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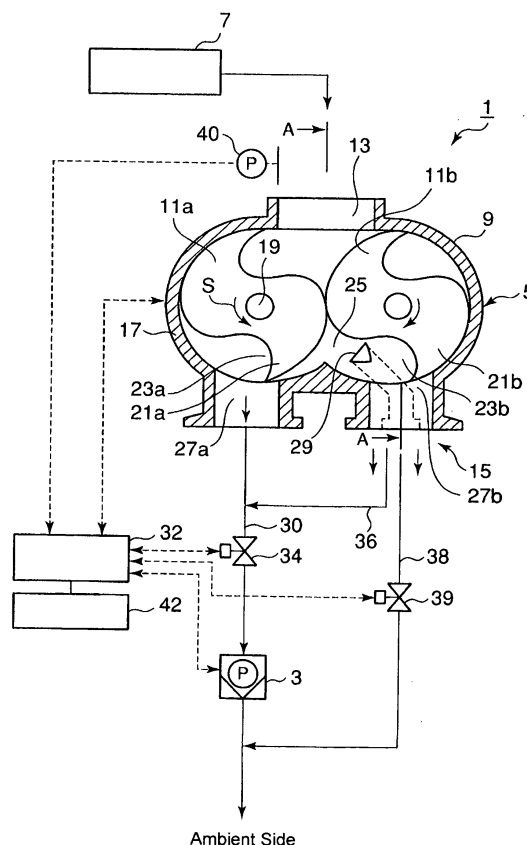
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(54) **Evacuation apparatus**

(57) The present invention proposes an evacuation apparatus including a mechanical booster pump (5), a back pump (3) placed at a down-stream side of the mechanical booster pump in series, the booster pump (5) having discharge openings (27a and 27b) for discharging a low compression gas and a discharge opening (29) for discharging a high compression gas, and, in a stage where gas-discharging is started, the gas is discharged toward the ambient side only through the discharge opening (29) for discharging a high compression gas with the operation of the mechanical booster pump and, in a stage where the discharged gas pressure reaches afterward a medium vacuum, the back pump starts operation and the gas is sent to the back pump only through the discharge openings (27a and 27b) for discharging a low compression gas.

FIG. 1



Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to an evacuation apparatus for evacuating a tank, a chamber, and the like, provided with a mechanical vacuum booster pump and an back pump which is placed at a down-stream side of the mechanical vacuum booster pump in series.

Description of the Related Art

[0002] In order to realize a vacuum inside a tank, a chamber and the like, with a rapid pumping speed, a mechanical booster pump for vacuums is conventionally utilized at an up-stream side (a vacuum side) of a vacuum pump (a back pump) with a lower pumping speed. As for the mechanical booster pump, Roots type vacuum pumps 021 are generally applied which perform compression/discharge works by rotating pairs of Roots type vanes 020 as shown in Fig.5. And it is known that the back pump realizes several times of a maximum pumping speed by the use of the mechanical booster pump.

[0003] However, even though the mechanical booster pump feeds a large amount of gas into the back pump provided at the down-stream side, i.e. at the ambient side, an improvement in the pumping speed during an operation in the vicinity around an ambient pressure is not so great, because of the limited pumping speed of the whole apparatus due to the limited discharging-capacity of the back pump.

[0004] That is, as the relation between an pumping speed and a pressure in Fig.3 shows, at the beginning of feeding the gas with the booster pump under an ambient pressure, the pumping speed of the whole apparatus is not improved so effectively with the assistance of the mechanical booster pump because of the limited discharging-capacity intrinsic to the back pump. The improvement effect is obtained as vacuum degree becomes high, but not obtained over a whole pressure range.

[0005] On the other hand, for instance, Japanese granted utility model No. JP/7-19554 (hereafter, referred to as reference 1) discloses an application; wherein a booster pump like a mechanical booster pump is provided at the up-stream side of a vacuum pump; and wherein gas discharge is performed by the two stage vacuum pumps placed in series.

[0006] In the technology of the reference 1, as quoted in Fig. 6, a preliminary discharge line (passage) A and a main discharge line (passage) B start from the inside of a chamber and are connected to each other. The preliminary discharge line A is provided with a stop valve 03a and a butterfly valve 04 in series and connected to a preliminary pump 01. The main discharge line B is provide with stop valves 03b1, 03b2 and a discharge pump 02. According to the constitution, a main discharge (evac-

uating) is performed through the preliminary pump 01 and the discharge pump 02 by closing the stop valve 03a and the butterfly valve 04 and opening the stop valves 03b1, 03b2 and the discharge pump 02.

5 [0007] In addition, as an example of vacuum pumps installed in two stages, a constitution is disclosed as quoted in Fig. 7 in which a booster pump 012 is connected to an intermediate stage of a dry vacuum pump 10 of a multi-stage type or the last stage of the vacuum pump 10 so that the reduction of power consumption is aimed at (Patent reference 2; JP: 2003-155988,A).

10 [0008] However, according to the patent literature 1, since only the preliminary pump 01 discharges gas when the preliminary discharge is performed, an improved pumping speed cannot be expected. Although the preliminary pump 01 and the discharge pump 02 discharge gas in two stages when the main discharge is operated, the operation control with regard to the discharge pump 02 is not disclosed in the patent literature 1. Therefore, the technology of the reference leaves a problem on how to improve a pumping speed, not only over the pressure range from an ambient pressure to a low vacuum but also over the whole pressure range from a low vacuum to a high vacuum.

20 [0009] In addition, the booster pump 012 in the patent literature 2 aims at the reduction of power consumption necessary for driving the dry vacuum pump 010. Improving the pumping speed is not mentioned in the patent literature 2.

SUMMARY OF THE INVENTION

30 [0010] In view of the above-stated background, a purpose of the present invention is to realize an evacuation apparatus for evacuating a tank, a chamber, and the like, which are provided with a mechanical vacuum booster pump and an back pump placed at the down-stream side of the mechanical booster pump in series, so as to increase the pumping speeds over a pressure range from an ambient pressure to a low vacuum, thereby improving the pumping speed over the whole pressure range from an ambient pressure to a high vacuum.

35 [0011] In order to achieve the above-mentioned purpose, the present invention is proposes an evacuation apparatus for evacuating a tank, a chamber and the like, including a mechanical booster pump, an back pump placed at a down-stream side of the mechanical booster pump in series, and a controller for controlling operation of the apparatus; in which the mechanical booster pump has a discharge opening for discharging a low compression gas, through which lowly-compressed gas with low compression ratio on a part way of compression in the booster pump is emitted, and a discharge opening for discharging a high compression gas, through which highly-compressed gas with high compression ratio is emitted; and the controller controls so that, in a stage where gas-discharging is started, the gas is discharged toward the ambient side through the discharge opening for dis-

charging a high compression gas with the operation of the mechanical booster pump and, in a stage where the discharged gas pressure reaches afterward a medium vacuum, the back pump starts operation and the gas is sent to the back pump through the discharge opening for discharging a low compression gas.

[0012] According to the above-mentioned embodiment, in the beginning of discharging gas, the gas is discharged toward the ambient side (outside) through the discharge opening for discharging a high compression gas by operating the mechanical booster pump. In this way, the gas of an ambient pressure level in the tank is compressed with a high compression ratio and is discharged directly outside. Since the gas is sent outside without the influence of the back pump, it becomes possible to improve pumping speeds without introducing large back pump of higher discharging capacity so as to secure higher pumping speeds.

[0013] Further, since a pumping speed of the booster pump is higher in comparison with that of the back pump, it is possible to discharge gas, maintaining the pumping speed in the beginning when the pressure is an ambient pressure. In the first place, it becomes possible to improve pumping speeds in a range from an ambient pressure to a low vacuum.

[0014] When achieving a medium vacuum, which is attainable by means of discharging through the discharge opening for discharging a high compression gas of the mechanical booster pump, then the gas of the medium vacuum is fed from the discharge opening(s) for discharging low compression gas to the back pump, while the back pump is started. Thus, the gas of vacuum state to some extent is fed to the back pump from the discharge opening(s) for discharging a low compression gas. Because of the gas-pressurizing/flow-increasing function of the mechanical booster pump, the pumping speeds of the back pump are enhanced and the enhanced pumping speeds are maintained, thereby a high vacuum is realized.

[0015] Therefore, it becomes possible to improve the pumping speeds not only in the range from an ambient pressure to a low vacuum but also over a whole range from an ambient pressure to a high vacuum.

[0016] According to another embodiment of the present invention, preferably the controller recognizes the accomplishment of the medium vacuum by means of an elapsed time signal from a timer.

[0017] In the above embodiment, the controller automatically controls the operation of the back pump feeds by such construction that the discharged gas is supplied through the discharge opening(s) for discharging a low compression gas to the back pump as well as the back pump is driven. Here, since the control is performed based not on a signal from a pressure sensor but on an elapsed time signal from a timer, risks of malfunction and/or deterioration about pressure sensor are eliminated. Thus, highly reliable control realized.

[0018] According a preferable embodiment of the

present invention, the mechanical booster pump is a vacuum pump of a claw type, in which the discharge opening for discharging a high compression gas is located at a wall of the pump casing, the wall being in a plane vertical to the axes of the pump rotors, while the discharge opening for discharging a high compression gas faces the compression space, being located in a plane parallel to the plane containing both rotation axes of the pump rotors.

[0019] The above embodiment realizes a booster pump provided with the discharge opening for discharging a high compression gas and the discharge opening for discharging a low compression gas, in which the discharge opening for discharging a high compression gas is located at the wall of the pump casing so as to face the compression space, the wall being in a plane vertical to the axes of the pump rotors, and the discharge opening for discharging a low compression gas is located, on a side-wall-surface of the pump casing, in a plane parallel to the plane containing both rotation axes of the pump rotors.

[0020] The present invention realizes an evacuation apparatus for evacuating a tank, a chamber and the like, comprising a mechanical booster pump and a back pump placed at the down-stream side of the mechanical booster pump in series, which can improve the pumping speeds over a whole range from an ambient pressure to a high vacuum by increasing the pumping speed in the range from an ambient pressure to a low vacuum

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The present invention will now be described in greater detail with reference to the preferred embodiments of the invention and the accompanying drawings, wherein:

FIG. 1 shows a whole constitution of a first embodiment of the present invention;

FIG. 2 shows a view of the A-A cross-section in Fig. 1; FIG. 3 illustrates a characteristic of pumping speeds to vacuums;

FIG. 4 illustrates a time chart, in which (a) illustrates that of a mechanical booster pump; (b) illustrates that of an back pump; (c) illustrates that of a first open/close valve; (d) illustrates that of a second open/close valve;

FIG. 5 shows an explanation of a Roots-type vacuum pump;

FIG. 6 is a drawing for explaining a conventional technology; and

FIG. 7 is also a drawing for explaining a conventional technology.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0022] Hereafter, the present invention will be de-

scribed in detail with reference to the embodiments shown in the figures. However, the dimensions, materials, shape, the relative placement and so on of a component described in these embodiments shall be only for explanation and shall not be construed as limiting the scope of the invention thereto, unless any specific mention is placed.

[0023] FIG. 1 shows a whole constitution of the embodiment of the present invention and FIG. 2 shows a view of the A-A cross-section in Fig. 1.

[0024] As shown in Fig. 1, an evacuation apparatus 1 is equipped with a back pump 3 and a mechanical vacuum booster pump 5 which is provided at the up-stream side of the back pump 3 so that a vacuum tank 7 is evacuated by running both of the pumps 3 and 5.

[0025] The mechanical vacuum booster pump 5 is of a claw type vacuum pump 9, comprising of a pair of pump rotors 11a and 11b, a gas suction port 13, and a gas discharge port 15. The mechanical booster pump 5 further comprise a pump casing 17 (a housing) where the pair of pump rotors 11a and 11b are built-in, and a rotating mechanism by which the pump rotors 11a and 11b are rotated around shafts 19 by transferring powers from a motor (not shown) as a power source to the rotors. In addition, the type of the back pump 3 is not limited to a Roots-type and can be any other type of vacuum pumps such as a claw type, a screw type, a gear type and so on.

[0026] While the above-mentioned rotating mechanism makes the pump rotors 11a and 11b rotate in a reverse direction each other (as shown with the arrow S in Fig. 1), gas suction and gas discharge are carried out by utilizing volumetric changes of the sealed spaces environed with the pump casing 17 and the pump rotors 11a and 11b.

[0027] The pump rotors 11a and 11b have protrusive parts 21a and 21b like a claw (a nail of raptorial birds) respectively. And the protrusive parts 21a and 21b fit into counter-depressed parts 23b and 23a respectively. Thus, the fitting space forms a compression space 25.

[0028] The gas discharge port 15 has two openings, namely, a discharge opening for discharging a low compression gas (hereafter, referred to as DOLC) 27 and a discharge opening for discharging a high compression gas (hereafter, referred to as DOHC) 29. The DOLC 27 discharges the gas compressed within the mechanical booster pump at a stage of a lower compression ratio, while the DOHC 29 discharges the gas when a stage of a higher compression ratio is realized. In addition, the DOLC 27 is placed so that the gas sucked through the gas suction port 13 is discharged before the gas is compressed into a compression space 25 formed by the pump rotors 11a and 11b. Further, the DOLC 27 is comprised of a first discharge opening for discharging a low compression gas 27a corresponding to the pump rotor 11a and a second discharge opening for discharging a low compression gas 27b corresponding to the pump rotor 11b.

[0029] In addition, while the cross-sectional area of the

first discharge opening for discharging a low compression gas 27a is the same as that of the second discharge opening for discharging a low compression gas 27b, the cross-sectional area of these openings is formed more greatly than the cross-sectional area of the DOHC 29.

[0030] As shown in Fig. 2, the DOHC 29 is located at the wall of the pump casing 17, the wall being in a plane vertical to the axes of the pump rotors 11a and 11b, while the DOHC 29 faces the compression space 25 so as to discharge highly compressed gas.

[0031] Moreover, as shown in Fig. 2, the gas suction port 13 is located, on one side-wall-surface of the pump casing 17, in a plane parallel to the plane containing both the rotation axes of the pump rotors 11a and 11b, while the first and second discharge openings for low compression 27a and 27b are located, on another side-wall-surface of the pump casing 17, in a plane parallel to the plane containing both the rotation axes of the pump rotors 11a and 11b.

[0032] Thus, by forming a discharge port on a casing-wall-surface vertical to the axes of the pump rotors 11a and 11b and on a casing-wall-surface parallel to the plane containing both axes of the pump rotors 11a and 11b, a mechanical booster pump 5 provided with a DOHC 29 and a DOLC 27 can be composed.

[0033] On a first low compression discharge passage 30 which communicatively connects the first discharge opening for discharging a low compression gas 27a and the back pump 3, is provided an first open/close valve 34 controlled by the a controller 32. On the other hand, a second low compression discharge passage 36, which feeds the gas through the second discharge opening for discharging a low compression gas 27b, is joined together with the first low compression discharge passage 30 at the up-stream side of the valve 34, so that the gas through the second discharge opening for low compression 27b flows into the first low compression discharge passage 30. Moreover, a high compression discharge passage 38 is joined together with the passage 30 at the down-stream side of the valve 34, so that the gas through the discharge opening for discharging a high compression gas 29 flows into the passage 30. In addition, on the line of the passage 38, is provided a second open/close valve 39, the opening/closing of which is controlled by the controller 32.

[0034] Here, an explanation as to the controller 32 will be given. Pressure signals from the vacuum tank 7 or inlet pressure signals from the mechanical booster pump 5 are inputted into a controller 32 via a pressure sensor 40, and elapsed-time signals are inputted into the controller 32 from a timer 42.

[0035] At the beginning of gas discharging, the first open/close valve 34 is to be closed, the second open/close valve 39 is to be opened, the back pump 3 is to be stopped so that only the mechanical booster pump 5 is to be run. Thus, the discharged gas from the first discharge opening for discharging a low compression gas 27a and the second discharge opening for discharging

a low compression gas 27b is shut, and the discharged gas from the DOHC 29 is fed directly outside through the high compression discharge passage 38.

[0036] At the above-mentioned operation stage of discharging gas through the high compression discharge passage 38, the gas of an ambient pressure inside the tank is discharged directly outside after being compressed with a high compression ratio. Since the gas is discharged directly outside without passing through the back pump 3, namely without being influenced by the back pump 3, for example, it becomes possible to discharge gas without choosing an back pump 3 of larger capacity so as to obtain a higher pumping speed.

[0037] Moreover, the pumping speed of the mechanical booster pump 5 is adopted so that the pumping speed exceeds that of the back pump 3. Therefore, the gas is discharged without deterioration of the pumping speed of the mechanical booster pump 5, therefore the pumping speed is not lowered substantially from an original pumping speed at the beginning of gas-discharging.

[0038] At the above operation stage of discharging gas just through the high compression discharge passage 38, as shown in Fig. 3, the gas discharging is performed with a pumping speed over the pumping speed of the back pump 3, which is indicated as Q, then the gas pressure is lowered from an ambient pressure P0 to a medium vacuum P1.

[0039] In a second stage, the controller 32 opens the first open/close valve 34, closes the second open/close valve 39, and makes the back pump 3 start, when the controller judges, by an input signal from the pressure sensor 40, that a predetermined medium vacuum P1 is reached.

[0040] By the above method, the gas discharged through the first discharge opening for discharging a low compression gas 27a and the second discharge opening for discharging a low compression gas 27b is fed to the back pump 3.

[0041] By means of feeding a gas of a medium vacuum P1 (of the tank) toward the back pump 3 through the first discharge opening for discharging a low compression gas 27a and the second discharge opening for discharging a low compression gas 27b, it becomes possible for the gas of the medium vacuum P1 to reach a high vacuum without deterioration of pumping speeds because of a boosting function of the mechanical booster pump 5 as well as a compression function of the back pump 3.

[0042] Fig. 4(a)-(d) show the on/off timings as to the mechanical booster pump 5, the back pump 3, the first open/close valve 34 and the second open/close valve 39, respectively. At a time t0 in the beginning of discharging gas, the mechanical booster pump 5, the back pump 3, the first open/close valve 34, and the second open/close valve 39 are under a condition of ON, OFF, CLOSE, and OPEN respectively. Under such condition, the gas discharged through the discharge opening for discharging a high compression gas 29 is sent directly outside through the high compression discharge passage 38.

Thereafter, at a time t1 when the pressure P1, which can be attained by a gas-feeding through the discharge opening for discharging a high compression gas 29 of the mechanical booster pump 5, is achieved, the mechanical booster pump 5, the back pump 3, the first open/close valve 34, and the second open/close valve 39 are placed under a condition of ON, ON, OPEN, and CLOSE respectively. Thus, the discharged gas from the first discharge opening for discharging a low compression gas 27a and the second discharge opening for discharging a low compression gas 27b is sent to the back pump 3.

[0043] An above-described embodiment of the present invention makes it possible to improve a pumping speed in a range of a low vacuum around an ambient pressure and to achieve a high vacuum without deterioration of pumping speeds even when the back pump 3 is of small size and of small discharge capacity. Further, it becomes possible to improve pumping speeds over the whole pressure range from an ambient pressure to a high vacuum.

[Second Embodiment]

[0044] Then, an explanation on a second embodiment will be given.

[0045] In this second embodiment, an elapsed time signal from a timer 42, instead of a pressure signal from a pressure sensor 40, switches an on/off condition of the pumps 5 and 3 as well as an open/close condition of the open/close valve 34 and 39.

[0046] A time t1, which is the time required for the pressure P0 to decrease until the pressure P1 (a medium vacuum), is to be predetermined by calculation based on the conditions such as the volume of the vacuum tank 7, the discharging capacity of the compression space 25 of the mechanical booster pump 5, the specific operation factors of the mechanical booster pump 5, ambient temperatures and so on.

[0047] When the controller, by means of a signal from the timer 42, recognizes that the time t1 has passed through the time t0, the controller controls the conditions such that the mechanical booster pump 5 is under ON state, the back pump 3 is under ON state, the first open/close valve 34 is under OPEN state, and the second open/close valve 39 is under CLOSED state. Thus, it becomes possible to achieve a high vacuum via a medium vacuum P1 without deterioration of pumping speeds.

[0048] The second embodiment, as well as the first embodiment, makes it possible to increase a pumping speed in a range from an ambient pressure to a low vacuum resulting in that the pumping speed is improved over a whole range from an ambient pressure to a high vacuum.

[0049] Moreover, in a case of using the pressure sensor 40, there is a risk of clogging and/or deterioration of the sensor 40 because of dust, refuse particles, or water droplet in the vacuum tank 7 or gas passages, thereby causing incorrect pressure detection. On the other hand,

in case of using the timer 42, there is no risk of such detection failure or deterioration. Therefore, highly reliable control can be performed.

[0050] In addition, in the first and second embodiments described above, it is explained that the controller 32 automatically opens and closes the first open/close valve 34 and the second open/close valve 39. However, as a matter of course, operators can manually open and closes the valves 34 and 39, based on their own judgment as to the values detected by the pressure sensor 40.

[0051] As for the mechanical booster pump 5, the explanation was given in consideration that the mechanical booster pump 5 is of a claw type vacuum pump 9. However, it goes without saying that the mechanical booster pump 5 can be of a Roots type pump or of a screw type pump other than of a claw type pump, so long as the mechanical booster pump 5 is provided with the DOLC 27 which discharges the gas of low compression ratio and the DOHC 29 which discharges the gas of high compression ratio.

[0052] Moreover, it should be noted that the explanation was given in consideration that the gas as a medium is any one of general gases including a specific gas such as air.

[0053] Since the present invention makes it possible to increase pumping speeds in a range from an ambient pressure to a low vacuum so as to improve the speed in a whole range from an ambient pressure to a high vacuum, the present invention can be usefully applied to evacuation apparatuses for evacuating a tank, a chamber and the like, which is provided with a booster pump and a back pump provided in an ambient side at the downstream side of the booster pump in series.

Claims

1. An evacuation apparatus for evacuating a tank, a chamber and the like, comprising a mechanical booster pump, a back pump placed at a downstream side of the mechanical booster pump in series, and a controller for controlling operation of the apparatus; wherein the mechanical booster pump has at least one discharge opening for discharging a low compression gas, through which lowly-compressed gas with low compression ratio on a part way of compression in the booster pump is emitted, and a discharge opening for discharging a high compression gas, through which highly-compressed gas with high compression ratio is emitted; and wherein the controller controls so that, in a stage where gas-discharging is started, the gas is discharged toward the ambient side through the discharge opening for discharging a high compression gas with the operation of the mechanical booster pump and, in a stage where the discharged gas pressure reaches afterward a medium vacuum, the back pump starts operation and the gas is sent to the back

pump through the discharge openings for discharging a low compression gas.

2. An evacuation apparatus according to claim 1, wherein the controller recognizes the medium vacuum attained by means of an elapsed time detected by a timer.
3. An evacuation apparatus according to claim 1, wherein the mechanical booster pump is a vacuum pump of a claw type, in which the discharge opening for discharging a high compression gas is located at a wall of the pump casing, the wall being in a plane vertical to the axes of the pump rotors, while the discharge opening for discharging a high compression gas faces the compression space, being located in a plane parallel to the plane containing both rotation axes of the pump rotors.

FIG. 1

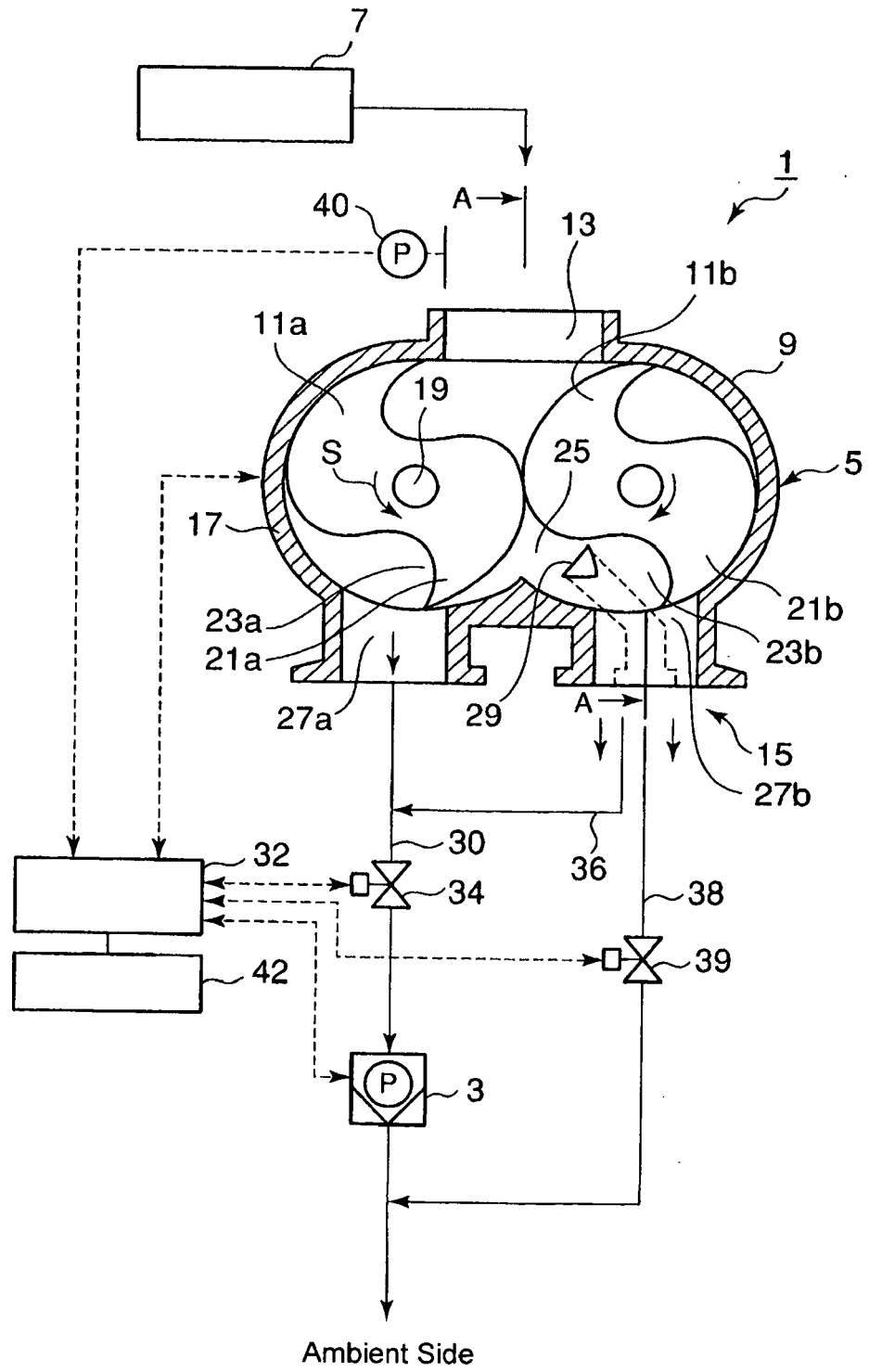


FIG. 2

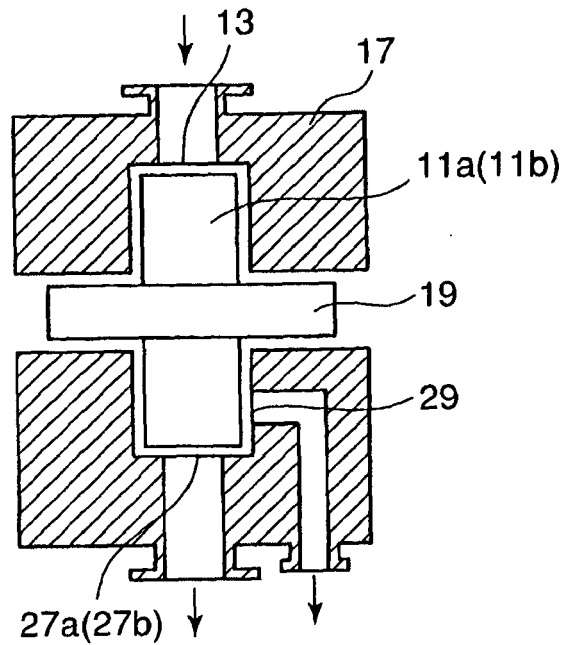


FIG. 3

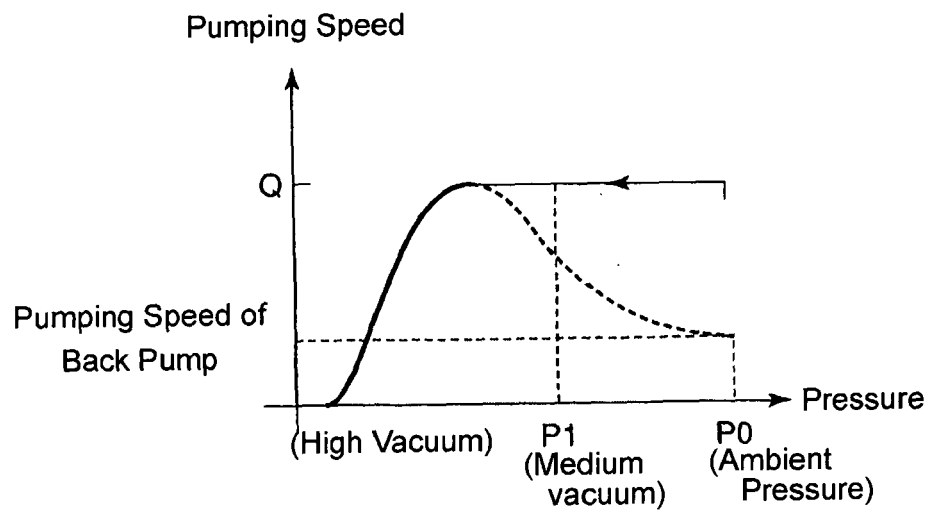


FIG. 4

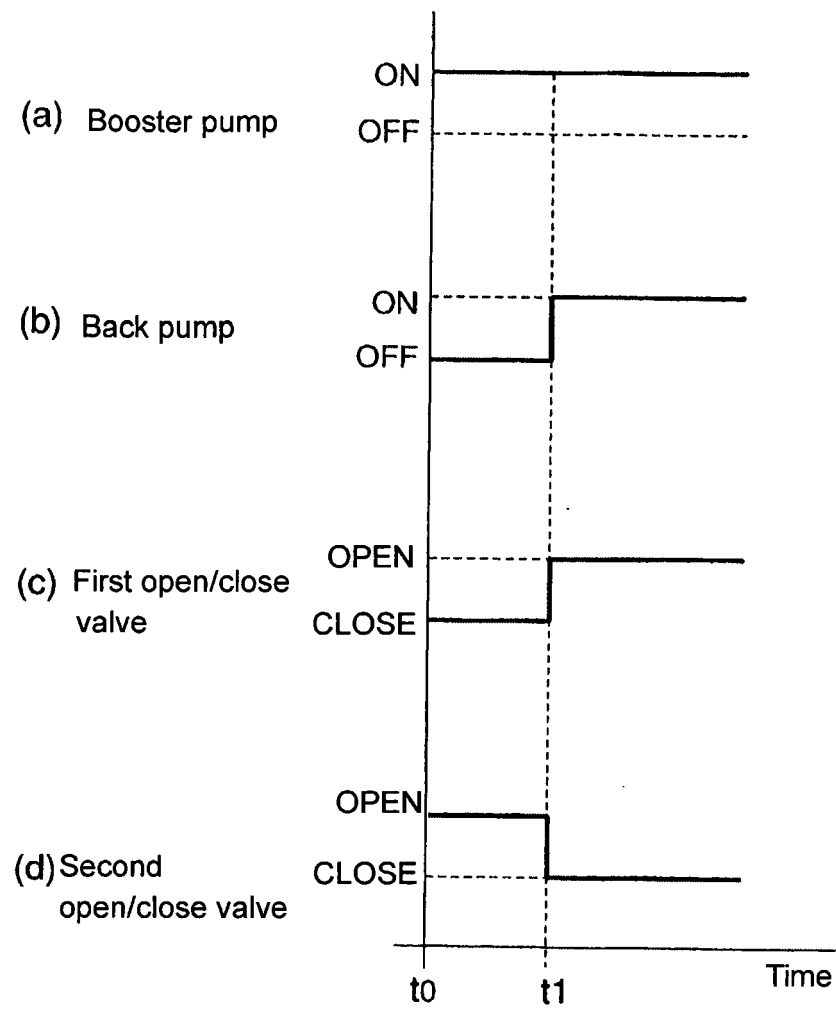


FIG. 5

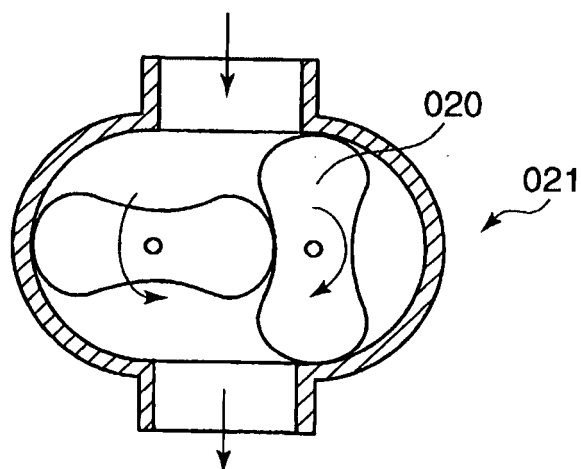


FIG. 6

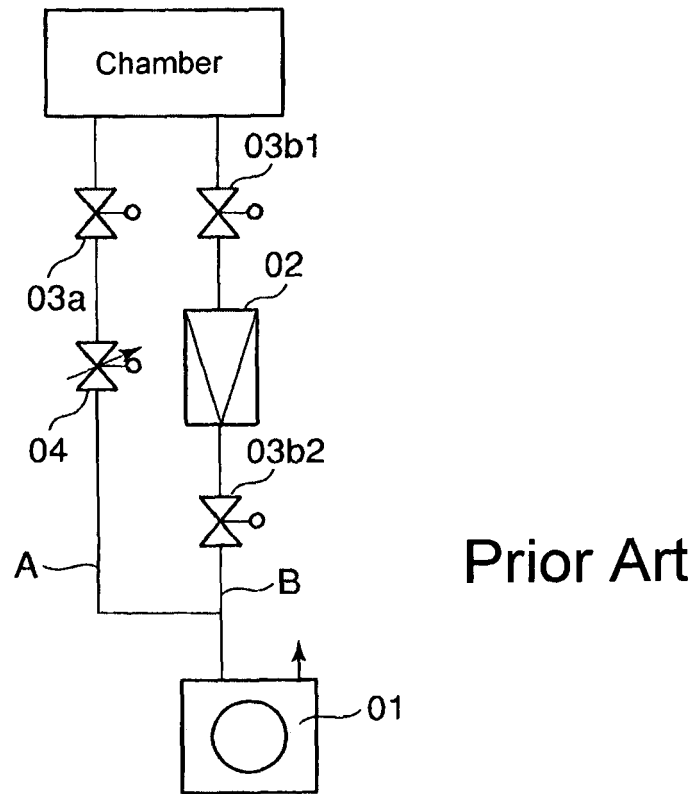
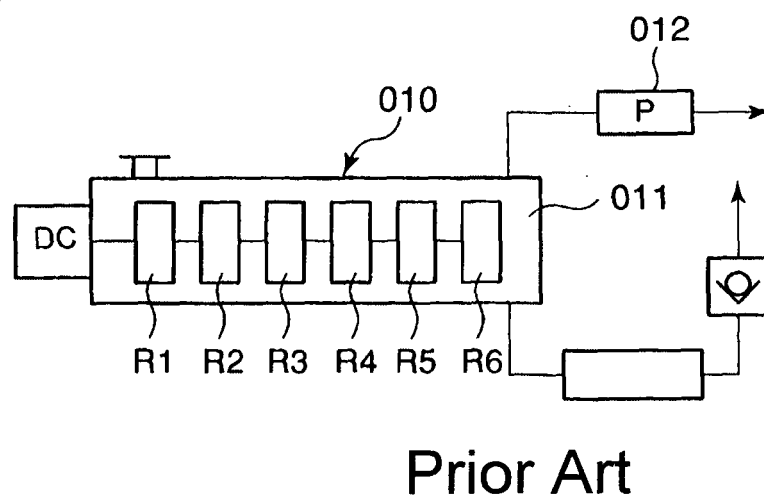


FIG. 7





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 07 01 8944

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 07 01 8944

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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