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

(11) EP 1 477 664 A2

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
17.11.2004 Bulletin 2004/47

(51) Int Cl.[7]: **F02M 37/04**, F02M 37/08, F02M 37/10

(21) Application number: **04010792.2**

(22) Date of filing: **06.05.2004**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LI LU MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL HR LT LV MK

(30) Priority: **09.05.2003 JP 2003132311**
02.09.2003 JP 2003310294
19.12.2003 JP 2003423587

(71) Applicant: **KABUSHIKI KAISHA TOYODA JIDOSHOKKI SEISAKUSHO**
Kariya-shi, Aichi-ken (JP)

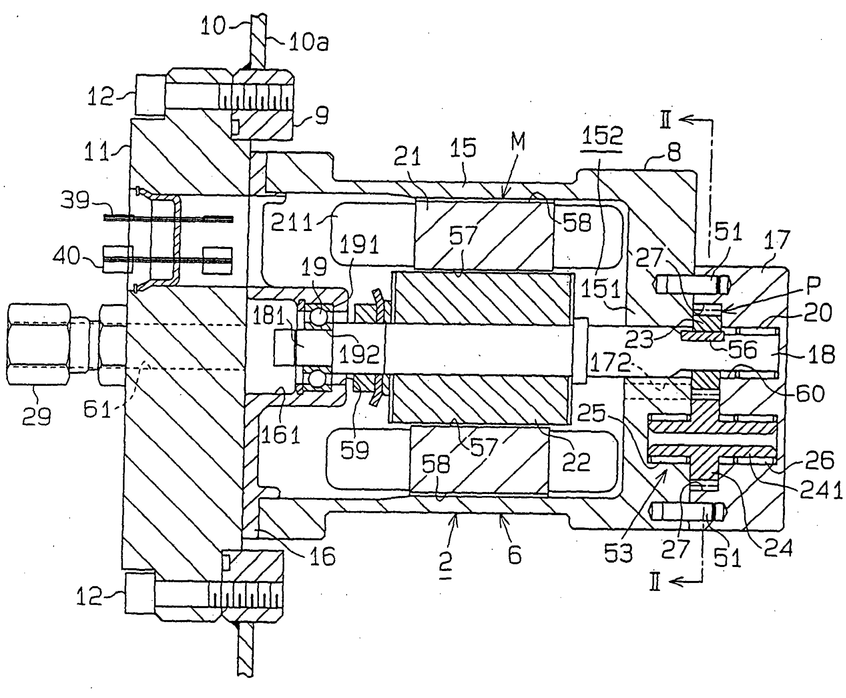
(72) Inventors:
- **Suzuki, Shigeru**
2-1, Toyoda-cho Kariya-shi Aichi-ken (JP)
- **Fujii, Toshiro**
2-1, Toyoda-cho Kariya-shi Aichi-ken (JP)

(74) Representative: **Böckelen, Rainer**
Tiedtke-Bühling-Kinne & Partner (GbR), TBK-Patent
Bavariaring 4
80336 München (DE)

(54) **Electric pump**

(57) An electric pump (2) draws and discharges fluid. When the fluid receives heat from the pump (2), the fluid has a saturation vapor pressure that can surpass the pressure of fluid that is drawn into the pump (2) and is lower than the pressure of fluid discharged from the pump (2). The pump (2) includes an electric motor; a pump section that is driven by the electric motor (M) to draw, pressurize, and discharge the fluid; and a housing (6) for accommodating the pump section. The housing (6) defines a motor chamber (156) that accommodates the electric motor (M). The pressure in the motor chamber (152) is equal to the pressure of fluid that is discharged from the pump section. Therefore, the pump (2) prevents fluid in the motor chamber (152) from vaporizing.

Fig.1



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Printed by Jouve, 75001 PARIS (FR)

Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to an electric pump in which a motor chamber is defined in a housing that accommodates a pump section, and an electric motor for driving the pump section is accommodated in the motor chamber. Particularly, the present invention pertains to an electric pump in which the saturation vapor pressure of fluid that is drawn and pressurized by a pump section can surpass a suction pressure of the pump section according to a temperature increase in a motor chamber, and in which the saturation vapor pressure has a property of being less than a discharge pressure of the pump section due to heat in the motor chamber.

[0002] A typical electric pump is used in a fuel supply system of an internal combustion engine that uses dimethyl ether (hereinafter, referred to as DME) as the fuel (for example, Japanese Laid-Open Patent Publication No. 2003-83188). Japanese Laid-Open Patent Publication No. 2003-83188 discloses an in-tank pump that includes an electric pump accommodated in a fuel tank. The electric pump has a motor chamber opened to the interior of the fuel tank. Therefore, the electric motor is cooled with DME the temperature of which is relatively low.

[0003] Similar in-tank pumps are disclosed in Japanese Laid-Open Patent Publications No. 1-151765, No. 6-288313, and No. 2002-98018. In each of these prior art systems, a discharge pipe is connected to a lid that forms part of a tank. A rubber flexible hose is connected to the pump. The hose is also connected to the pipe in the tank.

[0004] Since the motor chamber is opened to the interior of the fuel tank, the motor chamber is exposed to a suction pressure of the pump section. In this configuration, a great amount of DME is vaporized in the motor chamber due to the characteristics of DME (heating the motor chamber causes the saturation vapor pressure of DME to surpass the suction pressure). A considerable amount of vaporized DME in the motor chamber reduces the heat exchanger effectiveness between DME and heat producing portions of the electric motor, which results in an insufficient cooling of the electric motor.

[0005] Therefore, the housing of the electric motor needs to have a vent passage that vents vaporized DME from the motor chamber to the fuel tank. When forming a vent passage in the housing, the vent passage needs to be located above a portion of the motor chamber in which vaporized DME collects, so that vaporized DME is effectively vented from the motor chamber. Accordingly, the position and the orientation of the electric pump relative to the fuel tank are limited according to the position of the vent passage formed in the housing. This reduces the versatility of the electric pump.

[0006] Also, the flexible hose, which functions as part of a discharge passage, is connected to the pipe by fitting the pipe into the hose. At the joint of the hose and the pipe, the hose needs to be fastened with a clip. In this manner, a section of the discharge passage corresponding to the pipe and a section of the discharge passage corresponding to the flexible hose are connected. This configuration increases the space in the tank for accommodating the pump, and complicates the connecting process.

SUMMARY OF THE INVENTION

[0007] Accordingly, it is an objective of the present invention to provide an improved electric pump that is capable of preventing fluid in a motor chamber from vaporizing.

[0008] To achieve the above-mentioned objective, the present invention provides an electric pump for drawing and discharging fluid. When the fluid receives heat from the pump, the fluid has a saturation vapor pressure that can surpass the pressure of fluid that is drawn into the pump and is lower than the pressure of fluid discharged from the pump. The pump includes an electric motor; a pump section that is driven by the electric motor to draw, pressurize, and discharge the fluid; and a housing for accommodating the pump section. The housing defines a motor chamber that accommodates the electric motor. The pressure in the motor chamber is equal to the pressure of fluid that is discharged from the pump section.

[0009] Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The invention, together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

Fig. 1 is a cross-sectional view illustrating an electric pump according to a first embodiment of the present invention;

Fig. 2 is a cross-sectional view taken along line II-II in Fig. 1;

Fig. 3 is a diagrammatic view showing a fuel supply system;

Fig. 4 is a graph showing the saturation vapor pressure of DME;

Fig. 5 is a cross-sectional view illustrating an electric pump according to a modification of the first embodiment;

Fig. 6(a) is a diagrammatic view showing a fuel supply system according to a second embodiment of the present invention;

Fig. 6(b) is a cross-sectional view illustrating the electric pump of Fig. 6(a);

Fig. 7 is an enlarged partial cross-sectional view of the electric pump shown in Fig. 6(b);

Fig. 8 is an enlarged partial cross-sectional view of the electric pump shown in Fig. 6(b);

Fig. 9 is an enlarged view showing the tension spring of Fig. 6(b);

Fig. 10 is a cross-sectional view taken along line A-A in Fig. 6(b);

Fig. 11 is a cross-sectional view taken along line B-B in Fig. 6(b);

Fig. 12 is a cross-sectional view illustrating a third embodiment of the present invention;

Fig. 13(a) is a cross-sectional view illustrating an electric pump according to a fourth embodiment of the present invention;

Fig. 13(b) is an enlarged partial cross-sectional view of the electric pump shown in Fig. 13(a);

Fig. 14(a) is a cross-sectional view taken along line D-D in Fig. 13(a);

Fig. 14(b) is an enlarged partial cross-sectional view of Fig. 14(a);

Fig. 15(a) is a partial cross-sectional view illustrating a fifth embodiment of the present invention;

Fig. 15(b) is an enlarged partial cross-sectional view of Fig. 15(a);

Fig. 16 is an enlarged cross-sectional view illustrating a sixth embodiment of the present invention;

Fig. 17 is an enlarged cross-sectional view illustrating a seventh embodiment of the present invention;

Fig. 18 is an enlarged cross-sectional view illustrating an eighth embodiment of the present invention;

Fig. 19 is an enlarged cross-sectional view illustrating a ninth embodiment of the present invention;

Fig. 20(a) is a partial cross-sectional view illustrating an electric pump according to a tenth embodiment of the present invention; and

Fig. 20(b) is an enlarged partial cross-sectional view of Fig. 20(a).

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0011] A first embodiment of the present invention will now be described with reference to Figs. 1 to 4.

[0012] As shown in Fig. 3, a diesel type internal combustion engine 34, which functions as a driving source of a vehicle, has a fuel supply system. The fuel supply system includes an electric pump 2. The entire electric pump 2 is an in-tank pump that is substantially entirely accommodated in a bottom portion of a tank 10, in which DME, or fluid (fuel), is stored. A suction side of the electric pump 2 is opened to the interior of the tank 10. A discharge side of the pump 2 is connected to a fuel injection pump 31 with a discharge pipe 30. The discharge side of the fuel injection pump 31 is connected to the engine 34. The fuel injection pump 31 receives pressurized DME from the electric pump 2, and sends the DME to the engine 34 under a high pressure. Surplus DME in the fuel injection pump 31 is returned to the tank 10 through a return passage 4a.

[0013] As shown in Fig. 1, the electric pump 2 has a connection member 11 and an accommodation case 8. In a state where the pump 2 is installed in the tank 10, the connection member 11 is exposed to the outside of the tank 10. The accommodation case 8 is fixed with bolts (not shown) to a side of the connection member 11 that faces inward of the tank 10. An inlet forming ring 9 is formed in a wall 10a, or a sidewall of the tank 10. The electric pump 2 is fixed to the inlet forming ring 9. The electric pump 2 is installed in the tank 10 by securing radially end portions of the connection member 11 to the inlet forming ring 9 with screws 12 such that the accommodation case 8 is located inside the tank 10.

[0014] The accommodation case 8 includes a lid 16, a motor housing 15, and a gear housing 17, which are arranged in this order from the connection member 11. In this embodiment, the motor housing 15, the gear housing 17, the lid 16 and the connection member 11 form a pump housing 6, or a housing of the electric pump 2. The motor housing 15 is fixed to the connection member 11 with bolts (not shown). The lid 16 is held between the proximal end (left end as viewed in Fig. 1) of the motor housing 15 and the connection member 11. The position of the gear housing 17 is determined by positioning pins 51. In this state, the gear housing 17 is fixed to the distal end (right end as viewed in Fig. 1) by bolts (not shown).

[0015] A motor chamber 152 is defined inside the motor housing 15. An electric motor M, which functions as a drive source of the electric pump 2, is accommodated in the motor chamber 152. The electric motor M includes a stator 21 and a rotor 22. The stator 21 has a coil 211 and fixed to the inner surface of the motor housing 15. The rotor 22 has an iron core and rotates relative to the stator 21. A space (gap) 57 exists between the stator 21 and the rotor 22. Recesses 58 are formed on a surface of the stator 21 that faces the motor housing 15. The recesses 58 are arranged along the circumferential direction.

[0016] A rotary shaft 18 is fixed to the rotor 22 such that the rotary shaft 18 rotates integrally with the rotor 22. The rotary shaft 18, which functions as a motor shaft, extends between the lid 16 and the gear housing 17. A connection hole 161 is formed in the lid 16. A radial bearing 19 is located in the connection hole 161 and supports a proximal end portion 181 of the rotary shaft 18. A distal end of the rotary shaft 18 is supported by a needle bearing 20 accommodated in the gear housing 17. The coil 211 of the stator 21 is connected to terminals 39, 40 (wiring of which is not shown in Fig. 1) provided in the connection member 11. When current is supplied to the coil 211 through the terminals 39, 40, the rotary shaft 18 rotates due to electromagnetic induction between the coil 211 and the iron core.

[0017] A pump section P, which is a gear pump, is located in an interior of a joint of the motor housing 15 and the gear housing 17. The pump section P includes a gear train 53 that rotates when the rotary shaft 18 rotates. The gear train 53 has a drive gear 23 and a driven gear 24. The drive gear 23 is fixed to the distal end of the rotary shaft 18. The driven gear 24 is integrally formed with a support shaft 241 and is meshed with the drive gear 23. As shown in Figs. 1 and 2, a key 56 is attached to the distal circumferential surface of the rotary shaft 18. The key 56 extends along the axis of the rotary shaft 18. The drive gear 23 is engaged with the key 56.

[0018] In the interior of the distal portion of the electric pump 2, a set of pump chambers 27 are defined between the teeth of drive gear 23 and an upper section of the inner circumferential surface of the gear housing 17. Another set of pump chambers 27 are defined between the teeth of driven gear 24 and a lower section of the inner circumferential surface of the gear housing 17. The pump chambers 27 function as pressurizing passages for DME. Also, a shaft chamber 60 for accommodating the distal end of the rotary shaft 18 is defined in the interior of the distal portion of the electric pump 2. The shaft chamber 60 extends through the motor housing 15 and the gear housing 17.

[0019] The support shaft 241 is arranged parallel to the rotary shaft 18. One end of the support shaft 241 is supported by the motor housing 15 with a needle bearing 25, and the other end is supported by the gear housing 17 with a needle bearing 26. When the rotary shaft 18 rotates, the support shaft 241 rotates following the rotation of the rotary shaft 18 with the drive gear 23 and the driven gear 24.

[0020] As shown in Fig. 2, spaces exist frontward and rearward of the meshed sections of the drive gear 23 and the driven gear 24 in the gear housing 17. Accordingly, a suction chamber 271 and a discharge chamber 272, or a discharge side of the pump section P are defined. DME passes through the suction chamber 271 and the discharge chamber 272. A suction port 55 is formed in the gear housing 17 to connect the suction chamber 271 with the outside of the pump 2, or the interior of the tank 10 outside the pump housing 6. A discharge passage 172 is formed in an end wall 151 of the motor housing 15 that contacts the gear housing 17. The discharge passage 172 functions as an introducing passage, or a first passage, that connects the discharge chamber 272 with the motor chamber 152.

[0021] When the rotary shaft 18 rotates in a direction indicated by an arrow (clockwise direction), the support shaft 241 rotates following rotation of the rotary shaft 18. That is, the support shaft 241 rotates in a direction indicated by a hollow arrow. At this time, DME in the tank 10 flows into the suction chamber 271 from the suction port 55. The DME then flows through the pump chambers 27, while being pressurized. After reaching the discharge chamber 272, the DME flows out to the motor chamber 152 through the discharge passage 172.

[0022] As shown in Fig. 1, an annular space 59 is defined in the lid 16 at a side of the radial bearing 19 that faces the motor chamber 152. A connection hole 161 is also formed in the lid 16 at a side of the radial bearing 19 that faces the connection member 11. The connection hole 161 communicates with the space 59 and is open to the side of the connection member 11. The connection member 11 has a pipe joint 29 to which the discharge pipe 30 (see Fig. 3) from the fuel injection pump 31 is connected. A discharge port 61 is formed in the connection member 11 and the pipe joint 29. The discharge port 61 connects the connection hole 161 with the outside of the tank 10. In this embodiment, the space 59, the connection hole 161, and the discharge port 61 form a lead-out passage, or a second passage that connects the motor chamber 152 to the outside of the pump housing 6, or the outside of the tank 10. Further, the discharge passage 172, the space 59, the connection hole 161, and the discharge port 61 form a discharge path.

[0023] In the motor chamber 152, the space 57 between the stator 21 and the rotor 22, and the recesses 58 of the stator 21 form a discharge channel for DME sent to the motor chamber 152 from the pump section P. The space 59 of the lid 16, a space between an outer ring 191 and an inner ring 192 of the radial bearing 19, and the connection hole 161 of the lid 16 form a discharge channel when DME that flows out from the space 57 and the recesses 58 reaches the discharge port 61. DME in the motor chamber 152 is sent to the fuel injection pump 31 through the discharge port 61 and the discharge pipe 30. As described above, the motor chamber 152 forms part of the discharge path of DME. Therefore, the motor chamber 152 is exposed to the discharge pressure of the pump section P, or the pressure in the discharge chamber 272.

[0024] As shown in Fig. 4, DME has a property that, when expressed in a graph with a horizontal axis of temperature (°C) and a vertical axis of pressure (MPa), the saturation vapor pressure of DME is a quadric curve. When the point defined by the pressure and the temperature of DME is located in an area above the quadric curve, DME is liquid. When the point is below the quadric curve, DME is gas. In the graph of Fig. 4, Pin represents the suction pressure of the electric pump 2 (pump section P), or the pressure in the suction chamber 271. In this embodiment, Pin is 1 MPa. Pout represents the discharge pressure of the electric pump 2 (pump section P). In this embodiment, Pin is 3 MPa.

[0025] When the electric pump 2 is in a normal operation state that corresponds to a low or intermediate speed of the vehicle, the temperature of DME in the motor chamber 152 is approximately 40°C to 50°C at the maximum. In these temperatures, the saturation vapor pressure of DME is in a range from approximately 0.8 MPa to value slightly higher than 1 MPa as shown in the graph of Fig. 4. When the electric pump 2 is in a harsh operation state that corresponds to a high speed or an abrupt acceleration speed of the vehicle, the temperature of DME in the motor chamber 152 is increased to approximately 80°C at the maximum. When the temperature is increased approximately 80°C, the saturation vapor pressure of DME in the motor chamber 152 surpasses the suction pressure Pin. However, as obvious from the graph of Fig. 4, even if the DME temperature is increased to approximately 80°C, the saturation vapor pressure does not exceed the discharge pressure Pout.

[0026] Accordingly, DME, which is used in the electric pump 2 of this embodiment, has the following property. That is, when DME is heated according to a temperature increase in the motor chamber 152, the saturation vapor pressure of DME can surpass the suction pressure Pin of the pump section P. At the same time, despite the temperature increase in the motor chamber 152, the saturation vapor pressure stays below the discharge pressure Pout of the pump section P. Therefore, in this embodiment in which the motor chamber 152 is exposed to the discharge pressure, even if the saturation vapor pressure DME is increased due to a temperature increase, the pressure in the motor chamber 152 does not fall below the saturation vapor pressure. Thus, DME is not vaporized in the motor chamber 152.

[0027] Accordingly, unlike the system disclosed in Japanese Laid-Open Patent Publication 2003-83188, the present embodiment does not require a vent passage for venting DME from a motor chamber to a tank. Therefore, the position and the orientation of the electric pump 2 relative to the tank 10 are not limited. As a result, the electric pump 2 is versatile (advantage (1)).

[0028] Other than the advantage (1), the above embodiment provides the following advantages.

[0029] (2) The motor chamber 152 forms part of the discharge path of DME from the pump section P to the outside of the pump housing 6, or the outside of the tank 10. Therefore, a flow of DME from the pump section P to the outside of the pump housing 6 is generated in the motor chamber 152. This permits the electric motor M to be effectively cooled with DME.

[0030] (3) The electric pump 2 is of an in-tank type. That is, the motor chamber 152 is located adjacent to the wall 10a of the tank 10, and the pump section P is located on the opposite side of the motor chamber 152 from the wall 10a. In other words, a portion of the pump housing 6 that defines the motor chamber 152 is attached to the wall 10a. Since the motor chamber 152 is located close to the wall 10a of the tank 10, the lead-out passage, or the second passage from the motor chamber 152 to the outside of the tank 10 is short and simple. In other words, since the motor chamber 152 is used as the part of the discharge path of DME from the pump section P to the outside of the pump housing 6, the layout of this embodiment is applied without complicating the routing of the lead-out passage.

[0031] (4) The discharge path of DME from the pump section P to the outside of the pump housing 6 passes through the radial bearing 19, which rotatably supports the rotary shaft (drive shaft) 18. Thus, the radial bearing 19 is exposed to a flow of DME and is effectively cooled with DME.

[0032] (5) The passage of DME when passing through the electric motor M in the motor chamber 152 is defined not only by the space 57 between the stator 21 and the rotor 22, but also the recesses 58 on the circumferential surface of the stator 21. Thus, compared to the case where the passage is defined only by the space 57, the discharge path of DME is broadened.

[0033] (6) The shaft chamber 60 is exposed to the discharge pressure. Thus, leakage of DME from the pump chamber 27 to the shaft chamber 60 is suppressed.

[0034] In the above embodiment, the electric pump 2 includes the single-stage pump section P. However, the present invention is not limited to electric pumps having a single-stage pump section, but may be embodied in electric pumps having a multi-stage pump section, such as a two-stage pump section shown in Fig. 5.

[0035] A second embodiment according to the present invention will now be described with reference to Figs. 6(a) to 11. As shown in Fig. 6(a), a connection member 11 is fixed to an upper wall 101 of a tank 10 with screws 12. As shown in Fig. 6(b), the connection member 11, which forms part of the tank 10, covers an insertion hole 102.

[0036] In this embodiment, the motor housing 15, the gear housing 17 and the lid 16 form a pump housing 7, or a housing of the electric pump 13. Below the connection member 11, the pump housing 7 is suspended with tension springs 14, the number of which is three in this embodiment.

[0037] A suction chamber 271, which is shown in Fig. 10, is connected to the interior of the tank 10 through a suction passage 171. A discharge chamber 272 of the pump chamber 27 is connected to the interior of the motor housing 15 (the motor chamber 152) through a discharge passage 172.

[0038] The rotary shaft 18 rotates in a direction indicated by an arrow R in Fig. 10. When the rotary shaft 18 rotates, the drive gear 23 rotates integrally with the rotary shaft 18. Accordingly, the driven gear 24, while being meshed with the drive gear 23, rotates in a direction indicated by an arrow Q in Fig. 10. When the drive gear 23 and the driven gear 24 rotate, fluid F (dimethyl ether) in the tank 10 is drawn into the suction chamber 271 through the suction passage 171.

[0039] An upper end 141 of each spring 14 is hooked to the connection member 11 as shown in Fig. 9. A lower end 142 of each spring 14 is hooked to a screw 43 in a recess 164 formed in the upper surface of the lid 16. When transmitted to the connection member 11, vibration of the electric pump 13, or vibration of the pump housing 7 generates noise. However, the tension springs 14 function as vibration prevention mechanism (dumper) that prevents vibration of the electric pump 13 from being transmitted to the connection member 11.

[0040] As shown in Fig. 6(b), a discharge pipe 28 is integrally formed with and projects from a center of the lower surface of the connection member 11. A pipe joint 29 is attached to a center of the upper surface of the connection member 11. A channel 291 in the pipe joint 29 communicates with a discharge passage 281 in the discharge pipe 28. As shown in Fig. 6(a), the discharge pipe 30 is connected to the pipe joint 29. The discharge pipe 30 is connected to the fuel injection pump 31.

[0041] As shown in Figs. 6(b) and 7, the discharge pipe 28 is inserted in the connection hole 161 so that the discharge passage 281 communicates with the connection hole 161. A sealing member, which is a lip seal 32, is located between a circumferential surface 162 of the connection hole 161 and an outer circumferential surface 282 of the discharge pipe 28. The lip seal 32 includes an annular case 321, a pair of retainer rings 322, 323, and a lip ring 324 held between the retainer rings 322, 323. The lip ring 324 is made of polytetrafluorethylene. The case 321 is fitted in the connection hole 161. The position of the case 321 is determined by a snap ring 33 fitted to a circumferential surface 162 of the connection hole 161. The lip ring 324 contacts the outer circumferential surface 282 of the discharge pipe 28.

[0042] Fluid F in the motor chamber 152 is sent to the discharge passage 281 via space between the outer ring 191 and the inner ring 192 of the radial bearing 19, and the connection hole 161. Fluid F in the discharge passage 281 is sent to the fuel injection pump 31 via the channel 291 in the pipe joint 29 and the discharge pipe 30. The fuel injection pump 31 receives fluid F, and sends the fluid F to the engine 34 shown in Fig. 6(a).

[0043] As shown in Fig. 6(b), a surrounding cylinder 35 projects and integrally formed with the lower surface of the connection member 11. A through hole 163 is formed in the lid 16, and the surrounding cylinder 35 is inserted in the through hole 163. A sealing member, which is a lip seal 36, is located between an outer circumferential surface 352 of the surrounding cylinder 35 and a circumferential surface 166 of the through hole 163. As shown in Fig. 8, the lip seal 36 includes an annular case 361, a pair of retainer rings 362, 363, and a lip ring 364 held between the retainer rings 362, 363. The lip ring 364 is made of polytetrafluoroethylene. The case 361 is fitted in the through hole 163. The position of the case 361 is determined by a snap ring 37 fitted to a circumferential surface 166 of the through hole 163. The lip ring 364 contacts an outer circumferential surface 352 of the surrounding cylinder 35.

[0044] As shown in Fig. 6(b), the surrounding cylinder 35 has a wiring hole 351 that passes through the connection member 11. A cup-shaped shutter 38 is fitted in the wiring hole 351. The terminals 39, 40 pass through and are fixed to the bottom wall of the shutter 38. The stator 21 and the inner ends of the terminals 39, 40 are electrically connected to each other with conductive members, which are lead wires 41. The outer ends of the terminals 39, 40 are electrically connected to a power supply (not shown). The position of the shutter 38 is determined by a snap ring 42 fitted to a circumferential surface of the wiring hole 351. The shutter 38 disconnects the interior of the motor housing 15 (the motor chamber 152) and the outside of the tank 10.

[0045] The pressure of the interior of the motor housing 15 is higher than the pressure in the tank 10 outside the motor housing 15. The pressure difference presses the lip ring 324 of the lip seal 32 against the outer circumferential surface 282 of the discharge pipe 28. The pressure difference also presses the lip ring 364 of the lip seal 36 against the outer circumferential surface 352 of the surrounding cylinder 35. The interior of the motor housing 15 (the motor chamber 152) is disconnected from the interior of the tank 10 outside the pump housing 7 by the lip seals 32, 36.

[0046] The pump housing 7, or the main body of the electric pump 13 is attached to the connection member 11 before being installed in the tank 10. Before attaching the pump housing 7 to the connection member 11, the lead wires 41 are not connected to the terminals 39, 40, and the shutter 38 is not attached to the connection member 11. The attachment is carried out in the following manner. First, the lead wires 41 are drawn through the wiring hole 351 from the surrounding cylinder 35. The length of the lead wires 41 are determined such that a sufficient length of each lead wire 41 is drawn from the wiring hole 351. In this state, the lip seal 32 is fitted in the discharge pipe 28, and the lip seal 36 is fitted in the surrounding cylinder 35. In a state where the discharge pipe 28 is fitted in the lip seal 32 and the surrounding cylinder 35 is fitted in the lip seal 36, the lower ends 142 of the tension springs 14 are inserted in the recesses 164. Then, each screw 43 is threaded into a threaded hole 165 such that the screw 43 crosses the corresponding recess 164.

[0047] Next, the lead wires 41, which have been drawn out of the wiring hole 351, are soldered to the terminals 39, 40. Thereafter, the shutter 38 is fitted in the wiring hole 351 and fixed with the snap ring 42. In a state where the shutter 38 is fitted in and fixed to the wiring hole 351, pressurized fluid F in the motor chamber 152 does not leak to the outside of the tank 10 through the wiring hole 351.

[0048] In this manner, the pump housing 7 is attached to the connection member 11. The pump housing 7 is then placed in the tank 10 through the insertion hole 102. The connection member 11, to which the pump housing 7 is attached, is fastened to the upper wall 101 of the tank 10 with the screws 12.

[0049] The second embodiment provides the following advantages besides the advantages (1) to (6) of the first embodiment.

[0050] (2-1) In a state where the pump housing 7 is attached to the connection member 11, which forms part of the tank 10, the space between the circumferential surface 162 of the connection hole 161 and the outer circumferential surface 282 of the discharge pipe 28 is sealed with the lip seal 32, and the space between the circumferential surface 166 of the through hole 163 and the outer circumferential surface 352 of the surrounding cylinder 35 is sealed with the lip seal 36. That is, the discharge pipe 28 is connected to the connection hole 161, and the surrounding cylinder 35 is connected to the through hole 163. In a state where the discharge pipe 28 is connected to the connection hole 161, pressurized fluid F in the motor chamber 152 does not leak to the interior of the tank 10 through the connection hole 161. Also, in a state where the surrounding cylinder 35 is connected to the through hole 163, pressurized fluid F in the motor chamber 152 does not leak to the interior of the tank 10 through the through hole 163.

[0051] The connection of the discharge pipe 28 and the connection hole 161 and the connection of the surrounding cylinder 35 and the through hole 163 are completed by a simple process in which the discharge pipe 28 is inserted into the connection hole 161 and the surrounding cylinder 35 is inserted in the through hole 163.

[0052] (2-2) The lip seals 32, 36, which exert sealing performance using pressure differences, are favorable as sealing members for preventing pressurized fluid F in the motor chamber 152 from leaking into the interior of the tank 10. The lip rings 324, 364 of the lip seals 32, 36 prevent vibration of the electric pump 13 (the pump housing 7) from being transmitted to the connection member 11. Dimethyl ether damages rubber. That is, the dimethyl ether causes rubber to harden or swell, which can result in breakage. However, since the lip rings 324, 364 are made of polytetrafluoroethylene, dimethyl ether does not damage the lip rings 324, 364. Accordingly, the damping property of the lip rings 324, 364 does not deteriorate.

[0053] (2-3) The rotary shaft 18 is rotatably supported in the connection hole 161 formed in the lid 16. That is, a hole for rotatably supporting the rotary shaft 18, which is the connection hole 161, is also used as a connection hole for connecting the interior of the motor housing 15 (the motor chamber 152) with the discharge passage 281 of the discharge pipe 28. In this structure where a single hole is used for two purposes, no additional connection hole is required. This simplifies the structure.

[0054] (2-4) The power supply terminals for the motor M, which are the terminals 39, 40, are electrically connected to the stator 21 with the lead wires 41. The lip seal 36 is located between the lid 16 and the surrounding cylinder 35, which surrounds the lead wires 41. This structure is favorable for guaranteeing the sealing property about the lead wires 41.

[0055] (2-5) Unlike Japanese Laid-Open Patent Publications No. 1-151765, No. 6-288313, No. 2002-98018, no flexible hose is used for connecting a section of the discharge path in the connection member 11 with a section of the discharge path in the pump housing 7 (the motor chamber 152 in this embodiment). A connection structure using a flexible tube enlarges the space occupied by a pump in a tank. However, since no flexible tube is used in this embodiment, such a problem is avoided.

[0056] (2-6) To facilitate the attachment of the pump housing 7 (the main body of the electric pump 13) to the connection member 11, it is preferably that the tension spring 14 be easily attached to either one of the pump housing 7 and the connection member 11 during the attaching process. In this embodiment, after the lower end 142 of each tension spring 14 is inserted in the corresponding recess 164 formed in the lid 16 of the pump housing 7, the spring 14 is coupled to the pump housing 7 simply by threading the screw 43 in the corresponding threaded hole 165 of the lid 16. The attachment of the springs 14 is thus simple.

[0057] A third embodiment of the present invention will now be described with reference to Fig. 12. In the third embodiment, like or the same reference numerals are given to those components that are like or the same as the corresponding components of the second embodiment.

[0058] The pump housing 7 is suspended from the connection member 11 with vibration insulators 65 (only one is shown in Fig. 12) in between. The vibration insulators 65, which function as dampers are located about the axis of the rotary shaft 18. The vibration insulators 65 are made of polytetrafluorethylene. The vibration insulators 65 are adhered to the upper surface of the lid 16 and to the lower surface of the connection member 11. The vibration insulators 65 prevent vibration of the pump housing 7 from being transmitted to the connection member 11.

[0059] When attaching the pump housing 7 (the electric motor M) to the connection member 11, a face of each vibration insulator 65 is adhered to one of the electric motor M and the connection member 11. Adhesive is applied to the opposite face of each vibration insulator 65. Then, the lead wires 41 are drawn out through the wiring hole 351. In this state, the lip seal 32 is fitted in the discharge pipe 28, and the lip seal 36 is fitted in the surrounding cylinder 35. In a state where the discharge pipe 28 is fitted in the lip seal 32 and the surrounding cylinder 35 is fitted in the lip seal 36, the vibration insulators 65 are adhered to the electric motor M and the connection member 11. Next, the lead wires 41, which have been drawn out of the wiring hole 351, are soldered to the terminals 39, 40. Thereafter, the shutter 38 is fitted in the wiring hole 351 and fixed with the snap ring 42.

[0060] Alternatively, the shutter 38 may be fitted in the wiring hole 351 in advance. In this case, the lead wires 41 are connected to the terminals 39, 40. Thereafter, the connection member 11 and the electric motor M are brought close to each other such that the vibration insulators 65 are adhered to the connection member 11.

[0061] The third embodiment has the same advantages as the advantages (2-1) to (2-5) of the second embodiment.

[0062] A fourth embodiment will now be described with reference to Figs. 13(a), 13(b), 14(a) and 14(b).

[0063] As shown in Figs. 13(a) and 13(b), vibration insulating mechanism, or a damper 71 having a vibration insulating rubber member 70 is located between the lid 16 of the pump housing 7 and the connection member 11. As shown in Fig. 13(b), the damper 71 includes the rubber member 70, a coupling member 72, a threaded hole forming member 73, a pair of first screws 74, and a second screw 75. The first screws 74 are used to fasten the coupling member 72, which functions as a first attachment member, with the lid 16. The second screw 75 is used to fasten the threaded hole forming member 73, which functions as a second attachment member, to the connection member 11. The coupling member 72 contacts and is attached to a first contacting end face 701 of the rubber member 70 that faces the pump housing 7. The thread hole forming member 73 includes a nut portion 731 having a threaded hole, and a coupling plate portion 732 coupled to the nut portion 731. The nut portion 731 is embedded in the rubber member 70. The coupling plate portion 732 is attached to a second contacting end face 702 of the rubber member 70 that faces the connection member 11.

[0064] The coupling member 72 is fastened to the upper surface of the lid 16 with the first screws 74 threaded to the lid 16. The threaded hole forming member 73 is fastened to the lower surface of the connection member 11 with the second screw 75, which is passed through a through hole 113 formed in the connection member 11 and is threaded to the nut portion 731. That is, the damper 71 is attached to the lid 16 with the coupling member 72, and is also attached to the connection member 11 with the threaded hole forming member 73.

[0065] As shown in Fig. 14 (a), two or more sets (three in this embodiment) of the dampers 71 are provided about the discharge pipe 28. The sets of the dampers 71, which are attached to the connection member 11, suspend the pump housing 7.

[0066] As shown in Figs. 13(b) and 14(b), a polytetrafluoroethylene coating layer 76 is formed on a surface of each vibration insulating rubber member 70 (a circumferential surface 703 in this embodiment). Also, the coating layer 76 is formed on the surface of each coupling member 72 and the surface of each threaded hole forming member 73. Each vibration insulating rubber member 70 is covered with the coating layer 76 so that the surface of the rubber member 70 is not exposed.

[0067] The fourth embodiment provides the following advantages.

[0068] (4-1) The rubber members 70 prevent vibration of the pump housing 7 from being transmitted to the connection member 11. Part of the surface of each vibration insulating rubber member 70 is not covered with the coupling member 72 and the threaded hole forming member 73. Such part of the surface is covered with the polytetrafluoroethylene coating layer 76. That is, the surface of each vibration insulating rubber member 70 is not exposed to dimethyl ether, which is a liquefied gas fuel. Therefore, when the pump housing 7 is suspended in the tank 10 storing dimethyl ether by using the damper 71, the rubber members 70 do not deteriorate.

[0069] (4-2) Each damper 71 is attached to the lid 16 and the connection member 11 in the following manner. First, the first screws 74 are threaded to fasten the coupling member 72 to the lid 16. Then, the second screw 75 is passed through the through hole 113 and threaded to the nut portion 731 of the threaded hole forming member 73. That is, each damper 71, in which the coupling member 72 and the threaded hole forming member 73 are coupled to the rubber member 70, is easily installed between the pump housing 7 and the connection member 11.

[0070] A fifth embodiment will now be described with reference to Figs. 15(a) and 15(b).

[0071] As shown in Fig. 15(a), dampers 78 having a cylindrical vibration insulating rubber member 77 is located between the lid 16 of the pump housing 7 and the connection member 11. As shown in Fig. 15(b), the damper 78 includes the rubber member 77, a coupling member 79, a threaded hole forming member 80, a first screw 81, and the second screw 75. The first screw 81 is used to fasten the coupling member 79, which functions as a first attachment member, to the lid 16. The second screw 75 is used to fasten the threaded hole forming member 80, which functions as a second attachment member, to the connection member 11. The coupling member 79 contacts and is attached to a first contacting end face 771 of the rubber member 77. The thread hole forming member 80 includes a nut portion 801 having a threaded hole, and a coupling plate portion 802 coupled to the nut portion 801. The nut portion 801 is fitted in an inner surface 773 of the rubber member 77. The coupling plate portion 802 is attached to a second contacting end face 772 of the rubber member 77.

[0072] The coupling member 79 is fastened to the upper surface of the lid 16 with the first screw 81 threaded to the lid 16. The threaded hole forming member 80 is fastened to the lower surface of the connection member 11 with the second screw 75, which is passed through a through hole 113 formed in the connection member 11 and is threaded to the nut portion 801. That is, the damper 78 is attached to the lid 16 with the coupling member 79, and is also attached to the connection member 11 with the threaded hole forming member 80.

[0073] The inner diameter of the nut portion 801 of the threaded hole forming member 80 and the inner diameter of the rubber member 77 are greater than the diameter of the head of the first screw 81. Therefore, the first screw 81 can be threaded to the lid 16 through the nut portion 801 and the rubber member 77.

[0074] As shown in Fig. 15(b), a polytetrafluoroethylene coating layer 82 is formed on a surface of the rubber member 77 and on an inner surface 773 of the rubber member 77. Also, the coating layer 82 is formed on the surface of the coupling member 79 and the surface of the threaded hole forming member 80. The rubber member 77 is covered with the coating layer 82 so that the surface of the rubber member 77 is not exposed.

[0075] The damper 78 is attached to the lid 16 and the connection member 11 in the following manner. First, the first screw 81 is threaded to fasten the coupling member 79 to the lid 16. Then, the second screw 75 is passed through the through hole 113 and threaded to the nut portion 801 of the threaded hole forming member 80. That is, the dampers 78, in which the coupling member 79 and the threaded hole forming member 80 are coupled to the rubber member 77, is easily installed between the pump housing 7 and the connection member 11. The fifth embodiment has the same advantage as the advantage (4-1) of the fourth embodiment.

[0076] A sixth embodiment will now be described with reference to Fig. 16.

[0077] A damper 83 includes a cylindrical vibration insulating rubber member 84, a cylindrical coupling member 85, a threaded hole forming member 86, first screws 87, and a second screw 75. The first screws 87 are used to fasten the coupling member 85, which functions as a first attachment member, to the lid 16. The second screw 75 is threaded to the threaded hole forming member 86, which functions as a second attachment member. The thread hole forming member 86 includes a nut portion 861 having a threaded hole, and a flange 862 coupled to the nut portion 861. The rubber member 84 is fitted in the cylinder of the cylindrical coupling member 85. An annular plate portion 851 of the coupling member 85 contacts an upper end face 841 of the rubber member 84. The nut portion 861 is fitted in the cylinder of the rubber member 84. The flange 862 is contacts a lower end face 842 of the rubber member 84.

[0078] The flange 852 of the coupling member 85 is fastened to the upper surface of the lid 16 with the first screws 87 threaded to the lid 16. The second screw 75 is threaded to the nut portion 861 of the threaded hole forming member 86.

[0079] A polytetrafluoroethylene coating layer 88 is formed on the surface of the rubber member 84. The rubber member 84 is covered with the coating layer 88 so that the surface of the rubber member 84 is not exposed.

[0080] The sixth embodiment thus provides the same advantages as the fourth embodiment.

[0081] A seventh embodiment will now be described with reference to Fig. 17.

[0082] A damper 89 includes an annular vibration insulating rubber member 90, an annular holding member 91, and screws 92. The screws 92 are used to fastening the rubber member 90 and the holding member 91 to the pump housing 7. The insertion hole 102, which is formed with an inlet forming ring 9, is formed in the upper wall 101 of the tank 10. A flange 901 of the rubber member 90 is held between the inlet forming ring 9 and the connection member 11.

[0083] A polytetrafluoroethylene coating layer 94 is formed on the surface of the rubber member 90. The rubber member 90 is covered with the coating layer 94 so that the surface of the rubber member 90 is not exposed.

[0084] The seventh embodiment provides the same advantage as the advantage (4-1) of the fourth embodiment.

[0085] An eighth embodiment will now be described with reference to Fig. 18. An annular rim portion 931 is formed on the inlet forming ring 9. An annular vibration insulating rubber member 95 is located between the rim portion 931 and a flange 153 of the motor housing 15. A vibration insulating rubber member 95 is placed on the rim portion 931, and the flange 153 is placed on the rubber member 95. The rubber member 95 functions as damper that prevents vibration of the pump housing 7 from being transmitted to the connection member 11.

[0086] A polytetrafluoroethylene coating layer 96 is formed on the surface of the rubber member 95. The rubber member 95 is covered with the coating layer 96 so that the surface of the rubber member 95 is not exposed.

[0087] The eighth embodiment provides the same advantage as the advantage (4-1) of the fourth embodiment.

[0088] A ninth embodiment will now be described with reference to Fig. 19. A head 971 of a bolt 97 and an annular washer 98 are embedded in a vibration insulating rubber member 48. The threaded portion of the bolt 97 passes through the through hole 113 of the connection member 11 and protrudes to the outside of the tank 10. A nut 99 is threaded to the projecting portion of the bolt 97. Screws 74, a coupling member 72, the rubber member 48, the bolt 97, and the washer 98 form a damper.

[0089] A polytetrafluoroethylene coating layer 100 is formed on the surface of the coupling member 72 and the surface of the rubber member 48. The rubber member 48 is covered with the coating layer 100 so that the surface of the rubber member 48 is not exposed.

[0090] The ninth embodiment thus provides the same advantages as the fourth embodiment.

[0091] A tenth embodiment will now be described with reference to Figs. 20(a) and 20(b). In the tenth embodiment, the lip seal 32 and the lip seal 36 of the second embodiment are replaced by damper 103 and damper 104, respectively.

[0092] The damper 103 includes an annular vibration insulating rubber member 105, an annular coupling member 106, an annular thread hole forming member 107, first screws 74, and second screws 75. The first screws 74 are used to fasten the coupling member 106, which functions as a first attachment member, to the lid 16. The second screws 75 are used to fasten the threaded hole forming member 107, which functions as a second attachment member, to the connection member 11. The discharge pipe 28 is fitted in the annular rubber member 105. The rubber member 105 has an annular sealing portion 1053. The sealing portion 1053 is pressed against the circumferential surface 282 of the discharge pipe 28 by the difference between the pressure in the motor housing 15 and the pressure in the tank 10, so that the inner circumferential surface of the sealing portion 1053 closely contacts the circumferential surface 282 of the discharge pipe 28.

[0093] The coupling member 106 contacts and is attached to a first contacting end faces 1051 of the rubber member 105. The threaded hole forming member 107 includes an annular contacting plate portion 1072, and nut portions 1071 each having a threaded hole. The annular contacting plate portion 1072 surrounds the discharge pipe 28, and the nut portions 1071 are located about the discharge pipe 28. The nut portions 1071 are embedded in the rubber member 105. The contacting plate portion 1072 is attached to a second contacting end face 1052 of the rubber member 105.

[0094] A polytetrafluoroethylene coating layer 108 is formed on the surface of the rubber member 105, the coupling member 106, and the surface of the threaded hole forming member 107. The rubber member 105 is covered with the coating layer 108 so that the surface of the rubber member 105 is not exposed.

[0095] The coupling member 106 is fastened to the upper surface of the lid 16 with the first screws 74 threaded to the lid 16. The threaded hole forming member 107 is fastened to the lower surface of the connection member 11 with the second screw 75, which is passed through a through hole 113 formed in the connection member 11 and is threaded to the nut portion 1071.

[0096] Except for the inner diameter of the rubber member 105, the damper 104 has the same configuration as the damper 103. Thus, like or the same reference numerals are given to those components that are like or the same as the corresponding components of the damper 103. The sealing portion 1053 of the damper 104 is pressed against the circumferential surface 352 of the surrounding cylinder 35 by the difference between the pressure in the motor housing 15 and the pressure in the tank 10, so that the inner circumferential surface of the sealing portion 1053 of the damper 104 closely contacts the circumferential surface 352 of the discharge pipe 35.

[0097] The damper 103, 104 are arranged between the lid 16 and the connection member 11 in the following manner. First, the first screws 74 are fastened to secure the coupling member 106 to the lid 16. Then, the discharge pipe 28 is fitted in the rubber member 105 of the damper 103, and the surrounding cylinder 35 is fitted in the rubber member 105 of the damper 104. Subsequently, the second screws 75 are passed through the through holes 113 and threaded to the nut portions 1071 of the through hole forming members 107 of the damper 103, 104. Accordingly, the damper 103, 104 are attached to the lid 16 and the connection member 11.

[0098] In the tenth embodiment, the damper 103, 104 also function as the lip seals 32, 36 in the first embodiment. The tenth embodiment also provides the same advantage as the advantage (4-1) of the fourth embodiment.

[0099] The invention may be embodied in the following forms.

[0100] The lip rings of the lip seals 32, 36 may be made of rubber.

[0101] The lip seals 32, 36 may be replaced by O-ring shaped sealing members.

[0102] In the second to tenth embodiment of the present invention, the pump housing 7 may be located on the bottom of a tank with dampers in between.

[0103] The present invention may be applied to a system where a sub tank is connected to the tank 10 through a pipe, and a pump is located in the sub tank.

[0104] In the second embodiment of the present invention, the electric pump may be oriented horizontally and accommodated in the tank 10. In this case, the connection hole and the through holes are formed in the sidewall of the motor housing 15.

[0105] The electric pump may be suspended from the connection member 11 with elastic belts. If the belts are made of rubber, it is preferable that the surface of the belts be coated with a layer of polytetrafluorethylene.

[0106] The present invention may be applied to a pump that is used in a cogeneration system (private electric generator), which generates electricity while using exhaust heat to heat water (fluid).

[0107] In the third embodiment, instead of using adhesive, a plate may be welded to each side of the vibration insulator 65, so that the electric motor M is fastened to one side with screws, and the connection member 11 is fastened to the other side with screws.

[0108] In the illustrated embodiments, the present invention is applied to the electric pump, which uses DME. However, the present invention may be applied to pumps that use other types of fluid. That is, as long as a fluid that has the above described properties (the saturation vapor pressure can surpass the suction pressure of the pump section due to heat of the motor chamber, and the saturation vapor pressure stays below the discharge pressure of the pump section despite the heat in the motor chamber) is used, the present invention may be any electric pump that uses a fluid other than DME.

[0109] In the first embodiment, the electric pump 2 need not be of an in-tank type, but may be of a type that is arranged outside the tank 10.

[0110] In the illustrated embodiments, the motor chamber 152 need not form part of the discharge path of DME. That is, the gear housing 17 may have a discharge port, so that the motor chamber 152 does not form part of the discharge path. In this case, the discharge port is connected to the motor chamber 152 through the passage 172 so that the motor chamber 152 is exposed to the discharge pressure.

[0111] In the second to tenth embodiments, the pump housing 7 may have the discharge pipe 28 and the connection member 11 may have the connection hole 161.

[0112] In the illustrated embodiments, the pump section is a gear pump. However, the pump section does not need to be a gear pump. For example, the pump section may be a screw pump or a piston pump.

[0113] The present examples and embodiments are to be considered as illustrative and not restrictive and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalence of the appended claims.

[0114] An electric pump draws and discharges fluid. When the fluid receives heat from the pump, the fluid has a saturation vapor pressure that can surpass the pressure of fluid that is drawn into the pump and is lower than the pressure of fluid discharged from the pump. The pump includes an electric motor; a pump section that is driven by the electric motor to draw, pressurize, and discharge the fluid; and a housing for accommodating the pump section. The housing defines a motor chamber that accommodates the electric motor. The pressure in the motor chamber is equal to the pressure of fluid that is discharged from the pump section. Therefore, the pump prevents fluid in the motor chamber from vaporizing.

Claims

1. An electric pump for drawing and discharging fluid, wherein, when the fluid receives heat from the pump, the fluid has a saturation vapor pressure that can surpass the pressure of fluid that is drawn into the pump and is lower than the pressure of fluid discharged from the pump, the pump comprising:

    an electric motor;
    a pump section that is driven by the electric motor to draw, pressurize, and discharge the fluid; and
    a housing for accommodating the pump section, wherein the housing defines a motor chamber that accommodates the electric motor, the electric pump being **characterized in that**:

        the pressure in the motor chamber is equal to the pressure of fluid that is discharged from the pump section.

2. The electric pump according to claim 1, **characterized in that** fluid discharged from the pump section is drawn into the motor chamber.

3. The electric pump according to claim 1 or 2, **characterized by** a discharge path that guides fluid discharged by the pump section to the outside of the housing, wherein the motor chamber forms part of the discharge path.

4. The electric pump according to claim 3, **characterized in that** the housing has a first passage and a second passage, wherein the first passage guides fluid discharged by the pump section to the motor chamber, and wherein the second passage guides fluid from the motor chamber to the outside of the housing.

5. The electric pump according to claim 4, **characterized in that** the housing is accommodated in a tank for storing fluid, and wherein, compared to the pump section, the motor chamber is located closer to a wall of the tank.

6. The electric pump according to claim 5, **characterized in that** a portion of the housing that defines the motor chamber is attached to the wall of the tank.

7. The electric pump according to any one of claims 3 to 6, **characterized in that** a bearing for rotatably supporting a rotary shaft of the electric motor is provided in the housing, and wherein the discharge path passes through the bearing.

8. The electric pump according to claim 7, **characterized in that** the bearing is exposed to fluid that passes through the discharge path.

9. The electric pump according to claim 7 or 8, **characterized in that** the bearing has a space that forms part of the discharge path.

10. The electric pump according to any one of claims 1 to 9, **characterized in that** the pump is accommodated in a tank for storing fluid, wherein the pump further including a connection member that supports the housing with a damper, the connection member forming part of the tank, wherein one of the connection member and the housing has a discharge pipe, and the other one of the connection member and the housing has a connection hole, wherein the discharge pipe is inserted in the connection hole, wherein the discharge pipe and the connection hole form part of a discharge path that guides fluid discharged from the pump section to the outside of the tank, and wherein a sealing member is located between a circumferential surface of the connection hole and an outer circumferential surface of the discharge pipe.

11. The electric pump according to claim 10, **characterized in that** the discharge pipe is formed in the connection member, and wherein the connection hole is formed in the housing.

12. The electric pump according to claim 10 or 11, **characterized in that** the sealing member permits the circumferential surface of the connection hole and the outer circumferential surface of the discharge pipe to move relative to each other.

13. The electric pump according to any one of claims 10 to 12, **characterized in that** the sealing member is an annular lip seal.

14. The electric pump according to any one of claims 10 to 13, **characterized in that** the sealing member is made of polytetrafluoroethylene.

15. The electric pump according to any one of claims 10 to 14, **characterized in that** the housing has an end wall that is perpendicular to a rotary shaft of the electric motor, wherein the connection hole is formed in the end wall, wherein one end of the rotary shaft extends into and is rotatably supported in the connection hole, and wherein the discharge pipe extends from the connection member toward the connection hole.

16. The electric pump according to claim 15, **characterized in that** a bearing for supporting the one end is located in the connection hole.

17. The electric pump according to any one of claims 10 to 16, **characterized by:**

a power supply terminal for the motor, the terminal being located in the connection member;
a conductive member for electrically connecting the power supply terminal with a stator coil of the motor;
a surrounding cylinder provided in the connection member, wherein the surrounding cylinder surrounds at least one of the power supply terminal and the conductive member, the surrounding cylinder passing through the housing and extending to the motor chamber; and
a sealing member located between the surrounding cylinder and the housing.

18. The electric pump according to any one of claims 10 to 17, **characterized in that** the damper has a vibration insulating rubber member, and wherein the surface of the rubber member is coated with polytetrafluoroethylene.

19. The electric pump according to claim 18, **characterized in that** the damper includes a first attachment member and a second attachment member, the first and second attachment members being separated from each other, wherein the first attachment member is fixed to the housing, and the second attachment member is fixed to the connection member, wherein each attachment member has a rigidity higher than that of the rubber member, and wherein the rubber member is located between the attachment members.

20. The electric pump according to claim 19, **characterized in that** the damper further includes:

a first screw for fixing the first attachment member to the housing; and
a second screw for fixing the second attachment member to the connection member.

21. The electric pump according to claim 20, **characterized in that** the second attachment member has a threaded hole, and wherein the second screw passes through the connection member and is threaded to the second attachment member.

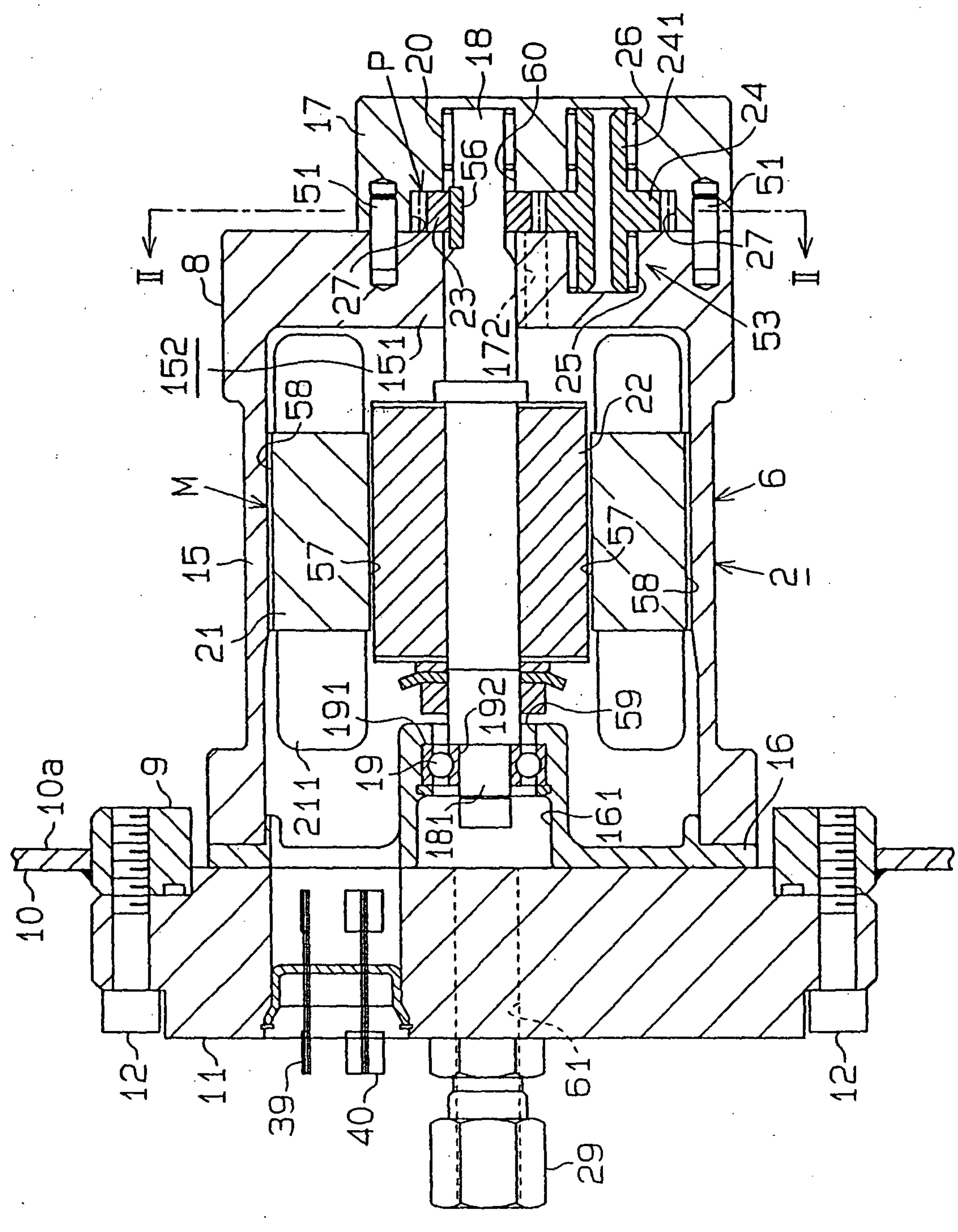
22. The electric pump according to any one of claims 19 to 21, **characterized in that** the rubber member has a first contacting end face that faces the housing and a second contacting end face that faces the connection member, wherein the first attachment member is attached to the first contacting end face, and the second attachment member is attached to the second contacting end face.

23. The electric pump according to any one of claims 18 to 22, **characterized in that** the sealing member includes the rubber member.

24. The electric pump according to any one of claims 10 to 23, **characterized in that** the damper also functions as the seal member.

25. An electric pump for supplying dimethyl ether as fuel to an internal combustion engine, the pump being **characterized by:**

an electric motor;
a pump section driven by the electric motor; and
a housing for accommodating the pump section, wherein the housing defines a motor chamber that accommodates the electric motor, and wherein the pressure in the motor chamber is equal to the pressure of dimethyl ether that is discharged from the pump section.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22
M
6
15
57
57
58
2
21
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12
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Fig.1

Fig.2

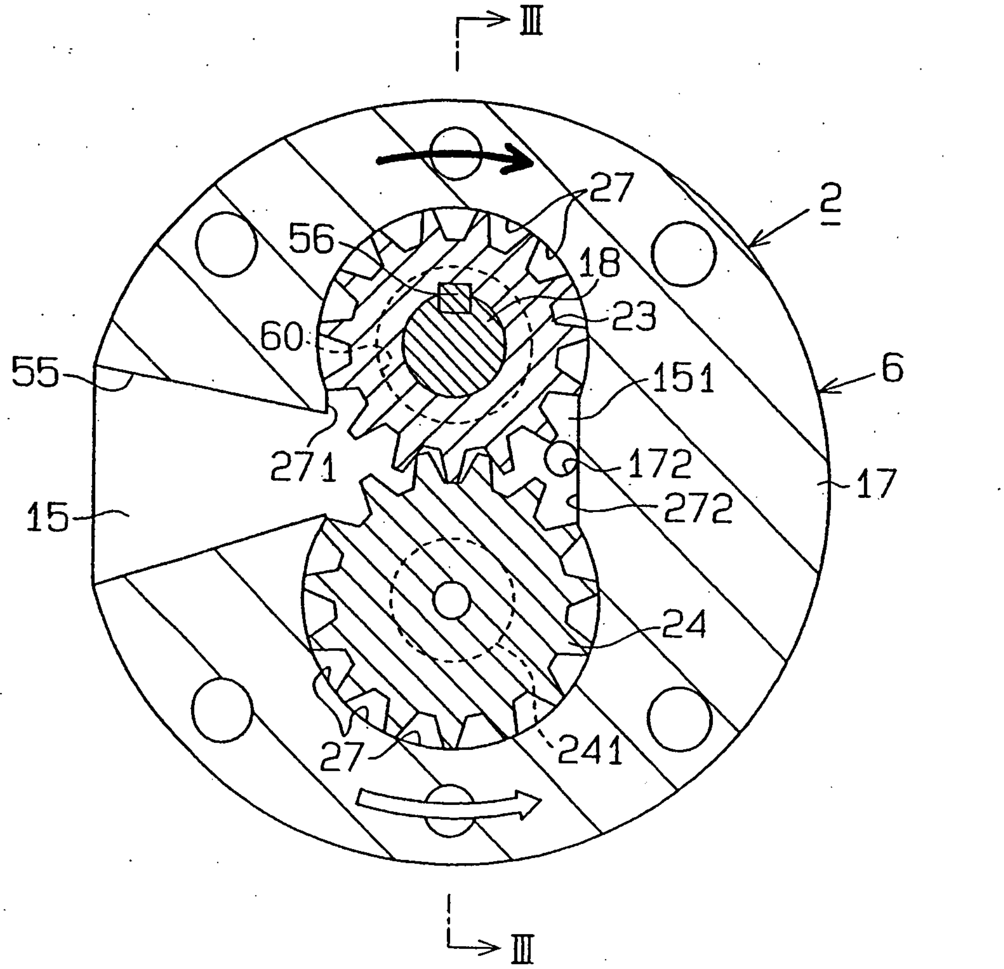
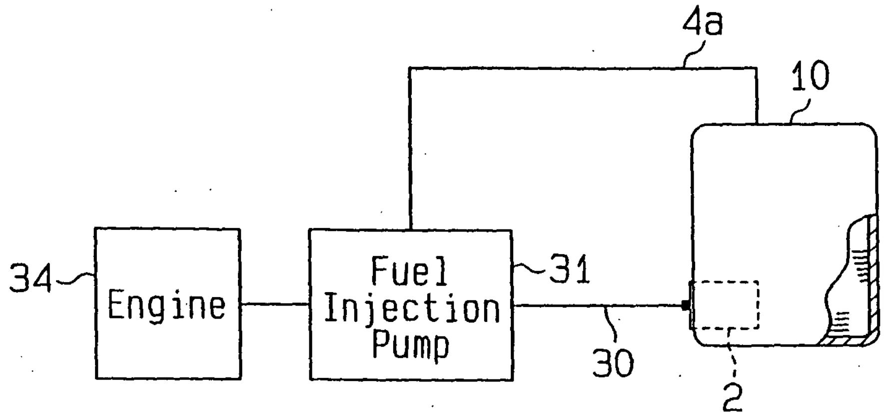


Fig.3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Pump
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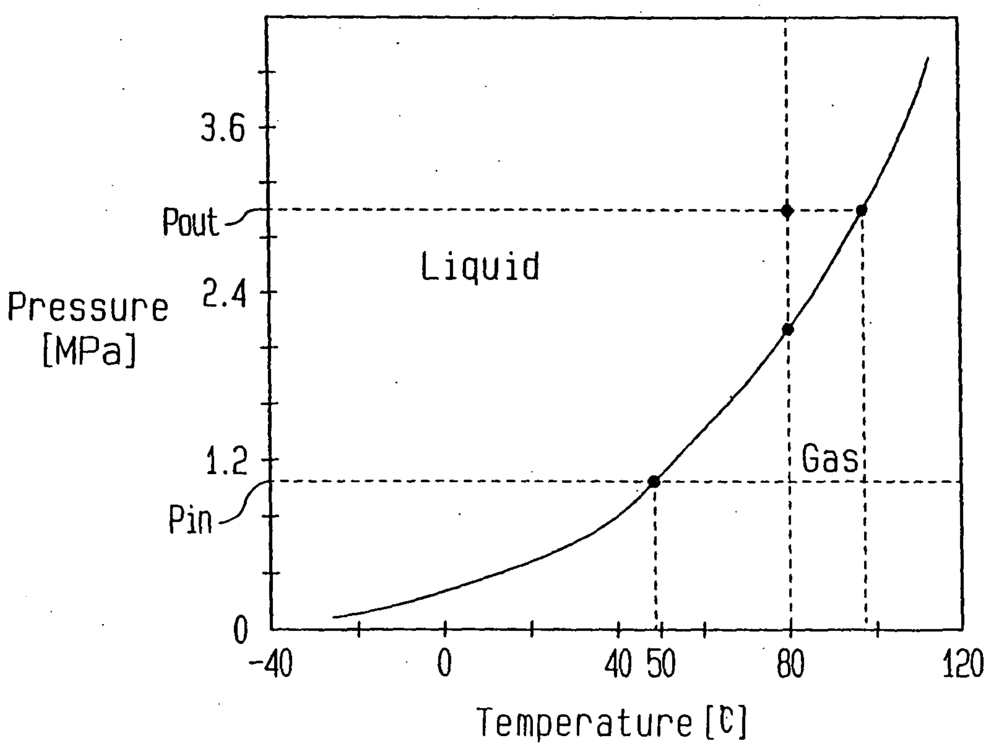
30
2

Fig.4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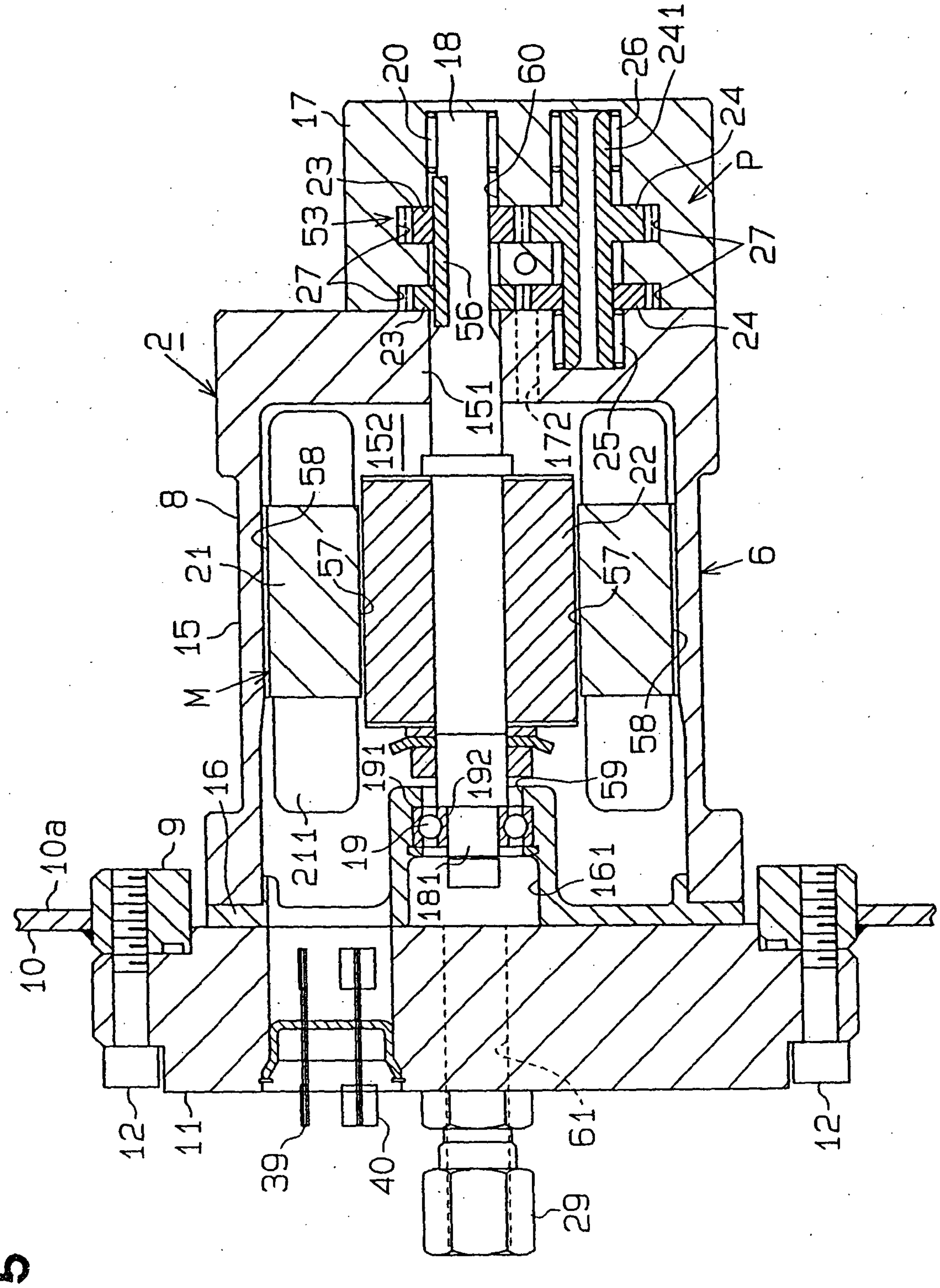
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192
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181
161
59
58
57
22
25
172
152
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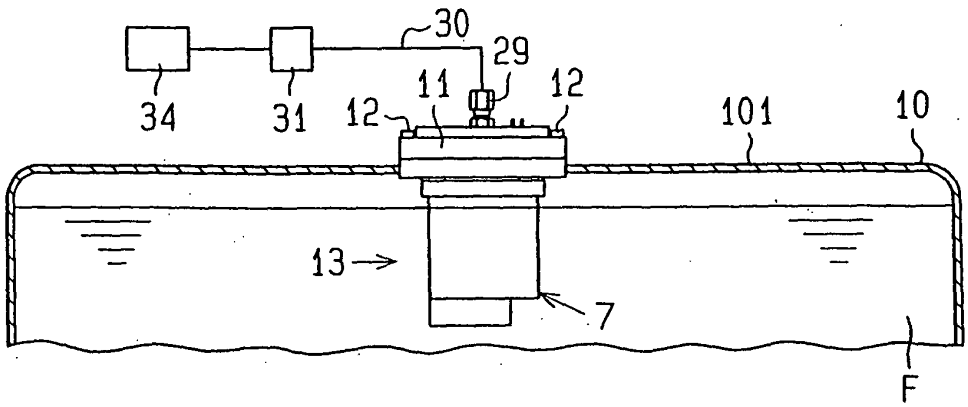
Fig. 5

Fig.6(a)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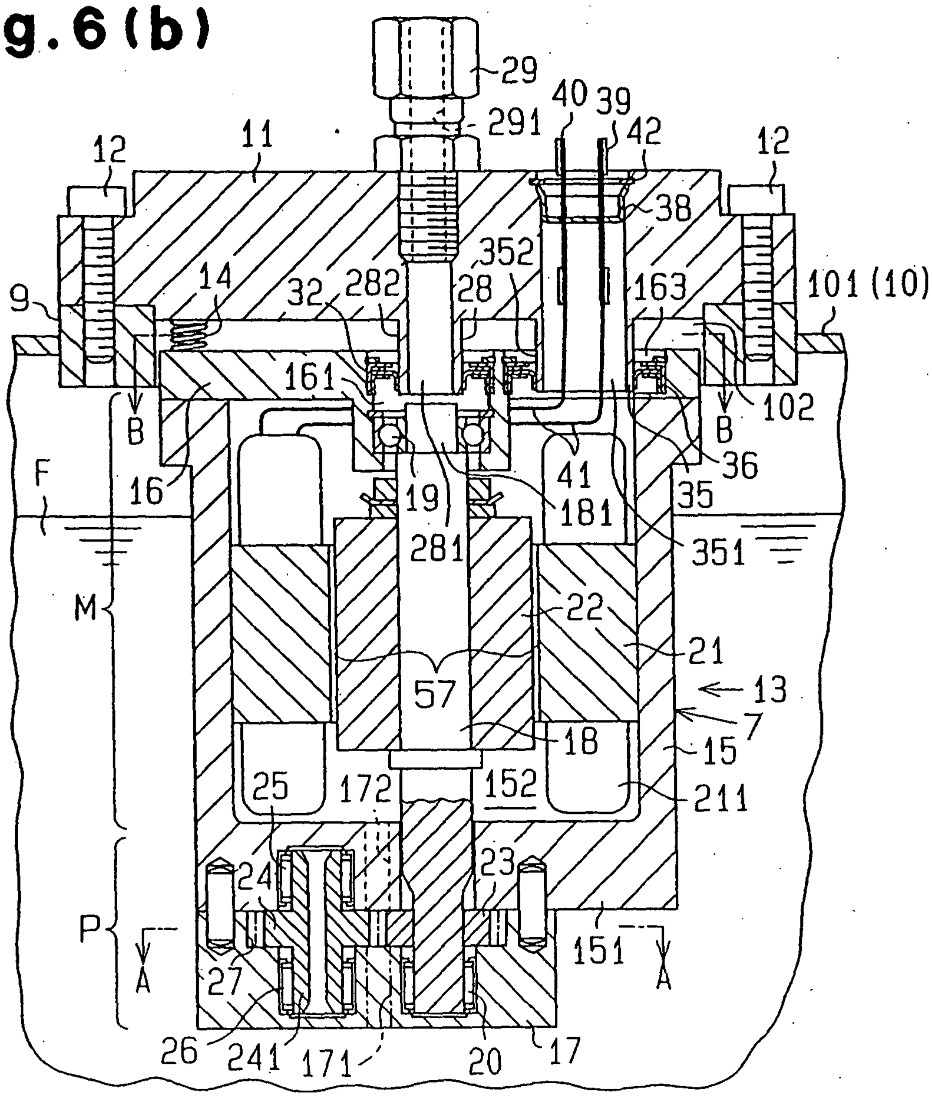
F

Fig.6(b)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161
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B
B
16
19
41
36
35
F
181
281
351
M
22
21
57
13
7
18
15
25
172
152
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24
23
P
151
A
A
27
26
241
171
20
17

Fig.7

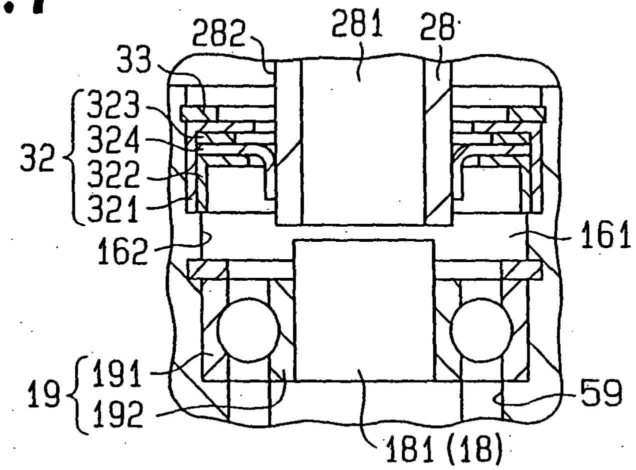


Fig.8

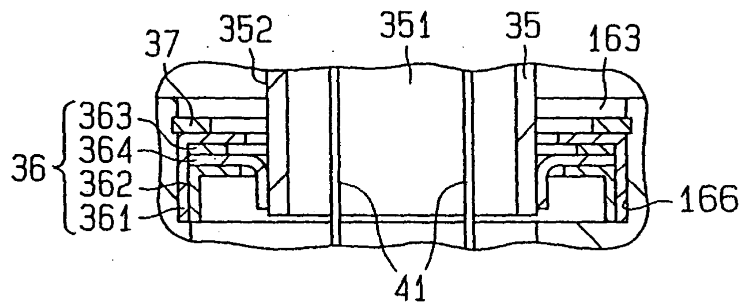


Fig.9

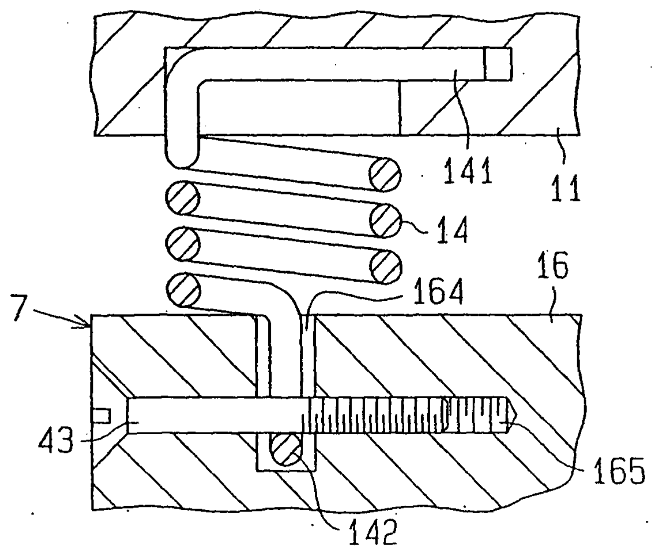
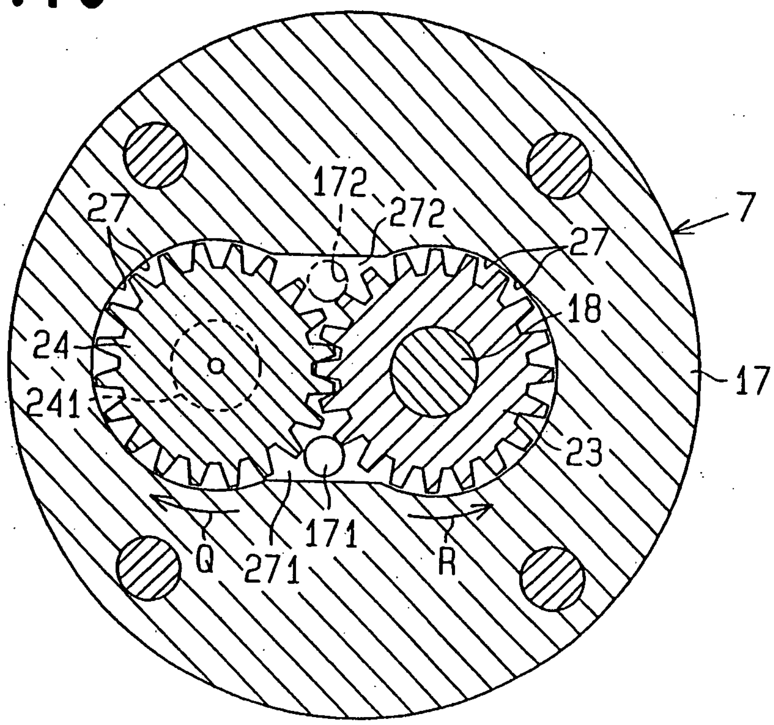


Fig.10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272
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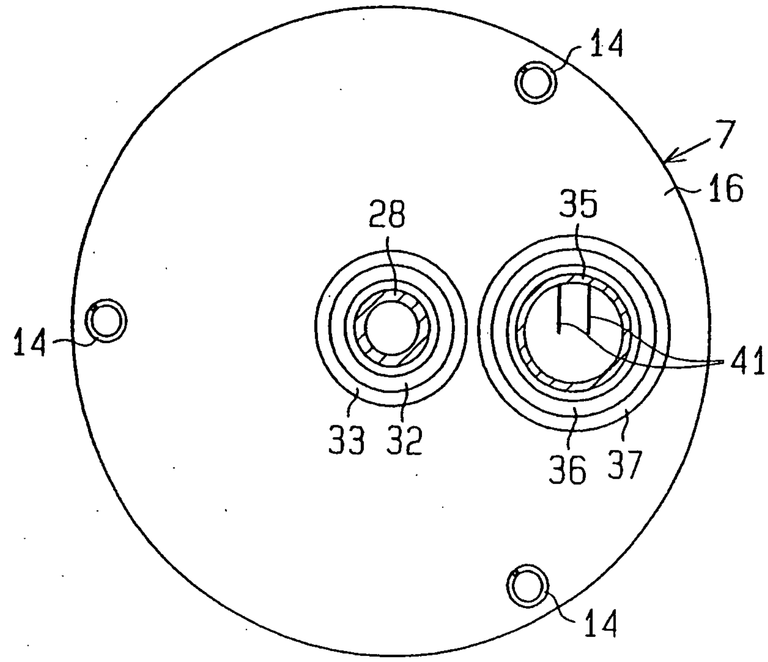
7
18
24
17
241
23
Q
271
171
R

Fig.11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7
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35
14
41
33
32
36
37
14

Fig.12

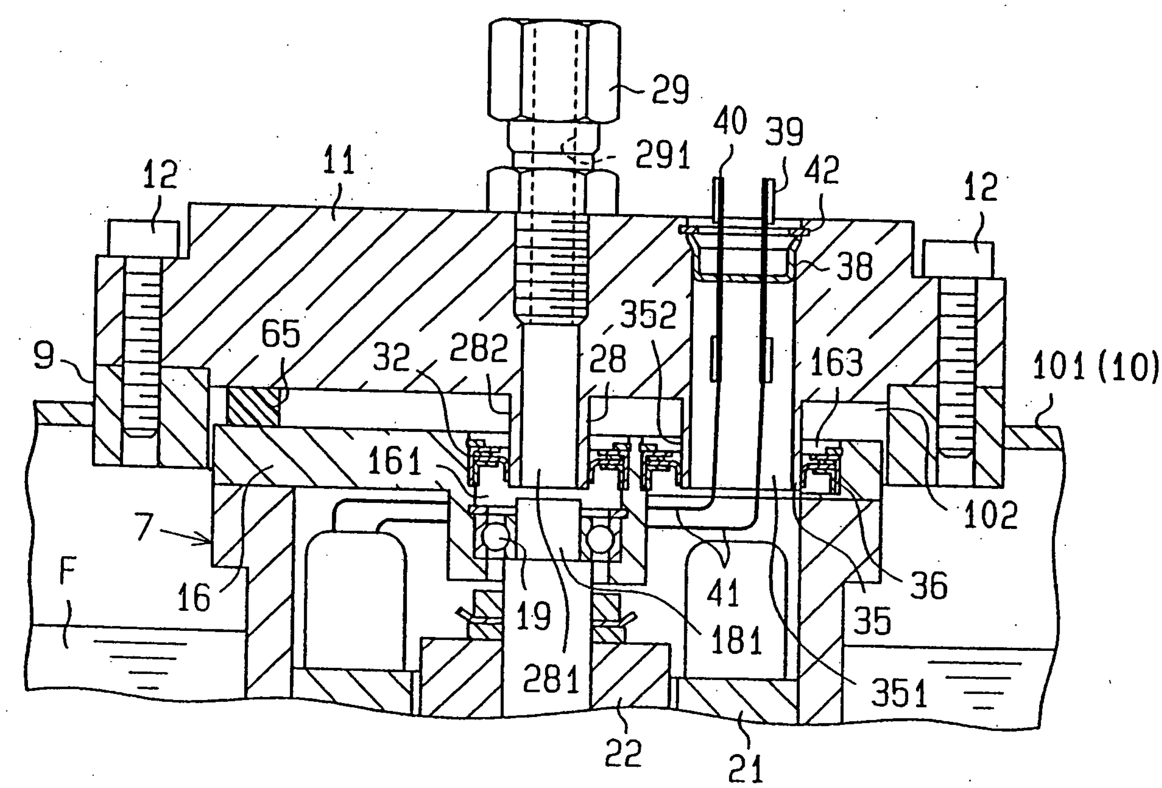

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Fig.13(a)

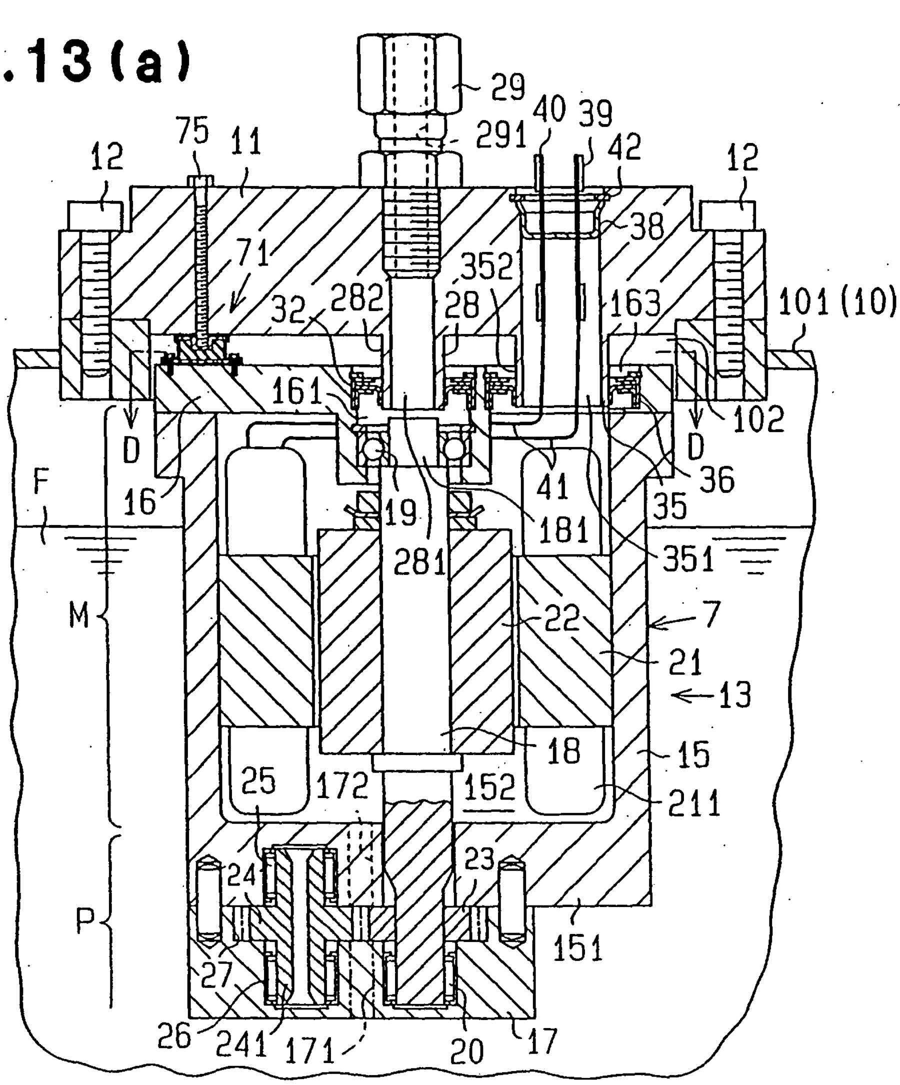

Fig.13(b)

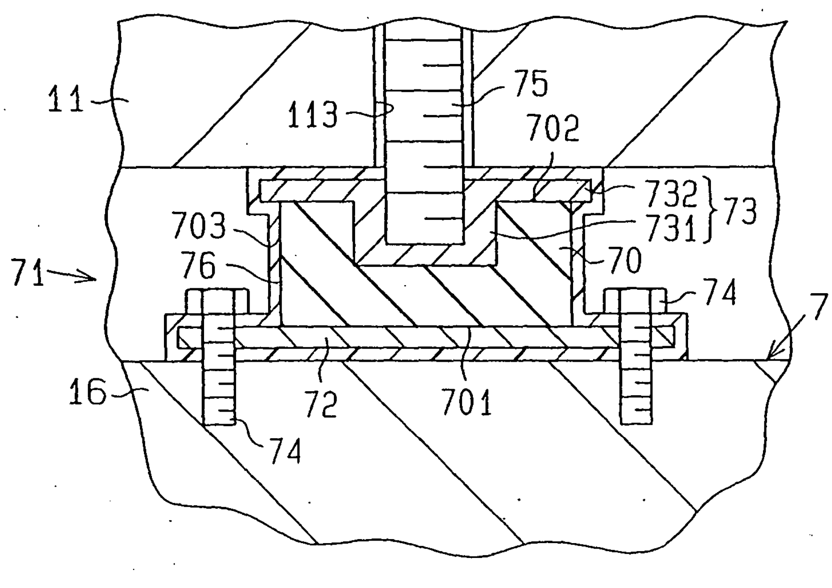

Fig.14(a)

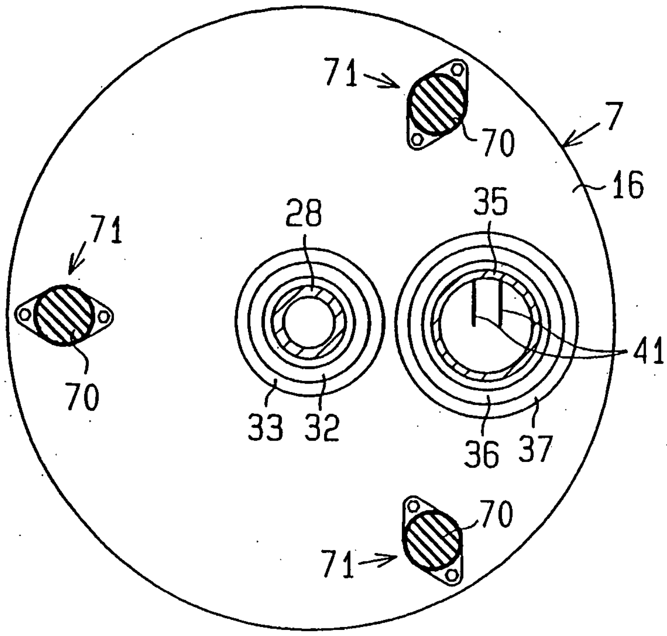

Fig.14(b)

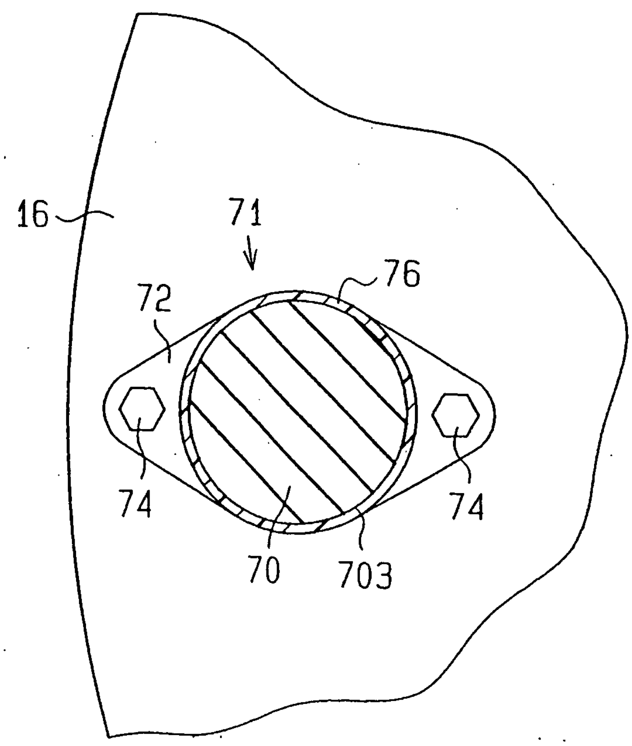

Fig.15(a)

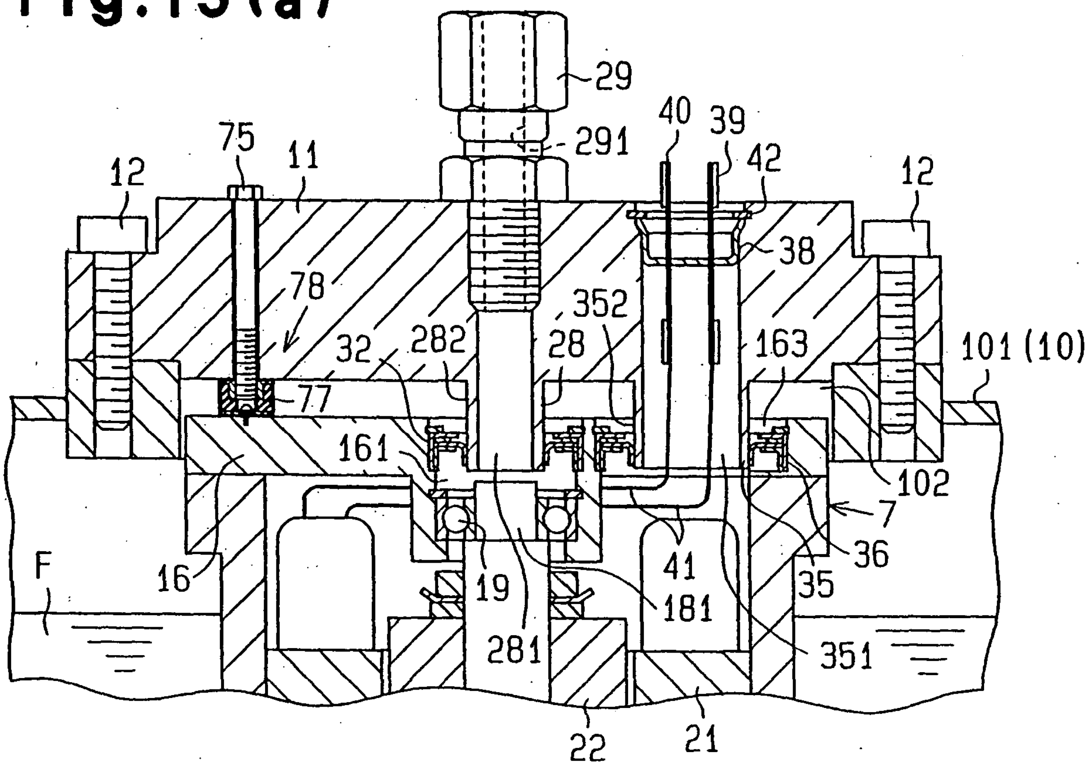

Fig.15(b)

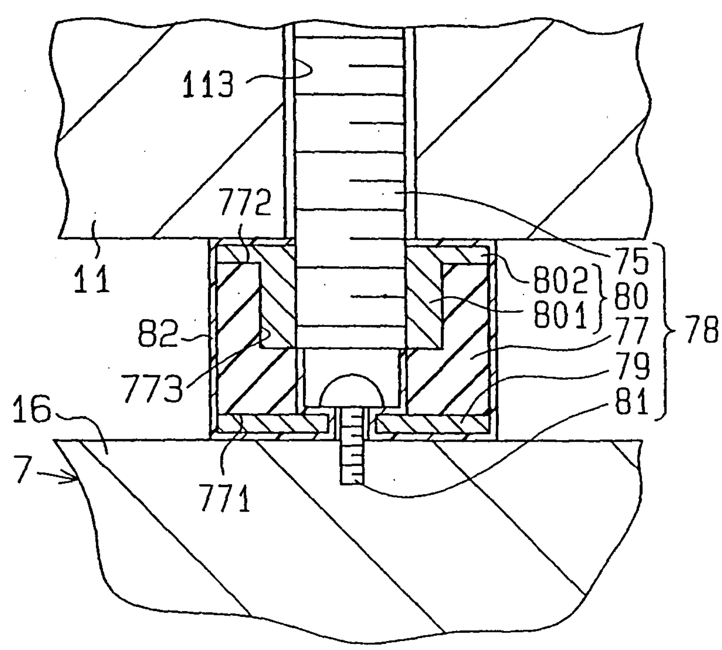

Fig.16

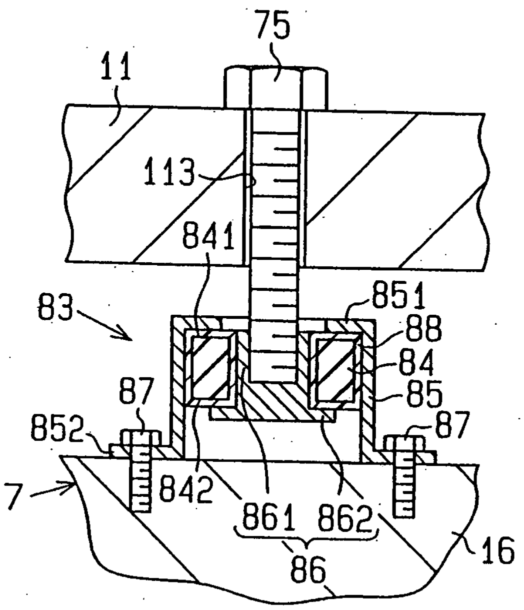
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Fig.17

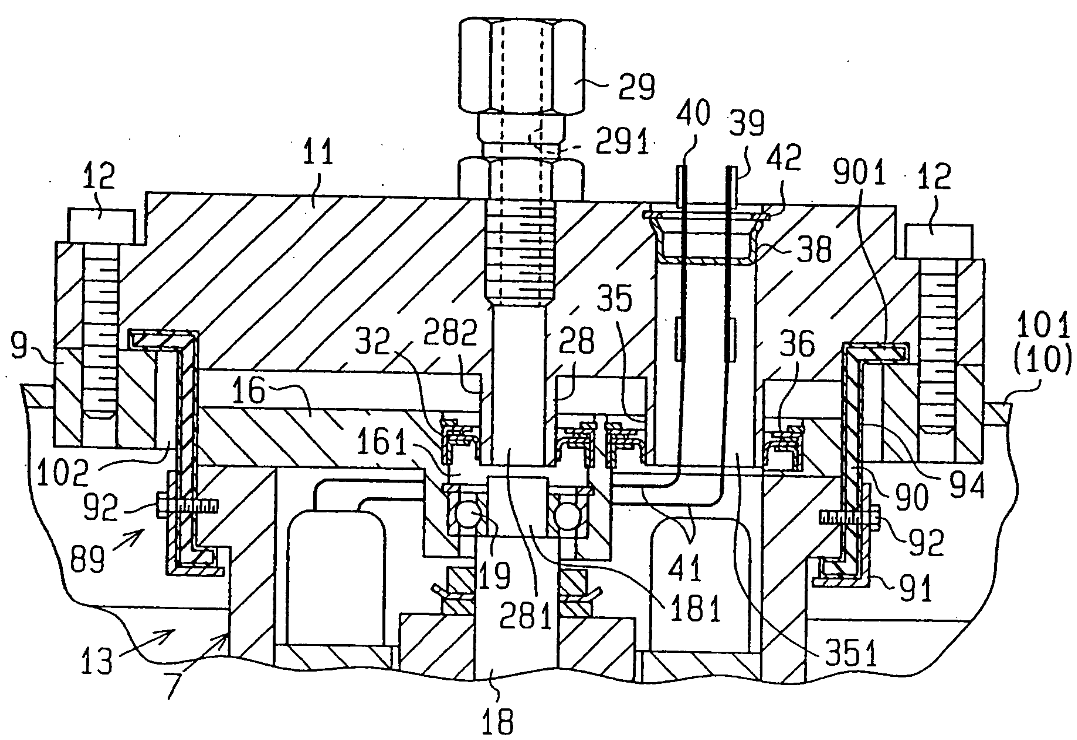
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Fig.18

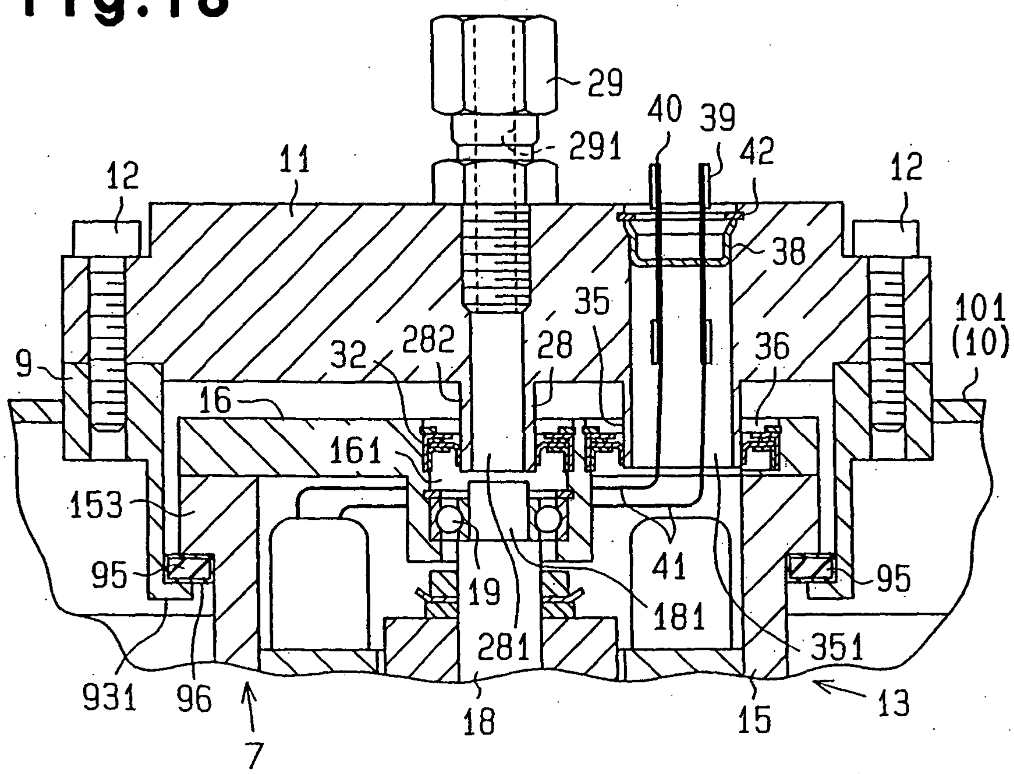
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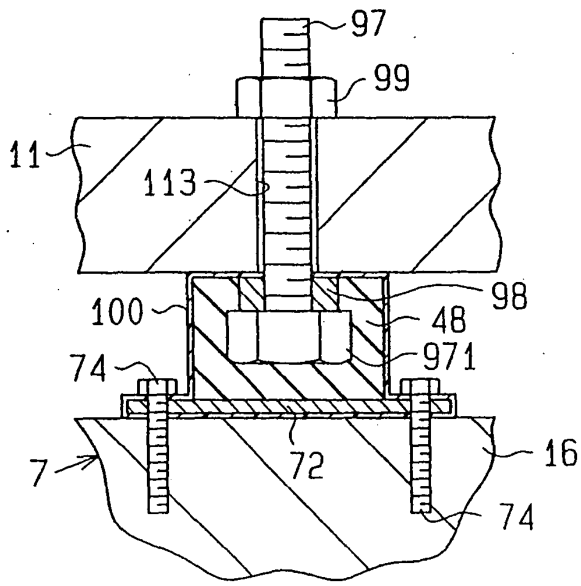
Fig.19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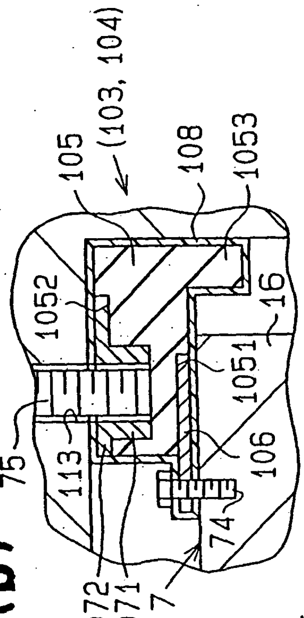

Fig.20(b)

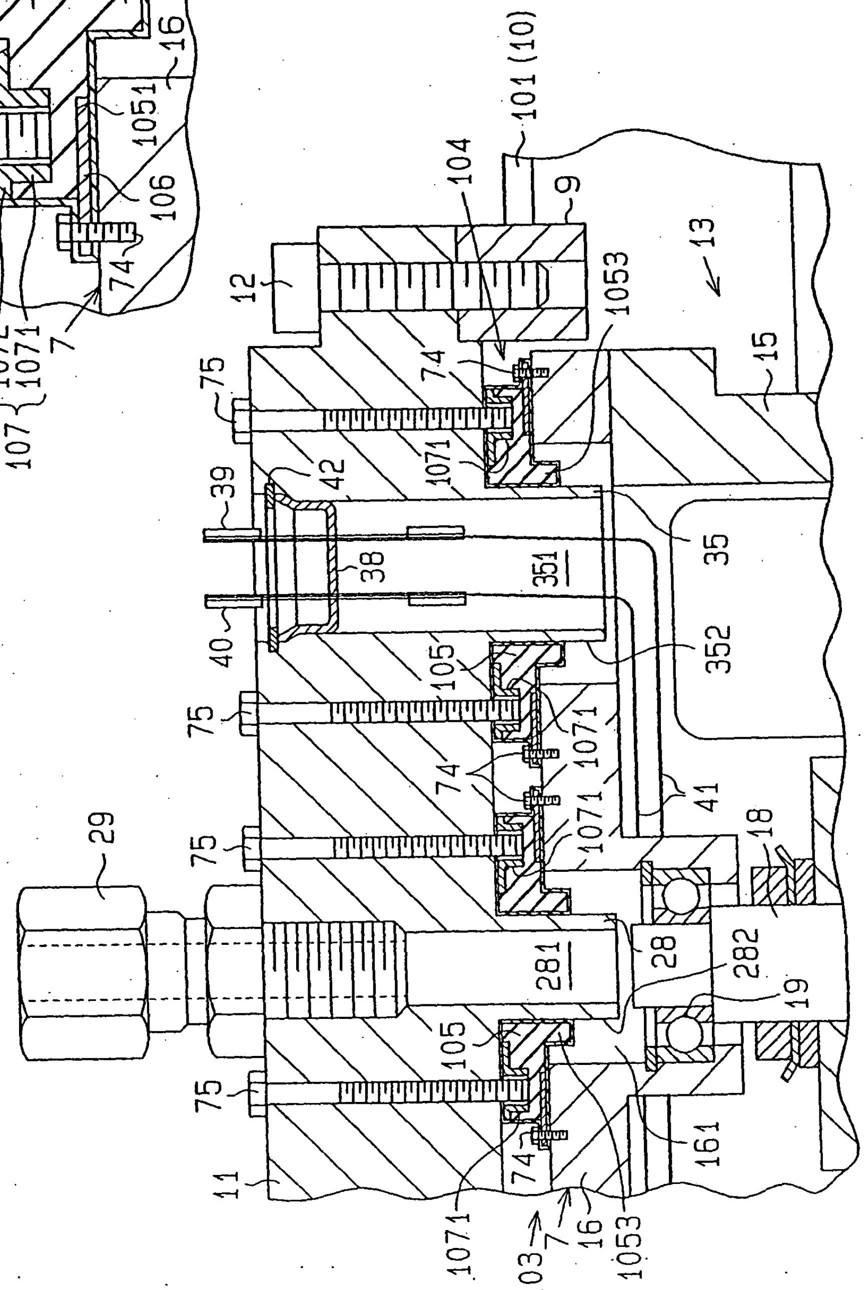

Fig.20(a)