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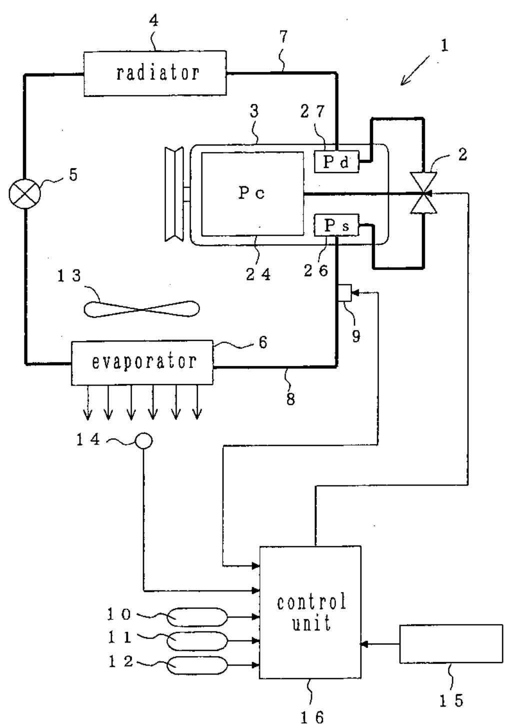
(54) ## CONTROL DEVICE OF VARIABLE DISPLACEMENT COMPRESSOR AND VARIABLE DISPLACEMENT CONTROL DEVICE OF REFRIGERATING CYCLE

(57) The present invention provides a control device of a variable displacement compressor and a variable displacement control device of a refrigerating cycle, capable of providing optimal responsiveness and stability under different conditions, by adopting a structure in which a control chamber pressure is controlled with a control valve electrically controlled by a control signal provided from the outside without using a pressure sensitive member. The present invention is adopted in conjunction with a variable displacement compressor 3, the discharge capacity of which is controlled through an adjustment of a crank chamber pressure achieved by electrically controlling a pressure control valve that enables a pressure supply from a discharge space 27 to a crank chamber 24 and also a pressure release from the crank chamber 24 to a suction space 26 with a control signal provided from the outside and adjusts a gain in an arithmetic expression used to calculate the control signal in correspondence to a value representing a physical quantity that affects the air conditioning state.

Fig. 1




EP 1 455 143 A1

## Description

TECHNICAL FIELD

**[0001]** The present invention relates to a control device of a variable displacement compressor that varies the discharge capacity by controlling a pressure supplied from a discharge pressure area to a control pressure chamber and a pressure released from the control pressure chamber to a suction pressure area and also related to a variable displacement control device of a refrigerating cycle employing the variable displacement compressor.

BACKGROUND ART

**[0002]** Variable displacement compressors used in automotive air-conditioning systems in the related art include the one disclosed in Japanese Unexamined Patent Publication No. H 63-16177. This variable displacement compressor, which includes a regulating valve that regulates the state of communication between a crank chamber and a suction space, a pressure sensitive means constituted of a bellows or the like that controls the regulating valve by sensing an suction pressure and an external control means that varies a pressure control point of the pressure sensitive means by applying a variable load to the pressure sensitive means in response to an input from the outside, adjusts a pressure setting value at the pressure sensitive means with the external control means and controls the suction pressure at the compressor so as to achieve the adjusted pressure setting value.

**[0003]** In addition, Japanese Unexamined Patent Publication No. H 64-60778, Japanese Examined Patent Publication No. H 7-6503 and the like disclose variable displacement compressors that control the crank chamber pressure with an external control signal without employing the pressure sensitive means mentioned above. In such a compressor, an electromagnetic valve 202, the open/closed state of which is controlled by a control signal provided from the outside, is disposed on a passage connecting a discharge space 200 and a crank chamber 201, the crank chamber 201 and a suction space 203 are made to communicate with each other via a passage and control is implemented to achieve a desired pressure with the electromagnetic valve 202 while constantly leaking the crank chamber pressure into the suction space, as shown in FIG. 12(a).

**[0004]** However, a problem arises when the pressure control valve, which includes the pressure sensitive member described first, is employed in a refrigerating cycle using carbon dioxide as a coolant in that since the pressure within the refrigerating cycle rises to a level 10 times as high as that in a conventional freon cycle, the pressure sensitive member may not have high enough pressure withstanding performance. There is another problem in that the pressure sensitive member such as a bellows, which must have a specific size in order to assure a large enough pressure receiving area, cannot be provided in a size smaller than that in the related art. For these reasons, a great deal of interest is focused on the use of a control valve, the open/closed state of which can be electrically controlled with a control signal provided from the outside as a replacement for the control valve that uses a pressure sensitive member.

**[0005]** While the latter structure, which uses an electromagnetic valve to control the pressure supply from the discharge space to the crank chamber, can be miniaturized with greater ease, it has a problem in that the compressor efficiency is poor since the pressure is constantly leaked from the crank chamber into the suction space and thus it is necessary to constantly supply pressure from the discharge space to the crank chamber in order to maintain the discharge capacity at a specific level.

**[0006]** Accordingly, a structure in which a single control valve 204 is employed to adjust both the state of communication between the crank chamber 201 and the discharge space 200 and the state of communication between the crank chamber 201 and the suction space 203 at once, as shown in FIG. 12(b), and a structure in which a first switching control valve 205 is disposed on a pressure supply passage connecting the discharge space 200 and the crank chamber 201 and a second switching control valve 206 is disposed on a pressure release passage connecting the crank chamber 201 and the suction space 203, as shown in FIG. 12(c), have been proposed to address the problem resulting from leaking the crank chamber pressure at all times.

**[0007]** By adopting either of these structures, it becomes possible to reduce or eliminate the loss of the crank chamber pressure and thus, the efficiency of the compressor is improved. However, unlike the structure having a pressure sensitive member such as a bellows, neither structure is equipped with a function of automatically controlling the pressure on the suction side to a target value and for this reason, feedback control must be implemented by using a controller in order to control the suction-side pressure at a desired pressure level. When implementing feedback control on the pressure in the suction pressure area through PI control or PID control, it is necessary to tune and set in advance the gains corresponding to a proportional term, an integral term and a differential term so as to achieve the optimal response and stability.

**[0008]** However, it has been learned by the inventor of the present invention and others through research that even though the gains can be set so as to achieve the optimal response and stability under a given set of conditions, the gain settings cannot satisfy the response and stability requirements under the conditions that may manifest as the initial conditions change constantly. Namely, after the gains are adjusted so as to achieve good control characteristics (achieving both stability and quick response) at a given heat load, the heat load may subsequently become lower and, as a result, fast response may no longer be a crucial factor. Under such circumstances, if the response is unnecessarily fast, the control signal provided to the compressor becomes unstable to result in hunting. If, on the other hand, the heat load becomes even higher, the response may no longer be fast enough.

**[0009]** In addition, while the ultimate control target in the control described above is the air temperature, the compressor controls the pressure on the suction side and thus, appropriate feedback control must be implemented in correspondence the suction-side pressure.

DISCLOSURE OF THE INVENTION

**[0010]** Accordingly, an object of the present invention is to provide a control device of a variable displacement compressor and a variable displacement control device of a refrigerating cycle, with which the efficiency of the compressor is improved and, at the same time, the optimal response and stability can be achieved under varying conditions by adopting a structure having a control valve controlled by a control signal provided from the outside to control a control chamber pressure without using a pressure sensitive member. Another object of the present invention is to provide a variable displacement control device of a refrigerating cycle 'capable of implementing appropriate feedback control when electrically controlling the control valve.

**[0011]** In order to achieve the objects described above, in a variable displacement compressor having a means for pressure control that enables a pressure supply from a discharge pressure area to a control pressure chamber and a pressure release from the control pressure chamber to a suction pressure area and is controlled with a control signal provided from the outside in response to which the means for pressure control adjusts the pressure in the control pressure chamber so as to reduce the discharge capacity as the pressure in the control pressure chamber rises and to increase the discharge capacity as the pressure in the control pressure chamber becomes lower in the variable displacement compressor, a control device of the variable displacement compressor according to the present invention comprises a means for pressure detection that detects the pressure on the suction pressure area side, a means for control signal calculation that calculates the control signal for the means for pressure control so as to set the pressure detected by the means for pressure detection to a target pressure and a means for gain adjustment that adjusts a gain in an arithmetic expression used to calculate the control signal in correspondence to a physical quantity that affects the air conditioning state.

**[0012]** As described above, in the compressor in which the control chamber pressure is controlled by the means for pressure control that is controlled with a control signal provided from the outside so as to improve the efficiency of the compressor, the gain in the arithmetic expression used to calculate the control signal for the means for pressure control is adjusted based upon a volume representing a physical quantity that affects the air conditioning state and, as a result, the optimal response and stability are achieved under varying conditions.

**[0013]** The means for pressure control may be constituted as a single control valve that simultaneously adjusts the state of communication between the control pressure chamber and the discharge pressure area and the state of communication between the control pressure chamber and the suction pressure area, or it may be constituted with a first switching control valve disposed on a pressure supply passage connecting the discharge pressure area with the control pressure chamber and a second switching control valve disposed on a pressure release passage connecting the control pressure chamber with the suction pressure area.

**[0014]** It is desirable that the variable displacement compressor be a so-called swash plate variable displacement compressor comprising a drive shaft disposed within a cylinder block, a drive swash plate that rotates together with the drive shaft and allows the angle of inclination formed relative to the drive shaft to be varied freely, a cylinder disposed within the cylinder block and having an axis extending parallel to the drive shaft, a piston slidably disposed within the cylinder which makes a reciprocal movement inside the cylinder as the drive swash plate rotates, a compression space formed by the cylinder and the piston, a crank chamber constituting the control pressure chamber formed at the piston on the side opposite from the compression space side, a suction space that constitutes the suction pressure area coming into communication with the compression space during a suction stroke of the piston and a discharge space that constitutes the discharge pressure area coming into communication with the compression space during the compression stroke of the piston.

**[0015]** In addition, a variable displacement control device according to the present invention, to be adopted in conjunction with a refrigerating cycle having at least a variable displacement compressor that includes a means for pressure control enabling a pressure supply from a discharge pressure area to a control pressure chamber and a pressure release from the control pressure chamber to a suction pressure area and adjusts the pressure in the control pressure chamber by controlling the means for pressure control with a control signal provided from the outside so as to reduce the discharge capacity as the pressure in the control pressure chamber rises and to increase the discharge capacity as the pressure in the control pressure chamber becomes lower, a radiator that cools a coolant having been compressed at the variable displacement compressor, an expansion device that depressurizes the coolant having been cooled at the radiator and an evaporator that evaporates the depressurized coolant at the expansion device, comprises a means for pressure detection that detects the pressure on the suction pressure area side, a means for control signal calculation that calculates the control signal for the means for pressure control so as to set the pressure detected by the means for pressure detection to a target pressure and a means for gain adjustment that adjusts a gain in an arithmetic expression used to calculate the control signal in correspondence to a physical quantity that affects the air-conditioning state.

**[0016]** In this structure, the gain in the arithmetic expression used to calculate the control signal for the means for pressure control is adjusted in correspondence to a physical quantity that affects the air conditioning state and, as a result, the optimal response and stability are assured under varying conditions.

**[0017]** Alternatively, a variable displacement control device according to the present invention, to be adopted in conjunction with a refrigerating cycle having at least a variable displacement compressor that includes a means for pressure control enabling a pressure supply from a discharge pressure area to a control pressure chamber and a pressure release from the control pressure chamber to a suction pressure area and adjusts pressure in the control pressure chamber by controlling the means for pressure control with a control signal provided from the outside so as to reduce the discharge capacity as the pressure in the control pressure chamber rises and to increase the discharge capacity as the pressure in the control pressure chamber becomes lower, a radiator that cools a coolant having been compressed at the variable displacement compressor, an expansion device depressurizes the coolant having been cooled at the radiator and an evaporator that evaporates the depressurized coolant at the expansion device, comprises a means for pressure detection that detects the pressure on the suction pressure area side, a means for control signal calculation that calculates the control signal for the means for pressure control so as to set the pressure detected by the means for pressure detection to a target pressure, a means for temperature detection that detects an air temperature on the outlet side of the evaporator and a means for target pressure calculation that calculates a target pressure to be achieved on the suction pressure area side so as to set the air temperature on the outlet side of the evaporator to a target temperature.

**[0018]** By adopting the structure described above, control is implemented to achieve the target pressure on the suction pressure area side of the compressor to ultimately control the outlet-side air temperature at the evaporator so as to achieve the target temperature and thus, the control performance can be improved. Namely, through the control described above, cascade control is achieved by a major controller that controls the air temperature at the evaporator on the outlet side and a minor controller that controls the pressure on the suction pressure area side and, by using the outlet-side air temperature at the evaporator as a control variable of the major controller, the target pressure on the suction pressure area side, which is a target value for the minor controller as an operation variable of the major controller, the pressure on the suction pressure area side as a control variable of the minor controller and the control signal provided to the means for pressure control as an operation variable of the minor controller, faster control response is achieved.

**[0019]** The variable displacement control device may further include a means for control signal calculation gain adjustment that adjusts a gain in an arithmetic expression used to calculate the control signal in correspondence to a physical quantity that affects the air conditioning state to be utilized in conjunction with such cascade control, or a means for target pressure calculation gain adjustment that adjusts a gain in an arithmetic operation used to calculate the target pressure on the suction pressure area side in correspondence to a physical quantity that affects the air conditioning state to be utilized in conjunction with the cascade control.

**[0020]** The means for pressure control may be constituted as a single control valve that simultaneously adjusts the state of communication between the control pressure chamber and the discharge pressure area and the state of communication between the control pressure chamber and the suction pressure area, or it may be constituted with a first switching control valve disposed on a pressure supply passage connecting the discharge pressure area with the control pressure chamber and a second switching control valve disposed on a pressure release passage connecting the control pressure chamber with the suction pressure area.

**[0021]** The control efficiency of the compressor may be improved by providing a means for comparison that compares the air temperature at the evaporator on the outlet outside with a target temperature and, in such a case, the first switching control valve should be fully closed if the air temperature on the outlet side of the evaporator is higher than the target temperature so as to control the second switching control valve alone with the control signal or the second switching control valve should be fully closed if the air temperature on the outlet side of the evaporator is equal to or lower than the target temperature so as to control the first switching control valve alone with the control signal. Alternatively, these control measures may be adopted in combination or control may be implemented to control the first switching control valve and the second switching control valve with the control signal if the air temperature at the evaporator on the outlet side is equal to or lower than the target temperature.

**[0022]** It is desirable that the variable displacement compressor used in the refrigerating cycle described above be a so-called swash plate variable displacement compressor comprising a drive shaft disposed within a cylinder block, a drive swash plate that rotates together with the drive shaft and allows the angle of inclination formed relative to the drive shaft to be varied freely, a cylinder disposed within the cylinder block and having an axis extending parallel to the drive shaft, a piston slidably disposed within the cylinder, which makes a reciprocal movement inside the cylinder as the drive swash plate rotates, a compression space formed by the cylinder and the piston, a crank chamber constituting the control pressure chamber formed at the piston on the side opposite from compression space side, a suction space that constitutes the suction pressure area coming into communication with the compression space during a suction stroke of the piston and a discharge space that constitutes the discharge pressure area coming into communication with the compression space during the compression stroke of the piston, and the variable displacement control device is ideal in an application in a refrigerating cycle in which carbon dioxide is used as a coolant.

**[0023]** The physical quantity that affects the air conditioning state described above may be a measured value (external information) detected with a sensor such as the outlet-side air temperature at the evaporator, the external air temperature, the cabin internal temperature, the discharge pressure at the compressor, the suction pressure at the compressor, the coolant pressure at the outlet of the evaporator, the rotational speed of the compressor or the vehicle speed, or an arithmetic value (internal information) such as a target rotational speed of the blower fan (i.e., a target air flow), a target pressure for the low-pressure line in the refrigerating cycle or a target air temperature on the outlet side of the evaporator calculated at a control unit.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0024]**

FIG. 1 schematically illustrates the structures adopted in the refrigerating cycle and the compressor in an embodiment of the present invention;
FIG. 2 is a sectional view of the variable displacement compressor achieved in an embodiment of the present invention;
FIG. 3 presents a flowchart of an example of a control operation that may be executed at the control unit adopting the structure shown in FIG. 1;
FIG. 4 is a diagram showing the relationship between the target air temperature Tset on the outlet side of the evaporator and the gains;
FIG. 5 presents a flowchart of the arithmetic processing executed to calculate the target pressure Pset for the low-pressure line in steps 56, 90, 102 and 114;
FIG. 6 presents a flowchart of the arithmetic processing executed to a calculate the control signal DL in steps 62, 96, 108 and 120;
FIG. 7 is a block diagram of the control implemented according to the present invention;
FIG. 8 schematically shows alternative structures that may be adopted in the refrigerating cycle and the compressor in an embodiment of the present invention;
FIG. 9 presents a flowchart of an example of a control operation that may be executed at the control unit adopting the structure shown in FIG. 8;
FIG. 10 is a diagram showing the relationship between the target air temperature Tset on the outlet side of the evaporator and the gains;
FIG. 11 presents a flowchart of another example of a control operation that may be executed at the control unit adopting the structure shown in FIG. 8; and
FIG. 12 illustrates various structures that may be adopted in the control valve in the compressor.

## BEST MODE FOR CARRYING OUT THE INVENTION

**[0025]** The following is an explanation of the preferred embodiments of the present invention, given in reference to the drawings. In FIG. 1, presenting a structural example that may be adopted in a refrigerating cycle installed in a vehicle, the refrigerating cycle 1 comprises a variable displacement compressor (hereafter referred to as a compressor) 3 having a pressure control valve 2 used to adjust a discharge capacity and capable of compressing a coolant to a supercritical range, a radiator 4 that cools the coolant, an expansion device 5 that lowers the pressure of the coolant and an evaporator 6 that evaporates the coolant. In the refrigerating cycle 1, the discharge side of the compressor 3 is connected to the expansion device 5 via the radiator 4 and the path extending from the discharge side of the compressor 3 through the inflow side of the expansion device 5 constitutes a high-pressure line 7. In addition, the outflow side of the expansion device 5 is connected to the evaporator 6, the outflow side of the evaporator 6, in turn, is connected to the suction side of the compressor 3 and the path extending from the outflow side of the expansion device 5 to the suction side of the compressor 3 constitutes a low-pressure line 8.

**[0026]** In the refrigerating cycle 1, the coolant constituted of carbon dioxide ($CO_2$) is compressed at the compressor

3 enters the radiator 4 as a high-temperature, high-pressure coolant in a supercritical state, radiates heat and thus becomes cooled at the radiator 4 and is then supplied to the expansion device 5 without becoming liquefied. The coolant is depressurized at the expansion device 5 and, as a result, it becomes a low temperature, low pressure moist steam. It then exchanges heat with the air passing through the evaporator 6 and thus becomes gaseous at the evaporator 6. Subsequently, it is returned to the compressor 3.

**[0027]** Reference numeral 9 indicates a pressure sensor provided in the low-pressure line 8 to detect a low level pressure Ps, and a signal output by the pressure sensor 9 is input to a control unit 16 together with signals provided by various sensors such as an external air temperature sensor 10 which detects the outside air temperature, an internal cabin temperature sensor 11 which detects the cabin internal temperature, a solar radiation sensor 12 that detects a solar radiation quantity and an outlet air temperature sensor 14 disposed on the evaporator outlet side to detect the temperature of air supplied from a fan 13 and passing through the evaporator 6 and signals provided through an operation panel 15 to set a target temperature in the cabin and the like.

**[0028]** The control unit 16 is constituted with an input circuit through which the various types of signals described above are input as data, a memory unit which includes a read only memory (ROM) and a random access memory (RAM), a central processing unit (CPU) that processes the data and calculates control data by using a program called up from the memory unit, a duty ratio calculation circuit that calculates the duty ratio for the control signal based upon the control data calculated at the central processing unit, a control signal output circuit that outputs the control signal with the duty ratio calculated at the duty ratio calculation circuit to the pressure control valve 2.

**[0029]** A peripheral block 20 of the compressor 3 which may be, for instance, a swash plate variable displacement compressor such as that shown in FIG. 2, includes a front block 21 that defines a crank chamber 24, a central block 22 at which a plurality of cylinders 25 are defined and a rear block 23 that defines a suction space 26 and a discharge space 27.

**[0030]** A drive shaft 28 passing through the peripheral block 20 is rotatably held at the front block 21 and the central block 22 via bearings 29a and 29b respectively. The drive shaft 28 is connected with a driving engine (not shown) via a belt, a pulley and an electromagnetic clutch, and as the electromagnetic clutch is engaged, the rotation of the engine is communicated to cause the drive shaft 28 to rotate. In addition, a swash plate 30 which is caused to rotate as the drive shaft 28 rotates and is allowed to a tilt freely relative to the drive shaft 28 is provided at the drive shaft 28.

**[0031]** A plurality of cylinders 25 formed at the central block 22 over specific intervals around the drive shaft 28 each assumes a cylindrical shape having a central axis extending parallel to the axis of the drive shaft 28. A piston 31, one end thereof is held at the swash plate 30, is slidably inserted at each cylinder 25.

**[0032]** As the drive shaft 28 rockets in the structure described above, the swash plate 30 rotates with a predetermined angle of inclination and, as a result, the end of the swash plate 30 is caused to rock over a specific range along the axis of the drive shaft 28. As a result, the pistons 31 secured to the front end of the swash plate 30 along the radial direction move reciprocally along the axis of the drive shaft 28 to change the volumetric capacity of a compression space 32 defined within the cylinder 25 so that the coolant is taken in from the suction space 26 via an suction port 34 having a suction valve 33 and the compressed coolant is discharged into the discharge space 27 via a discharge port 36 having a discharge valve 35.

**[0033]** The discharge capacity of the compressor 3 is determined by the stroke of the pistons 31, which, in turn, is determined in correspondence to the pressure difference between the pressure applied to the front surfaces of the pistons 31, i.e., the pressure in the compression spaces 32, and the pressure applied to the rear surfaces of the pistons, i.e., the pressure within the crank chamber 24 (the crank chamber pressure Pc). More specifically, as the pressure inside the crank chamber 24 is raised, the pressure difference between the compression spaces 32 and the crank chamber 24 becomes smaller and, as a result, the angle of inclination (oscillating angle) of the swash plate 30 becomes smaller as well to lead to a smaller stroke of the pistons 31 and a smaller discharge capacity, whereas as the pressure in the crank chamber 24 is lowered, the pressure difference between the compression spaces 32 and the crank chamber 24 increases and, as a result, the angle of inclination (oscillating angle) of the swash plate 30 becomes larger to lead to a larger stroke of the pistons 31 and a larger discharge capacity.

**[0034]** The pressure Pc in the crank chamber 24 is controlled with the pressure control valve 2 disposed at the rear block 23 or the like of the compressor 3. The pressure control valve 2 used in this structure, which is capable of simultaneously adjusting the state of communication between the crank chamber 24 and the discharge space 27 and the state of communication between the crank chamber 24 and the suction space 26 may adopt a structure in the known art such as that disclosed in Japanese Unexamined Patent Publication No. 2001-12358. It is electrically controlled with a control signal provided by the control unit 16 and controls the discharge capacity by adjusting the crank chamber pressure Pc so as to set the low level pressure Ps detected with the pressure sensor 9 to a target pressure Pset.

**[0035]** FIG. 3 presents a flowchart of an example of a control operation that may be executed in the compressor control by the control unit 16, and an example of the control operation executed for the compressor 3 is explained below in reference to the flowchart. In step 50, the control unit 16 enters a target air temperature Tset for the evaporator outlet side. Tset may be entered by directly setting the target air temperature through the operation panel 15 or it may be calculated based upon various types of heat load information such as the external air temperature and the cabin internal temperature.

**[0036]** Subsequently, in step 52, the air temperature T on the evaporator outlet side detected with the outlet air temperature sensor 14 is entered, and in the following step 54, gains A, B and C in an arithmetic expression (mathematical expression 1 below) used to calculate the target value Pset for the low level pressure are determined. A is a proportional gain by which the proportional term is multiplied, B is an integral gain by which the integral term is multiplied and C is a differential gain by which the differential term is multiplied.

$$Pset - A (Tset - T) + B \int (Tset - T)\, dt + Cd (Tset - T) / dt \qquad \text{mathematical expression 1}$$

**[0037]** The individual gains (A, B and C) are adjusted in correspondence to a value representing a physical quantity that affects the air conditioning state, e.g., the target air temperature Tset for the evaporator outlet side, input as external information, as indicated in FIG. 4 (a). When Tset is smaller than a predetermined value T0, the gains are set so that A = A1, B = B1 and C = C1, whereas when Tset is greater than the predetermined value T0, the gains are set so that A = A2, B = B2 and C = C2.

**[0038]** Then, in step 56, the target value Pset for the low level pressure is calculated by using mathematical expression 1, based upon the difference between the target air temperature Tset for the evaporator outlet side and the actual temperature T detected on the evaporator outlet side. More specifically, as shown in FIG. 5, a proportional component Pp, an integral component Pi and a differential component Pd are individually calculated based upon the difference between the target air temperature Tset for the evaporator outlet side and the actual air temperature T on the evaporator outlet side (steps 560 through 564), and then, in step 566, the individual components are multiplied by the corresponding gains to calculate the target value Pset for the low level pressure.

**[0039]** It is to be noted that when the air temperature T on the evaporator outlet side is higher than the target air temperature Tset, the target value Pset for the low level pressure is set to a lower value (so as to increase the discharge capacity of the compressor 3), whereas when T is lower than Tset, the target value Pset is set to a higher value (so as to reduce the discharge capacity of the compressor 3).

**[0040]** Then, in step 58, the lower level pressure Ps is detected and entered, and in the following step 60, gains D, E and F in an arithmetic expression (mathematical expression 2 below) used to calculate the control signal DL to be provided to the pressure control valve 2 are determined. D is a proportional gain by which the proportional term is multiplied, E is an integral game by which the integral term is multiplied and F is a differential gain by which the differential term is multiplied.

$$DL = D(Pset - Ps) + E \int (Pset - Ps)\, dt + Fd (Pset - Ps) /dt \ldots$$

mathematical expression 2

**[0041]** The individual gains are adjusted in correspondence to a value representing a physical quantity that affects the air conditioning state, e.g., the target air temperature Tset for the evaporator outlet side, input as external information, as indicated in FIG. 4(b). When Tset is smaller than a predetermined value T1, the gains are set so that D = D1, E = E1 and F = F1, whereas when Tset is greater than the predetermined value T1, the gains are set so that D = D2, E = E2 and F = F2.

**[0042]** Then, in step 62, the control signal DL to be provided to the pressure control valve 2 is calculated by using mathematical expression 2 based upon the difference between the target pressure Pset for the low level pressure and the actual low level pressure Ps detected with the pressure sensor 9. In more specific terms, a proportional component Dp, an integral component Di and a differential component Dd are individually calculated based upon the difference between the target pressure Pset for the low level pressure and the actual low level pressure Ps (steps 620 through 624), and the individual components are multiplied by the corresponding gains in step 626 to calculate the control signal DL for the pressure control valve 2, as shown in FIG. 6.

**[0043]** Subsequently, the control signal DL obtained as described above is output from the control unit 16 to the pressure control valve 2 in step 64. It is to be noted that when the low-level pressure Ps is higher than the target pressure Pset, the duty ratio increases and thus, a control signal with the higher duty ratio is provided to the pressure control valve 2 to increase the discharge volume. If, on the other hand, the low-level pressure Ps is lower than the target pressure Pset, the duty ratio becomes lower and thus, a control signal with the lower duty ratio is provided to the pressure control valve 2 to reduce the discharge volume.

**[0044]** As shown in FIG. 7 presenting a block diagram of the control described above, the gains in the arithmetic expression used to calculate Pset are determined based upon the external information indicating a physical quantity that affects the air-conditioning state in block 70, and in the next block 72, Pset is calculated with mathematical expression 1 based upon the difference between Tset and T ( Tset error) by using the gains thus determined so as to set the Tset error to 0. Subsequently, the gains in the arithmetic expression used to calculate DL are determined in block 74 based upon the external information through the external control described above, and in the next block 76, DL is calculated with mathematical expression 2 based upon the difference between Pset and Ps ( Ps error) by using the gains thus determined, so as to set the Ps error to 0. Then, DL is provided to the pressure control valve 2 of the compressor 3 in the air-conditioning system.

**[0045]** In the control described above, the gains (A, B and C) in the arithmetic expression used to calculate Pset and the gains (D, E and F) in the arithmetic expression used to calculate DL are adjusted based upon the external information indicating a physical quantity that affects the air conditioning state, and, as a result, it is possible to prevent deterioration of the response and the stability which may occur when the gains are fixed at specific values. In other words, the optimal response and stability can be assured under varying conditions.

**[0046]** In addition, the control described above achieves cascade control implemented with a major controller that uses the air temperature T on the evaporator outlet side as a control variable and the target value Pset for the low-level pressure as an operation variable and a minor controller that uses the operation variable of the major controller as a target value, the low level pressure Ps as a control variable and the control signal DL provided to the pressure control valve 2 as an operation variable. Thus, feedback control for converging the air temperature T on the evaporator outlet side to the target temperature Tset can be implemented in a desirable manner to ultimately control the air temperature T on the evaporator outlet side by controlling the suction-side pressure which can be directly controlled with the compressor 3 in the structure described above, which does not include a pressure sensitive member such as a bellows and adopts an electrically controlled pressure control valve 2, while also achieving faster control response.

**[0047]** FIG. 8 presents another structural example that may be adopted. While the basic structures of the refrigerating cycle 1 and the compressor 3 are similar to those in the previous structural example, this example differs in that the pressure control valve 2 at the compressor 3 is constituted with a first switching control valve (Pd-Pc valve) 2a, which is an electromagnetic valve disposed on a pressure supply passage connecting the discharge space 27 with the crank chamber 24 and a second switching control valve (Pc - Ps valve) 2b, which is an electromagnetic valve disposed on a pressure release passage connecting the crank chamber 24 with the suction space 26 and in that the control unit 16 implements control on these switching control valves. Since other structural features are similar to those in the previous example, the same reference numerals are assigned to corresponding parts to preclude the necessity for a repeated explanation thereof.

**[0048]** An example of a control operation that may be executed in the compressor control by the control unit 16 in conjunction with the structure described above is now explained in reference to the flowchart presented in FIG. 9. In step 80, the control unit 16 enters a target air temperature Tset for the evaporator outlet side. Tset may be entered by directly setting the target air temperature through the operation panel 15 or it may be calculated based upon various types of heat load information such as the external air temperature and the cabin internal temperature.

**[0049]** Then, in step 82, the air temperature T on the evaporator outlet side detected with the outlet air temperature sensor 14 is entered, and in the following step 84, the actual air temperature T on the evaporator outlet side is compared with the target air temperature Tset for the evaporator outlet outside. If Tset < T, it is necessary to lower the air temperature, i.e., it is necessary to increase the discharge volume of the compressor 3, and accordingly, the first switching control valve 2a and the second switching control valve 2b are controlled as described below.

**[0050]** Namely, a full close signal is output for the first switching control valve (Pd - Pc valve) 2a to set it in a fully closed state and thus, the pressure supply from the discharge space 27 to the crank chamber 24 is stopped completely (step 86). In addition, the gains A, B and C in the arithmetic expression (mathematical expression 1) used to calculate the target value Pset for the low level pressure are determined in step 88 in the control implemented on the second switching control valve (Pc - Ps valve) 2b. The individual gains are adjusted in correspondence to a value representing a physical quantity that affects the air conditioning state, e.g., the target air temperature Tset for the evaporator outlet side, input as external information, as indicated in FIG. 10(a). When Tset is smaller than the predetermined value T0, the gains are set so that A = A3 - 2, B = B3 - 2 and C = C3 - 2, whereas when Tset is greater than the predetermined value T0, the gains are set so that A = A4 -2, B = B4 -2 and C = C4 -2.

**[0051]** Then, in step 90, the target value Pset for the low level pressure is calculated based upon the difference between the target air temperature Tset for the evaporator outlet side and the actual temperature T detected on the evaporator outlet side by using mathematical expression 1 as in the processing shown in FIG. 5 explained earlier.

**[0052]** Then, in step 92, the lower level pressure Ps is detected and entered, and in the following step 94, the gains D, E and F in the arithmetic expression (mathematical expression 2 presented earlier) used to calculate the control signal DL to be provided to the pressure control valve 2 are determined. The individual gains are adjusted in correspondence to a value representing a physical quantity that affects the air conditioning state, e.g., the target air temperature Tset for the evaporator outlet side, input as external information, as indicated in FIG. 10(b). When Tset is smaller than a predetermined value T1, the gains are set so that D = D3-2, E = E3-2 and F = F3-2, whereas when Tset is greater than the predetermined value T1, the gains are set so that D = D4-2, E = E4-2 and F = F4-2.

**[0053]** Then, in step 96, the control signal DL to be provided to the pressure control valve 2 is calculated based upon the difference between the target pressure Pset for the low level pressure and the actual low level pressure Ps by using mathematical expression 2 as in the processing shown in FIG. 6 explained earlier, and in step 98, the control signal DL is output from the control unit 16 to the second switching control valve (Pc - Ps valve) 2b.

**[0054]** If, on the other hand, it is judged in step 84 that Tset ≥ T, the air temperature is too low, i.e., it is necessary to reduce the discharge volume at the compressor 3, and accordingly, the discharge capacity is reduced by controlling the first switching control valve 2a and the second switching control valve 2b as described below.

**[0055]** Namely, in the control of the first switching control valve (Pd-Pc valve) 2a, the gains A, B and C in the arithmetic expression (mathematical expression 1) used to calculate the target value Pset for the low level pressure are determined in step 100. The individual gains are adjusted in correspondence to a value representing a physical quantity that affects the air conditioning state, e.g., the target air temperature Tset for the evaporator outlet side, input as external information, as indicated in FIG. 10(a). When Tset is smaller than the predetermined value T0, the gains are set so that A = A3 -1, B = B3 -1 and C = C3 -1, whereas when Tset is greater than the predetermined value T0, the gains are set so that A = A4 -1, B = B4 -1 and C = C4 -1.

**[0056]** Then, in step 102, the target value Pset for the low level pressure is calculated based upon the difference between the target air temperature Tset for the evaporator outlet side and the actual temperature T detected on the evaporator outlet side by using mathematical expression 1 as in the processing shown in FIG. 5 explained earlier.

**[0057]** Then, in step 104, the lower level pressure Ps is detected and entered, and in the following step 106, the gains D, E and F in the arithmetic expression (mathematical expression 2 presented earlier) used to calculate the control signal DL to be provided to the pressure control valve 2 are determined. The individual gains are adjusted in correspondence to a value representing a physical quantity that affects the air conditioning state, e.g., the target air temperature Tset for the evaporator outlet side, input as external information, as indicated in FIG. 10(b). When Tset is smaller than a predetermined value, the gains are set so that D = D3-1, E = E3-1 and F = F3-1, whereas when Tset is greater than the predetermined target value, the gains are set so that D = D4-1, E = E4-1 and F = F4-1.

**[0058]** Then, in step 108, the control signal DL to be provided to the pressure control valve 2 is calculated based upon the difference between the target pressure Pset for the low level pressure and the actual low level pressure Ps by using mathematical expression 2 as in the processing shown in FIG. 6 explained earlier, and in step 110, the control signal DL is output from the control unit 16 to the first switching control valve (Pd - Pc valve) 2a.

**[0059]** In addition, control similar to that executed in steps 88 through 98 is implemented on the second switching control valve (Pc - Ps valve) 2b in steps 112 to 122.

**[0060]** Thus, in the structure described above in which the switching control valves 2a and 2b are individually controlled as indicated in the block diagram in FIG. 7, the gains (A, B and C) in the arithmetic expression used to calculate Pset and the gains (D, E and F) in the arithmetic expression used to calculate DL are adjusted based upon the external information indicating a physical quantity that affects the air conditioning state. As a result, it is possible to prevent deterioration in response and stability that may otherwise occur if the gains are fixed at specific values, and optimal response and stability are assured under varying conditions.

**[0061]** The control implemented on the individual switching control valves 2a and 2b described above constitutes cascade control achieved with a major controller that uses the air temperature T on the evaporator outlet side as a control variable and the target value Pset for the low-level pressure as an operation variable and a minor controller that uses the operation variable of the major controller as a target value, the low level pressure Ps as a control variable and the control signal DL provided to the pressure control valves as an operation variable. Thus, feedback control for converging the air temperature T on the evaporator outlet side to the target temperature Tset can be implemented in a desirable manner to ultimately control the air temperature T on the evaporator outlet side by controlling the suction-side pressure which can be directly controlled with the compressor 3 in the structure described above, which does not include a pressure sensitive member such as a bellows and adopts electrically controlled switching control valves 2a and 2b, while also achieving faster control response.

**[0062]** Furthermore, in the control described above, if it is judged that Tset < T and accordingly, the crank chamber pressure needs to be released, the discharge volume is adjusted simply by regulating the release quantity with the pressure supply to the crank chamber from the discharge space stopped altogether and thus, the crank chamber pressure can be utilized effectively. Namely, if open/close control was implemented on the first switching control valve (Pd - Pc valve) 2a as well, it would be necessary to release extra pressure from the crank chamber to the suction space in correspondence to the pressure supplied from the discharge space to the crank chamber in order to achieve the desired crank chamber pressure Pc, which would result in poorer compressor efficiency. However, since the crank chamber pressure is controlled simply by controlling the second switching control valve (Pc - Ps valve) 2b when increasing the discharge capacity as described above, the crank chamber pressure can be adjusted with a high degree of efficiency to improve the efficiency of the compressor itself.

**[0063]** It is to be noted that when the crank chamber pressure is released, i.e., when it is judged that Tset < T and it is necessary to increase the discharge volume at the compressor in order to increase the cooling capability, the first switching control valve (Pd - Pc valve) 2a is set in a fully closed state in the control described above. Alternatively, the second switching control valve (Pc - Ps valve) 2b may be set in a fully closed state and duty ratio control may be implemented on the first switching control valve (Pd - Pc valve) 2a when supplying the crank chamber pressure, i.e., when it is judged that Tset ≥ T and the discharge volume at the compressor needs to be reduced in order to lower the cooling capability.

**[0064]** As a further alternative, if it is judged that Tset < T, the first switching control valve (Pd - Pc valve) 2a may be set in a fully closed state (step 86) and then duty ratio control may be implemented on the second switching control valve (Pc - Ps valve) 2b (steps 88 through 98) as in the control shown in FIG. 9, whereas if it is judged that Tset ≥ T, the second switching control valve (Pc - Ps valve) 2b may be first set in a fully closed state (step 124) and then duty ratio control may be implemented on the first switching control valve (Pd - Pc valve) 2a (steps 100 through 110), as shown in FIG. 11. By adopting this control method, which enables control to be executed with a single switching control valve both when supplying the pressure to the crank chamber 24 and when releasing the pressure from the crank chamber 24, further improvement in the efficiency is achieved.

**[0065]** Also, while the target air temperature Tset for the evaporator outlet is used as the physical quantity that affects the air conditioning state in the control described above, the gains may be adjusted in conformance to any of measured values (external information) detected with sensors such as the outlet-side air temperature T at the evaporator 6, the external air temperature Ta, the cabin internal air temperature Tinc, the discharge pressure Pd at the compressor, the suction pressure Ps at the compressor, the coolant pressure at the evaporator outlet, the rotational speed of the compressor and the vehicle speed or any of arithmetic values (internal information) calculated at the control unit 16 such as the target rotational speed (i.e., the target air flow rate) for the blower fan 13, the target pressure Pset for the low-pressure line 8 in the refrigeration cycle 1 and the target air temperature Tset for the evaporator outlet side. Moreover, the gains may be adjusted by using some of the values listed above in combination.

**[0066]** Furthermore, while the gains are adjusted over two stages in the control described above, they may be instead adjusted over three stages or more, or they may be adjusted continuously. In addition, while PID control is adopted in the examples explained above, the gains may be adjusted in a similar manner based upon a physical quantity that affects the air conditioning state in conjunction with another control mode such as PI control.

INDUSTRIAL APPLICABILITY

**[0067]** As described above, according to the present invention, which enables control of the control chamber pressure with a control signal provided from the outside without having to utilize a pressure sensitive member by adjusting the gains in the arithmetic expression used to calculate the control signal to be provided to a means for pressure control in correspondence to a value representing a physical quantity that affects the air conditioning state, to be adopted in conjunction with a variable displacement compressor having the means for pressure control which controls the pressure supply from the discharge pressure area to the control pressure chamber and the pressure release from the control pressure chamber to the suction pressure area, with the means for pressure control electrically controlled with the control signal provided from the outside to adjust the pressure in the pressure chamber so as to reduce the discharge capacity as the pressure in the control pressure chamber rises and to increase the discharge capacity as the pressure in the control pressure chamber becomes lower, a control device of the variable displacement compressor and a variable displacement control device of a refrigerating cycle with optimal response and stability assured under varying conditions while improving the efficiency of the compressor are provided.

**[0068]** In addition, since the control signal to be provided to the means for pressure control is calculated so as to set the pressure detected by the means for pressure detection to the target pressure and the target pressure for the suction pressure area side is calculated so as to set the outlet-side air temperature at the evaporator to the target temperature, the outlet-side air temperature at the evaporator, which is the ultimate control target, can be controlled with a high degree of effectiveness by adopting cascade control to achieve feedback control, which is ideal in an application in which control is implemented with an electrically controlled control valve without providing a pressure sensitive member such as a bellows.

**Claims**

**1.** A control device of a variable displacement compressor having a means for pressure control that enables a pressure supply from a discharge pressure area to a control pressure chamber and a pressure release from said control pressure chamber to a suction pressure area and is controlled with a control signal provided from the outside in response to which said means for pressure control adjusts the pressure in said control pressure chamber so as to reduce the discharge capacity as the pressure in said control pressure chamber rises and to increase the discharge capacity as the pressure in said control pressure chamber becomes lower in said variable displacement compressor, with said control device comprising:

a means for pressure detection that detects a pressure on said suction pressure area side;
a means for control signal calculation that calculates said control signal for said means for pressure control so as to set the pressure detected by said means for pressure detection to a target pressure; and
a means for gain adjustment that adjusts a gain in an arithmetic expression used to calculate said control signal in correspondence to a physical quantity that affects the air conditioning state.

**2.** A control device of a variable displacement compressor according to claim 1, **characterized in:**

**that** said means for pressure control is constituted with a single control valve that simultaneously adjusts the state of communication between said control pressure chamber and said discharge pressure area and the state of communication between said control pressure chamber and said suction pressure area.

**3.** A control device of a variable displacement compressor according to claim 1, **characterized in:**

**that** said means for pressure control is constituted with a first switching control valve disposed on a pressure supply passage connecting said discharge pressure area with said control pressure chamber and a second switching control valve disposed on a pressure release passage connecting said control pressure chamber with said suction pressure area.

**4.** A control device of a variable displacement compressor according to claim 1, **characterized in:**

**that** said variable displacement compressor comprises:

a drive shaft disposed within a cylinder block;
a drive swash plate that rotates together with said drive shaft and allows the angle of inclination formed relative to said drive shaft to be varied freely;
a cylinder disposed within said cylinder block and having an axis extending parallel to said drive shaft;
a piston slidably disposed within said cylinder which makes reciprocal movement inside said cylinder as said drive swash plate rotates;
a compression space formed by said cylinder and said piston;
a crank chamber constituting said control pressure chamber formed at said piston on the side opposite from said compression space;
a suction space that constitutes said suction pressure area coming into communication with said compression space during a suction stroke of said piston; and
a discharge space that constitutes said discharge pressure area coming into communication with said compression space during the compression stroke of said piston.

**5.** A variable displacement control device of a refrigerating cycle having at least a variable displacement compressor that includes a means for pressure control enabling a pressure supply from a discharge pressure area to a control pressure chamber and a pressure release from said control pressure chamber to a suction pressure area and adjusts the pressure in said control pressure chamber by controlling said means for pressure control with a control signal provided from the outside so as to reduce the discharge capacity as the pressure in said control pressure chamber rises and to increase the discharge capacity as the pressure in said control pressure chamber becomes lower, a radiator that cools a coolant having been compressed at said variable displacement compressor, an expansion device depressurizes the coolant having been cooled at said radiator and an evaporator that evaporates the depressurized coolant at said expansion device, comprising:

a means for pressure detection that detects the pressure on said suction pressure area side;
a means for control signal calculation that calculates said control signal for said means for pressure control so as to set the pressure detected by said means for pressure detection to a target pressure; and
a means for gain adjustment that adjusts a gain in an arithmetic expression used to calculate said control signal in correspondence to a physical quantity that affects the air-conditioning state.

**6.** A variable displacement control device of a refrigerating cycle having at least a variable displacement compressor that includes a means for pressure control enabling a pressure supply from a discharge pressure area to a control pressure chamber and a pressure release from said control pressure chamber to a suction pressure area and adjusts the pressure in said control pressure chamber by controlling said means for pressure control with a control signal provided from the outside so as to reduce the discharge capacity as the pressure in said control pressure chamber rises and to increase the discharge capacity as the pressure in said control pressure chamber becomes lower, a radiator that cools a coolant having been compressed at said variable displacement compressor, an expansion device that depressurizes the coolant having been cooled at said radiator and an evaporator that evaporates the depressurized coolant at said expansion device, comprising:

a means for pressure detection that detects the pressure on said suction pressure area side;
a means for control signal calculation that calculates said control signal for said means for pressure control so as to set the pressure detected by said means for pressure detection to a target pressure;
a means for air temperature detection that detects an air temperature on the outlet side of said evaporator; and
a means for target pressure calculation that calculates a target pressure to be achieved on said suction pressure area side so as to set the air temperature on the outlet side of said evaporator to a target temperature.

**7.** A variable displacement control device of a refrigerating cycle according to claim 6, further comprising:

a means for control signal calculation gain adjustment that adjusts a gain in an arithmetic expression used to calculate said control signal in correspondence to a physical quantity that affects the air conditioning state.

**8.** A variable displacement control device of a refrigerating cycle according to claim 6 or claim 7, further comprising:

a means for target pressure calculation gain adjustment that adjusts a gain in an arithmetic operation used to calculate said target pressure on said suction pressure area side in correspondence to a physical quantity that affects the air conditioning state.

**9.** A variable displacement control device of a refrigerating cycle according to claim 5 or claim 6, **characterized in:**

**that** said means for pressure control is constituted with a single control valve that simultaneously adjusts the state of communication between said control pressure chamber and said discharge pressure area and the state of communication between said control pressure chamber and said suction pressure area.

**10.** A variable displacement control device of a refrigerating cycle according to claim 5 or claim 6, **characterized in:**

**that** said means for pressure control is constituted with a first switching control valve disposed on a pressure supply passage connecting said discharge pressure area with said control pressure chamber and a second switching control valve disposed on a pressure release passage connecting said control pressure chamber with said suction pressure area.

**11.** A variable displacement control device of a refrigerating cycle according to claim 10, further comprising;
a means for comparison that compares the outlet-side air temperature at said evaporator with a target temperature, **characterized in:**

**that** control is implemented with said control signal only on said second switching control valve by setting said first switching control valve in a fully closed state when the outlet-side air temperature at said evaporator is higher than the target temperature.

**12.** A variable displacement control device of a refrigerating cycle according to claim 10 or claim 11, further comprising;
a means for comparison that compares the outlet-side air temperature at said evaporator with a target temperature, **characterized in:**

**that** control is implemented with said control signal on said first switching control file and said second switching control valve if the outlet-side air temperature at said evaporator is equal to or lower than the target temperature.

**13.** A variable displacement control device of a refrigerating cycle according to claim 10 or claim 11, further comprising;
a means for comparison that compares the outlet-side air temperature at said is evaporator with a target temperature **characterized in that**:

control is implemented with said control signal only on said first switching control valve by setting said second switching control valve in a fully closed state when the outlet-side air temperature at said evaporator is equal to or lower than the target temperature.

**14.** A variable displacement control device of a refrigerating cycle according to claim 5 or claim 6, **characterized in that**; said variable displacement compressor comprises:

a drive shaft disposed within a cylinder block;
a drive swash plate that rotates together with said drive shaft and allows the angle of inclination formed relative to said drive shaft to be varied freely;
a cylinder disposed within said cylinder block and having an axis extending parallel to said drive shaft;
a piston slidably disposed within said cylinder which makes reciprocal movement inside said cylinder as said drive swash plate rotates;
a compression space formed by said cylinder and said piston, a crank chamber constituting said control pressure chamber formed at said piston on the side opposite from said compression space;
a suction space that constitutes said suction pressure area coming into communication with said compression space during a suction stroke of said piston; and
a discharge space that constitutes said discharge pressure area coming into communication with said compression space during the compression stroke of said piston.

**15.** A variable displacement control device of a refrigerating cycle according to claim 5 or claim 6, **characterized in that** the coolant is carbon dioxide.

Fig. 1

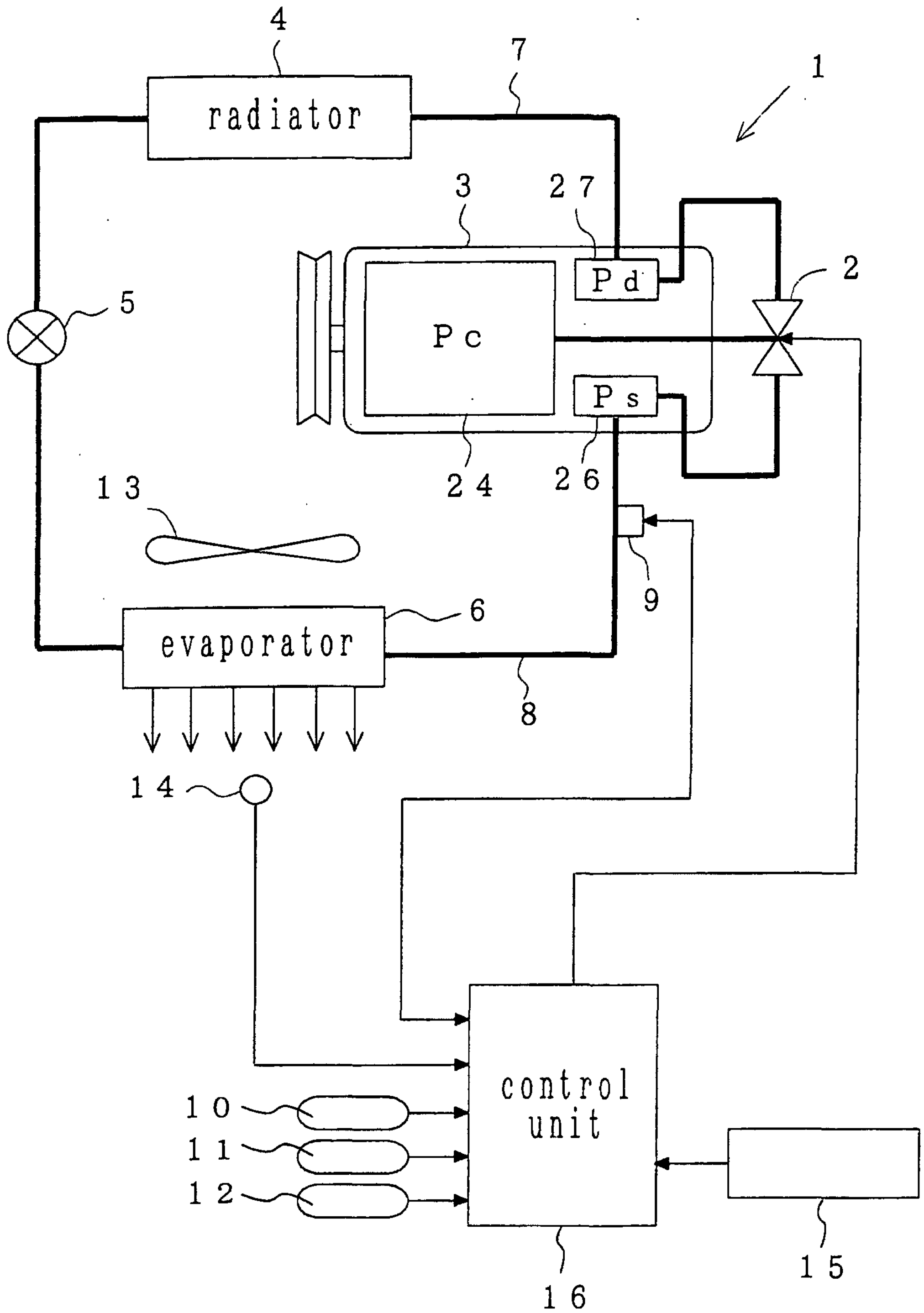

4
radiator
7
1
3
27
Pd
2
5
Pc
Ps
24
26
13
9
evaporator
6
8
14
control unit
10
11
12
15
16

Fig. 2

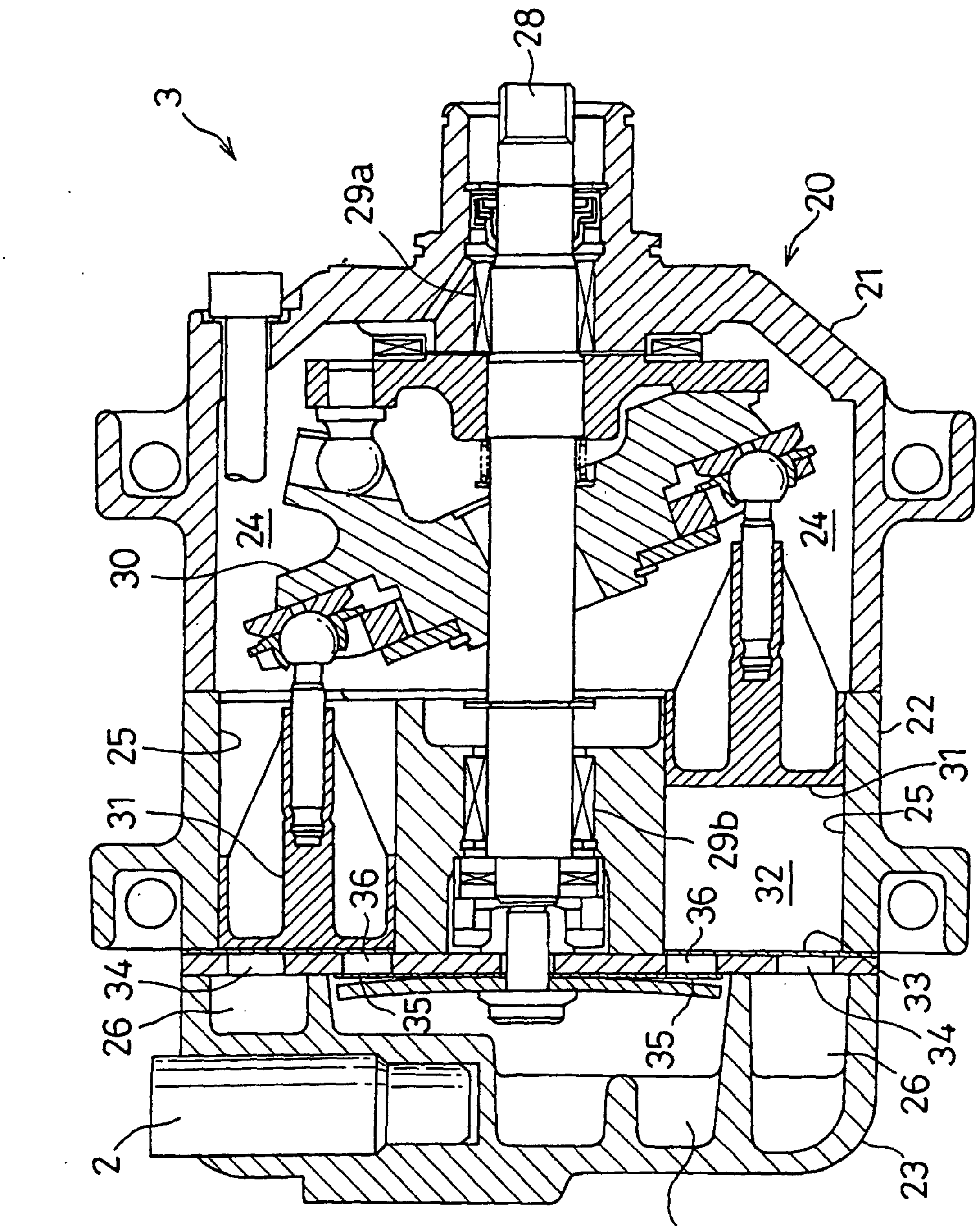

3
28
29a
20
21
24
30
24
25
31
36
22
31
25
29b
32
36
33
34
26
35
35
34
26
2
27
23

Fig. 3

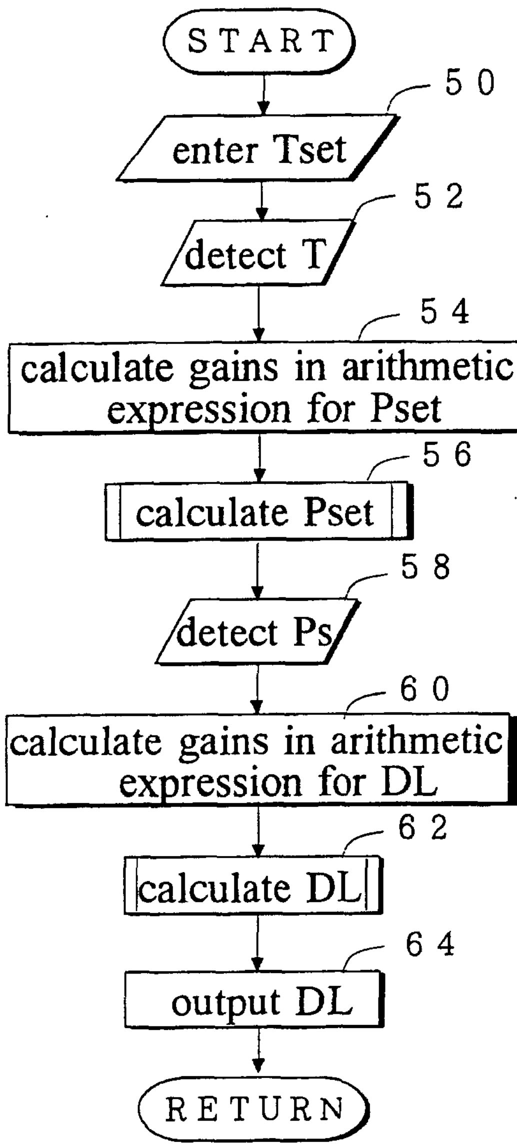
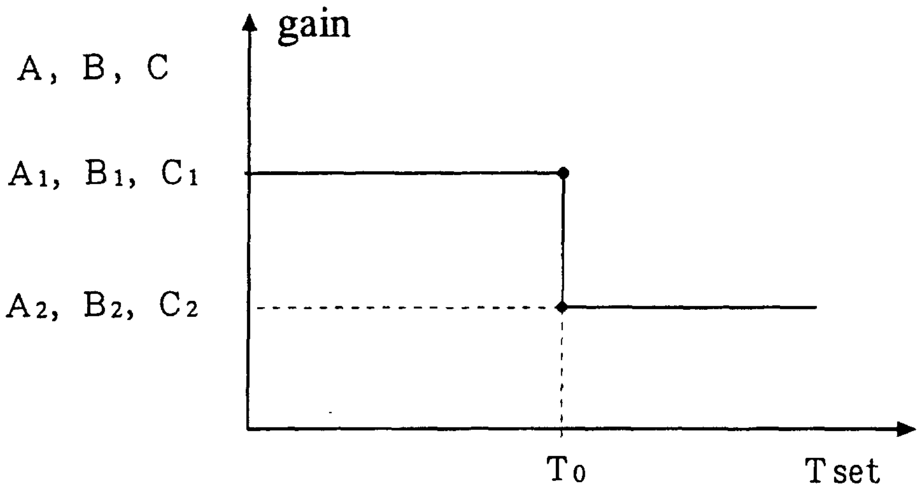

START
50
enter Tset
52
detect T
54
calculate gains in arithmetic expression for Pset
56
calculate Pset
58
detect Ps
60
calculate gains in arithmetic expression for DL
62
calculate DL
64
output DL
RETURN

Fig. 4

(a)


gain
A, B, C
A1, B1, C1
A2, B2, C2
T0
Tset

(b)

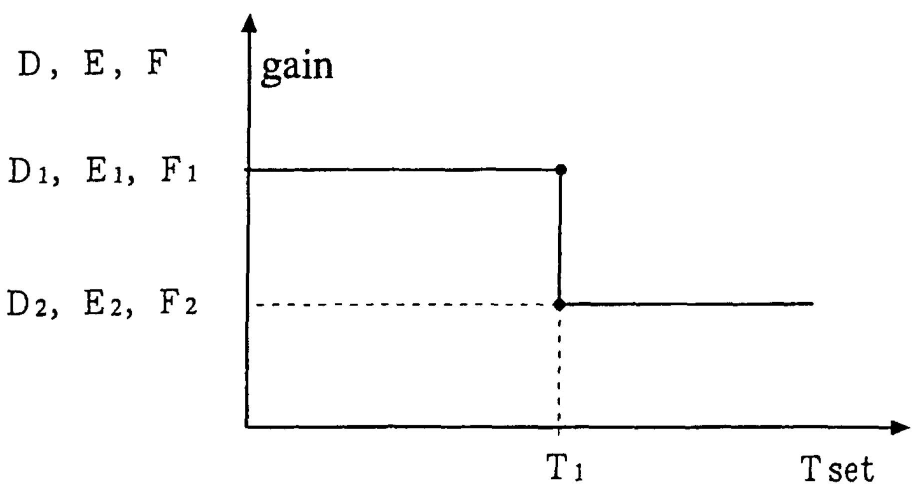

D, E, F
gain
D1, E1, F1
D2, E2, F2
T1
Tset

Fig. 5

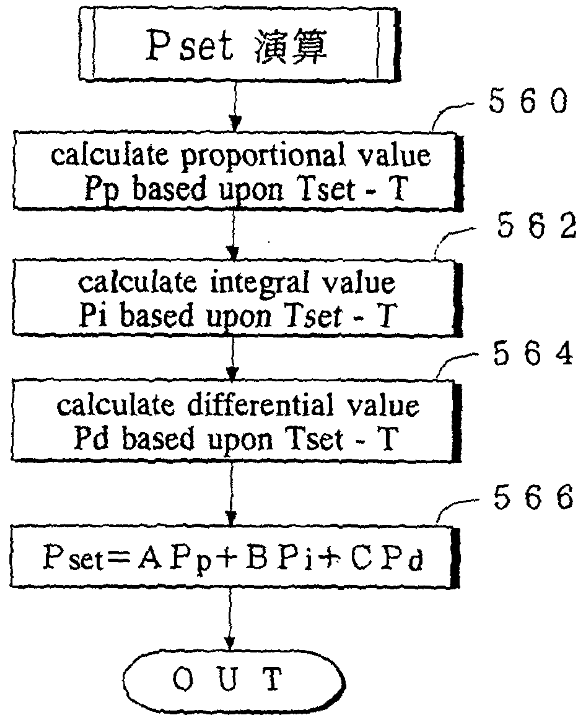

Pset 演算
560
calculate proportional value
Pp based upon Tset - T
562
calculate integral value
Pi based upon Tset - T
564
calculate differential value
Pd based upon Tset - T
566
Pset=APp+BPi+CPd
OUT

Fig. 6

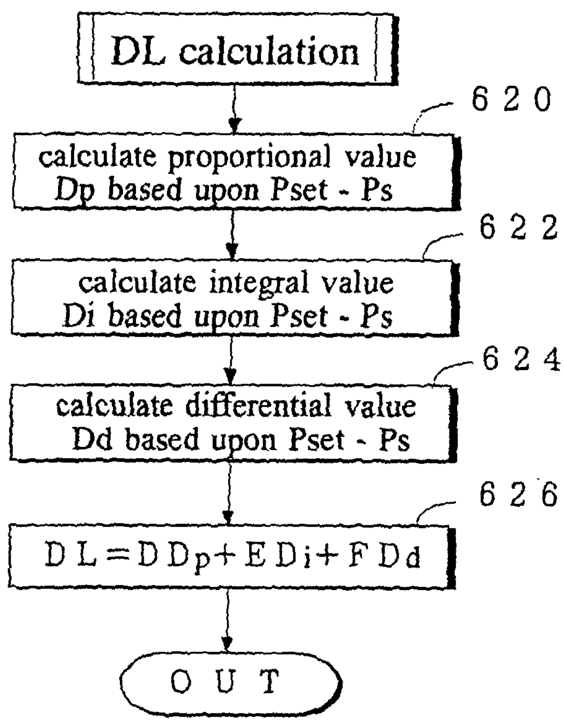

DL calculation
620
calculate proportional value
Dp based upon Pset - Ps
622
calculate integral value
Di based upon Pset - Ps
624
calculate differential value
Dd based upon Pset - Ps
626
DL=DDp+EDi+FDd
OUT

Fig. 7

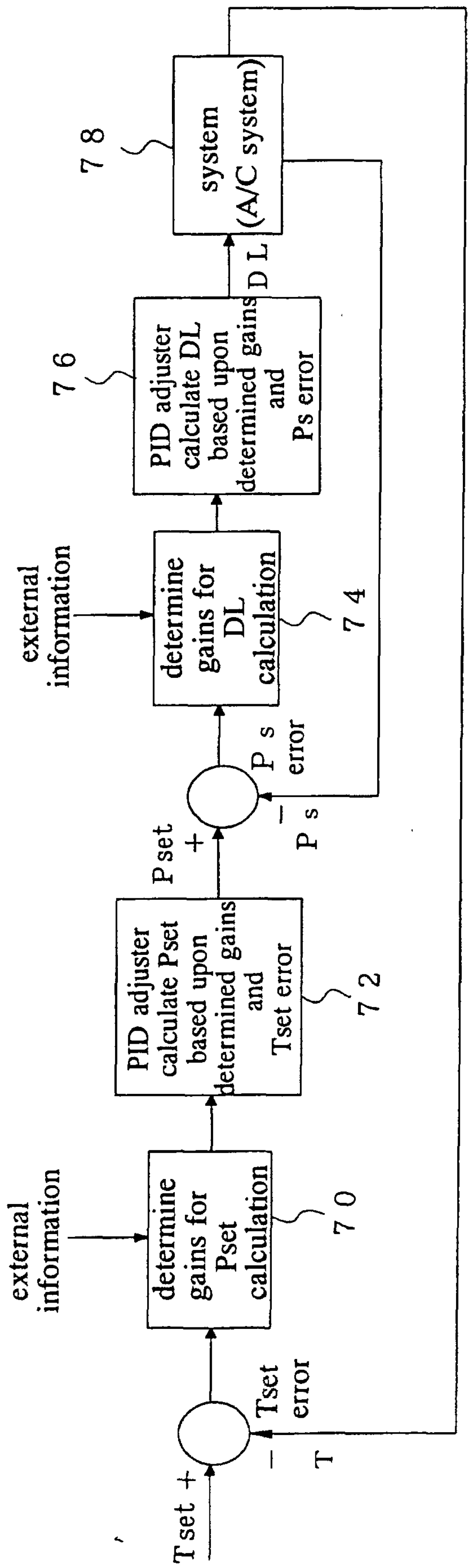

Tset +
−
T
Tset error
external information
determine gains for Pset calculation
70
PID adjuster calculate Pset based upon determined gains and Tset error
72
Pset +
−
Ps
Ps error
external information
determine gains for DL calculation
74
PID adjuster calculate DL based upon determined gains and Ps error
76
DL
system (A/C system)
78

Fig. 8

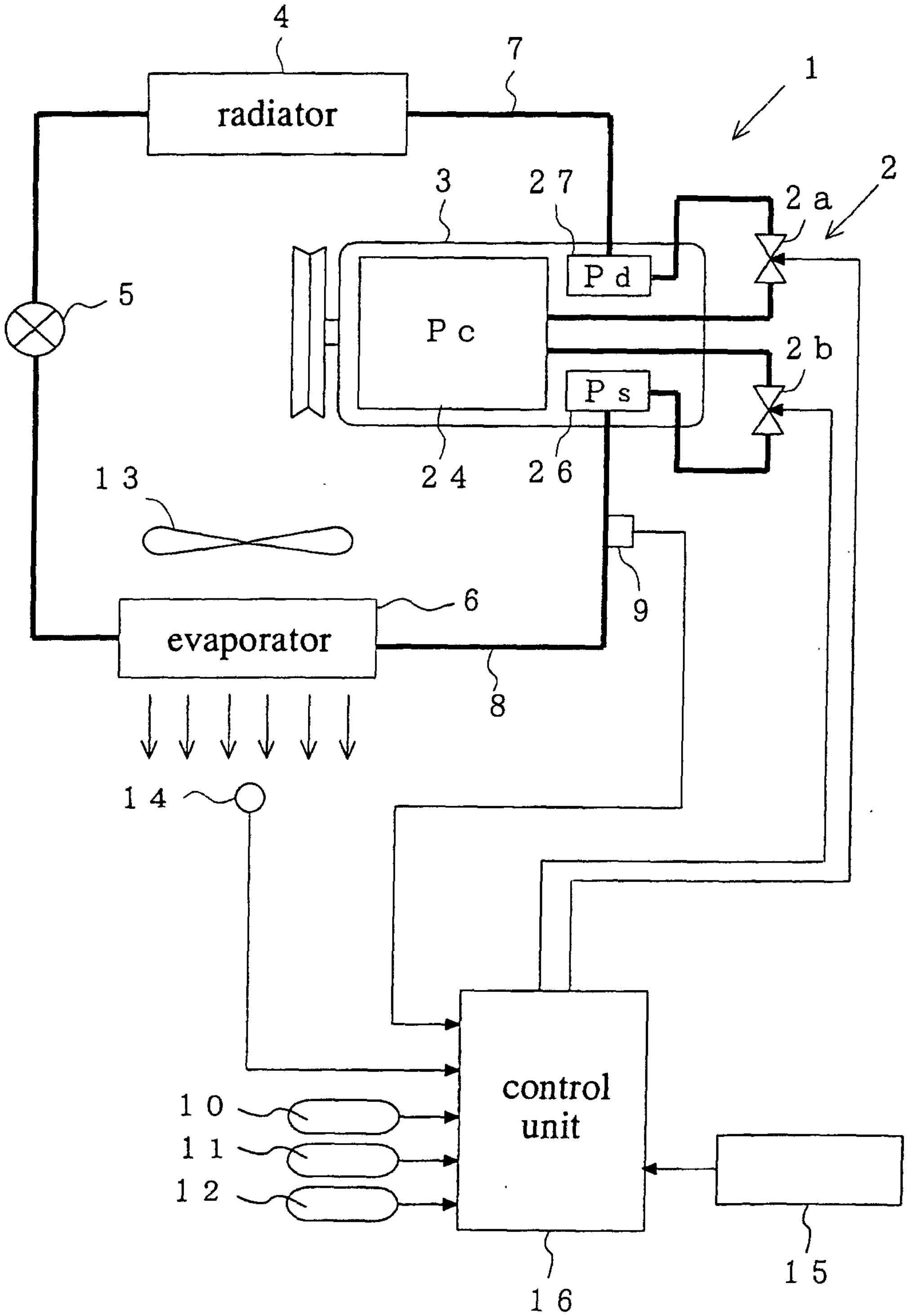

4
7
1
radiator
3
2 7
2
2 a
P d
5
P c
2 b
P s
1 3
2 4
2 6
9
6
evaporator
8
1 4
control unit
1 0
1 1
1 2
1 5
1 6

Fig. 9

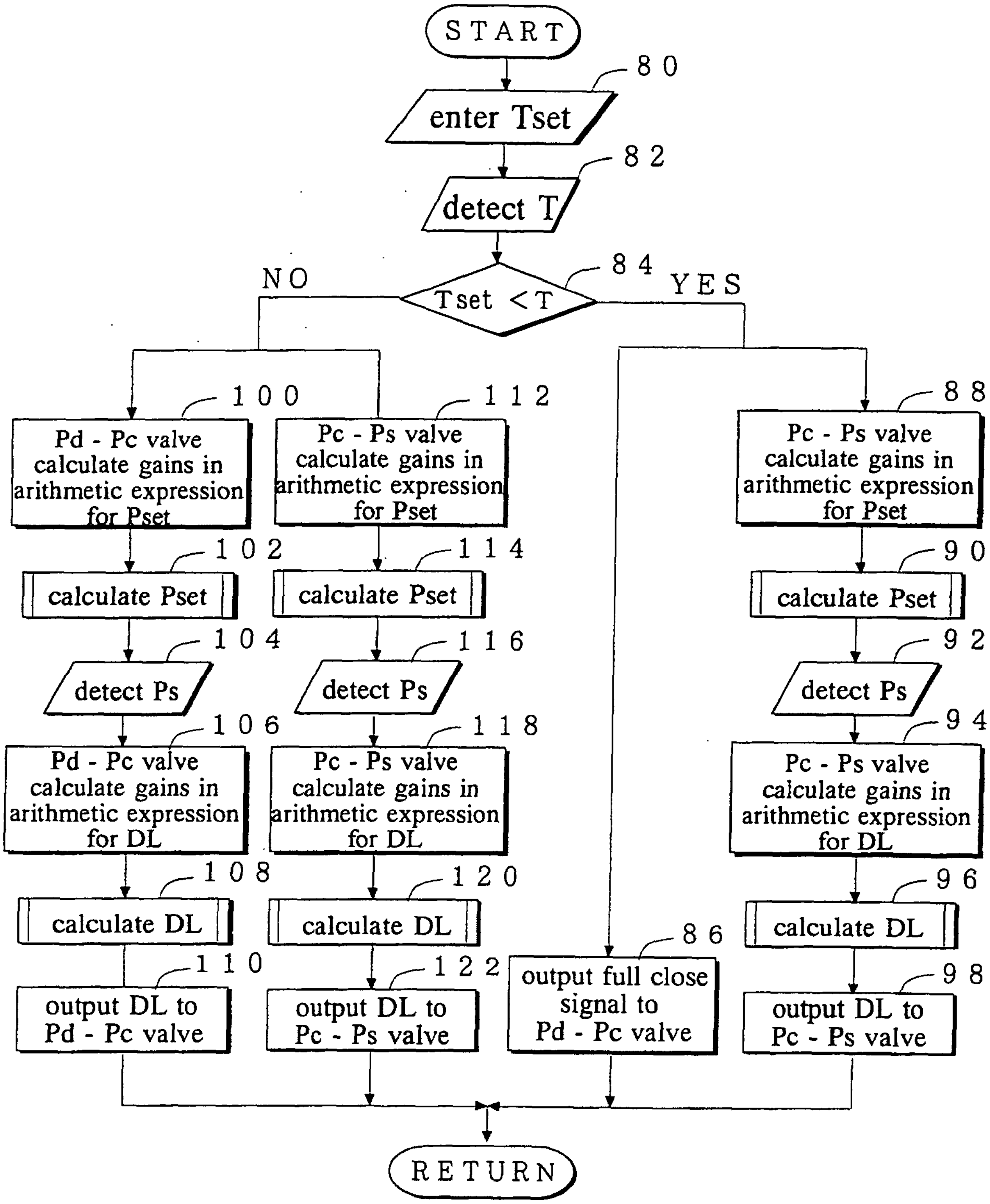
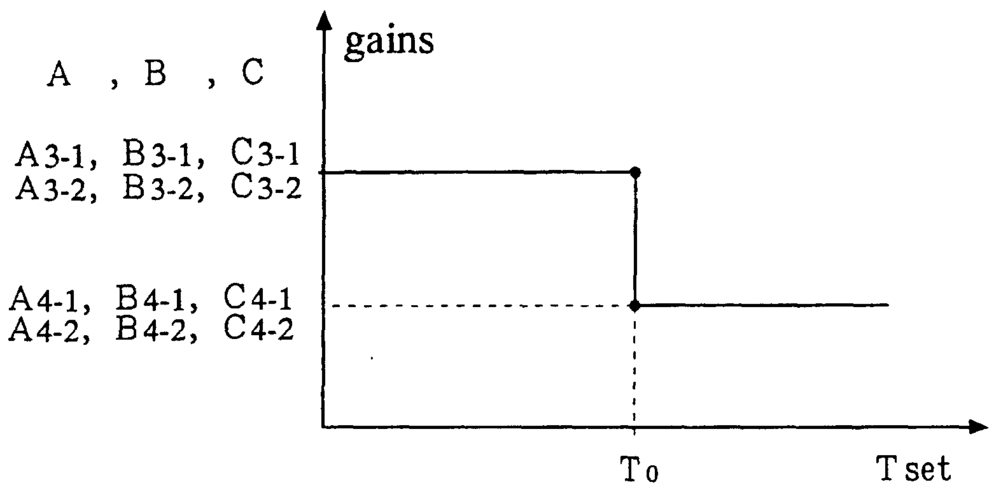

START
80
enter Tset
82
detect T
84
Tset <T
NO
YES
100
Pd - Pc valve calculate gains in arithmetic expression for Pset
102
calculate Pset
104
detect Ps
106
Pd - Pc valve calculate gains in arithmetic expression for DL
108
calculate DL
110
output DL to Pd - Pc valve
112
Pc - Ps valve calculate gains in arithmetic expression for Pset
114
calculate Pset
116
detect Ps
118
Pc - Ps valve calculate gains in arithmetic expression for DL
120
calculate DL
122
output DL to Pc - Ps valve
86
output full close signal to Pd - Pc valve
88
Pc - Ps valve calculate gains in arithmetic expression for Pset
90
calculate Pset
92
detect Ps
94
Pc - Ps valve calculate gains in arithmetic expression for DL
96
calculate DL
98
output DL to Pc - Ps valve
RETURN

Fig. 1 0

(a)


gains
A , B , C
A3-1, B3-1, C3-1
A3-2, B3-2, C3-2
A4-1, B4-1, C4-1
A4-2, B4-2, C4-2
T0
Tset

(b)

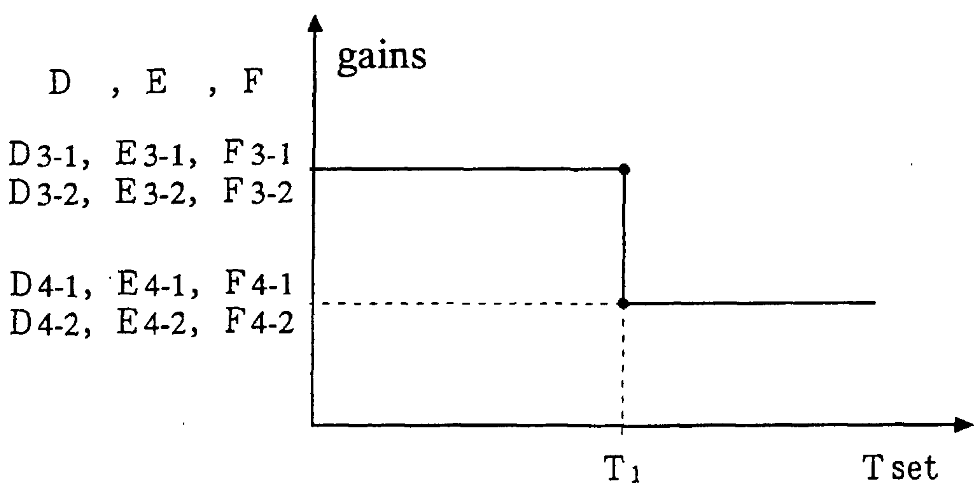

gains
D , E , F
D3-1, E3-1, F3-1
D3-2, E3-2, F3-2
D4-1, E4-1, F4-1
D4-2, E4-2, F4-2
T1
Tset

Fig. 1 1

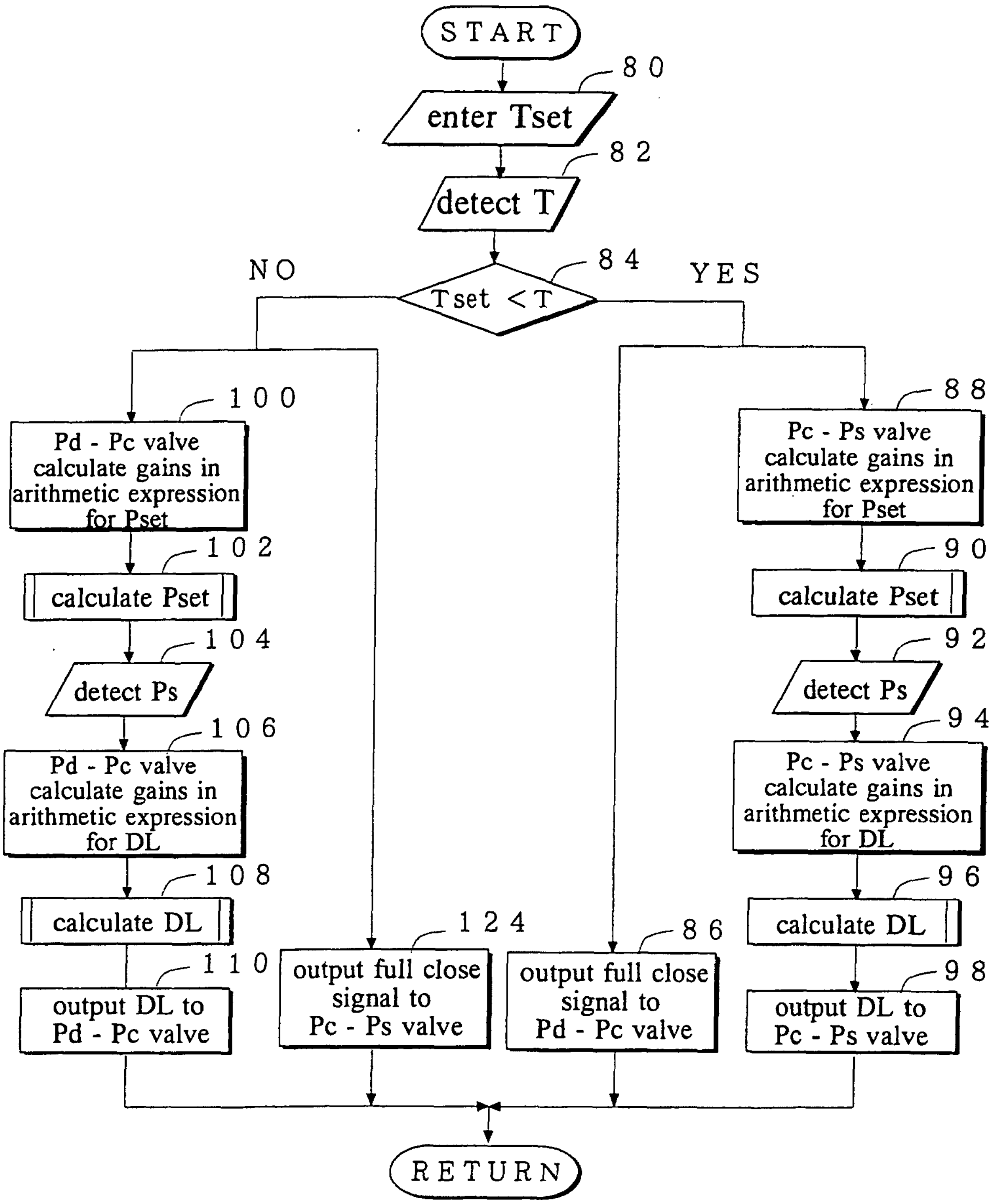
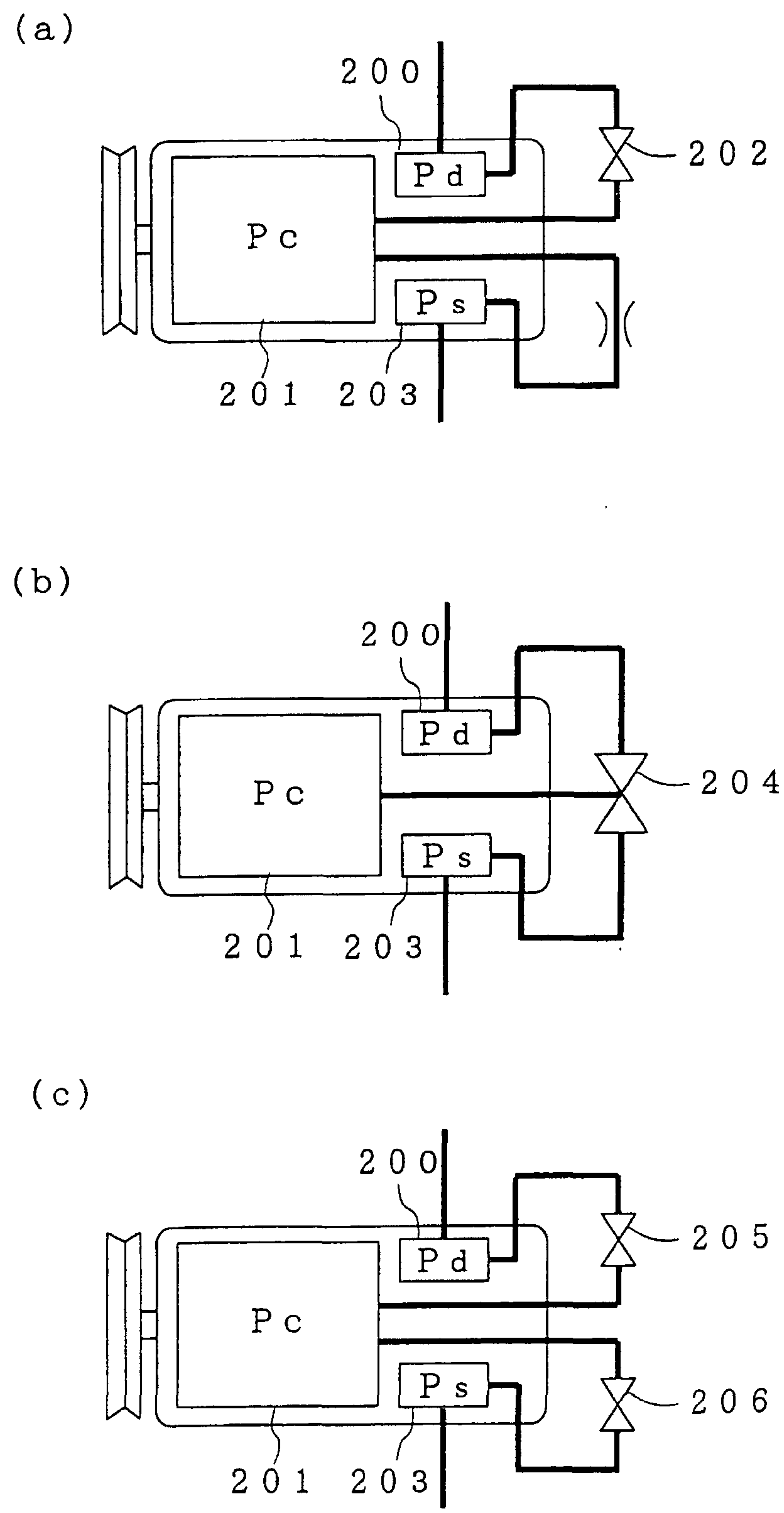

START
80
enter Tset
82
detect T
84
Tset <T
NO
YES
100
Pd - Pc valve calculate gains in arithmetic expression for Pset
102
calculate Pset
104
detect Ps
106
Pd - Pc valve calculate gains in arithmetic expression for DL
108
calculate DL
110
output DL to Pd - Pc valve
124
output full close signal to Pc - Ps valve
86
output full close signal to Pd - Pc valve
88
Pc - Ps valve calculate gains in arithmetic expression for Pset
90
calculate Pset
92
detect Ps
94
Pc - Ps valve calculate gains in arithmetic expression for DL
96
calculate DL
98
output DL to Pc - Ps valve
RETURN

Fig. 1 2


(a)
200
202
Pd
Pc
Ps
201
203
(b)
200
204
Pd
Pc
Ps
201
203
(c)
200
205
Pd
Pc
Ps
206
201
203

## INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP02/08722

**A. CLASSIFICATION OF SUBJECT MATTER**
Int.Cl[7] F24F11/02, F04B27/08

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] F24F11/02, F04B27/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

| | | | |
|---|---|---|---|
| Jitsuyo Shinan Koho | 1926-1996 | Toroku Jitsuyo Shinan Koho | 1994-2002 |
| Kokai Jitsuyo Shinan Koho | 1971-2002 | Jitsuyo Shinan Toroku Koho | 1996-2002 |

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. |
|---|---|---|
| P,A | JP 2001-349624 A (Toyota Industries Corp.), 21 December, 2001 (21.12.01), Full text (Family: none) | 1-15 |

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

* Special categories of cited documents:
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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 03 December, 2002 (03.12.02) | 17 December, 2002 (17.12.02) |
| Name and mailing address of the ISA/ Japanese Patent Office | Authorized officer |
| Facsimile No. | Telephone No. |

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