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(72) Inventors:  

- **MASUSHIGE, Eiji, Tsu Plant, Teijin Seiki Co., Ltd**  
**Tsu-shi, Mie 514-8533 (JP)**
- **NACHI, Tsuyoshi, Tsu Plant, Teijin Seiki Co., Ltd**  
**Tsu-shi, Mie 514-8533 (JP)**

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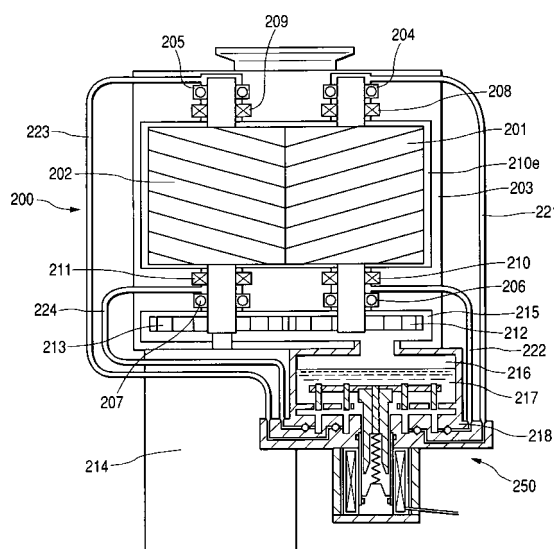
(74) Representative: **Grünecker, Kinkeldey,**  
**Stockmair & Schwanhäusser Anwaltssozietät**  
**Maximilianstrasse 58**  
**80538 München (DE)**

(71) Applicant: **Nabtesco Corporation**  
**Tokyo (JP)**

(54) **LIQUID PUMP**

(57) The invention is directed to provide a liquid pump (lubricant circulation or lubricant supply pump) that is capable of lubricating a machine or apparatus even in a case that a passage supplying a liquid (lubricant) is in a vacuum condition. To solve the above, the invention is **characterized in** a liquid pump (lubricant circulation or lubricant supply pump) for delivering a liquid (lubricant) from a liquid storing portion (lubricant storing portion) to a predetermined position of at least one location, wherein at least one cylinder chamber is formed inside of the pump, a piston is arranged to reciprocate by a driving means in the cylinder chamber, the cylinder chamber is communicated with a liquid (lubricant) delivery port, so that the liquid (lubricant) discharged into a fluid passage communicating with the predetermined position of at least one location, the driving means is provided with a solenoid including an axial portion all of which or at least a part of which is made of a ferromagnetic substance and a solenoid coil that are relatively movable to each other, the axial portion all of which or at least a part of which is made of the ferromagnetic substance and the cylinder chamber are fixed by a predetermined means.

**FIG. 9**



## Description

### Technical Field

**[0001]** The present invention relates to a liquid pump capable of forming a lubricating path completely isolated from outside of the lubricating path by using a solenoid and relates to a liquid pump having pluralities of pistons and cylinder chambers movable relative to each other in axial directions and a system using the same.

### Background Art

**[0002]** Various pumps have been disclosed in background arts for delivering a liquid from a certain portion to other portion. As a condition of such a pump, a liquid is operated not to leak. Further, there is also a case of needing a condition that a liquid can be delivered from a certain portion to other portion by a pertinent flow rate.

**[0003]** For example, there is a pump of a type using a mechanism of a rotary pump as a lubricating apparatus for supplying a liquid. A rotary pump is a pump for delivering a liquid by rotating a blade having a function of a fan or a propeller with motor. Here, a "blade" is formed in a shape of a vane having an angle which is packed into a pump. By rotating the blade per se in a liquid in a constant direction, a flow of the liquid in the constant direction is produced and the liquid is made to flow in the constant direction in a conduit.

**[0004]** There is other type of a shaft rotating type using a screw type blade. Further, there is also a liquid pump using an auger or the like in a long spiral shape used in boring instead of using a comparatively small blade. According to the screw type shaft rotating pump, a screw thereof is rotated at high speed. According to a method of attaching the above-described rotary pump, as shown by Fig.12, a liquid pump 3 is mounted to an outer side of a liquid storing tank 1 via a shaft seal 2. Fig. 12 shows a blade type liquid pump and a liquid is delivered from a delivery port 7 by driving to rotate a rotating shaft 5 of a blade 4 by a motor 6.

**[0005]** Further, according to a rotary vacuum pump, a lubricant for a bearing or a gear is filled in a space arranged with the gear and by providing means for guiding the lubricant to the gear or the bearing (for example, splash plate), or arranging a portion of the gear to dip into the lubricant, the lubricant is supplied to the bearing or the gear by rotating the gear.

**[0006]** However, when the liquid pump having the above-described structure is used, there poses a problem that the liquid is leaked to contaminate from between the rotating shaft and the shaft seal by sliding the shaft seal 2 in rotating movement. Further, when wear of the seal portion is progressed, there poses a problem that an amount of leakage is increased and a motor constituting a pump storing portion electrically moved is broken.

**[0007]** Further, when the liquid pump having the

above-described rotating portion is used for circulating a lubricant of a rotary vacuum pump having a structure in which a bearing or a gear which needs to be lubricated is arranged in vacuum, although not only the lubricant for the bearing or the gear arranged at inside of a vacuum chamber needs to be prevented from being leaked to outside of the vacuum pump but also outside air needs to be prevented from being brought into the pump, there is a possibility that the shaft seal wears by driving to rotate the shaft seal, and leakage of the atmosphere into the vacuum chamber or leakage of the lubricant to outside is increased. For example, when the vacuum pump is used in a semiconductor fabricating apparatus, there is a possibility that a clean room is contaminated by oil to significantly damage production of a semiconductor plant. Further, when a large amount of a lubricant is leaked, a sufficient amount of the lubricant cannot be supplied and there is a possibility of destructing the bearing, the gear or the like.

**[0008]** As other problem, when a pressure of a bearing portion is increased by delivering a large amount of a lubricant, there is a possibility that a lubricant or oil molecules are leaked into an exhaust chamber, further, a vacuum chamber which is prohibited from being contaminated by oil. Further, when oil is circulated in vacuum, there poses a problem that not only outside air invades inside of a lubricating path to effect adverse influence on sucking performance of a vacuum pump but also a lubricant cannot be delivered by mixing with the atmosphere. Further, when an amount of a lubricant to be supplied is increased, there is a possibility that the lubricant constitutes a resistance at the bearing portion, the gear or the like, power consumption of the pump is increased, heat generated at the bearing portion is increased and the bearing is broken, and there also poses a problem that when the amount is excessively small conversely, a sufficient lubricating function cannot be achieved.

**[0009]** Further, the rotary pump of the background art needs to rotate at high speed in order to deliver the liquid from a certain portion to other certain portion, the rotary pump cannot be controlled to drive for delivering a small amount of the liquid, finely controlling an amount to be delivered, stopping the rotary pump for stopping a flow of the liquid, swiftly increasing a rotational number for delivering the liquid or for delivering the liquid intermittently and a delicate control of flow rate for resolving the problem is difficult.

**[0010]** When the liquid is supplied to a plurality of portions, there also poses a problem that by only branching the liquid supply path at one portion, the liquid is made to flow to a portion easy to flow and the liquid cannot firmly be supplied to the respective portions. Hence, although it is conceivable to add an apparatus of distributing the supplied liquid to the plurality of liquid supply portions, in that case, there poses a new problem that a mechanism is complicated, expense is taken and an installing location therefor is needed. Further, according

to a general one of the above-described distributing apparatus, there also poses a problem that when a lubricating path is brought into vacuum, distribution is difficult.

**[0011]** Further, according to means for lubricating a bearing or a gear of a vacuum pump of the background art, there poses a problem that a rotating shaft or the gear is dipped into oil and therefore, a resistance is constituted thereby in rotating and power consumption is increased.

#### Disclosure of the Invention

**[0012]** The invention is characterized in a liquid pump for delivering a liquid from a liquid storing portion to a predetermined position of at least one location, wherein at least a cylinder chamber for introducing the liquid from the liquid storing portion is formed, a piston is arranged at the cylinder chamber, the cylinder chamber is formed with a liquid delivery port, and the piston includes driving means for driving a cylinder in an axial direction in the cylinder chamber. The piston of the cylinder chamber may be arranged vertically or may be arranged horizontally. Further, the piston and the cylinder chamber may be arranged at inside of the liquid storing portion.

**[0013]** The invention is characterized in that the piston is inserted from one end of the cylinder chamber and other end portion of the cylinder chamber is arranged with the liquid delivery port. Although the delivery port may be arranged at an endmost portion, by opening the delivery port at a side face of the cylinder chamber at which a vicinity of the endmost portion of the cylinder chamber remains slightly, after closing the delivery port of the cylinder chamber by the piston, the liquid stored at the endmost portion of the cylinder chamber serves as a cushion and it can be prevented that an end portion of the piston and the cylinder chamber are brought into contact with each other to be destructed or produce dust and dirt.

**[0014]** The invention is characterized in that a pair of the cylinder chambers are arranged at both ends of the piston, the piston is inserted from one end of each of the cylinder chambers, and other end of each of the cylinder chambers is opened with the liquid delivery port. Although when the cylinder chamber is arranged horizontally, an influence on a projecting force by a gravitational force is made to be difficult to be effected, the pair of cylinder chambers may be arranged by changing an angle thereof as necessary.

**[0015]** The invention is characterized in that sectional shapes and/or lengths of the piston and the cylinder chamber are optimized in accordance with an amount of supplying the liquid in the piston and the cylinder chamber. Further, the amount of supplying the liquid can also be controlled further finely by partitioning the cylinder chamber into a plurality of chambers along an axial direction and providing the pistons and projected ports of the respective chambers in accordance with the

shape of the cylinder chamber arranged with the plurality of chambers.

**[0016]** The invention is characterized in that the piston is inserted into the cylinder chamber and the cylinder chamber is formed with a single or a plurality of the liquid delivery ports. Such a constitution can also be achieved by providing a plurality of portions enlarging axial sectional areas at constant intervals in the axial direction.

**[0017]** The invention is characterized in that a structure of forming a single of a plurality of stages of stepped portions at the cylinder chamber is constituted, the piston is formed by a shape to be substantially equal to a shape of the cylinder chamber, and the liquid delivery ports are arranged at the single or the plurality of respective stepped portions formed at the cylinder chamber are arranged.

**[0018]** The invention is characterized in that the single or the plurality of stepped portions of the cylinder chamber are formed to be substantially symmetrical in an axial direction, the piston is formed by a shape substantially equal to shapes of the substantially symmetrical stepped portions, and the single or the plurality of respective stepped portions formed at the cylinder chamber are formed with the liquid delivery ports.

**[0019]** The invention is characterized in that the cylinder chamber is arranged with a member for forming the single or the plurality of stepped portions substantially symmetrically.

**[0020]** The invention is characterized in that relative lengths in the axial direction and/or sectional areas orthogonal to an axis of the cylinder chamber and the piston are optimized in accordance with an amount of supplying the liquid by a shape of a liquid storage formed between the cylinder chamber and the piston. Further, the amount of supplying the liquid can also be controlled further finely by partitioning the cylinder chamber into a plurality of chambers along the axial direction, and providing the piston and the delivery ports of the respective chambers in accordance with the shape of the cylinder chamber arranged with the plurality of chambers.

**[0021]** The invention is characterized in that the cylinder chamber is provided with a liquid drawing hole. Although the liquid drawing hole is connected to the liquid storing tank, the liquid drawing hole may be made to constitute a liquid delivery hole.

**[0022]** The invention is characterized in that a plurality of structures each formed with the single or the plurality of stages of stepped portions at the cylinder chamber are arranged in series.

**[0023]** The invention is characterized in that pluralities of the pistons and the cylinder chambers are provided for single driving means.

**[0024]** The invention is characterized in that the driving means is constituted by a solenoid including a shaft portion a total or a portion of which comprises a magnetic member and a solenoid coil capable of moving relative to each other, the shaft portion and the solenoid coil isolated by a partition wall therebetween are brought

into noncontract with each other, and the shaft portion and the piston are cooperatively moved by predetermined connecting means.

**[0025]** The invention is characterized in that a partition wall comprising a nonmagnetic member is used for the partition wall. As a material of the partition wall, there is brass, aluminum, stainless steel, ceramics, plastic resin or the like.

**[0026]** The invention is characterized in a vacuum pump using the solenoid as driving means, using the liquid pump as a lubricant circulating or lubricant supplying pump, and a portion needing to lubricate and a lubricating path of an essential portion of delivering a lubricant of the lubricant circulating or lubricant supplying pump is hermetically sealed. As the vacuum pump, there is a rotary type, a piston type or the like thereof.

**[0027]** The invention is characterized in an apparatus having a rotating portion needing a lubricant to lubricate, formed with a lubricant storing tank communicated to the apparatus having the rotating portion to make the lubricant flow thereto for storing the lubricant, and arranged with a lubricant circulating or lubricant supplying pump and a supply path for supplying the oil to the predetermined portion from the lubricant storing tank. As the apparatus having the rotating portion, there is a rotary type vacuum pump, a reduction gear or the like.

**[0028]** The invention is characterized in that an essential portion of delivering the lubricant of the lubricant circulating or lubricant supplying pump is integrally formed at inside of the lubricant storing portion.

**[0029]** The invention is characterized in that the lubricant storing tank is arranged at a position at which the lubricant of the apparatus having the rotating portion is made to flow by a gravitational force.

**[0030]** The invention is characterized in that the liquid pump is used as the lubricating or lubricant supplying pump.

#### Brief Description of the Drawings

#### **[0031]**

Fig.1 is a view of connecting a liquid pump according to a first embodiment of the invention as a pump for circulating a lubricant of a vacuum pump or supplying the lubricant thereto.

Fig.2 shows other embodiment of a piston portion of the first embodiment.

Fig.3 is a view of connecting a liquid pump according to a second embodiment of the invention as a pump for circulating a lubricant of a vacuum pump or supplying the lubricant thereto.

Fig.4 is a sectional view in a horizontal direction in parallel with an axis of a liquid pump according to a third embodiment of the invention.

Fig.5 is a sectional view in a vertical direction in parallel with the axis of the liquid pump according to the third embodiment of the invention.

Fig.6 is a sectional view of a piston and a cylinder chamber of a liquid pump according to a fourth embodiment of the invention.

Fig.7 is a sectional view of a piston and a cylinder chamber of a liquid pump according to a fifth embodiment of the invention.

Fig.8 is a sectional view of a piston and a cylinder chamber of a liquid pump according to a sixth embodiment of the invention.

Fig.9 is a view adapting the pump for circulating the lubricant or supplying the lubricant of the first embodiment to an oil lubrication circulating system of a screw type vacuum pump.

Fig.10 shows an example of a lubricant circulating pump of a background art.

#### Best Mode for Carrying Out the Invention

**[0032]** An explanation will be given of cases of using a liquid pump according to the invention as a lubricant circulating or lubricant supplying pump in reference to the drawings as follows.

**[0033]** Fig.1 is a view of connecting the lubricant circulating or lubricant supplying pump of the invention to a vacuum pump. In Fig.1, numeral 100 designates a first embodiment of the lubricant circulating or lubricant supplying pump according to the invention.

**[0034]** Numeral 101 designates a housing and inside thereof is filled with a liquid 103. Numeral 102 designates a plunger comprising a magnetic member and a base 104 comprising a magnetic member is provided to a lower portion of the plunger 102. Numeral 105 designates a solenoid coil. An interval between the plunger 102 and a solenoid coil 105 comprising the magnetic members is partitioned by the housing 101 and a nonmagnetic cylinder (partition wall) 109.

**[0035]** Further, a space for storing a lubricant is completely isolated from an outside atmosphere space by sealing by O rings at the case 101, the nonmagnetic cylinder 109 and the base 104 to prevent the lubricant from flowing to outside and outside atmosphere from invading. A spring 106 is provided between the plunger 102 and the base 104, and when a magnetic force is not exerted to the plunger 102 and the base 104, the plunger 102 and the base 104 are separated from each other. When a current is made to flow to the solenoid coil 105, the plunger 102 and the base 104 comprising magnetic members magnetized, a suction force is exerted therebetween and the plunger 102 can be moved downward. Therefore, by making the current flowing in the solenoid coil ON/OFF, the plunger can be driven continuously in an up and down direction. Coupling portions of a lower end of the plunger 102 and an upper end of the portion of the base are constituted by a taper shape in order to achieve the large suction force regardless of a position of the plunger 102. Further, when the plunger 102 and the base 104 are brought into contact with each other, the suction force is lost and therefore, in order to avoid

the contact, there is provided a contact preventing structure between the plunger 102 and the base 104 such that a small gap can be produced necessarily therebetween. In the case of the embodiment, there is provided a catch stepped portion 108 for stopping to move the plunger 102 before bringing the plunger 102 and the base 104 into contact with each other at an upper portion of the plunger. A plate 122 integrated with the plunger 102 is fixed with a plurality of pistons 110.

**[0036]** The pistons 110 are arranged to be inserted into a plurality of respective cylinder chambers 112. Further, the cylinder chambers 112 are disposed in the liquid. The cylinder chambers 112 are connected with pipes 114, 115 for delivering the liquid. The pipes 114, 115 are connected to a vacuum pump 130 to deliver the lubricant to the vacuum pump 130. The lubricant is dropped from the vacuum pump 130 to a lubricant chamber 150 (liquid storing portion). Therefore, since the plunger 102 and the pistons 110 are integrally moved, by making a power source of the solenoid coil ON/OFF, the pistons 110 are reciprocated in the cylinder chambers 112 and the liquid in the cylinder chambers 112 are continuously be discharged from the pipes 114, 115. The delivered liquid is prevented from returning to the cylinder chambers by check valves 116, 117. Thereby, a rectified amount of the lubricant can also be supplied firmly.

**[0037]** Further, when there is constructed a structure in which a spring 118 is arranged at a portion of the piston 110 as shown by Fig.2, the plunger 102 only presses the piston 110 and the piston is returned by the spring 118, it is not necessary to fixedly attach the piston 110 to the plunger 102.

**[0038]** The pipes 114, 115 communicate with lubricant delivery ports 111.

**[0039]** The invention is characterized in that a shaft portion a total or a portion of which comprises a ferromagnetic substance is divided and elastic means of the spring 106 or the like is formed between divided portions of the shaft portion. By constructing the constitution in this way, the cylinder chamber can be moved by making the power source of the solenoid coil ON/OFF. As the ferromagnetic member, iron, cobalt, nickel or the like is pointed out. Further, there is rubber or the like as elastic means in place of the spring. Further, as the nonmagnetic member, there is brass, aluminum, stainless steel, ceramics, plastic resin or the like.

**[0040]** Although according to the example, an explanation has been given of the case of the plurality of pistons, the invention can naturally be embodied even in the case of a single piston. Further, an amount of the lubricant necessary for portions to be supplied can be controlled by changing lengths in an axial direction of the pistons and the cylinder chambers and/or axial sectional areas thereof. In this case, when a number of constituent parts is large in the axial direction, a dimensional error or an attaching error in the axial direction is increased and therefore, by constructing a constitution of

making a stroke of the piston as long as possible, an influence of the attaching error in the axial direction is made to be difficult to be effected, a variation in the amount of delivering the lubricant can be restrained further accurately for a necessary amount and for the plurality of pistons. Further, although according to the example, the case and the nonmagnetic cylinder 109 as well as the nonmagnetic cylinder 109 and the base 104 are sealed by O rings, the sealing can naturally be carried out by bonding means capable of hermetically sealing the intervals such as welding, adhering or the like. Further, there is also a case in which when the plunger and the housing portion brought into contact with the plunger comprise the magnetic members, the plunger and the housing are formed into permanent magnets by the magnetic force to be difficult to be separated from each other and therefore, it is preferable to construct a constitution of interposing the nonmagnetic member of at least 0.2 mm or more between the contact portions.

**[0041]** Next, a second embodiment of a lubricant circulating or lubricant supplying pump of the invention will be explained in reference to Fig.3.

**[0042]** Fig. 3 is other view of connecting a lubricant circulating or lubricant supplying pump of the invention to a vacuum pump.

**[0043]** Numeral 300 designates a second embodiment of a lubricant circulating or a lubricant supplying pump of the invention.

**[0044]** The lubricant circulating or lubricant supplying pump of the second embodiment differs from the first embodiment in that a plurality of pistons 310 are directed to a side of a vacuum pump 320 and other constitution thereof is the same as that of the first embodiment. Further, by combining the first embodiment and the second embodiment, there can be constituted a structure in which cylinder chambers are arranged on both ends of the pistons and the lubricant can be delivered even when the plunger are moved in either of directions. In this case, there can also be constituted an arrangement in which the cylinder chambers and the pistons are moved vertically relative to a gravitational force and in that case, an influence of a delivery force of each cylinder chamber by the gravitational force can be dispensed with.

**[0045]** Next, a third embodiment of the invention will be explained in reference to Fig.4 and Fig.5.

**[0046]** Fig.4 is a sectional view in a horizontal direction in parallel with an axis of a liquid pump (lubricant circulating or lubricant supplying pump) according to a third embodiment of the invention. Fig.4 shows a state in which a current is conducted to a solenoid coil 405 and a plunger 402 and a piston 410 fixedly thereto are moved mostly to a side of a base by a magnetic force. Fig.5 is a sectional view in a vertical direction in parallel with the axis of the solenoid of the lubricant circulating or lubricant supplying pump (liquid pump) according to the third embodiment of the invention. Fig. 5 shows a state in which a current is not made to flow to the sole-

noid coil 405 and the plunger 402 and the piston 410 fixedly thereto are mostly remote from the base 404.

**[0047]** Numeral 402 designates a plunger comprising a magnetic member arranged at inside of a housing 401 and there is the base 404 comprising a magnetic member at an end portion of the plunger 402. Numeral 405 designates the solenoid coil. An interval between the plunger 402 and the solenoid coil 405 comprising the magnetic members is partitioned by a nonmagnetic cylinder (partition wall) 419 and the base 404. An interval between the nonmagnetic cylinder 419 and the base 404 are completely isolated by an O ring 403 and an interval between the nonmagnetic cylinder 419 and a member 409 fixedly to the housing 401 are completely isolated by an O ring 418. Further, a lubricant stored at an interval between the plunger 402 and the base 404 is returned to a drain, not illustrated, from a discharge port 407 such that the lubricant does not constitute a resistance in rocking the plunger 402. The lubricant injected from the discharge port 407 can also be supplied to a portion needing the lubricant by providing a check valve and an oil introducing port.

**[0048]** There is a projecting portion 413 in a shape of a circular disk at an end portion of an opposed side of the plunger 402.

**[0049]** There is a spring 406 between the projecting portion 413 and the member 409, and when the plunger 402 and the base 404 are not exerted with a magnetic force, the plunger 402 and the base 404 are separated from each other. Further, when a magnetic member is used for the projecting portion 413, there is also a case in which when the housing portion brought into contact with the plunger 402 is constituted by a magnetic member, the projecting portion 413 is formed into a permanent magnet by the magnetic force to be difficult to separate therefrom and therefore, it is preferable that the projecting portion 413 is constituted by a nonmagnetic member of at least 0.2 mm or more. When a current is made to flow to the solenoid coil 405, the plunger 402 and the base 404 comprising the magnetic members are magnetized, a suction force is exerted to each other and the plunger 402 can be moved in a direction of the base 404. Therefore, the plunger 402 can continuously be driven by making the current flowing in the solenoid coil 405 ON/OFF. Coupling portions of an end portion of the plunger 401 and an end portion of the base 404 are constituted by a taper shape in order to achieve a sufficient suction force regardless of a position of the plunger 402. Further, when the plunger 402 and the base 404 are brought into contact with each other, the suction force is lost and therefore, in order to avoid the contact, a contact preventing structure is provided between the plunger 402 and the base 404 such that a slight gap is necessarily produced therebetween. In the case of the embodiment, by bringing the projecting portion 413 in the circular disk shape with the member 409, the plunger 402 is stopped to move before bringing the plunger 402 and the base 404 into contact with each other.

**[0050]** The piston 410 is integrated with the plunger 402. The piston is provided with a portion 426 (bold portion) at which a sectional area orthogonal to the axis is increased at a middle portion thereof and a portion 427 at which a sectional area orthogonal to the axis is reduced at an end portion thereof. The piston 410 is inserted into a cylinder chamber portion 424 formed at a cylinder chamber member 423. The cylinder chamber portion 424 is constituted by a portion 426 (narrow portion) having a sectional area substantially equal to that of the portion 427 (slender portion) of the piston at which the sectional area orthogonal to the axis is reduced at an end portion thereof, a portion 429 (wide portion) having a sectional area substantially equal to that of the portion 426 of the piston 410 at which the sectional area orthogonal to the axis is increased, and a portion 431 of inserting a supplied lubricant storing space constituting member (supplied liquid storing space constituting member) 430. Further, a length in the axial direction of the wide portion 429 is constituted to be longer than the length in the axial direction of the bold portion 426 and the lubricant stored in spaces 434 and 440 between the piston 410 and the wide portion 429 is delivered from lubricant supply ports 432 and 433. Numeral 441 designates a check valve for preventing the supplied lubricant from flowing back. By constructing such a constitution, the lubricant can be supplied by moving the piston in either sense of the axial direction. Further, an amount of supplying the lubricant can be controlled by changing a size of the space 434 or/and a width of a relative space of axis sections of the cylinder chamber portion 424 and the piston 410.

**[0051]** Further, an end portion of the cylinder chamber portion 424 is opened with a lubricant drawing hole 435 to a drain such that by moving the piston 410 to the side of the base 404 the lubricant stored at the narrow portion 428 does not constitute a resistance when the piston 410 is moved in a direction of being remote from the base 404. Further, the lubricant from the drain is supplied to the liquid pump from a supply port 436.

**[0052]** According to the liquid pump of the embodiment, the portions filled with the lubricant by the O rings 403, 418, 437 and 438 or the like can completely be sealed hermetically from outside air and a possibility of contaminating outside by the lubricant can be restrained. Further, rocking portions of the plunger 402, the piston 410 and the like are completely filled with the lubricant and therefore, an impurity of a metal powder or the like by wear by friction can be restrained from being produced and a failure by a metal wear powder or the like can be reduced. Therefore, it is necessary to use an axial seal at the rocking portion and a failure by wear of the axial seal can also be eliminated. As an example, when the liquid pump is used as a lubricant circulating or lubricant supplying pump for a bearing or a gear portion of a vacuum pump, there can hermetically be sealed completely a portion of circulating the lubricant in vacuum including a portion of driving the pump

at which the problem of leaking the lubricant or the like has been posed in the background art and therefore, leakage of the lubricant or leakage of the atmosphere to the vacuum portion can be prevented.

**[0053]** Further, by arranging the pluralities of the cylinder chamber portions and the pistons to a single solenoid in series or in parallel, the lubricant can be supplied to a larger number of portions.

**[0054]** Next, a fourth embodiment of the invention will simply be explained in reference to Fig.6. In Fig.6, whereas in the third embodiment, the cylinder chamber and the piston are provided with two stages of wide width portions in sections orthogonal to the axis, three stages of wide width portions are constituted therefor. Further, also the lubricant drawing hole as the lubricant drain can also be made to constitute a lubricant supply port. Numeral 601 designates a cylinder chamber portion, numeral 602 designates a piston, numeral 603 designates a supplied lubricant storing space constituting member and numeral 604 designates a check valve for preventing the supplied lubricant from flowing back. By constituting in this way, lubricant supply ports 605 can be provided at six locations.

**[0055]** By further increasing a number of the stages, the lubricant can be supplied to a larger number of portions per the single solenoid. Further, also by arranging pluralities of cylinder chamber portions and pistons in parallel to per single solenoid, the lubricant can be supplied to a larger number of portions.

**[0056]** Fig.7 shows a fifth embodiment of the invention. Fig.7 shows a type of aligning a plurality of the constitutions of the third embodiment of providing two stages of the wide width portions to the cylinder chamber and the piston at sections orthogonal to the axis in series. Numeral 701 designates a cylinder chamber portion, numeral 702 designates a piston, numeral 703 designates a supplied lubricant storing space constituting member and numeral 704 designates a check valve for preventing the supplied lubricant from flowing back. By constituting in this way, lubricant supply ports 705 can be provided at six locations.

**[0057]** By further increasing a number of steps, the lubricant can be supplied to a larger number of portions per the single solenoid. Further, also by arranging pluralities of cylinder chamber portions and the pistons in parallel per the single solenoid, the lubricant can be supplied to a larger number of portions.

**[0058]** Fig.8 shows a sixth embodiment of the invention. Fig.7 shows a type in which a center portion is slender contrary to the fourth embodiment. Numeral 801 designates a cylinder chamber portion, numeral 802 designates a piston, and numeral 804 designates a check valve for preventing the supplied lubricant from flowing back. By constituting in this way, lubricant supply ports 805 can be provided at six locations. Further, by constituting such a structure, the piston is facilitated to arrange to the cylinder chamber and is facilitated to mount to the plunger, also an end portion may be sealed

by covering the end portion by a flange 803 and a simple structure can be constituted.

**[0059]** Fig.9 shows an embodiment of adapting the liquid pump according to the first embodiment of the invention to a lubricant circulating system of a vacuum pump.

**[0060]** Numeral 200 designates a screw type vacuum pump, numeral 250 designates a lubricant circulating or a lubricant supplying pump of the invention. The screw type vacuum pump 200 is provided with a pair of screw rotors 201 and 202. The screw rotors 201, 202 are contained in an exhaust side rotor containing chamber formed at inside of a housing 203. Describing in details, the screw rotor 201 is rotatably supported by the housing 203 by bearings 204 and 206, and the screw rotor 202 is rotatably supported by the housing 203 by bearings 205 and 207. Further, seals 208, 209, 210 and 211 isolate the bearings 204, 205, 206 and 207 and an exhaust chamber 210e in the housing 203, prevent the lubricant of the bearings 204, 205, 206 and 207 from leaking into the housing 203, and prevent a foreign matter from invading the bearings 204, 205, 206 and 207 from the exhaust chamber 210e of the housing 203.

**[0061]** Further, end portions on one side of the screw rotor 201 and the screw rotor 202 are fixed with timing gears 212 and 213 for rotating other of the screw rotor 201 and the screw rotor in accordance with rotation of one of the screw rotor 201 and the screw rotor 202 to be brought in mesh with each other. Further, one end portion of the screw rotor is integrally connected with a motor 214.

**[0062]** The lubricant 217 is stored to a bottom portion of a lubricant storing tank 216 in a lubricant circulating or lubricant supplying pump 218 contiguous to a gear chamber 215 containing the timing gears 212 and 213. The lubricant storing tank 216 is arranged with the lubricant circulating or lubricant supplying pump 218 according to the invention, and the lubricant is supplied to the bearings 204, 205, 206, 207 at four locations by delivering the lubricant to lubricant supply paths 221, 222, 223 and 224. Further, according to a vacuum pump having a structure in which the gear chamber and the bearing portion are brought into a vacuum state, by using a lubricant supply system capable of forming the circulating paths of the lubricant including the pump portion according to the invention into hermetically sealed spaces completely, the lubricant can be prevented from being leaked from the lubricant circulating pump drive portion to outside and the atmosphere can be prevented from leaking into the vacuum pump. Further, by using the lubricant circulating pump of the invention, an amount of supplying a liquid can easily be controlled from a small amount. Further, by constituting a structure in which the lubricant storing tank 216 is arranged on a lower side of the gear chamber 215 in a gravitational force direction and the lubricant of the gear chamber 215 is made to flow to the lubricant storing tank 216 naturally by the gravitational force, the rotating shaft and the gear are

arranged not to dip to the lubricant, thereby, a resistance by the lubricant can be eliminated to thereby save energy.

**[0063]** Further, although according to the example, an explanation has been given of the screw type vacuum pump, the invention is naturally applicable to a vacuum pump of any type needing to lubricate a bearing, a gear or the like regardless of a mechanism of vacuuming.

#### Industrial Applicability

**[0064]** As has been explained above, the liquid pump according to the invention is the liquid pump for delivering the liquid to the predetermined position of at least one location from the liquid storing portion, and is constructed by the constitution in which at least one cylinder chamber introduced with the liquid from the liquid storing portion is formed, the piston is arranged at the cylinder chamber, the cylinder chamber is formed with the liquid delivery port, and the driving means for driving the cylinder in the axial direction in the cylinder chamber by the piston is provided. Thereby, for example, a constant amount and a small amount of the lubricant necessary for a bearing, a gear or the like can firmly be supplied, heat generation at a portion to be supplied therewith can be restrained and power consumption of the apparatus can be restrained to be low.

**[0065]** The liquid pump according to the invention is inserted with the piston from one end of the cylinder chamber, and the other end portion of the cylinder chamber is arranged with the liquid delivery port. By constituting in this way, it is possible to deliver a small amount of the liquid, to finely control an amount to be delivered, stopping the liquid pump instantaneously to stop a flow of the liquid, and control to drive to deliver the liquid intermittently.

**[0066]** The liquid pump according to the invention is arranged with the pair of cylinder chambers at the both ends of the piston, the piston is inserted from one end of each cylinder, and other end of the cylinder chamber is opened with the liquid delivery port.

**[0067]** By constituting in this way, the liquid can be supplied to two locations per single piston.

**[0068]** According to the liquid pump of the invention, in the piston and the cylinder chamber, the sectional shapes and/or the lengths of the piston and the cylinder chamber are optimized in accordance with the amount of supplying the liquid. By constituting in this way, even when a frequency of operating the piston stays the same, the amount of supplying the oil can be controlled. Further, even when pluralities of the cylinder chambers and the pistons are operated by the same frequency, the amounts of supplying the oil for the respective cylinder chambers can be changed.

**[0069]** The liquid pump according to the invention is inserted with the piston at inside of the cylinder chamber, and the cylinder chamber is formed with a single or a plurality of the liquid delivery ports. By constituting in this

way, the liquid can be supplied to a plurality of portions of two portions or more per single piston.

**[0070]** The liquid pump according to the invention is constituted by a structure formed with a single or a plurality of stages of the stepped portions at the cylinder chamber, the piston is formed by a shape substantially equal to the shape of the cylinder chamber, and the liquid delivery paths are arranged at the single or the plurality of stepped portions formed at the cylinder. By constituting in this way, the liquid can be supplied to a plurality of portions of two or more portions per the single piston by a simple structure.

**[0071]** According to the liquid pump of the invention, a single or a plurality of the stepped portions of the cylinder chamber are formed substantially symmetrically in the axial direction, the piston is formed in a shape substantially equal to shapes of the substantially symmetrical stepped portions, and the liquid delivery ports are formed at the single or the plurality of respective stepped portions formed at the cylinder chamber. By constituting in this way, the liquid can be supplied to a plurality of portions of two portions or more per the single piston by a simple structure.

**[0072]** According to the liquid pump of the invention, a member for forming the single or the plurality of stepped portions substantially symmetrically is arranged at the cylinder chamber. By constituting in this way, after inserting the piston having the symmetrical stepped portions at the cylinder, the liquid pump can easily be integrated by arranging the member for forming the stepped portions substantially symmetrically.

**[0073]** According to the liquid pump of the invention, with regard to a shape of the liquid storage formed between the cylinder chamber and the piston, relative lengths in the axial direction and/or sectional areas orthogonal to the axis of the cylinder chamber and the piston are optimized in accordance with the amount of supplying the liquid. By constituting in this way, the amount of supplying the oil can be controlled even when the frequency of operating the piston is the same. Further, even when pluralities of the cylinder chambers and the pistons are operated by the same frequency, the amounts of supplying the oil at the respective cylinder chambers can be changed.

**[0074]** The liquid pump according to the invention is provided with the liquid drawing hole at the cylinder chamber. By constituting in this way, in driving the liquid stored between the end portion of the piston and the cylinder chamber by the piston, the liquid can be removed such that the piston is not prevented from being moved.

**[0075]** According to the liquid pump of the invention there are arranged a plurality of structures for forming a single or a plurality of stages of the stepped portions at the hollow portion of the cylinder chamber and gradually increasing the sectional area orthogonal to the axis of the stepped portions along the axial direction in series. By constituting such a structure, the liquid can be supplied to a plurality of portions of two portions or more per

single piston by a simple structure.

[0076] According to the liquid pump of the invention, pluralities of the pistons and the cylinder chambers are provided per single driving means. By constituting in this way, it is not necessary to provide a plurality of the driving means for moving pluralities of the pistons and the cylinder chambers and a number of parts can be reduced.

[0077] According to the liquid pump of the invention, the driving means is constituted by the solenoid including the shaft portion a total of a portion of which comprises a magnetic member and the solenoid coil which are movable relative to each other, an interval therebetween is isolated by the partition wall to thereby bring the shaft portion of the solenoid coil into a noncontact state and the shaft portion and the piston are cooperatively moved by predetermined connecting means. By constituting in this way, even when the shaft portion and the piston constituting the portion of driving the liquid pump are dipped in the liquid in a space which is hermetically sealed completely, the shaft portion and the piston can be operated by the solenoid coil in noncontact and therefore, the liquid can be prevented from leaking from the liquid piston pump. That is, by the invention, a rotating shaft as in a rotating pump is dispensed with, it is not necessary to rotate or slide the rotating shaft at the O ring or the shaft seal portion for isolating the liquid from the outside atmosphere and therefore, there is not a possibility of leaking the liquid from shaft portion or invading the lubricating path by the atmosphere when the lubricating path is in vacuum.

[0078] According to the liquid pump of the invention, as the partition wall, the partition wall comprising the nonmagnetic member is used. By constituting in this way, a magnetic field generated at the solenoid coil can be made to pass only a plunger made of a magnetic member and an attracting force between the plunger and the base can be increased.

[0079] According to the vacuum pump of the invention, the solenoid is used as driving means, further, the above-described liquid pump is used as the lubricant circulating or lubricant supplying pump, and a portion needing the lubricant and the lubricating path and an essential portion of delivering the lubricant of the lubricant circulating pump are hermetically sealed. By constituting in this way, a portion lubricated by the lubricant and the piston constituting a rocking portion of the lubricant circulating pump and a portion of driving the piston can be sealed hermetically, it is not necessary to seal the rocking or/and rotating portion and a possibility of leaking the lubricant can be reduced. Particularly, when the lubricant circulating portion is disposed in vacuum, a concern that the outer air invades from the seal of the rocking or/and rotating portion to deteriorate a degree of vacuum can be reduced as less as possible.

[0080] According to the lubricant circulating or lubricant supplying pump of the invention, in the apparatus having the rotating portion needing the lubricant for lu-

bricating a bearing or the like, there is formed the lubricant storing tank communicated with the apparatus having the rotating portion for making the lubricant flow thereto for storing the lubricant, and the lubricant circulating or lubricant supplying pump and the supply path for supplying the oil from the lubricant storing tank to a predetermined portion of the bearing, the gear or the like are arranged. By constituting in this way, the rotating shaft, the gear or the like is not dipped in the lubricant, the resistance in driving can be reduced, and conservation of energy can be achieved. As apparatus having such a constitution, there are the rotary type vacuum pump, the reduction gear and the like.

[0081] The apparatus having the rotating portion according to the invention is characterized in that the essential portion for delivering the lubricant of the lubricant circulating or lubricant supplying pump is integrally formed at inside of the lubricant storing tank. By constituting in this way, it is not necessary to provide means for supplying the oil to the lubricant circulating or lubricant supplying pump, and also a space of arranging the lubricant circulating or lubricant supplying pump can be reduced.

[0082] The apparatus having the rotating portion according to the invention is arranged at the position at which the lubricant of the apparatus in which the lubricant storing tank is provided with the rotating portion flows by the gravitational force. By constituting in this way, it is not necessary to provide complicated means for returning the lubricant to the lubricant storing tank.

[0083] The apparatus having the rotating portion according to the invention uses the liquid pump according to anyone of Claims 1 through 15 as the lubricant circulating or lubricant supplying pump. By constituting in this way, a simple structure can be constituted.

## Claims

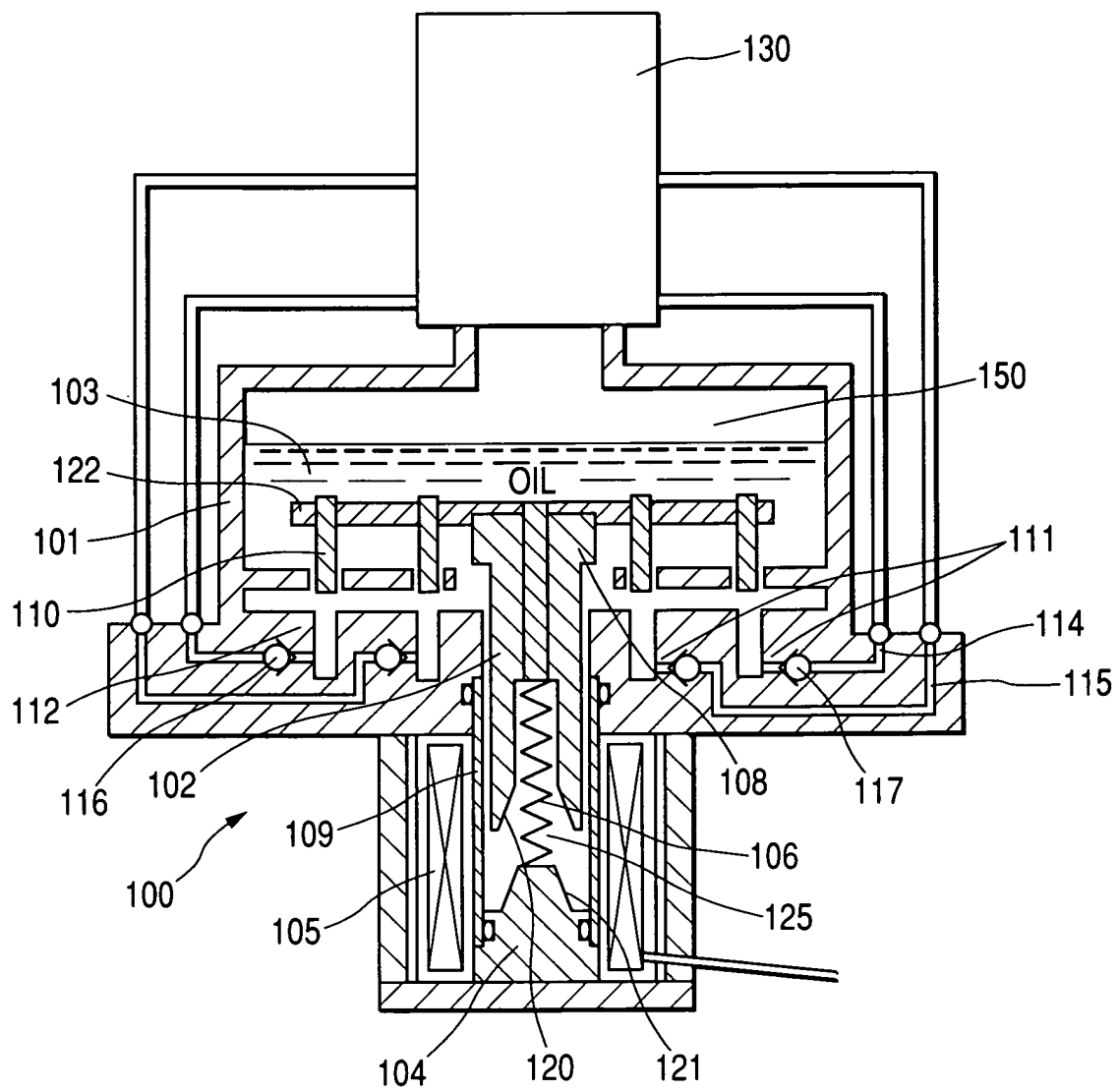
1. A liquid pump **characterized in** a liquid pump for delivering a liquid from a liquid storing portion to a predetermined position of at least one location, wherein at least a cylinder chamber for introducing the liquid from the liquid storing portion is formed, a piston is arranged at the cylinder chamber, the cylinder chamber is formed with a liquid delivery port, and the piston includes driving means for driving a cylinder in an axial direction in the cylinder chamber.
2. The liquid pump according to Claim 1, **characterized in that** the piston is inserted from one end of the cylinder chamber and other end portion of the cylinder chamber is arranged with the liquid delivery port.
3. The liquid pump according to Claim 1 or 2, **characterized in that** a pair of the cylinder chambers are arranged at both ends of the piston, the piston is

inserted from one end of each of the cylinder chambers, and other end of each of the cylinder chambers is opened with the liquid delivery port.

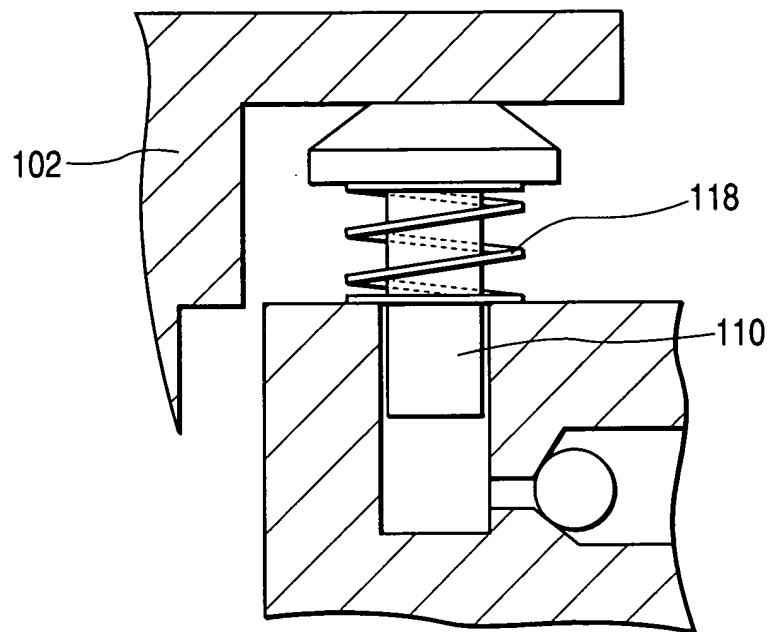
4. The liquid pump according to Claim 2 or 3, **characterized in that** sectional shapes and/or lengths of the piston and the cylinder chamber are optimized in accordance with an amount of supplying the liquid in the piston and the cylinder chamber. 5
5. The liquid pump according to Claim 1, **characterized in that** the piston is inserted into the cylinder chamber and the cylinder chamber is formed with a single or a plurality of the liquid delivery ports. 10
6. The liquid pump according to Claim 5, **characterized in that** a structure of forming a single of a plurality of stages of stepped portions at the cylinder chamber is constituted, the piston is formed by a shape to be substantially equal to a shape of the cylinder chamber, and the liquid delivery ports are arranged at the single or the plurality of respective stepped portions formed at the cylinder chamber are arranged. 15
7. The liquid pump according to Claim 6, **characterized in that** the single or the plurality of stepped portions of the cylinder chamber are formed to be substantially symmetrical in an axial direction, the piston is formed by a shape substantially equal to shapes of the substantially symmetrical stepped portions, and the single or the plurality of respective stepped portions formed at the cylinder chamber are formed with the liquid delivery ports. 20
8. The liquid pump according to Claim 7, **characterized in that** the cylinder chamber is arranged with a member for forming the single or the plurality of stepped portions substantially symmetrically. 25
9. The liquid pump according to any one of Claims 5 through 8, **characterized in that** relative lengths in the axial direction and/or sectional areas orthogonal to an axis of the cylinder chamber and the piston are optimized in accordance with an amount of supplying the liquid by a shape of a liquid storage formed between the cylinder chamber and the piston. 30
10. The liquid pump according to any one of Claims 5 through 9, **characterized in that** the cylinder chamber is provided with a liquid drawing hole. 35
11. The liquid pump according to any one of Claims 5 through 10, **characterized in that** a plurality of structures each formed with the single or the plurality of stages of stepped portions at the cylinder chamber are arranged in series. 40

12. The liquid pump according to any one of Claims 1 through 11, **characterized in that** pluralities of the pistons and the cylinder chambers are provided for single driving means. 45
13. The liquid pump according to any one of Claims 1 through 12, **characterized in that** the driving means is constituted by a solenoid including a shaft portion a total or a portion of which comprises a magnetic member and a solenoid coil capable of moving relative to each other, the shaft portion and the solenoid coil isolated by a partition wall therebetween are brought into noncontact with each other, and the shaft portion and the piston are co-operatively moved by predetermined connecting means. 50
14. The liquid pump according to Claim 13, **characterized in that** a partition wall comprising a nonmagnetic member is used for the partition wall. 55
15. A vacuum pump **characterized in that** the liquid pump according to Claim 13 or 14 is used as a lubricant circulating or a lubricant supplying pump, and a portion needing to lubricate and a lubricating path of an essential portion for delivering a lubricant of the lubricant circulating or the lubricant supplying pump are hermetically sealed.
16. An apparatus having a rotating portion **characterized in that** an apparatus having a rotating portion needing a lubricant to lubricate the rotating portion, wherein a lubricant storing tank for storing the lubricant communicating with the apparatus having the rotating portion to make the lubricant flow thereto is formed, and a lubricant circulating or a lubricant supplying pump and a supply path for supplying the oil from the lubricant storing tank to a predetermined portion needing to lubricate are arranged.
17. The apparatus having a rotating portion according to Claim 16, **characterized in that** an essential portion for delivering the lubricant of the lubricant circulating or lubricant supplying pump is integrally formed at inside of the lubricant storing tank.
18. The apparatus having a rotating portion according to Claim 16 or 17, **characterized in that** the lubricant storing tank is arranged at a position at which the lubricant of the apparatus having the rotating portion is made to flow by a gravitational force.
19. The apparatus having a rotating portion according to any one of Claims 16 through 18, **characterized in that** the liquid pump according to any one of Claims 1 through 14 is used as the pump.

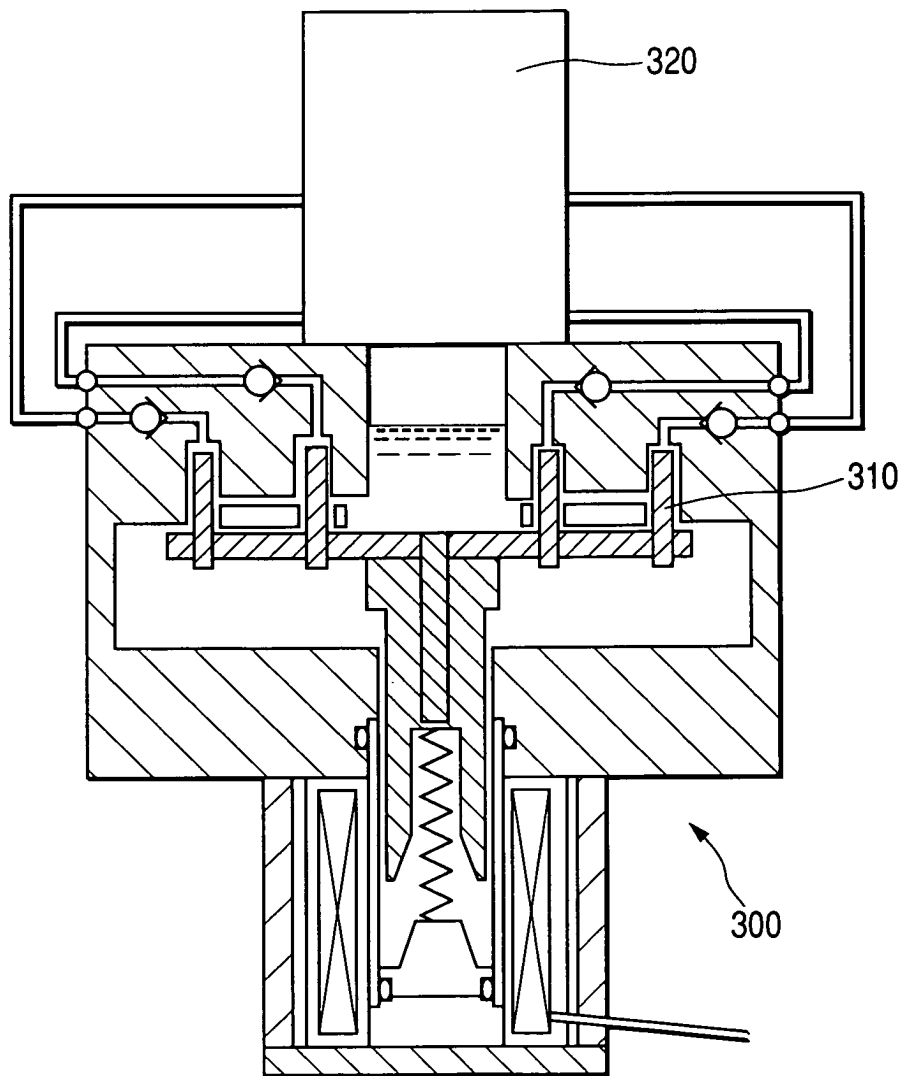
FIG. 1



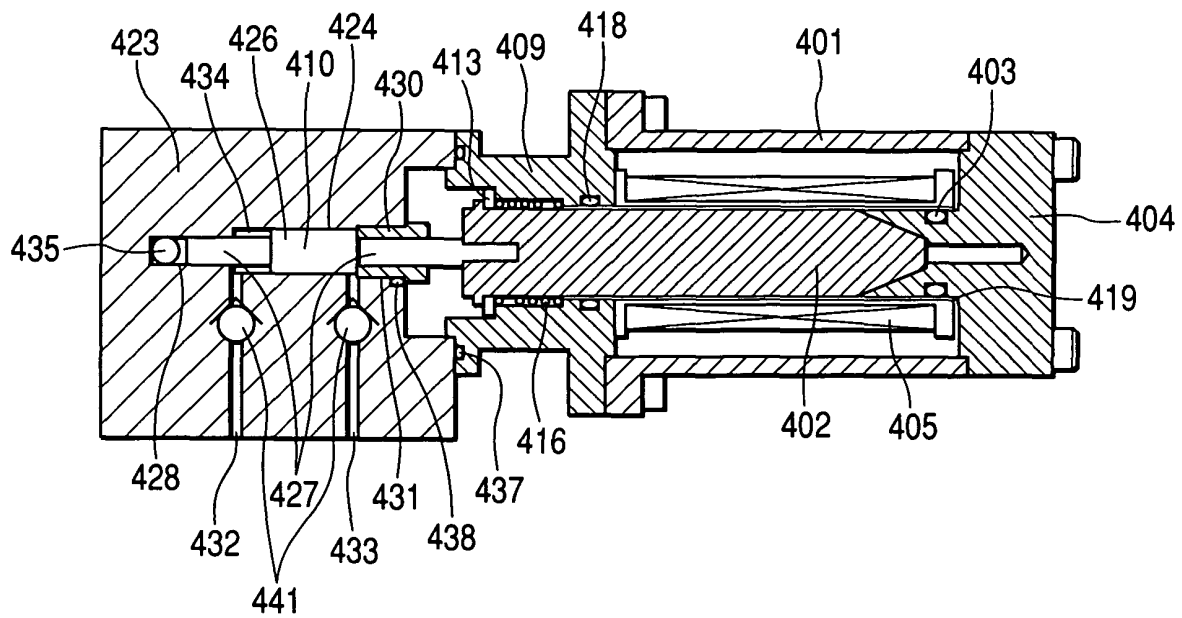
*FIG. 2*



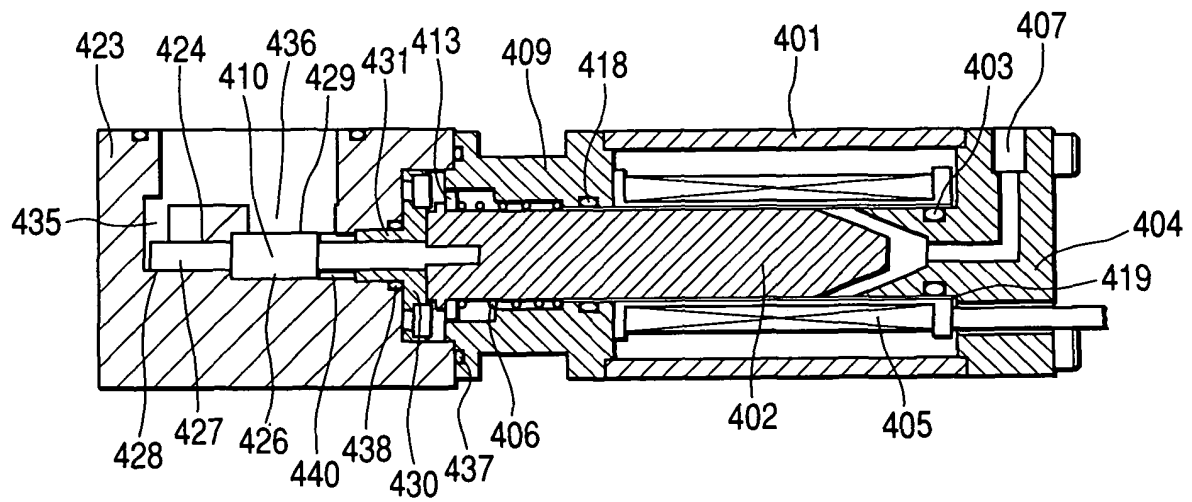
*FIG. 3*



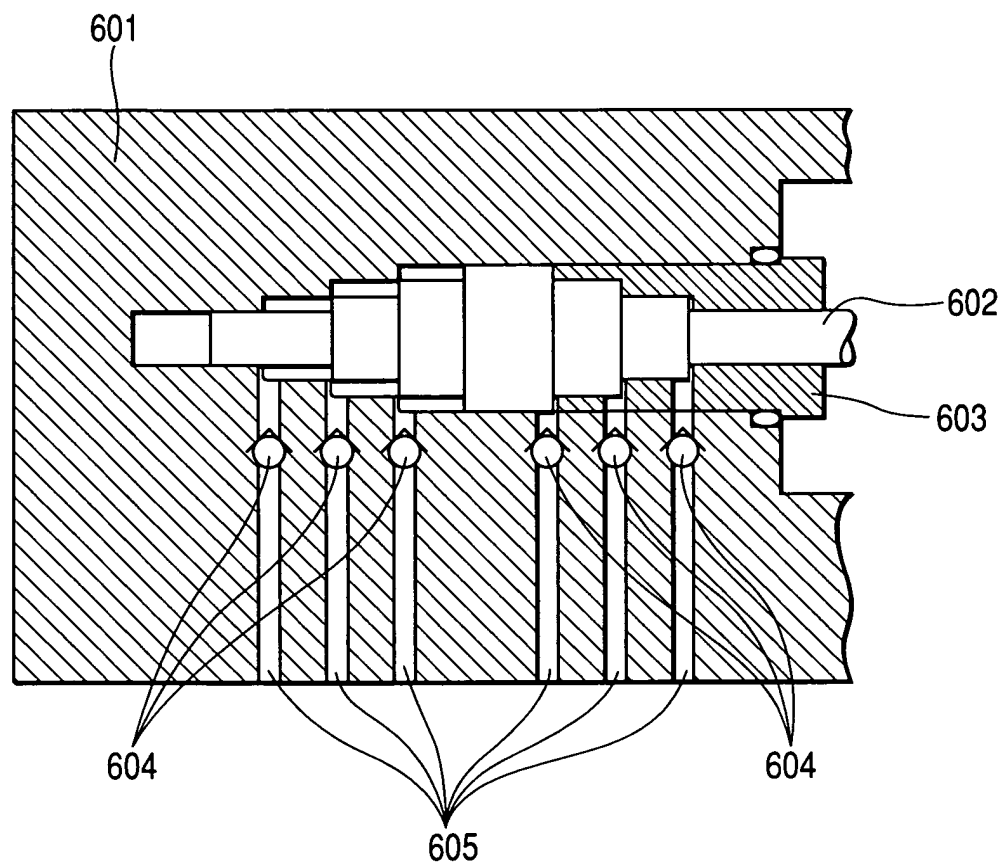
**FIG. 4**



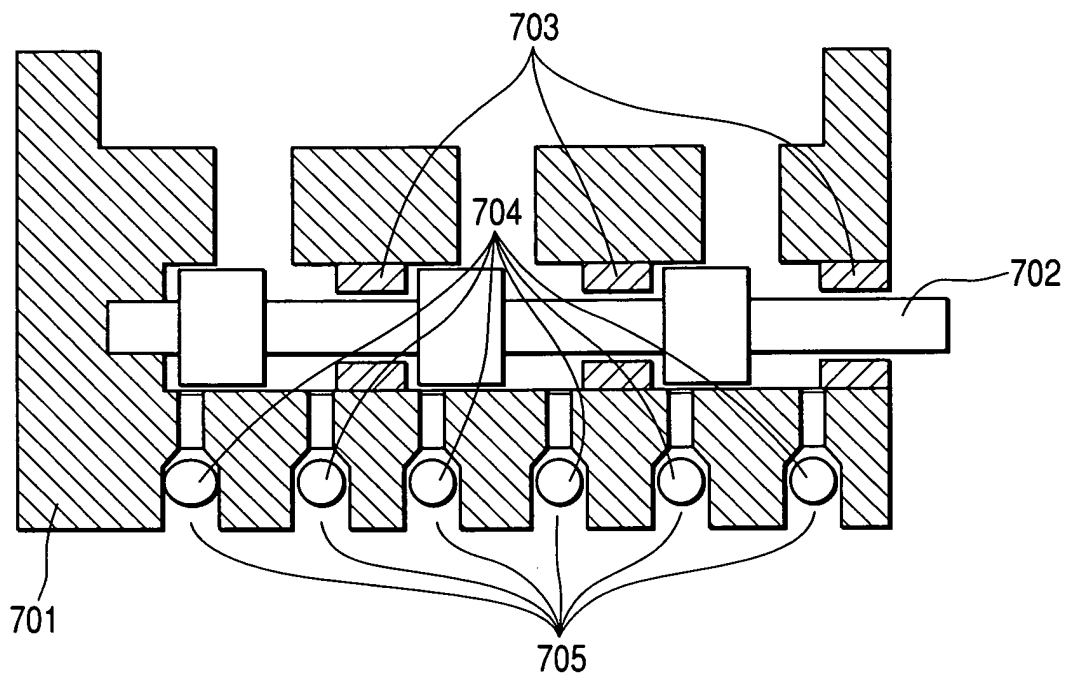
**FIG. 5**



**FIG. 6**



**FIG. 7**



**FIG. 8**

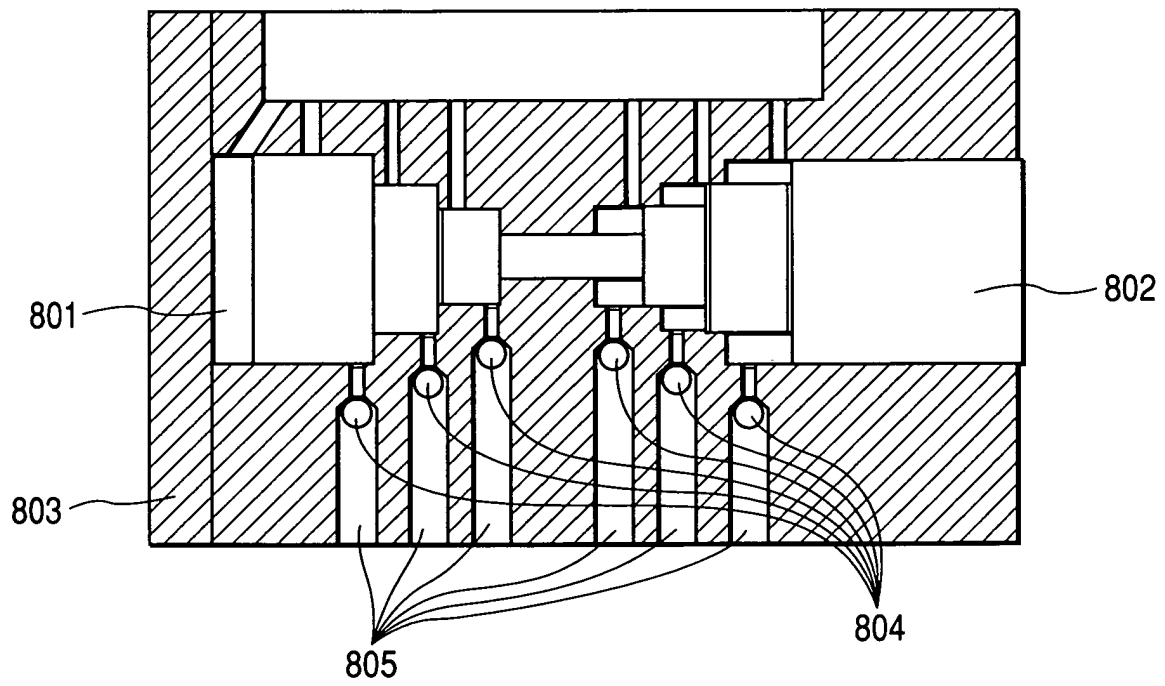
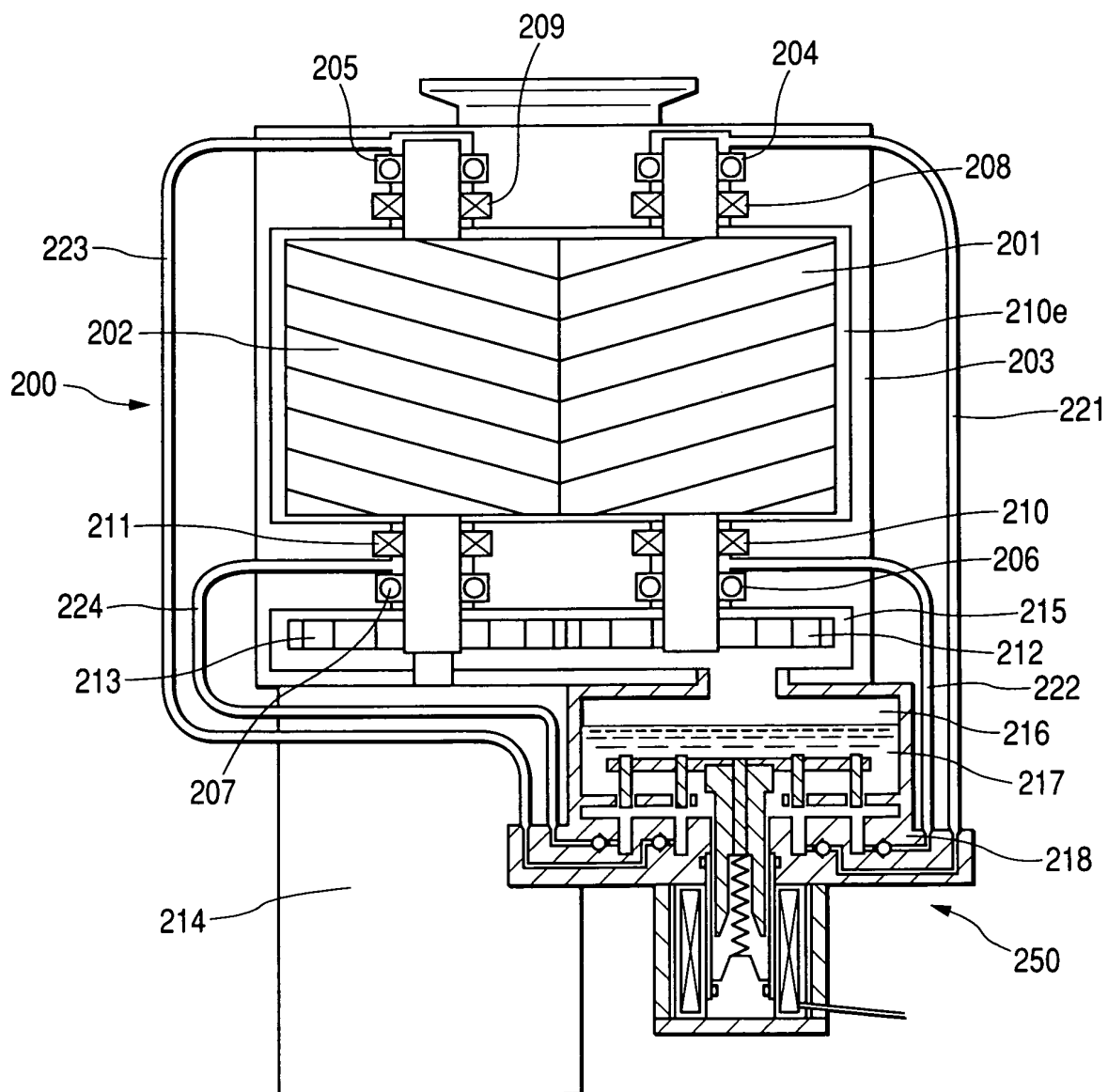
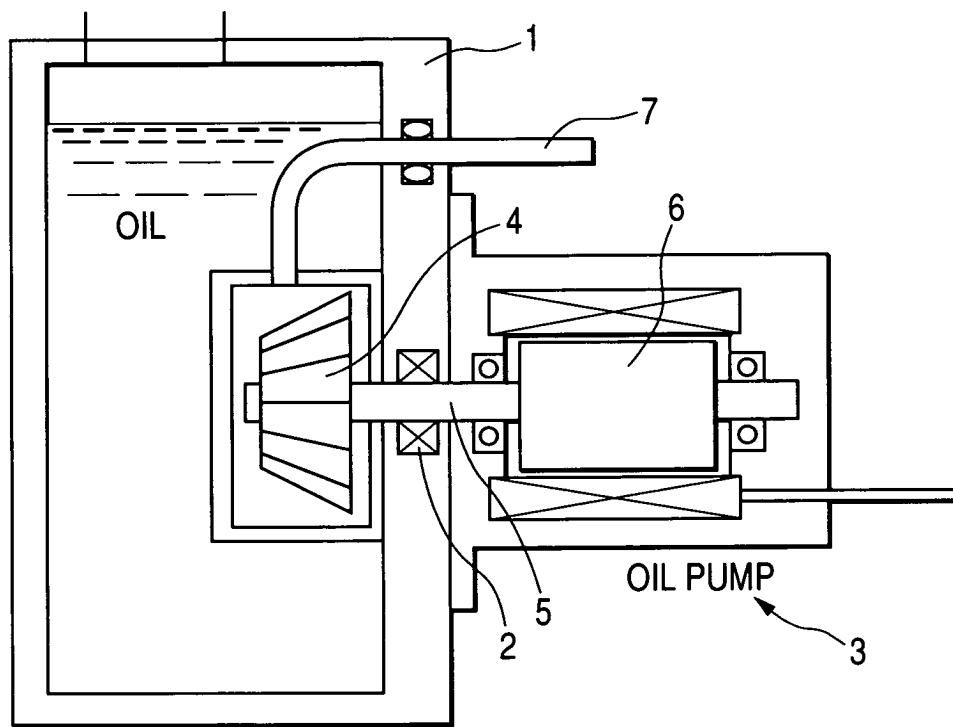


FIG. 9



*FIG. 10*



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP03/08547

| <b>A. CLASSIFICATION OF SUBJECT MATTER</b><br>Int.Cl. <sup>7</sup> F04B5/00, F04B9/00, F04B23/02                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| According to International Patent Classification (IPC) or to both national classification and IPC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>B. FIELDS SEARCHED</b><br>Minimum documentation searched (classification system followed by classification symbols)<br>Int.Cl. <sup>7</sup> F04B5/00, F04B9/00                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched<br>Jitsuyo Shinan Koho 1926-1996 Toroku Jitsuyo Shinan Koho 1994-2003<br>Kokai Jitsuyo Shinan Koho 1971-2003 Jitsuyo Shinan Toroku Koho 1996-2003                                                                                                                                                                                                                                                                                                                           |                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Category*                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Citation of document, with indication, where appropriate, of the relevant passages                                           | Relevant to claim No.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| X<br>Y                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | JP 6-49774 U (ShinMaywa Industries, Ltd., Maroru Kabushiki Kaisha),<br>08 July, 1994 (08.07.94),<br>Fig. 1<br>(Family: none) | 1-9, 11, 12<br>10, 13-15, 19                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Y                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | JP 7-238888 A (Nikkiso Co., Ltd.),<br>12 September, 1995 (12.09.95),<br>Par. No. [0015]; Figs. 1 to 3<br>(Family: none)      | 10                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| * Special categories of cited documents:<br>"A" document defining the general state of the art which is not considered to be of particular relevance<br>"E" earlier document but published on or after the international filing date<br>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)<br>"O" document referring to an oral disclosure, use, exhibition or other means<br>"P" document published prior to the international filing date but later than the priority date claimed |                                                                                                                              | "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention<br>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone<br>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art<br>"&" document member of the same patent family |
| Date of the actual completion of the international search<br>04 September, 2003 (04.09.03)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                              | Date of mailing of the international search report<br>24 September, 2003 (24.09.03)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Name and mailing address of the ISA/<br>Japanese Patent Office                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                              | Authorized officer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Facsimile No.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                              | Telephone No.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |

Form PCT/ISA/210 (second sheet) (July 1998)

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP03/08547

| C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT |                                                                                                                                                                                                                                                                                       |                       |
|-------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| Category*                                             | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                                                                                                    | Relevant to claim No. |
| Y                                                     | US 6203288 B1 (Air Products and Chemicals, Inc.),<br>20 March, 2001 (20.03.01),<br>Column 13, lines 26 to 30; Figs. 1, 2<br>& TW 444103 B & EP 1018601 A2<br>& CN 1259624 A & JP 2000-205120 a<br>& BR 9906017 A & US 6203288 B1<br>& US 6283720 B1 & JP 2002-147344 A                | 13,14                 |
| X                                                     | JP 7-217748 A (Hitachi, Ltd.),                                                                                                                                                                                                                                                        | 16-18                 |
| Y                                                     | 15 August, 1995 (15.08.95),<br>Par. Nos. [0009] to [0011]; Fig. 3<br>(Family: none)                                                                                                                                                                                                   | 15,19                 |
| X                                                     | JP 10-159780 A (Aisin Seiki Co., Ltd.),                                                                                                                                                                                                                                               | 16-18                 |
| Y                                                     | 16 June, 1998 (16.06.98),<br>Par. Nos. [0025] to [0028]; Figs. 1, 2<br>(Family: none)                                                                                                                                                                                                 | 15,19                 |
| A                                                     | US 6139288 A (Karasawa Fine Co., Ltd.),<br>31 October, 2000 (31.10.00),<br>Fig. 2<br>& WO 98/36172 A & JP 10-281056 A<br>& US 6139288 A                                                                                                                                               | 11                    |
| A                                                     | Microfilm of the specification and drawings annexed<br>to the request of Japanese Utility Model Application<br>No. 174337/1982 (Laid-open No. 79568/1984)<br>(Miwa Seiki Kabushiki Kaisha),<br>29 May, 1984 (29.05.84),<br>Page 6, line 5 to page 7, line 5; Fig. 1<br>(Family: none) | 10                    |
| A                                                     | JP 10-220345 A (Hidekazu ITO),<br>18 August, 1998 (18.08.98),<br>Par. No. [0026]; Fig. 1<br>(Family: none)                                                                                                                                                                            | 10                    |
| A                                                     | JP 64-15506 A (Aisei Seiki Kabushiki Kaisha),<br>19 January, 1989 (19.01.89),<br>Fig. 8<br>(Family: none)                                                                                                                                                                             | 4,9                   |
| A                                                     | US 4145165 A (California Institute of<br>Technology),<br>20 March, 1979 (20.03.79),<br>Fig. 1<br>& US 4276003 A                                                                                                                                                                       | 13                    |

Form PCT/ISA/210 (continuation of second sheet) (July 1998)