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(54) INTERNAL COMBUSTION ENGINE AND STRADDLED VEHICLE HAVING THE SAME

(57) An internal combustion engine is provided, with which it is possible to desirably supply oil to lubricated members while reducing the machining cost. The engine includes a gasket **50** placed between a crankcase **7** and a cover **22,** and gears **28** and **36** placed so that at least a part of the gears **28** and **36** is aligned with the gasket **50,** as the vehicle is seen from above. A primary slit **61** and an internal slit **62** connected to the primary slit **61** are formed in the gasket **50,** wherein the primary slit **61** is placed between a first mating surface **7A** of the crankcase **7** and a second mating surface **22A** of the cover **22** and overlaps with an oil supply hole **84,** and the internal slit **62** is placed in an internal space **90** defined by the crankcase **7** and the cover **22** and placed upward of the gears **28** and **36.** The gasket **50** is closed around the primary slit **61** and the internal slit **62.**

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to an internal combustion engine and a straddled vehicle having the same.

Description of the Related Art

[0002] An internal combustion engine includes lubricated members to be lubricated with oil, such as gears, for example. A configuration has been known in the art, in which an oil passageway and an oil discharge port are formed in a case accommodating lubricated members therein in order to supply oil to the lubricated members, and oil is discharged via the discharge port toward the lubricated members.

[0003] However, this configuration has a problem in that an oil passageway and an oil discharge port need to be formed in the case by machining the case, thereby imposing an increased machining limitation and a high machining cost. Japanese Laid-Open Patent Publication No. 2011-38431 discloses a configuration in which an oil passageway is formed in a metal gasket provided between the cylinder head and the fuel pump housing member. Specifically, in a metal gasket disclosed in Japanese Laid-Open Patent Publication No. 2011-38431, a hole communicating with an oil supply passageway in a cylinder head and a slit, one end of which communicates with the hole and the other end of which is open in the longitudinal direction. Oil that flowed into the hole of the metal gasket via the oil supply passageway in the cylinder head passes through the slit of the metal gasket to be supplied to an internal space of a housing member via the open end of the slit.

SUMMARY OF THE INVENTION

[0004] It is an object of the present invention to provide an internal combustion engine, with which it is possible to desirably supply oil to lubricated members while reducing the machining cost, and to provide a straddled vehicle having the same.

[0005] This obj ect is achieved by an internal combustion engine and by a straddled vehicle as defined in the independent claims.

[0006] It has been found that in the above described conventional approach, when the housing member is fastened to the cylinder head, the gasket receives a substantial pressure from the cylinder head and the housing member. Then, the open end of the slit may be deformed and the passageway of oil may be narrowed, thereby failing to sufficiently supply oil.

[0007] An internal combustion engine of the present invention is an internal combustion engine installed on a vehicle, the internal combustion engine including: a first case including a first mating surface and an oil supply hole formed in the first mating surface; a second case including a second mating surface opposing the first mating surface, and fastened to the first case; a gasket placed between the first case and the second case; and a lubricated member placed in an internal space defined by the first case and the second case and placed so that at least a part the lubricated member is aligned with the gasket, as the vehicle is seen from above, when installed on a vehicle. A primary slit and an internal slit connected to the primary slit are formed in the gasket, wherein the primary slit is placed between the first mating surface and the second mating surface and overlaps with the oil supply hole, and the internal slit isplacedinthe internal space and placed upward of the lubricated member when installed on a vehicle; and the gasket is closed around the primary slit and the internal slit.

[0008] With the internal combustion engine described above, oil, which has been supplied between the first mating surface and the second mating surface via the oil supply hole, is guided into the internal slit through the primary slit of the gasket. Since the internal slit is placed in the internal space defined by the first case and the second case and is placed upward of the lubricated member, oil in the internal slit is supplied to the lubricated member by falling down in the internal space. With the internal combustion engine described above, there is no need to form a discharge port in the first case or the second case for discharging oil toward the lubricated member. Therefore, it is possible to reduce the machining cost. Since the gasket is closed around the primary slit and the internal slit, when the first case and the second case are fastened together, the portion of the gasket around the primary slit and the internal slit is not easily deformed. Therefore, the width of the oil passageway in the gasket, i.e., the width of the primary slit and the internal slit, is maintained, and it is possible to sufficiently supply oil to the lubricated member. Thus, with the internal combustion engine described above, it is possible to desirably supply oil to the lubricated member while reducing the machining cost.

[0009] According to a preferred embodiment of the present invention, the gasket is a paper gasket.

[0010] A paper gasket is less expensive than a metal gasket. On the other hand, a paper gasket is softer than a metal gasket, and has a property that it swells by absorbing oil. Therefore, a paper gasket is more easily deformed than a metal gasket. With the internal combustion engine described above, however, since the gasket is closed around the primary slit and the internal slit, the gasket is not easily deformed despite being a paper gasket. Thus, a paper gasket can be used. According to the above embodiment, it is possible to desirably supply oil to the lubricated member while further reducing the cost.

[0011] According to another preferred embodiment of the present invention, the first mating surface and the secondmating surface are surfaces parallel to a vertical

plane when installed on a vehicle.

[0012] According to the above embodiment, oil having passed through the internal slit of the gasket falls down from both sides of the gasket. Therefore, it is possible to supply oil over a wide area from the gasket.

[0013] According to another preferred embodiment of the present invention, the gasket includes a protrusion protruding downward, the protrusion placed in the internal space and located downward of the internal slit when installed on a vehicle.

[0014] Oil, being a liquid, has a property that it easily collects at a protrusion protruding downward. According to the above embodiment, it is possible to collect oil, which has passed through the internal slit of the gasket, at the protrusion. Therefore, it is possible to desirably supply oil from the protrusion.

[0015] According to another preferred embodiment of the present invention, the gasket includes a protrusion protruding downward, the protrusion placed in the internal space and located directly upward of the lubricated member when installed on a vehicle.

[0016] According to the above embodiment, oil having passed through the internal slit of the gasket collects at the protrusion and falls down from the protrusion toward the lubricated member. Therefore, oil can be supplied directly to the lubricated member. Thus, it is possible to desirably supply oil to the lubricated member while reducing the machining cost.

[0017] According to another preferred embodiment of the present invention, the lubricated member includes a first member and a second member. The gasket includes a first protrusion protruding downward, the first protrusion placed in the internal space and located directly upward of the first member when installed on a vehicle, and a second protrusion protruding downward, the second protrusion placed in the internal space and located directly upward of the second member when installed on a vehicle.

[0018] According to the above embodiment, oil having been guided into the internal slit of the gasket can be desirably supplied to the first member and to the second member.

[0019] According to another preferred embodiment of the present invention, the lubricated member includes a gear.

[0020] According to the above embodiment, it is possible to desirably supply oil to the gear of the internal combustion engine while reducing the machining cost.

[0021] According to another preferred embodiment of the present invention, the lubricated member includes an oil pump including an oil pump gear.

[0022] According to the above embodiment, it is possible to desirably supply oil to the oil pump gear while reducing the machining cost.

[0023] According to another preferred embodiment of the present invention, oil is stored at a bottom of the first case and/or the second case when installed on a vehicle; and the oil pump gear is placed upward of a liquid surface of the oil stored at the bottom when the internal combustion engine is inoperative.

[0024] When the oil pump gear is immersed in the oil stored at the bottom of the first case and/or the second case, the oil can be stirred up as the oil pump gear rotates, and the oil pump gear can be lubricated with the stirred-up oil. However, when the oil pump gear is placed upward of the liquid surface of oil, as in the embodiment described above, oil cannot be stirred up by the oil pump gear. Thus, the advantageous effect of supplying oil to the oil pump gear through the primary slit and the internal slit of the gasket is more pronounced.

[0025] According to another preferred embodiment of the present invention, the first case is a crankcase supporting a crankshaft. The internal combustion engine further includes: a cylinder body connected to the crankcase, the cylinder body accommodating therein a piston linked to the crankshaft via a connecting rod; a cylinder head connected to the cylinder body, the cylinder head including an intake valve and an exhaust valve; and a cylinder head cover connected to the cylinder head, the cylinder head cover including a valve operating mechanism configured to operate the intake valve and the exhaust valve. An oil intake hole overlapping with the primary slit of the gasket is formed in the crankcase. An oil passageway connecting between the oil intake hole and an internal space of the cylinder head cover is formed in the crankcase, the cylinder body, the cylinder head and the cylinder head cover.

[0026] According to the above embodiment, it is possible to desirably supply oil to the lubricated member and the valve operating mechanism.

[0027] According to another preferred embodiment of the present invention, the oil intake hole is provided between the oil supply hole and the internal slit along the primary slit of the gasket.

[0028] According to the above embodiment, a part of oil having flowed into the primary slit via the oil supply hole flows into the oil intake hole, and oil not having flowed into the oil intake hole flows into the internal slit. Since oil in the primary slit is preferentially supplied to the oil intake hole, it is possible to supply a sufficient amount of oil to the valve operating mechanism in the cylinder head cover. Therefore, it is possible to desirably supply oil to the lubricated member and the valve operating mechanism.

[0029] According to another preferred embodiment of the present invention, the internal slit of the gasket is formed in a shape extending in a vertically downward direction or a diagonally downward direction when installed on a vehicle.

[0030] According to the above embodiment, since it is more likely that oil flows quickly through the internal slit under the influence of gravity, it is possible to desirably supply oil in the primary slit to the lubricated member through the internal slit.

[0031] According to another preferred embodiment of the present invention, an outline of a distal end of the

internal slit of the gasket is formed in an arc shape.

[0032] According to the above embodiment, oil is unlikely to remain in the distal end of the internal slit, and it is possible to quickly supply oil to the lubricated member via the internal slit.

[0033] A straddled vehicle of the present invention includes the internal combustion engine set forth above.

[0034] Thus, it is possible to obtain a straddled vehicle with the advantageous effects set forth above.

Advantageous Effects Of Invention

[0035] According to the present invention, it is possible to provide an internal combustion engine, with which it is possible to desirably supply oil to lubricated members while reducing the machining cost, and to provide a straddled vehicle having the same.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036]

FIG. **1** is a side view of a motorcycle according to one embodiment of the present invention.

FIG. **2** is a cross-sectional view of a power unit.

FIG. 3 is a side view of the power unit, showing a crankcase with a cover removed and showing a cylinder body, a cylinder head and a cylinder head cover partially cut away.

FIG. **4** is a cross-sectional view of the power unit taken along line IV-IV of FIG. **3.**

FIG. **5** is a front view of a gasket.

FIG. **6** is a view showing how a gasket is laid on a first mating surface of the crankcase.

FIG. **7** is an enlarged cross-sectional view of a portion of the power unit.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0037] One embodiment of the present invention will now be described with reference to the drawings. As shown in FIG. **1,** a vehicle of the present embodiment is a motorcycle **1,** which is an example straddled vehicle to be straddled by a passenger. Note however that the vehicle of the present invention is not limited to the motorcycle **1,** but may be any other straddled vehicle to be straddled by a passenger, such as a three-wheeled vehicle, an all terrain vehicle (ATV) and a snowmobile. It may also be a vehicle other than a straddled vehicle.

[0038] The terms front, rear, left, right, up and down, as used in the description below, refer to these directions as seen from a passenger seated in a seat **4** while the motorcycle **1** is stationary in an upright position on a horizontal surface, unless specified otherwise. The designations F, Re, L, R, U and D, as used in the figures, refer to front, rear, left, right, up and down, respectively. The terms forward and rearward refer to these directions in the vehicle front-rear direction, unless specified otherwise. The terms upward and downward refer to these directions in the vehicle up-down direction. The terms leftward and rightward refer to these directions in the vehicle left-right direction. The directions as used in the following description of a power unit **3** and an internal combustion engine **5** refer to these directions with the power unit **3** installed on the motorcycle **1.**

[0039] As shown in FIG. **1,** the motorcycle **1** includes a vehicle body frame **2** including a head pipe **12,** a power unit **3** supported on the vehicle body frame **2,** a front wheel **20** and a rear wheel **30.** A steering shaft **13** is rotatably supported on the head pipe **12.** A handle bar **11** is fixed on an upper portion of the steering shaft **13,** and a front fork **14** is fixed on a lower portion of the steering shaft **13.** The front wheel **20** is attached to the front fork **14.** A fuel tank **10** is placed upward of the power unit **3.** The seat **4** is placed rearward of the fuel tank **10.** The power unit **3** is linked to the rear wheel **30** via a transmission member such as a chain **26** (not shown in FIG. **1;** see FIG. **2).**

[0040] Next, a configuration of the power unit **3** will be described. As shown in FIG. **2,** the power unit **3** includes an internal combustion engine **5.** The power unit **3** drives the rear wheel **30** using the power from the internal combustion engine **5.** In the present embodiment, the internal combustion engine **5** is a single-cylinder internal combustion engine including a single cylinder **6.** Note however that the internal combustion engine **5** may be a multi-cylinder internal combustion engine including a plurality of cylinders.

[0041] The internal combustion engine **5** includes a crankcase **7,** a cylinder body **8** connected to the crankcase **7,** a cylinder head **9** connected to the cylinder body **8,** and a cylinder head cover **15** connected to the cylinder head **9.** The cylinder body **8,** the cylinder head **9** and the cylinder head cover **15** extend in a diagonally upward direction from the crankcase **7.** The cylinder body **8** is placed upward of the crankcase **7,** the cylinder head **9** is placed upward of the cylinder body **8,** and the cylinder head cover **15** is placed upward of the cylinder head **9.**

[0042] A cover **17** is placed leftward of the crankcase **7,** and a cover **22** is placed rightward of the crankcase **7.** The cover **17** and the cover **22** are fixed to the crankcase **7.** A gasket **49** is placed between the cover **17** and the crankcase **7.** A gasket **50** is placed between the cover **22** and the crankcase **7.** The gasket **50** is sandwiched between the cover **22** and the crankcase **7.** The cover **22** and the crankcase **7** are fastened together by means of fastening members such as bolts **58.** Note that the fastening members are not limited to the bolts **58,** and may be screws, for example. The crankcase **7** and the cover **22** are examples of the "first case" and the "second case", respectively.

[0043] A crankshaft **18** is placed in an internal space **90** defined by the crankcase **7,** the cover **17** and the cover **22.** The crankshaft **18** is supported by the crankcase **7** via a bearing **39.** The piston 16 is placed inside the cyl-

inder body **8.** The crankshaft **18** and the piston **16** are linked together by a connecting rod **19.** A generator **21** is attached to the left end of the crankshaft **18.** The generator **21** is covered by the cover **17.** A gear **28** is placed at the right end of the crankshaft **18.**

[0044] A main shaft **23** and a drive shaft **24** are placed in the internal space **90** of the crankcase **7.** The main shaft **23** and the drive shaft **24** are placed parallel to the crankshaft **18.** A plurality of transmission gears **25A** are provided on the main shaft **23.** Transmission gears **25B**, meshing with the transmission gears **25A,** are provided on the drive shaft **24.** The main shaft **23,** the transmission gears **25A,** the transmission gears **25B** and the drive shaft **24** together form a transmission **35.** The left end **24a** of the drive shaft **24** is placed outside the crankcase **7.** A sprocket **26A** is fixed at the left end **24a** of the drive shaft **24,** with the chain **26** wrapped around the sprocket **26A.**

[0045] A clutch **40** is provided at the right end of the main shaft **40.** While the clutch **40** is a wet multiple-disc clutch in the present embodiment, there is no particular limitation on the type of the clutch **40.** The clutch **40** includes a clutch housing **41** rotatably supported on the main shaft **23,** a clutch boss **42** non-rotatably supported on the main shaft **23,** a plurality of plates **27** which are supported on the clutch housing **41** and rotate together with the clutch housing **41,** a plurality of plates **29** which are supported on the clutch boss **42** and rotate together with the clutch boss **42,** a pressure plate **43** configured to press the plates **27** and **29** against each other, and a spring **45** configured to urge the pressure plate **43** toward the plates **27** and **29.** A gear **31,** meshing with the gear **28** of the crankshaft **18,** is provided in the clutch housing **41.** The clutch housing **41** is configured to rotate with the crankshaft **18.** The cover **22** is placed rightward of the clutch **40.** The clutch **40** is covered by the cover **22.**

[0046] FIG. **3** is a view showing the crankcase **7** with the cover **22** removed and showing the cylinder body **8,** the cylinder head **9** and the cylinder head cover **15** partially cut away. Note that in FIG. **3,** the outline of the gasket **50** is indicated by a phantom line, and the flow of oil is indicated by a one-dot-chain line. As shown in FIG. **3,** the bottom of the crankcase **7** and the cover **22** forms an oil pan **32** storing oil therein. Reference sign **33** in FIG. **3** represents the liquid surface of oil when the internal combustion engine **5** is inoperative. An oil pump **34** is placed in the internal space **90** of the crankcase **7.** The oil pump **34** is placed upward of the liquid surface **33** of oil when the internal combustion engine **5** is inoperative. The oil pump **34** includes an oil pump gear **36** meshing with the gear **28** provided on the crankshaft **18.** The oil pump gear **36** rotates together with the crankshaft **18.** The oil pump **34** is configured to be driven by the crankshaft **18.** An oil filter **37** is placed in the oil pan **32.**

[0047] As shown in FIG. **4,** an oil path **81** connecting between the oil pan **32** and an inlet **34i** of the oil pump **34,** an oil path **82** connected to an outlet **34o** of the oil pump **34,** and an oil path **83** diverging from the oil path **82** are formed inside the crankcase **7.**

[0048] The crankcase **7** has a first mating surface **7A,** and the cover **22** has a secondmating surface **22A** opposing the first mating surface **7A.** The gasket **50** is placed between the first mating surface **7A** and the second mating surface **22A.** The gasket **50** is in contact with the first mating surface **7A** and the second mating surface **22A.** The first mating surface **7A** and the second mating surface **22A** are surfaces parallel to the vertical plane. An oil supply hole **84** connected to the oil path **83** is formed in the first mating surface **7A.** The oil supply hole **84** has an opening facing toward the second mating surface **22A.**

[0049] FIG. **5** is a front view of the gasket **50,** as seen from the right side of the motorcycle **1.** The gasket **50** has a slit **60,** in addition to holes **51** through which bolts **58** (see FIG. **2)** are inserted. The slit **60** is formed in a first surface of the gasket **50** facing the first mating surface **7A.** The slit may extend from the first surface into the gasket **50,** or the slit **60** may extend from the first surface through the gasket **50** to a second surface of the gasket **50** facing the secondmating surface **22A.** The slit **60** is formed in the gasket **50** at a distance from an edge of the surfaces of the gasket **50.** The gasket **50** may be a metal gasket, but the gasket **50** is a paper gasket containing fibers therein in the present embodiment.

[0050] FIG. **6** is a view showing how the gasket **50** is laid on the first mating surface **7A** of the crankcase **7.** In FIG. **6,** the gasket **50** is hatched to make it easier to understand the position and the shape of the gasket **50.** The hatching of FIG. **6** is not representing a cross section. In FIG. **6,** the gear **31** of the clutch housing **41,** the gear **28** provided on the crankshaft **18** and the oil pump gear **36** are simplified.

[0051] Reference sign **7B** in FIG. **6** refers to an inner wall surface of the crankcase **7.** The inner wall surface **7B** is a surface that is perpendicular to, or inclined from, the first mating surface **7A.** In FIG. **6,** the area on the opposite side from the first mating surface **7A** with respect to the inner wall surface **7B** is the internal space **90** of the crankcase **7.** As shown in FIG. **6,** the slit **60** includes a primary slit **61** and an internal slit **62.** The primary slit **61** is formed in a part of the gasket **50** that is placed between the first mating surface **7A** and the second mating surface **22A,** and the internal slit **62** is formed in a part of the gasket **50** that is placed in the internal space **90** defined by the crankcase **7** and the cover **22.** The primary slit **61** and the internal slit **62** are connected to each other. Along the internal slit **62,** both sides of the gasket **50** (the right side and the left side of the internal slit **62** in the present embodiment; the front side and the reverse side of the drawing sheet of FIG. **6)** are open into the internal space **90** of the crankcase **7** and the cover **22.** On the other hand, the internal slit **62** is not open in the direction perpendicular to the thickness direction of the gasket **50** (the direction perpendicular to the left-right direction in the present embodiment; the direction parallel to the drawing sheet of FIG. **6**). The gasket **50** is closed

around the primary slit **61** and the internal slit **62.** The outline of the primary slit **61** and the internal slit **62** is formed in a closed loop. When the cover **22** is fastened to the crankcase **7** with the gasket **50** therebetween, the gasket **50** receives a substantial pressure from the first mating surface **7A** and the second mating surface **22A.** However, since it is closed around the primary slit **61** and the internal slit **62,** the rigidity of the gasket **50** is ensured, and the gasket **50** is not easily deformed.

[0052] As shown in FIG. **3,** an oil passageway **85** is formed in the cylinder body **8,** the cylinder head **9** and the cylinder head cover **15.** The oil passageway **85** is a passageway for supplying oil to components such as the piston **16,** an intake valve **44,** an exhaust valve **46,** a valve operating mechanism **47** configured to operate the intake valve **44** and the exhaust valve **46,** and a cam chain **48** (see FIG. **2)** that links together the crankshaft **18** and the valve operating mechanism **47.** Also, an oil passageway **86** for supplying oil to the clutch **40** and the transmission **35** is formed in the crankcase **7.**

[0053] As shown in FIG. **6,** oil intake holes **87** and **88** communicating with the oil passageway **85** and an oil intake hole **89** communicating with the oil passageway **86** are formed in the crankcase **7,** in addition to the oil supply hole **84** described above. The primary slit **61** of the gasket **50** includes a portion **61A** overlapping with the oil supply hole **84,** a portion **61B** overlapping with the oil intake **hole 87,** a portion **61C** overlapping with the oil intake hole **88,** and a portion **61D** overlapping with the oil intake hole **89.** Where the downstream side refers to the side toward which oil flows and the upstream side refers to the opposite side, the overlapping portions **61A, 61B, 61C** and **61D** are placed in this order from the upstream side toward the downstream side.

[0054] The internal slit **62** is provided between the overlapping portion **61C** and the overlapping portion **61D** along the primary slit **61.** Although the internal slit **62** is formed in a linear shape in the present embodiment, there is no particular limitation on the shape. Although the internal slit **62** extends in a diagonally downward direction from the primary slit **61,** it may extend in a vertically downward direction. The internal slit **62** may extend in a horizontal direction. Although the outline of the distal end of the internal slit **62** is formed in an arc shape in the present embodiment, the outline shape of the distal end is not limited to an arc shape.

[0055] The internal slit **62** is placed upward of the gear **28** and the oil pump gear **36.** Note that the gear **28** and the oil pump gear **36** are examples of the lubricated members to which oil is supplied, and are an example of the first member and an example of the second member, respectively. As shown in FIG. **7,** the gasket **50** is placed so as to be aligned with the gear **28** and the oil pump gear **36,** as the vehicle is seen from above. As shown in FIG. **6,** the internal slit **62** is placed directly upward of the gear **28.**

[0056] The gasket **50** includes protrusions **52** and **53** protruding downward in the internal space **90** defined by the crankcase **7** and the cover **22.** The protrusion **52** is placed downward of the internal slit **62.** The protrusion **52** is placed upward of the gear **28,** and is placed directly upward of the gear **28** in the present embodiment. The protrusion **53** is placed upward of the oil pump gear **36,** and is placed directly upward of the oil pump gear **36** in the present embodiment. The protrusion **53** is placed downward of the protrusion **52.** The protrusion **53** and the protrusion **52** are connected together by a portion **54** of the gasket **50** placed in the internal space **90.**

[0057] Next, the oil-supplying operation of the internal combustion engine **5** will be described. As indicated by arrows in FIG. **4,** oil in the oil pan **32** is sucked into the oil pump **34** and then discharged from the oil pump **34** to be passed to the oil paths **82** and **83.** Oil having been passed to the oil path **83** flows into the inside of the primary slit **61** of the gasket **50** through the oil supply hole **84.**

[0058] As shown in FIG. **6,** a part of oil flowing through the primary slit **61** flows into the oil passageway **85** through the oil intake holes **87** and **88.** Oil having flowed through the oil passageway **85** is supplied to components such as the piston **16,** the intake valve **44,** the exhaust valve **46,** the valve operating mechanism **47** and the cam chain **48,** after which the oil falls down to be collected in the oil pan **32.**

[0059] Another part of oil flowing through the primary slit **61** diverges into the internal slit **62**. Oil having flowed through the internal slit **62** flows out of the internal slit **62** to both sides of the gasket **50** to fall down under the influence of gravity. Since the gasket **50** includes the protrusions **52** and **53,** a part of oil collects at the protrusion **52** and another part of oil collects at the protrusion **53.** Oil having collected at the protrusion **52** falls down toward the gear **28.** Oil having collected at the protrusion **53** falls down toward the oil pump gear **36.** Thus, the gear **28** and the oil pump gear **36** are lubricated.

[0060] The remaining oil inside the primary slit **61** flows into the oil passageway **86** via the oil intake hole **89.** The oil flows through the oil passageway **86,** and is then supplied to the clutch **40** and the transmission **35.** Thus, the clutch **40** and the transmission **35** are lubricated.

[0061] As described above, with the internal combustion engine **5** of the present embodiment, oil, which has been supplied between the first mating surface **7A** of the crankcase **7** and the second mating surface **22A** of the cover **22** via the oil supply hole **84** formed in the crankcase **7,** is guided into the internal slit **62** through the primary slit **61** of the gasket **50.** Since the internal slit **62** is placed in the internal space **90** defined by the crankcase **7** and the cover **22** and is placed upward of the gear **28** and the oil pump gear **36,** oil in the internal slit **62** is supplied to the gear **28** and the oil pump gear **36** by falling down therefrom. With the internal combustion engine **5** of the present embodiment, there is no need to form a discharge port in the crankcase **7** and the cover **22** for discharging oil toward the gear **28** or the oil pump gear **36.** Therefore, it is possible to reduce the machining cost.

Since the gasket **50** is closed around the primary slit **61** and the internal slit **62,** when the cover **22** is fastened to the crankcase **7** by the bolt **58,** the portion around the primary slit **61** and the internal slit **62** of the gasket **50** is not easily deformed. Therefore, the width of the oil passageway in the gasket **50,** i. e. , the width of the primary slit **61** and the internal slit **62,** is maintained, and it is possible to sufficiently supply oil to the gear **28** and the oil pump gear **36.** Thus, with the internal combustion engine **5** of the present embodiment, it is possible to desirably supply oil to the gear **28** and the oil pump gear **36** while reducing the machining cost.

[0062] With the internal combustion engine **5** of the present embodiment, the gasket **50** is a paper gasket. A paper gasket is less expensive than a metal gasket. On the other hand, a paper gasket is softer than a metal gasket, and has a property that it swells by absorbing oil. Therefore, a paper gasket is more easily deformed than a metal gasket. With the internal combustion engine **5** of the present embodiment, however, since the gasket **50** is closed around the primary slit **61** and the internal slit **62,** the gasket **50** is not easily deformed despite being a paper gasket. Thus, a paper gasket can be used as the gasket **50.** According to the present embodiment, it is possible to desirably supply oil to the gear **28** and the oil pump gear **36** while further reducing the cost.

[0063] With the internal combustion engine **5** of the present embodiment, the first mating surface **7A** and the second mating surface **22A** are surfaces parallel to the vertical plane. The internal slit **62** of the gasket **50** is open on the left side and on the right side in the internal space **90** defined by the crankcase **7** and the cover **22.** Therefore, oil having passed through the internal slit **62** of the gasket **50** falls down from both sides of the gasket **50.** Therefore, it is possible to supply oil over a wide area from the gasket **50.**

[0064] As shown in FIG. **6**, the gasket **50** includes the protrusions **52** and **53,** which are located downward of the internal slit **62** and protruding downward. Oil, being a liquid, has a property that it easily collects at the protrusions **52** and **53** protruding downward. Therefore, it is possible to allow oil, which has passed through the internal slit **62** of the gasket **50,** to collect at the protrusions **52** and **53,** and it is possible to desirably supply oil from the protrusions **52** and **53.** Particularly, the protrusion **52** is located directly upward of the gear **28,** and the protrusion **53** is located directly upward of the oil pump gear **36.** Therefore, oil having collected at the protrusion **52** can be supplied directly to the gear **28,** and oil having collected at the protrusion **53** can be supplied directly to the oil pump gear **36.** According to the present embodiment, it is possible to desirably supply oil to the gear **28** and the oil pump gear **36** while reducing the machining cost.

[0065] As shown in FIG. **6,** the oil pump gear **36** is placed upward of the liquid surface **33** of oil stored at the bottom of the crankcase **7** and the cover **22** when the internal combustion engine **5** is inoperative. When the oil pump gear **36** is immersed in the oil stored, the oil can be stirred up as the oil pump gear **36** rotates, and the stirred-up oil can be supplied to the oil pump gear **36** and the gear **28.** However, when the oil pump gear **36** is placed upward of the liquid surface **33** of oil, the oil cannot be stirred up by the oil pump gear **36.** According to the present embodiment, the advantageous effect of supplying oil to the gear **28** and the oil pump gear **36** through the primary slit **61** and the internal slit **62** of the gasket **50** is more pronounced.

[0066] With the internal combustion engine **5** of the present embodiment, the oil intake holes **87** and **88** communicating with the oil passageway **85** are provided between the oil supply hole **84** and the internal slit **62** along the primary slit **61** of the gasket **50.** A part of oil having flowed into the primary slit **61** via the oil supply hole **84** flows into the oil intake holes **87** and **88,** and oil not having flowed into the oil intake holes **87** and **88** flows into the internal slit **62.** Since oil in the primary slit **61** is preferentially supplied to the oil intake holes **87** and **88,** it is possible to supply a sufficient amount of oil to the valve operating mechanism **47,** etc., in the cylinder head cover **15.** Therefore, it is possible to desirably supply oil to the gear **28** and the oil pump gear **36,** and it is also possible to desirably supply oil to the valve operating mechanism **47,** etc., in the cylinder head cover **15.**

[0067] Although there is no particular limitation on the shape of the internal slit **62** of the gasket **50,** if it is shaped so as to extend in a diagonally downward direction or a vertically downward direction as in the present embodiment, it is more likely that oil flows quickly through the internal slit **62** under the influence of gravity. Therefore, it is possible to desirably supply oil in the primary slit **61** to the gear **28** and the oil pump gear **36** through the internal slit **62.**

[0068] According to the present embodiment, the outline of the distal end of the internal slit **62** of the gasket **50** is formed in an arc shape. Therefore, oil is unlikely to remain inside the internal slit **62,** and it is possible to quickly supply oil to the gear **28** and the oil pump gear **36** via the internal slit **62.**

[0069] While one embodiment of the present invention has been described above, it is understood that the present invention is not limited to the embodiment described above. Next, some alternative embodiments will be described briefly.

[0070] As described above, the gasket **50** is not limited to a paper gasket but may be a metal gasket. The gasket **50** may also be a resin gasket. There is no particular limitation on the material of the gasket **50.** The gasket **50** may be made of a single material, or may be a plurality of materials combined together.

[0071] The first mating surface **7A** and the secondmating surface **22A** do not always need to be surfaces parallel to the vertical plane, but may be, for example, surfaces inclined from the vertical plane or surfaces perpendicular to the vertical plane.

[0072] The protrusion **52** of the gasket **50** does not

always need to be placed directly upward of the gear **28.** Similarly, the protrusion **53** does not always need to be placed directly upward of the oil pump gear **36.**

[0073] Although the lubricated members, which receive oil having passed through the internal slit **62** of the gasket **50,** are the gear **28** and the oil pump gear **36** in the embodiment described above, there is no particular limitation on the lubricated members. The lubricated members may be other components of the internal combustion engine **5** such as the clutch **40** and the transmission **35,** for example.

[0074] The terms and expressions used herein are used for explanation purposes and should not be construed as being restrictive. It should be appreciated that the terms and expressions used herein do not eliminate any equivalents of features illustrated and mentioned herein, but include various modifications falling within the claimed scope of the present invention. The present invention may be embodied in many different forms. The present disclosure is to be considered as providing examples of the principles of the invention. These examples are described herein with the understanding that such examples are not intended to limit the present invention to preferred embodiments described herein and/or illustrated herein. Hence, the present invention is not limited to the preferred embodiments described herein. The present invention includes any and all preferred embodiments including equivalent elements, modifications, omissions, combinations, adaptations and/or alterations as would be appreciated by those skilled in the art on the basis of the present disclosure. The limitations in the claims are to be interpreted broadly based on the language included in the claims and not limited to examples described in the present specification or during the prosecution of the application.

Reference Signs List

[0075]

1	Motorcycle (straddled vehicle)
7	Crankcase (first case)
7A	First mating surface
8	Cylinder body
9	Cylinder head
15	Cylinder head cover
16	Piston
19	Connecting rod
22	Cover (second case)
22A	Second mating surface
28	Gear (lubricated member, first member)
33	Liquid surface of oil
36	Oil pump gear (lubricated member, second member)
44	Intake valve
46	Exhaust valve
47	Valve operating mechanism
50	Gasket
52	First protrusion
53	Second protrusion
61	Primary slit
62	Internal slit
84	Oil supply hole
85	Oil passageway
87, 88	Oil intake hole

Claims

1. An internal combustion engine (5) for a vehicle (1), the internal combustion engine (5) comprising:

a first case (7) including a first mating surface (7A) and an oil supply hole (84) formed in the first mating surface (7A);
a second case (22) including a second mating surface (22A) opposing the first mating surface (7A), and fastened to the first case (7);
a gasket (50) placed between the first case (7) and the second case (22); and
a lubricated member (28, 36) placed in an internal space (90) defined by the first case (7) and the second case (22) and placed so that, when the internal combustion engine (5) is installed on the vehicle (1), at least a part the lubricated member (28, 36) is aligned with the gasket (50), when the vehicle (1) is seen from above, wherein:

a primary slit (61) and an internal slit (62) connected to the primary slit (61) are formed in a surface of the gasket (50) facing the first mating surface (7A),
the primary slit (61) is formed in a part of the gasket (50) that is placed between the first mating surface (7A) and the second mating surface (22A),
the primary slit (61) overlaps with the oil supply hole (84),
the internal slit (62) is formed in a part of the gasket (50) that is placed in the internal space (90),
the internal slit (62) is placed upward of the lubricated member (28, 36), when the internal combustion engine (5) is installed on the vehicle (1), and
the outline of the primary slit (61) and the internal slit (62) is formed in a closed loop.

2. The internal combustion engine (5) according to claim 1, wherein the gasket (50) is a paper gasket.

3. The internal combustion engine (5) according to claim 1 or 2, wherein, when the internal combustion engine (5) is installed on the vehicle (1), the first mat-

ing surface (7A) and the second mating surface (22A) are surfaces parallel to a vertical plane.

4. The internal combustion engine (5) according to any one of claims 1 to 3, wherein the gasket (50) includes a protrusion (52) protruding downward, the protrusion (52) placed in the internal space (90) and, when the internal combustion engine (5) is installed on the vehicle (1), located downward of the internal slit (62).

5. The internal combustion engine (5) according to any one of claims 1 to 3, wherein the gasket (50) includes a protrusion (53) protruding downward, the protrusion (53) placed in the internal space (90) and, when the internal combustion engine (5) is installed on the vehicle (1), located directly upward of the lubricated member (28, 36).

6. The internal combustion engine (5) according to any one of claims 1 to 3, wherein:

the lubricated member comprises a first member (28) and a second member (36); and
the gasket (50) includes a first protrusion (52) protruding downward, the first protrusion (52) placed in the internal space (90) and, when the internal combustion engine (5) is installed on the vehicle (1), located directly upward of the first member (28), and a second protrusion (53) protruding downward, the second protrusion (53) placed in the internal space (90) and, when the internal combustion engine (5) is installed on the vehicle (1), located directly upward of the second member (36).

7. The internal combustion engine (5) according to any one of claims 1 to 6, wherein the lubricated member comprises a gear (28).

8. The internal combustion engine (5) according to any one of claims 1 to 7, wherein the lubricated member comprises an oil pump (34) including an oil pump gear (36).

9. The internal combustion engine (5) according to claim 8, wherein:

oil is stored at a bottom of the first case (7) and/or the second case (22), when the internal combustion engine (5) is installed on the vehicle (1); and
the oil pump gear (36) is placed upward of a liquid surface of the oil stored at the bottom when the internal combustion engine (5) is inoperative.

10. The internal combustion engine (5) according to any one of claims 1 to 9, wherein the first case is a crankcase (7) supporting a crankshaft (18), the internal combustion engine (5) comprising:

a cylinder body (8) connected to the crankcase (7), the cylinder body (8) accommodating therein a piston (16) linked to the crankshaft (18) via a connecting rod (19);
a cylinder head (9) connected to the cylinder body (8), the cylinder head (9) including an intake valve (44) and an exhaust valve (46); and
a cylinder head cover (15) connected to the cylinder head (9), the cylinder head cover (15) including a valve operating mechanism (47) configured to operate the intake valve (44) and the exhaust valve (46), wherein:

an oil intake hole (87, 88) overlapping with the primary slit (61) of the gasket (50) is formed in the crankcase (7); and
an oil passageway (85) connecting between the oil intake hole (87, 88) and an internal space of the cylinder head cover (15) is formed in the crankcase (7), the cylinder body (8), the cylinder head (9) and the cylinder head cover (15).

11. The internal combustion engine (5) according to claim 10, wherein the oil intake hole (87, 88) is provided between the oil supply hole (84) and the internal slit (62) along the primary slit (61) of the gasket (50).

12. The internal combustion engine (5) according to any one of claims 1 to 11, wherein the internal slit (62) of the gasket (50) is formed in a shape extending in a vertically downward direction or a diagonally downward direction, when the internal combustion engine (5) is installed on the vehicle (1).

13. The internal combustion engine (5) according to any one of claims 1 to 12, wherein an outline of a distal end of the internal slit (62) of the gasket (50) is formed in an arc shape.

14. A straddled vehicle (1) comprising the internal combustion engine (5) according to any one of claims 1 to 13.

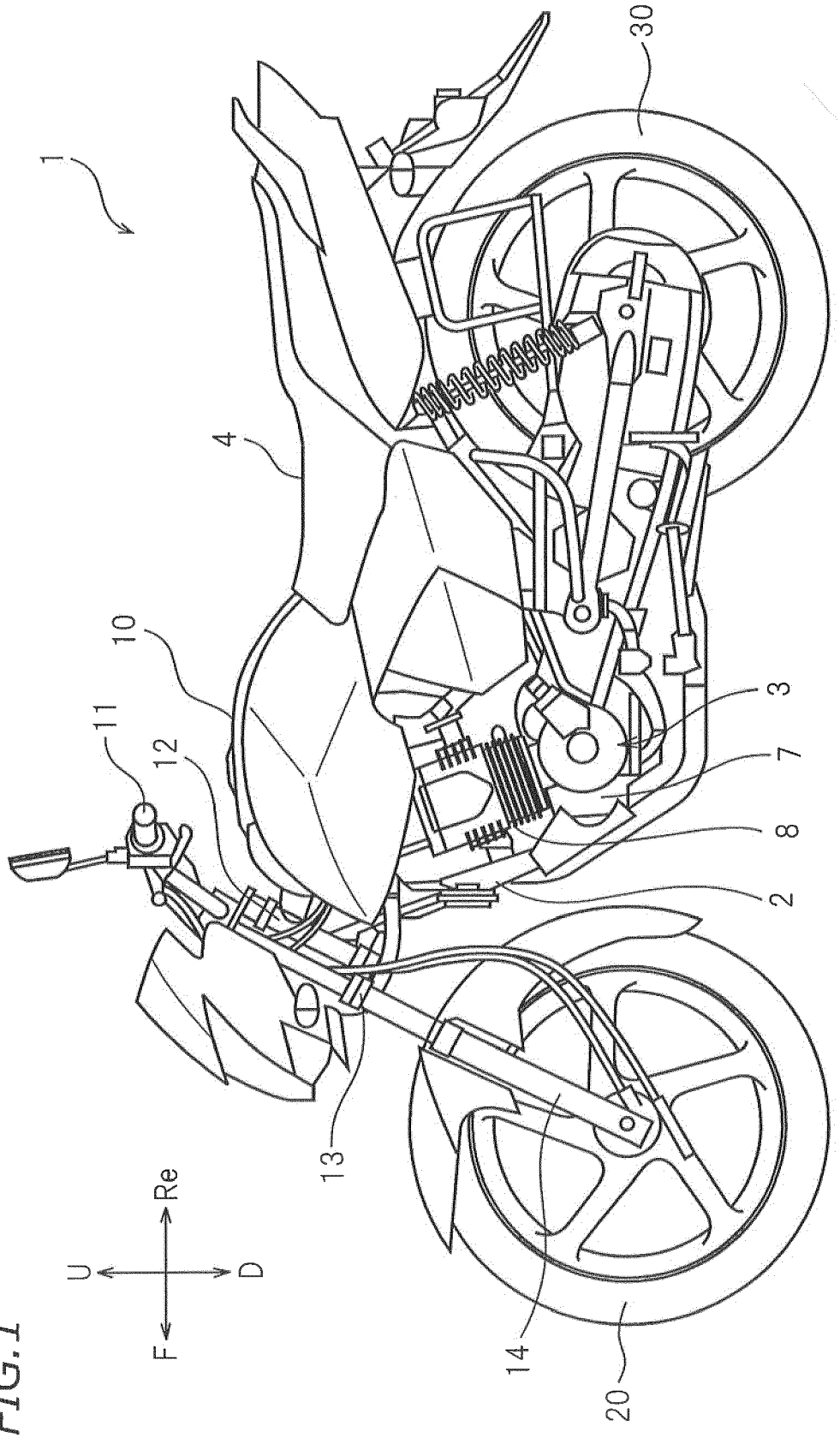
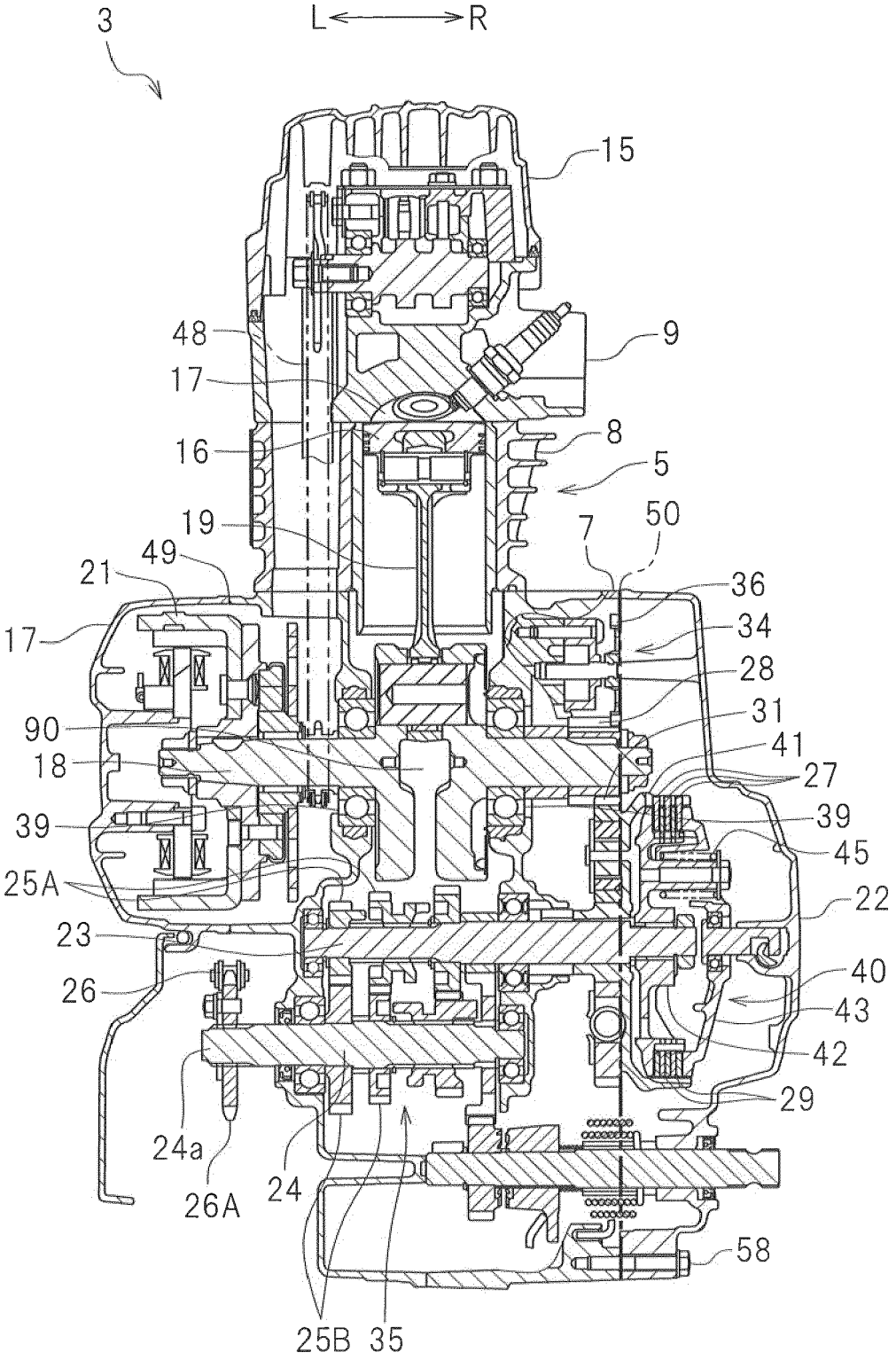


FIG.1

FIG.2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23
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24a
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26A
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25B
35

FIG.3

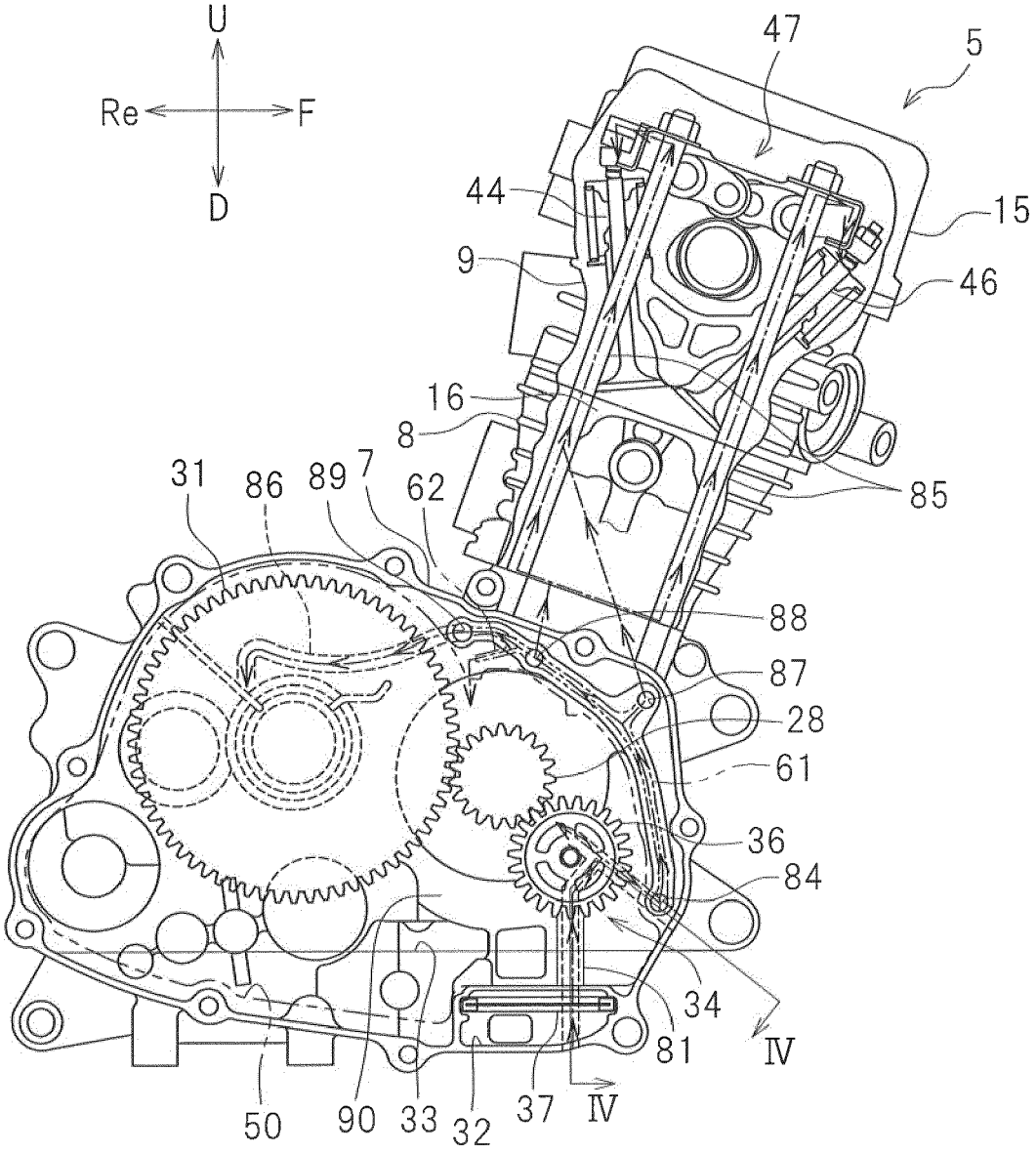
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FIG.4

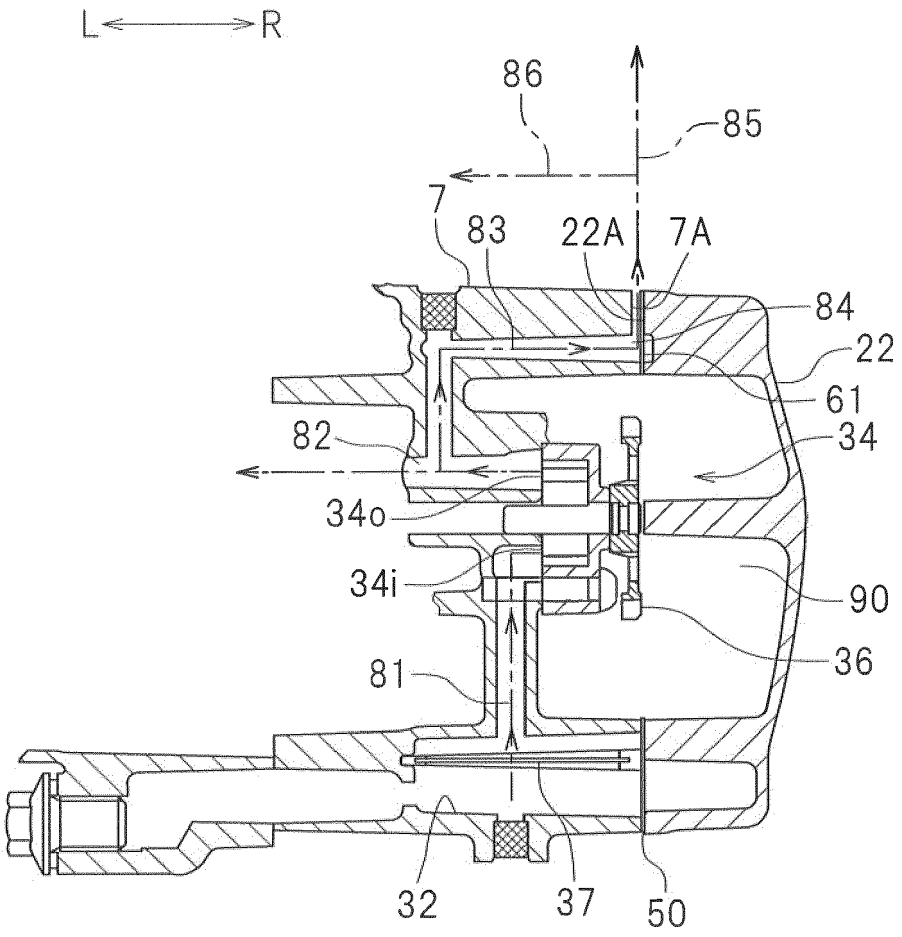

FIG.5

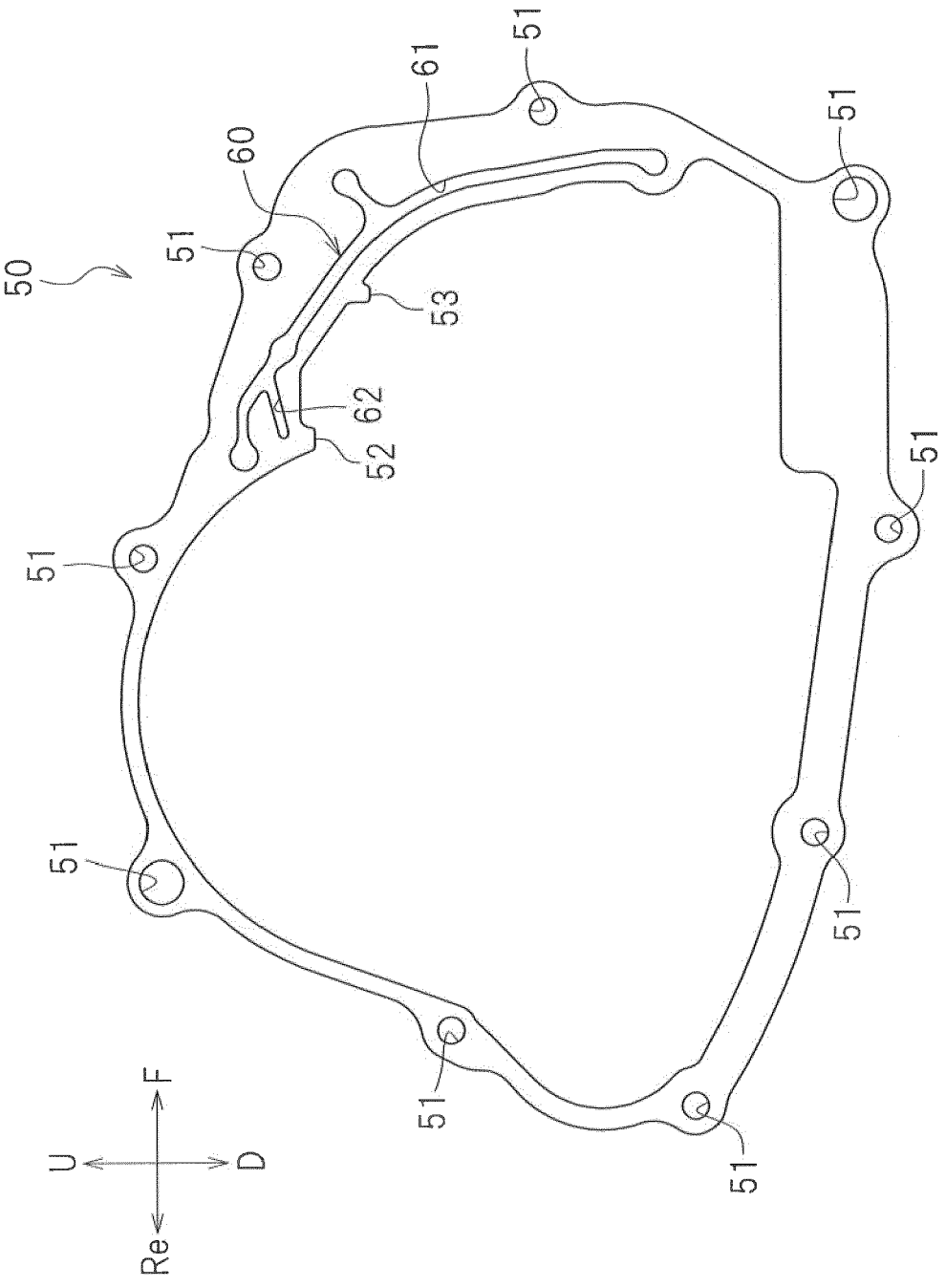

FIG.6

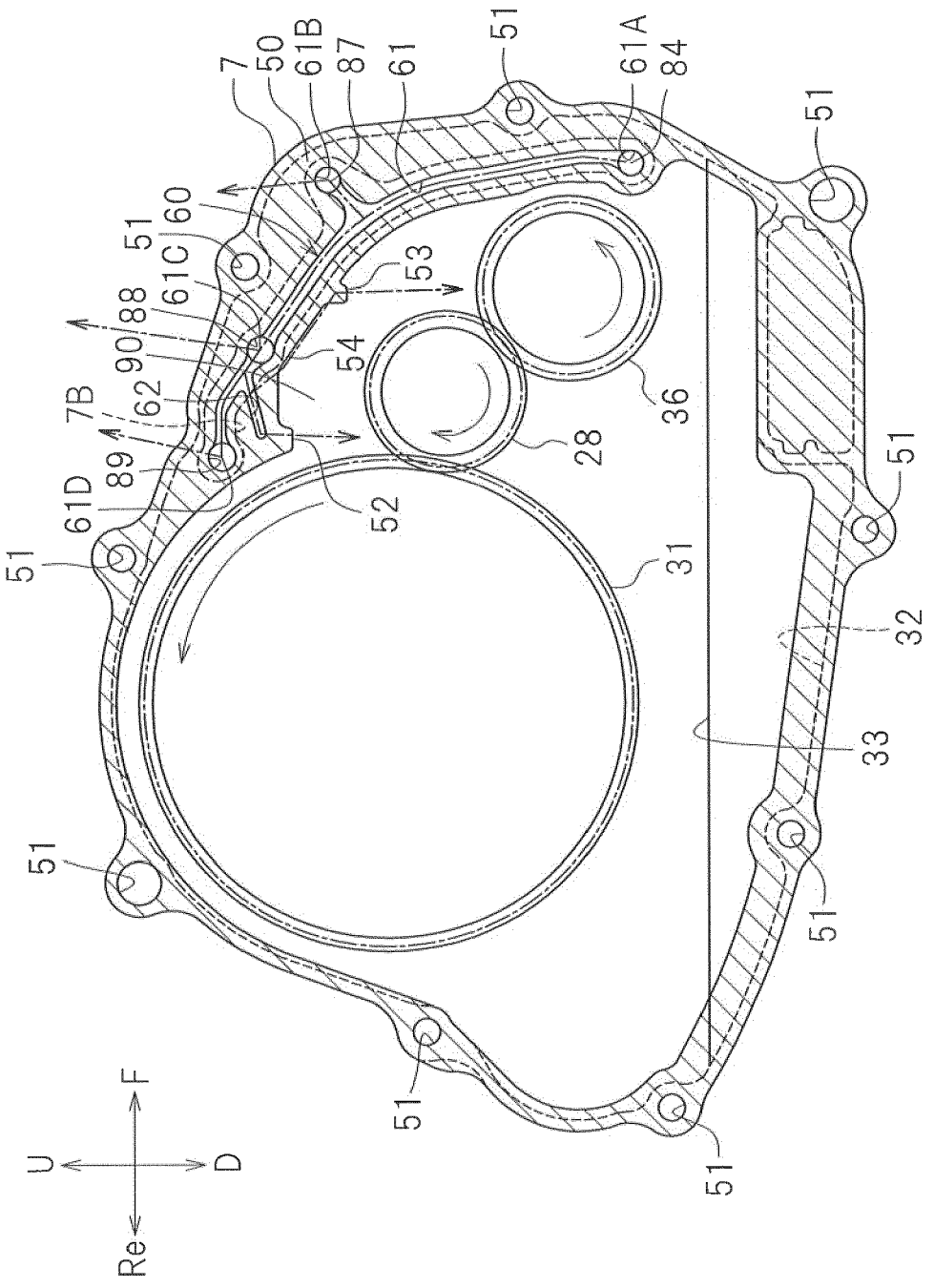
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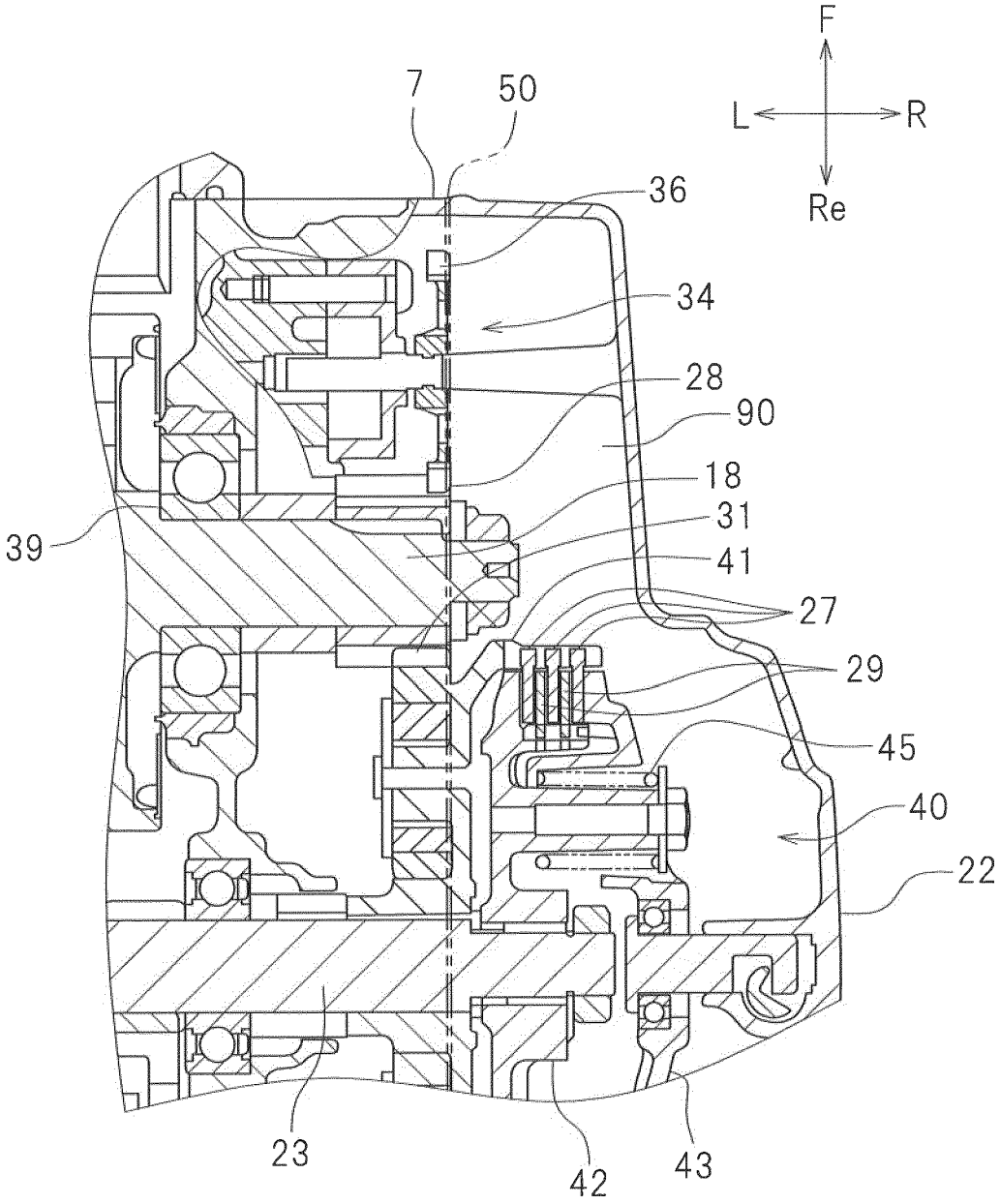
FIG.7



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EUROPEAN SEARCH REPORT

Application Number
EP 16 20 1394

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F01M

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	24 May 2017	Van Zoest, Peter

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