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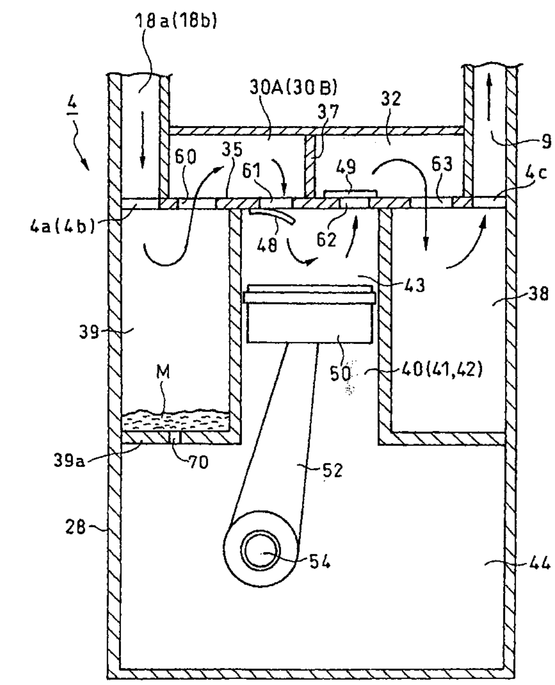
(54) **RECIPROCATING COMPRESSOR**

(57) A reciprocating compressor (1) according to the present invention has a main body (28), in which are provided a first low-pressure chamber (30A) for introducing low-pressure refrigerant into a pumping chamber (43) of a cylinder (40), a second low-pressure chamber (30B) for introducing low-pressure refrigerant into pumping chambers (43) of other cylinders (41, 43), and a high-pressure chamber (38) for letting in high-pressure refrigerant discharged from the pumping chambers (43). The low-pressure chambers (30A, 30B) are connected to respective suction pipes (18b, 18a) of refrigerant circuits, and the high-pressure chamber (38) is connected to a discharge pipe (9) of the refrigerant circuits. Accordingly, the refrigerant flows can be controlled separately from each other and variations in the load acting on one evaporator (10) can be prevented from affecting the other evaporator (11), thus making it possible to efficiently control the temperatures of respective different temperature zones independently of each other, whereby the performance of the compressor (1) as well as the operation efficiency of an overall system including the compressor (1) and the refrigerant circuits can be improved.

FIG. 5



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Description

Technical Field

[0001] The present invention relates to a reciprocating compressor in which pistons are reciprocated to compress fluid, and more particularly, to a reciprocating compressor for compressing a refrigerant circulated through a refrigeration cycle.

Background Art

[0002] There has generally been a demand for a refrigerated transport vehicle which has a chilled compartment and a frozen compartment set to different temperatures and in which a refrigerant is circulated through evaporators arranged in the respective compartments. Among systems applied to such a refrigerated vehicle, a system (one-compressor two-way system) is conventionally known wherein a plurality of refrigerant circuits connected to the respective evaporators are configured to supply the refrigerant to the individual evaporators and the refrigerant flowing through the individual refrigerant circuits is returned to one compressor and then circulated.
[0003] Examined Japanese Utility Model Publication (KOKOKU) No. 63-43132, for example, discloses refrigerant circuits for circulating a refrigerant through two evaporators, the circuits being configured such that the refrigerant is delivered under pressure from one discharge port of a compressor, then allowed to flow separately through the refrigerant circuits connected to the respective two evaporators, and again returned to the compressor. In this arrangement, the compressor has one discharge port and one suction port formed therein such that the flows of refrigerant returning from the two refrigerant circuits meet each other at the suction port in the compressor. Namely, the compressor is constructed so as to suck in the refrigerant from one suction port, then compress the refrigerant and discharge the compressed refrigerant from one discharge port.
[0004] However, in cases where one suction port is provided for two refrigerant circuits as mentioned above, variations in the load acting on the evaporator of the chilled compartment side, for example, exerts an influence upon the evaporator of the frozen compartment side, making it difficult to control the respective temperatures of the two compartments. Also, the refrigerant pressure in the chilled compartment-side evaporator can cause a pressure loss of the refrigerant pressure in the frozen compartment-side evaporator, and since the two refrigerant pressures are leveled off, the coefficient of performance of the compressor lowers.
[0005] Meanwhile, a swash plate compressor is known as a compressor having multiple discharge ports and multiple suction ports. The swash plate compressor, in which a swash plate is driven to successively reciprocate a plurality of pistons, may be used in a refrigerated transport vehicle. However, sliding parts connecting the swash plate and the respective pistons to actuate the pistons have a small area while the load acting on the sliding parts per unit area is large, so that the sliding parts often fail to make satisfactory sliding motion.
[0006] The present invention was created in view of the above circumstances, and an object thereof is to provide a reciprocating compressor which is capable of independently controlling a plurality of temperature zones connected to respective refrigerant circuits and which is also excellent in operation efficiency.

Disclosure of the Invention

[0007] A reciprocating compressor according to the present invention is characterized in that a main body of the compressor is provided with a plurality of cylinders, pistons for reciprocating within the respective cylinders, a first low-pressure chamber for introducing low-pressure refrigerant into a pumping chamber of at least one of the cylinders, at least one second low-pressure chamber for introducing low-pressure refrigerant into a pumping chamber of another cylinder, and a high-pressure chamber for letting in high-pressure refrigerant discharged from the pumping chambers, the low-pressure chambers are connected to respective suction pipes of refrigerant circuits, and the high-pressure chamber is connected to a discharge pipe of the refrigerant circuits.
[0008] With this arrangement of the invention, the flows of refrigerant circulated through the refrigerant circuits are guided along the respective suction pipes and returned to the compressor through separate suction ports. Accordingly, the refrigerant flows can be controlled separately from each other and variations in the load acting on one evaporator can be prevented from affecting the other evaporator, thus making it possible to efficiently control the temperatures of respective different temperature zones independently of each other. Also, the provision of multiple suction ports serves to reduce the flow resistance. Namely, the performance of the compressor as well as the operation efficiency of an overall system including the compressor and the refrigerant circuits can be improved.
[0009] Also, according to the present invention, the compressor further comprises a crank chamber in which a crankshaft for actuating the pistons is housed, and the main body has pressure equalizing passages formed therein for connecting the respective low-pressure chambers and the crank chamber to each other.

[0010] With this arrangement, high-pressure gas in the crank chamber is allowed to escape to the low-pressure chambers through the equalizing passages, whereby the pressures in the low-pressure chambers and the crank chamber can be maintained uniform. Also, oil collecting in the low-pressure chambers can be returned to the crank chamber. Accordingly, oil can be kept in the compressor without the need to provide a mechanism for returning the oil, such as an oil separator, thus making it possible to provide a high-reliability compressor.

[0011] Further, according to the present invention, the pressure equalizing passages are each formed at a location close to a line intersecting perpendicularly with an axis of the crankshaft and passing through a midpoint of the axis between adjacent ones of the pistons coupled to the crankshaft.

[0012] Specifically, the equalizing passages are formed at locations such that splashes of the oil caused in the crank chamber due to a centrifugal force produced by the rotary motion of driving parts such as the crankshaft do not reach the equalizing passages. This prevents the oil from escaping from the crank chamber to the low-pressure chambers through the equalizing passages.

[0013] According to the present invention, the main body has a plurality of cylinder chambers arranged in a row, the low-pressure chambers and the high-pressure chamber are arranged on opposite sides of the row of the cylinder chambers, and a partition wall for separating the low-pressure chambers from each other is formed at a location shifted from a line which intersects perpendicularly with a line connecting axes of adjacent ones of the cylinders and which passes through a midpoint between the adjacent cylinders.

[0014] This arrangement permits the equalizing passages to be formed at locations such that splashes of the oil caused in the crank chamber due to the centrifugal force produced by the rotary motion of the driving parts such as the crankshaft do not reach the equalizing passages.

[0015] Also, according to the present invention, the pressure equalizing passages each have an inner diameter of 1.5 mm to 3 mm.

[0016] With this arrangement, it is possible to increase the quantity of return or recovery of the oil flowing through the refrigerant circuits together with the refrigerant, without spoiling the pressure equalizing effect.

Brief Description of the Drawings

[0017]

FIG. 1 is a longitudinal sectional view of a reciprocating compressor according to one embodiment of the present invention;
FIG. 2 is a sectional view taken along line A-A in FIG. 1;
FIG. 3 is a sectional view taken along line B-B in FIG. 2;
FIG. 4 is a sectional view taken along line C-C in FIG. 2;
FIG. 5 is a schematic sectional view illustrating operation of the compressor shown in FIG. 1;
FIG. 6 is a partly sectional side view of a refrigerated vehicle to which the reciprocating compressor of FIG. 1 is applied;
FIG. 7 is a circuit diagram of refrigerant circuits of the refrigerated vehicle shown in FIG. 6;
FIG. 8 is a graph showing temperature changes of frozen and chilled compartments under various traveling conditions and operating states of solenoid valves associated with the respective compartments;
FIG. 9(a) illustrates graphs showing temperature changes of the chilled and frozen compartments observed in the case of one-compressor two-suction system, and FIG. 9(b) illustrates graphs showing temperature changes of the chilled and frozen compartments observed in the case of one-compressor two-way system; and
FIG. 10 is a longitudinal sectional view showing a modification of the reciprocating compressor.

Best Mode of Carrying out the Invention

[0018] An embodiment of the present invention will be hereinafter described with reference to the drawings.

[0019] Referring first to FIG. 6, there is illustrated a refrigerated transport vehicle 1 equipped with a refrigerating machine. As shown in the figure, the refrigerated vehicle 1 has a driver's cab 2 and a bed 3. Inside the driver's cab 2 is arranged a reciprocating compressor (hereinafter merely referred to as compressor) 4 according to the embodiment of the present invention. The compressor 4 is driven, through an electromagnetic clutch 5, by an engine for moving the vehicle or an auxiliary engine installed in the vehicle, neither is shown. A container 6 having an enclosed, insulated structure is mounted on the bed 3. The interior of the container 6 is divided into a front-side frozen compartment 6a and a rear-side chilled compartment 6b by a partition wall 7 which is made of a heat insulating material and arranged at an intermediate portion of the container. Evaporators 10 and 11 are placed in the compartments 6a and 6b, respectively, for cooling the interiors of the respective compartments.

[0020] FIG. 7 shows refrigerant circuits for circulating a refrigerant through the evaporators 10 and 11 arranged in the compartments 6a and 6b, respectively, and the compressor 4. As shown in the figure, the compressor 4 has two suction ports 4a and 4b and one discharge port 4c. A discharge pipe 9 extends from the discharge port 4c, and a condenser 8 is inserted midway in the discharge pipe 9. The condenser 8 is attached to an upper portion of an outer front wall of the container 6.

[0021] The discharge pipe 9 branches on a downstream side of the condenser 8 into pipes 9a and 9b leading to the frozen and chilled compartments, respectively. The first evaporator 10 is inserted midway in the frozen compartment-side pipe 9a. A solenoid valve (SV) 21a as a flow control valve is inserted in a portion of the frozen compartment-side pipe 9a more upstream than the first evaporator 10. The solenoid valve 21a is a normally-closed valve and accordingly, switches ON to open when energized. When the temperature inside the frozen compartment 6a has lowered to a preset temperature (in this embodiment, -18°C), the solenoid valve switches OFF and thus is closed. The frozen compartment-side pipe 9a is connected through an accumulator 15 to a first suction pipe 18a, which in turn is connected to the first suction port 4a of the compressor 4.

[0022] Similarly, the second evaporator 11 is inserted midway in the chilled compartment-side pipe 9b. A solenoid valve (SV) 21b as a flow control valve is inserted in a portion of the chilled compartment-side pipe 9b more upstream than the second evaporator 11. The solenoid valve 21b is a normally-closed valve and accordingly, switches ON to open when energized. When the temperature inside the chilled compartment 6b has decreased to a preset temperature (in this embodiment, 2°C), the solenoid valve switches OFF and thus is closed. The chilled compartment-side pipe 9b is connected through an accumulator 16 to a second suction pipe 18b, which in turn is connected to the second suction port 4b of the compressor 4.

[0023] As shown in FIG. 6, the accumulators 15 and 16 are mounted to one side of the bed 3. Also, the evaporators 10 and 11 are respectively provided with temperature detectors 19 and 20, each serving also as a temperature setting device. In FIG. 7, reference numerals 22a and 22b denote expansion valves associated with the respective evaporators 10 and 11.

[0024] FIGS. 1 to 5 show the structure of the compressor 4 in detail. As shown in FIGS. 1 and 2, the compressor 4 has three cylinder chambers 40, 41 and 42 formed in a main body 28 thereof. The cylinder chambers 40, 41 and 42 are arranged in a row and have respective upper open ends closed with a valve plate 35. Also, the cylinders 40, 41 and 42 have pistons 50 respectively received therein for sliding motion (reciprocating motion). Accordingly, pumping chambers 43 for compressing the circulating refrigerant are defined inside the respective cylinders 40, 41 and 42 between the valve plate 35 and the corresponding pistons 50.

[0025] Further, a crank chamber 44, in which a crankshaft 54, connecting rods 52, etc. for reciprocating the pistons 50 are arranged, is defined in the main body 28 of the compressor 4 in communication with the cylinder chambers 40, 41 and 42. The crankshaft 54 is rotatably supported by bearings 83 and is coupled to a driving gear 84 which is driven by the power of an engine, not shown. Also, the crankshaft 54 is coupled to the pistons 50 through the respective connecting rods 52. Namely, the rotary motion of the crankshaft 54 is converted into reciprocating motions of the pistons 50 through the respective connecting rods 52.

[0026] In the compressor 4 of this embodiment, oil is fed as lubricant to driving parts such as the crankshaft 54 and the connecting rods 52, to suppress wear of the driving parts. Specifically, oil as such lubricant is circulated by a gear pump 80 such that the oil discharged from the gear pump 80 is supplied to individual sliding portions through an oil passage (in FIG. 10 referred to later, indicated at 90), not shown, formed in the crankshaft 54.

[0027] As shown in detail in FIGS. 2 and 5, two low-pressure chambers 30A and 30B for introducing low-pressure refrigerant into the pumping chambers 43 are formed in the main body 28 of the compressor 4 on one side of the row of the cylinder chambers 40, 41 and 42. A single high-pressure chamber 32, into which high-pressure refrigerant is discharged from the pumping chambers 43, is formed on the other side of the row of the cylinder chambers 40, 41 and 42. The first and second low-pressure chambers 30A and 30B are separated from each other by a partition wall 36 and are also separated from the high-pressure chamber 32 by a partition wall 37. The first low-pressure chamber 30A communicates with the pumping chamber 43 of the first cylinder 40 through a through hole 61 formed in the valve plate 35. The second low-pressure chamber 30B communicates with the pumping chambers 43 of the second and third cylinders 41 and 42 through respective through holes 61 formed in the valve plate 35. On the other hand, the high-pressure chamber 32 communicates with the pumping chambers 43 of all cylinders 40, 41 and 42 through respective through holes 62 formed in the valve plate 35. Each of the through holes 61 is provided with a check valve 48 which opens to allow the refrigerant to flow only in the direction from the low-pressure chamber 30A, 30B to the pumping chamber 43, and each of the through holes 62 is provided with a check valve 49 which opens to allow the refrigerant to flow only in the direction from the pumping chamber 43 to the high-pressure chamber 32.

[0028] Also, as shown in detail in FIG. 5, the main body 28 of the compressor 4 has two suction chambers 39 and one discharge chamber 38 defined therein, which chambers are closed with the valve plate 35 and are located below the two low-pressure chambers 30A and 30B and the high-pressure chamber 32, respectively. One of the suction chambers 39 is connected to the first suction pipe 18a through the suction port 4a formed in the valve plate 35. This suction chamber 39 communicates with the second low-pressure chamber 30B through a through hole 60 formed in the valve plate 35. The other suction chamber 39 is connected to the second suction pipe 18b through the suction port 4b formed in the valve plate 35. This suction chamber 39 communicates with the first low-pressure chamber 30A through a through hole 60 formed in the valve plate 35. Consequently, the low-pressure chambers 30A and 30B are connected to the suction pipes 18b and 18a through the respective suction chambers 39.

[0029] On the other hand, the discharge chamber 38 is connected to the discharge pipe 9 through the discharge port 4c formed in the valve plate 35. The discharge chamber 38 also communicates with the high-pressure chamber 32 through a through hole 63 formed in the valve plate 35. Thus, the high-pressure chamber 32 is connected to the discharge pipe 9 through the discharge chamber 38.

[0030] As shown in FIGS. 1 and 3 to 5, a pressure equalizing passage 70 is formed through a bottom wall 39a of each suction chamber 39 to connect the suction chamber 39 and the crank chamber 44 to each other. The equalizing passages 70 have the effect (pressure equalizing effect) of relieving high pressure in the crank chamber 44 to maintain the pressures in the chambers 39 and 44 at an approximately equal level, and also allow oil M collecting in the suction chambers 39 to drop down into, or return to, the crank chamber 44.

[0031] The inner diameter of the equalizing passages 70 is set to 1.5 to 3 mm, preferably, 2 mm. If the inner diameter of the equalizing passages 70 is greater than 3 mm, too much oil flows out into the crank chamber. If, on the other hand, the inner diameter of the equalizing passages 70 is smaller than 1.5 mm, a satisfactory pressure equalizing effect possibly fails to be achieved.

[0032] Also, to prevent escape of the oil from the crank chamber 44 to the suction chambers 39 through the equalizing passages 70, the equalizing passages are formed at locations such that splashes of the oil caused in the crank chamber 44 due to the centrifugal force produced by the rotary motion of the crankshaft 54 and the connecting rods 52 do not reach the equalizing passages 70. Specifically, the equalizing passages are each formed on a line passing through approximately the midpoint between two adjacent connecting rods 52. To permit the equalizing passages 70 to be formed at such locations, the partition wall 36 separating the low-pressure chambers 30A and 30B from each other is shifted so as not to interfere with the equalizing passages 70.

[0033] Operation of the compressor 4 constructed as above and the resulting flow of refrigerant will be now described.

[0034] First, let it be assumed that the set temperatures for the frozen and chilled compartments 6a and 6b are -18°C and 2°C, respectively. With the temperatures thus set, the compressor 4 is driven (crankshaft 54 is rotated) through the electromagnetic clutch 5 by the power of the engine, whereupon the refrigerant starts to circulate through the refrigerant circuits. Specifically, the high-temperature, high-pressure refrigerant discharged from the discharge port 4c of the compressor 4 flows through the discharge pipe 9 into the condenser 8, in which the refrigerant is turned into high-temperature, high-pressure liquid refrigerant by the action known in the art, and the liquid refrigerant then flows separately into the frozen compartment-side and chilled compartment-side pipes 9a and 9b.

[0035] The liquid refrigerant introduced into the frozen compartment-side pipe 9a flows through the solenoid valve (SV) 21a into the first evaporator 10. Thus, the interior of the frozen compartment 6a is cooled by the evaporator 10 by the action known in the art, so that the internal temperature gradually decreases down to the set temperature (-18°C). The refrigerant flowing out of the first evaporator 10 passes through the first accumulator 15 into the first suction pipe 18a and then is introduced to the first suction port 4a of the compressor 4.

[0036] On the other hand, the liquid refrigerant introduced into the chilled compartment-side pipe 9b flows through the solenoid valve (SV) 21b into the second evaporator 11. As a result, the interior of the chilled compartment 6b is cooled by the evaporator 11 by the action known in the art, so that the internal temperature gradually lowers to the set temperature (2°C). The refrigerant flowing out of the second evaporator 11 passes through the second accumulator 16 into the second suction pipe 18b and then is introduced to the second suction port 4b of the compressor 4.

[0037] The refrigerant introduced to the first suction port 4a from the frozen compartment 6a flows into the corresponding suction chamber 39 and then to the second low-pressure chamber 30B through the through hole 60, as indicated by the arrows in FIG. 5. When the refrigerant is introduced into the suction chamber 39, the oil M separated from the refrigerant collects in the bottom 39a of the suction chamber 39 and then drops down into, and thus returns to, the crank chamber 44 through the equalizing passage 70. The refrigerant flowing into the second low-pressure chamber 30B is then introduced into the pumping chambers 43 of the second and third cylinders 41 and 42 through the through holes 61 and compressed by the respective pistons 50. The resulting high-temperature, high-pressure refrigerant is discharged into the high-pressure chamber 32 through the through holes 62, then introduced into the discharge chamber 38 through the through hole 63, and delivered again to the discharge pipe 9 from the discharge port 4c.

[0038] Similarly, the refrigerant introduced to the second suction port 4b from the chilled compartment 6b flows into the corresponding suction chamber 39, in which the oil M separated from the refrigerant collects in the bottom 39a of the suction chamber 39 and then drops down into, and thus returns to, the crank chamber 44 through the equalizing passage 70.

[0039] The refrigerant flowing into the first low-pressure chamber 30A is then introduced into the pumping chamber 43 of the first cylinder 40 through the through hole 61 and compressed. The resulting high-temperature, high-pressure refrigerant is discharged into the high-pressure chamber 32 through the through holes 62, whereby the refrigerant discharged from the first cylinder chamber 40 and that discharged from the second and third cylinder chambers 41 and 42 meet each other in the high-pressure chamber. The refrigerant is then introduced into the discharge chamber 38 through the through hole 63 and delivered again to the discharge pipe 9 from the discharge port 4c.

[0040] As described above, a circulation system (hereinafter referred to as one-compressor two-suction system) is employed in which one compressor 4 has separate suction ports 4a and 4b associated with the respective evaporators 10 and 11 and not communicating with each other inside the compressor 4, and the refrigerant from the compressor 4 is caused to flow through separate routes to be supplied to the respective evaporators 10 and 11, the refrigerant flows from which are collected through the respective suction ports 4a and 4b. With the one-compressor two-suction system, the refrigerant flows can be controlled separately from each other and variations in the load acting on one evaporator can be prevented from affecting the other evaporator, thus making it possible to efficiently control the temperatures of the respective different temperature zones (frozen and chilled compartments 6a and 6b) independently of each other. Also, the provision of the two suction ports 4a and 4b serves to reduce the flow resistance. Thus, the performance of the compressor 4 as well as the operation efficiency of the overall system can be improved, and this is evident from the below-mentioned data of experiments conducted by the inventors hereof.

[0041] FIG. 8 illustrates the experimental data showing temperature changes of the respective compartments 6a and 6b under various traveling conditions and operating states of the solenoid valves (SV) 21a and 21b associated with the respective compartments 6a and 6b. In the figure, L1 indicates the temperature change of the outside air with time, L2 indicates the temperature change of the rear-side chilled compartment 6b, L3 indicates the temperature change of the front-side frozen compartment 6a, L4 indicates the open/closed state of the solenoid valve 21a associated with the frozen compartment (front compartment) 6a, and L5 indicates the open/closed state of the solenoid valve 21b associated with the chilled compartment (rear compartment) 6b. Also, SA denotes a service area, and CR denotes the refrigerating machine.

[0042] As seen from L2 and L3 in the graph, when the door of the chilled compartment 6b is opened at points A, B and C, the temperature in the chilled compartment 6b rises (and thus the solenoid valve 21b opens to cool the interior of the chilled compartment 6b), but this temperature rise does not affect the frozen compartment 6a at all. Namely, although the temperature in the chilled compartment 6b rises at points A, B and C, the temperature in the frozen compartment 6a does not rise and is kept nearly at the set temperature (-18°C). In the conventional one-compressor two-way system, by contrast, if the door of the chilled compartment 6b is opened, the cooling power of the chilled compartment 6b side is increased to make up for the resulting temperature rise of the chilled compartment 6b, with the result that the cooling power of the frozen compartment 6a side drops, causing a rise of the temperature in the frozen compartment 6a. Namely, the temperature change of the chilled compartment 6b side exerts an influence on the frozen compartment 6a side. This is proved by data shown in FIG. 9. FIG. 9(a) shows the data obtained with the one-compressor two-suction system according to the embodiment, and FIG. 9(b) shows the data obtained with the conventional one-compressor two-way system. As shown in FIG. 9(a), in the case of the one-compressor two-suction system, the opening/closing of the door of the chilled compartment 6b does not affect the temperature in the frozen compartment 6a. In the one-compressor two-way system, by contrast, the opening/closing of the door of the chilled compartment 6b exerts an influence on the frozen compartment 6a side. Specifically, the temperature in the frozen compartment 6a rises by S with a certain time lag after the temperature rise of the chilled compartment 6b.

[0043] In FIG. 8, the internal temperature (L3) of the frozen compartment 6a shows a rise at point D, but this temperature rise was caused by a defrosting (DEF) operation and does not indicate an influence exerted by the chilled compartment 6b.

[0044] Table 1 below shows the comparison between the conventional one-compressor two-way system and the one-compressor two-suction system according to the embodiment in respect of the rate of operation (ratio of the compressor operating time to the total time).

Table 1

		Present Invention		Conventional System	
Front compartment Rear compartment	-18 °C 2°C	Front compartment Rear compartment	57.6% 26.9%	Front compartment Rear compartment	76.2% 35.0%
Front compartment Rear compartment	2°C -18°C	Front compartment Rear compartment	11.8% 69.4%	Front compartment Rear compartment	27.5% 90.0%

[0045] As will be understood from the above table, the one-compressor two-suction system is lower in the rate of operation than the one-compressor two-way system, proving that the former system has excellent operation efficiency. Consequently, according to the embodiment, a sufficient cooling effect can be obtained at a lower rate of operation.

[0046] As described above, the compressor 4 according to the embodiment has separate suction ports 4a and 4b associated with the respective evaporators 10 and 11 and not communicating with each other. Also, in the embodiment, the refrigerant from the compressor 4 is caused to flow through separate routes to be supplied to the respective evaporators 10 and 11, and the refrigerant flows therefrom are collected through the respective suction ports 4a and 4b. Thus, the refrigerant flows can be controlled separately from each other and variations in the load acting on one evaporator can be prevented from affecting the other evaporator, thus making it possible to efficiently control the temperatures of the respective different temperature zones (frozen and chilled compartments 6a and 6b) independently of each other. Also, the provision of the two suction ports 4a and 4b serves to reduce the flow resistance. Namely, the performance of the compressor 4 as well as the operation efficiency of the overall system can be improved.

[0047] Further, in the compressor 4 of the embodiment, since the pressure equalizing passages 70 are formed through the bottom walls 39a of the suction chambers 39 to connect the suction chambers 39 and the crank chamber 44 to each other, high-pressure gas (pressure) can be relieved from the crank chamber 44 to maintain the pressures in the chambers 39 and 44 at an equal level, and also the oil M collecting in the suction chambers 39 can be returned to the crank chamber 44. Accordingly, the oil can be retained in the compressor 4 without the need to provide a mechanism for returning the oil, such as an oil separator, thus making it possible to provide a high-reliability compressor.

[0048] Also, in the compressor 4 of the embodiment, since the inner diameter of the equalizing passages 70 is set to 1.5 to 3 mm, it is possible to increase the quantity of return or recovery of the oil flowing through the refrigerant circuits together with the refrigerant, without spoiling the pressure equalizing effect.

[0049] In the compressor 4 according to the embodiment, moreover, the equalizing passages 70 are formed at locations such that splashes of the oil caused in the crank chamber 44 due to the centrifugal force produced by the rotary motion of the crankshaft 54 and the connecting rods 52 do not reach the equalizing passages. This arrangement prevents the oil in the crank chamber 44 from escaping to the suction chambers 39 through the equalizing passages 70.

[0050] Since a sufficient quantity of oil can be kept in the crank chamber 44 (in the compressor 4) as mentioned above, it is possible to suppress noise as well as wear of the driving parts such as the connecting rods 52. For the purpose of comparison, an experiment was conducted using a compressor having the equalizing passages 70 with an inner diameter of 2 mm formed at the aforementioned specified locations, and it was confirmed that the quantity of oil that could be kept in the compressor was nine to ten times as much as the quantity of oil that remained in the case of the conventional arrangement.

[0051] The present invention is not limited to the foregoing embodiment alone and may be modified in various ways without departing from the scope and spirit of the invention. For example, advantages similar to those of the foregoing embodiment can be obtained also with a reciprocating compressor 4 having two cylinder chambers 40 and 41, as shown in FIG. 10. In the embodiment shown in FIG. 10, identical reference numerals are used to denote elements identical with those of the foregoing embodiment, and detailed description of the elements is omitted.

[0052] In the above embodiment, two low-pressure chambers 30A and 30B are provided for the respective two suction ports 4a and 4b. Alternatively, three low-pressure chambers corresponding to the respective cylinder chambers 40, 41 and 42 may be formed and selectively connected to the two suction ports 4a and 4b.

[0053] Further, in the foregoing embodiments are described compressors having three or two cylinder chambers, by way of example, but the number of cylinder chambers may be more than three. Also, the number of suction ports is not limited to two and may be three or more corresponding to the number of refrigerant circuits.

Industrial Applicability

[0054] As explained above, the reciprocating compressor according to the present invention is applied to a refrigerated transport vehicle etc. having frozen and chilled compartments, and is used to compress the refrigerant sucked in from the frozen and chilled compartment sides and to deliver the compressed refrigerant again to the frozen and chilled compartment sides.

Claims

1. A reciprocating compressor **characterized in that** a main body of the reciprocating compressor is provided with a plurality of cylinders, pistons for reciprocating within the respective cylinders, a first low-pressure chamber for introducing low-pressure refrigerant into a pumping chamber of at least one of the cylinders, at least one second low-pressure chamber for introducing low-pressure refrigerant into a pumping chamber of another cylinder, and a high-pressure chamber for letting in high-pressure refrigerant discharged from the pumping chambers, the low-pressure chambers are connected to respective suction pipes of refrigerant circuits, and the high-pressure chamber is connected to a discharge pipe of the refrigerant circuits.

2. The reciprocating compressor according to claim 1, **characterized by** further comprising a crank chamber in which a crankshaft for actuating the pistons is housed, the main body having pressure equalizing passages formed therein for connecting the respective low-pressure chambers and the crank chamber to each other.

3. The reciprocating compressor according to claim 2, **characterized in that** the pressure equalizing passages are each formed at a location close to a line intersecting perpendicularly with an axis of the crankshaft and passing through a midpoint of the axis between adjacent ones of the pistons coupled to the crankshaft.

4. The reciprocating compressor according to claim 3, **characterized in that** the main body has a plurality of cylinder chambers arranged in a row, the low-pressure chambers and the high-pressure chamber are arranged on opposite sides of the row of the cylinder chambers, and a partition wall for separating the low-pressure chambers from each other is formed at a location shifted from a line which intersects perpendicularly with a line connecting axes of adjacent ones of the cylinders and which passes through a midpoint between the adjacent cylinders.

5. The reciprocating compressor according to claim 1, **characterized in that** the pressure equalizing passages each have an inner diameter of 1.5 mm to 3 mm.

FIG. 1

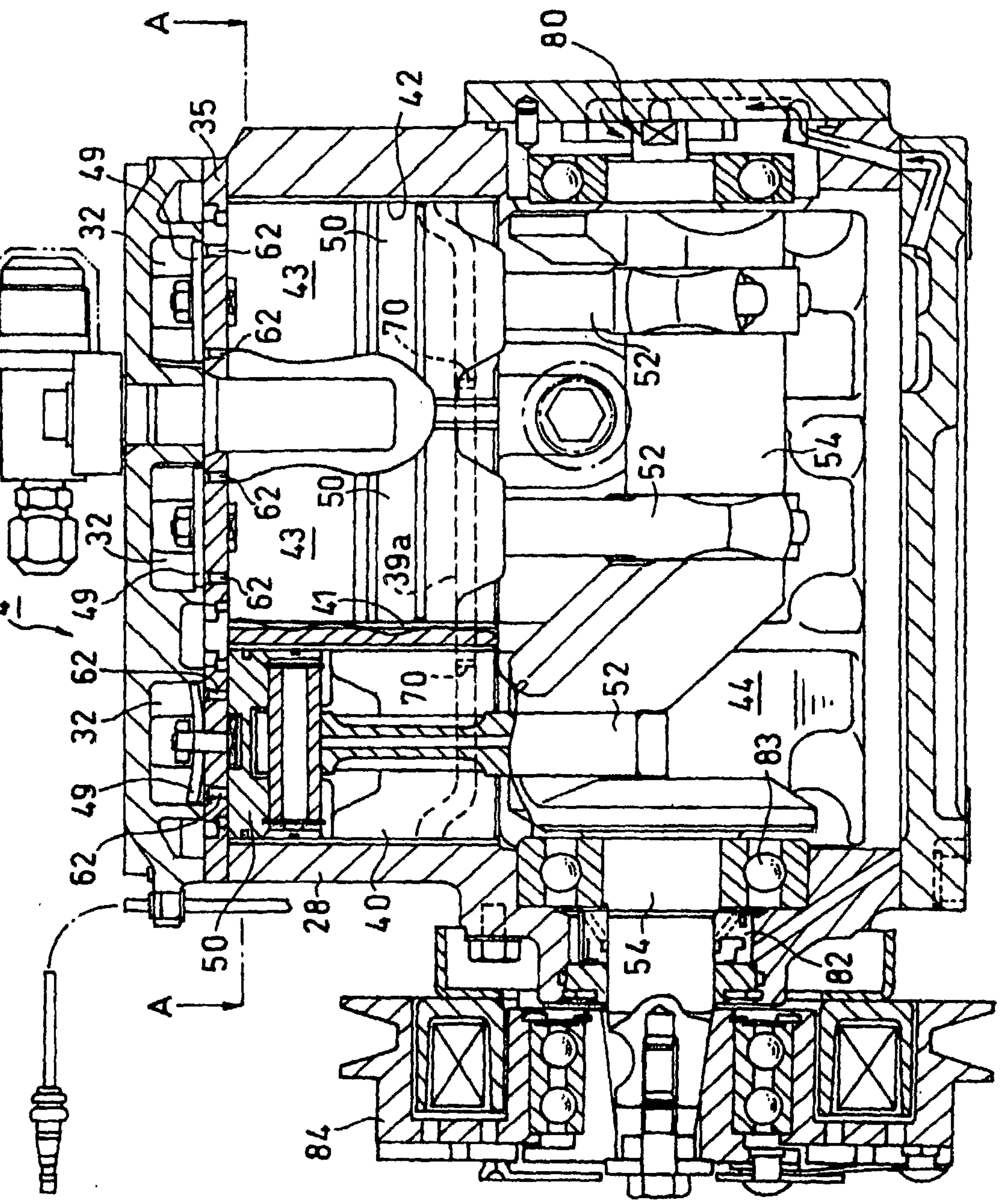
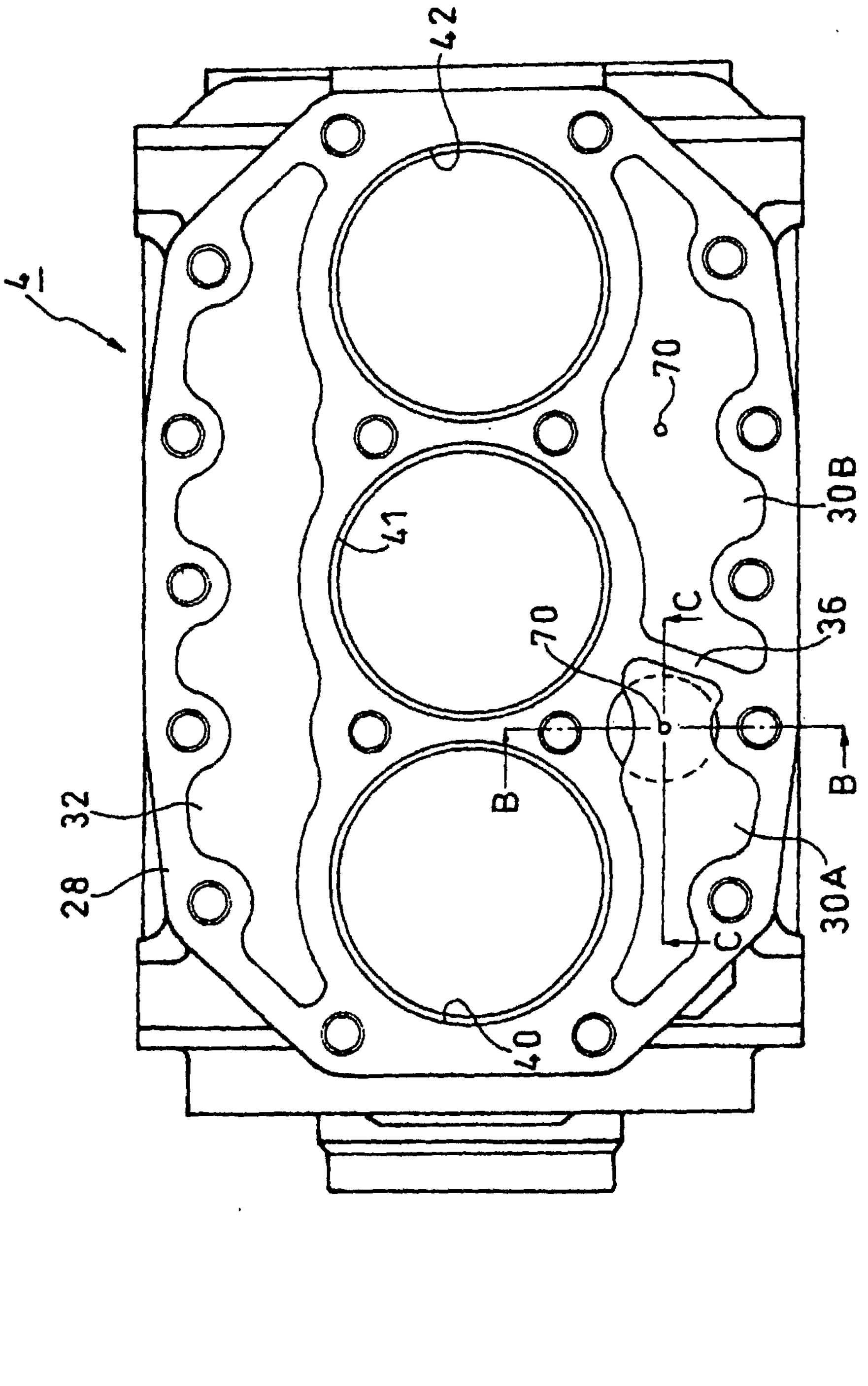
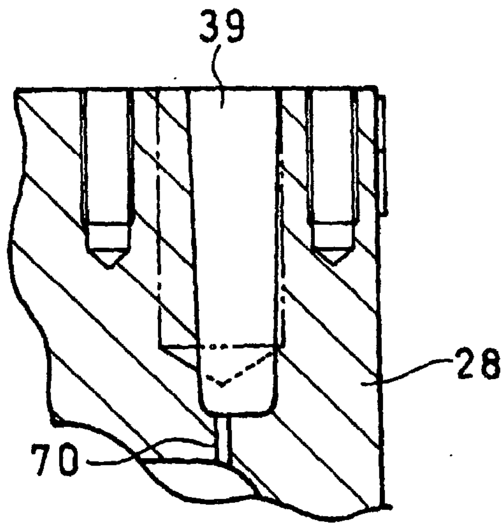


FIG. 2



F I G. 3



F I G. 4

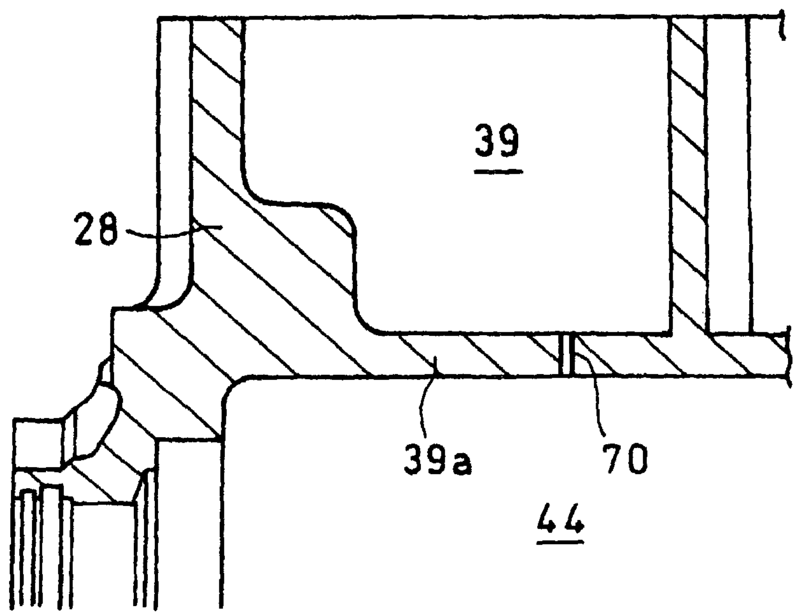
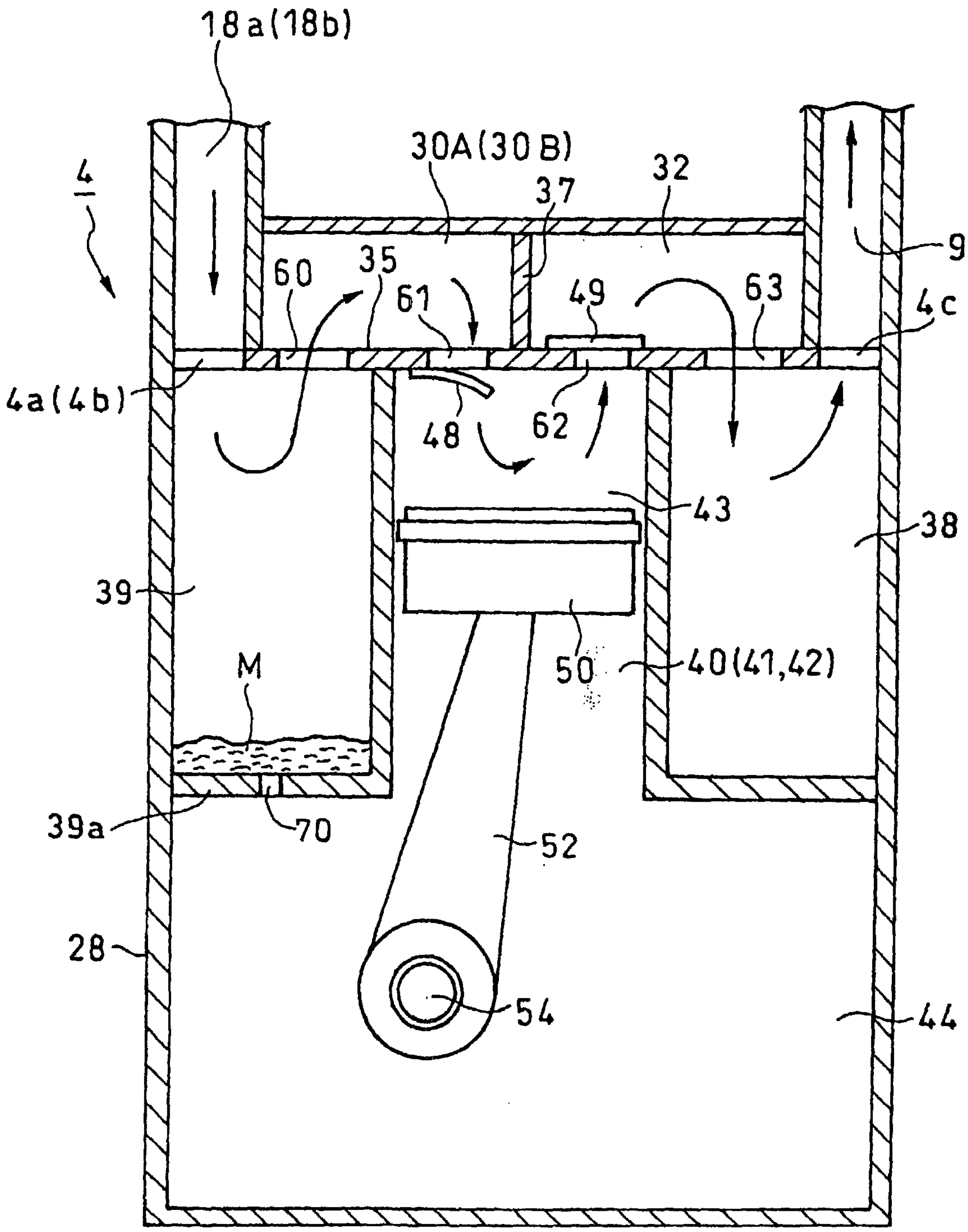
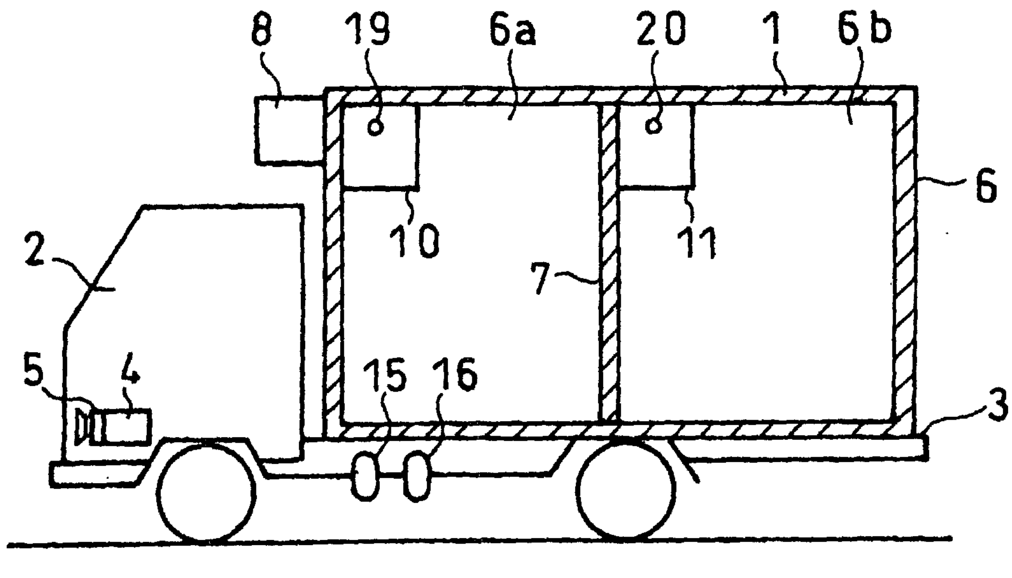


FIG. 5


18a(18b)
4
30A(30B)
32
37
9
60
35
61
49
63
4c
4a(4b)
48
62
43
38
39
50
40(41,42)
M
39a
70
52
28
54
44

F I G. 6



F I G. 7

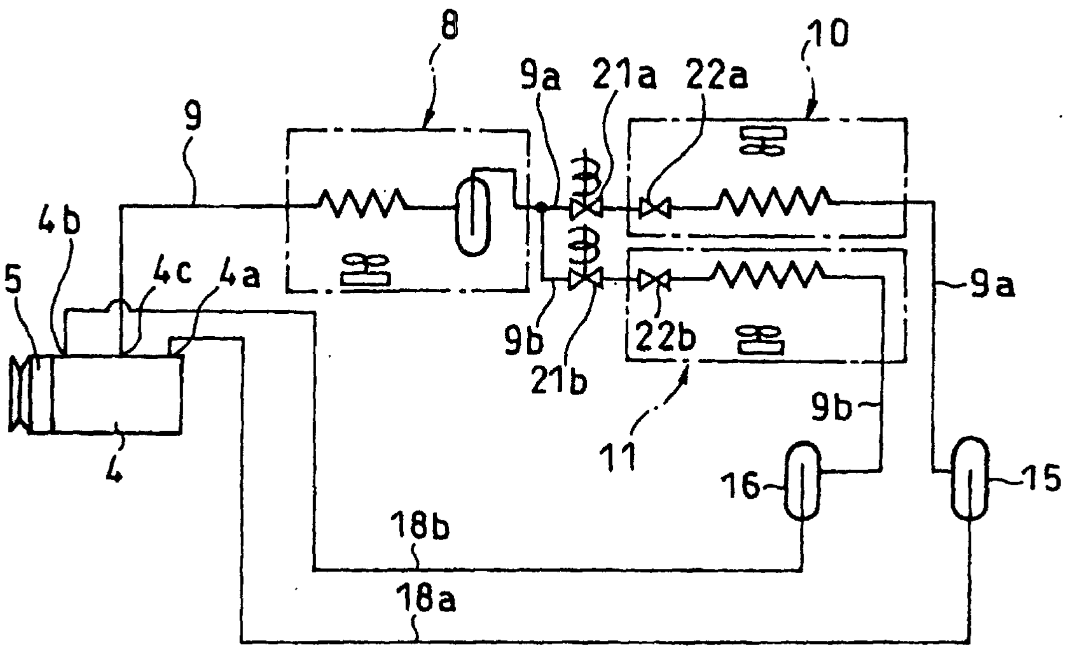


FIG. 8

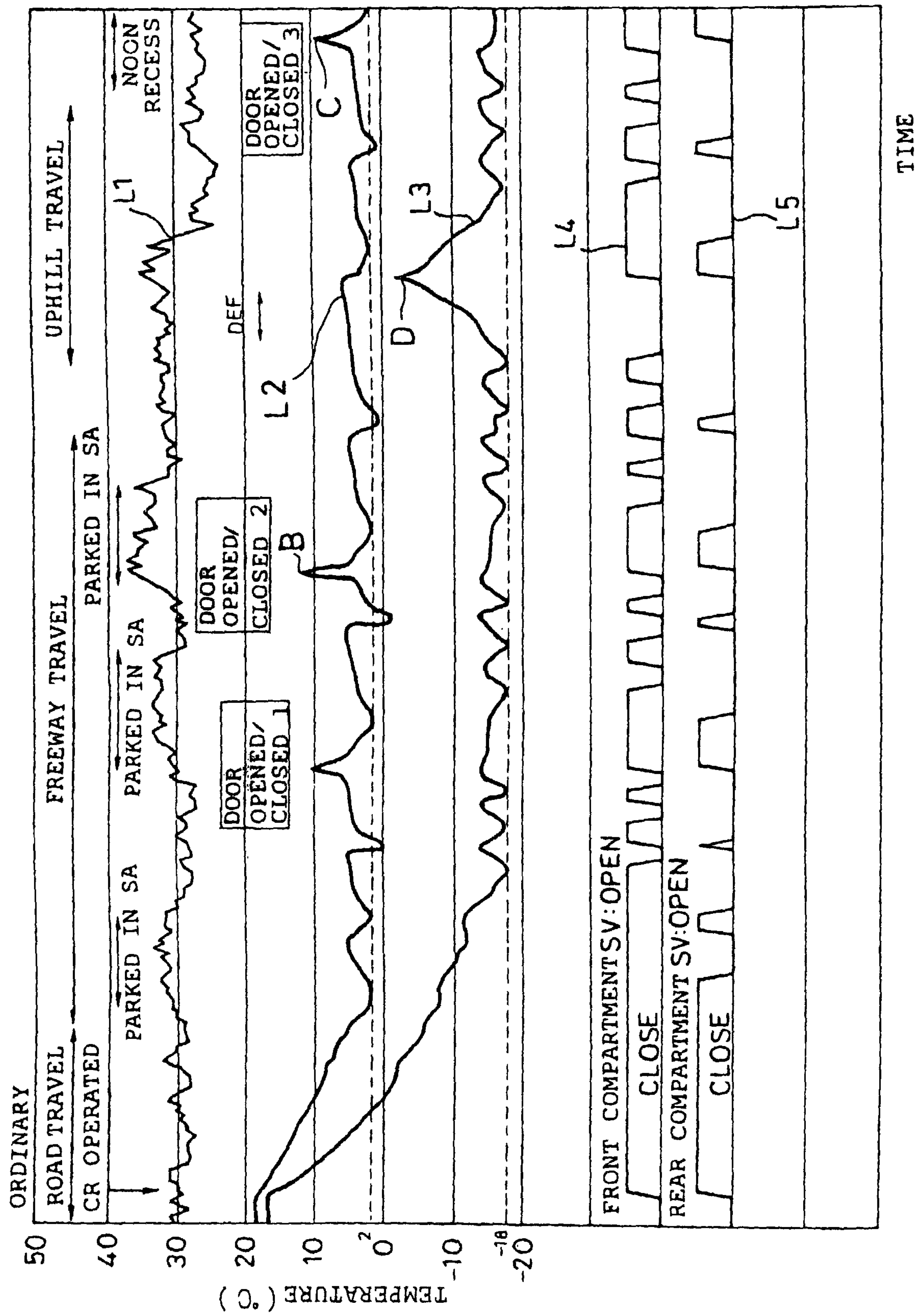

ORDINARY
ROAD TRAVEL
CR OPERATED
FREEWAY TRAVEL
UPHILL TRAVEL
PARKED IN SA
PARKED IN SA
PARKED IN SA
NOON RECESS
DOOR OPENED/ CLOSED 1
DOOR OPENED/ CLOSED 2
DOOR OPENED/ CLOSED 3
DEF
L1
L2
L3
L4
L5
B
C
D
FRONT COMPARTMENT SV: OPEN
CLOSE
REAR COMPARTMENT SV: OPEN
CLOSE
TEMPERATURE (°C)
50
40
30
20
10
2
0
-10
-18
-20
TIME

FIG. 9

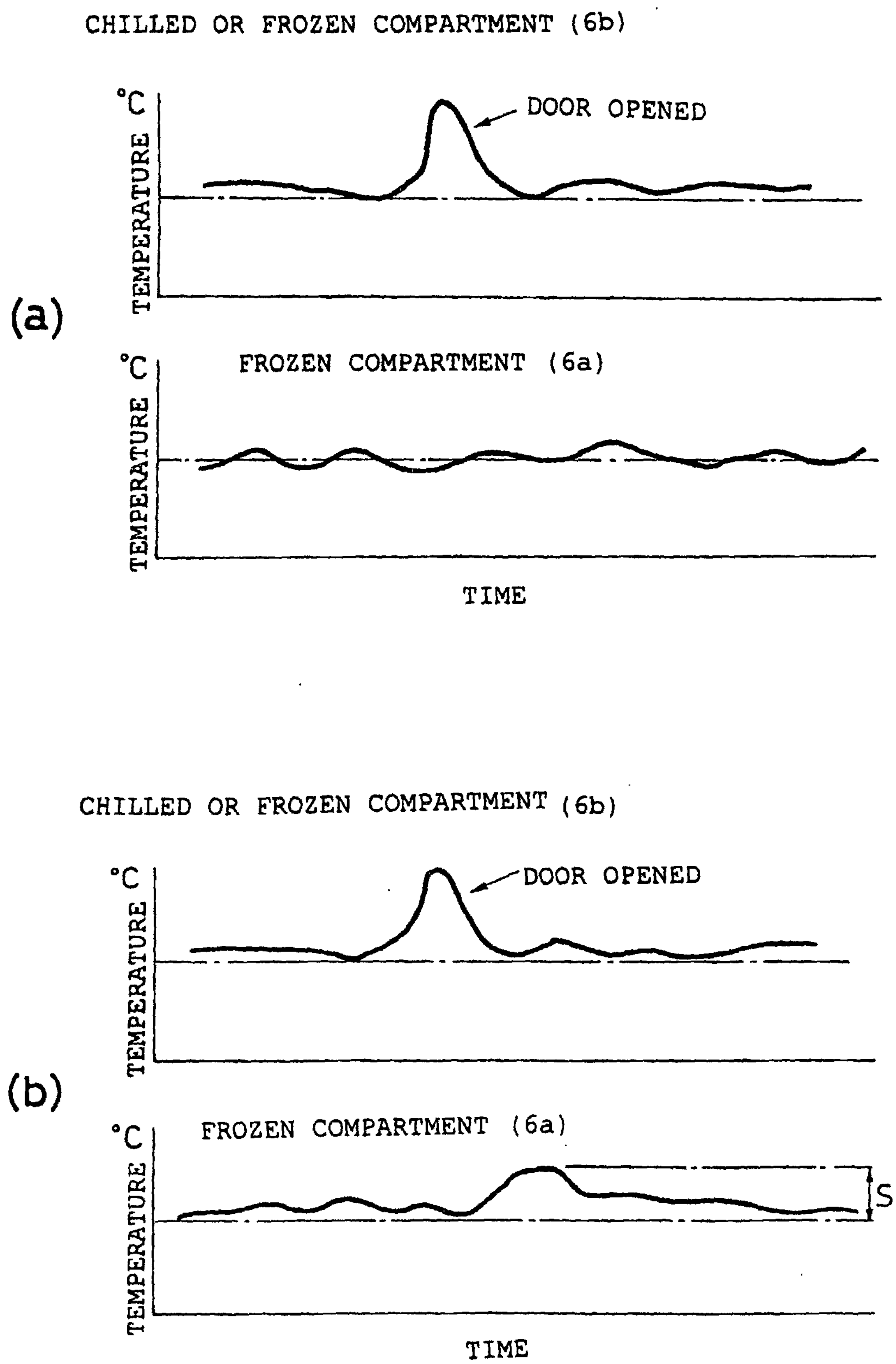
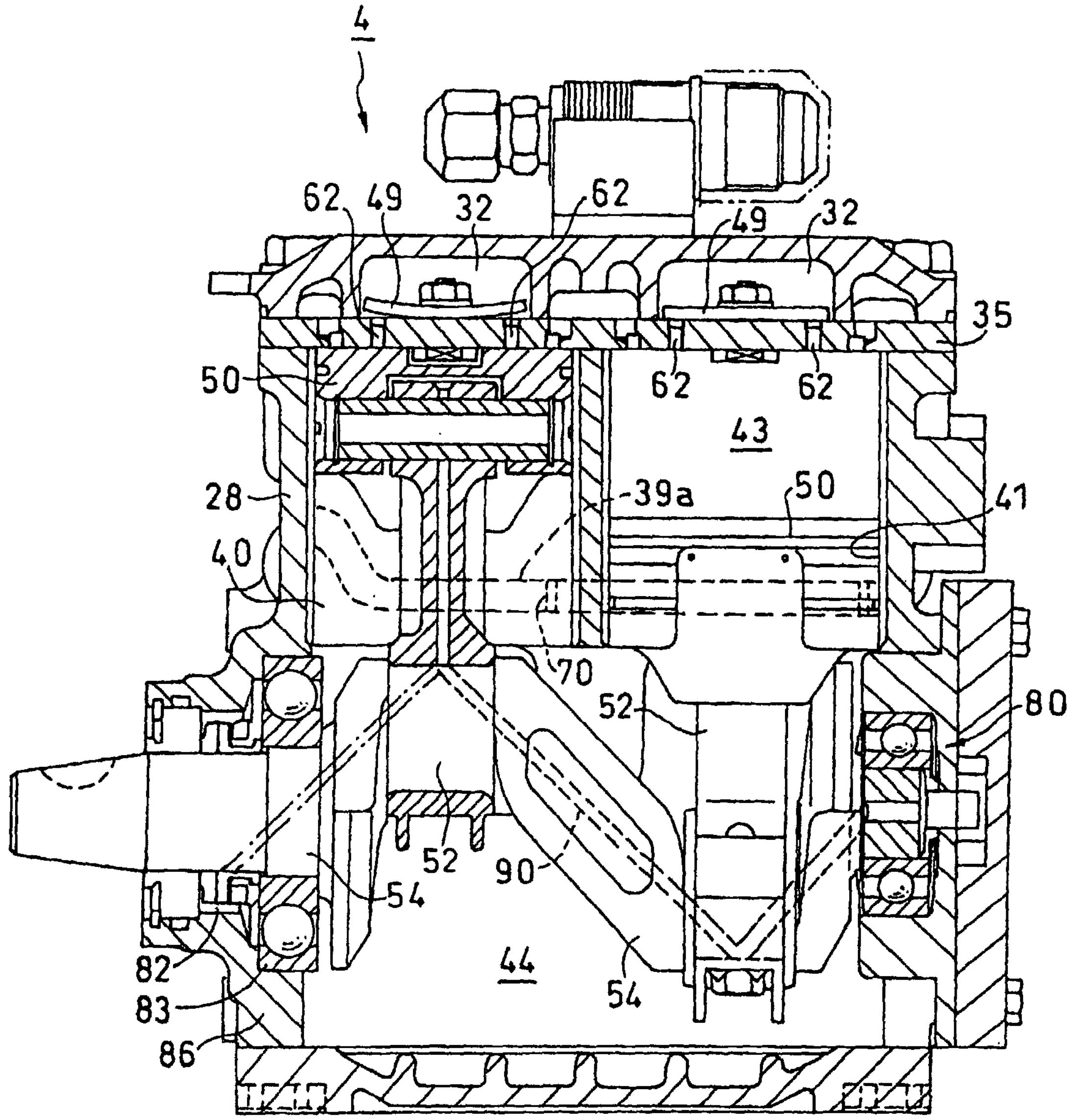

CHILLED OR FROZEN COMPARTMENT (6b)
°C
TEMPERATURE
DOOR OPENED
(a)
°C
FROZEN COMPARTMENT (6a)
TEMPERATURE
TIME
CHILLED OR FROZEN COMPARTMENT (6b)
°C
TEMPERATURE
DOOR OPENED
(b)
°C
FROZEN COMPARTMENT (6a)
TEMPERATURE
S
TIME

FIG. 10


4
62
49
32
62
49
32
35
50
62
62
43
28
39a
50
41
40
70
52
80
52
90
54
82
44
54
83
86

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP00/03158

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] F04B39/12 F04B35/01 F25B1/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[7] F04B39/12 F04B35/01 F25B1/02 B60H1/32

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Toroku Jitsuyo Shinan Koho 1994-2000
Kokai Jitsuyo Shinan Koho 1971-2000 Jitsuyo Shinan Toroku Koho 1996-2000

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 63-43132 Y2 (Diesel Kiki K.K.), 10 November, 1988 (10.11.88), Full text (Family: none)	1
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No.194451/1986 (Laid-open No.100681/1988) (Mitsubishi Heavy Industries, Ltd.), 30 June, 1988 (30.06.88), Full text (Family: none)	2,3
A	JP 54-59607 A (Tama Seisakusho K.K.), 14 May, 1979 (14.05.79), Full text (Family: none)	1-5

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"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
"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
"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
"&" document member of the same patent family

Date of the actual completion of the international search 15 August, 2000 (15.08.00)	Date of mailing of the international search report 29 August, 2000 (29.08.00)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)