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[54] **AXLE DRIVING APPARATUS**

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abandoned.

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[52] **U.S. Cl.** **60/454; 60/487; 60/488;**
60/486

[58] **Field of Search** 60/454, 464, 485,
60/487, 488, 486

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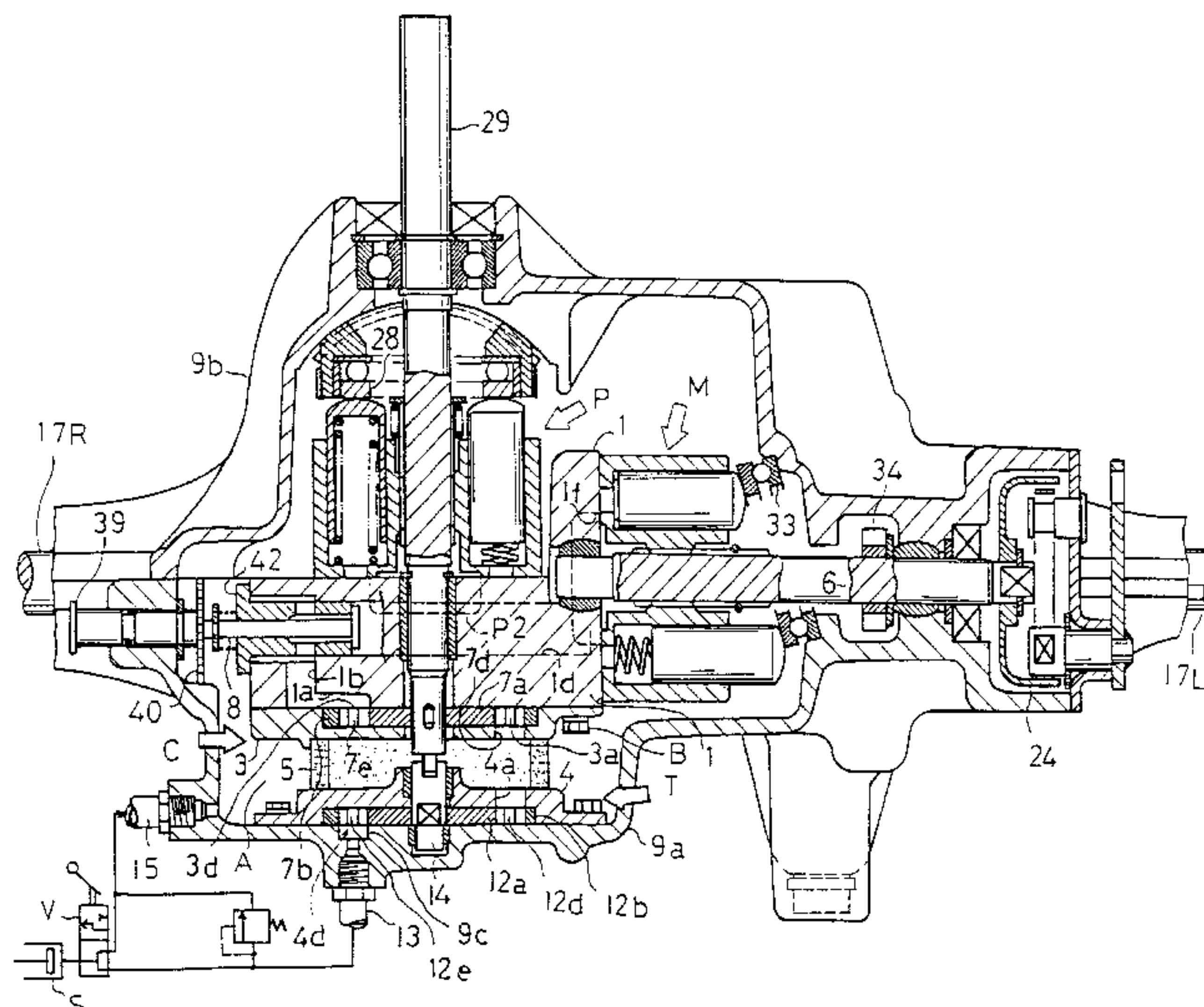
Primary Examiner—F. Daniel Lopez

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[57] **ABSTRACT**

In order that a hydraulic pump and a hydraulic motor of a hydrostatic transmission hitherto disposed to the exterior are attached to a hydrostatic transmission support member provided in a mission case, a charging pump hitherto attached to the hydraulic pump at the hydrostatic transmission is also attached to the hydrostatic transmission support member, and an oil filter hitherto attached to the outside of mission case is disposed therein, they are interposed between the lower surface of hydrostatic transmission support member and the charging pump. Furthermore, an outward takeout pump also is supported in the mission case.

79 Claims, 11 Drawing Sheets



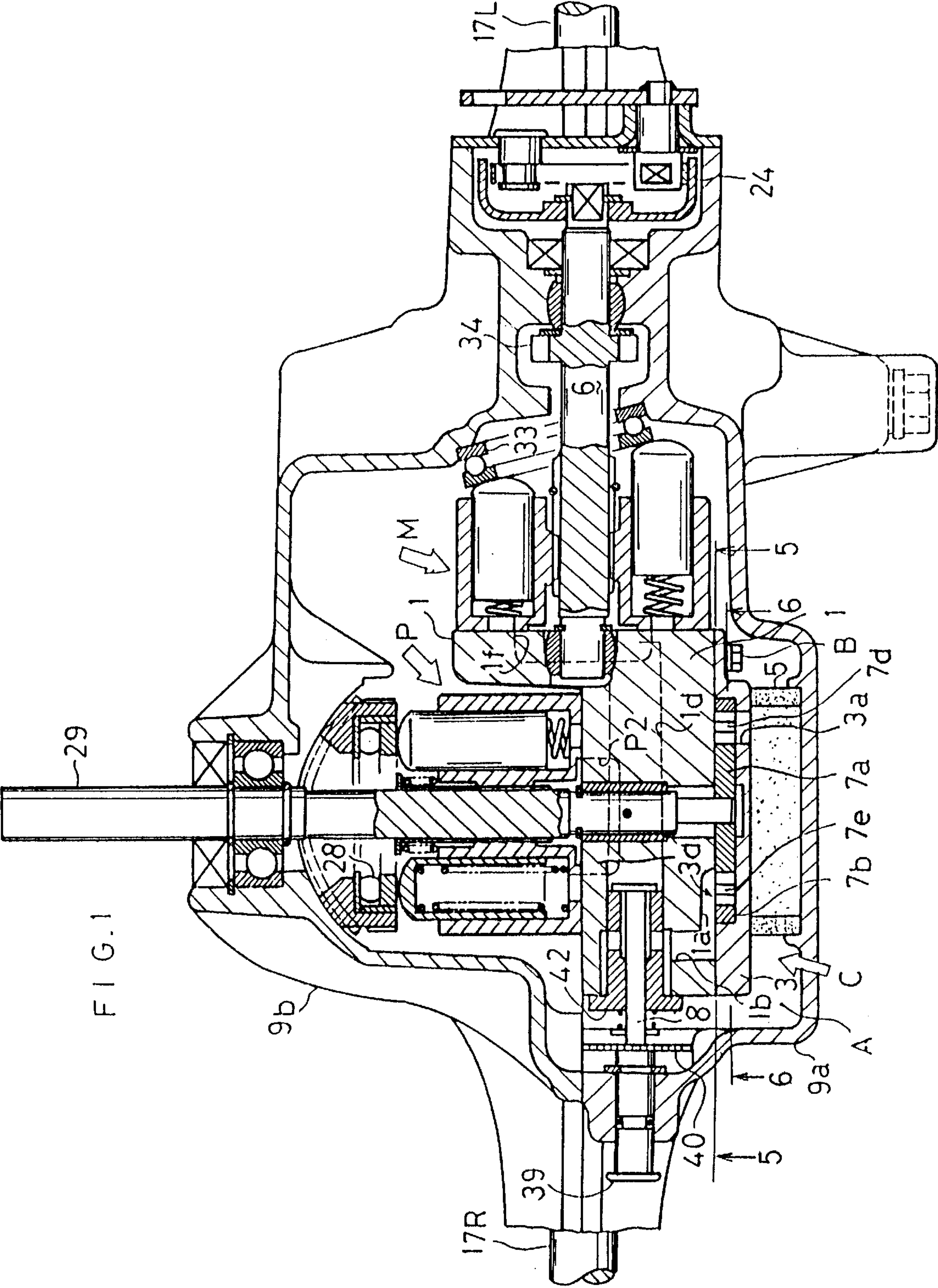
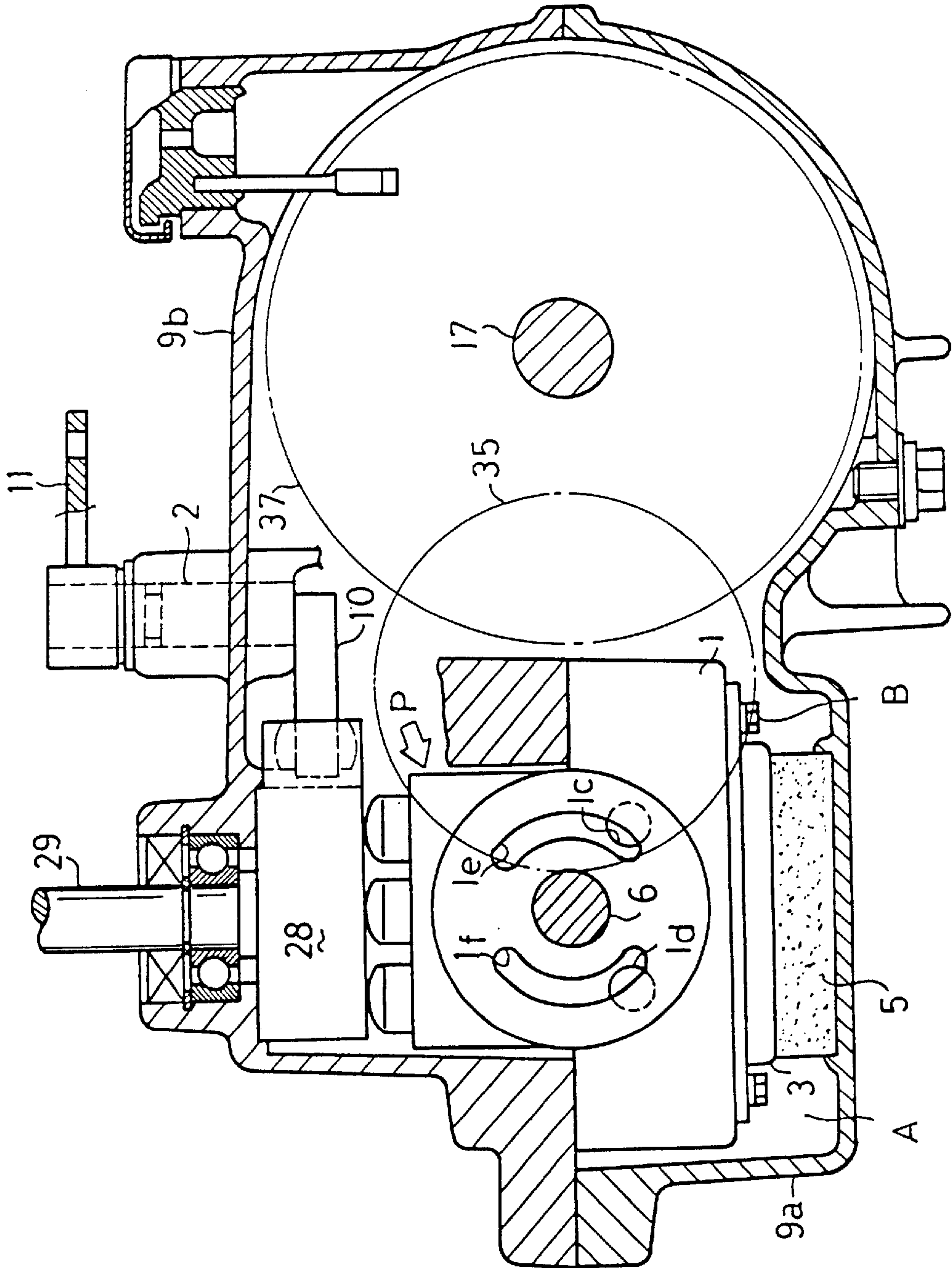
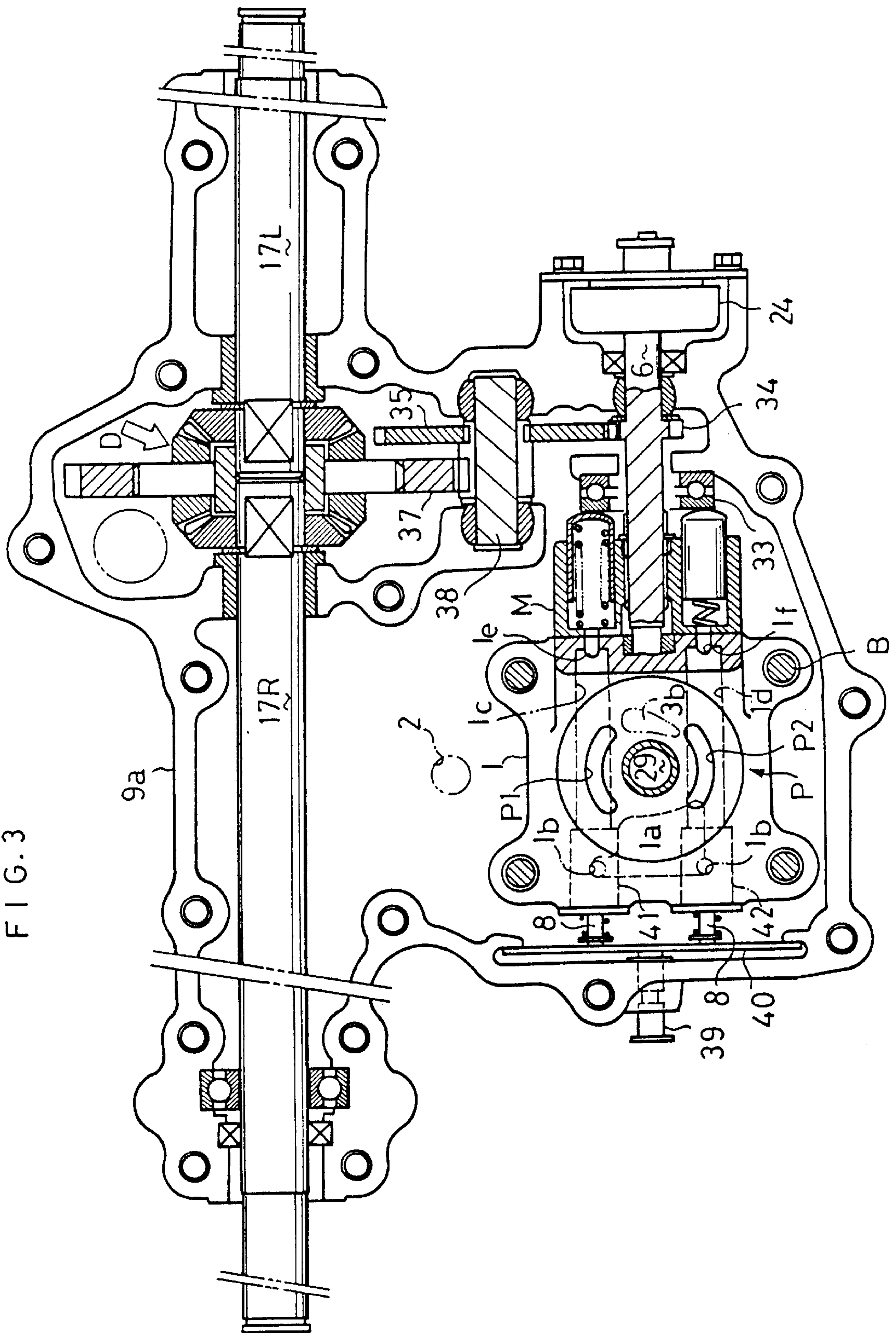


FIG. 2



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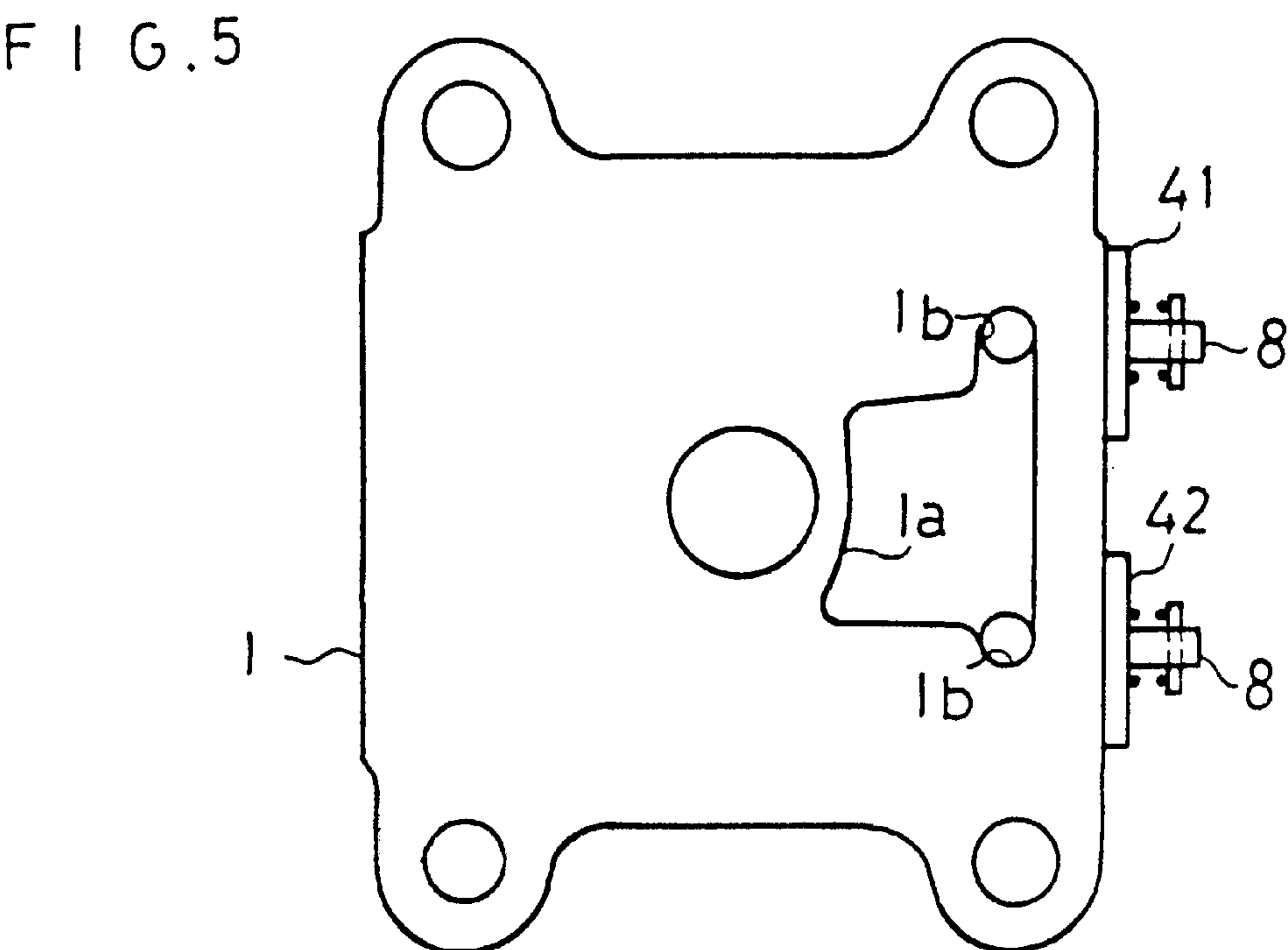
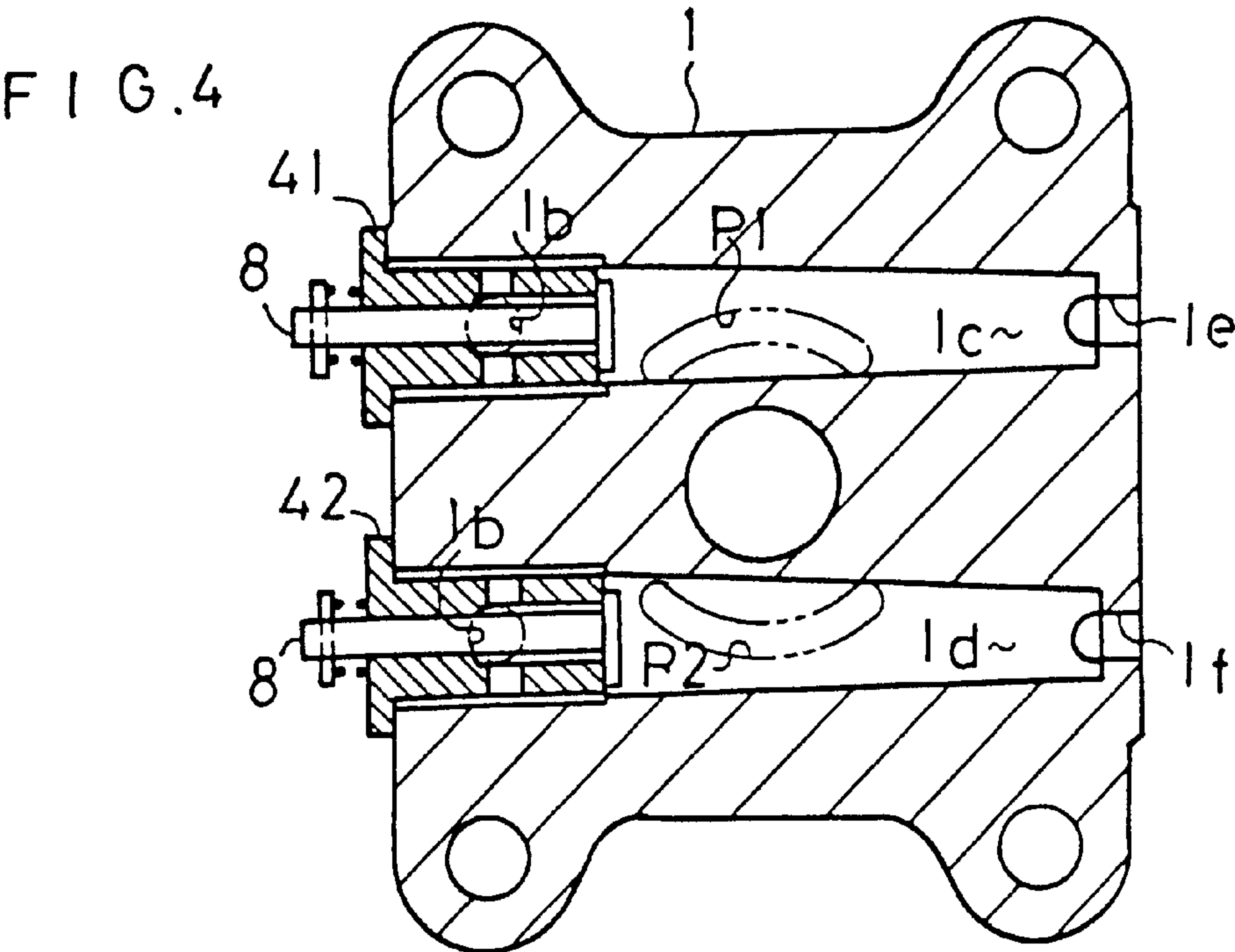


FIG. 6

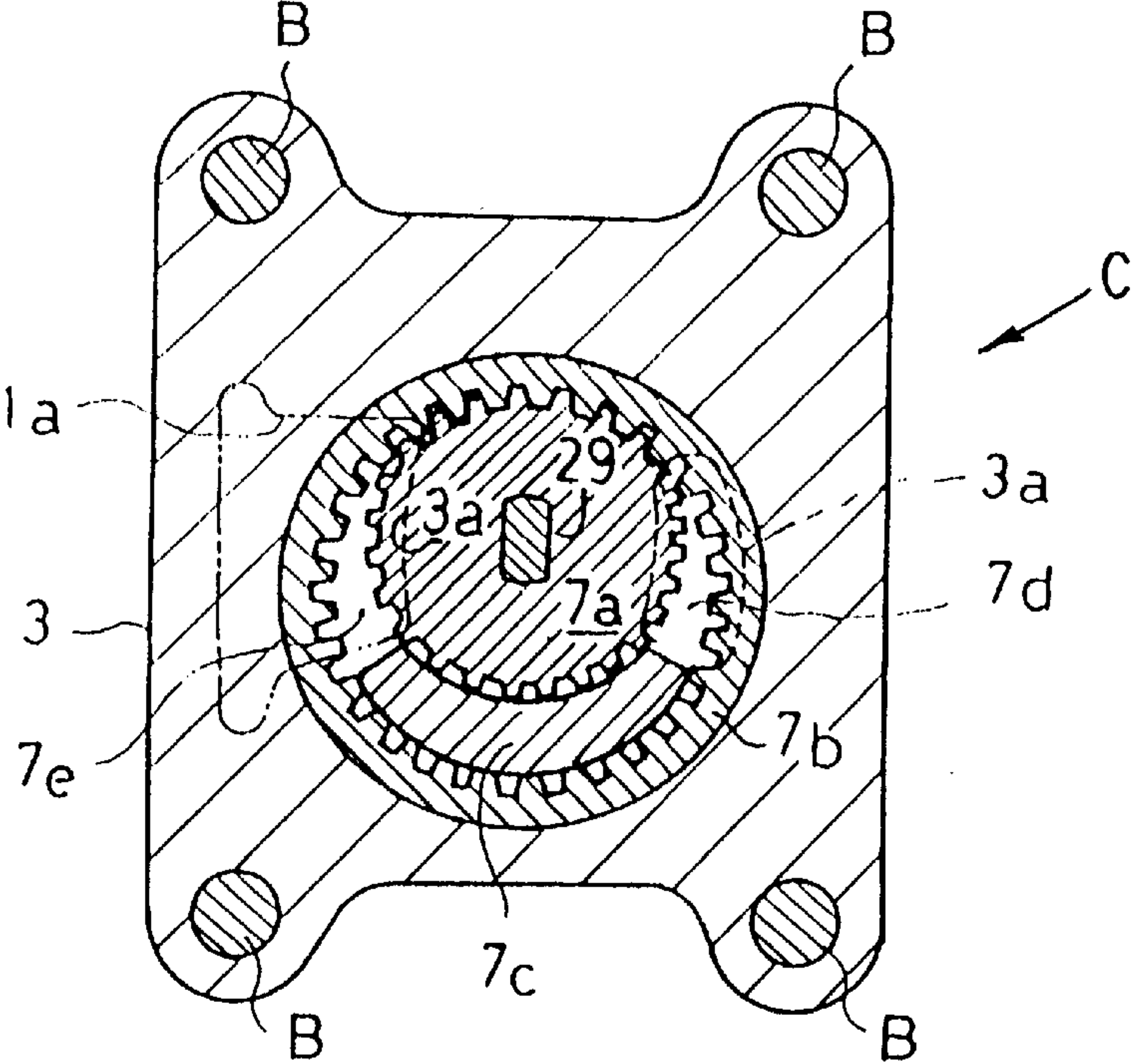


FIG. 7

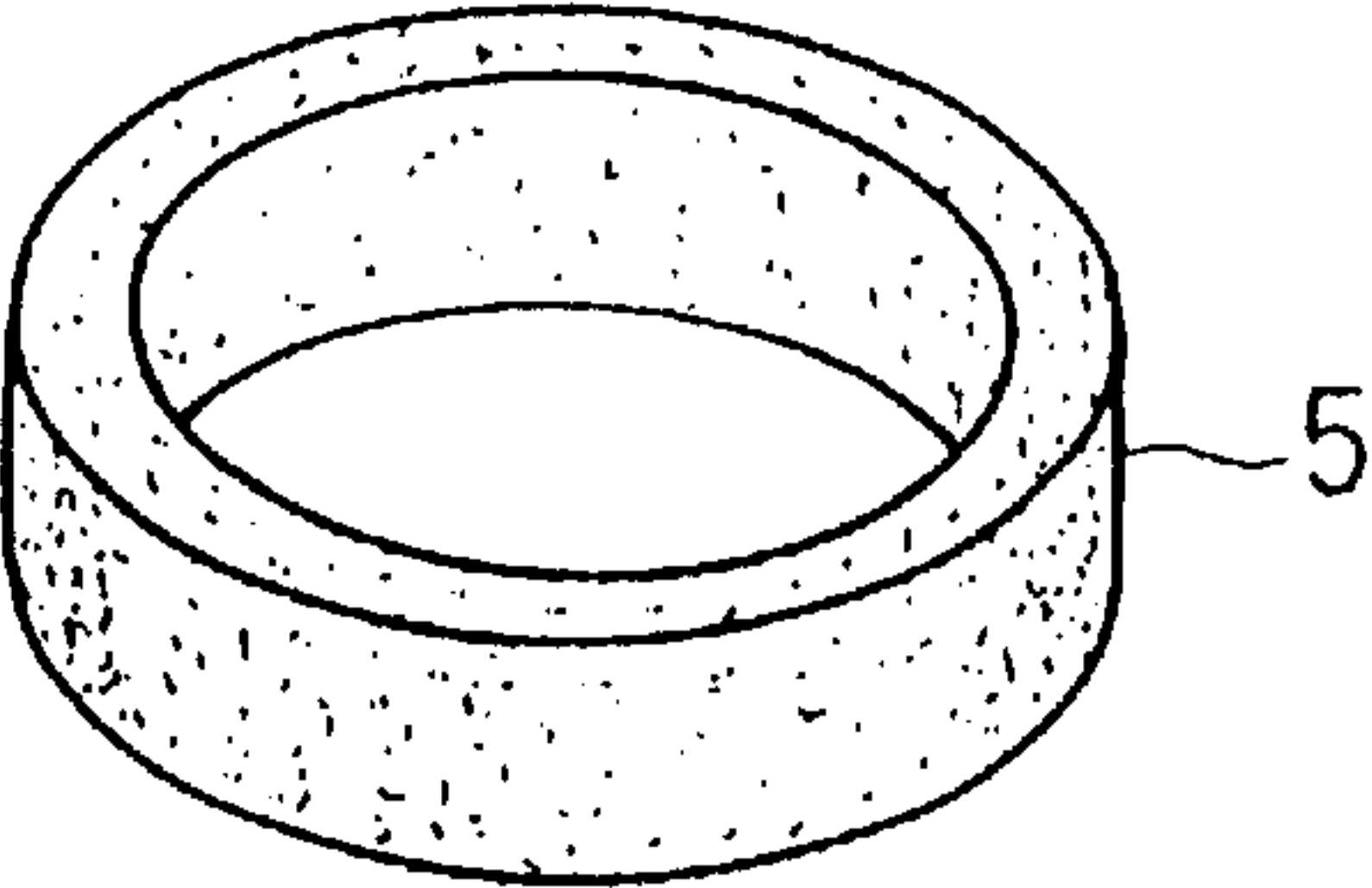
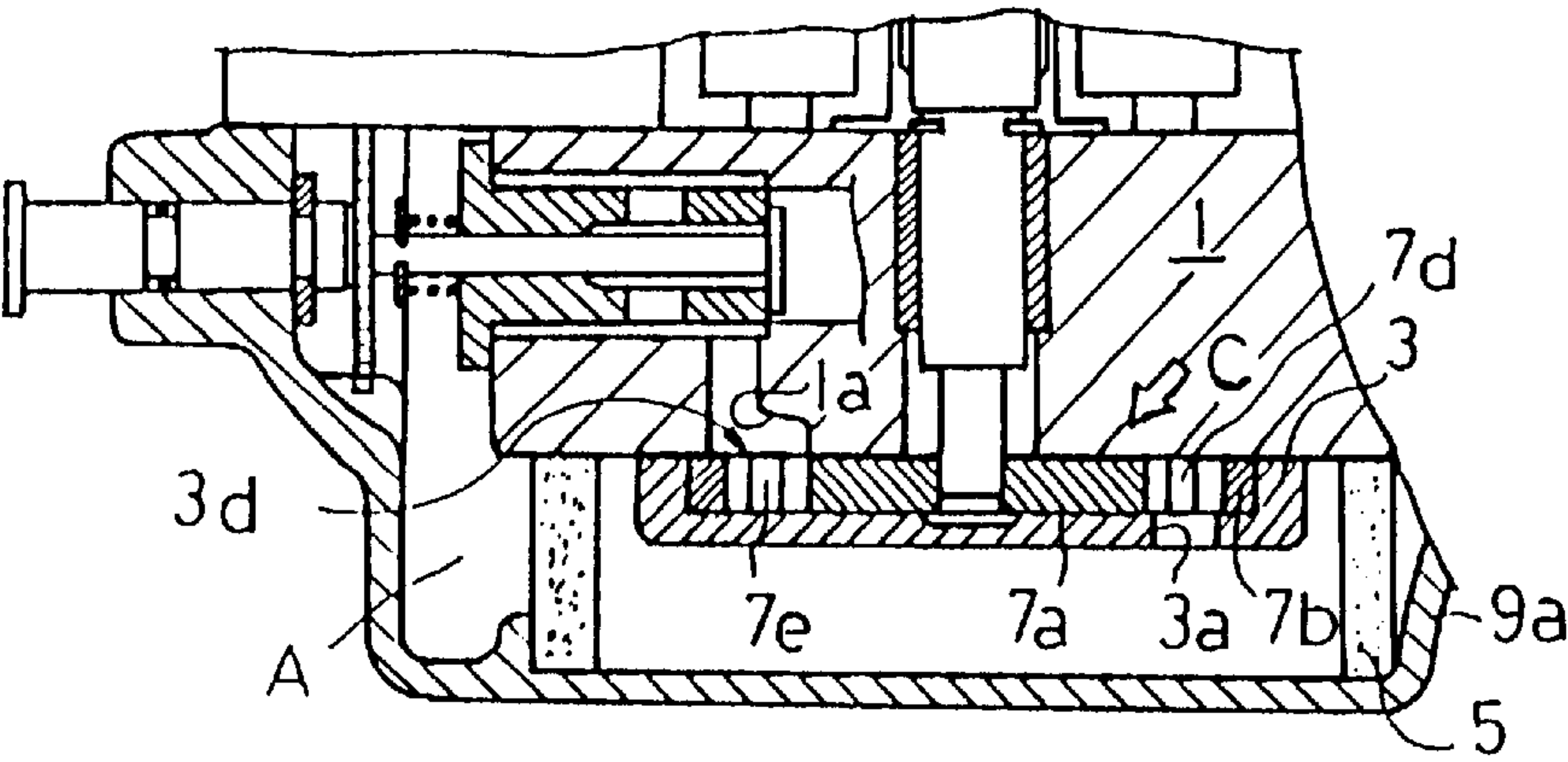
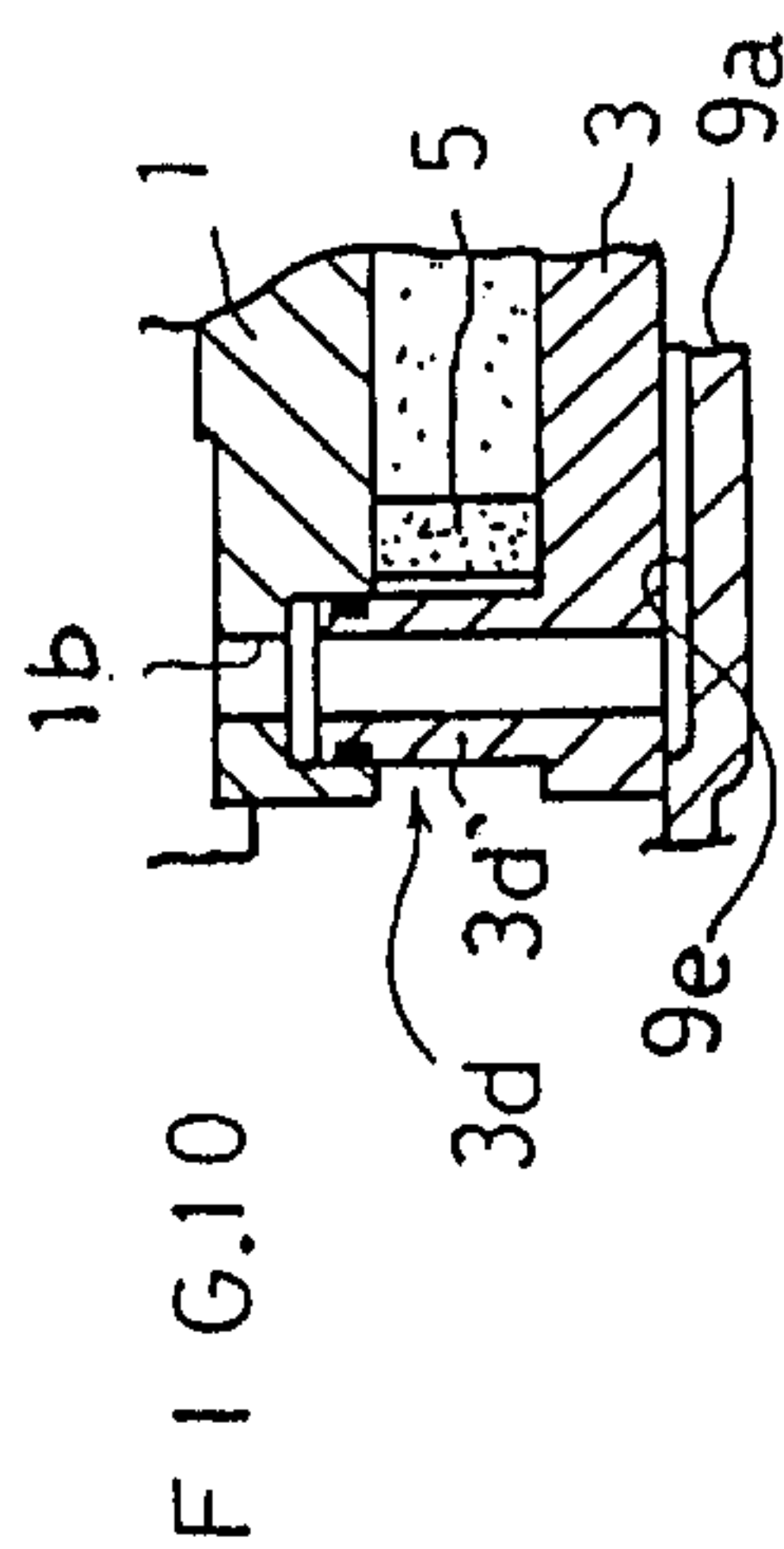
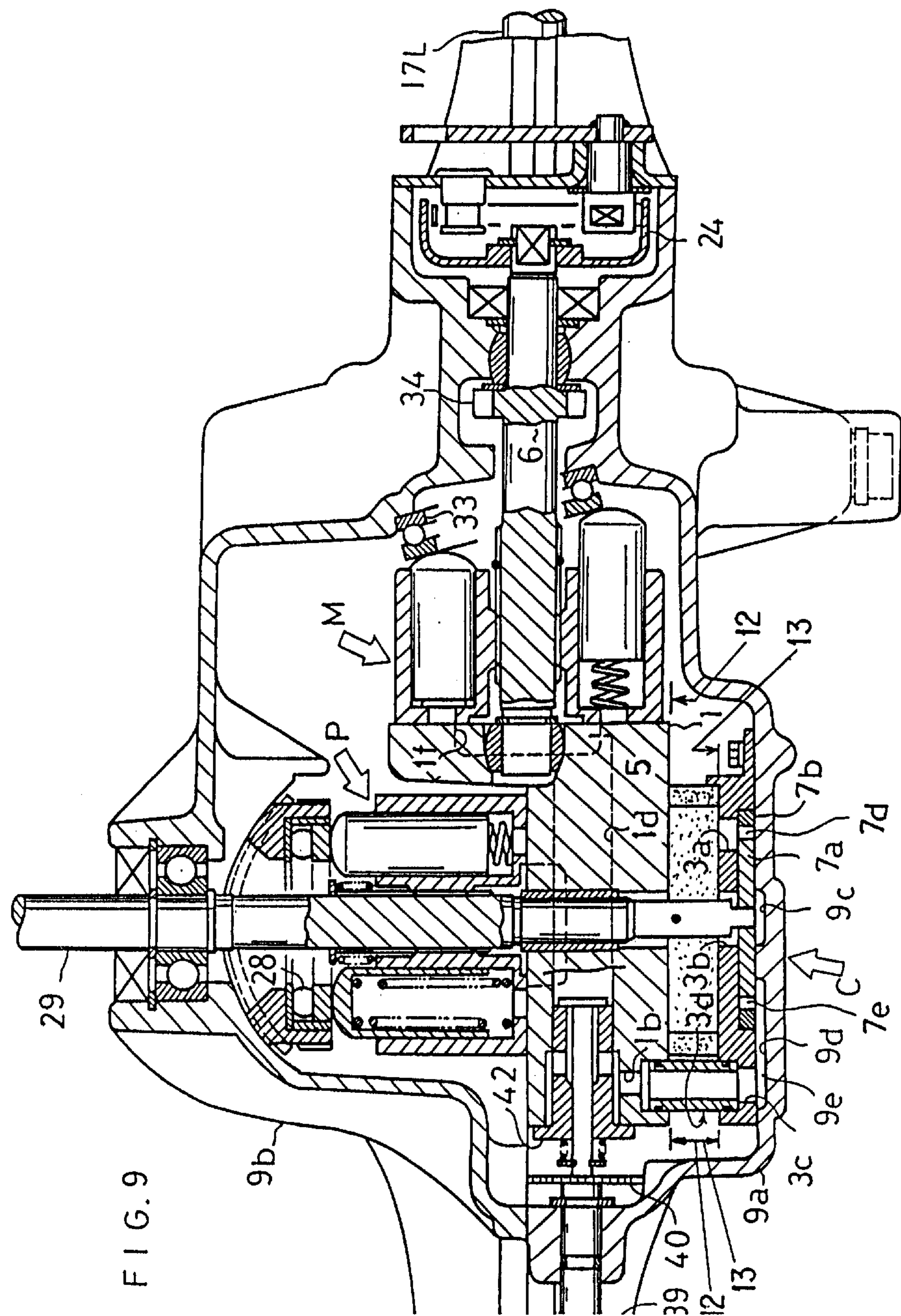
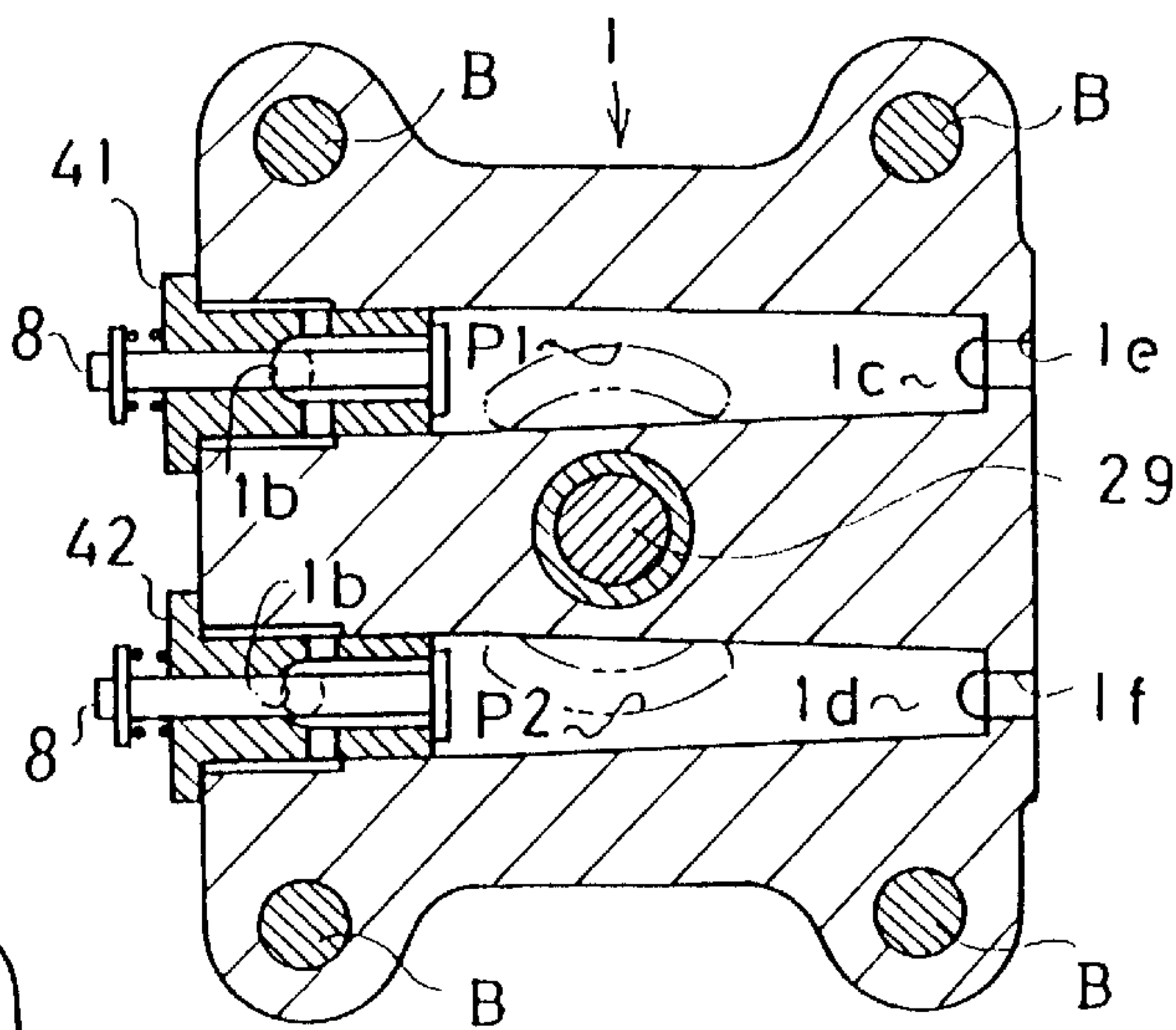


FIG. 8

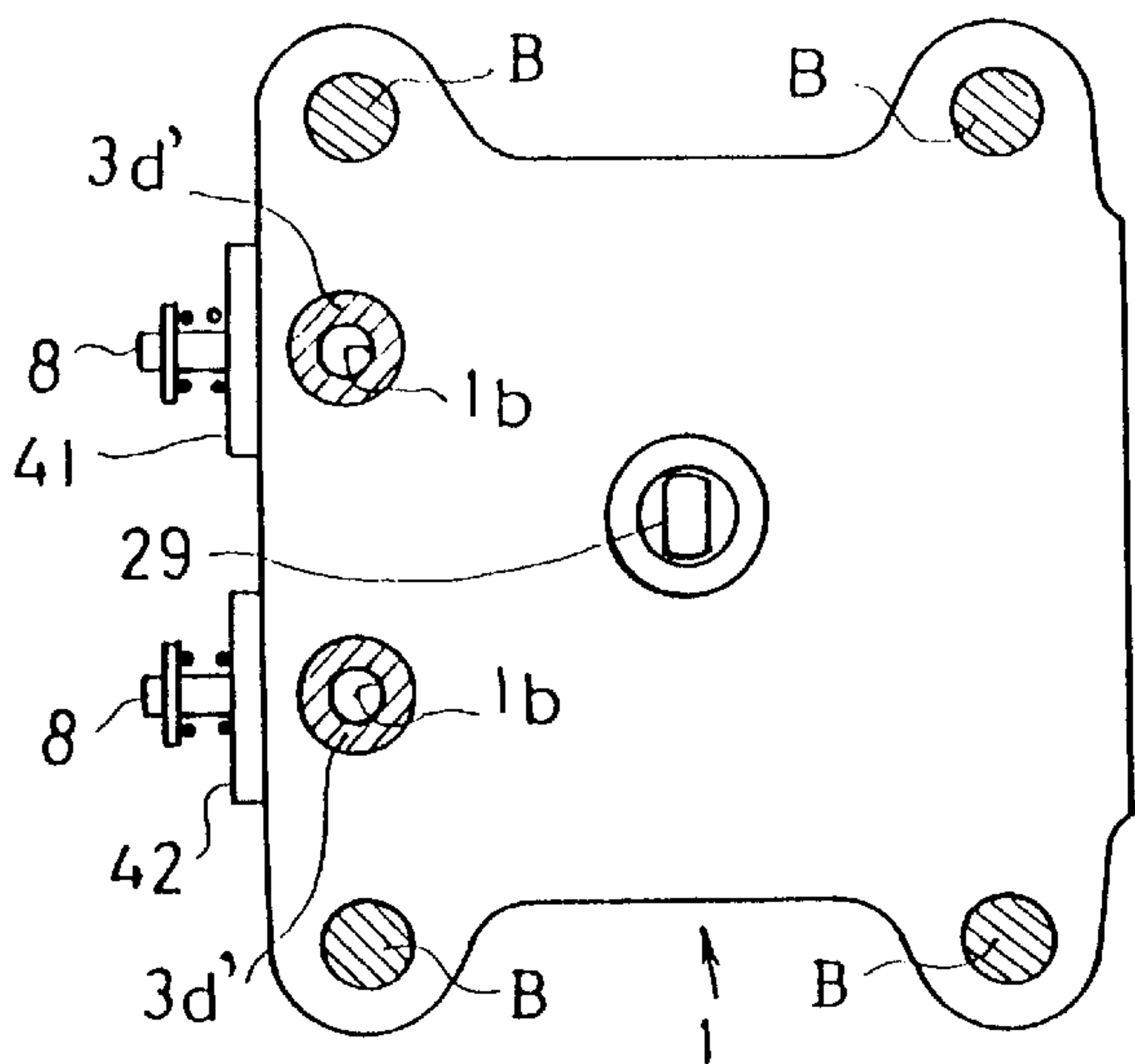




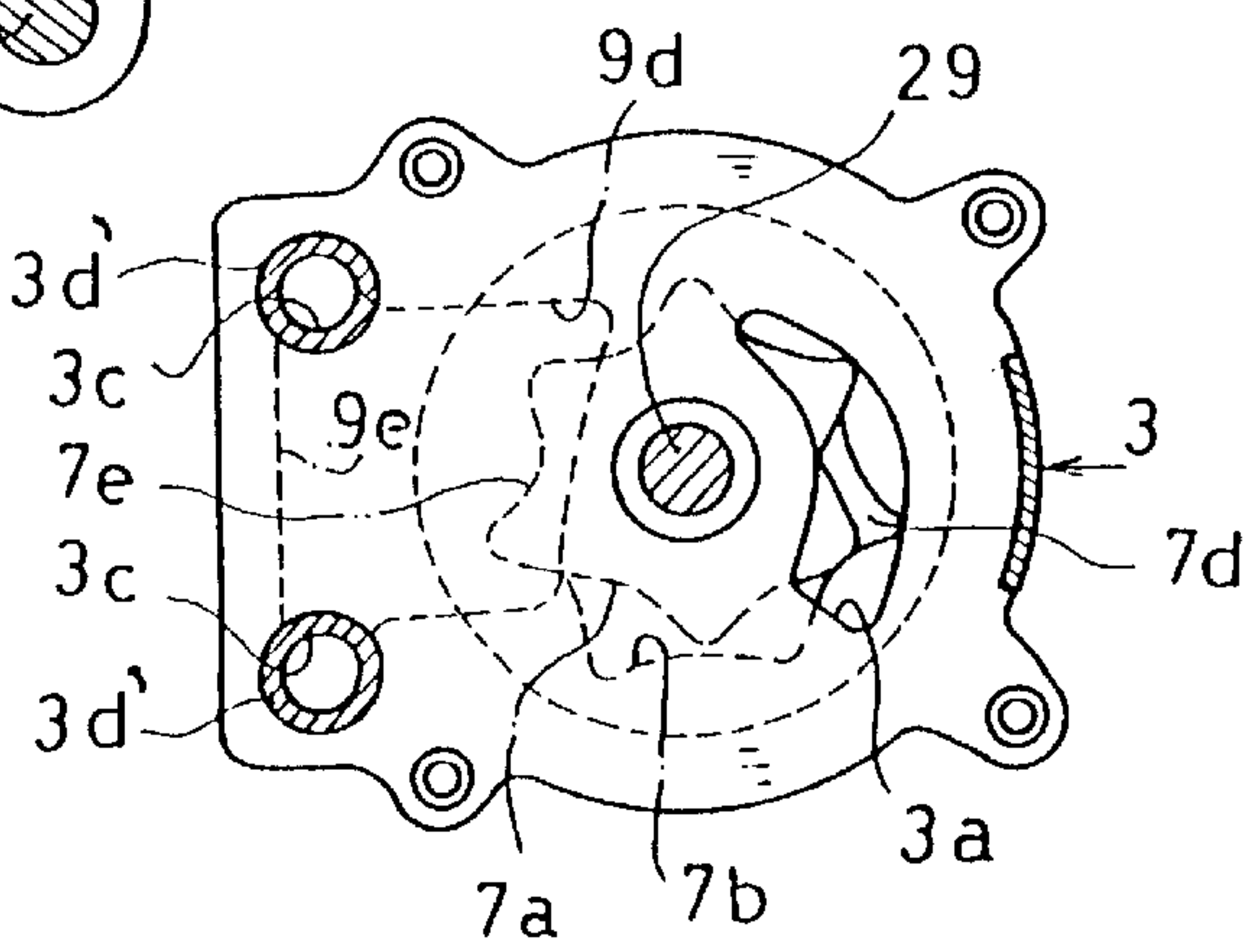
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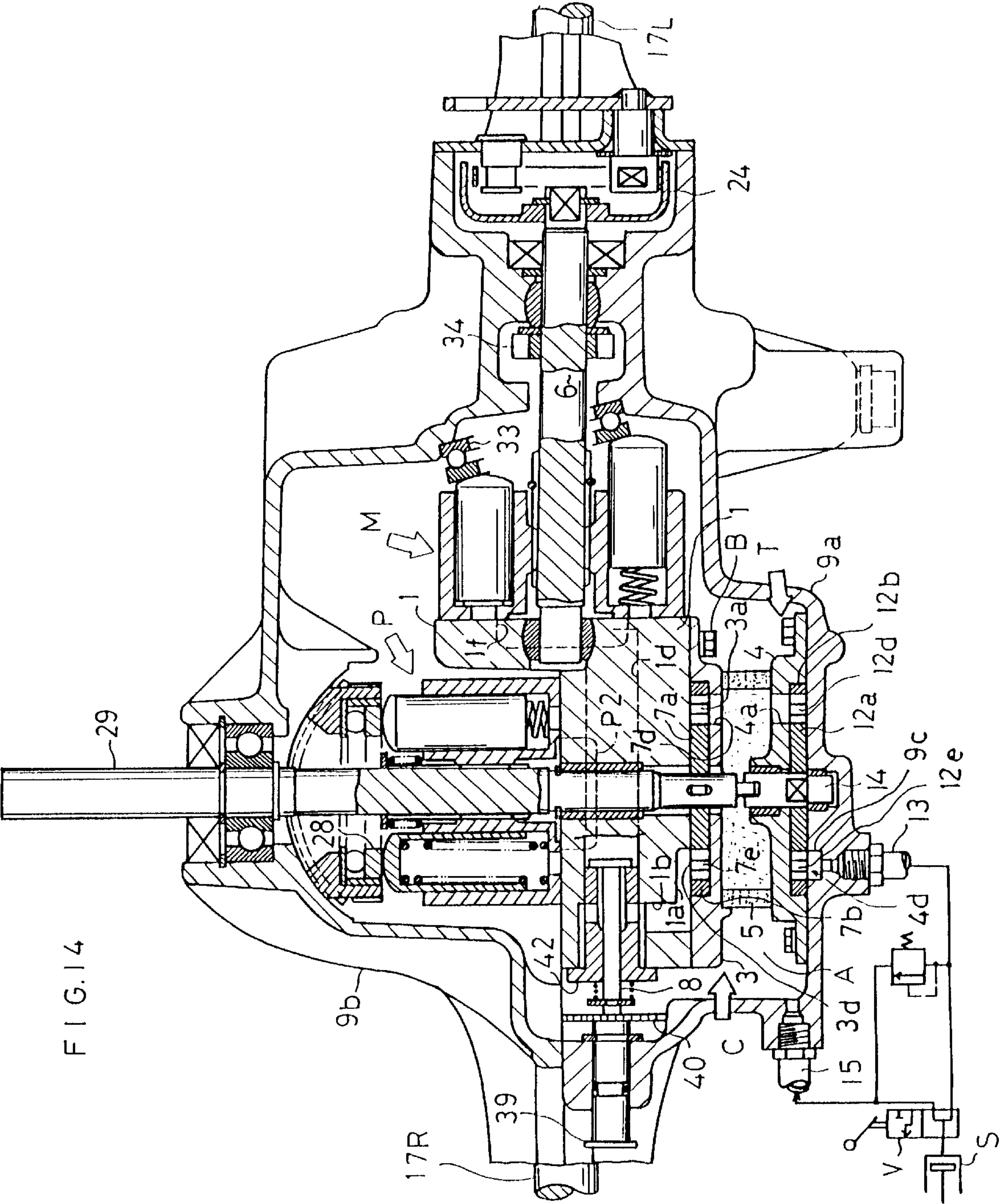


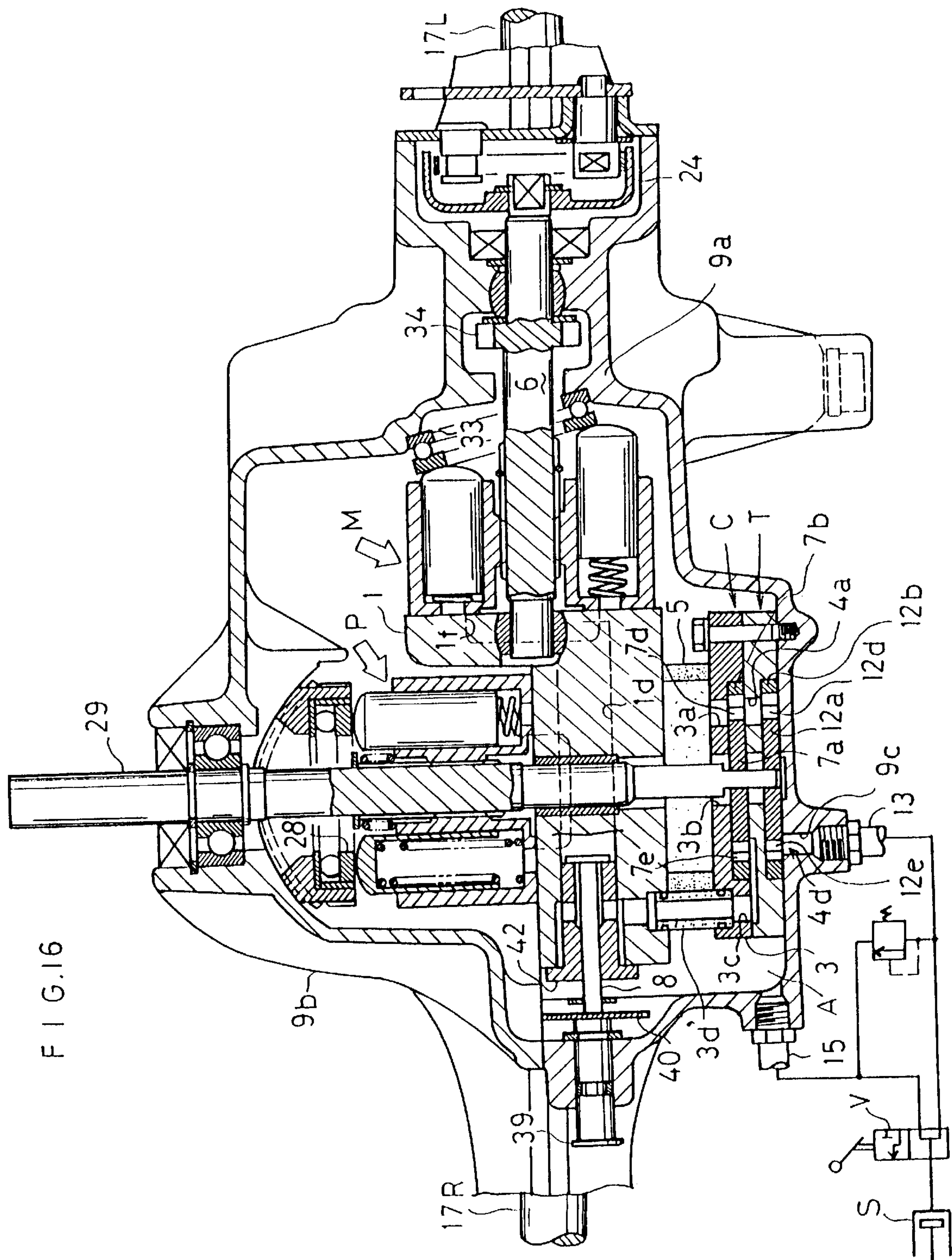
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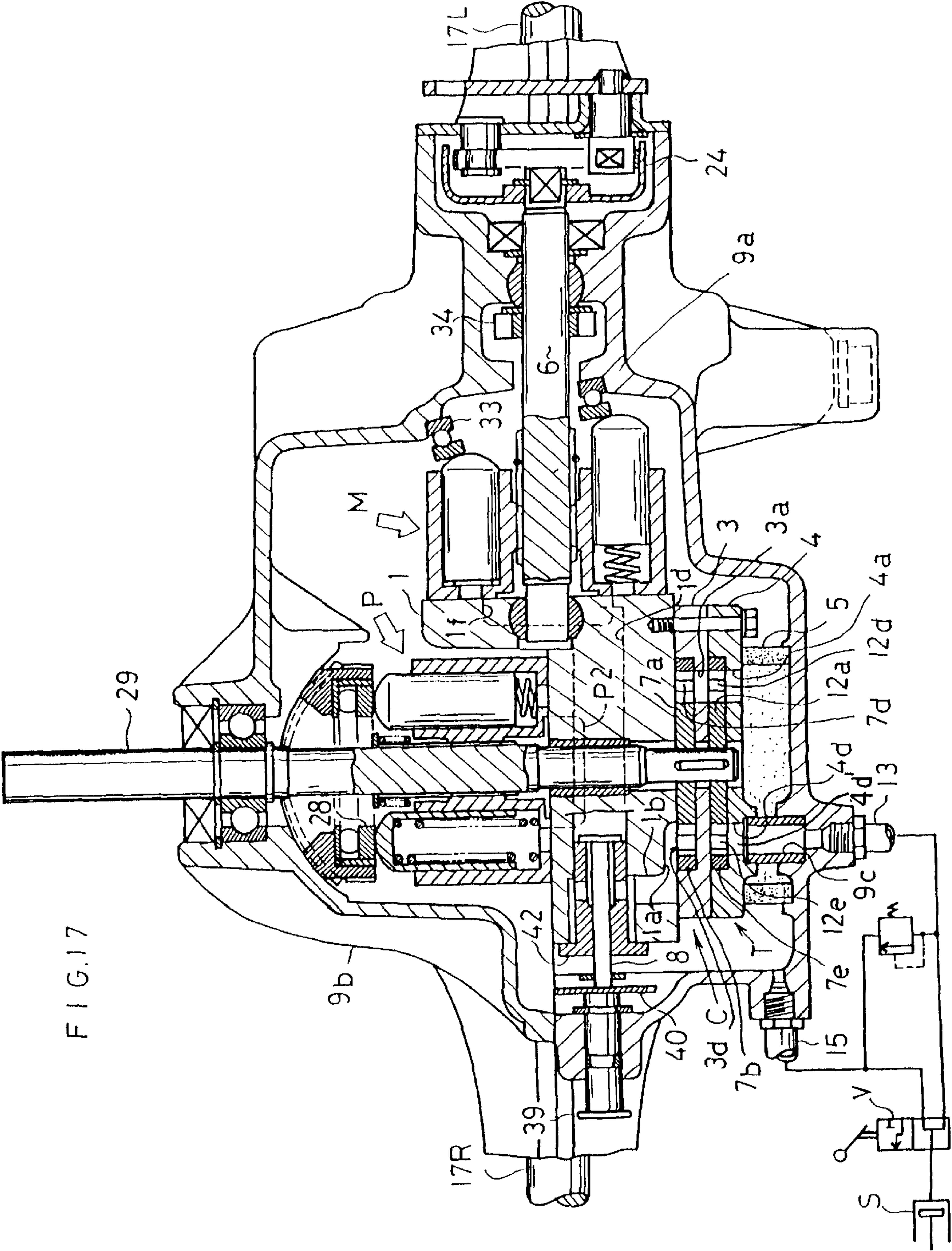


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AXLE DRIVING APPARATUS

Matter enclosed in heavy brackets [] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

This reissue application is a continuation of reissue application Ser. No. 08/092,685, filed Jul. 16, 1993, now abandoned, and a reissue of application Ser. No. 07/413,763, filed Sep. 28, 1989 (U.S. Pat. No. 5,031,403).

FIELD OF THE INVENTION

The present invention relates to an axle driving apparatus housing therein a hydrostatic-transmission (HST) used as a driving apparatus for a light running vehicle or the like.

DESCRIPTION OF THE PRIOR ART

Conventionally, for an axle driving apparatus with a hydrostatic-transmission (HST), the following technique has been well known as to a hydrostatic transmission support member or a charging pump:

U.S. Pat. Nos. 4,691,802 and 3,196,696, Japanese Utility Model Publication No. Sho 52-27345, Japanese Utility Model Laid-Open No. Sho 61-134433, Japanese Utility Model Publication No. Sho 56-8735, Japanese Utility Model Laid-Open No. Sho 60-51351, Japanese Patent Laid-Open No. Sho 61-48661, Japanese Utility Model Publication No. Sho 49-10698, and Japanese Patent Publication No. Sho 63-16630 disclose the following technique respectively.

SUMMARY OF THE INVENTION

The axle driving apparatus of the present invention attaches to a hydrostatic transmission support member provided in a transmission case a hydraulic pump and a hydraulic motor for the hydrostatic transmission which have hitherto have been disposed outside the axle driving apparatus; attaches a charging pump to the lower surface of the hydrostatic transmission support member; and also disposes an oil filter within the axle driving apparatus, so that suction oil passages for the charging pump are interposed, in condition of communicating with each other, under the hydrostatic transmission support member. Also, an outward takeout pump is supported within the transmission case.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional front view of an embodiment of an axle driving apparatus of the invention,

FIG. 2 is a sectional right side view of the same,

FIG. 3 is a plan view of the same, from which an upper transmission case part 9b is removed,

FIG. 4 is a sectional plan view of a hydrostatic transmission support member,

FIG. 5 is a sectional view taken on the line 5—5 in FIG. 1,

FIG. 6 is a sectional view taken on the line 6—6 in FIG. 1,

FIG. 7 is a perspective view of an oil filter,

FIG. 8 is a sectional front view in part of a modified embodiment of the present invention, in which the oil filter is disposed in a different position,

FIG. 9 is a sectional front view of a second embodiment of the present invention,

FIG. 10 is a partial sectional front view of another modified embodiment of the present invention, in which the discharge oil passage is modified,

FIG. 11 is a sectional plan view of the hydrostatic transmission support member of FIG. 9,

FIG. 12 is a sectional view of the hydrostatic transmission support member taken on line 12—12 in FIG. 9,

FIG. 13 is a sectional view taken along line 13—13 in FIG. 9,

FIG. 14 is a sectional front view of a third embodiment of the present invention,

FIG. 15 is a sectional front of a still further modified embodiment of the axle driving apparatus in FIG. 14, from which the outward takeout pump is removed,

FIG. 16 is a sectional front view of a fourth embodiment of the present invention, and

FIG. 17 is a sectional front view of a embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Next, one embodiment of the axle driving apparatus of the present invention will be described in accordance with the accompanying drawings.

In FIGS. 1, 2 and 3, a hydraulic pump P and a hydraulic motor M for a hydrostatic transmission in a mission or transmission case 9, a hydrostatic transmission support member 1 for supporting the hydraulic pump P and hydraulic motor M, and a charging pump C attached to the hydrostatic transmission support member 1 are shown and arrangement thereof will be described.

An upper mission or transmission case 9b and a lower mission or transmission case 9a are vertically connected by connecting bolts to form one mission case 9.

At the mating faces of the lower mission case 9a and upper mission case 9b are formed bearing faces for a hydraulic motor shaft 6, a countershaft 38 and axles 17L and 17R.

The hydrostatic transmission support member 1, which is preferably L-shaped, is connected to the mating face of the upper mission case 9b through four bolts B. Between the lower surface of the hydrostatic transmission support member 1 and the inner bottom surface of the lower mission case 9a is formed a space A including an oil sump for disposing therein a charging pump C to be discussed below and an outward takeout pump T. At the upper flat surface of the hydrostatic transmission support member 1 is fixed an axial piston type hydraulic pump P for the hydrostatic transmission and at the left side surface of a rising portion provided at the hydrostatic transmission support member 1 is fixed a hydraulic motor M of the same type as the hydraulic pump P. Thus, pump P is disposed perpendicular to Motor M.

A closed circuit connecting the hydraulic pump P and hydraulic motor M for the hydrostatic transmission comprises crescent-shaped oil passages P1 and P2 open at the upper flat surface of hydrostatic transmission support member 1, and 1e and 1f also of crescent-shape open at the right side surface of the rising portion (FIGS. 2 and 4), and two oil passages 1c and 1d communicating with these passages P1, P2 and 1e, 1f respectively (FIG. 4).

A hydraulic pump shaft or input shaft 29 perforates the upper mission case 9b so as to upwardly project and a movable swash plate 28 is disposed between the spherical wall of upper mission case 9b and the upper surface of hydraulic pump P.

An operational engaging portion projects laterally of the movable swash plate 28 and engages with a lever arm 10 (FIG. 2).

The lever arm **10** is fixed to a speed-change lever shaft **2** and a speed-change arm **11** is fixed thereto at the position where the speed-change lever shaft **2** perforates the upper wall of upper mission case **9b** and projects upwardly therefrom.

The movable swash plate **28** is rotated by the lever arm **10** so as to change the angle of swash plate **28**, thereby changing the discharge direction and a discharge amount of pressure oil from the hydraulic pump **P**.

Also, the lower end of hydraulic pump shaft **29** perforates the horizontal part of hydrostatic transmission support member **1** to enter the space **A** and fixedly supports a pump gear **7** of the charging pump **C** attached to the lower surface of hydrostatic transmission support member **1**. Pump **P** freely rotates on pump shaft **29**.

The charging pump **C** comprises the pump gear **7** covered by a charging pump case **3** attached to a lower surface of support member **1**. Pump gear **7** rotates to pressurize, as operating oil, lubricating oil taken into the case **3** through an oil filter **5** from the space **A** oil sump so that the pressurized lubricating oil is supplied from a charge oil passage **1a** to vertical oil passages **1b**.

The pump gear **7**, as shown in FIG. 6, comprises an internal gear pump of an internal gear **7b** and an external gear **7a**, the hydraulic pump shaft **29** being fixed at the center of external gear **7a**. A crescent shaped shutter **7c** within internal gears **7b**, and engages both gears **7a** and **7b**, creating two non-engaged spaces **7d** and **7e**. Lower pressure port **7d** communicates with suction oil passage **3a** in order to suck operating oil. Higher pressure port **7e** communicates with charge oil passage **1a** of support member **1**.

Check valve seats **41** and **42** communicating with the vertical oil passages **1b** respectively are disposed so as to form check valves **8** for supplying pressure oil from the oil passages **1b** to the oil passages **1c** and **1d** between the hydraulic pump **P** and the hydraulic motor **M** in a closed circuit.

The check valves **8** can be open by oil pressure from the oil passages **1b**, or mechanically as follows: The check valves **8** project at operating ends from the side surface of hydrostatic transmission support member **1** and a spring-loaded connecting rod **40** connects and urges against the projections of the two check valves **8**, a push pin **39** for pushing the connecting rod **40** projects outwardly from the lower mission case **9a**.

The push pin is pushed to simultaneously open the check valves **8** so that the oil passages **1c** and **1d** communicate with each other through the vertical oil passages **1b** and charge oil passage **1a** so as to short-circuit the closed circuit, thereby stopping rotation of the hydraulic motor **M**.

Furthermore, the charging pump **C** is attached to the lower surface of hydrostatic transmission support member **1** and between the charging pump case **3** of charging pump **C** and the inner surface of lower mission case **9a** is interposed a cylindrical oil filter **5** composed of porous material, such as sponge, as shown in FIG. 7.

In order to simplify fixing the unit, the oil filter **5** is not tightened by bolts, but is sandwiched between the charging pump case **3** and the inner surface of the lower mission case **9a**.

The hydraulic motor **M** fixed to the rising portion of hydrostatic transmission support member **1** obtains torque of the hydraulic motor shaft or output shaft **6** by allowing pistons of the motor **M** to abut against a fixed swash plate **33**. An output gear **34** is fixed to an intermediate portion of

hydraulic motor shaft **6**, and a braking drum **24** of a brake system is fixed to the outer end of the same. Motor **M** freely rotates on motor shaft **6**.

As shown in FIG. 3, the output gear **34** fixed to the hydraulic motor shaft **6** engages with a larger diameter gear **35** on the counter shaft **38** and a smaller diameter gear **37** thereon engages with a ring gear at a differential gear **D**.

FIG. 5 is a bottom view of the hydrostatic transmission support member **1**, the charging pump case **3** containing therein the pump gear **7** as in FIG. 6.

Operating oil for the charging pump **C** comprising the pump gear **7** and charging pump case **3** is taken in by a suction oil passage **3a** open at the lower surface of charging pump case **3**, the oil filter **5**, composed of cylindrical sponge, is tightly closed around the suction oil passage **3a**.

The pressure oil discharged through the pump gear **7** is guided from the discharge oil passage **3d** to the charge oil passage **1a** at the hydrostatic transmission support member **1**.

Then, the pressure oil is sent from the charge oil passage **1a** to inlets of check valves **8** at the check valve seats **41** and **42** through the vertical oil passages **1b**.

Usually, during running, high pressure oil is supplied to the oil passages **P1**, **1c** and **1e** or to **P2**, **1d** and **1f**, comprising the closed circuit between the hydraulic pump **P** and the hydraulic motor **M**. Assuming that the high pressure oil is applied to the oil passages **P1**, **1c** and **1e**, the pressure oil generated by the charging pump **C** is lower in oil pressure than the high pressure oil, whereby the check valve **8** is closed with respect to the check valve seat **41**. Hence, the pressure oil from the charging pump **C** does not flow to the oil passages **P1**, **1c** and **1e**.

Conversely, when the operating oil in the oil passages **P2**, **1d** and **1f** subjected to a decreased in pressure due to leakage from the hydraulic pump **P** or the hydraulic motor **M** and the oil pressure becomes lower than that of charging pump **C**, the pressure at the charging pump **C** side pushes open the check valve **8** applied with no pressure, thereby supplying the operating oil into the closed circuit of oil passages **P2**, **1d** and **1f**.

In the modified embodiment in FIG. 8, a small-sized charging pump **C** is attached to the bottom surface of hydrostatic transmission support member **1** and the charging pump case **3** also is small-sized, so that the cylindrical oil filter **5** is interposed outside the charging pump case **3** and between the inner bottom surface of lower mission case **9a** and the bottom surface of HST support member **1**.

Next, explanation will be given on the second embodiments in FIGS. 9, 10, 11 and 12.

A hydraulic pump shaft **29** perforates the hydrostatic transmission support member **1** and projects downwardly from the lower surface thereof, passes through the oil filter **5**, perforates a shaft bore **3b** at the charging pump case **3** attached to the inner bottom surface of the lower mission case **9a**, and engages rotatably with the external gear **7a** of the pump gear **7**.

The pump gear **7**, as shown in FIG. 13, comprises an internal trochoid gear of an internal gear **7b** and of an external gear **7a**, the hydraulic pump shaft **29** being fixed to the center thereof.

The charging pump **C** comprises the pump gear **7** covered by a charging pump case **3**, so that the pump gear **7** rotates to pressurize, as operating oil, the lubricating oil taken in from the oil filter **5** through the suction oil passage **3a**. Pressurized operating oil is supplied to the vertical oil passages **1b** of the hydrostatic transmission support member **1**.

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The check valve seats **41** and **42** are disposed to communicate with the vertical oil passages **1b** so that in the check valve seats **41** and **42** are formed check valves **8** for supplying pressure oil from the charging pump **C** to the closed circuit between the hydraulic pump **P** and the hydraulic motor **M**.

The check valves **8** project from one side surface of hydrostatic transmission support member and the connecting rod **40** connects the projections of the two left and right check valves **8**. The push pin **39** for pushing the connecting rod **40** projects from the lower mission case **9a**.

The push pin **39** is pushed to open both the check valves **8**, whereby the discharge side and return side of the hydraulic pump **P** short-circuit to stop the rotation of hydraulic motor **M**.

At the upper surface of the charging pump case **3** is open the suction oil passage **3a**, around which the oil filter **5** of cylindrical sponge is disposed.

The operating oil taken in from the suction oil passage **3a** is discharged to part of the discharge oil passage **9d**.

The discharge oil passage **9d** is recessed in the inner bottom surface of the lower mission case **9a**, and an oil passage **9e** is provided in extension of the discharge oil passage **9d**. The oil passage **9e** communicates with a higher pressure port **7e** and the vertical oil passage **3c**, which communicates with the discharge oil passage **3d** at a rising portion of the L-like shape of the charging pump case **3**.

The discharge oil passage **3d** communicates with vertical oil passage **1b** at the hydrostatic transmission support member **1**.

Alternatively, the cylindrical and separate oil passage **3d**, as shown in FIG. **9**, may be a cylindrical separate passage fitted into the case, as shown in the modified embodiment of FIG. **10** in which, the charging pump case **3** is of an L-like shaped and an integral discharge oil passage **3d** is bored therethrough.

FIG. **11** is a sectional view of the hydrostatic transmission support member **1**, FIG. **12** is a bottom view thereof, and the discharge oil passage **3d** is interposed between the bores of vertical oil passages **1b** at the hydrostatic transmission support member **1** and the bores of vertical oil passage **3c** at the charge pump case **3**.

The pressure oil discharged from the charging pump **C** is fed from the discharge oil passage **3d** to inlets of check valves **8** at the check valve seats **41** and **42** through the vertical oil passages **1b** at the hydrostatic transmission support member.

Next, explanation will be given on the third embodiment in FIG. **14**.

The embodiment in FIG. **14** is the same as the former embodiment in that the charging pump **C** is attached to the bottom surface of hydrostatic transmission support member **1**, but the hydraulic pump shaft **29** perforates the charging pump case **3** and projects therefrom so that at the position where the hydraulic pump shaft **29** projects from the charging pump case **3** is detachably mounted a takeout pump **T**.

The takeout pump shaft **14** is separate from the hydraulic pump shaft **29** so as to be removable when the outward takeout pump **T** is not required.

The takeout pump is similar to charging pump **C** and includes a takeout pump shaft **14** supported to a bearing provided at the bottom of the lower mission case **9a** and a takeout pump gear **12** for the outward takeout pump fixed to the pump shaft **14**. Takeout pump gear **12**, similar to charging pump gear **7**, includes an external gear **12a** and an

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internal gear **12b** and a crescent shaped shutter (not shown) which creates two non-engaged spaces lower pressure port **12** and higher pressure port **12e**. Port **12d** communicates with suction oil passage **4a** of outward takeout pump case **4** to suck operating oil in the mission case **9**. Oil filter **5** covers both charging pump suction oil passage **3a** and takeout pump suction oil passage **4a**.

The pump gear **7** and a pump gear **12** in the drawing are formed as an internal gear pump, however, the invention is not limited to such construction.

A suction oil passage **4a** is open at part of an outward takeout pump case **4**, so that the operating oil filtrated and taken in the oil filter **5** is guided by the suction oil passage **4a** into the outward takeout pump **T** and, after being high pressurized, the operating oil is discharged through the discharge pipe **13**.

The discharge pipe **13** is charged over in the vertical direction by a directional control valve **V** and the operating oil is supplied to a lift cylinder **S** or *hydraulic actuator* or the like at a mower **R**, for example.

Return oil from the directional control valve **V** and lift cylinder **S** is adapted to return into the mission case **9** through a return pipe **15**.

In the further modified embodiment in FIG. **15**, the outward takeout pump **T** attached to the inner bottom surface of lower mission case **9a** in FIG. **14** is removed therefrom and only the charging pump **C** is attached to the bottom surface of hydrostatic transmission support member **1**.

In FIG. **16**, a fourth embodiment is shown in which onto the inner bottom surface of the lower mission case **9a** is attached an outward takeout pump case **4** for the outward takeout pump **T** and a charging pump case **3** further is attached to the upper surface of outward takeout pump case **4**.

In this embodiment, both the outward takeout pump **T** and charging pump **C** (similar to FIG. **9**) are fixed to the inner bottom surface of lower mission case **9a** *along the longitudinal axis of hydraulic pumpshaft* **29**.

In this embodiment, an oil filter **5** is interposed between the bottom surface of hydrostatic transmission support member **1** and the upper surface of charging pump case **3**. Takeout pump suction oil passage **4a** communicates with charging pump suctional passage **3a**. However, oil filter **5** covers only the charging pump suction oil passage **3a**. Filtered operating oil is sucked to takeout pump suction oil passage through charging pump suction oil passage **3a**. Higher pressure port **12e** opens to the inner bottom surface of the mission case **9** at outward takeout port **9c**.

In FIG. **17**, a fifth embodiment is shown in which a charging pump case **3** of a charging pump **C** is fixed to the bottom surface of hydrostatic transmission support member **1** and an outward takeout pump case **4** of the outward takeout pump **T** is attached to the lower surface of the charging pump case **3**. *In this embodiment, both the outward takeout pump T and charging pump C are joined to the hydrostatic transmission support along the longitudinal axis of hydraulic pump shaft* **29**. Pressure oil is discharged from the outward takeout pump **T** to a discharge pipe **13** through a discharge oil passage **4d'** and thereafter the return oil returns into the mission case **9** through a return pipe **15**. A separate, cylindrical passage **4d** is inserted into passage **4d'** between the inner bottom surface of mission case **9**, and at takeout port **9c**.

An oil filter **5** is interposed between the lower surface of the outward takeout pump case **4** and the inner bottom

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surface of lower mission case 9a covering only charging pump suction oil passage 3a. Filtered operating oil is sucked to oil passage 3a through takeout pump suction oil passage 4a.

The axle driving apparatus of the present invention constructed according to the above-mentioned embodiments is advantageous as follows:

In the space A formed between the hydrostatic transmission support member and the lower mission case, the hydrostatic transmission support member serves as a baffle plate, so that, even when the vehicle body swings, the lubricating oil stays in the space A in a condition which is difficult to create air bubbles, which can cause a malfunction, such as cavitation, of the charging pump.

Since the charging pump is immersed in the lubricating oil, the lubricating oil cleaned by the filter is directly taken into the charging pump and not through pipings or the like, whereby there is little likelihood of line resistance and the suction efficiency is improved.

Also, since oil leaked from the charging pump can be returned directly to the space A, it is not required that the pump case be precisely tightly closed, for example, by using an O-ring or the like, which results in a lower manufacturing cost.

Since the outward takeout pump T can be disposed in the space A by the aforesaid construction, the axle driving apparatus can be used to drive external hydraulic instruments. Also, the oil filter is commonly usable between the charging pump C and outward takeout pump T, also lowering manufacturing costs.

What is claimed is:

1. An axle driving apparatus comprising,
 - a transmission case;
 - an L-shaped transmission support member housed within said transmission case;
 - a hydraulic pump mounted on said support member and communicating with an engine;
 - a hydraulic motor mounted on said support member and communicating with an axle;
 - a charging pump disposed on said support member, and driven by said hydraulic pump, said charging pump including a charging pump discharge oil passage in communication with a suction port provided in said support member, and a charging pump suction oil passage; and
 - an oil filter covering said charging pump suction oil passage.
2. The axle driving apparatus of claim 1 wherein said hydraulic pump is mounted to a horizontal surface of said L-shaped transmission support member.
3. The axle driving apparatus of claim 1 wherein said hydraulic motor is mounted to a vertical surface of said L-shaped transmission support member.
4. The axle driving apparatus of claim 1 wherein said charging pump is disposed on a lower horizontal surface of said transmission support member.
5. The axle driving apparatus of claim 1 further comprising,
 - a pair of check valves disposed within said support member [fluid] in a closed fluid circuit provided within said transmission support member.
6. The axle driving apparatus of claim 1, further comprising,
 - an outward takeout pump driven by said hydraulic pump disposed within said transmission case;

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a takeout pump suction oil passage provided in said takeout pump in communication with said charging pump suction oil passage;

a takeout pump discharge oil passage provided in said takeout pump, in communication with an outward takeout port on said transmission case;

wherein said oil filter covers said charging pump suction oil passage and said takeout pump suction oil passage.

7. The axle driving apparatus of claim 6 wherein said outward takeout pump is disposed on a inner bottom surface of said transmission case.

8. The axle driving apparatus of claim 1, further comprising,

- an outward takeout pump driven by said hydraulic pump;
- a charging pump case for receiving said charging pump, fixed to said support member;

- an outward takeout pump case for receiving said outward takeout pump, attached to said charging pump case;

- a takeout pump suction oil passage disposed within said outward takeout pump and in communication with said charging pump suction oil passage;

wherein said oil filter covers said takeout pump suction oil passage and said charging pump suction oil passage; and

- a takeout pump discharge oil passage disposed within said outward takeout pump and in communication with an outward takeout port on a surface of said transmission case.

9. The axle driving apparatus of claim 8 wherein said charging pump suction oil passage is open at a lower surface of said [changing] *charging* pump case and is covered by said oil filter.

10. An axle driving apparatus comprising,

- a transmission case;

- an L-shaped transmission support member housed within said transmission case;

- a hydraulic pump mounted on said support member and communicating with an engine;

- a hydraulic motor mounted on said support member and communicating with an axle;

- a charging pump disposed on an inner surface of said transmission case, and driven by said hydraulic pump, said charging pump including a charging pump discharge oil passage in communication with a suction port provided in said support member, and a charging pump suction oil passage; and

- an oil filter covering said charging pump suction oil passage.

11. The axle driving apparatus of claim 10 wherein said hydraulic pump is mounted to a horizontal surface of said L-shaped transmission support member.

12. The axle driving apparatus of claim 10 wherein said hydraulic motor is mounted to a vertical surface of said L-shaped transmission support member.

13. The axle driving apparatus of claim 10 wherein said charging pump is disposed on a lower surface of said transmission case.

14. The axle driving apparatus of claim 10 further comprising,

- a pair of check valves disposed within said support member in a closed fluid circuit provided within said transmission support member.

15. The axle driving apparatus of claim 10 further comprising,

an outward takeout pump case disposed within said transmission case;

a charging pump case for receiving said charging pump fixed to said outward takeout pump case;

an outward takeout pump disposed within said outward takeout pump case, driven by said hydraulic pump and having a takeout pump suction oil passage and a takeout pump discharge oil passage, wherein said takeout pump suction oil passage is open at a lower surface of said charging pump case and is covered by said oil filter, and wherein said takeout pump suction oil passage is in communication with said charging pump suction oil passage; and

an outward takeout port provided on said transmission case and connected to said takeout pump discharge oil passage.

16. An axle driving apparatus, comprising:

a transmission case;

an axle disposed within said transmission case;

a transmission support housed within said transmission case and having a generally horizontal surface;

a suction port provided in said transmission support;

a hydraulic motor having a hydraulic motor shaft, said hydraulic motor mounted on said transmission support and communicating with said axle;

a hydraulic pump having a hydraulic pump shaft, said hydraulic pump communicating with an engine and mounted to said generally horizontal surface of said transmission support so that said hydraulic pump shaft is disposed substantially perpendicular to said hydraulic motor shaft; and

a charging pump driven by said hydraulic pump shaft for supplying oil to said suction port.

17. The axle driving apparatus of claim 16, wherein said transmission support further comprises a generally vertical surface.

18. The axle driving apparatus of claim 17, wherein said hydraulic motor is mounted to said generally vertical surface of said transmission support.

19. The axle driving apparatus of claim 16, wherein said charging pump is mounted on said transmission support.

20. The axle driving apparatus of claim 16, wherein said charging pump is mounted to said transmission case.

21. The axle driving apparatus of claim 20, further comprising:

a charging pump discharge oil passage provided in said charging pump; and

means disposed within said transmission case for connecting said charging pump discharge oil passage to said suction port.

22. The axle driving apparatus of claim 16, further comprising:

an outward takeout pump disposed within said transmission case and driven by said hydraulic pump shaft;

an outward takeout port disposed within said transmission case; and

an outward takeout pump discharge oil passage provided within said outward takeout pump and in fluid communication with said outward takeout port.

23. The axle driving apparatus of claim 22, wherein said outward takeout pump is disposed on an inner bottom surface of said transmission case.

24. The axle driving apparatus of claim 22, further comprising:

a charging pump case fixed to said transmission support for receiving said charging pump;

an outward takeout pump case attached to said charging pump case for receiving said outward takeout pump; and

means disposed within said transmission case for connecting said outward takeout pump discharge oil passage to said outward takeout port.

25. An axle driving apparatus, comprising:

a transmission case;

an axle disposed within said transmission case;

a transmission support housed within said transmission case and having a generally horizontal surface;

a suction port provided in said transmission support;

a hydraulic motor having a hydraulic motor shaft, said hydraulic motor mounted on said transmission support and communicating with said axle;

a hydraulic pump having a hydraulic pump shaft, said hydraulic pump communicating with an engine and mounted to said generally horizontal surface of said transmission support so that said hydraulic pump shaft is disposed substantially perpendicular to said hydraulic motor shaft; and

a charging pump disposed within said transmission case and driven by said hydraulic pump shaft for supplying oil to said suction port.

26. The axle driving apparatus of claim 25, wherein said transmission support further comprises:

a generally vertical surface, and wherein said hydraulic motor is mounted to said generally vertical surface.

27. The axle driving apparatus of claim 25, further comprising:

an oil sump formed between an inner surface of said transmission case and a surface of said transmission support which is opposite to said generally horizontal surface, wherein said charging pump is disposed within said oil sump.

28. The axle driving apparatus of claim 27, further comprising:

a charging pump case attached to said surface of said transmission support which is opposite to said generally horizontal surface for receiving said charging pump; and

a charging pump discharge oil passage provided within said charging pump, wherein said suction port is open at said surface of said transmission support which is opposite to said generally horizontal surface and is in fluid communication with said charging pump discharge oil passage.

29. The axle driving apparatus of claim 27, further comprising:

a charging pump case attached to an inner surface of said transmission case for receiving said charging pump;

a charging pump discharge oil passage provided at said charging pump case; and

means for connecting said charging pump discharge oil passage to said suction port.

30. The axle driving apparatus of claim 25, further comprising:

an outward takeout pump case attached to an inner surface of said transmission case;

a charging pump case attached to said outward takeout pump case for receiving said charging pump;

an outward takeout pump disposed within said outward takeout pump case, said outward takeout pump including an outward takeout pump discharge oil passage; and

an outward takeout port disposed within said transmission case and in fluid communication with said outward takeout pump discharge oil passage.

31. *An axle driving apparatus, comprising:*

a transmission case;

an oil sump formed with said transmission case;

an axle disposed within said transmission case;

a hydraulic transmission disposed within said transmission case for driving said axle, said hydraulic transmission including an input shaft substantially vertically supported within said transmission case, and a transmission support housed within said transmission case;

a charging pump disposed within said oil sump, said charging pump driven by said input shaft and including a charging pump suction oil passage for supplying oil to said hydraulic transmission; and

an oil filter disposed within said oil sump and in fluid communication with said charging pump suction oil passage.

32. *The axle driving apparatus of claim 31, further comprising:*

a charging pump case mounted to an inner surface of said transmission case for receiving said charging pump, wherein said oil filter is disposed between said transmission support and said charging pump case.

33. *The axle driving apparatus of claim 31, further comprising:*

a charging pump case mounted on said transmission support for receiving said charging pump, wherein said oil filter is disposed between said charging pump case and an inner surface of said transmission case.

34. *The axle driving apparatus of claim 31, wherein said charging pump is mounted on said transmission support and said oil filter is disposed between said transmission support and an inner surface of said transmission case.*

35. *An axle driving apparatus, comprising:*

a transmission case;

a transmission support housed within said transmission case, said transmission support having a hydraulic pump mounting surface, a hydraulic motor mounting surface substantially perpendicular to said pump mounting surface, and a charging pump mounting surface separate from and substantially parallel to said hydraulic pump mounting surface;

a hydraulic pump having a hydraulic pump shaft and mounted to said hydraulic pump mounting surface;

a hydraulic motor having a hydraulic motor shaft and mounted to said hydraulic motor mounting surface so that said hydraulic motor shaft is disposed perpendicular to said hydraulic pump shaft;

a charging pump mounted to said charging pump mounting surface and driven by hydraulic pump shaft.

36. *The axle driving apparatus of claim 35, wherein said transmission support is substantially L-shaped, having a generally horizontal portion which includes said hydraulic pump mounting surface and said charging pump mounting surface and a generally vertical portion which includes said hydraulic motor mounting surface.*

37. *The axle driving apparatus of claim 36, wherein said hydraulic pump mounting surface is formed on an upper surface of said generally horizontal portion and said charging pump mounting surface is formed on a lower surface of said generally horizontal portion.*

38. *The axle driving apparatus of claim 37, further comprising:*

an oil sump formed between said lower surface and an inner bottom surface of said transmission case;

an oil filter disposed within said oil sump;

wherein said charging pump is disposed within said oil sump and includes a charging pump suction oil passage which is open to said oil sump and in fluid communication with said oil filter.

39. *The axle driving apparatus of claim 38, wherein said oil filter is disposed between said charging pump and said inner bottom surface of said transmission case.*

40. *The axle driving apparatus of claim 38, wherein said oil filter is disposed between said transmission support and said inner bottom surface of said transmission case.*

41. *The axle driving apparatus of claim 37, further comprising:*

a suction port open at said lower surface; and

wherein said charging pump is disposed within said oil sump and includes a charging pump discharge oil passage in fluid communication with said suction port.

42. *An axle driving apparatus, comprising:*

a transmission case comprising two case elements joined along a generally horizontal mating surface;

a hydraulic pump including a hydraulic pump shaft;

a hydraulic motor including a hydraulic motor shaft;

a closed fluid circuit connecting said hydraulic pump and said hydraulic motor;

a charging pump driven by said hydraulic pump shaft for supplying oil to said closed fluid circuit;

a transmission support having a generally horizontal portion and a generally vertical portion perpendicular to said horizontal portion, said horizontal portion disposed along said mating surface within one of said case elements;

a hydraulic pump mounting surface for mounting said hydraulic pump within said transmission case, said hydraulic pump mounting surface provided on one side of said horizontal portion of said transmission support;

a charging pump mounting surface for mounting said charging pump within said transmission case, said charging pump mounting surface provided on a side of said horizontal portion of said transmission support opposite to said one side; and

a hydraulic motor mounting surface for mounting said hydraulic motor within said transmission case, said hydraulic motor mounting surface provided at said vertical portion of said transmission support.

43. *The axle driving apparatus of claim 42, further comprising:*

an oil sump formed between said transmission support and one of said case elements;

an oil filter disposed within said oil sump;

wherein said charging pump includes a charging pump suction oil passage open to said oil sump and in fluid communication with said oil filter.

44. *The axle driving apparatus of claim 43, wherein said oil filter is disposed between said charging pump mounting surface and an inner surface of said one of said case elements.*

45. *The axle driving apparatus of claim 43, further comprising:*

a charging pump case for receiving said charging pump, wherein said oil filter is disposed between said charging pump case and an inner surface of said one of said case elements.

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46. An axle driving apparatus, comprising:
 a transmission case;
 an axle disposed within said transmission case;
 a hydraulic transmission disposed within said transmission case, said hydraulic transmission including a substantially vertical input shaft and a substantially horizontal output shaft operatively connected to said axle;
 a charging pump driven by said input shaft for supplying oil to said hydraulic transmission;
 a common oil sump formed within said transmission case common to said charging pump and said axle; and
 a charging pump case for receiving therein said charging pump, said charging pump case disposed within said common oil sump.
47. The axle driving apparatus of claim 46, further comprising a transmission support housed within said transmission case, wherein said charging pump case is attached to a lower surface of said transmission support.
48. The axle driving apparatus of claim 47, wherein said charging pump is disposed on a lower end of said input shaft.
49. The axle driving apparatus of claim 46, wherein said charging pump case is attached to an inner bottom surface of said transmission case.
50. The axle driving apparatus of claim 49, wherein said charging pump is disposed on a lower end of said input shaft.
51. An axle driving apparatus, comprising:
 a transmission case having an upper casing and a lower casing;
 a pair of axles disposed within said transmission case;
 a differential gear for connecting said pair of axles to each other, said differential gear disposed within said transmission casing;
 a hydraulic transmission disposed within said transmission case, said hydraulic transmission including a substantially vertical input shaft and a substantially horizontal output shaft connected to said differential gear;
 a charging pump driven by said input shaft for supplying oil to said hydraulic transmission; and
 a common oil sump formed within said transmission case common to said charging pump and said pair of axles, wherein said charging pump is disposed within said common oil sump.
52. The axle driving apparatus of claim 51, wherein said output shaft is supported between said upper casing and said lower casing.
53. The axle driving apparatus of claim 51, wherein said pair of axles is supported between said upper casing and said lower casing.
54. An axle driving apparatus, comprising:
 a transmission case having an upper casing and a lower casing;
 a pair axles disposed within said transmission case;
 a differential gear for connecting said pair of axles to each other, said differential gear disposed within said transmission case;
 a hydraulic transmission disposed within said transmission case, said hydraulic transmission including a substantially vertical input shaft and a substantially horizontal output shaft operatively connected to said pair of axles;
 a charging pump driven by said input shaft for supplying oil to said hydraulic transmission;

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- a common oil sump formed within said transmission case common to said charging pump and said pair of axles; and
 a charging pump case for receiving therein said charging pump, said charging pump case disposed within said common oil sump.
55. The axle driving apparatus of claim 54, further comprising a transmission support housed within said transmission case, wherein said charging pump case is attached to a lower surface of said transmission support.
56. The axle driving apparatus of claim 55, wherein said charging pump is disposed on a lower end of said input shaft.
57. The axle driving apparatus of claim 54, wherein said charging pump case is attached to an inner bottom surface of said lower casing.
58. The axle driving apparatus of claim 57, wherein said charging pump is disposed on a lower end of said input shaft.
59. The axle driving apparatus of claim 54, wherein said output shaft is supported between said upper casing and said lower casing.
60. The axle driving apparatus of claim 54, wherein said pair of axles is supported between said upper casing and said lower casing.
61. An axle driving apparatus, comprising:
 a transmission case;
 an axle disposed within said transmission case;
 a hydraulic transmission disposed within said transmission case for driving said axle, said hydraulic transmission including an input shaft substantially vertically supported within said transmission case;
 a takeout pump driven by said input shaft;
 a common oil sump formed within said transmission case common to said takeout pump and said axle;
 a takeout pump case for receiving therein said takeout pump, said take out pump case disposed within said common oil sump; and
 an actuator external to said transmission case in fluid communication with said takeout pump, wherein said takeout pump supplies operating oil for said actuator from said common oil sump.
62. The axle driving apparatus of claim 61, wherein said takeout pump case is mounted to an inner surface of said transmission case.
63. The axle driving apparatus of claim 62, wherein said takeout pump is disposed on an end of said input shaft.
64. The axle driving apparatus of claim 61, further comprising:
 a transmission supported housed within said transmission case, wherein said takeout pump case is mounted on a surface of said transmission support.
65. An axle driving apparatus, comprising:
 a transmission case;
 an axle disposed within said transmission case;
 a hydraulic transmission disposed within said transmission for driving said axle, said hydraulic transmission including an input shaft substantially vertically supported within said transmission case;
 a takeout pump driven by said input shaft;
 a common oil sump formed within said transmission case common to said takeout pump and said axle, said takeout pump disposed within said common oil sump;
 an actuator external to said transmission case;
 an outward takeout port disposed within said transmission case in fluid communication with said actuator,

wherein said takeout pump supplies operating oil for said actuator from said outward takeout port; and
a return pipe connected to said transmission case for returning takeout oil from said actuator into said transmission case.

66. The axle driving apparatus of claim 65, wherein said outward takeout port is open at a lower surface of said transmission case.

67. The axle driving apparatus of claim 65, wherein said return pipe is in fluid communication with said oil sump.

68. The axle driving apparatus of claim 67, wherein said return pipe is open at a bottom of said transmission case.

69. The axle driving apparatus of claim 65, further comprising:
a takeout pump case for receiving therein said takeout pump, wherein said takeout pump case is mounted to an inner surface of said transmission case.

70. The axle driving apparatus of claim 65, wherein said takeout pump is disposed on an end of said input shaft.

71. The axle driving apparatus of claim 65, further comprising:
a takeout pump case for receiving therein said takeout pump;
a transmission support housed within said transmission case, wherein said takeout pump case is mounted on a surface of said transmission support.

72. An axle driving apparatus, comprising:
a transmission case;
an axle disposed within said transmission case;
a hydraulic transmission disposed within said transmission case for driving said axle, said hydraulic transmission including an input shaft substantially vertically supported within said transmission case;
a charging pump driven by said input shaft;
a common oil sump formed within said transmission case common to said charging pump and said axle;
a charging pump case for receiving therein said charging pump, said charging pump case disposed within said common oil sump;
a takeout pump driven by said input shaft;
a takeout pump case for receiving therein said takeout pump, said takeout pump case disposed within said common oil sump; and
an actuator external to said transmission case in fluid communication with said takeout pump, wherein said charging pump and said takeout pump suck up oil within said common oil sump, said charging pump supplying operating oil for said hydraulic transmission, and said takeout pump supplying operating oil for said actuator.

73. The axle driving apparatus of claim 72, further comprising:
a transmission support housed within said transmission case, wherein said charging pump case and said takeout pump case are disposed between said transmission support and said transmission case.

74. The axle driving apparatus of claim 73, wherein said takeout pump case is mounted to said transmission case and said charging pump case is mounted to said transmission support.

75. The axle driving apparatus of claim 73, wherein said takeout pump case and said charging pump case are disposed along the longitudinal axis of said input shaft and are joined to said transmission support.

76. The axle driving apparatus of claim 72, wherein said takeout pump case and said charging pump case are dis-

posed along the longitudinal axis of said input shaft and are joined to said transmission case.

77. An axle driving apparatus, comprising:
a transmission case;
an axle disposed within said transmission case;
a hydraulic transmission disposed within said transmission case, said hydraulic transmission including a substantially vertical input shaft and a substantially horizontal output shaft operatively connected to said axle;
a charging pump driven by said input shaft for supplying oil to said hydraulic transmission;
a common oil sump formed within said transmission case common to said charging pump and said axle;
a charging pump case for receiving therein said charging pump, said charging pump case is attached to a bottom surface of said transmission case; and
an oil passage for supplying discharged oil from said charging pump to said hydraulic transmission, said oil passage is disposed within said common oil sump.

78. An axle driving apparatus, comprising:
a transmission case having an upper casing and a lower casing;
a pair of axles disposed within said transmission case;
a differential gear for connecting said pair of axles to each other, said differential gear disposed within said transmission case;
a hydraulic transmission disposed within said transmission case, said hydraulic transmission including a substantially vertical input shaft and a substantially horizontal output shaft operatively connected to said pair of axles;
a charging pump driven by said input shaft for supplying oil to said hydraulic transmission;
a common oil sump formed within said transmission case common to said charging pump and said pair of axles;
a charging pump case for receiving therein said charging pump, said charging pump case is attached to a bottom surface of said transmission case; and
an oil passage for supplying discharged oil from said charging pump to said hydraulic transmission, said oil passage is disposed within said common oil sump.

79. An axle driving apparatus, comprising:
a transmission case;
an axle disposed within said transmission case;
a hydraulic transmission disposed within said transmission case for driving said axle, said hydraulic transmission including an input shaft substantially vertically supported within said transmission case;
a charging pump driven by said input shaft;
a common oil sump formed within said transmission case common to said charging pump and said axle;
a charging pump case for receiving therein said charging pump;
a takeout pump driven by said input shaft;
a takeout pump case for receiving therein said takeout pump, wherein said charging pump case and said takeout pump case are along the longitudinal axis of said input shaft and are joined to a bottom surface of said transmission case; and
an oil passage for supplying discharged oil from said charging pump to said hydraulic transmission, said oil passage is disposed within said common oil sump.

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

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INVENTOR :Hideaki Okada

It is certified that an error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below.

In column 14, line 50 (claim 64), delete the word "supported" and insert –support– therefor.

Signed and Sealed this
Seventeenth Day of April, 2001

Attest:



NICHOLAS P. GODICI

Attesting Officer

Acting Director of the United States Patent and Trademark Office