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Aoki et al.

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(54) **SUPPORT STRUCTURE FOR INTAKE MANIFOLD**

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F02M 35/10 (2006.01)

(52) **U.S. Cl.**
CPC ***F02M 35/104*** (2013.01); ***F02M 35/10078*** (2013.01)

(58) **Field of Classification Search**
CPC F02M 35/104; F02M 35/10078
USPC 123/184.21
See application file for complete search history.

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(57) **ABSTRACT**

A support structure for an intake manifold that reduces a burden of support on a front side of the intake manifold. The support structure includes a cylinder head and a fixing structure, and supports the intake manifold. An axial length direction of a crankshaft center is defined as a left-right direction, a horizontal direction orthogonal to the left-right direction is defined as a front-rear direction, and one side in the front-rear direction is defined as a front side. The intake manifold includes a collector and a plurality of branch pipes led out to the front side from the collector. An intake outlet at a front end of each of the branch pipes is supported by the cylinder head. The collector is elastically supported by the fixing structure. A throttle body is attached to a left or right end of the collector.

12 Claims, 13 Drawing Sheets

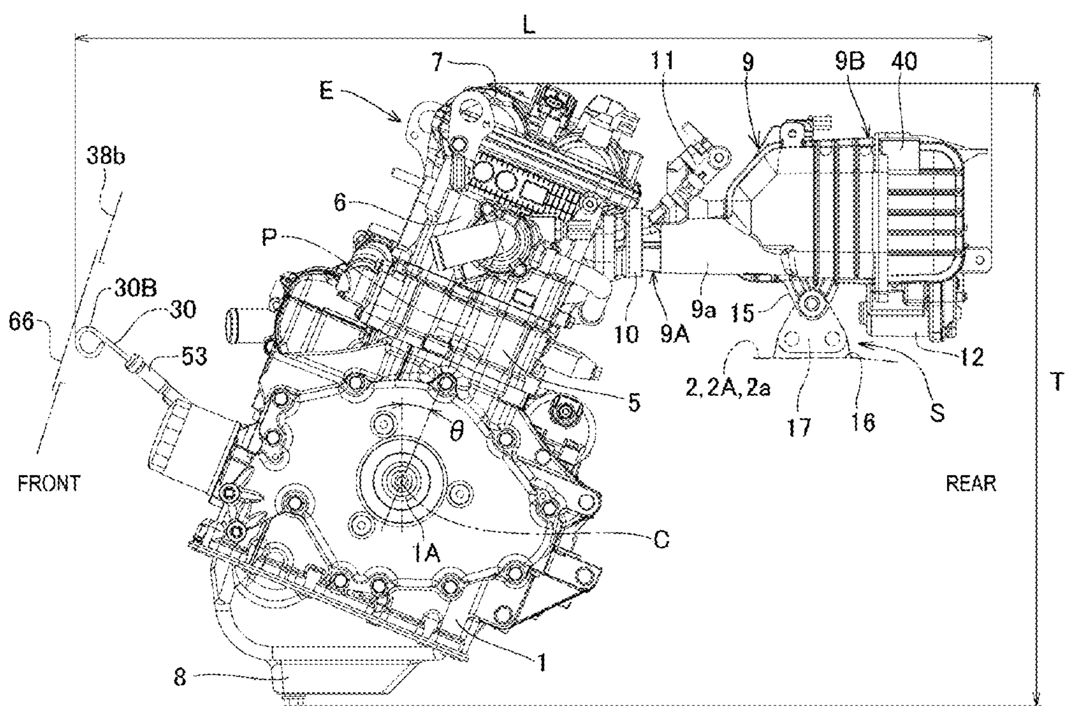


FIG. 1

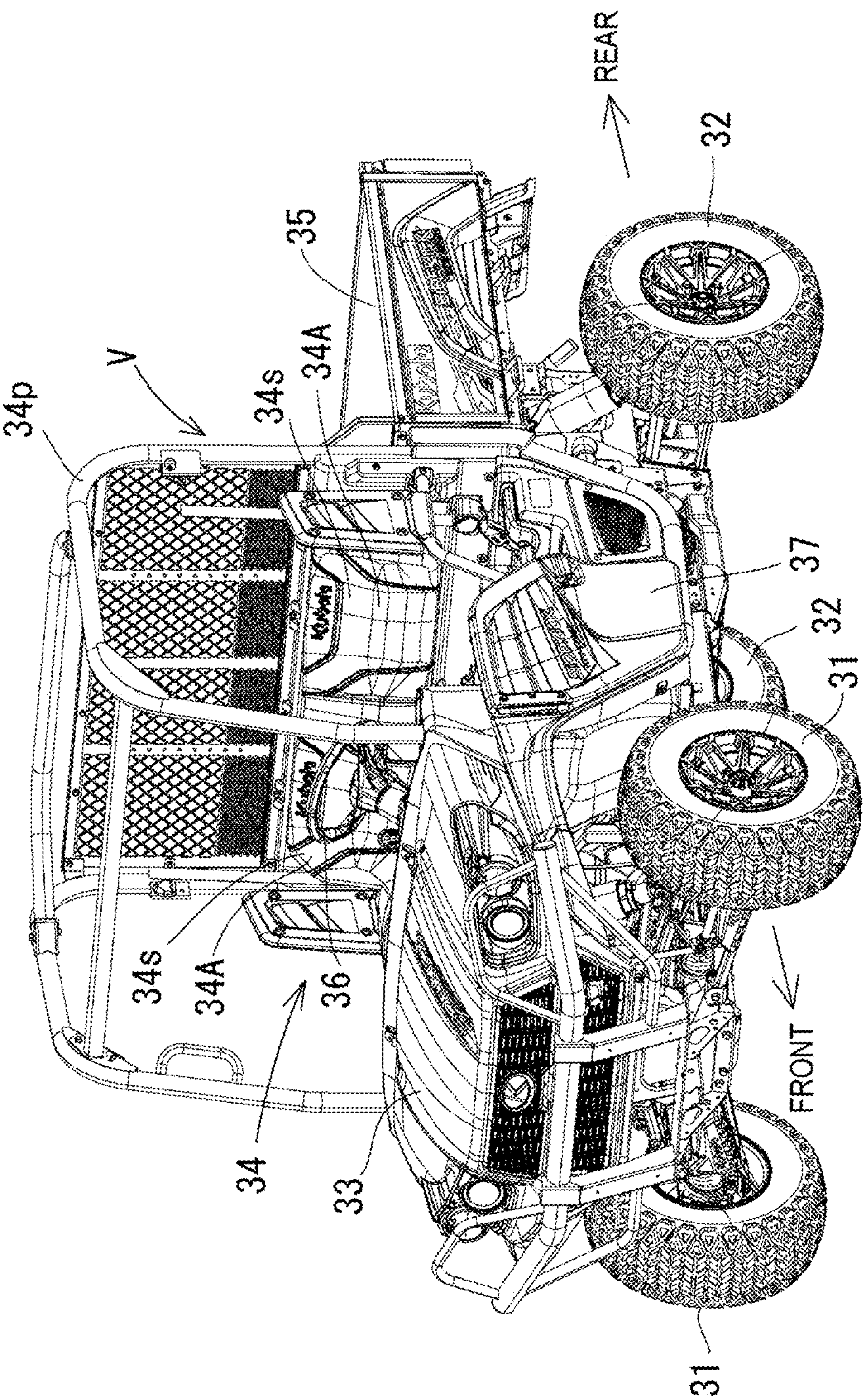
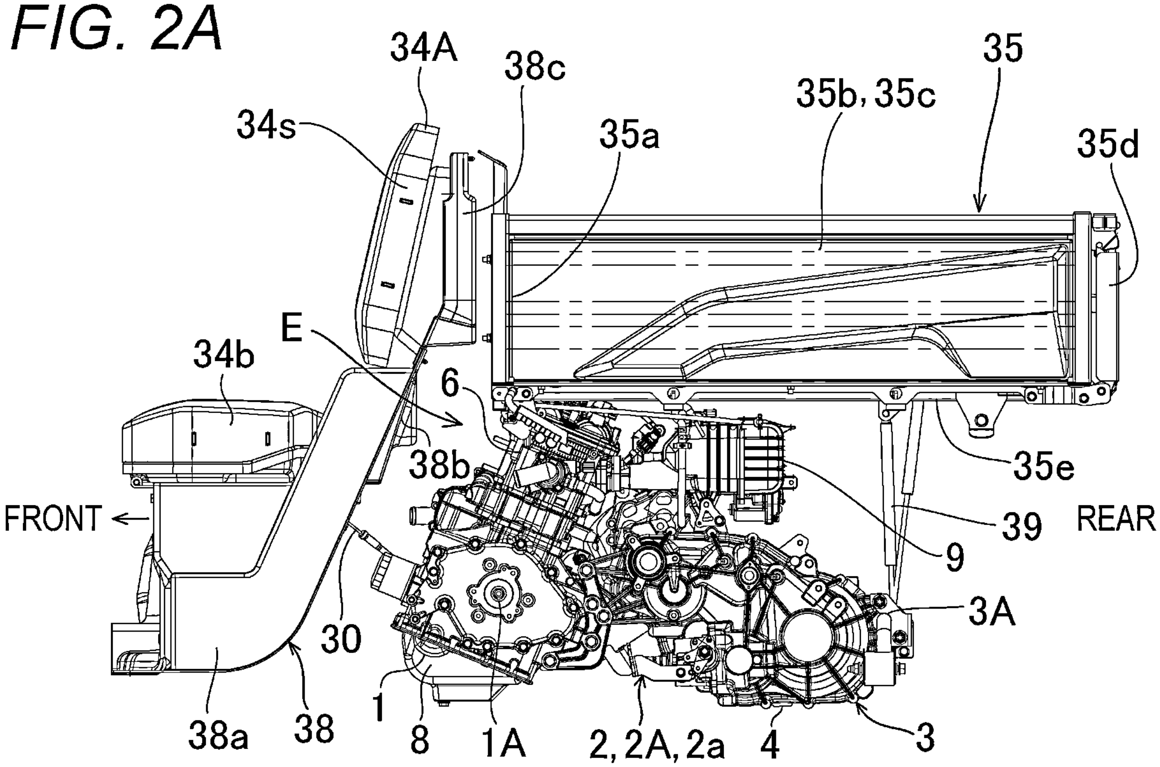


FIG. 2A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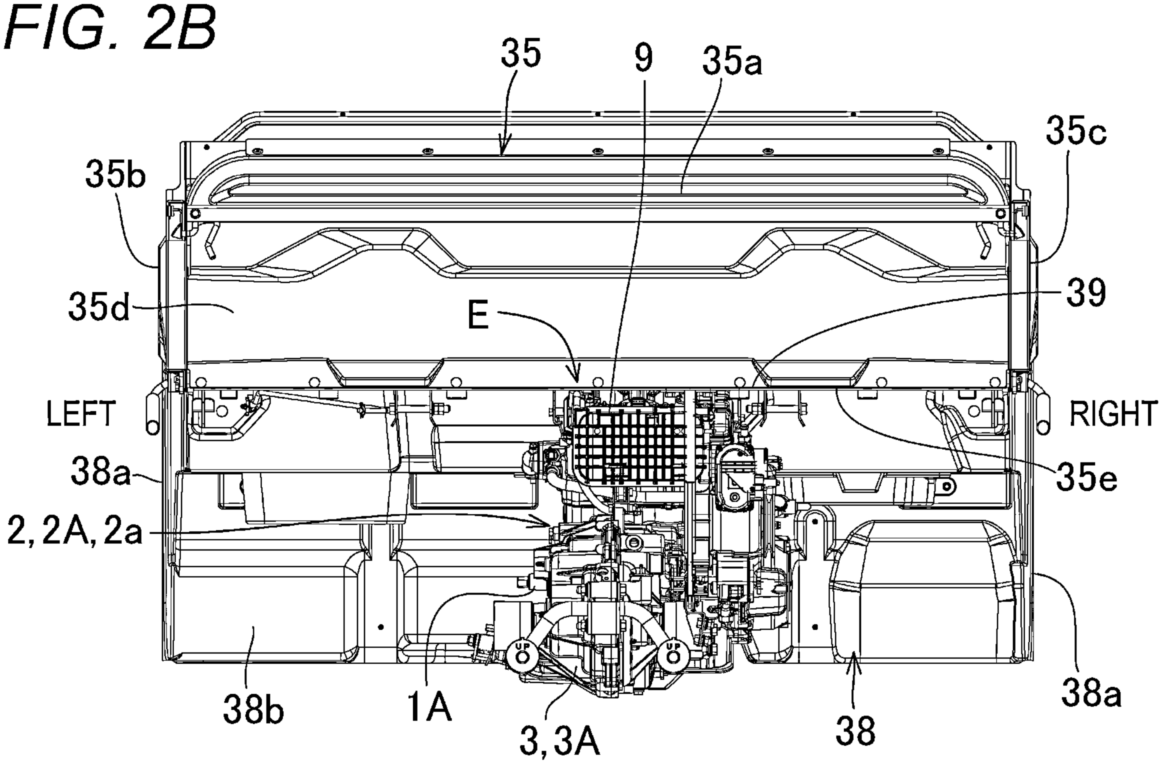
38c
35
35b, 35c
34s
35a
35d
E
34b
6
38b
35e
FRONT
39
REAR
9
30
3A
1
38a
38
8
1A
2, 2A, 2a
4
3

FIG. 2B


35
9
35a
35c
35b
35d
39
E
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RIGHT
38a
35e
2, 2A, 2a
38a
38b
1A
38
3, 3A

FIG. 3

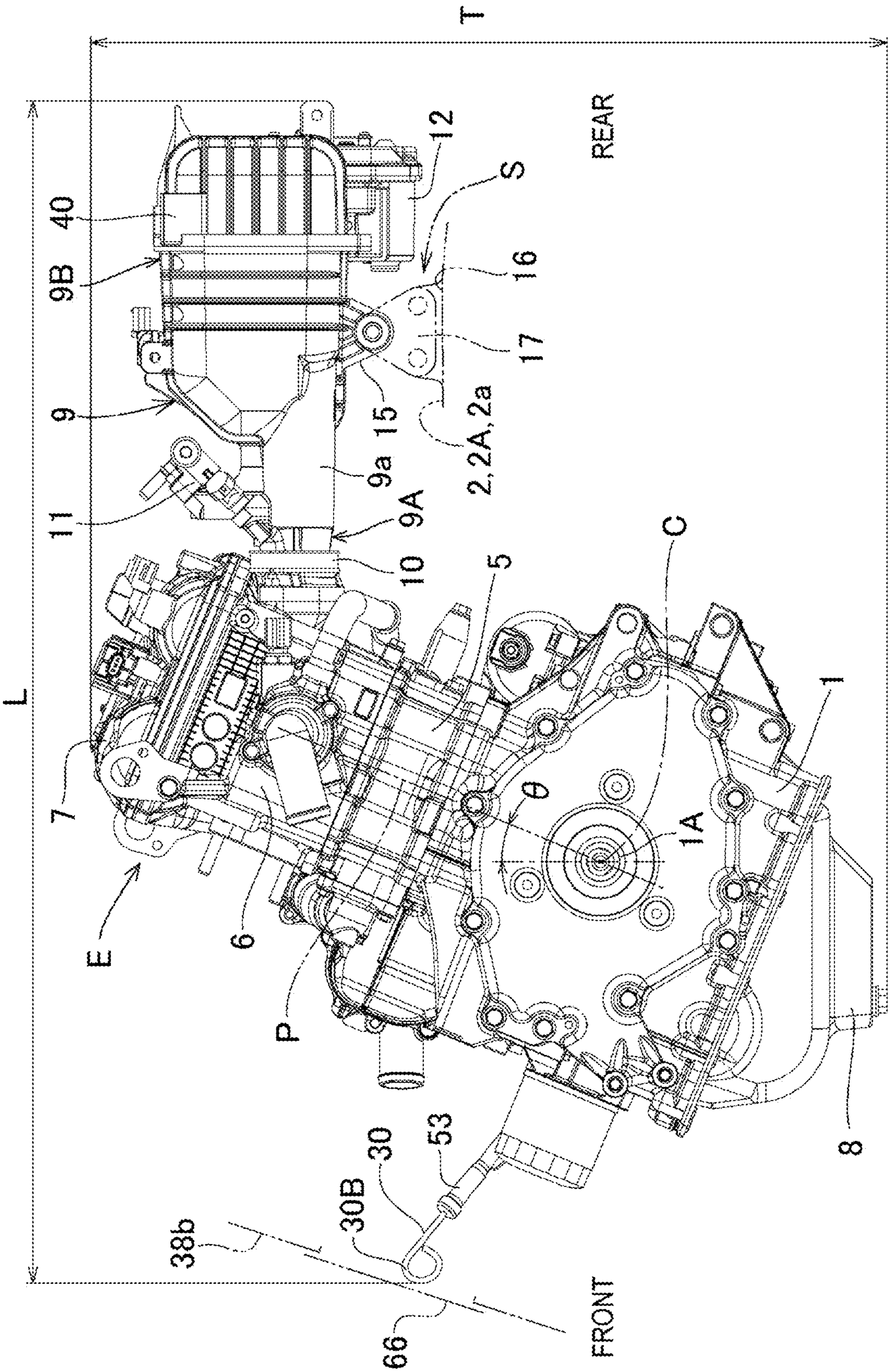

T
L
REAR
FRONT
12
40
9B
S
16
17
9
15
2, 2A, 2a
9a
11
9A
10
5
C
7
θ
1
1A
E
6
P
8
53
30
30B
38b
66

FIG. 4

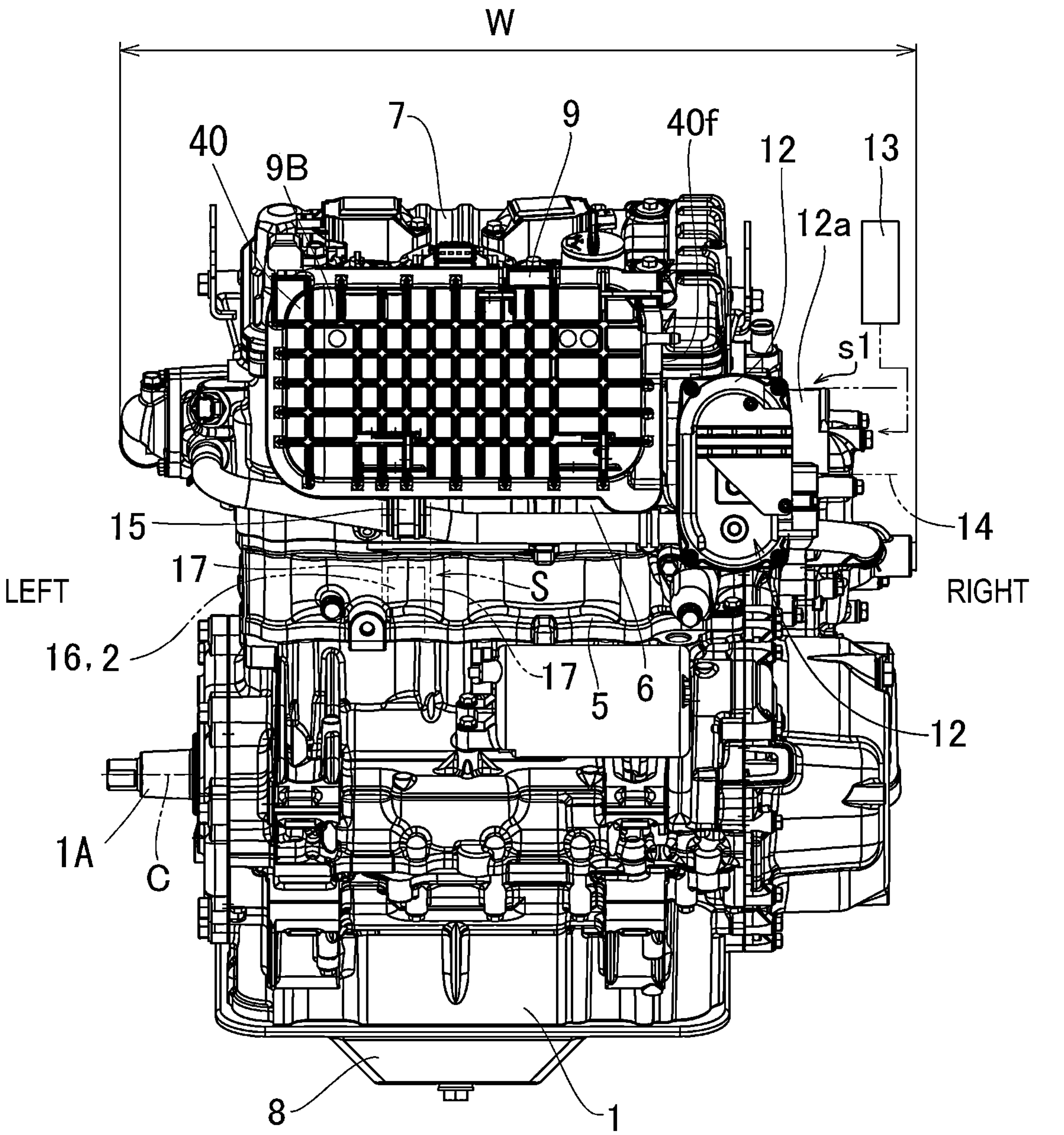
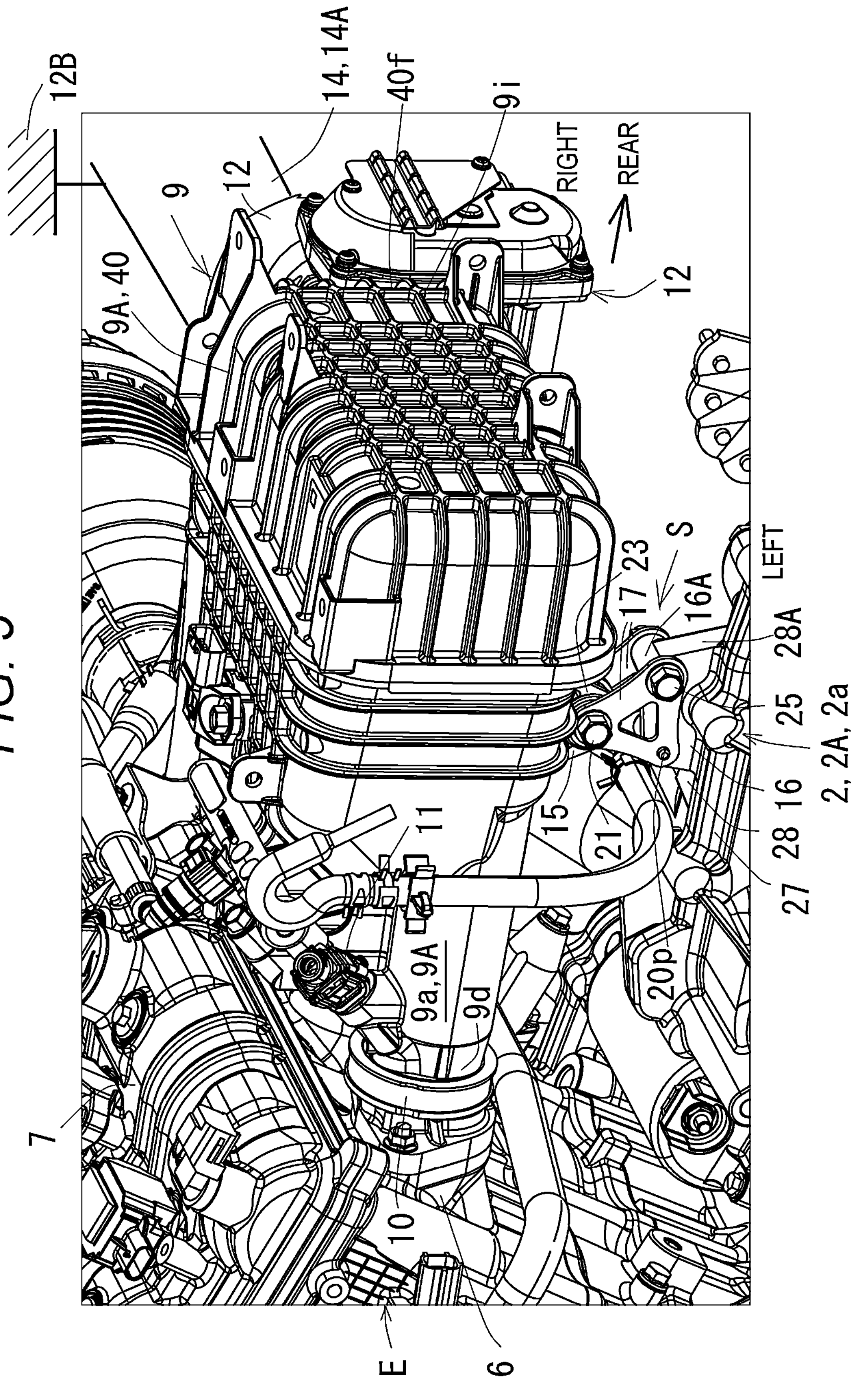
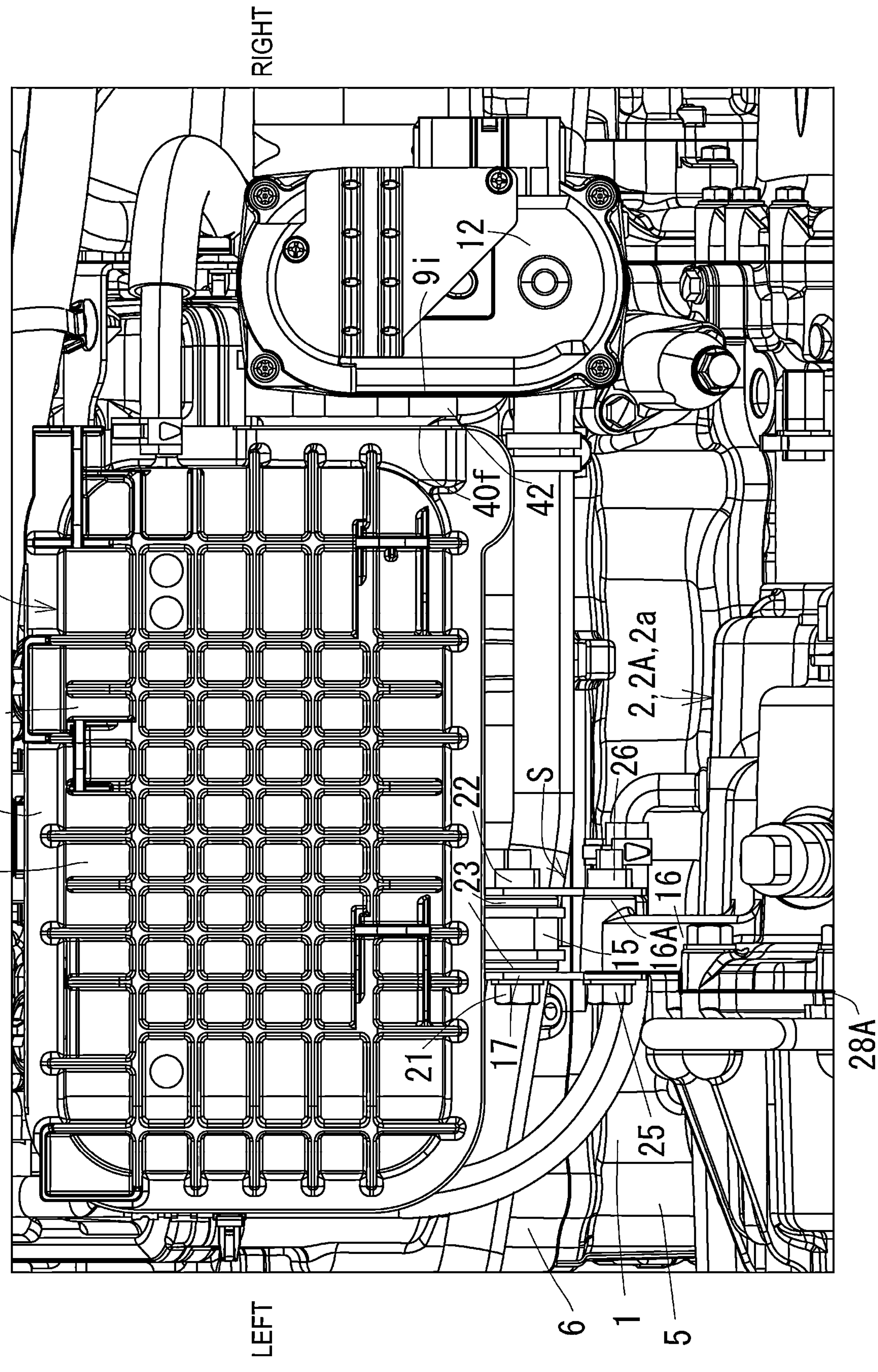


FIG. 5


12B
14,14A
40f
9i
9
12
9A, 40
RIGHT
REAR
12
S
23
17
16A
LEFT
28A
25
2, 2A, 2a
16
28
27
15
21
11
20p
9a,9A
9d
7
10
E
6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40
9B
40c
12
9i
40F
42
2,2A,2a
26
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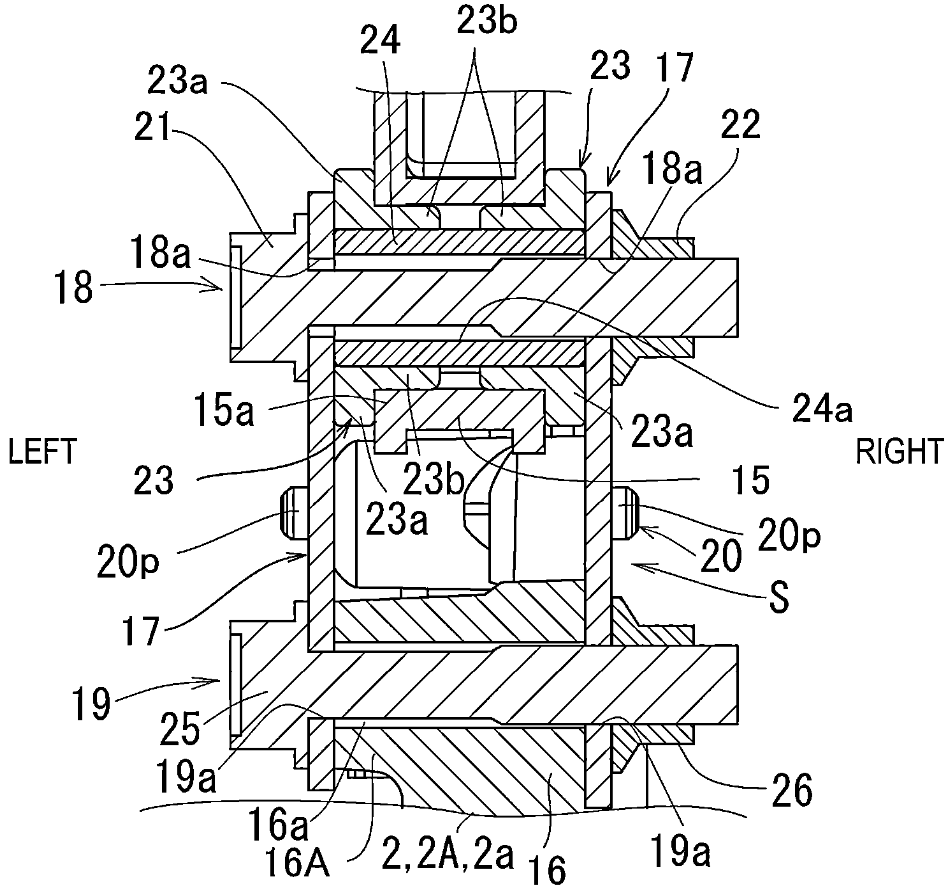
16
16A
15
21
17
25
28A
6
1
5

FIG. 6

FIG. 7A



24
23b
23
17
23a
21
22
18a
18a
18
24a
15a
23a
LEFT
RIGHT
23
23b
15
23a
20p
20p
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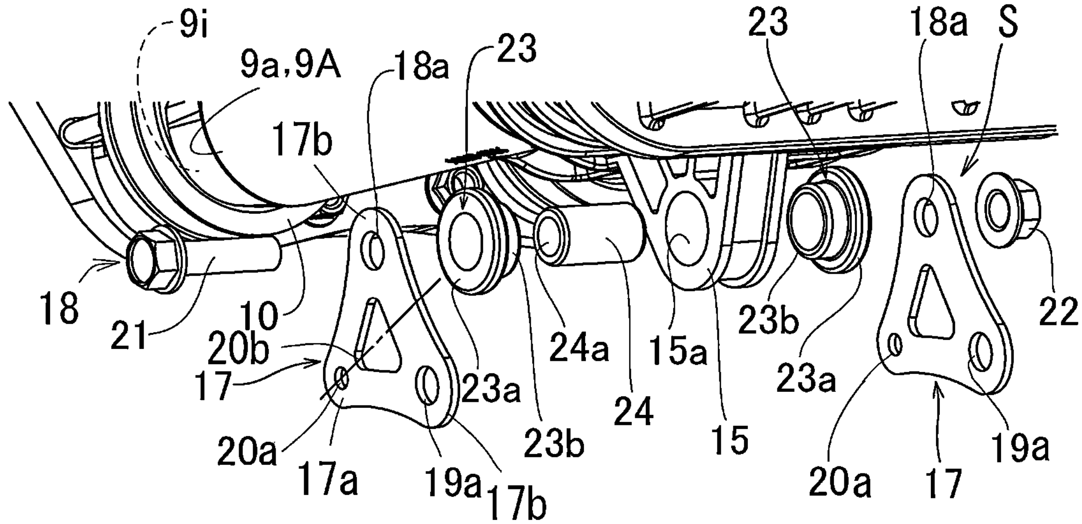
19a
26
16a
16A
2,2A,2a
16
19a

FIG. 7B



9i
9a,9A
18a
23
23
18a
S
17b
18
21
10
20b
17
24a
24
15a
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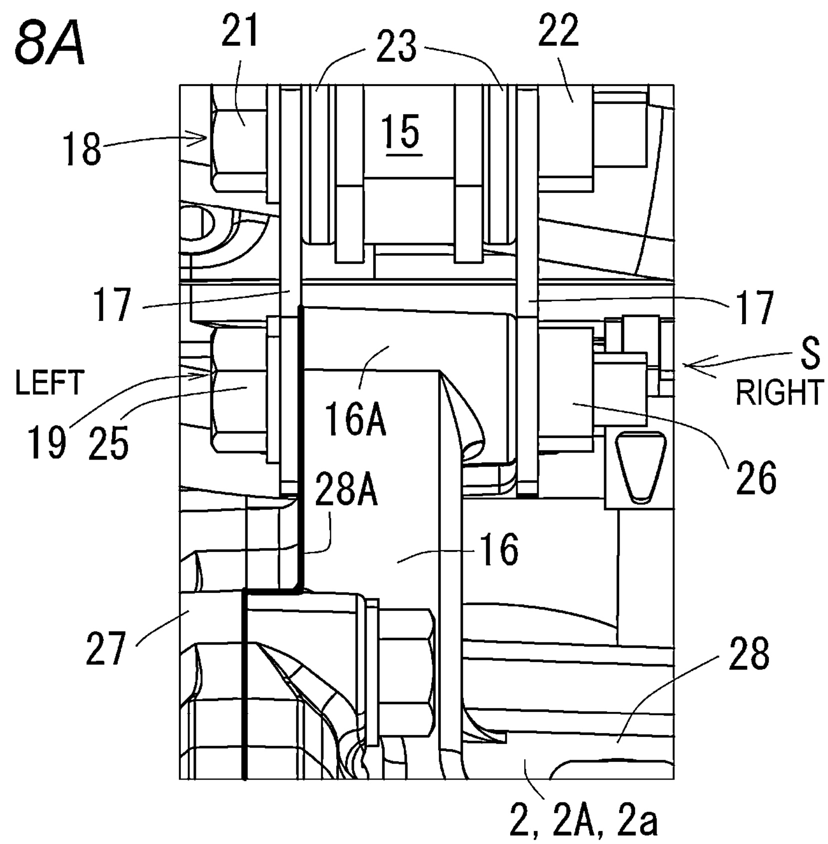
23a
22
23a
23b
20a
17a
19a
17b
20a
17
19a

FIG. 8A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23
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17
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S
LEFT
RIGHT
16A
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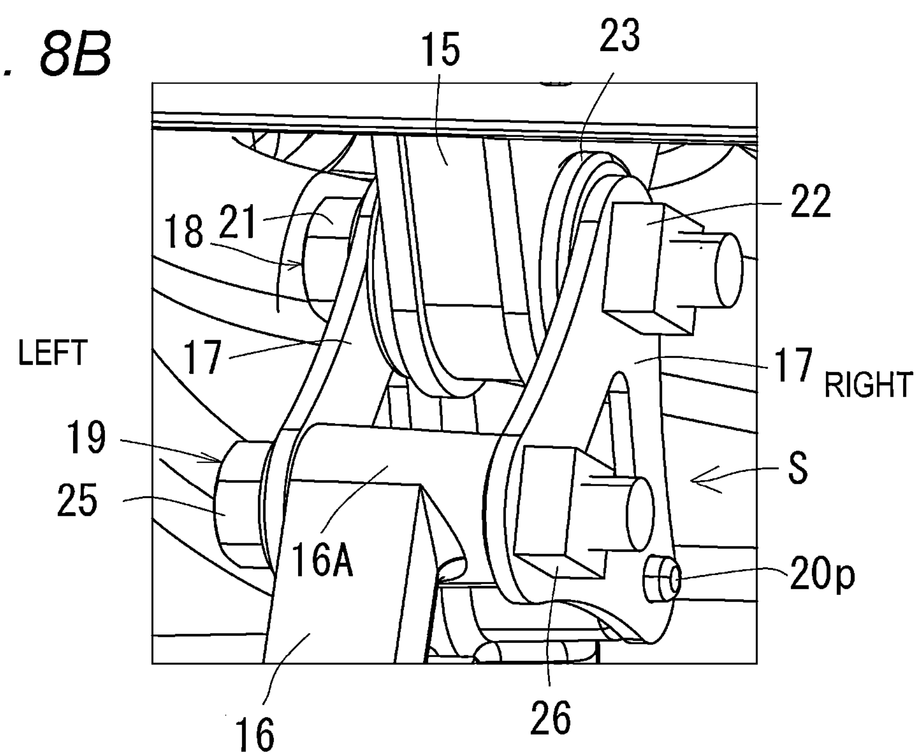
25
26
28A
16
27
28
2, 2A, 2a

FIG. 8B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22
18
21
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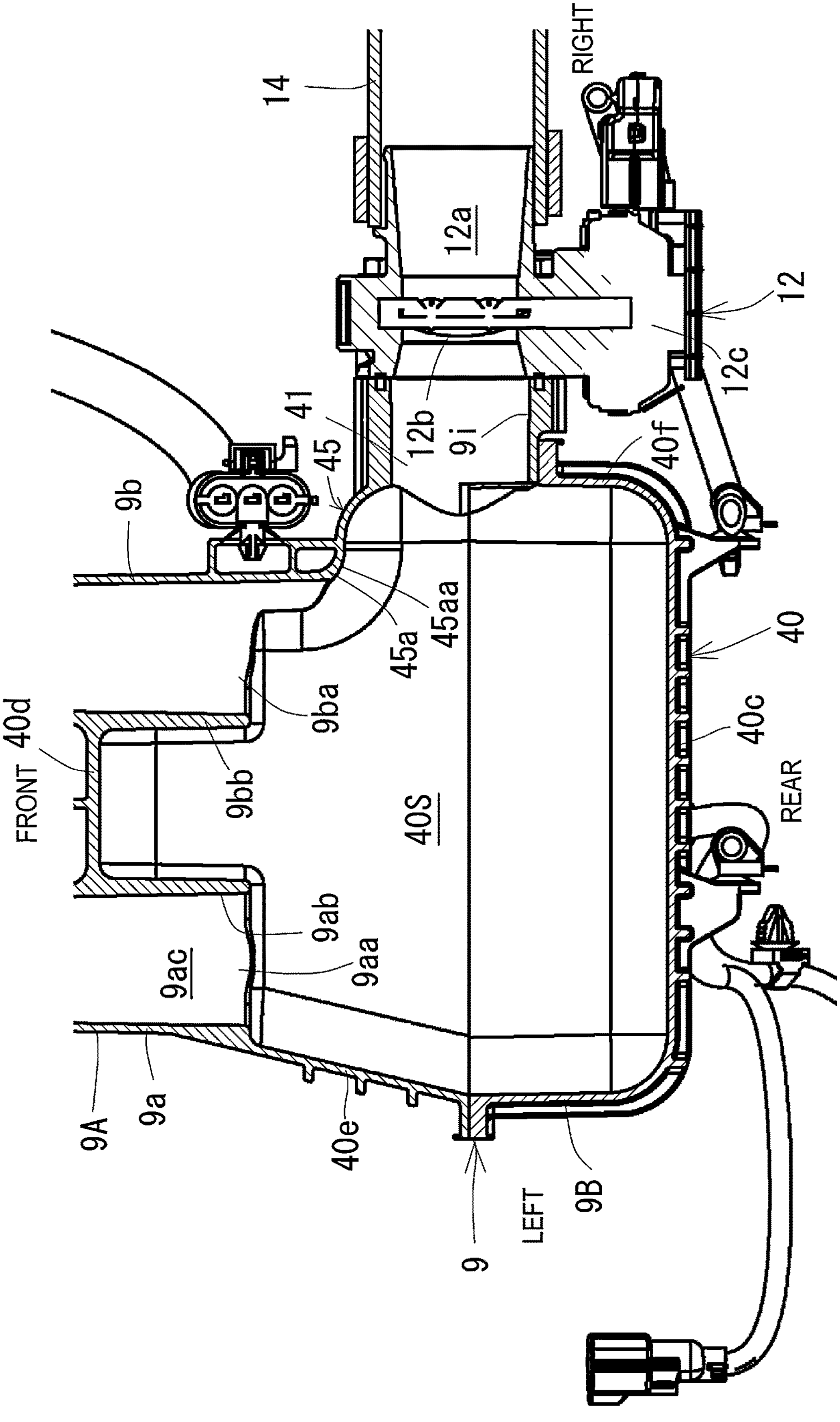
17
17
RIGHT
19
S
25
16A
20p
16
26

FIG. 9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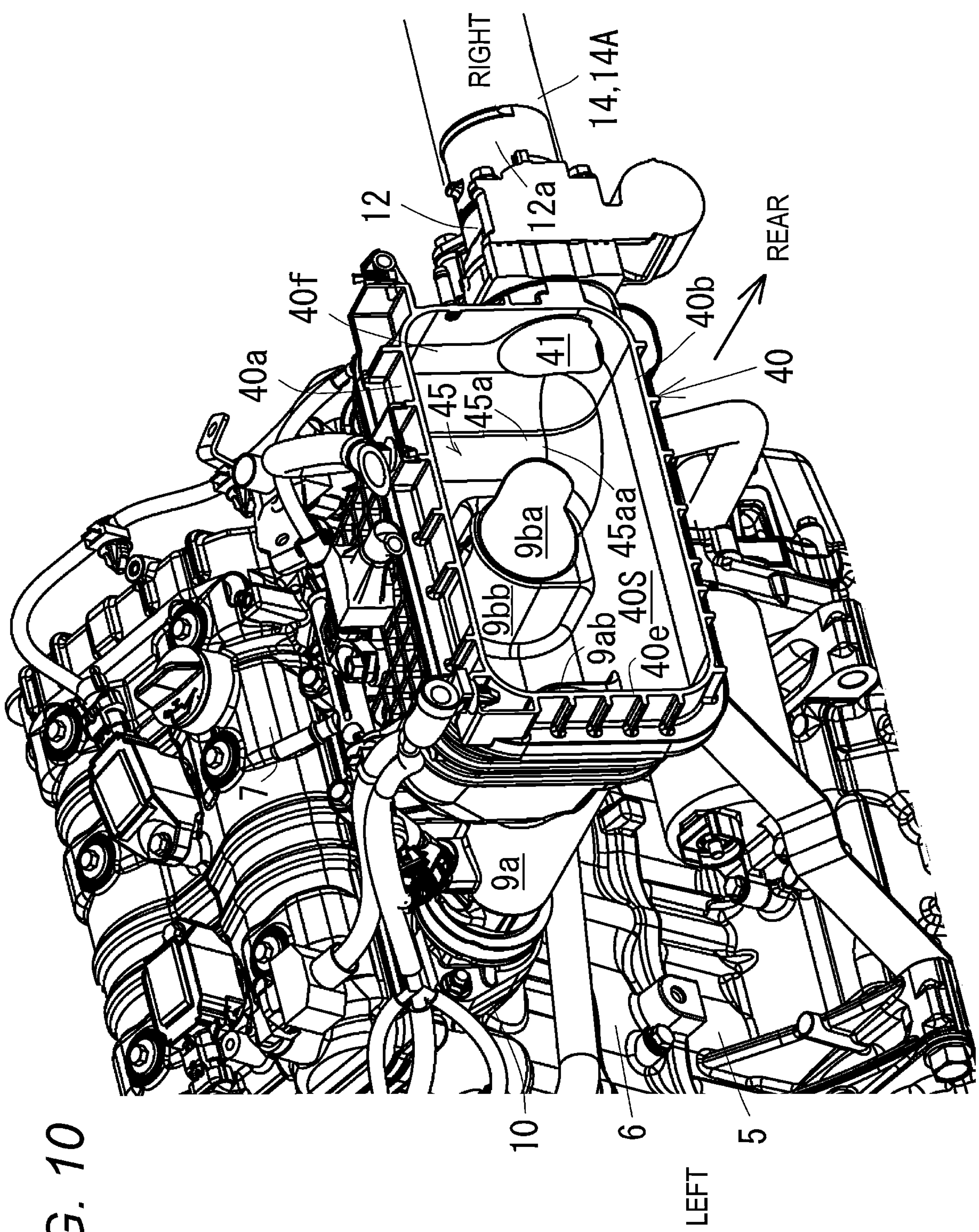
12
12c
12b
9i
41
45
40f
9b
45aa
45a
40
9ba
40c
40d
FRONT
9bb
40S
REAR
9ab
9aa
9ac
9A
9a
40e
9B
LEFT
9

FIG. 10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REAR
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40b
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41
40a
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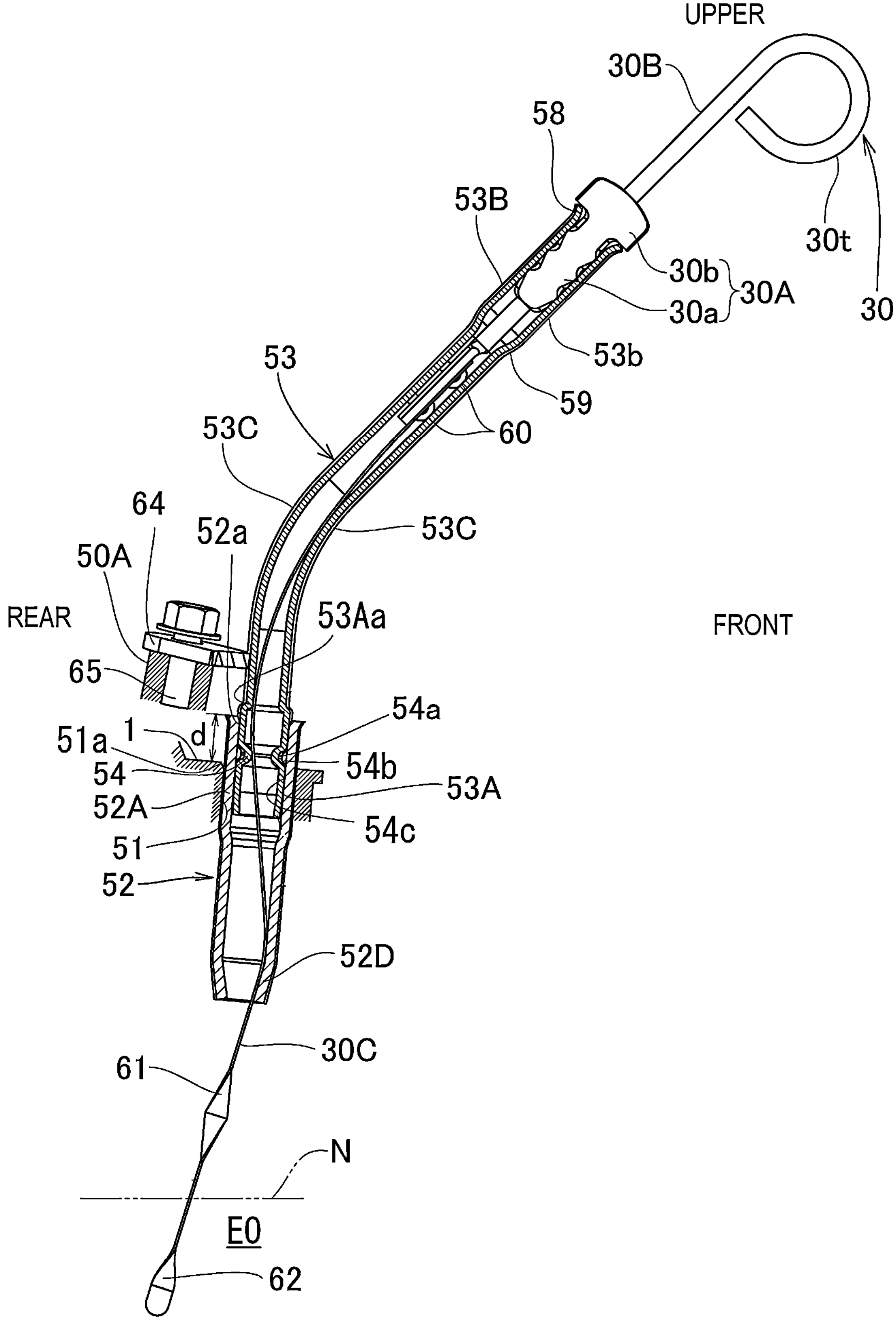
45a
45aa
9ba
9bb
40S
9ab
40e
7
9a
10
6
5
LEFT

FIG. 11



UPPER
30B
58
53B
30b
30A
30a
30t
30
53b
53
59
53C
60
64
53C
50A
52a
REAR
53Aa
FRONT
65
54a
51a
1
d
54
54b
53A
52A
54c
51
52
52D
30C
61
N
E0
62

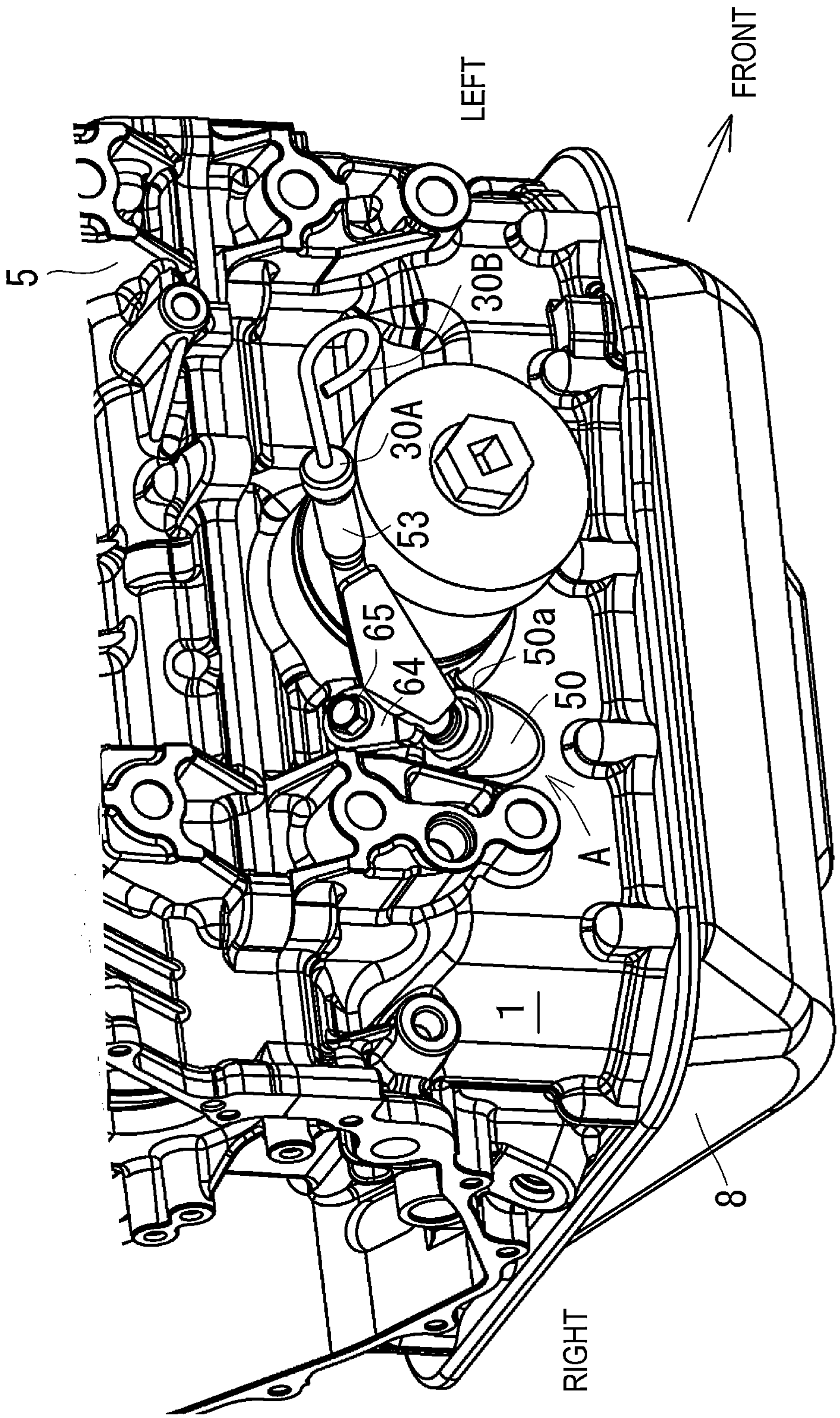
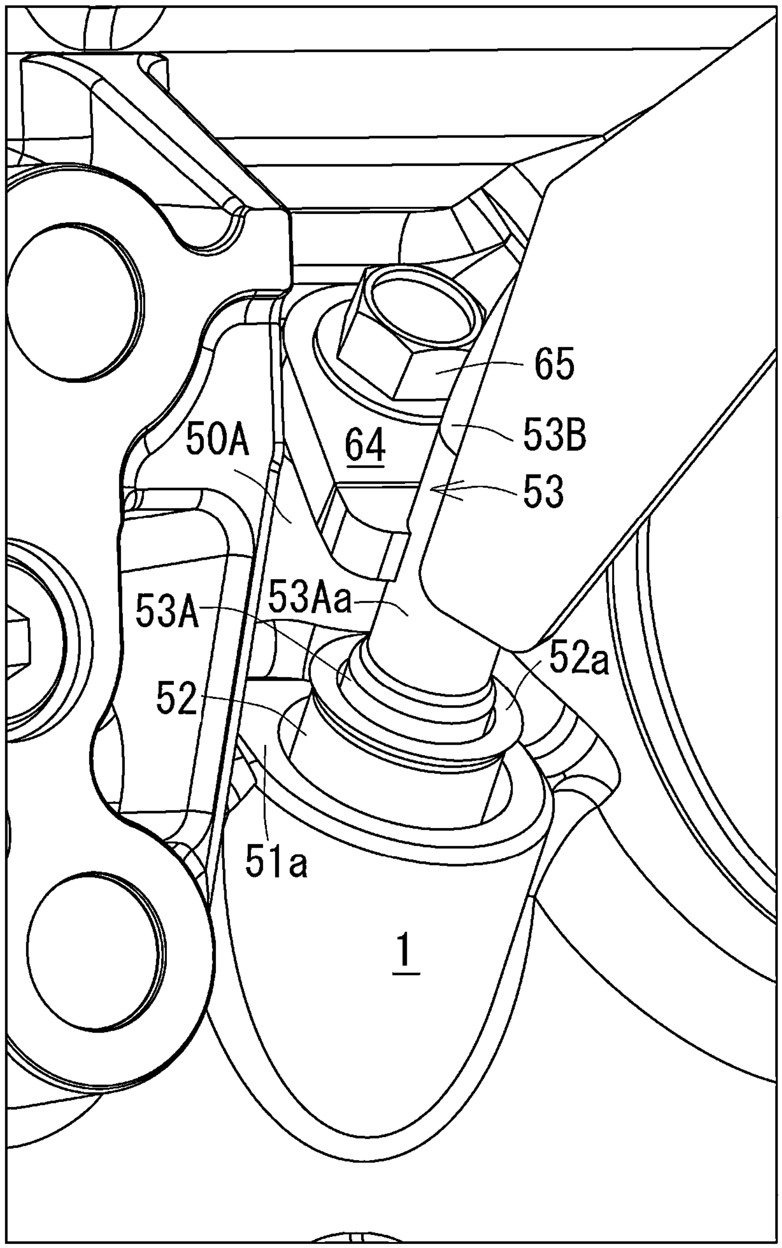


FIG. 12

FIG. 13



SUPPORT STRUCTURE FOR INTAKE MANIFOLD

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority under 35 U.S.C. § 119(b) to Japanese Application No. 2023-107316, filed Jun. 29, 2023, the disclosure of which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

(1) Field of the Invention

The present invention relates to a support structure for an intake manifold.

(2) Description of Related Art

In a conventional engine, since the intake manifold is supported in a cantilever manner on a cylinder head side, a load of support on the front side of the intake manifold increases due to a rotational moment caused by vertical movement of a collector.

In particular, since a throttle body having a relatively large weight is attached to the collector, a burden of support on a front side of the intake manifold increases due to a rotational moment caused by vertical movement of the throttle body.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a support structure for an intake manifold, the support structure reducing a burden of support on a front side of the intake manifold.

The main configuration of the present invention is as follows.

A support structure for an intake manifold includes a cylinder head and a fixing structure and supports an intake manifold, in which

an axial length direction of a crankshaft center is defined as a left-right direction, a horizontal direction orthogonal to the left-right direction is defined as a front-rear direction, one side in the front-rear direction is defined as a front side,

the intake manifold includes a collector including a synthetic resin, the intake manifold including a plurality of branch pipes led out to the front side from the collector, an intake outlet at a front end of each of the branch pipes is supported by the cylinder head, the collector is elastically supported by the fixing structure via a pair of coupling plates having an identical isosceles triangle shape, and

a throttle body is attached to a left or right end of the collector, the left or right end being opposite to a side supported by the fixing structure.

Effects

The present invention has the following effects.

The collector is elastically supported by the fixing structure via the pair of coupling plates, and the intake manifold is supported at the both front and rear sides. Therefore, a burden of supporting the front side of the intake manifold is reduced.

Since the collector separated rearward from the cylinder head includes lightweight synthetic resin, a rotational moment caused by vertical movement of the collector is reduced, and in this respect, the burden of supporting the front side of the intake manifold is also reduced.

Since the collector is elastically supported by the fixing structure, the vertical vibration between the collector and the throttle body having a relatively large weight is reduced, and the burden of supporting the front side of the intake manifold is reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a multipurpose four-wheeled vehicle according to an embodiment of the present invention as viewed from front and above;

FIGS. **2**A and **2**B are explanatory diagrams of an engine mounted on the multipurpose four-wheeled vehicle in FIG. **1** and a periphery of the engine, FIG. **2**A is a side view, and FIG. **2**B is a rear view;

FIG. **3** is a side view of the engine in FIG. **2**A and FIG. **2**B;

FIG. **4** is a rear view of the engine in FIG. **2**A and FIG. **2**B;

FIG. **5** is a perspective view of an intake manifold and a periphery of the intake manifold;

FIG. **6** is a rear view of FIG. **5**;

FIGS. **7**A and **7**B are diagrams illustrating a lower support structure of the intake manifold in FIG. **5**, FIG. **7**A is a sectional view of a main part, and FIG. **7**B is an exploded perspective view of the main part;

FIGS. **8**A and **8**B are diagrams for describing the lower support structure of FIG. **5**, FIG. **8**A is a rear view of a main part, and FIG. **8**B is a perspective view of the main part;

FIG. **9** is a sectional plan view of the intake manifold used in the engine mounted on the multipurpose four-wheeled vehicle in FIG. **1**;

FIG. **10** is a perspective view illustrating a longitudinal rear surface of the intake manifold in FIG. **9**;

FIG. **11** is a longitudinal sectional side view of an oil inspector used for the engine mounted on the multipurpose four-wheeled vehicle in FIG. **1**;

FIG. **12** is a perspective view of the oil inspector in FIG. **11** and a periphery of the oil inspector; and

FIG. **13** is an enlarged perspective view of the oil inspector in FIG. **12**.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIGS. **1** to **13** are diagrams for describing a multipurpose four-wheeled vehicle according to an embodiment of the present invention and an engine and a transmission mounted on the multipurpose four-wheeled vehicle. In this embodiment, a multipurpose four-wheeled vehicle equipped with an inclined four-cycle in-line two-cylinder diesel engine and a continuously variable transmission (CVT) will be described.

FIG. **1** illustrates a multipurpose four-wheeled vehicle V for off-road use, and as illustrated in FIG. **2**A and FIG. **2**B, an engine E is disposed in a lateral position with a crankshaft **1**A facing sideways.

In this embodiment, as illustrated in FIG. **4**, an axial length direction of a crankshaft center C is described as a left-right direction, as illustrated in FIG. **3**, a horizontal direction orthogonal to the left-right direction is described as a front-rear direction, a vehicle forward side in the front-rear direction is described as a front side, and the opposite side of the front side is described as a rear side.

As illustrated in FIG. **1**, the multipurpose four-wheeled vehicle V includes a pair of left and right front wheels **31** and **31**, a pair of left and right rear wheels **32** and **32**, a front hood **33**, a boarding section **34**, and a rear cargo bed **35** in the rear side. A pair of left and right seats (boarding seats) **34**A and **34**A is disposed in the boarding section **34** surrounded by a pipe material **34***p*. In FIG. **1**, a reference sign **34***s* denotes a backrest of the seat **34**A, a reference sign **36** denotes a steering wheel, and a reference sign **37** denotes an opening and closing door.

FIGS. **2**A and **2**B illustrate the engine E mounted on the multipurpose four-wheeled vehicle V and a periphery of the engine E. As illustrated in FIG. **2**A, the engine E and the transmission **2**A are disposed behind the seat **34**A and below a front portion of the cargo bed **35**. The seat **34**A is configured such that a seat bottom **34***b* and the backrest **34***s* are supported by a support frame **38** in a rearward tilting oblique orientation, and the engine E is provided immediately behind the support frame **38** and at a position in a center slightly rightward in the left-right direction as illustrated in FIG. **2**B.

As illustrated in FIG. **2**A, the engine E is mounted on a body frame (not illustrated) in an orientation in which a piston (not illustrated) moving direction slightly falls rearward, and the transmission **2**A is disposed behind the crankcase **1** of the engine E. The transmission **2**A is a continuously variable transmission (CVT), and a differential device **3** is provided on the rear side of the transmission **2**A. A rear axle **4** extends from the differential device **3** to the left and right, and as illustrated in FIG. **2**A, a support connecting member **39** that connects a bottom plate **35***e* of the cargo bed **35** and a differential case **3**A is installed.

As illustrated in FIG. **2**B, the support frame **38** that supports the seat **34**A includes left and right side plates **38***a* and **38***a* and a back plate **38***b* between the side plates **38***a* and **38***a*, and as illustrated in FIG. **2**A, an upper portion of the back plate **38***b* is a vertical frame **38***c* that supports the backrest **34***s*.

As illustrated in FIG. **2**A, the cargo bed **35** includes a front plate **35***a*, left and right side plates **35***b* and **35***c*, a rear plate (tailgate) **35***d*, and the bottom plate **35***e*, and is provided immediately above the engine E disposed in the rear part of a vehicle body.

As illustrated in FIG. **2**A, this engine is a lateral inclined engine, and as illustrated in FIG. **3**, when viewed in a direction parallel to the crankshaft center C, the engine is mounted with a piston movement axis P inclined rearward at an angle θ with respect to a perpendicular line, and includes a crankcase **1**, a cylinder **5**, a cylinder head **6**, and a head cover **7**. A total length (engine front-rear length dimension) L and a total height (engine height) T of the engine E illustrated in FIG. **3** and a total width (engine width) W illustrated in FIG. **4** are made compact as compared with a conventional engine.

As illustrated in FIG. **2**A, an oil pan **8** is assembled under the crankcase **1**, and an intake manifold **9** is assembled on the rear side (intake side) of the cylinder head **6**. The output of the engine E is shifted by the transmission **2**A disposed behind the crankcase **1**, and then transmitted to the left and right rear axles **4** and **4** and the rear wheels **32** and **32** (see FIG. **1**) via the differential device **3**. On the front side of the crankcase **1**, an oil inspector including an oil gauge **30** is provided in an orientation facing forward and obliquely upward.

The intake manifold **9** illustrated in FIG. **9** includes synthetic resin, and including a manifold front portion **9**A provided with a pair of branch pipes **9***a* and **9***b* and a manifold rear portion **9**B following the manifold front portion **9**A.

As illustrated in FIG. **5**, a front end of the manifold front portion **9**A is elastically supported by the cylinder head **6** via an elastic insulator **10**, and a supported portion **15** provided at a lower portion of the manifold rear portion **9**B is supported by a housing **2***a* of the transmission **2**A.

As illustrated in FIG. **5**, a fuel injector **11** is provided in an upper portion of each of the branch pipes **9***a* and **9***b* (see FIG. **9** for the branch pipe **9***b*) in an orientation facing forward and downward, and a throttle body **12** is attached to a right side wall **40***f* of the manifold rear portion **9**B. The intake manifold **9** includes an intake inlet **9***i* that opens sideways on the right side of the rear portion of the intake manifold **9**, and two intake outlets **9***d* at the front end (front end of each of the branch pipes **9***a* and **9***b*).

As illustrated in FIG. **9**, the throttle body **12** includes a venturi **12***a*, a throttle valve **12***b*, and a valve actuator **12***c*.

A support structure for the intake manifold **9**, an internal structure and an outer wall structure of a collector **40** of the intake manifold **9**, an engine model using the intake manifold **9**, and the oil inspector of the engine, which are main elements of the engine, will be described.

The support structure for the intake manifold **9** is as follows.

As illustrated in FIG. **5**, the support structure for the intake manifold **9** includes the cylinder head **6** and a fixing structure **2**, and supports the intake manifold **9**.

As described above, the axial length direction of the crankshaft center C illustrated in FIG. **4** is defined as the left-right direction, as illustrated in FIG. **3**, the horizontal direction orthogonal to the left-right direction is defined as the front-rear direction, and one side (the vehicle forward side) in the front-rear direction is defined as the front side.

As illustrated in FIG. **5**, the intake manifold **9** includes the collector **40** including synthetic resin, and a plurality of the branch pipes **9***a* and **9***b* (see FIG. **9** for the branch pipes **9***b*) led out to the front side from the collector **40**, the intake outlet **9***d* at the front end of each of the branch pipes **9***a* and **9***b* is supported by the cylinder head **6**, and the collector **40** is supported by the fixing structure **2**.

As illustrated in FIG. **5**, the throttle body **12** is attached to a left or right end of the collector **40** including synthetic resin, the left or right end being opposite to a side supported by the fixing structure **2**.

As illustrated in FIG. **5**, in the support structure for the intake manifold **9**, since the throttle body **12** is attached to the left or right end of the collector **40**, the engine front-rear length dimension L is kept short as illustrated in FIG. **3**.

As illustrated in FIG. **5**, the collector **40** is supported by the fixing structure **2**, and the intake manifold **9** is supported at the both front and rear sides. Therefore, a burden of supporting the front side of the intake manifold **9** is reduced.

As illustrated in FIG. **5**, since the collector **40** separated rearward from the cylinder head **6** includes lightweight synthetic resin, a rotational moment caused by vertical movement of the collector **40** is reduced, and in this respect, the burden of supporting the front side of the intake manifold **9** is also reduced.

Since the throttle body **12** having a relatively large weight and usually disposed on the rear side of the collector **40** is attached to the left or right side of the collector **40**, the rotational moment caused by the vertical movement of the throttle body **12** is reduced as compared with the case where the throttle body is attached to the rear side of the collector **40**. In this respect, the burden of supporting the front side of the intake manifold **9** is also reduced.

In the support structure for the intake manifold **9**, in addition to the above support structure, as illustrated in FIG. **7**B, the collector **40** is elastically supported by the fixing structure **2** via a pair of coupling plates **17** and **17** having an identical isosceles triangle shape.

In addition to a geometric isosceles triangle in which the three vertices are edges, the isosceles triangle of the present invention includes a shape similar to a geometric isosceles triangle whose three vertices have an arc shape or another shape and two included angles sandwiched between two sides are equal (hereinafter, referred to as a "similar isosceles triangle").

As illustrated in FIG. **5**, the collector **40** is elastically supported by the fixing structure via the pair of coupling plates **17** and **17**, and the intake manifold **9** is supported at the both front and rear sides. Therefore, the burden of supporting the front side of the intake manifold **9** is reduced.

Since the collector **40** is elastically supported by the fixing structure **2**, the vertical vibration between the collector **40** and the throttle body **12** having a relatively large weight is reduced, and the burden of supporting the front side of the intake manifold **9** is reduced.

As illustrated in FIG. **5**, in the support structure for the intake manifold **9**, the throttle body **12** is supported by a fixing structure **12**B via an intake pipe **14**, and a flexible pipe **14**A having elasticity is used for the intake pipe **14**.

Although the body frame of a vehicle is used as the fixing structure **12**B, the fixing structure **12**B may be a device mounted on the vehicle.

As illustrated in FIG. **5**, in the support structure for the intake manifold **9**, since the rear side of the intake manifold **9** is elastically supported via the flexible pipe **14**A, the vertical vibration of the throttle body **12** is reduced, and the burden of supporting the front side of the intake manifold **9** is further reduced.

As illustrated in FIG. **3**, in the support structure for the intake manifold **9**, the fixing structure **2** is disposed below the intake manifold **9**, the collector **40** includes a supported portion **15** at a lower portion of the collector **40**, the fixing structure **2** includes a supporting portion **16** protruding upward from an upper side of the fixing structure **2**, and the supported portion **15** of the collector **40** is supported by the supporting portion **16** of the fixing structure **2**.

As illustrated in FIG. **3**, in the support structure for the intake manifold **9**, a space under the intake manifold **9** is effectively used as a space in which the fixing structure **2** is disposed.

As illustrated in FIG. **8**A, in the support structure for the intake manifold **9**, the fixing structure **2** includes a divided mating surface **28**A of the housing **2***a*, and the supporting portion **16** of the fixing structure **2** protrudes from the housing **2***a* along the divided mating surface **28**A.

In the support structure for the intake manifold **9** illustrated in FIG. **8**A, the supporting portion **16** can be formed at the same time when the housing **2***a* is molded by a mold.

The fixing structure **2** is a transmission **2**A, the housing **2***a* of the transmission **2**A is divided into a left housing portion **27** and a right housing portion **28** and is joined by the divided mating surface **28**A, and the supporting portion **16** is formed in the right housing portion **28**.

As illustrated in FIG. **8**A, in the support structure for the intake manifold **9**, the fixing structure **2** includes the supporting portion **16**, and the supporting portion **16** and the supported portion **15** of the collector **40** are coupled via an elastic coupling body S.

As illustrated in FIG. **8**B, in the support structure for the intake manifold **9**, the supporting portion **16** and the supported portion **15** are shortened due to the intervention of the elastic coupling body S as compared with a case where the supported portion **15** is directly coupled to the supporting portion **16**. Therefore, the rigidity of the supporting portion and the supported portion is enhanced, and durability of the supporting portion **16** and the supported portion **15** is improved.

As illustrated in FIG. **7**A, in the support structure for the intake manifold **9**, the elastic coupling body S includes the pair of coupling plates **17** and **17** that sandwiches the supporting portion **16** and the supported portion **15** from both sides, a pair of fasteners **18** and **19** that attaches the pair of coupling plates **17** and **17** to the supporting portion **16** and the supported portion **15**, and a knock pin **20** that is attached to either the supporting portion **16** or the supported portion **15**. The knock pin **20** is inserted into the pair of coupling plates **17** and **17**, elastic collars **23** and **23** are attached to at least one fastener **18** of the pair of fastener **18** or **19**, and the supported portion **15** of the collector **40** is elastically supported by the supporting portion **16** of the fixing structure **2** via the pair of fasteners **18** and **19** and the elastic collars **23** and **23** positioned by the knock pin **20**.

The support structure for the intake manifold **9** allows the fixing structure **2** to elastically support the intake manifold **9** with the elastic coupling body S having a simple structure.

As illustrated in FIG. **7**B, in the support structure for the intake manifold **9**, the pair of coupling plates **17** and **17** includes a knock pin insertion hole **20***a* through which the knock pin **20** is inserted and fastener insertion holes **18***a* and **19***a* through which the pair of fasteners **18** and **19** (see FIG. **7**A for the fastener **18**) is inserted, and a pair of the fastener insertion holes **18***a* and **19***a* is arranged at a line-symmetric position in a line-symmetric shape with respect to a virtual symmetric axis **20***b* radially crossing the knock pin insertion hole **20***a*.

The pair of coupling plates **17** and **17** is a similar isosceles triangle whose three vertices are arc-shaped, and includes a metal plate.

As illustrated in FIG. **7**B, in the support structure for the intake manifold **9**, the coupling plates **17** and **17** have the same assembling shape in both front and reverse faces, and the knock pin insertion holes **20***a* and the pair of fastener insertion holes **18***a* and **19***a* have the same relative positions. Therefore, it is not necessary to check the front and reverse faces of the coupling plates **17** and **17**, and the attachment work of the coupling plates **17** and **17** is facilitated.

As illustrated in FIG. **7**B, the knock pin insertion hole **20***a* is provided at a top corner **17***a* of each of the coupling plates **17** and **17**, and the pair of fastener insertion holes **18***a* and **19***a* are provided at a pair of bottom corners **17***b* and **17***b* having different angles from the top corner **17***a*.

As illustrated in FIG. **7**B, in the support structure for the intake manifold **9**, during the attachment work of the coupling plates **17** and **17**, the top corner **17***a* provided with the knock pin insertion hole **20***a* and the bottom corner **17***b* and **17***b* provided with the fastener insertion holes **18***a* and **19***a* can be identified only by confirming a difference in angle of the corners, and an attachment orientation of the coupling plates **17** and **17** can be confirmed. Therefore, the attachment work of the coupling plates **17** and **17** is further facilitated.

As illustrated in FIG. **7**A, a boss portion **16**A of the supporting portion **16** sandwiched between the left and right coupling plates **17** and **17** and the coupling plates **17** and **17** are rigidly fastened and fixed by a boss hole **16***a* formed in the boss portion **16**A and a first bolt **25** and a first nut **26** constituting a first fastener **19** inserted into the fastener insertion holes **19***a* and **19***a* of the coupling plates **17** and **17**. The orientation of each of the coupling plates **17** and **17** around the first bolt **25** is determined by fitting both ends **20***p* and **20***p* of the knock pin **20** protruding from the supporting portion **16** to the left and right with the knock pin insertion holes **20***a* and **20***a* of the coupling plates **17** and **17** illustrated in FIG. 7B.

As illustrated in FIG. 7A, the elastic collars **23** and **23** including a flexible material such as rubber are fitted into the through hole **15***a* of the supported portion **15** on both left and right sides, and a metal spacer **24** is fitted into the boss portions **23***b* and **23***b* of the elastic collars **23** and **23**. Then, in a state where the spacer **24** is sandwiched between the left and right coupling plates **17** and **17**, fastening and fixing are achieved by the second bolt **21** and the second nut **22** constituting a second fastener **18** passing through the fastener insertion holes **18***a* and **18***a* of the coupling plates **17** and **17** and an inner hole **24***a* of the spacer **24**.

As illustrated in FIG. 7A, the elastic collar **23** has an L-shaped cross section including the cylindrical boss portion **23***b* and a disk-shaped flange **23***a*, and in an assembled state where the elastic collar **23** is fastened by the second bolt **21** and the second nut **22**, the left and right flanges **23***a* and **23***a* are slightly compressed left and right. As a result, the intake manifold **9** is elastically supported by a housing **2**Aa of the transmission **2**A. The coupling plates **17** and **17** rigidly fixed to the supported portion **15** may be attached to the supporting portion **16** in an elastically supported state.

Next, an internal structure of the collector **40** of the intake manifold **9** will be described.

As illustrated in FIG. **9**, the intake manifold **9** includes the collector **40** and the plurality of branch pipes **9***a* and **9***b* led out from the collector **40**.

Assuming that a longitudinal direction of the collector **40** is the left-right direction, a throttle communication port **41** is opened on the left or right end of the collector **40**.

The branch pipes **9***a* and **9***b* include tank-side openings **9***aa* and **9***ba* facing an internal space **40**S of the collector **40**.

As illustrated in FIG. **9**, the collector **40** includes a boundary wall **45** at a boundary between the throttle communication port **41** and the tank-side opening **9***ba* of the branch pipe **9***b* close to the throttle communication port **41**, and the boundary wall **45** includes an inward protrusion **45***a* protruding toward the internal space **40**S of the collector **40**.

As illustrated in FIG. **5**, in the collector **40**, the throttle communication port **41** is opened on the left or right end of the collector **40**, and the throttle body **12** is connected to the throttle communication port **41**. Therefore, as illustrated in FIG. **3**, the engine front-rear length dimension L is kept short.

In the internal structure of the collector **40**, an intake amount of each cylinder is equalized. The reason is estimated as follows.

An intake resistance of the inward protrusion **45***a* illustrated in FIG. **9** hinders intake air supply to a cylinder close to the throttle communication port **41** whose intake amount is likely to increase, and intake air that has not been used for supply to the cylinder is supplied to a distant cylinder whose intake amount is likely to decrease, so that the intake amount of each cylinder is equalized.

As illustrated in FIG. **9**, in the internal structure of the collector **40**, an inner surface of the inward protrusion **45***a* is formed by an arc surface **45***aa* having an inward protruding shape.

In the internal structure of the collector **40**, the inward protruding arc surface **45***aa* illustrated in FIG. **9** makes it difficult for a turbulence to occur in the intake air, and the intake air supply to each cylinder is hardly hindered by the turbulence.

Next, the outer wall structure of the collector **40** will be described.

As illustrated in FIG. **9**, in the outer wall structure of the collector **40**, among left and right end walls of the collector **40**, a non-throttle side end wall **40***e* on the opposite side to the end wall provided with the throttle communication port **41** protrudes to a non-throttle side from an internal passage **9***ac* of the branch pipe **9***a* on the non-throttle side.

In the outer wall structure of the collector **40**, the internal space **40**S of the collector **40** is expanded to the non-throttle side with respect to the internal passage **9***ac* of the branch pipe **9***a* on the non-throttle side at the non-throttle side end wall **40***e* illustrated in FIG. **9**, the air intake of the cylinders far from the throttle communication port **41** is promoted, and the intake amount of each cylinder approaches an equal amount.

As illustrated in FIG. **9**, in the outer wall structure of the collector **40**, a non-cylinder head side end wall **40***c* of the collector **40** protrudes to a non-cylinder head side from the throttle communication port **41**.

In the outer wall structure of the collector **40**, in the non-cylinder head side end wall **40***c* illustrated in FIG. **9**, the internal space **40**S of the collector **40** is expanded to the non-cylinder head side with respect to the throttle communication port **41**, the air intake to the cylinders far from the throttle communication port **41** is promoted, and the intake amount of each cylinder approaches an equal amount.

In FIG. **10**, a reference sign **40***a* denotes a ceiling wall of the collector **40**, and a reference sign **40***b* denotes a bottom wall.

Next, the engine model using the intake manifold will be described.

As illustrated in FIG. **9**, the intake manifold **9** is an intake manifold in which the pair of left and right branch pipes **9***a* and **9***b* is led out from the collector **40**, and is used for a two-cylinder engine.

When the intake manifold **9** is used for a two-cylinder engine having a large difference in intake path from the throttle communication port **41**, the effect of equalizing the intake amount of each cylinder becomes apparent.

The pair of branch pipes **9***a* and **9***b* (see FIG. **9** for the branch pipe **9***b*) illustrated in FIG. **5** extends straight and parallel from the collector **40** toward the cylinder head **6**. As shown in FIG. **9**, peripheral walls **9***ab* and **9***bb* of the tank-side openings **9***aa* and **9***ba* of the pair of branch pipes **9***a* and **9***b* each protrude from a cylinder head side end wall **40***d* of the collector **40** toward the internal space **40**S of the collector **40**.

The intake manifold **9** is used in a four-cycle inline two-cylinder engine in which a crank pin angle of the crankshaft **1**A illustrated in FIG. **4** is 180°, and a phase difference between an intake stroke of a second cylinder on the side of the throttle communication port **41** illustrated in FIG. **9** and an intake stroke of a first cylinder performed following the intake stroke is 180° in crank angle.

When the first cylinder is used in this engine model, an intake shortage is likely to occur in the first cylinder in which the intake stroke is started with a relatively small phase difference of 180° after the start of the intake stroke of the second cylinder. When this intake manifold is used in the engine, the effect of equalizing the intake amount of each cylinder becomes more apparent.

Next, the oil inspector for the engine will be described.

The engine **2** illustrated in FIG. **2**A includes the oil inspector, and as illustrated in FIG. **11**, the oil inspector includes the oil gauge **30**, a guide pipe **53** that guides the oil gauge **30** to an engine oil EO in the oil pan **8**, and a support pipe **52** that supports the guide pipe **53** in the crankcase **1**.

The support pipe **52** is inserted into a support pipe insertion hole **51** of the crankcase **1**.

An inner fitting portion **53**A is provided at a lower end of the guide pipe **53**, the inner fitting portion **53**A is internally fitted and fixed to an upper end of the support pipe **52**, a ridge **54** is circumferentially provided on an inner periphery of the inner fitting portion **53**A, and a curved portion **53***c* is provided at an intermediate portion of the guide pipe **53**.

As illustrated in FIG. **11**, an upper side of the guide pipe **53** is inclined upward in a direction away from the crankcase **1** due to the curved portion **53***c*, and the oil gauge **30** inserted into the guide pipe **53** is configured to be in contact with inner peripheral surfaces of the curved portion **53***c*, the ridge **54**, and the support pipe **52**.

The oil inspector of the engine is suitable when there is an access path to the oil inspector only obliquely above the guide pipe **53** due to an engine mounting environment, the oil inspector is accessible from obliquely above the guide pipe **53**, and the oil gauge **30** can be inserted and removed along an obliquely upward direction of the guide pipe **53**.

As illustrated in FIG. **11**, in the oil inspector of the engine, the oil gauge **30** inserted into the guide pipe **53** comes into contact with three points of the inner peripheral surfaces of the curved portion **53***c*, the ridge **54**, and the support pipe **52**. Therefore, resistance in a pulling direction of the oil gauge **30** is large, and it is possible to prevent the oil gauge **30** from being pulled out of the guide pipe **53** by inertia force at the time of braking of the vehicle equipped with the engine.

As illustrated in FIG. **11**, the oil inspector of the engine includes a tapered portion **52**D whose inner diameter gradually decreases downward at a lower end of the support pipe **52**.

As illustrated in FIG. **11**, in the oil inspector of the engine, the oil gauge **30** penetrating the support pipe **52** is received inside the tapered portion **52**D at the lower end of the support pipe **52**, and swinging of the oil gauge **30** protruding from the support pipe **52** toward the oil pan **8** is suppressed.

As illustrated in FIG. **11**, in the oil inspector for the engine, the inner fitting portion **53**A of the guide pipe **53** is enlarged in diameter, and the oil gauge **30** inserted into the guide pipe **53** is also configured to come into contact with a non-enlarged diameter portion **53**Aa of the guide pipe **53** adjacent to the enlarged inner fitting portion **53**A on the upper side of the inner fitting portion **53**A.

As illustrated in FIG. **11**, in the oil inspector of the engine, since the oil gauge **30** also comes into contact with the non-enlarged diameter portion **53**Aa of the guide pipe **53** adjacent to the inner fitting portion **53**A, the resistance of the oil gauge **30** in the pulling direction further increases.

As illustrated in FIG. **11**, in the oil inspector of the engine, a recessed groove **54***a* is circumferentially provided on an outer periphery of the ridge **54**, an O-ring **54***b* is internally fitted in the recessed groove **54***a*, and an inter-pipe gap **54***c* between the inner fitting portion **53**A of the guide pipe **53** and the support pipe **52** is sealed by the O-ring **54***b*.

The oil inspector of the engine enhances sealability of the inter-pipe gap **54***c*.

As illustrated in FIG. **11**, in the oil inspector of the engine, an upper end **52***a* of the support pipe **52** is separated upward from an upper edge **51***a* of the support pipe insertion hole **51** of the crankcase **1** by a distance d.

As illustrated in FIG. **11**, in the oil inspector of the engine, since foreign matter such as dust accumulated around the support pipe insertion hole **51** does not enter the inter-pipe gap **54***c* from the upper end **52***a* of the support pipe **52** separated upward by the distance d, damage of the O-ring **54***b* due to engagement of the foreign matter is prevented.

As illustrated in FIG. **11**, the guide pipe **53** including a metal material or the like includes the inner fitting portion **53**A internally fitted to an enlarged diameter portion **52**A of the support pipe **52**, an upper end (proximal end) **53**B into which a plug **30**A including an elastic material and fitted to an upper end of the oil gauge **30** is internally fitted, and an intermediate portion **53**C between the inner fitting portion **53**A and the upper end **53**B. The curved portion **53***c* in which an intermediate portion in a longitudinal direction is bent at an angle x (for example, from 35 degrees to 45 degrees) is formed in the intermediate portion **53**C which is the diameter of an original pipe member.

As illustrated in FIG. **11**, the upper end **53**B has an enlarged diameter opening **53***b* that is a point where the plug **30**A is tightly fitted by enlarging the diameter of the original pipe material. The enlarged diameter opening **53***b* has an upper side (proximal end) formed as a dilated opening **58** and a lower side (distal end) formed as a diameter changing portion **59** in which the diameter gradually increases from the original diameter toward the enlarged diameter opening **53***b*. The diameter of the enlarged diameter opening **53***b* is set to such a diameter that the plug **30**A pushed into the inner peripheral surface by the operation of a finger does not easily come out.

As illustrated in FIG. **11**, the oil gauge **30** includes a grip **30**B in an upper portion (proximal end) including a metal bar material, a gauge **30**C coupled and integrated with a lower portion of the grip **30**B by a rivet **60**, and the plug **30**A fitted to the grip **30**B. The plug **30**A includes a stepped cylindrical portion **30***a* that is lightly press-fitted into the enlarged diameter opening **53***b*, and a large-diameter stop portion **30***b* that is received by the dilated opening **58**. The upper end of the grip **30**B is substantially rounded at 270 degrees to form a hook **30***t* through which a finger can pass.

As illustrated in FIG. **11**, the gauge **30**C includes a flexible material (for example, spring steel) having a thin long plate shape with a flat cross section, and is provided with first and second twisted portions **61** and **62** twisted at 180 degrees at a lower end and at 90 degrees at a lower end, respectively.

A line N illustrated in FIG. **11** is an upper limit of the engine oil EO accumulated in the oil pan **8** and a lower portion of the crankcase **1**.

As illustrated in FIG. **11**, a bracket **64** including a metal plate is attached to a position between the inner fitting portion **53**A and the curved portion **53***c* of the guide pipe **53** by welding or the like. The bracket **64** can be fastened and fixed to an attachment boss **50**A formed in the crankcase **1** by a bolt **65** through a hole (not illustrated) formed in the bracket **64**. The attachment boss **50**A is a boss portion for mounting an oil gauge in a crankcase of an engine before improvement, and is effectively used as a boss for screwing a bolt **65** in the engine.

FIG. **12** is a perspective view of the oil inspector of FIG. **11** and a periphery of the oil inspector, and FIG. **13** is an enlarged perspective view of the oil inspector of FIG. **12**.

In the multipurpose four-wheeled vehicle V illustrated in FIG. **1**, as illustrated in FIG. **2**A, the engine E is disposed behind the seat **34**A and below the front portion of the cargo bed **35**, the oil inspector is disposed on the front side of the crankcase **1**, and the upper portion of the guide pipe **53** obliquely extends forward and upward.

As illustrated in FIG. **3**, the grip **30**B at the upper end of the oil gauge **30** is located behind the back plate **38***b* which is a support member of the seat **34**A (see FIGS. **2**A and **2**B), the back plate **38***b* is provided with an openable (or detachable) lid body **66**, the lid body **66** is opened (or removed), the oil gauge **30** is inserted and removed along an obliquely forward upper direction of the guide pipe **53** by accessing the oil inspector from obliquely forward and above of the guide pipe **53**, and the inspection work of an engine oil amount can be performed. In FIG. **3**, a reference sign **67** denotes an oil filter.

What is claimed is:

1. A support structure for an intake manifold, the support structure comprising: a cylinder head; and

a fixing structure, the support structure supporting the intake manifold, wherein

an axial length direction of a crankshaft center is defined as a left-right direction,

a horizontal direction orthogonal to the left-right direction is defined as a front-rear direction,

one side in the front-rear direction is defined as a front side,

the intake manifold includes a collector including a synthetic resin, the intake manifold including a plurality of branch pipes led out to the front side from the collector,

an intake outlet at a front end of each of the branch pipes is supported by the cylinder head,

the collector is elastically supported by the fixing structure via a pair of coupling plates having an identical isosceles triangle shape,

a throttle body is attached to a left or right end of the collector, the left or right end being opposite to a side supported by the fixing structure,

the fixing structure is disposed below the intake manifold,

the collector includes a supported portion at a lower portion of the collector,

the fixing structure includes a supporting portion protruding upward from an upper side of the fixing structure,

the supported portion of the collector is supported by the supporting portion of the fixing structure,

the supporting portion and the supported portion of the collector are coupled via an elastic coupling body,

the elastic coupling body includes a pair of coupling plates that sandwiches the supporting portion and the supported portion from both sides, a pair of fasteners that attaches the pair of coupling plates to the supporting portion and the supported portion, and a knock pin that is attached to either the supporting portion or the supported portion,

the knock pin is inserted into the pair of coupling plates,

an elastic collar is attached to at least one fastener of the pair of fasteners, and

the supported portion of the collector is elastically supported by the supporting portion of the fixing structure via the pair of fasteners and the elastic collar positioned by the knock pin.

2. The support structure for the intake manifold according to claim **1**, wherein

the throttle body is supported by the fixing structure via an intake pipe, and

a flexible pipe having elasticity is used for the intake pipe.

3. The support structure for the intake manifold according to claim **2**, wherein

the pair of coupling plates includes a knock pin insertion hole through which the knock pin is inserted and a fastener insertion hole through which the pair of fasteners is inserted, and

a pair of the fastener insertion holes is arranged at a line-symmetric position in a line-symmetric shape with respect to a virtual symmetric axis radially crossing the knock pin insertion hole.

4. The support structure for the intake manifold according to claim **3**, wherein

the knock pin insertion hole is provided at a top corner of each of the coupling plates, and

the pair of fastener insertion holes is provided at a pair of bottom corners having different angles from the top corner.

5. The support structure for the intake manifold according to claim **1**, wherein

the fixing structure includes a divided mating surface of a housing, and

the supporting portion of the fixing structure protrudes from the housing along the divided mating surface.

6. The support structure for the intake manifold according to claim **5**, wherein

the pair of coupling plates includes a knock pin insertion hole through which the knock pin is inserted and a fastener insertion hole through which the pair of fasteners is inserted, and

a pair of the fastener insertion holes is arranged at a line-symmetric position in a line-symmetric shape with respect to a virtual symmetric axis radially crossing the knock pin insertion hole.

7. The support structure for the intake manifold according to claim **6**, wherein

the knock pin insertion hole is provided at a top corner of each of the coupling plates, and

the pair of fastener insertion holes is provided at a pair of bottom corners having different angles from the top corner.

8. The support structure for the intake manifold according to claim **5**, wherein

the throttle body is supported by the fixing structure via an intake pipe, and

a flexible pipe having elasticity is used for the intake pipe.

9. The support structure for the intake manifold according to claim **8**, wherein

the pair of coupling plates includes a knock pin insertion hole through which the knock pin is inserted and a fastener insertion hole through which the pair of fasteners is inserted, and

a pair of the fastener insertion holes is arranged at a line-symmetric position in a line-symmetric shape with respect to a virtual symmetric axis radially crossing the knock pin insertion hole.

10. The support structure for the intake manifold according to claim **9**, wherein

the knock pin insertion hole is provided at a top corner of each of the coupling plates, and

the pair of fastener insertion holes is provided at a pair of bottom corners having different angles from the top corner.

11. The support structure for the intake manifold according to claim **1**, wherein

the pair of coupling plates includes a knock pin insertion hole through which the knock pin is inserted and a fastener insertion hole through which the pair of fasteners is inserted, and a pair of the fastener insertion holes is arranged at a line-symmetric position in a line-symmetric shape with respect to a virtual symmetric axis radially crossing the knock pin insertion hole.

12. The support structure for the intake manifold according to claim **11**, wherein

the knock pin insertion hole is provided at a top corner of each of the coupling plates, and

the pair of fastener insertion holes is provided at a pair of bottom corners having different angles from the top corner.

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