipes 41 passes in front of the crankcase 32 and below the crankcase 32 from the cylinder head 34 to extend rearward. A muffler (a silencer) 42 is connected to a downstream end of each exhaust pipe 41.

[0028] An air cleaner 4 is supported above the engine unit 3 by the head pipe 11 and the main frame 12. A fuel tank 5 is supported behind the air cleaner 4 by the main frame 12. Further, a seat 6 is supported behind the fuel tank 5 by the sub-frame 13. A swing arm 14 is provided to extend rearward from a center of the rear end of the main frame 12. A rear wheel 24 is rotatably supported at the rear end of the swing arm 14. The rear wheel 24 is rotated by motive power generated from the engine unit 3.

(2) Cooling Liquid Circulation System

[0029] Fig. 2 is a block diagram showing a schematic configuration of the cooling liquid circulation system provided in the engine unit 3 of Fig. 1. As shown in Fig. 2, the cooling liquid circulation system 200 includes a water pump 210, a first pipe 220, a second pipe 230 and a third pipe 240. The first pipe 220, the second pipe 230 and the third pipe 240 are formed of aluminum, for example. The first pipe 220, the second pipe 230 and the third pipe 240 may be formed of resin. As the resin, a polyimide

resin including a glass fiber, for example, can be used.

[0030] The radiator 40 and the water pump 210 are connected to each other by the first pipe 220. The water pump 210 and the cylinder body 33 are connected to each other by the second pipe 230. The cylinder body 33 and the radiator 40 are connected to each other by the third pipe 240.

[0031] When the water pump 210 is operated, a cooling liquid in the radiator 40 is led to the water pump 210 by the first pipe 220 as indicated by a thick solid arrow in Fig. 2. Further, as indicated by a thick one-dot and dash arrow in Fig. 2, the cooling liquid led to the water pump 210 is led to the cylinder body 33 by the second pipe 230. Further, as indicated by a thick dotted arrow in Fig. 2, the cooling liquid led to the cylinder body 33 is led to the radiator 40 by the third pipe 240.

[0032] A plurality (four in the present example) of cylinders and a water jacket is formed in the cylinder body 33. The cooling liquid cooled in the radiator 40 flows in the water jacket of the cylinder body 33. Thus, the plurality of cylinders are cooled.

[0033] While water is used as the cooling liquid in the present embodiment, the present teaching is not limited to this. As the cooling liquid, a liquid mixture of water and a liquid other than water can be used instead of water. For example, a liquid mixture of at least one of a corrosion inhibitor and an antifreeze agent, and water can be used as the cooling liquid. Further, as the cooling liquid, a liquid other than water (such as oil) can be used.

(3) Configurations of Multi-Cylinder Engine and Its Peripheral Members

[0034] Fig. 3 is a front view of the engine unit 3 of Fig. 1, Fig. 4 is a right side view of the engine unit 3 of Fig. 1, and Fig. 5 is a left side view of the engine unit 3 of Fig. 1.

[0035] As shown in Fig. 3, the cylinder body 33 and the cylinder head 34 are provided above the crankcase 32. Further, the oil pan 35 is provided at a bottom portion of the crankcase 32.

[0036] The cylinder body 33 of the present example includes the four cylinders. As shown in Figs. 4 and 5, a piston 91 is stored inside of each cylinder. In the crankcase 32, the crankshaft 31 extends in the left-and-right direction W. Further, the crankshaft 31 is rotatably supported about its axial center by the crankcase 32. Each piston 91 and the crankshaft 31 are coupled to each other via a connecting rod 92.

[0037] In the cylinder head 34, four combustion chambers V respectively corresponding to the four cylinders of the cylinder body 33 are formed. Further, in the cylinder head 34, a plurality of ignition devices, a plurality of intake valves, a plurality of exhaust valves and the like are stored. The crankshaft 31 is rotated, so that the four pistons 91 respectively reciprocate in the four cylinders. Thus, a fuel-air mixture is led to each combustion chamber V. Further, each ignition device is operated, so that the fuel-air mixture led to the combustion chamber V is combusted, and the combusted gas is exhausted from each combustion chamber V.

[0038] As shown in Fig. 3, the cylinder head 34 has a front surface portion 34F facing forward. Four exhaust ports 34a, 34b, 34c, 34d for exhausting the gas from inside of the plurality of combustion chambers V (Figs. 4 and 5) are formed at the front surface portion 34F. The exhaust ports 34a, 34b, 34c, 34d are arranged in this order from the right to the left.

[0039] Upstream ends of the plurality of exhaust pipes 41 are respectively connected to the plurality of exhaust ports 34a, 34b, 34c, 34d. The plurality of exhaust pipes 41 are arranged in the left-and-right direction W to be spaced apart from one another. Further, the plurality of exhaust pipes 41 extend downward in front of the crankcase 32 from the front surface portion 34F of the cylinder head 34 as shown in Figs. 3 to 5. Further, the plurality of exhaust pipes 41 are curved rearward at positions further downward than the crankcase 32 and in front of the oil pan 35.

[0040] As described above, the water jacket (not shown) is formed inside of the cylinder body 33 to surround the four cylinders. The cylinder body 33 has a front surface portion 33F facing forward as shown in Fig. 3. At a substantially center portion of the front surface portion 33F in the left-and-right direction W, a lead-in port 33a for leading the cooling liquid into the water jacket is formed. Further, the cylinder body 33 has a right side surface portion 33R facing rightward and a left side surface portion 33L facing leftward. Further, the cylinder body 33 has a back surface portion 33B facing rearward as shown in Figs. 4 and 5. At a substantially central portion of the back surface portion 33B in the left-and-right direction W, a lead-out port 33b for discharging the cooling liquid from the water jacket is formed.

[0041] The crankcase 32 has a front surface portion 32F facing forward as shown in Fig. 3. At the front surface portion 32F, a projection 32P locally projecting forward is formed to be close to the rightmost exhaust pipe 41 (see Fig. 4). The projection 32P is located in front of the crankshaft 31. Further, at the front surface portion 32F, a projection 32Q locally projecting forward is formed to be close to the leftmost exhaust pipe 41 as shown in Fig. 3 and 5. The projection 32Q is located in front of the crankshaft 31.

[0042] Further, as shown in Fig. 3, the crankcase 32 has a right side surface portion 32R facing rightward and a left side surface portion 32L facing leftward. As indicated by thick one-dot and dash lines in Figs. 3 and 4, the right side surface portion 32R of the crankcase 32 includes a first portion 321 and a second portion 322. The first portion 321 is located at a position further downward than the crankshaft 31. The second portion 322 is located above the first portion 321. Further, as shown in Fig. 3, the first portion 321 is located at a position further leftward than the second portion 322 (inward of the multi-cylinder engine 30) in the left-and-right direction W in a front view of the motorcycle 100.

[0043] At the right side surface portion 32R of the crankcase 32, the water pump 210 is provided behind the first portion 321 as shown in Fig. 4. The water pump 210 has a lead-in port 211 and a lead-out port 212 for the cooling liquid. The lead-in port 211 and the lead-out port 212 are arranged in this order in the top-and-bottom direction. Further, the lead-in port 211 and the lead-out port 212 are both provided to be directed forward.

[0044] As shown in Figs. 4 and 5, the radiator 40 is provided in front of the cylinder head 34. The radiator 40 is arranged at a position further forward than the plurality of exhaust pipes 41. The radiator 40 is not shown in Fig. 3 in order to facilitate understanding of a positional relationship between the plurality of exhaust pipes 41 and each of the first pipe 220 and the second pipe 230, described below. As the radiator 40, a crossflow type radiator is used. A lead-in port for the cooling liquid is provided at a left side portion of the radiator 40 of the present example. Further, a lead-out port for the cooling liquid is provided at a right side portion of the radiator 40. In the radiator 40, the cooling liquid led to the lead-in port flows from the left to the right and is led to the lead-out port.

[0045] A region between a left end and a right end of the plurality of the exhaust pipes 41 in the left-and-right direction W in the front view of the motorcycle 100 is referred to as an inner region AR. In Fig. 3, a range of the inner region AR in the left-and-right direction W is indicated by two-dots and dash lines.

[0046] As shown in Fig. 4, the downstream end of the first pipe 220 is connected to the lead-in port 211 of the water pump 210. The first pipe 220 extends forward at the right of the first portion 321 of the right side surface portion 32R from the lead-in port 211 to a position between the front surface portion 32F and the exhaust pipes 41 in a side view of the motorcycle 100. Further, the first pipe 220 is curved leftward from the right of the right side surface portion 32R in the front view of the motorcycle 100 as shown in Fig. 3. Further, the first pipe 220 passes through the inner region AR to be connected to the lead-out port of the radiator 40 in the front view of the motorcycle 100.

[0047] More specifically, in front of the front surface portion 32F, the first pipe 220 extends leftward below the projection 32P from the first portion 321 of the right side surface portion 32R, extends upward at the left of the projection 32P, and further extends rightward from the left of the projection 32P, as shown in Fig. 3. Thus, portions of the first pipe 220 intersect with the rightmost exhaust pipe 41 in the front view of the motorcycle 100 (the exhaust pipe 41 connected to the exhaust port 34a of Fig. 3) at two positions at substantially right angles.

[0048] A gap is formed between a portion, of the first pipe 220, passing through the right of the first portion 321 and the first portion 321. Further, a gap is formed between a portion, of the first pipe 220, passing in front of the front surface portion 32F and the front surface portion 32F. As shown in Fig. 4, the upstream end of the second pipe 230 is connected to the lead-out port 212 of the water pump 210. The second pipe 230 extends forward at the right of the first portion 321 of the right side surface portion 32R from the lead-out port 212 to a position between the front surface portion 32F and the exhaust pipes 41 in the side view of the motorcycle 100. A portion, of the second pipe 230, passing through the right of the first portion 321 is located at a position further downward than the first pipe 220. Further, the second pipe 230 is curved leftward from the right of the right side surface portion 32R in the front view of the motorcycle 100 as shown in Fig. 3. Further, the second pipe 230 passes through the inner region AR to be connected to the lead-in port 33a of the cylinder body 33 in the front view of the motorcycle 100. In the inner region AR, part of the second pipe 230 extends upward from below at a substantially center portion of the multi-cylinder engine 30.

[0049] A gap is formed between a portion, of the second pipe 230, passing through the right of the first portion 321 and the first portion 321. Further, a gap is formed between a portion, of the second pipe 230, passing in front of the front surface portion 32F and the front surface portion 32F.

[0050] As shown in Figs. 4 and 5, the upstream end of the third pipe 240 is connected to the lead-out port 33b of the cylinder body 33. The third pipe 240 is curved leftward behind the back surface portion 33B of the cylinder body 33 from the lead-out port 33b and extends leftward behind the back surface portion 33B to the left of the left side surface portion 33L. Further, the third pipe 240 is curved forward and extends forward at the left of the left surface portion 33L. Further, the third pipe 240 is connected to the lead-in port of the radiator 40 at a position further forward than the front surface portion 33F. A thermostat 240T is provided at a portion, of the third pipe 240, passing behind the back surface portion 33B.

[0051] A gap is formed between a portion, of the third pipe 240, passing behind the back surface portion 33B and the back surface portion 33B. Further, a gap is formed between a portion, of the third pipe 240, passing through the left of the left side surface portion 33L and the left side surface portion 33L.

[0052] In Figs. 3 and 4, flows of the cooling liquid in the first pipe 220 during the operation of the water pump 210 are indicated by thick solid arrows. Further, flows of the cooling liquid in the second pipe 230 are indicated by thick one-dot and dash arrows. Further, in Figs. 3 and 5, flows of the cooling liquid in the third pipe 240 are indicated by thick dotted arrows.

(4) Measurement of Temperature

[0053] The inventors of the present application performed the measurement of temperature, described below, regarding the above-mentioned engine unit 3 in order to examine to what degree the temperature of the space between the crankcase 32 and the plurality of exhaust pipes 41 increases during the operation of the multi-cylinder engine 30.

[0054] As shown in Figs. 3 and 4, two measurement portions P1, P2 are set to be spaced apart from each other at portions, of the first pipe 220, extending in the top-and-bottom direction H in the inner region AR. The measurement portions P1, P2 are portions, of the first pipe 220, closest to one exhaust pipe 41. Further, the measurement portions P1, P2 are located at a front portion of the outer peripheral surface of the first pipe 220. In the present example, the measurement portions P1, P2 are close to the second rightmost exhaust pipe 41 (the exhaust pipe 41 connected to the exhaust port 34b of Fig. 3).

[0055] The motorcycle 100 including the above-mentioned engine unit 3 is made to travel continuously for a predetermined time period such that the temperature of the multi-cylinder engine 30 sufficiently increases. Thereafter, the traveling of the motorcycle 100 is stopped while the multi-cylinder engine 30 is operated such that a warm-up operation of the multi-cylinder engine 30 is continued. In this case, an air flow from the front to the rear is not generated around the engine unit 3, so that the temperature of the space between the crankcase 32 and the plurality of exhaust pipes 41 increases. Temperatures of the measurement portions P1, P2 are measured after a predetermined time period (about 30 minutes, for example) has elapsed since the travelling of the motorcycle 100 is stopped.

[0056] It is considered that the temperatures of the measurement portions P1, P2 increase the most in the space between the crankcase 32 and the plurality of exhaust pipes 41 since the measurement portions P1, P2 are the closest portions to the one exhaust pipe 41 in the first pipe 220. As a result of the above-mentioned measurement of temperature, it was found that the temperature of the space between the crankcase 32 and the plurality of exhaust pipes 41 was kept at not more than 140°C.

[0057] From the conventional technical knowledge, it is known that cooling efficiency of the multi-cylinder engine does not markedly decrease even when a cooling liquid pipe that connects the radiator to the multi-cylinder engine is arranged in a space of a temperature of not more than 150°C. Therefore, according to the above-mentioned result of measurement, it is found that the cooling efficiency of the multi-cylinder engine 30 does not markedly decrease even when part of the first pipe 220 is arranged to pass through a space between the front surface portion 32F and the one or plurality of exhaust pipes 41 in the side view of the motorcycle 100.

(5) Comparative Example

[0058] Fig. 6 is a front view of an engine unit 3 of the comparative example, and Fig. 7 is a right side view of the engine unit 3 of the comparative example. The engine unit 3 of the present comparative example has the same configuration as the engine unit 3 of Figs. 3 to 5 except for the following points. In Fig. 6, the radiator 40 is not shown.

[0059] As shown in Figs. 6 and 7, in the engine unit 3 of the comparative example, arrangement of a first pipe 290 that connects the water pump 210 to the radiator 40 is different from the arrangement of the first pipe 220 of Figs. 3 to 5.

[0060] As shown in Fig. 7, a downstream end of the first pipe 290 is connected to the lead-in port 211 of the water pump 210. The first pipe 290 extends forward at the right of the first portion 321 of the right side surface portion 32R from the lead-in port 211 to a position between the front surface portion 32F and the exhaust pipes 41 in the side view of the motorcycle 100. Further, the first pipe 290 is obliquely curved rightward and upward of the inner region AR in the front view of the motorcycle 100 as shown in Fig. 6. Further, the first pipe 290 extends upward at the right of the inner region AR to a position in the vicinity of the upper end of the crankcase 32 to be connected to the lead-out port of the radiator 40.

[0061] Fig. 8 is a front view of the engine unit 3 showing a result of comparison between the first pipe 220 according to the one preferred embodiment and the first pipe 290 of the comparative example. In Fig. 8, the first pipe 220 and the first pipe 290 provided in the engine unit 3 that are superimposed with each other are shown. Further, in Fig. 8, the first pipe 220 is indicated with thick hatching, and the first pipe 290 is indicated by a dotted pattern.

[0062] As indicated by a thick outlined arrow in Fig. 8, the first pipe 290 of the comparative example projects rightward in the vicinity of the front end of the crankcase 32. In contrast, the first pipe 220 does not project rightward from the right side surface portion 32R in the vicinity of the front end of the crankcase 32. From the result of this comparison, when the first pipe 220 is used, it is confirmed that limit of a bank angle of the motorcycle 100 is eased as compared to a case in which the first pipe 290 of the comparative example is used.

(6) Effects

[0063] In the above-mentioned motorcycle 100, the first pipe 220 does not project rightward from the right side surface portion 32R in the vicinity of the front end of the crankcase 32, so that the limit of the bank angle of the motorcycle 100 by the first pipe 220 is eased.

[0064] Further, the first pipe 220 passes through the inner region AR in the front view of the motorcycle 100, so that the center of gravity of the first pipe 220 can be brought close to the center of the multi-cylinder engine 30. Therefore, centralization of the mass in the motorcycle 100 is possible. In this case, a temperature of the region close to the plurality of exhaust pipes 41 in front of the front surface portion 32F of the crankcase 32 does not increase to a degree at which the cooling efficiency of the radiator 40 markedly decreases. As a result, the motorcycle 100 can travel at a larger bank angle while a decrease in cooling efficiency of the multi-cylinder engine

30 is inhibited.

[0065] Further, the first pipe 220 passes through the right of the first portion 321 of the right side surface portion 32R. In this case, the first pipe 220 is arranged more inward in the left-and-right direction W below the crankshaft 31. Therefore, the limit of the bank angle by the first pipe 220 is more sufficiently eased.

[0066] Further, part of the first pipe 220 intersects with the rightmost exhaust pipe 41 (the exhaust pipe 41 connected to the exhaust port 34a of Fig. 3) in the front view of the motorcycle 100. In this case, the first pipe 220 is exposed from a space between the rightmost exhaust pipe 41 and the exhaust pipe 41 adjacent to the exhaust pipe 41. Thus, during the travelling of the motorcycle 100, the first pipe 220 is cooled by air flowing through a space among the plurality of exhaust pipes 41. Therefore, the cooling efficiency of the multi-cylinder engine 30 is improved.

(7) Other Embodiments

[0067] (a) While the multi-cylinder engine 30 is the water-cooled straight four-cylinder engine in the above-mentioned embodiment, the present teaching is not limited to this. The multi-cylinder engine 30 only has to be a water-cooled multi-cylinder engine and may be any one engine of a straight three-cylinder engine and a straight two-cylinder engine, for example.

[0068] (b) While the water jacket for cooling the multi-cylinder engine 30 is formed in the cylinder body 33 in the above-mentioned embodiment, the present teaching is not limited to this. Part or all of the water jacket may be formed in the cylinder head 34.

[0069] (c) In the above-mentioned embodiment, as shown in Fig. 3, a portion, of the first pipe 220, extending in the top-and-bottom direction H in the inner region AR and the second rightmost exhaust pipe 41 (the exhaust pipe 41 connected to the exhaust port 34b of Fig. 3) locally overlap with each other in the front view of the motorcycle 100. However, the arrangement of the first pipe 220 in the inner region AR is not limited to the above-mentioned example.

[0070] For example, when the projection 32P is not formed at the front surface portion 32F of the crankcase 32, part of the first pipe 220 may be arranged to extend in the top-and-bottom direction H between the adjacent two exhaust pipes 41 in the front view of the motorcycle 100. In this case, the first pipe 220 is exposed over a wide range from a space between the adjacent two exhaust pipes 41. Thus, during the travelling of the motorcycle 100, the first pipe 220 is cooled over a wide range by the air flowing through a space among the plurality of exhaust pipes 41. Therefore, the cooling efficiency of the multi-cylinder engine 30 is more sufficiently improved.

[0071] (d) While the vehicle body cover 23 is provided at the motorcycle 100 in the above-mentioned embodiment, the present teaching is not limited to this. The vehicle body cover 23 does not have to be provided at the motorcycle 100. When the vehicle body cover 23 is provided at the motorcycle 100, part of the vehicle body cover 23 may be formed to be located at the right of the first pipe 220. Also in this case, part of the vehicle body cover 23 is formed to be close to a portion directed rightward of the first pipe 220, so that the effects similar to the above-mentioned embodiment can be acquired.

(8) Correspondences between Constituent Elements in Claims and Parts in Preferred Embodiments

[0072] In the following paragraphs, non-limiting examples of correspondences between various elements recited in the claims below and those described above with respect to various preferred embodiments of the present teaching are explained.

[0073] In the above-mentioned embodiment, the crankcase 32 is an example of a crankcase, the cylinder head 34 is an example of a cylinder head, the multi-cylinder head 30 is an example of a multi-cylinder engine and the plurality of exhaust pipes 41 are examples of a plurality of exhaust pipes.

[0074] Further, the radiator 40 is an example of a radiator, the water pump 210 is an example of a pump, the first pipe 220 is an example of a cooling liquid pipe, the front surface portion 32F of the crankcase 32 is an example of a front surface portion, and the right side surface portion 32R and the left side surface portion 32L of the crankcase 32 are examples of a pair of side surface portions.

[0075] Further, the right side surface portion 32R of the crankcase 32 is an example of one side surface portion, the motorcycle 100 is an example of a motorcycle, the first portion 321 of the right side surface portion 32R is an example of a first portion, and the second portion 322 of the right side surface portion 32R is an example of a second portion.

[0076] As each of constituent elements recited in the claims, various other elements having configurations or functions described in the claims can be also used.

INDUSTRIAL APPLICABILITY

[0077] The present teaching can be effectively utilized for a vehicle that advances while tilting during turning, and the like.

Claims

1. A motorcycle comprising:

a multi-cylinder engine (30) having a crankcase (32) and a cylinder head (34);
a plurality of exhaust pipes (41) connected to the cylinder head (34);
a radiator (40);
a pump (210); and

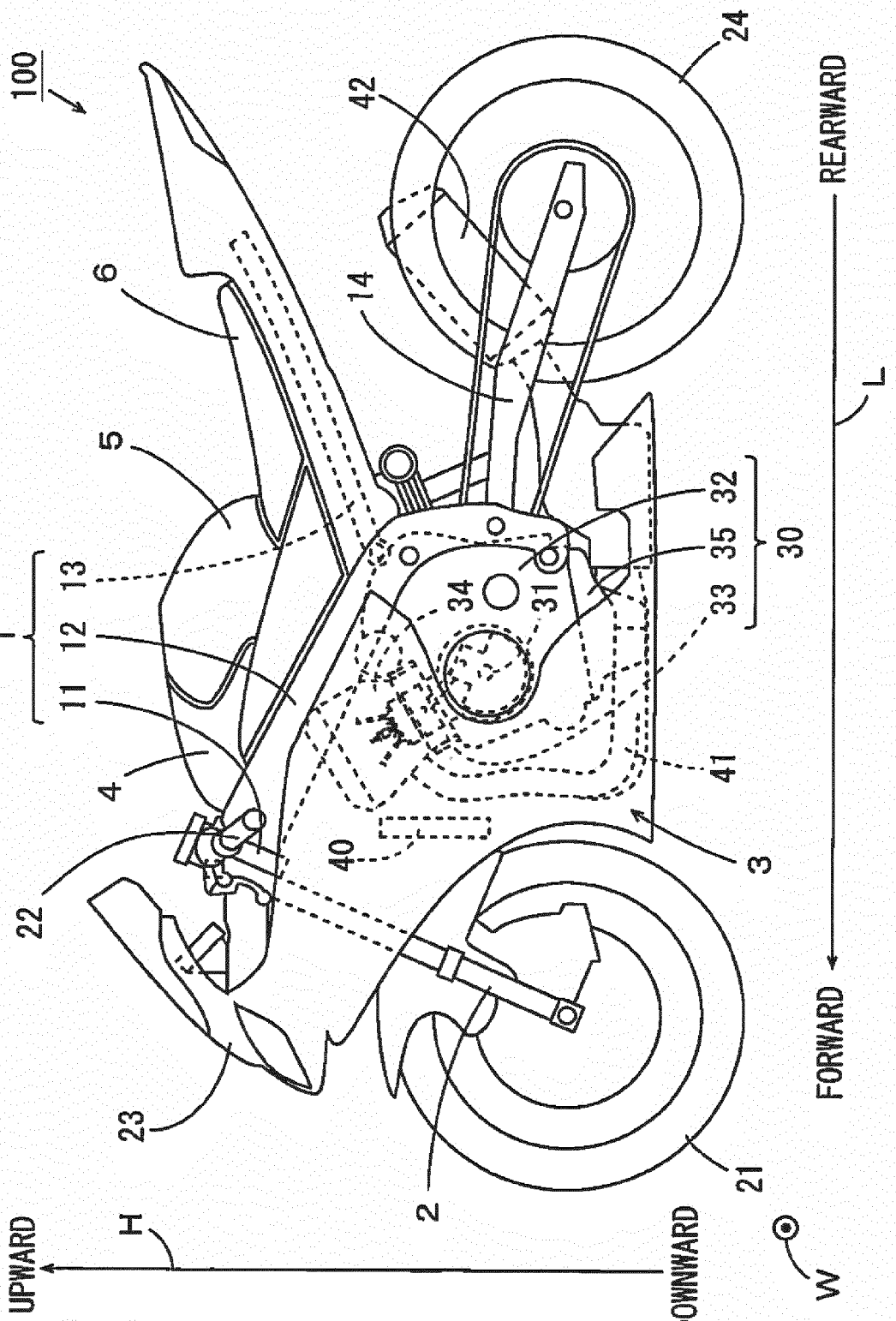
a cooling liquid pipe (220) configured to lead a cooling liquid between the radiator (40) and the pump (210), wherein
the crankcase (32) has a front surface portion (32F) facing forward of the motorcycle and a pair of side surface portions (32L,32R) facing leftward and rightward,
the plurality of exhaust pipes (41) extend downward and are arranged in a left-and-right direction of the motorcycle in front of the front surface portion (32F) of the crankcase (32),
the radiator (40) is provided at a position further forward than the plurality of exhaust pipes (41), and
the cooling liquid pipe (220) extends forward outside of one side surface portion (32R) of the pair of side surface portions (32L,32R) to the front surface portion (32F) of the crankcase (32), is curved inward from outside of the one side surface portion (32R) in a front view of the motorcycle, and passes through a region between a left end and a right end of the plurality of exhaust pipes (41) in the front view of the motorcycle to be connected to the radiator (40).

2. A motorcycle according to claim 1, wherein the one side surface portion (32R) of the crankcase (32) has a first portion (321) located below a crankshaft (31) supported by the crankcase (32), and a second portion (322) located above the first portion (321),
the first portion (321) is located at a position further inward than the second portion (322) in the left-and-right direction of the motorcycle in the front view of the motorcycle, and
the cooling liquid pipe (220) extends forward outside of the first portion (321) to the front surface portion (32F) of the crankcase (32).

3. A motorcycle according to claim 1 or 2, wherein part of the cooling liquid pipe (220) extends to intersect with at least one of the plurality of exhaust pipes (41) in the front view of the motorcycle.

4. A motorcycle according to any one of claims 1 to 3, wherein the cooling liquid pipe (220) is formed of resin.

FIG. 1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UPWARD
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FIG. 2

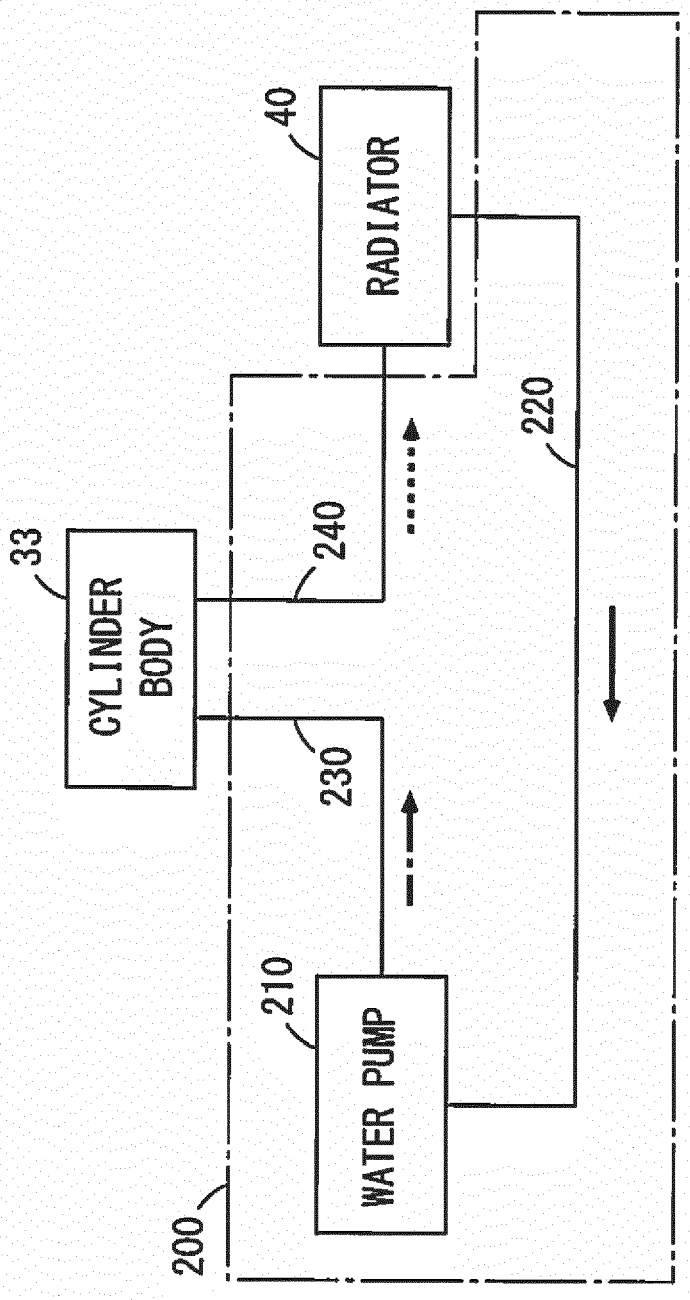
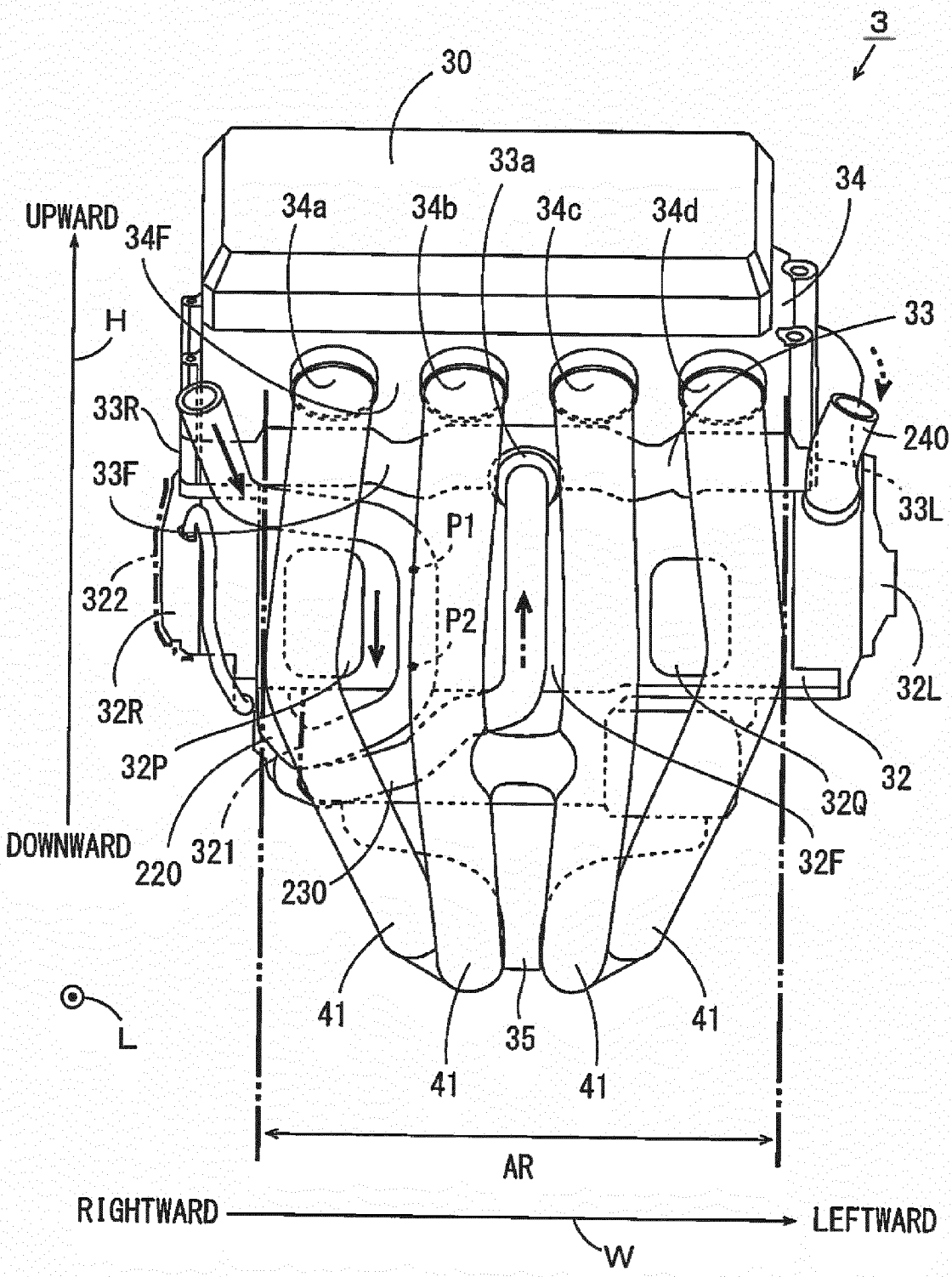


FIG. 3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30
33a
34
34a
34b
34c
34d
UPWARD
34F
H
33
33R
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33F
33L
P1
322
P2
32L
32R
32P
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DOWNWARD
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FIG. 4

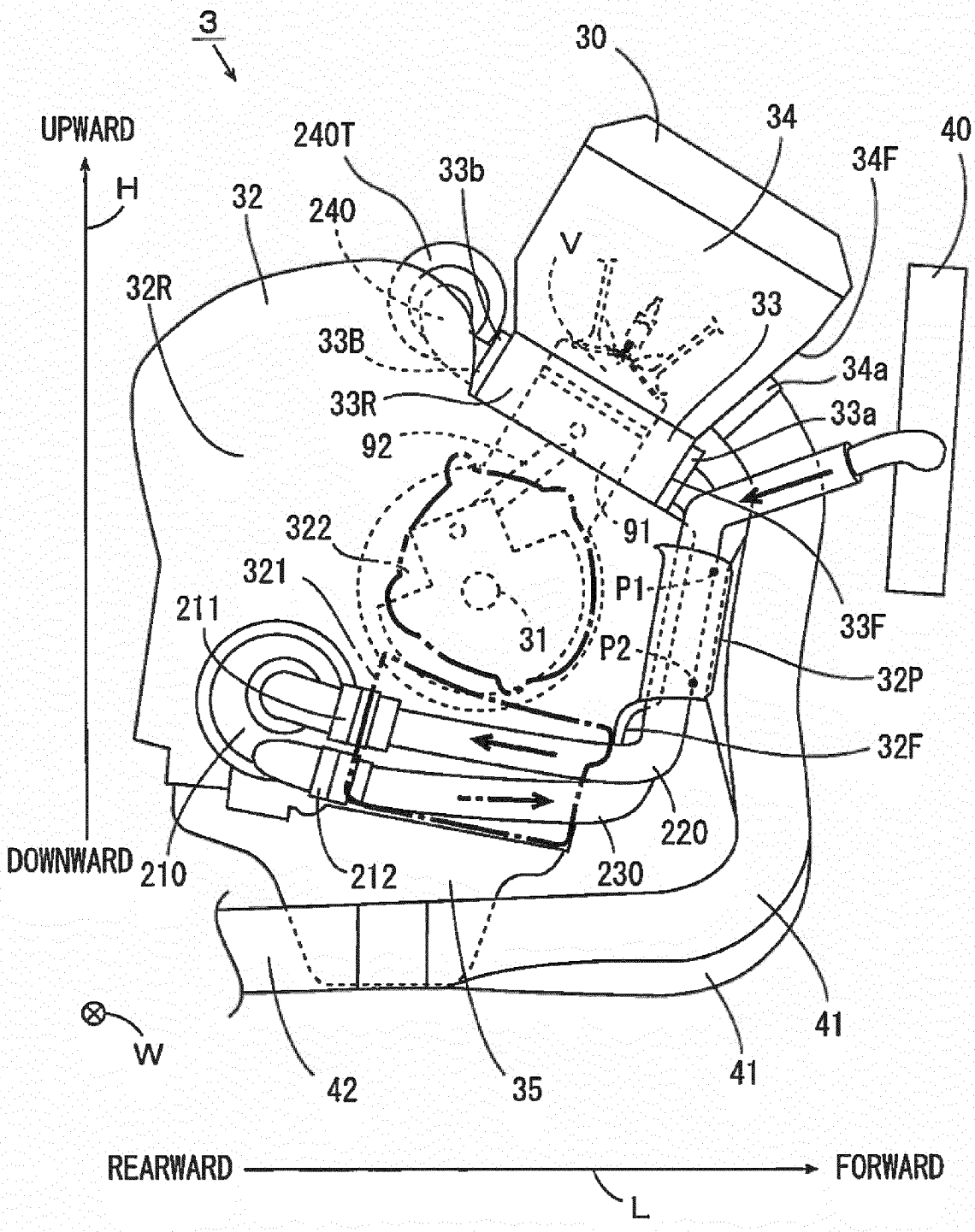
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FIG. 5

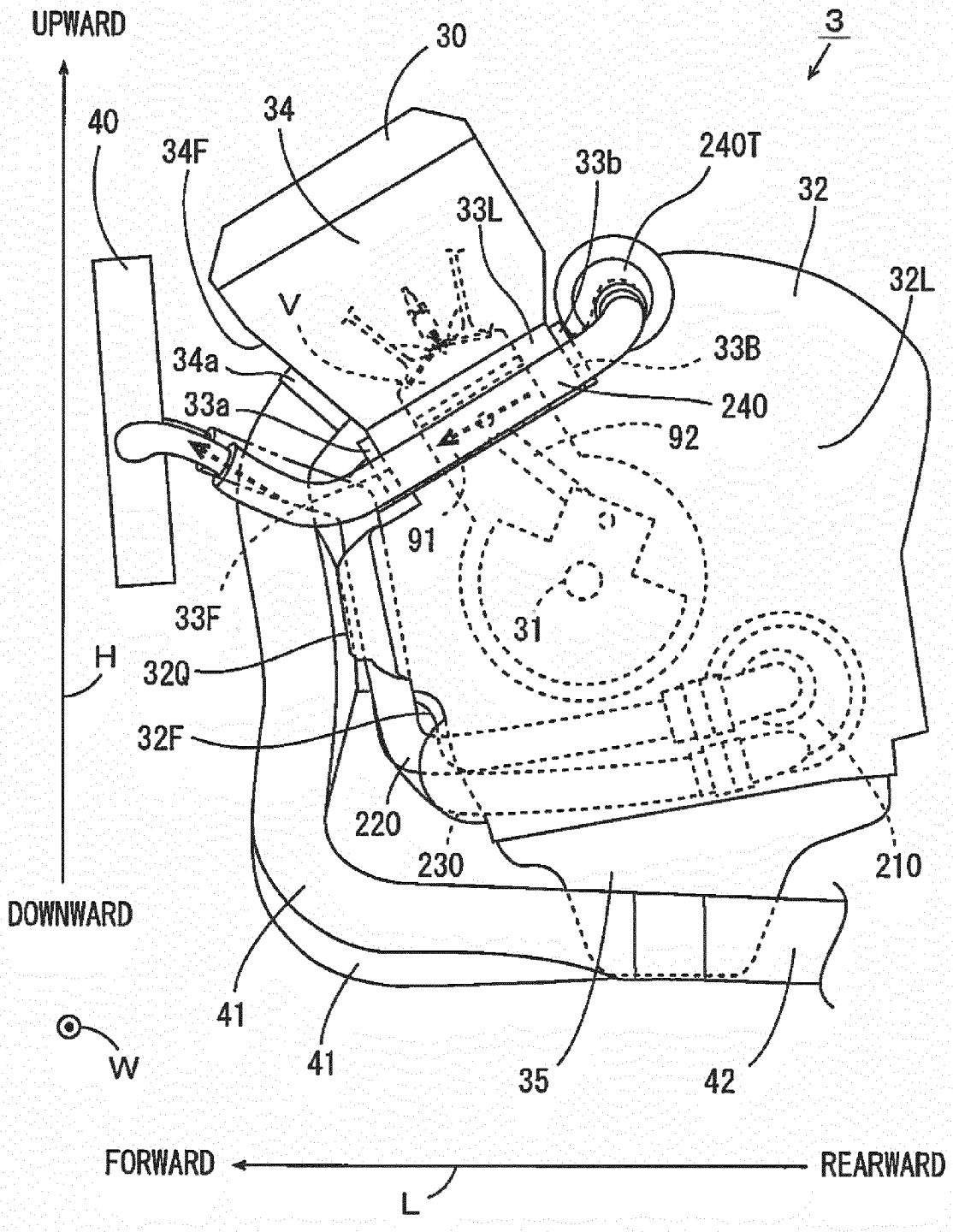
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FIG. 6

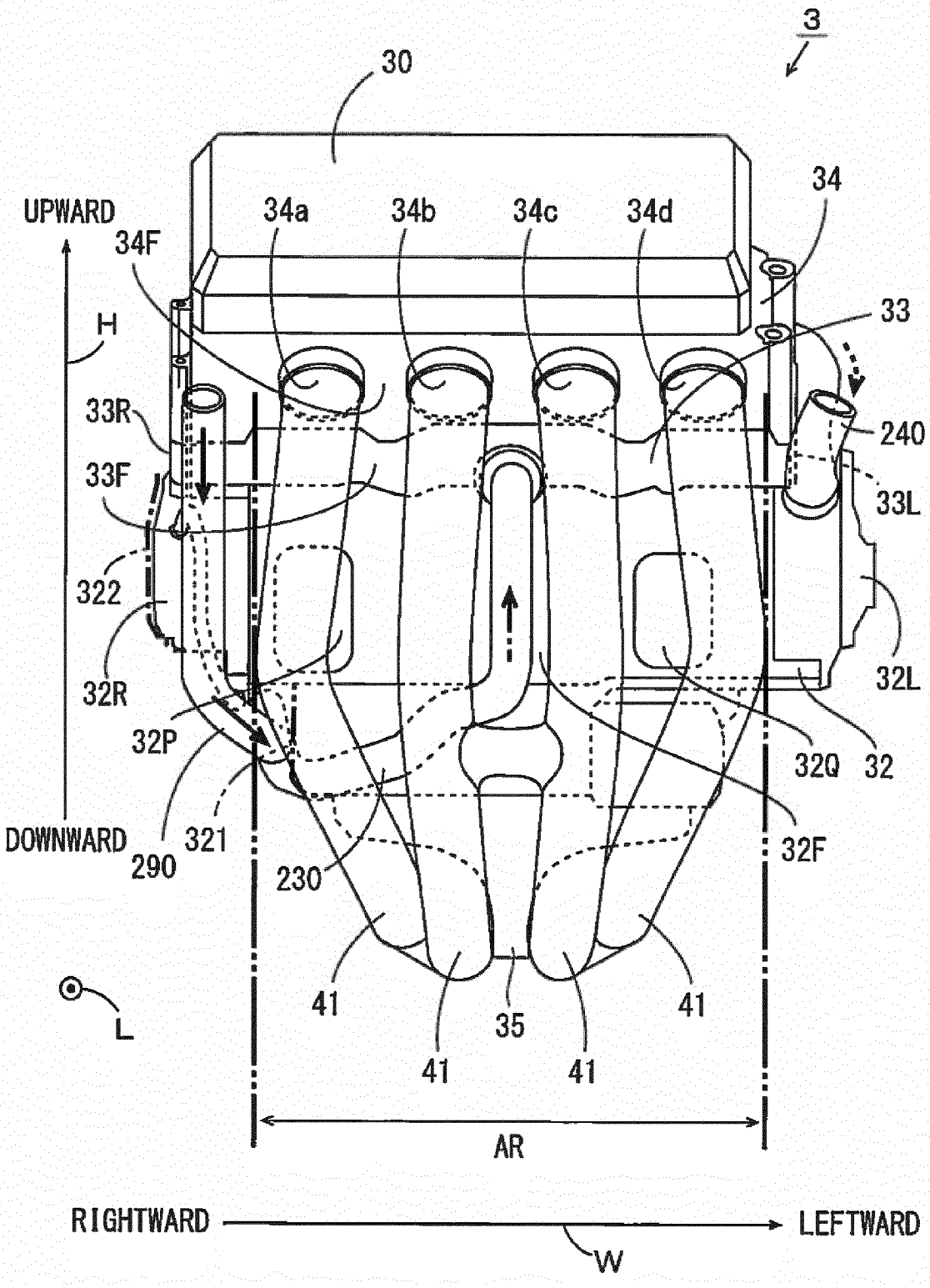
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FIG. 7

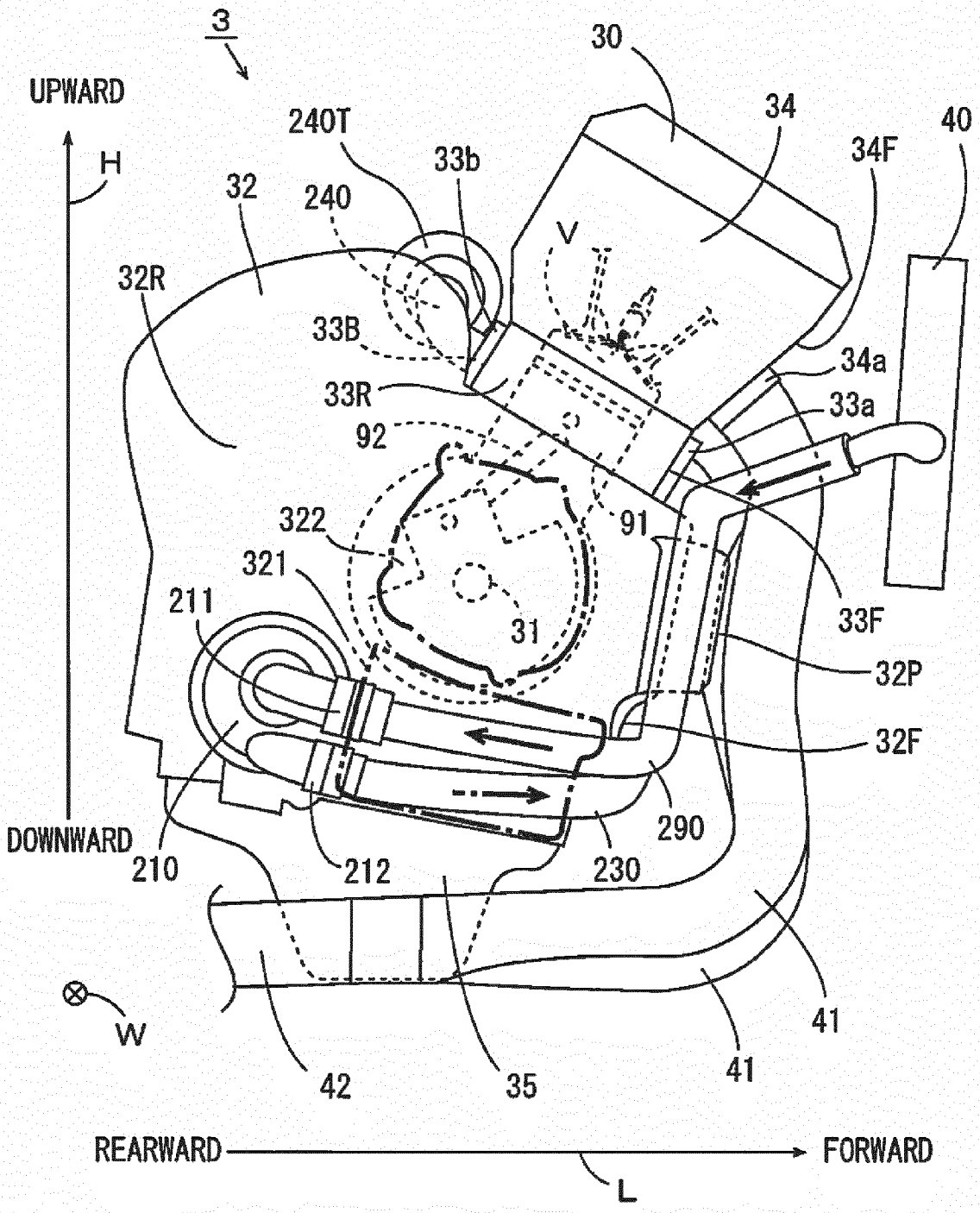
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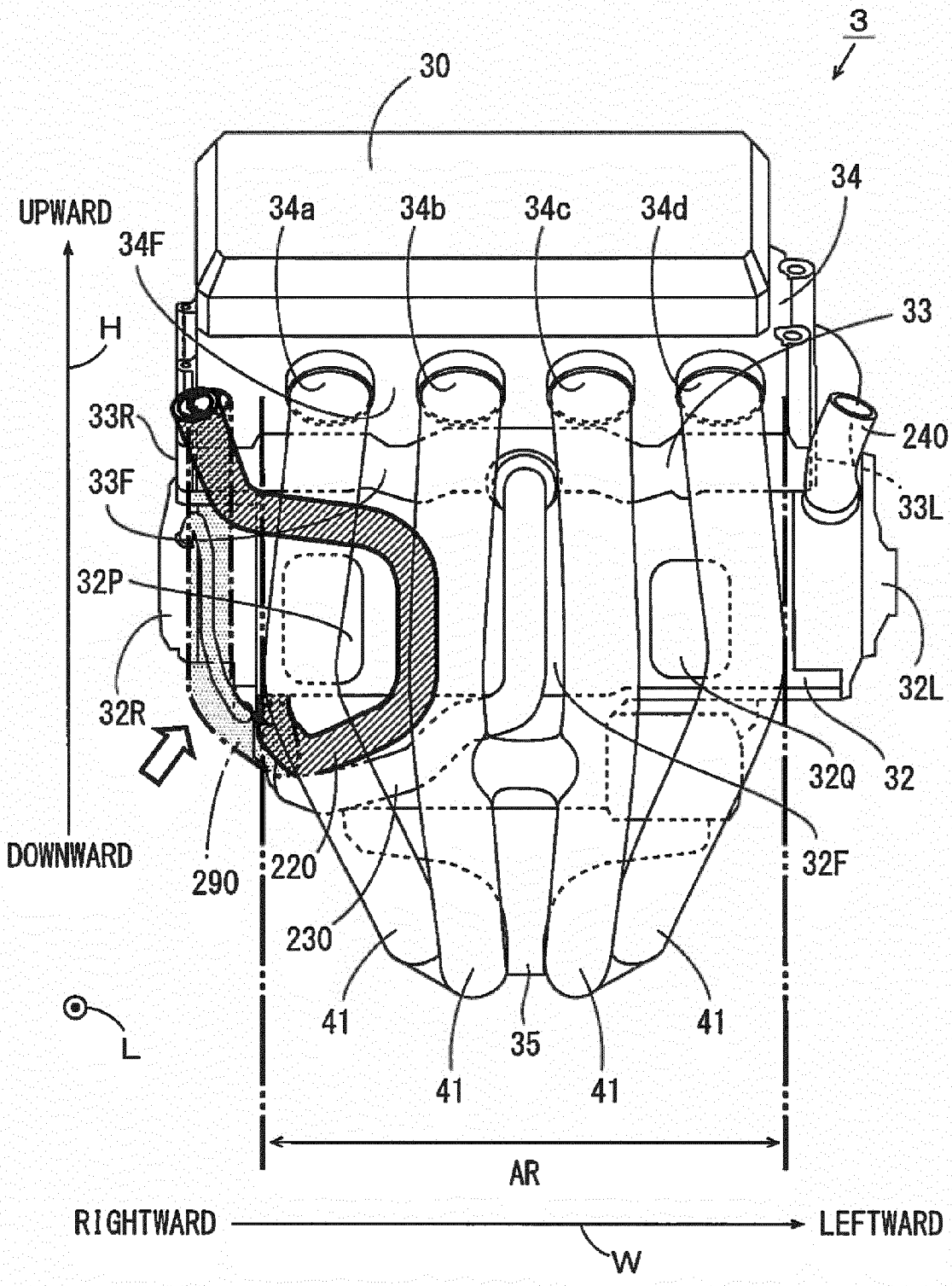
FIG. 8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EUROPEAN SEARCH REPORT

Application Number
EP 15 18 3179

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Y	* column 1, lines 46-60; figures 2,3 *	2,4	
Y	EP 2 110 303 A1 (YAMAHA MOTOR CO LTD [JP]) 21 October 2009 (2009-10-21) * paragraphs [0029], [0033], [0041], [0048], [0054], [0056], [0057], [0061], [0064], [0072], [0075], [0079] - [0084]; figures 1-4,6 *	4	
Y	US 2005/263110 A1 (YASUI NOBUHIRO [JP]) 1 December 2005 (2005-12-01) * paragraphs [0035], [0036], [0047], [0051], [0062] - [0065]; figures 1,2,4,5 *	2	

TECHNICAL FIELDS SEARCHED (IPC)

F01P
F01N

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	10 December 2015	Luta, Dragos

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