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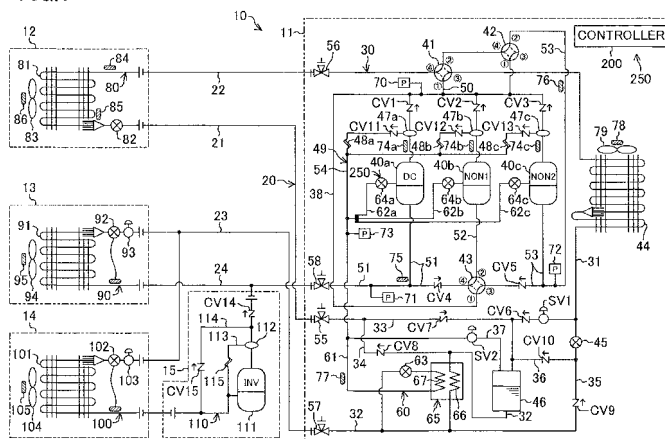
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(54) **REFRIGERATION UNIT**

(57) In a refrigerant circuit (20), the variable capacity compressor (40a) sucks refrigerant through a first suction pipe (51), and a second fixed capacity compressor (40c) sucks refrigerant through a third suction pipe (53). Refrigeration oil of an oil separator (47a-47c) flows into the compressor (40a-40c) through an oil return pipe (54) and a main injection pipe (61) together with intermediate-pressure refrigerant. During a normal operation, a controller (200) adjusts the degree of opening of an injection motor-operated valve (64a-64c) so that the temperature of refrigerant discharged from the corresponding com-

pressor reaches a predetermined target value. If the first suction pipe (51) has a pressure lower than that of the third suction pipe (53), the controller temporarily decreases the degree of opening of the first injection motor-operated valve (64a) as compared to that during the normal operation, and temporarily increases the degree of opening of the third injection motor-operated valve (64c) as compared to that during the normal operation. As a result, the flow rate of intermediate-pressure refrigerant and refrigeration oil flowing into the second fixed capacity compressor (40c) is increased.

FIG.1



Description

TECHNICAL FIELD

[0001] The present invention relates to a refrigerating apparatus in which so-called "intermediate-pressure injection" to supply intermediate-pressure refrigerant to a compressor, and particularly relates to a refrigerating apparatus in which refrigeration oil separated from refrigerant discharged from a compressor is supplied to a compressor together with intermediate-pressure refrigerant.

BACKGROUND ART

[0002] Conventionally, a refrigerating apparatus has been known, which includes a refrigerant circuit performing a refrigeration cycle. The refrigerating apparatus of this type has been widely used for coolers such as refrigerators and freezers for storing food etc. and air conditioners for cooling/heating an inside of a room.

[0003] Patent Document 1 discloses a refrigerating apparatus including a heat source unit, a compartment unit, and an indoor unit. In a refrigerant circuit of the refrigerating apparatus, the followings are connected together: a first compressor, a second compressor, and a heat source heat exchanger which are accommodated in the heat source unit, a compartment expansion valve and a compartment heat exchanger which are accommodated in the compartment unit, and an indoor expansion valve and an indoor heat exchanger which are accommodated in the indoor unit.

[0004] Specifically, high-pressure lines extending from outlets of the first and second compressors are joined together, and are switchably connected to the heat source heat exchanger and the indoor heat exchanger. A first low-pressure line extending from an inlet of the first compressor is connected to the compartment heat exchanger through the compartment expansion valve. A second low-pressure line extending from an inlet of the second compressor is connected to the indoor heat exchanger through the indoor expansion valve. During an operation of the refrigerating apparatus, an inside of a refrigerator compartment is cooled by the compartment heat exchanger while conditioning air inside a room by the indoor heat exchanger.

[0005] In the refrigerant circuit of the refrigerating apparatus disclosed in Patent Document 1, an oil separator is provided on an outlet side of the first and second compressors, and an oil return pipe extending from an oil outlet port of the oil separator is connected to an injection pipe. The injection pipe is for injecting intermediate-pressure refrigerant to the first and second compressors. The injection pipe includes a main pipe branched from the high-pressure line connected to the outlet of the heat source heat exchanger, and a plurality of branch pipes, each of which is further branched from the main pipe and is connected to each of intermediate ports of the first and second compressors.

[0006] During an operation of the first and second compressors, refrigeration oil is separated from refrigerant discharged from the first and second compressors and containing the refrigeration oil in the oil separator. The refrigeration oil separated from the discharged refrigerant in the oil separator flows into the injection pipe through the oil return pipe. The refrigeration oil joins refrigerant flowing through the injection pipe, and then returns to the first and second compressors.

CITATION LIST

PATENT DOCUMENT

- [0007]** PATENT DOCUMENT 1: Japanese Patent Publication No. 2008-076017

SUMMARY OF THE INVENTION

TECHNICAL PROBLEM

[0008] However, when the injection pipe is used to returns refrigeration oil in the oil separator to the first and second compressors as in the refrigerating apparatus disclosed in Patent Document 1, there is a possibility that more refrigeration oil returns to either one of the first and second compressors than to the remaining one of the first and second compressors.

[0009] That is, in a conventional refrigerating apparatus, first and second low-pressure lines are provided as low-pressure lines of a refrigerant circuit, and the pressures of the first and second low-pressure lines (i.e., the pressure of refrigerant flowing through the low-pressure lines) are determined depending on an evaporation pressure of a utilization heat exchanger connected to the low-pressure lines. Typically, an evaporation pressure of refrigerant in a compartment heat exchanger cooling an inside of a refrigerator compartment is lower than an evaporation pressure of refrigerant in an indoor heat exchanger cooling an inside of a room. Thus, when comparing the pressures of the first and second low-pressure lines with each other, the pressure of the first low-pressure line connected to the compartment heat exchanger is lower than that of the second low-pressure line during cooling the inside of the room.

[0010] When the pressures of the first and second low-pressure lines are different from each other as in the foregoing, pressures at the intermediate ports of the compressors connected to the low-pressure lines are also different from each other. Thus, during cooling the inside of the room, the pressure at the intermediate port of the first compressors is lower than that of the second compressor, and the amount of refrigeration oil sent back from the oil separator to the compressor (i.e., the first compressor) having a lower pressure at the intermediate port is larger than the amount of refrigeration oil sent back from the oil separator to the compressor having a higher pressure at the intermediate port. As a result, the amount

of refrigeration oil stored in the second compressor is decreased, and therefore there is a possibility that the second compressor is damaged due to inadequate lubrication.

[0011] The present invention has been made in view of the foregoing, and it is an objective of the present invention to, in a refrigerating apparatus including a plurality of compressors, in which intermediate-pressure injection to the compressors is performed so that refrigeration oil separated from refrigerant discharged from the compressors is supplied to the compressors together with intermediate-pressure refrigerant, ensure the amount of refrigeration oil stored in all of the compressors to avoid damaging the compressor in advance, and improve reliability of the refrigerating apparatus.

SOLUTION TO THE PROBLEM

[0012] A first aspect of the invention is intended for a refrigerating apparatus includes a refrigerant circuit (20) in which a refrigeration cycle is performed. The refrigerant circuit (20) includes a first evaporator (91), a second evaporator (81, 44), a first compressor (40a) sucking refrigerant evaporated in the first evaporator (91), a second compressor (40c) sucking refrigerant evaporated in the second evaporator (81, 44), a condenser (44, 81) into which refrigerant discharged from the first compressor (40a) and the second compressor (40c) flows, an injection circuit (60) having a main injection pipe (61) through which intermediate-pressure refrigerant flows, a first branched pipe (62a) connecting the main injection pipe (61) to the first compressor (40a), and a second branched pipe (62c) connecting the main injection pipe (61) to the second compressor (40c), and an oil return circuit (49) in which refrigeration oil separated from refrigerant discharged from the first compressor (40a) and the second compressor (40c) is supplied to the main injection pipe (61). The refrigerating apparatus further includes a flow rate adjusting mechanism (250) configured to perform a normal operation in which a refrigerant flow rate in each of the first branched pipe (62a) and the second branched pipe (62c) is adjusted so that a physical amount for control reaches a predetermined target control value. The flow rate adjusting mechanism (250) makes determination using either one of a condition in which a pressure of refrigerant sucked into the first compressor (40a) is greater than a pressure of refrigerant sucked into the second compressor (40c), and a condition in which the pressure of refrigerant sucked into the first compressor (40a) is equal to or greater than the pressure of refrigerant sucked into the second compressor (40c), as a determination condition. The flow rate adjusting mechanism (250) intermittently performs an operation in which the refrigerant flow rate in the first branched pipe (62a) is increased as compared to that during the normal operation, and the refrigerant flow rate in the second branched pipe (62c) is decreased as compared to that during the normal operation, as an oil distribution operation when

the determination condition is satisfied. The flow rate adjusting mechanism (250) intermittently performs an operation in which the refrigerant flow rate in the first branched pipe (62a) is decreased as compared to that during the normal operation, and the refrigerant flow rate in the second branched pipe (62c) is increased as compared to that during the normal operation, as the oil distribution operation when the determination condition is not satisfied.

[0013] In the first aspect of the invention, intermediate-pressure refrigerant is supplied to the first compressor (40a) and the second compressor (40c) by the injection circuit (60). Intermediate-pressure refrigerant flowing through the first branched pipe (62a) is supplied to a compression chamber of the first compressor (40a) in the middle of a compression process. Intermediate-pressure refrigerant flowing through the second branched pipe (62c) is supplied to a compression chamber of the second compressor (40c) in the middle of a compression process. Note that the intermediate-pressure refrigerant has a pressure higher than those of refrigerant (sucked refrigerant) sucked into the first compressor (40a) and refrigerant (sucked refrigerant) sucked into the second compressor (40c), and has a pressure lower than those of refrigerant discharged from the first compressor (40a) and refrigerant discharged from the second compressor (40c).

[0014] In the first aspect of the invention, refrigeration oil is supplied from the oil return circuit (49) to the main injection pipe (61) of the injection circuit (60). The refrigeration oil flowing into the main injection pipe (61) flows into the first compressor (40a) through the first branched pipe (62a) together with intermediate-pressure refrigerant, and flows into the second compressor (40c) through the second branched pipe (62c) together with intermediate-pressure refrigerant.

[0015] In the first aspect of the invention, the flow rate adjusting mechanism (250) adjusts the refrigerant flow rate in the first branched pipe (62a) and the refrigerant flow rate in the second branched pipe (62c). An increase/decrease in refrigerant flow rate in the first branched pipe (62a) results in an increase/decrease in amount of refrigeration oil supplied to the first compressor (40a) together with intermediate-pressure refrigerant. In addition, an increase/decrease in refrigerant flow rate in the second branched pipe (62c) results in an increase/decrease in amount of refrigeration oil supplied to the second compressor (40c) together with intermediate-pressure refrigerant.

[0016] In the first aspect of the invention, the flow rate adjusting mechanism (250) intermittently performs the oil distribution operation. The flow rate adjusting mechanism (250) performs an operation which is different between a case where the determination condition is satisfied and a case where the determination condition is not satisfied, as the oil distribution operation.

[0017] When the determination condition is satisfied, it can be assumed that a pressure in the compression

chamber of the first compressor (40a) in the middle of the compression process is higher than that in the compression chamber of the second compressor (40c) in the middle of compression process, and it is more likely that refrigeration oil returns to the second compressor (40c) than to the first compressor (40a). Thus, as the oil distribution operation when the determination condition is satisfied, the flow rate adjusting mechanism (250) of the first aspect of the invention performs an operation in which the refrigerant flow rate in the first branched pipe (62a) is increased as compared to that during the normal operation, and the refrigerant flow rate in the second branched pipe (62c) is decreased as compared to that during the normal operation. During the oil distribution operation, the flow rate of intermediate-pressure refrigerant and refrigeration oil flowing into the first compressor (40a) through the first branched pipe (62a) is increased as compared to that during the normal operation, and the flow rate of intermediate-pressure refrigerant and refrigeration oil flowing into the second compressor (40c) through the second branched pipe (62c) is decreased as compared to that during the normal operation. Thus, when the determination condition is satisfied, the amount of refrigeration oil stored in the first compressor (40a) is decreased while performing the normal operation by the flow rate adjusting mechanism (250), but is increased while performing the oil distribution operation by the flow rate adjusting mechanism (250). The flow rate adjusting mechanism (250) temporarily stops the normal operation and performs the oil distribution operation. In such a manner, the flow rate adjusting mechanism (250) recovers the amount of refrigeration oil stored in the first compressor (40a), and then restarts the normal operation.

[0018] When the determination condition is not satisfied, it can be assumed that the pressure in the compression chamber of the second compressor (40c) in the middle of the compression process is higher than that in the compression chamber of the first compressor (40a) in the middle of compression process, and it is more likely that refrigeration oil returns to the first compressor (40a) than to the second compressor (40c). Thus, as the oil distribution operation when the determination condition is not satisfied, the flow rate adjusting mechanism (250) of the first aspect of the invention performs an operation in which the refrigerant flow rate in the first branched pipe (62a) is decreased as compared to that during the normal operation, and the refrigerant flow rate in the second branched pipe (62c) is increased as compared to that during the normal operation. During the oil distribution operation, the flow rate of intermediate-pressure refrigerant and refrigeration oil flowing into the first compressor (40a) through the first branched pipe (62a) is decreased as compared to that during the normal operation, and the flow rate of intermediate-pressure refrigerant and refrigeration oil flowing into the second compressor (40c) through the second branched pipe (62c) is increased as compared to that during the normal operation. Thus, when the determination condition is not satisfied, the

amount of refrigeration oil stored in the second compressor (40c) is decreased while performing the normal operation by the flow rate adjusting mechanism (250), but is increased while performing the oil distribution operation by the flow rate adjusting mechanism (250). The flow rate adjusting mechanism (250) temporarily stops the normal operation and performs the oil distribution operation. In such a manner, the flow rate adjusting mechanism (250) recovers the amount of refrigeration oil stored in the second compressor (40c), and then restarts the normal operation.

[0019] A second aspect of the invention is intended for the refrigerating apparatus of the first aspect of the invention, in which the flow rate adjusting mechanism (250) includes a first flow rate adjusting valve (64a) provided in the first branched pipe (62a), a second flow rate adjusting valve (64c) provided in the second branched pipe (62c), and an opening degree control section (220) configured to control a degree of opening of each of the first flow rate adjusting valve (64a) and the second flow rate adjusting valve (64c) so that the physical amount for control reaches a predetermined target control value. In the second aspect of the invention, the opening degree control section (220) performs one or both of an operation in which the degree of opening of the first flow rate adjusting valve (64a) is increased as compared to that during the normal operation, and an operation in which the degree of opening of the second flow rate adjusting valve (64c) is decreased as compared to that during the normal operation, as the oil distribution operation when the determination condition is satisfied, and performs one or both of an operation in which the degree of opening of the first flow rate adjusting valve (64a) is decreased as compared to that during the normal operation, and an operation in which the degree of opening of the second flow rate adjusting valve (64c) is increased as compared to that during the normal operation, as the oil distribution operation when the determination condition is not satisfied.

[0020] In the second aspect of the invention, the flow rate adjusting mechanism (250) includes the first flow rate adjusting valve (64a), the second flow rate adjusting valve (64b), and the opening degree control section (220). The opening degree control section (220) adjusts the first flow rate adjusting valve (64a) in order to adjust the refrigerant flow rate in the first branched pipe (62a), and adjusts the second flow rate adjusting valve (64c) in order to adjust the refrigerant flow rate in the second branched pipe (62c).

[0021] When the determination condition is satisfied, the flow rate adjusting mechanism (250) of the second aspect of the invention performs one or both of the operation in which the degree of opening of the first flow rate adjusting valve (64a) is increased as compared to that during the normal operation, and the operation in which the degree of opening of the second flow rate adjusting valve (64c) is decreased as compared to that during the normal operation, as the oil distribution operation.

In the injection circuit (60), intermediate-pressure refrigerant and refrigeration oil flowing through the main injection pipe (61) flow so as to be branched into the first branched pipe (62a) and the second branched pipe (62c). Thus, not only in the case where both of the operation in which the degree of opening of the first flow rate adjusting valve (64a) is increased as compared to that during the normal operation, and the operation in which the degree of opening of the second flow rate adjusting valve (64c) is decreased as compared to that during the normal operation, but also in the case where either one of such two operations is performed, the refrigerant flow rate in the first branched pipe (62a) is increased, and the refrigerant flow rate in the second branched pipe (62c) is decreased.

[0022] When the determination condition is not satisfied, the flow rate adjusting mechanism (250) of the second aspect of the invention performs one or both of the operation in which the degree of opening of the first flow rate adjusting valve (64a) is decreased as compared to that during the normal operation, and the operation in which the degree of opening of the second flow rate adjusting valve (64c) is increased as compared to that during the normal operation, as the oil distribution operation. As described above, in the injection circuit (60), intermediate-pressure refrigerant and refrigeration oil flowing through the main injection pipe (61) flow so as to be branched into the first branched pipe (62a) and the second branched pipe (62c). Thus, not only in the case where both of the operation in which the degree of opening of the first flow rate adjusting valve (64a) is decreased as compared to that during the normal operation, and the operation in which the degree of opening of the second flow rate adjusting valve (64c) is increased as compared to that during the normal operation, but also in the case where either one of such two operations is performed, the refrigerant flow rate in the first branched pipe (62a) is decreased, and the refrigerant flow rate in the second branched pipe (62c) is increased.

[0023] A third aspect of the invention is intended for the refrigerating apparatus of the second aspect of the invention, in which the opening degree control section (220) uses a temperature or a superheating degree of refrigerant discharged from the first compressor (40a) as a first physical amount for control and adjusts the degree of opening of the first flow rate adjusting valve (64a) so that the first physical amount for control reaches a first target control value; uses a temperature or a superheating degree of refrigerant discharged from the second compressor (40c) as a second physical amount for control and adjusts the degree of opening of the second flow rate adjusting valve (64c) so that the second physical amount for control reaches a second target control value; in the normal operation, sets the first and second target control values to a predetermined normal target value to adjust the degree of opening of each of the first flow rate adjusting valve (64a) and the second flow rate adjusting valve (64c); if the degree of opening of the first flow rate adjusting valve (64a) is increased as compared to that

during the normal operation in the oil distribution operation, sets the first target control value to a value lower than the normal target value; if the degree of opening of the first flow rate adjusting valve (64a) is decreased as compared to that during the normal operation in the oil distribution operation, sets the first target control value to a value higher than the normal target value; if the degree of opening of the second flow rate adjusting valve (64c) is increased as compared to that during the normal operation in the oil distribution operation, sets the second target control value to a value lower than the normal target value; and if the degree of opening of the second flow rate adjusting valve (64c) is decreased as compared to that during the normal operation in the oil distribution operation, sets the second target control value to a value higher than the normal target value.

[0024] A fourth aspect of the invention is intended for the refrigerating apparatus of the first aspect of the invention, in which the flow rate adjusting mechanism (250) uses a temperature or a superheating degree of refrigerant discharged from the first compressor (40a) as a first physical amount for control and adjusts the refrigerant flow rate in the first branched pipe (62a) so that the first physical amount for control reaches a first target control value, and uses a temperature or a superheating degree of refrigerant discharged from the second compressor (40c) as a second physical amount for control and adjusts the refrigerant flow rate in the second branched pipe (62c) so that the second physical amount for control reaches a second target control value.

[0025] In the third and fourth aspects of the invention, the opening degree control section (220) uses the temperature or the superheating degree of refrigerant (discharged refrigerant) discharged from the first compressor (40a) as the first physical amount for control and adjusts the degree of opening of the first flow rate adjusting valve (64a). The opening degree control section (220) uses the temperature or the superheating degree of refrigerant (discharged refrigerant) discharged from the second compressor (40c) as the second physical amount for control and adjusts the degree of opening of the second flow rate adjusting valve (64c). During the normal operation, in the opening degree control section (220), both of the first and second target control values are set to the normal target value. That is, during the normal operation, the opening degree control section (220) adjusts the degree of opening of the first flow rate adjusting valve (64a) so that the first physical amount for control reaches the normal target value, and adjusts the degree of opening of the second flow rate adjusting valve (64c) so that the second physical amount for control reaches the normal target value.

[0026] Typically, in a compressor in which intermediate-pressure refrigerant is supplied to a compression chamber in the middle of a compression process, a greater flow rate of intermediate-pressure refrigerant supplied to the compressor results in a lower temperature or superheating degree of refrigerant discharged from the

compressor, and a smaller flow rate of intermediate-pressure refrigerant supplied to the compressor results in a higher temperature or superheating degree of refrigerant discharged from the compressor.

[0027] When the first target control value is set so as to be lower than the normal target value, the refrigerant flow rate in the first branched pipe (62a) is increased, and the temperature or superheating degree of refrigerant discharged from the first compressor (40a). Thus, the degree of opening of the first flow rate adjusting valve (64a) is increased as compared to that during the normal operation. When the first target control value is set so as to be higher than the normal target value, the refrigerant flow rate in the first branched pipe (62a) is decreased, and the temperature or superheating degree of refrigerant discharged from the first compressor (40a) is increased. Thus, the degree of opening of the first flow rate adjusting valve (64a) is decreased as compared to that during the normal operation.

[0028] Similarly, when the second target control value is set so as to be lower than the normal target value, the refrigerant flow rate in the second branched pipe (62c) is increased, and the temperature or superheating degree of refrigerant discharged from the second compressor (40c). Thus, the degree of opening of the second flow rate adjusting valve (64c) is increased as compared to that during the normal operation. When the second target control value is set so as to be higher than the normal target value, the refrigerant flow rate in the second branched pipe (62c) is decreased, and the temperature or superheating degree of refrigerant discharged from the second compressor (40c) is increased. Thus, the degree of opening of the second flow rate adjusting valve (64c) is decreased as compared to that during the normal operation.

[0029] During the oil distribution operation, the opening degree control section (220) of the third aspect of the invention changes the first target control value from the normal target value to increase/decrease the degree of opening of the first flow rate adjusting valve (64a) as compared to that during the normal operation, and changes the second target control value from the normal control value to increase/decrease the degree of opening of the second flow rate adjusting valve (64c) as compared to that during the normal operation.

[0030] A fifth aspect of the invention is intended for the refrigerating apparatus of the first aspect of the invention, in which the refrigerant circuit (20) further includes a third compressor (40b) configured to selectively sucks either one of refrigerant evaporated in the first evaporator (91) and refrigerant evaporated in the second evaporator (81, 44), the injection circuit (60) further includes a third branched pipe (62b) connecting the main injection pipe (61) to the third compressor (40b), and the oil return circuit (49) supplies refrigeration oil which is separated from refrigerant discharged from the first compressor (40a), the second compressor (40c), and the third compressor (40b), to the main injection pipe (61). In the fifth aspect

of the invention, the flow rate adjusting mechanism (250) includes a first flow rate adjusting valve (64a) provided in the first branched pipe (62a), a second flow rate adjusting valve (64c) provided in the second branched pipe (62c), a third flow rate adjusting valve (64b) provided in the third branched pipe (62b), and an opening degree control section (220) configured to control a degree of opening of each of the first flow rate adjusting valve (64a), the second flow rate adjusting valve (64c), and the third flow rate adjusting valve (64b) so that the physical amount for control is a predetermined target control value. In the fifth aspect of the invention, in a state in which the third compressor (40b) sucks refrigerant evaporated in the first evaporator (91), the opening degree control section (220) performs one or both of an operation in which the degree of opening of each of the first flow rate adjusting valve (64a) and the third flow rate adjusting valve (64b) is increased as compared to that during the normal operation, and an operation in which the degree of opening of the second flow rate adjusting valve (64c) is decreased as compared to that during the normal operation, as the oil distribution operation when the determination condition is satisfied; and performs one or both of an operation in which the degrees of opening of the first flow rate adjusting valve (64a) and the third flow rate adjusting valve (64b) are decreased as compared to that during the normal operation, and an operation in which the degree of opening of the second flow rate adjusting valve (64c) is increased as compared to that during the normal operation, as the oil distribution operation when the determination condition is not satisfied. In the fifth aspect of the invention, in a state in which the third compressor (40b) sucks refrigerant evaporated in the second evaporator (81, 44), the opening degree control section (220) performs one or both of an operation in which the degree of opening of the first flow rate adjusting valve (64a) is increased as compared to that during the normal operation, and an operation in which the degree of opening of each of the second flow rate adjusting valve (64c) and the third flow rate adjusting valve (64b) is decreased as compared to that during the normal operation, as the oil distribution operation when the determination condition is satisfied; and performs one or both of an operation in which the degree of opening of the first flow rate adjusting valve (64a) is decreased as compared to that during the normal operation, and an operation in which the degree of opening of each of the second flow rate adjusting valve (64c) and the third flow rate adjusting valve (64b) is increased as compared to that during the normal operation, as the oil distribution operation when the determination condition is not satisfied.

[0031] In the fifth aspect of the invention, intermediate-pressure refrigerant flowing through the third branched pipe (62b) is supplied to a compression chamber of the third compressor (40b) in the middle of a compression process. Refrigeration oil flowing into the main injection pipe (61) from the oil return circuit (49) flows into the third compressor (40b) through the third branched pipe (62b).

An increase/decrease in refrigerant flow rate in the third branched pipe (62b) results in an increase/decrease in amount of refrigeration oil supplied to the third compressor (40b) together with intermediate-pressure refrigerant.

[0032] The flow rate adjusting mechanism (250) of the fifth aspect of the invention includes the first flow rate adjusting valve (64a), the second flow rate adjusting valve (64c), the third flow rate adjusting valve (64b), and the opening degree control section (220). The opening degree control section (220) adjusts the degree of opening of the first flow rate adjusting valve (64a) in order to adjust the refrigerant flow rate in the first branched pipe (62a), adjusts the degree of opening of the second flow rate adjusting valve (64c) in order to adjust the refrigerant flow rate in the second branched pipe (62c), and adjusts the degree of opening of the third flow rate adjusting valve (64b) in order to adjust the refrigerant flow rate in the third branched pipe (62b).

[0033] It is assumed that, in a state in which the third compressor (40b) and the first compressor (40a) suck refrigerant evaporated in the first evaporator (91), a pressure in the compression chamber of the third compressor (40b) in the middle of the compression process is substantially equal to the pressure in the compression chamber of the first compressor (40a) in the middle of the compression process. Thus, when the determination condition is satisfied in such a state, it can be assumed that it is more likely that refrigeration oil returns to the second compressor (40c) than to the first compressor (40a) and the third compressor (40b). When the determination condition is satisfied in the foregoing state, the opening degree control section (220) of the fifth aspect of the invention performs one or both of the operation in which the degree of opening of each of the first flow rate adjusting valve (64a) and the third flow rate adjusting valve (64b) is increased as compared to that during the normal operation, and the operation in which the degree of opening of the second flow rate adjusting valve (64c) is decreased as compared to that during the normal operation, as the oil distribution operation. On the other hand, when the determination condition is not satisfied in the foregoing state, it can be assumed that it is more likely that refrigeration oil returns to the first compressor (40a) and the third compressor (40b) than to the second compressor (40c). When the determination condition is not satisfied in the foregoing state, the opening degree control section (220) of the fifth aspect of the invention performs one or both of the operation in which the degree of opening of each of the first flow rate adjusting valve (64a) and the third flow rate adjusting valve (64b) is decreased as compared to that during the normal operation, and the operation in which the degree of opening of the second flow rate adjusting valve (64c) is increased as compared to that during the normal operation, as the oil distribution operation.

[0034] In the injection circuit (60) of the fifth aspect of the invention, intermediate-pressure refrigerant and refrigeration oil flowing through the main injection pipe (61)

flow so as to be branched into the first branched pipe (62a), the second branched pipe (62c), and the third branched pipe (62b). Thus, not only in the case where both of the operation in which the degree of opening of each of the first flow rate adjusting valve (64a) and the third flow rate adjusting valve (64b) is increased as compared to that during the normal operation, and the operation in which the degree of opening of the second flow rate adjusting valve (64c) is decreased as compared to that during the normal operation, but also in the case where either one of such two operations is performed, the refrigerant flow rate in the first branched pipe (62a) and the third branched pipe (62b) is increased, and the refrigerant flow rate in the second branched pipe (62c) is decreased. As a result, the flow rate of refrigeration oil flowing into the first compressor (40a) through the first branched pipe (62a), and the flow rate of refrigeration oil flowing into the third compressor (40b) through the third branched pipe (62b) are increased, and the flow rate of refrigeration oil flowing into the second compressor (40c) through the second branched pipe (62c) is decreased. In addition, not only in the case where both of the operation in which the degree of opening of each of the first flow rate adjusting valve (64a) and the third flow rate adjusting valve (64b) is decreased as compared to that during the normal operation, and the operation in which the degree of opening of the second flow rate adjusting valve (64c) is increased as compared to that during the normal operation, but also in the case where either one of such two operations is performed, the refrigerant flow rate in the first branched pipe (62a) and the third branched pipe (62b) is decreased, and the refrigerant flow rate in the second branched pipe (62c) is increased. As a result, the flow rate of refrigeration oil flowing into the first compressor (40a) through the first branched pipe (62a) and the flow rate of refrigeration oil flowing into the third compressor (40b) through the third branched pipe (62b) are decreased, and the flow rate of refrigeration oil flowing into the second compressor (40c) through the second branched pipe (62c) is increased.

[0035] It is assumed that, in a state in which the third compressor (40b) and the second compressor (40c) suck refrigerant evaporated in the second evaporator (81, 44), the pressure in the compression chamber of the third compressor (40b) in the middle of the compression process is substantially equal to the pressure in the compression chamber of the second compressor (40c) in the middle of the compression process. Thus, when the determination condition is satisfied in such a state, it can be assumed that it is more likely that refrigeration oil returns to the second compressor (40c) and the third compressor (40b) than to the first compressor (40a). When the determination condition is satisfied in the foregoing state, the opening degree control section (220) of the fifth aspect of the invention performs one or both of the operation in which the degree of opening of the first flow rate adjusting valve (64a) is increased as compared to that during the normal operation, and the operation in which the

degree of opening of each of the second flow rate adjusting valve (64c) and the third flow rate adjusting valve (64b) is decreased as compared to that during the normal operation, as the oil distribution operation. On the other hand, when the determination condition is not satisfied in the foregoing state, it can be assumed that it is more likely that refrigeration oil returns to the first compressor (40a) than to the second compressor (40c) and the third compressor (40b). When the determination condition is not satisfied in the foregoing state, the opening degree control section (220) of the fifth aspect of the invention performs one or both of the operation in which the degree of opening of the first flow rate adjusting valve (64a) is decreased as compared to that during the normal operation, and the operation in which the degree of opening of each of the second flow rate adjusting valve (64c) and the third flow rate adjusting valve (64b) is increased as compared to that during the normal operation, as the oil distribution operation.

[0036] As described above, in the injection circuit (60) of the fifth aspect of the invention, intermediate-pressure refrigerant and refrigeration oil flowing through the main injection pipe (61) flow so as to be branched into the first branched pipe (62a), the second branched pipe (62c), and the third branched pipe (62b). Thus, not only in the case where both of the operation in which the degree of opening of the first flow rate adjusting valve (64a) is increased as compared to that during the normal operation, and the operation in which the degree of opening of each of the second flow rate adjusting valve (64c) and the third flow rate adjusting valve (64b) is decreased as compared to that during the normal operation, but also in the case where either one of such two operations is performed, the refrigerant flow rate in the first branched pipe (62a) is increased, and the refrigerant flow rate in the second branched pipe (62c) and the third branched pipe (62b) is decreased. As a result, the flow rate of refrigeration oil flowing into the first compressor (40a) through the first branched pipe (62a) is increased, and the flow rate of refrigeration oil flowing into the second compressor (40c) through the second branched pipe (62c) and the flow rate of refrigeration oil flowing into the third compressor (40b) through the third branched pipe (62b) are decreased. In addition, not only in the case where both of the operation in which the degree of opening of the first flow rate adjusting valve (64a) is decreased as compared to that during the normal operation, and the operation in which the degree of opening of each of the second flow rate adjusting valve (64c) and the third flow rate adjusting valve (64b) is increased as compared to that during the normal operation, but also in the case where either one of such two operations is performed, the refrigerant flow rate in the first branched pipe (62a) is decreased, and the refrigerant flow rate in the second branched pipe (62c) and the third branched pipe (62b) is increased. As a result, the flow rate of refrigeration oil flowing into the first compressor (40a) through the first branched pipe (62a) is decreased, and the flow rate of refrigeration oil flowing

into the second compressor (40c) through the second branched pipe (62c) and the flow rate of refrigeration oil flowing into the third compressor (40b) through the third branched pipe (62b) are increased.

[0037] A sixth aspect of the invention is intended for the refrigerating apparatus of any one of the first to fifth aspects of the invention, in which the flow rate adjusting mechanism (250) extends a duration time of the oil distribution operation as a difference between the pressure of refrigerant sucked into the first compressor (40a) and the pressure of refrigerant sucked into the second compressor (40c) increases.

[0038] In the sixth aspect of the invention, the flow rate adjusting mechanism (250) adjusts the duration time of the oil distribution operation. A larger difference between the pressure of refrigerant sucked into the first compressor (40a) and the pressure of refrigerant sucked into the second compressor (40c) results in a larger difference between the flow rate of refrigeration oil flowing into the first compressor (40a) through the first branched pipe (62a) and the flow rate of refrigeration oil flowing into the second compressor (40c) through the second branched pipe (62c). Thus, the flow rate adjusting mechanism (250) extends the duration time of the oil distribution operation as the difference between the pressure of refrigerant sucked into the first compressor (40a) and the pressure of refrigerant sucked into the second compressor (40c) increases, and increases the amount of refrigeration oil flowing into one of the first compressor (40a) and the second compressor (40c), which has a lower pressure of sucked refrigerant during the oil distribution operation.

[0039] A seventh aspect of the invention is intended for the refrigerating apparatus of any one of the first to fifth aspects of the invention, in which the injection circuit (60) is connected to an intermediate-pressure expansion valve (63) configured to expand high-pressure refrigerant into intermediate-pressure refrigerant and provided in the main injection pipe (61), and to a subcooling heat exchanger (65) configured to cool high-pressure liquid refrigerant flowing from the condenser (44,81) to at least one of the first evaporator (91) and the second evaporator (81, 44) by exchanging heat between the high-pressure liquid refrigerant and intermediate-pressure refrigerant flowing through the main injection pipe (61), and the injection circuit (60) further includes an intermediate-pressure control section (225) which, if both of the first compressor (40a) and the second compressor (40c) are in operation, adjusts a degree of opening of the intermediate-pressure expansion valve (63) so that a pressure of intermediate-pressure refrigerant flowing through the main injection pipe (61) reaches a predetermined target pressure, and which, if either one of the first compressor (40a) and the second compressor (40c) is in operation, and the remaining one of the first compressor (40a) and the second compressor (40c) is stopped, adjusts the degree of opening of the intermediate-pressure expansion valve (63) so that a degree of superheating of intermediate-pressure refrigerant flowing out from the subcool-

ing heat exchanger (65) reaches a predetermined target superheating degree.

[0040] In the seventh aspect of the invention, the intermediate-pressure expansion valve (63) and the subcooling heat exchanger (65) are connected to the injection circuit (60). In the main injection pipe (61), intermediate-pressure refrigerant flowing out from the intermediate-pressure expansion valve (63) is supplied to the subcooling heat exchanger (65). In the subcooling heat exchanger (65), high-pressure liquid refrigerant flowing out from the condenser (44, 81) is cooled by the intermediate-pressure refrigerant. The degree of opening of the intermediate-pressure expansion valve (63) is adjusted by the intermediate-pressure control section (225). By changing the degree of opening of the intermediate-pressure expansion valve (63), the pressure of intermediate-pressure refrigerant flowing through the main injection pipe (61) is changed.

[0041] When both of the first compressor (40a) and the second compressor (40c) are in operation, there is a possibility that the pressure of intermediate-pressure refrigerant flowing through the main injection pipe (61) is lower than the pressure in the compression chamber of one of the first compressor (40a) and the second compressor (40c) in the middle of the compression process depending on the degree of opening of the intermediate-pressure expansion valve (63). In the foregoing state, refrigerant backwardly flows from the compression chamber in the compression process to the injection circuit (60). In such a case, the intermediate-pressure control section (225) of the seventh aspect of the invention adjusts the degree of opening of the intermediate-pressure expansion valve (63) so that the pressure of intermediate-pressure refrigerant flowing through the main injection pipe (61) reaches the predetermined target pressure. As long as the target pressure is set to an appropriate value, supply of intermediate-pressure refrigerant to both of the first compressor (40a) and the second compressor (40c) is ensured.

[0042] On the other hand, when either one of the first compressor (40a) and the second compressor (40c) is in operation, and the remaining one of the first compressor (40a) and the second compressor (40c) is stopped, refrigerant does not backwardly flow from the compression chamber of the operated compressor in the middle of the compression process to the injection circuit (60). In such a case, the intermediate-pressure control section (225) of the seventh aspect of the invention adjusts the degree of opening of the intermediate-pressure expansion valve (63) so that the degree of superheating of intermediate-pressure refrigerant flowing out from the intermediate-pressure expansion valve (63) reaches the predetermined target superheating degree. As long as the target superheating degree is set to an appropriate value, high-pressure refrigerant is sufficiently cooled in the subcooling heat exchanger (65).

ADVANTAGES OF THE INVENTION

[0043] In the present invention, the flow rate adjusting mechanism (250) intermittently performs the oil distribution operation. The flow rate adjusting mechanism (250) performs the operation which is different between the case where the determination condition is satisfied and the case where the determination condition is not satisfied, as the oil distribution operation.

[0044] As described above, when the determination condition is satisfied, it can be assumed that it is more likely that refrigeration oil returns to the second compressor (40c) than to the first compressor (40a). In such a case, the flow rate adjusting mechanism (250) of the present invention intermittently performs the operation in which the refrigerant flow rate in the first branched pipe (62a) is increased as compared to that during the normal operation, and the refrigerant flow rate in the second branched pipe (62c) is decreased as compared to that during the normal operation, as the oil distribution operation. During the oil distribution operation, the flow rate of refrigeration oil flowing into the first compressor (40a) through the first branched pipe (62a) is increased as compared to that during the normal operation. Thus, when the determination condition is satisfied, if the oil distribution operation is performed, the amount of refrigeration oil stored in the first compressor (40a) and decreased during the normal operation can be recovered.

[0045] When the determination condition is not satisfied, it can be assumed that it is more likely that refrigeration oil returns to the first compressor (40a) than to the second compressor (40c). In such a case, the flow rate adjusting mechanism (250) of the present invention intermittently performs the operation in which the refrigerant flow rate in the first branched pipe (62a) is decreased as compared to that during the normal operation, and the refrigerant flow rate in the second branched pipe (62c) is increased as compared to that during the normal operation, as the oil distribution operation. During the oil distribution operation, the flow rate of refrigeration oil flowing into the second compressor (40c) through the second branched pipe (62c) is increased as compared to that during the normal operation. Thus, when the determination condition is not satisfied, if the oil distribution operation is performed, the amount of refrigeration oil stored in the second compressor (40c) and decreased during the normal operation can be recovered.

[0046] As described above, according to the present invention, the flow rate adjusting mechanism (250) performs the oil distribution operation to ensure the sufficient amount of refrigeration oil stored in both of the first compressor (40a) and the second compressor (40c). Thus, according to the present invention, damage of the first compressor (40a) and the second compressor (40c) due to inadequate lubrication can be avoided in advance, thereby improving reliability of the refrigerating apparatus (10).

[0047] In the second aspect of the invention, the first

flow rate adjusting valve (64a) is provided in the first branched pipe (62a), and the second flow rate adjusting valve (64c) is provided in the second branched pipe (62c). The degrees of opening of the first flow rate adjusting valve (64a) and the second flow rate adjusting valve (64c) are adjusted by the opening degree control section (220). Thus, according to the second aspect of the invention, the degrees of opening of the first flow rate adjusting valve (64a) and the second flow rate adjusting valve (64c) are adjusted to ensure a control of the flow rate of refrigeration oil supplied to the first compressor (40a) through the first branched pipe (62a) together with intermediate-pressure refrigerant and the flow rate of refrigeration oil supplied to the second compressor (40c) through the second branched pipe (62c) together with intermediate-pressure refrigerant.

[0048] In the third aspect of the invention, the opening degree control section (220) sets the target control value to the normal target value during the normal operation to adjust the degrees of opening of the first flow rate adjusting valve (64a) and the second flow rate adjusting valve (64c), and sets the target control value to the value different from the normal target value during the oil distribution operation to adjust the degrees of opening of the first flow rate adjusting valve (64a) and the second flow rate adjusting valve (64c). Thus, according to the third aspect of the invention, a change in opening degree of the first flow rate adjusting valve (64a) and the second flow rate adjusting valve (64c) during the oil distribution operation from the value during the normal operation can be ensured, and an increase/decrease in refrigerant flow rate in the first branched pipe (62a) and the second branched pipe (62c) during the oil distribution operation from the value during the normal operation can be ensured.

[0049] The refrigerant circuit (20) of the fifth aspect of the invention is switchable between the state in which the first compressor (40a) and the third compressor (40b) suck refrigerant evaporated in the first evaporator (91), and the second compressor (40c) sucks refrigerant evaporated in the second evaporator (81, 44); and the state in which the first compressor (40a) sucks refrigerant evaporated in the first evaporator (91), and the second compressor (40c) and the third compressor (40b) suck refrigerant evaporated in the second evaporator (81, 44). The opening degree control section (220) of the fifth aspect of the invention performs the two operation modes corresponding to the foregoing two states as the oil distribution operation of the third flow rate adjusting valve (64b) corresponding to the third compressor (40b). Thus, according to the fifth aspect of the invention, the sufficient amount of refrigeration oil stored in the third compressor (40b) selectively sucking refrigerant evaporated in the first evaporator (91) and refrigerant evaporated in the second evaporator (81, 44) can be ensured, and damage of the third compressor (40b) due to inadequate lubrication can be avoided in advance.

[0050] In the sixth aspect of the invention, the flow rate

adjusting mechanism (250) extends the duration time of the oil distribution operation as the difference between the pressure of refrigerant sucked into the first compressor (40a) and the pressure of refrigerant sucked into the second compressor (40c) increases. Thus, according to the sixth aspect of the invention, the duration time of the oil distribution operation can be extended as the difference between the amount of refrigeration oil stored in the first compressor (40a) and the amount of refrigeration oil stored in the second compressor (40c) increases, and the sufficient amount of refrigeration oil stored in both of the first compressor (40a) and the second compressor (40c) can be ensured.

[0051] In the seventh aspect of the invention, when both of the first compressor (40a) and the second compressor (40c) are in operation, the intermediate-pressure control section (225) adjusts the degree of opening of the intermediate-pressure expansion valve (63) so that the pressure of intermediate-pressure refrigerant flowing through the main injection pipe (61) reaches the predetermined target pressure. Thus, as long as the target pressure is set to the appropriate value, the supply of intermediate-pressure refrigerant to both of the first compressor (40a) and the second compressor (40c) can be ensured. In addition, when either one of the first compressor (40a) and the second compressor (40c) is in operation, the intermediate-pressure control section (225) adjusts the degree of opening of the intermediate-pressure expansion valve (63) so that the degree of superheating of intermediate-pressure refrigerant flowing out from the subcooling heat exchanger (65) reaches the predetermined target superheating degree. Thus, as long as the target superheating value is set to the appropriate value, high-pressure liquid refrigerant can be sufficiently cooled in the subcooling heat exchanger (65).

BRIEF DESCRIPTION OF THE DRAWINGS

[0052]

[FIG. 1] FIG. 1 is a refrigerant circuit diagram illustrating a configuration of a refrigerating apparatus of a first embodiment.

[FIG. 2] FIG. 2 is a refrigerant circuit diagram illustrating a process during a first mode of a cooling operation in the refrigerating apparatus of the first embodiment.

[FIG. 3] FIG. 3 is a refrigerant circuit diagram illustrating a process during a second mode of the cooling operation in the refrigerating apparatus of the first embodiment.

[FIG. 4] FIG. 4 is a refrigerant circuit diagram illustrating a process during a normal heating operation in the refrigerating apparatus of the first embodiment.

[FIG. 5] FIG. 5 is a refrigerant circuit diagram illustrating a process during a heat recovery heating operation in the refrigerating apparatus of the first embodiment.

[FIG. 6] FIG. 6 is a block diagram illustrating a configuration of a controller of the first embodiment.

[FIG. 7] FIG. 7 is a table illustrating an operation of a time setting section of the controller of the first embodiment.

[FIG. 8] FIG. 8 is a control flowchart illustrating an opening degree control operation of a first injection motor-operated valve, which is performed by the controller of the first embodiment.

[FIG. 9] FIG. 9 is a control flowchart illustrating an opening degree control operation of a second injection motor-operated valve, which is performed by the controller of the first embodiment.

[FIG. 10] FIG. 10 is a control flowchart illustrating an opening degree control operation of a third injection motor-operated valve, which is performed by the controller of the first embodiment.

[FIG. 11] FIG. 11 is a block diagram illustrating a configuration of a controller of a second embodiment.

[FIG. 12] FIG. 12 is a control flowchart illustrating an opening degree control operation of a first injection motor-operated valve, which is performed by a motor-operated valve control section of the second embodiment.

[FIG. 13] FIG. 13 is a control flowchart illustrating a process performed by the motor-operated valve control section at step ST36 of FIG. 12.

[FIG. 14] FIG. 14 is a control flowchart illustrating an opening degree control operation of a second injection motor-operated valve, which is performed by the motor-operated valve control section of the second embodiment.

[FIG. 15] FIG. 15 is a control flowchart illustrating a process performed by the motor-operated valve control section at step ST56 of FIG. 14.

[FIG. 16] FIG. 16 is a control flowchart illustrating an opening degree control operation of a third injection motor-operated valve, which is performed by the motor-operated valve control section of the second embodiment.

[FIG. 17] FIG. 17 is a control flowchart illustrating a process performed by the motor-operated valve control section at step ST86 of FIG. 16.

[FIG. 18] FIG. 18 is a control flowchart illustrating an opening degree control operation of a subcooling expansion valve, which is performed by an intermediate-pressure control section of the second embodiment.

DESCRIPTION OF EMBODIMENTS

[0053] Embodiments of the present invention will be described below in detail with reference to the drawings.

<<First Embodiment of the Invention>>

[0054] A first embodiment of the present invention will

be described. A refrigerating apparatus (10) of the present embodiment is installed in, e.g., a convenience store to condition air inside the store and cool an inside of a showcase etc.

[0055] As illustrated in FIG. 1, the refrigerating apparatus (10) of the present embodiment includes an outdoor unit (11), an air-conditioning unit (12), a chilling unit (13), a freezing unit (14), and a booster unit (15). Note that the number of each of the foregoing units has been set forth merely for purposes of examples in nature. The outdoor unit (11) is installed outside a room. The air-conditioning unit (12) is installed in a store such as salerooms. The chilling unit (13) is installed in a showcase of a chiller, and cools an inside of the showcase. The freezing unit (14) is installed in a showcase of a freezer, and cools an inside of the showcase. The booster unit (15) is installed near the showcase of the freezer.

[0056] An outdoor circuit (30) is accommodated in the outdoor unit (11). An air-conditioning circuit (80) is accommodated in the air-conditioning unit (12). A chilling circuit (90) is accommodated in the chilling unit (13). A freezing circuit (100) is accommodated in the freezing unit (14). A booster circuit (110) is accommodated in the booster unit (15). In the refrigerating apparatus (10), the air-conditioning circuit (80), the chilling circuit (90), the freezing circuit (100), and the booster circuit (110) are connected together through pipes to form a refrigerant circuit (20).

<Outdoor Unit and Outdoor Circuit>

[0057] The outdoor circuit (30) includes a variable capacity compressor (40a) which is a first compressor, a first fixed capacity compressor (40b) which is a third compressor, and a second fixed capacity compressor (40c) which is a second compressor. All of the three compressors (40a, 40b, 40c) are hermetic scroll compressors.

[0058] An electric motor of the variable capacity compressor (40a) is driven by alternate current supplied from an inverter which is not shown in the figure. When changing an output frequency of the inverter, a rotational speed of the electric motor of the variable capacity compressor (40a) is changed, and an operational capacity of the variable capacity compressor (40a) is changed. On the other hand, electric motors of the first fixed capacity compressor (40b) of the second fixed capacity compressor (40c) are driven by alternate current directly supplied from a commercial power source. In the first fixed capacity compressor (40b) and the second fixed capacity compressor (40c), a rotational speed of each of the electric motors is a value corresponding to a frequency of the alternate current supplied from the commercial power source, and an operational capacity of the compressor (40b, 40c) is maintained constant.

[0059] The outdoor circuit (30) further includes an outdoor heat exchanger (44), an outdoor expansion valve (45), a receiver (46), and a subcooling heat exchanger (65). In addition, the outdoor circuit (30) includes two liq-

uid inlet/outlet side closing valves (55, 57) and two gas inlet/outlet side closing valves (56, 58). Further, the outdoor circuit (30) includes three four-way valves (41, 42, 43).

[0060] The outdoor heat exchanger (44) is a fin-and-tube heat exchanger, and exchanges heat between refrigerant and outdoor air. The outdoor expansion valve (45) is an electronic expansion valve having a variable degree of opening. The subcooling heat exchanger (65) is a plate-type heat exchanger including a plurality of first flow paths (66) and a plurality of second flow paths (67), and exchanges heat between refrigerant flowing through the first flow path (66) and refrigerant flowing through the second flow path (67). The four-way valve (41, 42, 43) is switchable between a first state (state indicated by a solid line in FIG. 1) in which a first port is communicated with a third port, and a second port is communicated with a fourth port; a second state (state indicated by a dashed line in FIG. 1) in which the first port is communicated with the fourth port, and the second port is communicated with the third port.

[0061] A discharge pipe (50) is connected to an outlet of the compressor (40a, 40b, 40c). Specifically, an inlet end of the discharge pipe (50) is branched into three pipes. A first branched pipe is connected to the outlet of the variable capacity compressor (40a). A second branched pipe is connected to the outlet of the first fixed capacity compressor (40b). A third branched pipe is connected to the outlet of the second fixed capacity compressor (40c). An outlet end of the discharge pipe (50) is connected to the first port of the first four-way valve (41). An oil separator (47a, 47b, 47c) and a check valve (CV1, CV2, CV3) are provided in each of the branched pipes of the discharge pipe (50). In each of the branched pipes of the discharge pipe (50), the check valve (CV1, CV2, CV3) is arranged downstream the oil separator (47a, 47b, 47c). The check valve (CV1, CV2, CV3) allows a refrigerant flow from the compressor (40a, 40b, 40c) to the first four-way valve (41), and blocks a refrigerant flow in an opposite direction.

[0062] A first suction pipe (51) is connected to an inlet of the variable capacity compressor (40a). Specifically, an outlet end of the first suction pipe (51) is branched into two pipes. A first branched pipe is connected to the inlet of the variable capacity compressor (40a), and a second branched pipe is connected to the fourth port of the third four-way valve (43). A check valve (CV4) is provided in the second branched pipe of the first suction pipe (51). The check valve (CV4) allows a refrigerant flow toward the third four-way valve (43), and blocks a refrigerant flow in an opposite direction. An inlet end of the first suction pipe (51) is connected to the second gas inlet/outlet side closing valve (58).

[0063] An outlet end of a second suction pipe (52) is connected to an inlet of the first fixed capacity compressor (40b). An inlet end of the second suction pipe (52) is connected to the third port of the third four-way valve (43).

[0064] A third suction pipe (53) is connected to an inlet

of the second fixed capacity compressor (40c). Specifically, an outlet end of the third suction pipe (53) is branched into two pipes. A first branched pipe is connected to the inlet of the second fixed capacity compressor (40c), and a second branched pipe is connected to the third port of the third four-way valve (43). A check valve (CV5) is provided in the second branched pipe of the third suction pipe (53). The check valve (CV5) allows a refrigerant flow toward the third four-way valve (43), and blocks a refrigerant flow in an opposite direction. An inlet end of the third suction pipe (53) is connected to the second port of the second four-way valve (42).

[0065] The second port of the first four-way valve (41) is connected to the fourth port of the second four-way valve (42). The third port of the first four-way valve (41) is connected to a gas inlet/outlet end of the outdoor heat exchanger (44). The fourth port of the first four-way valve (41) is connected to the first gas inlet/outlet side closing valve (56). The first port of the second four-way valve (42) is connected to the discharge pipe (50) downstream the check valve (CV1, CV2, CV3). The third port of the second four-way valve (42) is closed. The first port of the third four-way valve (43) is connected to the discharge pipe (50) downstream the check valve (CV1, CV2, CV3) through a high-pressure injection pipe (38).

[0066] One end of a first connecting pipe (31) is connected to a liquid inlet/outlet end of the outdoor heat exchanger (44). The other end of the first connecting pipe (31) is connected to a top portion of the receiver (46). In the first connecting pipe (31), a solenoid valve (SV1) and a check valve (CV6) are provided in this order from one end of the first connecting pipe (31) to the other end. The check valve (CV6) allows a refrigerant flow from the outdoor heat exchanger (44) to the receiver (46), and blocks a refrigerant flow in an opposite direction.

[0067] One end of a second connecting pipe (32) is connected to a bottom portion of the receiver (46). The other end of the second connecting pipe (32) is connected to the second liquid inlet/outlet side closing valve (57). The first flow path (66) of the subcooling heat exchanger (65) is arranged in the middle of the second connecting pipe (32).

[0068] One end of a third connecting pipe (33) is connected to the first liquid inlet/outlet side closing valve (55). The other end of the third connecting pipe (33) is connected to the first connecting pipe (31) between the check valve (CV6) and the receiver (46). A check valve (CV7) is provided in the third connecting pipe (33). The check valve (CV7) allows a refrigerant flow from the first liquid inlet/outlet side closing valve (55) to the receiver (46), and blocks a refrigerant flow in an opposite direction.

[0069] One end of a fourth connecting pipe (34) is connected to the second connecting pipe (32) between the receiver (46) and the subcooling heat exchanger (65). The other end of the fourth connecting pipe (34) is connected to the third connecting pipe (33) between the first liquid inlet/outlet side closing valve (55) and the check valve (CV7). A check valve (CV8) is provided in the fourth

connecting pipe (34). The check valve (CV8) allows a refrigerant flow from one end of the fourth connecting pipe (34) to the other end, and blocks a refrigerant flow in an opposite direction.

[0070] One end of a fifth connecting pipe (35) is connected to the second connecting pipe (32) between the subcooling heat exchanger (65) and the second liquid inlet/outlet side closing valve (57). The other end of the fifth connecting pipe (35) is connected to the first connecting pipe (31) between the outdoor heat exchanger (44) and the solenoid valve (SV1). In the fifth connecting pipe (35), a check valve (CV9) and the outdoor expansion valve (45) are provided in this order from one end of the fifth connecting pipe (35) to the other end. The check valve (CV9) allows a refrigerant flow from one end of the fifth connecting pipe (35) to the other end, and blocks a refrigerant flow in an opposite direction.

[0071] One end of a sixth connecting pipe (36) is connected to the fifth connecting pipe (35) between the check valve (CV9) and the outdoor expansion valve (45). The other end of the sixth connecting pipe (36) is connected to the first connecting pipe (31) between the check valve (CV6) and the receiver (46). A check valve (CV10) is provided in the sixth connecting pipe (36). The check valve (CV10) allows a refrigerant flow from one end of the sixth connecting pipe (36) to the other end, and blocks a refrigerant flow in an opposite direction.

[0072] One end of a seventh connecting pipe (37) is connected to an upper portion of the receiver (46). The other end of the seventh connecting pipe (37) is connected to a main injection pipe (61) of an injection circuit (60) which will be described later downstream the subcooling heat exchanger (65). A solenoid valve (SV2) is provided in the seventh connecting pipe (37).

[0073] The injection circuit (60) is provided in the outdoor circuit (30). The injection circuit (60) includes the main injection pipe (61), a first injection pipe (62a) which is a first branched pipe, a second injection pipe (62b) which is a third branched pipe, and a third injection pipe (62c) which is a second branched pipe.

[0074] One end of the main injection pipe (61) is connected to the second connecting pipe (32) between the subcooling heat exchanger (65) and the second liquid inlet/outlet side closing valve (57). The other end of the main injection pipe (61) is connected to one end of the injection pipe (62a, 62b, 62c). In the main injection pipe (61), the second flow path (67) of the subcooling heat exchanger (65) and a subcooling expansion valve (63) which is an intermediate-pressure expansion valve are provided in this order from one end of the main injection pipe (61) to the other end. The subcooling expansion valve (63) is an electronic expansion valve having a variable degree of opening.

[0075] The other end of the first injection pipe (62a) is connected to the variable capacity compressor (40a). The other end of the second injection pipe (62b) is connected to the first fixed capacity compressor (40b). The other end of the third injection pipe (62c) is connected to

the second fixed capacity compressor (40c). The first injection pipe (62a) can be communicated with a compression chamber of the variable capacity compressor (40a) in the middle of a compression process. The second injection pipe (62b) can be communicated with a compression chamber of the first fixed capacity compressor (40b) in the middle of a compression process. The third injection pipe (62c) can be communicated with a compression chamber of the second fixed capacity compressor (40c) in the middle of a compression process.

[0076] A first injection motor-operated valve (64a) which is a first flow rate adjusting valve is provided in the first injection pipe (62a). A second injection motor-operated valve (64b) which is a third flow rate adjusting valve is provided in the second injection pipe (62b). A third injection motor-operated valve (64c) which is a second flow rate adjusting valve is provided in the third injection pipe (62c). The injection motor-operated valve (64a, 64b, 64c) is an electronic expansion valve having a variable degree of opening, and adjusts a flow rate of refrigerant supplied from the injection circuit (60) to the compressor (40a, 40b, 40c).

[0077] An oil return pipe (54) is connected to the injection circuit (60). An outlet end of the oil return pipe (54) is connected to the main injection pipe (61) of the injection circuit (60) downstream the subcooling heat exchanger (65). In addition, an inlet end of the oil return pipe (54) is branched into three pipes. A first branched pipe is connected to the oil separator (47a). A second branched pipe is connected to the oil separator (47b). A third branched pipe is connected to the oil separator (47c). A check valve (CV11, CV12, CV13) and a capillary tube (48a, 48b, 48c) are provided in each of the branched pipes. In each of the branched pipes, the capillary tube (48a, 48b, 48c) is arranged downstream the check valve (CV11, CV12, CV13). The check valve (CV11, CV12, CV13) allows a refrigeration oil flow in a direction in which refrigeration oil flows out from the oil separator (47a, 47b, 47c), and blocks a refrigeration oil flow in an opposite direction. The oil return pipe (54) and the three oil separators (47a, 47b, 47c) provided in the discharge pipe (50) together form an oil return circuit (49).

[0078] A plurality of temperature sensors and a plurality of pressure sensors are provided in the outdoor circuit (30).

[0079] A discharge pipe temperature sensor (74a, 74b, 74c) is attached to each of the branched pipes of the discharge pipe (50) between the compressor (40a, 40b, 40c) and the oil separator (47a, 47b, 47c). The first discharge pipe temperature sensor (74a) measures the temperature of the branched pipe connected to the variable capacity compressor (40a) as a physical amount indicating the temperature of refrigerant discharged from the variable capacity compressor (40a). The second discharge pipe temperature sensor (74b) measures the temperature of the branched pipe connected to the first fixed capacity compressor (40b) as a physical amount indicating the temperature of refrigerant discharged from the

first fixed capacity compressor (40b). The third discharge pipe temperature sensor (74c) measures the temperature of the branched pipe connected to the second fixed capacity compressor (40c) as a physical amount indicating the temperature of refrigerant discharged from the second fixed capacity compressor (40c). A high-pressure sensor (70) is connected to the discharge pipe (50). The high-pressure sensor (70) measures the pressure of refrigerant discharged from the compressor (40a, 40b, 40c) and flowing through the discharge pipe (50).

[0080] A temperature sensor (75) is attached to a trunk portion of the first suction pipe (51). The first suction pipe temperature sensor (75) measures the temperature of the first suction pipe (51) as a physical amount indicating the temperature of refrigerant flowing toward the variable capacity compressor (40a) through the first suction pipe (51). In addition, a first low-pressure sensor (71) is connected to the trunk portion of the first suction pipe (51). The first low-pressure sensor (71) measures the pressure of refrigerant flowing toward the variable capacity compressor (40a) through the first suction pipe (51).

[0081] A second suction pipe temperature sensor (76) is attached to a trunk portion of the third suction pipe (53). The second suction pipe temperature sensor (76) measures the temperature of the third suction pipe (53) as a physical amount indicating the temperature of refrigerant flowing toward the second fixed capacity compressor (40c) through the third suction pipe (53). In addition, a second low-pressure sensor (72) is connected to the trunk portion of the third suction pipe (53). The second low-pressure sensor (72) measures the pressure of refrigerant flowing toward the second fixed capacity compressor (40c) through the third suction pipe (53).

[0082] An injection pipe temperature sensor (77) is attached to the main injection pipe (61) of the injection circuit (60) downstream the subcooling heat exchanger (65). The injection pipe temperature sensor (77) measures the temperature of the injection circuit (60) as a physical amount indicating the temperature of refrigerant flowing toward the compressor (40a, 40b, 40c) through the injection circuit (60). In addition, an intermediate pressure sensor (73) is connected to the main injection pipe (61) of the injection circuit (60) downstream the subcooling heat exchanger (65). The intermediate pressure sensor (73) measures the pressure of refrigerant flowing toward the compressor (40a, 40b, 40c) through the main injection pipe (61) of the injection circuit (60).

[0083] The outdoor unit (11) includes an outdoor fan (79) which is a heat source fan, and an outdoor temperature sensor (78). The outdoor fan (79) supplies outdoor air to the outdoor heat exchanger (44). The outdoor temperature sensor (78) measures the temperature of outdoor air sent to the outdoor heat exchanger (44) by the outdoor fan (79).

<Air-Conditioning Unit and Air-Conditioning Circuit>

[0084] A liquid inlet/outlet end of the air-conditioning

circuit (80) is connected to the first liquid inlet/outlet side closing valve (55) of the outdoor circuit (30) through a first liquid inlet/outlet side communication pipe (21), and a gas inlet/outlet end of the air-conditioning circuit (80) is connected to the first gas inlet/outlet side closing valve (56) of the outdoor circuit (30) through a first gas inlet/outlet side communication pipe (22). In the air-conditioning circuit (80), an air-conditioning expansion valve (82) and an air-conditioning heat exchanger (81) which is a utilization heat exchanger are provided in this order from the liquid inlet/outlet end of the air-conditioning circuit (80) to the gas inlet/outlet end. The air-conditioning expansion valve (82) is an electronic expansion valve having a variable degree of opening. The air-conditioning heat exchanger (81) is a fin-and-tube heat exchanger, and exchanges heat between refrigerant and room air.

[0085] Two temperature sensors are attached to the air-conditioning circuit (80). A gas refrigerant temperature sensor (84) is attached to the air-conditioning circuit (80) between the air-conditioning heat exchanger (81) and the gas inlet/outlet end of the air-conditioning circuit (80). The gas refrigerant temperature sensor (84) measures the temperature of a pipe forming the air-conditioning circuit (80) as a physical amount indicating the temperature of refrigerant flowing between the air-conditioning heat exchanger (81) and the gas inlet/outlet end of the air-conditioning circuit (80) in the air-conditioning circuit (80). A heat exchanger temperature sensor (85) is attached to a heat transfer pipe forming the air-conditioning heat exchanger (81). The heat exchanger temperature sensor (85) measures the temperature of the heat transfer pipe as a physical amount indicating a temperature (i.e., an evaporation temperature and a condensation temperature) of refrigerant, a phase of which is being changed in the heat transfer pipe of the air-conditioning heat exchanger (81).

[0086] The air-conditioning unit (12) includes an air-conditioning fan (83) and an indoor temperature sensor (86). The air-conditioning fan (83) supplies room air of, e.g., a saleroom to the air-conditioning heat exchanger (81). The indoor temperature sensor (86) measures the temperature of room air sent to the air-conditioning heat exchanger (81) by the air-conditioning fan (83).

<Chilling Unit and Chilling Circuit>

[0087] A liquid inlet/outlet end of the chilling circuit (90) is connected to the second liquid inlet/outlet side closing valve (57) of the outdoor circuit (30) through a second liquid inlet/outlet side communication pipe (23), and a gas inlet/outlet end of the chilling circuit (90) is connected to the second gas inlet/outlet side closing valve (58) of the outdoor circuit (30) through a second gas inlet/outlet side communication pipe (24). In the chilling circuit (90), a chilling solenoid valve (93), a chilling expansion valve (92), and a chilling heat exchanger (91) are provided in this order from the liquid inlet/outlet end of the chilling circuit (90) to the gas inlet/outlet end. The chilling expan-

sion valve (92) is a thermostatic expansion valve including a thermo sensitive tube. The chilling heat exchanger (91) is a fin-and-tube heat exchanger, and exchanges heat between refrigerant and compartment air in the showcase of the chiller.

[0088] The chilling unit (13) includes a chilling fan (94) and a chiller compartment temperature sensor (95). The chilling fan (94) supplies compartment air in the showcase of the chiller to the chilling heat exchanger (91). The chiller compartment temperature sensor (95) measures the temperature of compartment air sent to the chilling heat exchanger (91) by the chilling fan (94).

<Freezing Unit and Freezing Circuit>

[0089] A liquid inlet/outlet end of the freezing circuit (100) is connected to the second liquid inlet/outlet side closing valve (57) of the outdoor circuit (30) through the second liquid inlet/outlet side communication pipe (23), and a gas inlet/outlet end of the freezing circuit (100) is connected to the booster circuit (110) through a pipe. In the freezing circuit (100), a freezing solenoid valve (103), a freezing expansion valve (102), and a freezing heat exchanger (101) are provided in this order from the liquid inlet/outlet end of the freezing circuit (100) to the gas inlet/outlet end. The freezing expansion valve (102) is a thermostatic expansion valve including a thermosensitive tube. The freezing heat exchanger (101) is a fin-and-tube heat exchanger, and exchanges heat between refrigerant and compartment air in the showcase of the freezer.

[0090] The freezing unit (14) includes a freezing fan (104) and a freezer compartment temperature sensor (105). The freezing fan (104) supplies compartment air in the showcase of the freezer to the freezing heat exchanger (101). The freezer compartment temperature sensor (105) measures the temperature of compartment air sent to the freezing heat exchanger (101) by the freezing fan (104).

<Booster Unit and Booster Circuit>

[0091] One end of the booster circuit (110) is connected to the gas inlet/outlet end of the freezing circuit (100) through a pipe, and the other end of the booster circuit (110) is connected to the second gas inlet/outlet side closing valve (58) of the outdoor circuit (30) through the second gas inlet/outlet side communication pipe (24). In the booster circuit (110), a booster compressor (111), an oil separator (112), and a check valve (CV14) are provided in this order from one end of the booster circuit (110) to the other end.

[0092] The booster compressor (111) is a hermetic scroll compressor. An electric motor of the booster compressor (111) is driven by alternate current supplied from an inverter which is not shown in the figure. When changing an output frequency of the inverter, a rotational speed of the electric motor of the booster compressor (111) is

changed, and an operational capacity of the booster compressor (111) is changed. The check valve (CV14) allows a refrigerant flow from the booster compressor (111) to the second gas inlet/outlet side communication pipe (24), and blocks a refrigerant flow in an opposite direction.

[0093] The booster circuit (110) includes an oil return pipe (113) and a bypass pipe (114). One end of the oil return pipe (113) is connected to the oil separator (112), and the other end of the oil return pipe (113) is connected to the booster circuit (110) upstream the booster compressor (111). A capillary tube (115) is provided in the oil return pipe (113). One end of the bypass pipe (114) is connected to the booster circuit (110) upstream the booster compressor (111), and the other end of the bypass pipe (114) is connected to the booster circuit (110) between the oil separator (112) and the check valve (CV14). A check valve (CV15) is provided in the bypass pipe (114). The check valve (CV15) allows a refrigerant flow from one end of the bypass pipe (114) to the other end, and blocks a refrigerant flow in an opposite direction.

<Controller>

[0094] A controller (200) receives detection values of the foregoing sensors (70-78), and controls an operation of the refrigerating apparatus (10) based on the detection values.

[0095] For example, in the controller (200), the degree of opening of the injection motor-operated valve (64a, 64b, 64c) is adjusted based on the detection value of the discharge pipe temperature sensor (74a, 74b, 74c). That is, the controller (200) uses the temperature of refrigerant discharged from the compressor (40a, 40b, 40c) as a physical amount for control, and adjusts the degree of opening of the injection motor-operated valve (64a, 64b, 64c) so that the detection value of the discharge pipe temperature sensor (74a, 74b, 74c), which is an actual measured value of the physical amount for control reaches a predetermined target control value.

[0096] Specifically, the controller (200) uses the temperature of refrigerant discharged from the variable capacity compressor (40a) as a first physical amount for control, and adjusts the degree of opening of the first injection motor-operated valve (64a) so that the detection value of the first discharge pipe temperature sensor (74a) falls within a predetermined temperature range. In addition, the controller (200) uses the temperature of refrigerant discharged from the first fixed capacity compressor (40b) as a second physical amount for control, and adjusts the degree of opening of the second injection motor-operated valve (64b) so that the detection value of the second discharge pipe temperature sensor (74b) falls within a predetermined temperature range. Further, the controller (200) uses the temperature of refrigerant discharged from the second fixed capacity compressor (40c) as a third physical amount for control, and adjusts the degree of opening of the third injection motor-operated valve (64c) so that the detection value of the third

discharge pipe temperature sensor (74c) falls within a predetermined temperature range.

[0097] If the temperature of refrigerant discharged from the compressor (40a, 40b, 40c) (i.e., the detection value of the discharge pipe temperature sensor (74a, 74b, 74c)) exceeds the predetermined temperature range, the controller (200) increases the degree of opening of the injection motor-operated valve (64a, 64b, 64c) corresponding to the compressor (40a, 40b, 40c) to increase the amount of intermediate-pressure refrigerant supplied to the compressor (40a, 40b, 40c), thereby decreasing the temperature of refrigerant discharged from the compressor (40a, 40b, 40c).

[0098] On the other hand, if the temperature of refrigerant discharged from the compressor (40a, 40b, 40c) falls below the predetermined temperature range, the controller (200) decreases the degree of opening of the injection motor-operated valve (64a, 64b, 64c) corresponding to the compressor (40a, 40b, 40c) to decrease the amount of intermediate-pressure refrigerant supplied to the compressor (40a, 40b, 40c), thereby increasing the temperature of refrigerant discharged from the compressor (40a, 40b, 40c).

[0099] Since an operation frequency of the variable capacity compressor (40a) (i.e., a frequency of alternate current supplied to the electric motor of the variable capacity compressor (40a)) is variable, the temperature of discharged refrigerant is likely to be lower than the predetermined temperature range. This is because, when lowering the operation frequency of the variable capacity compressor (40a), a time period for which the compression chamber of the variable capacity compressor (40a) in the middle of the compression process is communicated with the first injection pipe (62a) is extended, and the amount of intermediate-pressure refrigerant flowing into the compression chamber through the first injection pipe (62a) is increased.

[0100] Thus, when decreasing the operational capacity of the variable capacity compressor (40a) (i.e., lowering the operation frequency of the variable capacity compressor (40a)), the temperature of discharged refrigerant is lowered, and therefore the degree of opening of the first injection motor-operated valve (64a) is decreased in response to such a temperature change. This reduces flowing of a large amount of intermediate-pressure refrigerant into the compression chamber of the variable capacity compressor (40a) in the middle of the compression process.

[0101] As illustrated in FIG. 6, the controller (200) includes a target setting section (205), an adjusting section (210), and a time setting section (215). The target setting section (205), the adjusting section (210), and the time setting section (215) will be described below in detail.

[0102] The controller (200) serves as an opening degree control section configured to separately control the degrees of opening of the injection motor-operated valves (64a, 64b, 64c). In addition, the controller (200) and the injection motor-operated valves (64a, 64b, 64c)

provided in the injection circuit (60) together form a flow rate adjusting mechanism (250).

Operations

[0103] Operations of the refrigerating apparatus (10) will be described. The refrigerating apparatus (10) of the present embodiment performs various operations. A cooling operation, a normal heating operation, and a heat recovery heating operation of the operations performed in the refrigerating apparatus (10) will be described. Note that, as will be described later, compartment air is cooled in the chilling unit (13) and the freezing unit (14) in any of the cooling operation, the normal heating operation, and the heat recovery heating operation.

<Cooling Operation>

[0104] The cooling operation of the refrigerating apparatus (10) will be described with reference to FIG. 2.

[0105] During the cooling operation, in the refrigerant circuit (20), refrigerant circulates to perform a refrigeration cycle. In such a state, in the refrigerant circuit (20), the outdoor heat exchanger (44) is operated as a condenser (i.e., a radiator), and the air-conditioning heat exchanger (81), the chilling heat exchanger (91), and the freezing heat exchanger (101) are operated as evaporators. In the air-conditioning heat exchanger (81) operated as a second evaporator, an evaporation temperature of refrigerant is set to, e.g., 5°C. In the chilling heat exchanger (91) operated as a first evaporator, the evaporation temperature of refrigerant is set to, e.g., -5°C. In the freezing heat exchanger (101), the evaporation temperature of refrigerant is set to, e.g., -20°C.

[0106] In the cooling operation, the first four-way valve (41) and the second four-way valve (42) are set to the first state. The third four-way valve (43) is set to the first state when refrigerant flowing into the outdoor circuit (30) through the second gas inlet/outlet side communication pipe (24) is sucked into the first fixed capacity compressor (40b), and is set to the second state when refrigerant flowing into the outdoor circuit (30) through the first gas inlet/outlet side communication pipe (22) is sucked into the first fixed capacity compressor (40b). An example will be described herein, in which the third four-way valve (43) is set to the first state.

[0107] In the cooling operation, the outdoor expansion valve (45) is set to a completely-closed state. The degrees of opening of the air-conditioning expansion valve (82), the subcooling expansion valve (63), the first injection motor-operated valve (64a), the second injection motor-operated valve (64b), and the third injection motor-operated valve (64c) are adjusted as necessary. The controller (200) adjusts the degrees of opening of the air-conditioning expansion valve (82), the injection motor-operated valves (64a, 64b, 64c), and the subcooling expansion valve (63). Further, in the cooling operation, the solenoid valve (SV1) is opened, and the solenoid valve

(SV2) is closed.

[0108] High-pressure refrigerant discharged from the variable capacity compressor (40a), the first fixed capacity compressor (40b), and the second fixed capacity compressor (40c) to the discharge pipe (50) flows into the outdoor heat exchanger (44) through the first four-way valve (41). Such refrigerant is condensed by dissipating heat to outdoor air supplied by the outdoor fan (79). The high-pressure refrigerant flowing out from the outdoor heat exchanger (44) flows into the second connecting pipe (32) through the receiver (46). Subsequently, a part of the refrigerant flowing through the second connecting pipe (32) flows into the first liquid inlet/outlet side communication pipe (21) through the fourth connecting pipe (34), and the remaining refrigerant flows into the first flow path (66) of the subcooling heat exchanger (65). The refrigerant flowing into the first flow path (66) of the subcooling heat exchanger (65) is cooled by intermediate-pressure refrigerant flowing through the second flow path (67), and the degree of subcooling of such refrigerant is increased. A part of the refrigerant flowing into the second connecting pipe (32) through the first flow path (66) of the subcooling heat exchanger (65) flows into the injection circuit (60), and the remaining refrigerant flows into the second liquid inlet/outlet side communication pipe (23).

[0109] The pressure of the high-pressure refrigerant flowing into the first liquid inlet/outlet side communication pipe (21) is reduced when passing through the air-conditioning expansion valve (82), and the refrigerant flows into the air-conditioning heat exchanger (81). Such refrigerant is evaporated by absorbing heat from room air supplied by the air-conditioning fan (83). The air-conditioning unit (12) supplies the air cooled in the air-conditioning heat exchanger (81) to the room. The refrigerant flowing out from the air-conditioning heat exchanger (81) flows into the outdoor circuit (30) through the first gas inlet/outlet side communication pipe (22). Then, such refrigerant passes through the first four-way valve (41) and the second four-way valve (42) in this order, and flows into the third suction pipe (53). The refrigerant flowing into the third suction pipe (53) is sucked into the second fixed capacity compressor (40c). The second fixed capacity compressor (40c) compresses the sucked refrigerant, and discharges the compressed refrigerant to the discharge pipe (50).

[0110] A part of the high-pressure refrigerant flowing into the second liquid inlet/outlet side communication pipe (23) flows into the chilling circuit (90), and the remaining refrigerant flows into the freezing circuit (100).

[0111] The pressure of the refrigerant flowing into the chilling circuit (90) is reduced when passing through the chilling expansion valve (92), and the refrigerant flows into the chilling heat exchanger (91). Such refrigerant is evaporated by absorbing heat from compartment air supplied by the chilling fan (94). The chilling unit (13) supplies the air cooled in the chilling heat exchanger (91) to the showcase of the chiller. The refrigerant flowing out from

the chilling heat exchanger (91) flows into the second gas inlet/outlet side communication pipe (24).

[0112] The pressure of the refrigerant flowing into the freezing circuit (100) is reduced when passing through the freezing expansion valve (102), and the refrigerant flows into the freezing heat exchanger (101). Such refrigerant is evaporated by absorbing heat from compartment air supplied by the freezing fan (104). The freezing unit (14) supplies the air cooled in the freezing heat exchanger (101) to the showcase of the freezer. The refrigerant flowing out from the freezing heat exchanger (101) flows into the booster circuit (110), and is sucked into the booster compressor (111). The booster compressor (111) compresses the sucked refrigerant and discharge the compressed refrigerant. The refrigerant discharged from the booster compressor (111) flows into the second gas inlet/outlet side communication pipe (24), and joins the refrigerant flowing out from the chilling circuit (90).

[0113] The refrigerant flowing through the second gas inlet/outlet side communication pipe (24) flows into the first suction pipe (51) of the outdoor circuit (30). A part of the refrigerant flowing through the first suction pipe (51) is sucked into the variable capacity compressor (40a). The remaining refrigerant passes through the third four-way valve (43) and the second suction pipe (52) in this order, and is sucked into the first fixed capacity compressor (40b). Both of the variable capacity compressor (40a) and the first fixed capacity compressor (40b) compress the sucked refrigerant, and discharge the compressed refrigerant to the discharge pipe (50).

[0114] The pressure of the high-pressure liquid refrigerant flowing into the injection circuit (60) is reduced when passing through the subcooling expansion valve (63), and the refrigerant is changed into intermediate-pressure refrigerant in a gas-liquid two-phase state. The intermediate-pressure refrigerant flows into the second flow path (67) of the subcooling heat exchanger (65), and is evaporated by absorbing heat from refrigerant flowing through the first flow path (66) of the subcooling heat exchanger (65). The intermediate-pressure refrigerant flowing out from the subcooling heat exchanger (65) passes through the main injection pipe (61), and flows so as to be branched into the three injection pipes (62a, 62b, 62c). Then, such refrigerant flows into the compression chambers of the compressors (40a, 40b, 40c) in the middle of the compression process.

[0115] Refrigeration oil is stored in a casing of the compressor (40a, 40b, 40c), and is used for lubrication of a compression mechanism. A part of the refrigeration oil used for the lubrication of the compression mechanism is discharged from the compressor (40a, 40b, 40c) together with the compressed high-pressure refrigerant.

[0116] The refrigeration oil contained in the refrigerant (discharged refrigerant) discharged from the variable capacity compressor (40a) is separated from gas refrigerant in the oil separator (47a). The refrigeration oil contained in the refrigerant (discharged refrigerant) discharged from the first fixed capacity compressor (40b) is

separated from gas refrigerant in the oil separator (47b). The refrigeration oil contained in the refrigerant (discharged refrigerant) discharged from the second fixed capacity compressor (40c) is separated from gas refrigerant in the oil separator (47c).

[0117] The refrigeration oil separated from the discharged refrigerant in the oil separators (47a, 47b, 47c) flows into the main injection pipe (61) through the oil return pipe (54). The refrigeration oil flowing into the main injection pipe (61) and the intermediate-pressure refrigerant flow so as to be branched into the three injection pipes (62a, 62b, 62c), and then flow into the compression chambers of the compressors (40a, 40b, 40c) in the middle of the compression process.

[0118] The refrigerating apparatus (10) of the present embodiment can perform a first mode of the cooling operation as illustrated in FIG. 2, and a second mode of the cooling operation as illustrated in FIG. 3.

[0119] In the first mode of the cooling operation, the third four-way valve (43) is set to the first state (see FIG. 2). As described above, in the first mode of the cooling operation, the variable capacity compressor (40a) and the first fixed capacity compressor (40b) suck low-pressure refrigerant flowing through the first suction pipe (51), and the second fixed capacity compressor (40c) sucks low-pressure refrigerant flowing through the third suction pipe (53). That is, in the first mode of the cooling operation, the variable capacity compressor (40a) and the first fixed capacity compressor (40b) suck refrigerant evaporated in the chilling heat exchanger (91), and the second fixed capacity compressor (40c) sucks refrigerant evaporated in the air-conditioning heat exchanger (81).

[0120] In the second mode of the cooling operation, the third four-way valve (43) is set to the second state (see FIG. 3). In the second mode of the cooling operation, the variable capacity compressor (40a) sucks low-pressure refrigerant flowing through the first suction pipe (51), and the first fixed capacity compressor (40b) and the second fixed capacity compressor (40c) suck low-pressure refrigerant flowing through the third suction pipe (53). That is, in the second mode of the cooling operation, the variable capacity compressor (40a) sucks refrigerant evaporated in the chilling heat exchanger (91), and the first fixed capacity compressor (40b) and the second fixed capacity compressor (40c) suck refrigerant evaporated in the air-conditioning heat exchanger (81).

<Normal Heating Operation>

[0121] The normal heating operation of the refrigerating apparatus (10) will be described with reference to FIG. 4.

[0122] During the normal heating operation, in the refrigerant circuit (20), refrigerant circulates to perform a refrigeration cycle. In such a state, in a normal heating circuit, the air-conditioning heat exchanger (81) is operated as a condenser (i.e., a radiator), and the outdoor heat exchanger (44), the chilling heat exchanger (91),

and the freezing heat exchanger (101) are operated as evaporators. In the outdoor heat exchanger (44) operated as a second evaporator, an evaporation temperature of refrigerant is set to, e.g., 0°C. In the chilling heat exchanger (91) operated as a first evaporator, the evaporation temperature of refrigerant is set to, e.g., -5°C. In the freezing heat exchanger (101), the evaporation temperature of refrigerant is set to, e.g., -20°C. Note that the evaporation temperature of refrigerant in the outdoor heat exchanger (44) is changed depending on an outdoor temperature. Thus, during midwinter during which the outdoor temperature drops below freezing, the evaporation temperature of refrigerant in the outdoor heat exchanger (44) may be set to, e.g., -10°C.

[0123] Specifically, in the normal heating operation, the first four-way valve (41) is set to the second state, and the second four-way valve (42) is set to the first state. An example will be described herein, in which the third four-way valve (43) is set to the first state.

[0124] In the normal heating operation, the degrees of opening of the outdoor expansion valve (45), the air-conditioning expansion valve (82), the subcooling expansion valve (63), the first injection motor-operated valve (64a), the second injection motor-operated valve (64b), and the third injection motor-operated valve (64c) are adjusted as necessary. In the controller (200), an expansion valve control section (201) adjusts the degree of opening of the outdoor expansion valve (45), a discharge temperature control section (203) adjusts the degrees of opening of the injection motor-operated valves (64a, 64b, 64c), and a subcooling control section (204) adjusts the degree of opening of the subcooling expansion valve (63). Further, in the normal heating operation, both of the solenoid valves (SV1, SV2) are closed.

[0125] High-pressure refrigerant discharged from the variable capacity compressor (40a), the first fixed capacity compressor (40b), and the second fixed capacity compressor (40c) to the discharge pipe (50) passes through the first four-way valve (41), and then flows into the air-conditioning heat exchanger (81) through the first gas inlet/outlet side closing valve (56). Such refrigerant is condensed by dissipating heat to room air supplied by the air-conditioning fan (83). The air-conditioning unit (12) supplies the air heated in the air-conditioning heat exchanger (81) to the room.

[0126] The refrigerant flowing out from the air-conditioning heat exchanger (81) passes through the air-conditioning expansion valve (82), and then flows into the outdoor circuit (30) through the first liquid inlet/outlet side communication pipe (21). Subsequently, such refrigerant flows into the receiver (46) through the third connecting pipe (33). The refrigerant flowing out from the receiver (46) to the second connecting pipe (32) flows into the first flow path (66) of the subcooling heat exchanger (65). The refrigerant is cooled by intermediate-pressure refrigerant flowing through the second flow path (67), and the degree of subcooling of such refrigerant is increased. A part of the refrigerant flowing out from the first flow path

(66) of the subcooling heat exchanger (65) flows into the fifth connecting pipe (35), and the remaining refrigerant continues to flow through the second connecting pipe (32). A part of the refrigerant flowing toward the second liquid inlet/outlet side closing valve (57) through the second connecting pipe (32) flows into the injection circuit (60), and the remaining refrigerant flows into the second liquid inlet/outlet side communication pipe (23).

[0127] The pressure of the refrigerant flowing into the fifth connecting pipe (35) is reduced when passing through the outdoor expansion valve (45), and then the refrigerant flows into the outdoor heat exchanger (44). Such refrigerant is evaporated by absorbing heat from outdoor air supplied by the outdoor fan (79). The refrigerant flowing out from the outdoor heat exchanger (44) passes through the first four-way valve (41) and the second four-way valve (42) in this order, and flows into the third suction pipe (53). Such refrigerant is sucked into the second fixed capacity compressor (40c). The second fixed capacity compressor (40c) compresses the sucked refrigerant and discharges the compressed refrigerant to the discharge pipe (50).

[0128] A part of the high-pressure refrigerant flowing into the second liquid inlet/outlet side communication pipe (23) flows into the chilling circuit (90), and the remaining refrigerant flows into the freezing circuit (100). As in the cooling operation, the pressure of the refrigerant flowing into the chilling circuit (90) is reduced when passing through the chilling expansion valve (92), and then the refrigerant flows into the chilling heat exchanger (91). Such refrigerant is evaporated by absorbing heat from compartment air supplied by the chilling fan (94), and flows into the second gas inlet/outlet side communication pipe (24). Meanwhile, as in the cooling operation, the pressure of the refrigerant flowing into the freezing circuit (100) is reduced when passing through the freezing expansion valve (102), and the refrigerant flows into the freezing heat exchanger (101). Such refrigerant is evaporated by absorbing heat from compartment air supplied by the freezing fan (104). Then, the refrigerant is compressed by the booster compressor (111), and flows into the second gas inlet/outlet side communication pipe (24). As in the first mode of the cooling operation, a part of the refrigerant flowing through the second gas inlet/outlet side communication pipe (24) is sucked into the variable capacity compressor (40a), and the remaining refrigerant is sucked into the first fixed capacity compressor (40b). Both of the variable capacity compressor (40a) and the first fixed capacity compressor (40b) compress the sucked refrigerant, and discharge the compressed refrigerant to the discharge pipe (50).

[0129] The pressure of the refrigerant flowing into the injection circuit (60) is reduced when passing through the subcooling expansion valve (63), and the refrigerant flows into the second flow path (67) of the subcooling heat exchanger (65). Such refrigerant is evaporated by absorbing heat from refrigerant flowing through the first flow path (66) of the subcooling heat exchanger (65). The

intermediate-pressure refrigerant flowing out from the subcooling heat exchanger (65) is mixed with refrigeration oil supplied from the oil separators (47a, 47b, 47c) through the oil return pipe (54), and then flows into the compression chambers of the compressors (40a, 40b, 40c) in the middle of the compression process.

[0130] The refrigerating apparatus (10) of the present embodiment can perform first and second modes of the heating operation.

[0131] In the first mode of the heating operation, the third four-way valve (43) is set to the first state (see FIG. 4). As described above, in the first mode of the heating operation, the variable capacity compressor (40a) and the first fixed capacity compressor (40b) suck low-pressure refrigerant flowing through the first suction pipe (51), and the second fixed capacity compressor (40c) sucks low-pressure refrigerant flowing through the third suction pipe (53). That is, in the first mode of the heating operation, the variable capacity compressor (40a) and the first fixed capacity compressor (40b) suck refrigerant evaporated in the chilling heat exchanger (91), and the second fixed capacity compressor (40c) sucks refrigerant evaporated in the outdoor heat exchanger (44).

[0132] In the second mode of the heating operation, the third four-way valve (43) is set to the second state. In the second mode of the heating operation, the variable capacity compressor (40a) sucks low-pressure refrigerant flowing through the first suction pipe (51), and the first fixed capacity compressor (40b) and the second fixed capacity compressor (40c) suck low-pressure refrigerant flowing through the third suction pipe (53). That is, in the second mode of the heating operation, the variable capacity compressor (40a) sucks refrigerant evaporated in the chilling heat exchanger (91), and the first fixed capacity compressor (40b) and the second fixed capacity compressor (40c) suck refrigerant evaporated in the outdoor heat exchanger (44).

<Heat Recovery Heating Operation>

[0133] The heat recovery heating operation of the refrigerating apparatus (10) will be described with reference to FIG. 5.

[0134] During the heat recovery heating operation, in the refrigerant circuit (20), refrigerant circulates to perform a refrigeration cycle. In such a state, in the heat recovery heating operation, the air-conditioning heat exchanger (81) is operated as a condenser (i.e., a radiator), and the chilling heat exchanger (91) and the freezing heat exchanger (101) are operated as evaporators. In addition, the outdoor heat exchanger (44) is stopped. Since the outdoor heat exchanger (44) is stopped in the heat recovery heating operation, the outdoor fan (79) is stopped. Further, the second fixed capacity compressor (40c) is stopped in the heat recovery heating operation.

[0135] Specifically, in the heat recovery heating operation, the first four-way valve (41) is set to the second state, the second four-way valve (42) is set to the first

state, and the third four-way valve (43) is set to the first state.

[0136] In the heat recovery heating operation, the outdoor expansion valve (45) is set to a completely-closed state. The degrees of opening of the air-conditioning expansion valve (82), the subcooling expansion valve (63), the first injection motor-operated valve (64a), the second injection motor-operated valve (64b), and the third injection motor-operated valve (64c) are adjusted as necessary. Further, in the heat recovery heating operation, both of the solenoid valves (SV1, SV2) are closed.

[0137] High-pressure refrigerant discharged from the variable capacity compressor (40a) and the first fixed capacity compressor (40b) to the discharge pipe (50) passes through the first four-way valve (41), and then flows into the air-conditioning heat exchanger (81) through the first gas inlet/outlet side closing valve (56). Such refrigerant is condensed by dissipating heat to room air supplied by the air-conditioning fan (83). The air-conditioning unit (12) supplies the air heated in the air-conditioning heat exchanger (81) to the room. The refrigerant flowing out from the air-conditioning heat exchanger (81) passes through the air-conditioning expansion valve (82), and then flows into the outdoor circuit (30) through the first liquid inlet/outlet side communication pipe (21). Subsequently, such refrigerant flows into the receiver (46) through the third connecting pipe (33).

[0138] The refrigerant flowing out from the receiver (46) to the second connecting pipe (32) flows into the first flow path (66) of the subcooling heat exchanger (65). The refrigerant is cooled by intermediate-pressure refrigerant flowing through the second flow path (67), and the degree of subcooling of such refrigerant is increased. A part of the refrigerant flowing out from the first flow path (66) of the subcooling heat exchanger (65) flows into the injection circuit (60), and the remaining refrigerant flows into the second liquid inlet/outlet side communication pipe (23).

[0139] A part of the high-pressure refrigerant flowing into the second liquid inlet/outlet side communication pipe (23) flows into the chilling circuit (90), and the remaining refrigerant flows into the freezing circuit (100). As in the cooling operation, the pressure of the refrigerant flowing into the chilling circuit (90) is reduced when passing through the chilling expansion valve (92), and the refrigerant flows into the chilling heat exchanger (91). Such refrigerant is evaporated by absorbing heat from compartment air supplied by the chilling fan (94), and then flows into the second gas inlet/outlet side communication pipe (24). Meanwhile, as in the cooling operation, the pressure of the refrigerant flowing into the freezing circuit (100) is reduced when passing through the freezing expansion valve (102), and the refrigerant flows into the freezing heat exchanger (101). Such refrigerant is evaporated by absorbing heat from compartment air supplied by the freezing fan (104). Then, the refrigerant is compressed by the booster compressor (111), and flows into the second gas inlet/outlet side communication pipe

(24). As in the cooling operation, a part of the refrigerant flowing through the second gas inlet/outlet side communication pipe (24) is sucked into the variable capacity compressor (40a), and the remaining refrigerant is sucked into the first fixed capacity compressor (40b). Both of the variable capacity compressor (40a) and the first fixed capacity compressor (40b) compress the sucked refrigerant and discharge the compressed refrigerant to the discharge pipe (50).

[0140] The pressure of the refrigerant flowing into the injection circuit (60) is reduced when passing through the subcooling expansion valve (63), and the refrigerant flows into the second flow path (67) of the subcooling heat exchanger (65). Such refrigerant is evaporated by absorbing heat from the refrigerant flowing through the first flow path (66). The intermediate-pressure refrigerant flowing out from the subcooling heat exchanger (65) is mixed with refrigeration oil supplied from the first and second oil separators (47a, 47b) through the oil return pipe (54), and then flows into the compression chambers of the first and second compressors (40a, 40b) in the middle of the compression process.

Control Operation of Controller

[0141] As described above, the controller (200) includes the target setting section (205), the adjusting section (210), and the time setting section (215) (see FIG. 6).

[0142] The target setting section (205) sets a target discharge temperature value which is a target value of a discharged refrigerant temperature of the compressor (40a, 40b, 40c). The target setting section (205) includes a first setting section (206) and a second setting section (207).

[0143] The first setting section (206) compares the pressure of the first suction pipe (51) (i.e., the detection value of the first low-pressure sensor (71)) and the pressure of the third suction pipe (53) (i.e., the detection value of the second low-pressure sensor (72)) to each other, and sets the target value of the discharged refrigerant temperature (target discharge temperature value) of the compressor (40a, 40b, 40c) sucking refrigerant through either one of the first suction pipe (51) and the third suction pipe (53), which has a lower pressure, to a value higher than a normal target value T_dm in a normal operation. The first setting section (206) performs such an operation as an oil distribution operation.

[0144] The second setting section (207) compares the pressure of the first suction pipe (51) (i.e., the detection value of the first low-pressure sensor (71)) and the pressure of the third suction pipe (53) (i.e., the detection value of the second low-pressure sensor (72)) to each other, and sets the target value of the discharged refrigerant temperature (target discharge temperature value) of the compressor (40a, 40b, 40c) sucking refrigerant through either one of the first suction pipe (51) and the third suction pipe (53), which has a higher pressure, to a value lower than the normal target value T_dm in the normal

operation. The second setting section (207) performs such an operation as the oil distribution operation.

[0145] The adjusting section (210) adjusts the degree of opening of the injection motor-operated valve (64a, 64b, 64c) corresponding to the compressor (40a, 40b, 40c) so that the discharge temperature of the compressor (40a, 40b, 40c) reaches the target discharge temperature value which is set by the target setting section (205).

[0146] The time setting section (215) sets a duration time of the oil distribution operation. As illustrated in FIG. 7, the time setting section (215) sets a longer duration time of the oil distribution operation for a larger pressure difference ΔLP which is an absolute value of a difference between a detection value LP1 of the first low-pressure sensor (71) and a detection value LP2 of the second low-pressure sensor (72).

[0147] The time setting section (215) alternately sets "0" and "1" as a determination parameter F. If the determination parameter F = 0, the controller (200) performs the normal operation in which the target discharge temperature value of the compressor (40a, 40b, 40c) is set to the normal target value Tdm. On the other hand, if the determination parameter F = 1, the controller (200) performs the oil distribution operation in which the target discharge temperature value of the compressor (40a, 40b, 40c) is set to a value different from the normal target value Tdm.

[0148] A control cycle in FIG. 7 is a cycle in which the time setting section (215) switches the determination parameter F between "0" and "1." For example, if $1.5 \leq \Delta LP \leq 2.25$, the time setting section (215) performs an operation in which the determination parameter F is set to "0" for $(10 - 1.5) \times t_1$ seconds, is subsequently set to "1" for $1.5 \times t_1$ seconds, and then is set to "0" again. A value for "t1" in FIG. 7 is set to, e.g., "120."

[0149] Next, an opening degree control operation of the injection motor-operated valve (64a, 64b, 64c), which is performed by the controller (200) will be described with reference to control flowcharts of FIGS. 8-10.

<Opening Degree Control of First Injection Motor-operated Valve>

[0150] FIG. 8 is a control flowchart illustrating an operation in which the controller (200) controls the degree of opening of the first injection motor-operated valve (64a).

[0151] At step ST1, it is determined whether or not at least one of first and second conditions is satisfied. The first condition is a condition in which a discharge superheating degree Tdsh1 calculated by using detection values of the first discharge pipe temperature sensor (74a) and the high-pressure sensor (70) is smaller than a predetermined discharge superheating degree upper limit Tdshs ($Tdsh1 < Tdshs$), a detection value Td1 of the first discharge pipe temperature sensor (74a) is lower than a discharge temperature lower limit Tdmin which is set to a value lower than the normal target value Tdm ($Td1 <$

Tdmin), and an intermediate-pressure refrigerant superheating degree Tgsh calculated by using detection values of the injection pipe temperature sensor (77) and the intermediate pressure sensor (73) is smaller than a predetermined intermediate-pressure refrigerant superheating degree upper limit Tgshm ($Tgsh < Tgshm$).

[0152] The first condition is for determining whether or not the variable capacity compressor (40a) is in an abnormal wet operation (i.e., an operation in which the degree of wetness of refrigerant sucked into the variable capacity compressor (40a) is too high). The discharge superheating degree upper limit Tdshs is set within a range in which the variable capacity compressor (40a) is not in the abnormal wet operation. In addition, the discharge temperature lower limit Tdmin is set to a value so that, when the detection value Td1 of the first discharge pipe temperature sensor (74a) falls below the discharge temperature lower limit Tdmin, it can be determined that the variable capacity compressor (40a) is in the abnormal wet operation.

[0153] The second condition is a condition in which the detection value Td1 of the first discharge pipe temperature sensor (74a) is higher than a discharge temperature upper limit Tdmax which is set to a value higher than the normal target value Tdm ($Td1 > Tdmax$).

[0154] The second condition is for determining whether or not the variable capacity compressor (40a) is in an abnormal superheating operation (i.e., an operation in which the degree of superheating of refrigerant discharged from the variable capacity compressor (40a) is too high). The discharge temperature upper limit Tdmax is set to a value so that, when the detection value Td1 of the first discharge pipe temperature sensor (74a) exceeds the discharge temperature upper limit Tdmax, it can be determined that the variable capacity compressor (40a) is in the abnormal superheating operation.

[0155] If at least one of the first and second conditions is satisfied at step ST1, it is determined that the variable capacity compressor (40a) is in the abnormal wet operation or the abnormal superheating operation, and the process proceeds to step ST2.

[0156] At step ST2, it is determined whether or not the second condition is satisfied. If the second condition is satisfied, the process proceeds to step ST3. At step ST3, a change amount dpls of an opening degree value of the first injection motor-operated valve (64a) is calculated based on a current opening degree value EV3pls of the first injection motor-operated valve (64a). A larger current opening degree value EV3pls results in a larger change amount dpls, and a smaller current opening degree value EV3pls results in a smaller change amount dpls. Next, at step ST9, a value obtained by adding the change amount dpls calculated at step ST3 to the current opening degree value EV3pls of the first injection motor-operated valve (64a) is set as a new opening degree value EV3pls. Thus, the degree of opening of the first injection motor-operated valve (64a) is increased. In addition, a flow rate of intermediate-pressure refrigerant flowing into the var-

variable capacity compressor (40a) through the first injection pipe (62a) is increased, and the degree of superheating of refrigerant discharged from the variable capacity compressor (40a) is decreased. Consequently, continuation of the abnormal superheating operation of the variable capacity compressor (40a) is avoided.

[0157] On the other hand, if the second condition is not satisfied at step ST2, the process proceeds to step ST4. At step ST4, the change amount dpls of the opening degree value of the first injection motor-operated valve (64a) is calculated based on the current opening degree value EV3pls of the first injection motor-operated valve (64a). A larger current opening degree value EV3pls results in a larger change amount dpls, and a smaller current opening degree value EV3pls results in a smaller change amount dpls. Next, at step ST9, a value obtained by subtracting the change amount dpls calculated at step ST4 from the current opening degree value EV3pls of the first injection motor-operated valve (64a) is set as a new opening degree value EV3pls. Thus, the degree of opening of the first injection motor-operated valve (64a) is decreased. In addition, the flow rate of intermediate-pressure refrigerant flowing into the variable capacity compressor (40a) through the first injection pipe (62a) is decreased, and the degree of superheating of refrigerant discharged from the variable capacity compressor (40a) is increased. Consequently, continuation of the abnormal wet operation of the variable capacity compressor (40a) is avoided.

[0158] If both of the first and second conditions are not satisfied at step ST1, it is determined that the operation of the variable capacity compressor (40a) is the normal operation which is neither the abnormal wet operation nor the abnormal superheating operation, and the process proceeds to step ST5.

[0159] At step ST5, it is determined whether or not a condition in which both of the variable capacity compressor (40a) connected to the first suction pipe (51) and the second fixed capacity compressor (40c) connected to the third suction pipe (53) are in operation, and a condition in which the determination parameter F is "1" ($F = 1$) are satisfied. If the two conditions are satisfied, the process proceeds to step ST6. If the two conditions are not satisfied, the process proceeds to step ST7.

[0160] At step ST6, a detection value LP1 of the first low-pressure sensor (71) (i.e., an actual measured value of the pressure of the first suction pipe (51)) and a detection value LP2 of the second low-pressure sensor (72) (i.e., an actual measured value of the pressure of the third suction pipe (53)) are compared to each other. If the detection value LP1 of the first low-pressure sensor (71) is equal to or less than the detection value LP2 of the second low-pressure sensor (72) ($LP1 \leq LP2$), a target discharge temperature value a of the variable capacity compressor (40a) is set to a value $T_{dm} + \Delta T$, which is higher than the normal target value T_{dm} . If the detection value LP1 of the first low-pressure sensor (71) is greater than the detection value LP2 of the second low-

pressure sensor (72) ($LP1 > LP2$), the target discharge temperature value a of the variable capacity compressor (40a) is set to a value $T_{dm} - \Delta T$, which is lower than the normal target value T_{dm} . On the other hand, at step ST7, the target discharge temperature value of the variable capacity compressor (40a) is set to the normal target value T_{dm} .

[0161] As described above, $LP1 \leq LP2$ is a determination condition at step ST6. At step ST6, if the determination condition is satisfied (if $LP1 \leq LP2$), the target discharge temperature value a of the variable capacity compressor (40a) is set to the value higher than the normal target value T_{dm} . If the determination condition is not satisfied (if $LP1 > LP2$), the target discharge temperature value a of the variable capacity compressor (40a) is set to the value lower than the normal target value T_{dm} .

[0162] Note that, at step ST6, $LP1 < LP2$ may be a determination condition. In such a case, at step ST6, if the determination condition is satisfied (if $LP1 < LP2$), the target discharge temperature value a of the variable capacity compressor (40a) is set to the value higher than the normal target value T_{dm} . If the determination condition is not satisfied (if $LP1 \geq LP2$), the target discharge temperature value a of the variable capacity compressor (40a) is set to the value lower than the normal target value T_{dm} .

[0163] Next, at step ST8, the change amount dpls of the opening degree value of the first injection motor-operated valve (64a) is calculated based on a difference ($T_{d1} - a$) between the detection value T_{d1} of the first discharge pipe temperature sensor (74a) and the target discharge temperature value a of the variable capacity compressor (40a), which is set at step ST6 or ST7. Note that a smaller difference ($T_{d1} - a$) results in a smaller change amount dpls.

[0164] Next, at step ST9, a value obtained by adding the change amount dpls calculated at step ST8 to the current opening degree value EV3pls of the first injection motor-operated valve (64a) is set as a new opening degree value EV3pls. The degree of opening of the first injection motor-operated valve (64a) is set to the new opening degree value EV3pls.

[0165] At step ST9, a lower limit of the opening degree value EV3pls of the first injection motor-operated valve (64a) is set. Thus, the first injection motor-operated valve (64a) is not completely closed. In the present embodiment, the lower limit of the opening degree value EV3pls is set to "43." Note that the opening degree value EV3pls when the first injection motor-operated valve (64a) is completely opened is "480."

[0166] A flow from step ST5 to step ST9 corresponds to a control operation by the adjusting section (210). Such a control operation maintains the discharge temperature of the variable capacity compressor (40a) at a predetermined target value. A sequence from step ST5 to step ST9 through step ST6 corresponds to the oil distribution operation, and a sequence from step ST5 to step ST9 through step ST7 corresponds to the normal operation.

[0167] When step ST9 is completed, the process returns to step ST1, and the determination is made again at step ST1. In such a manner, a flow from step ST1 to step ST9 is repeated.

<Opening Degree Control of Second Injection Motor-operated Valve>

[0168] FIG. 9 is a control flowchart illustrating an operation in which the controller (200) controls the degree of opening of the second injection motor-operated valve (64b).

[0169] An opening degree control operation of the second injection motor-operated valve (64b) is similar to that of the first injection motor-operated valve (64a), except for a part of the opening degree control operation. The opening degree control operations of the first injection motor-operated valve (64a) and the second injection motor-operated valve (64b) are different from each other in that the variable capacity compressor (40a) corresponding to the first injection motor-operated valve (64a) exclusively sucks refrigerant through the first suction pipe (51), whereas the first fixed capacity compressor (40b) corresponding to the second injection motor-operated valve (64b) selectively sucks refrigerant through one of the first suction pipe (51) and the third suction pipe (53). That is, in the cooling operation and the normal heating operation, the first fixed capacity compressor (40b) sucks refrigerant through the first suction pipe (51) in the first mode, and sucks refrigerant through the third suction pipe (53) in the second mode.

[0170] Steps ST10-ST13 and ST19 of the control flowchart illustrated in FIG. 9 correspond to steps ST1-ST4 and ST8 of the control flowchart illustrated in FIG. 8. In a process at steps ST10-ST13 and ST19 of FIG. 9, the variable capacity compressor (40a), the first discharge pipe temperature sensor (74a), and the first injection motor-operated valve (64a) in the process at steps ST1-ST4 and ST8 of FIG. 8 are replaced by the first fixed capacity compressor (40b), the second discharge pipe temperature sensor (74b), and the second injection motor-operated valve (64b), respectively. In addition, a process at step ST14 of FIG. 9 is the same as the process at step ST5 of FIG. 8.

[0171] In the control flowchart illustrated in FIG. 9, step ST17 is performed after step ST15 instead of performing step ST6 of FIG. 8. That is, If it is determined that the refrigerating apparatus (10) is in the first mode (i.e., in a state in which the first fixed capacity compressor (40b) sucks refrigerant through the first suction pipe (51)) at step ST15, the process proceeds to step ST16, and the same process as that at step ST6 of FIG. 8 is performed. On the other hand, if it is determined that the refrigerating apparatus (10) is not in the first mode (i.e., in the second mode in which the first fixed capacity compressor (40b) sucks refrigerant through the third suction pipe (53)) at step ST15, the process proceeds to step ST17.

[0172] At step ST17, a detection value LP1 of the first

low-pressure sensor (71) and a detection value LP2 of the second low-pressure sensor (72) are compared to each other. If the detection value LP1 of the first low-pressure sensor (71) is equal to or less than the detection value LP2 of the second low-pressure sensor (72) ($LP1 \leq LP2$), a target discharge temperature value a of the first fixed capacity compressor (40b) is set to a value $T_{dm} - \Delta T$, which is lower than a normal target value T_{dm} . If the detection value LP1 of the first low-pressure sensor (71) is greater than the detection value LP2 of the second low-pressure sensor (72) ($LP1 > LP2$), the target discharge temperature value a of the first fixed capacity compressor (40b) is set to a value $T_{dm} + \Delta T$, which is higher than the normal target value T_{dm} .

[0173] As described above, at steps ST16 and ST17, $LP1 \leq LP2$ is a determination condition. The target discharge temperature value a of the first fixed capacity compressor (40b) is set to a value which is different between a case where the determination condition is satisfied ($LP1 \leq LP2$) and a case where the determination condition is not satisfied ($LP1 > LP2$). Note that, at steps ST16 and ST17, $LP1 < LP2$ may be a determination condition, and the target discharge temperature value a of the first fixed capacity compressor (40b) may be set to a value which is different between a case where the determination condition is satisfied ($LP1 < LP2$) and a case where the determination condition is not satisfied ($LP1 \geq LP2$).

[0174] At step ST20, a change amount $dpls$ of an opening degree value of the second injection motor-operated valve (64b) is used, which is calculated at step ST12, ST13, or ST19. At step ST20, a value obtained by adding the change amount $dpls$ to a current opening degree value $EV4pls$ of the second injection motor-operated valve (64b) is set as a new opening degree value $EV4pls$. The degree of opening of the second injection motor-operated valve (64b) is set to the new opening degree value $EV4pls$.

[0175] In addition, at step ST20, a lower limit of the new opening degree value $EV4pls$ is set to a value which is different between the first and second modes. Specifically, if either one of the following conditions is satisfied: a condition in which a determination parameter $F = 1$ and the refrigerating apparatus (10) is in the first mode, and a condition in which the determination parameter $F = 0$, the lower limit of the opening degree value $EV4pls$ of the second injection motor-operated valve (64b) is set to "43." On the other hand, if a condition is satisfied, in which the determination parameter $F = 1$ and the refrigerating apparatus (10) is in the second mode, the lower limit of the opening degree value $EV4pls$ of the second injection motor-operated valve (64b) is set to "200."

[0176] In the opening degree control operation of the second injection motor-operated valve (64b) by the controller (200), a sequence from step ST 14 to step ST20 through steps ST15 and ST16, and a sequence from step ST14 to step ST20 through steps ST15 and ST17 correspond to the oil distribution operation. A sequence from

step ST14 to step ST20 through step ST18 corresponds to the normal operation.

<Opening Degree Control of Third Injection Motor-operated Valve>

[0177] FIG. 10 is a control flowchart illustrating an operation in which the controller (200) controls the degree of opening of the third injection motor-operated valve (64c).

[0178] An opening degree control operation of the third injection motor-operated valve (64c) is similar to that of the first injection motor-operated valve (64a), except for a part of the opening degree control operation. The opening degree control operations of the first injection motor-operated valve (64a) and the third injection motor-operated valve (64c) are different from each other in that the variable capacity compressor (40a) corresponding to the first injection motor-operated valve (64a) exclusively sucks refrigerant through the first suction pipe (51), whereas the second fixed capacity compressor (40c) corresponding to the third injection motor-operated valve (64c) exclusively sucks refrigerant through the third suction pipe (53).

[0179] Steps ST21-ST24 and ST28 of the control flowchart illustrated in FIG. 10 correspond to steps ST1-ST4 and ST8 of the control flowchart illustrated in FIG. 8. In a process at steps ST21-ST24 and ST28 of FIG. 10, the variable capacity compressor (40a), the first discharge pipe temperature sensor (74a), and the first injection motor-operated valve (64a) in the process at steps ST1-ST4 and ST8 of FIG. 8 are replaced by the second fixed capacity compressor (40c), the third discharge pipe temperature sensor (74c), and the third injection motor-operated valve (64c), respectively. In addition, a process at step ST25 of FIG. 10 is the same as that at step ST5 of FIG. 8.

[0180] In the control flowchart illustrated in FIG. 10, step ST26 is performed instead of performing step ST6 of FIG. 8.

[0181] At step ST26, a detection value LP1 of the first low-pressure sensor (71) and a detection value LP2 of the second low-pressure sensor (72) are compared to each other. If the detection value LP1 of the first low-pressure sensor (71) is equal to or less than the detection value LP2 of the second low-pressure sensor (72) ($LP1 \leq LP2$), a target discharge temperature value a of the second fixed capacity compressor (40c) is set to a value $T_{dm} - \Delta T$, which is lower than a normal target value T_{dm} . If the detection value LP1 of the first low-pressure sensor (71) is greater than the detection value LP2 of the second low-pressure sensor (72) ($LP1 > LP2$), the target discharge temperature value a of the second fixed capacity compressor (40c) is set to a value $T_{dm} + \Delta T$, which is higher than the normal target value T_{dm} .

[0182] As described above, at step ST26, $LP1 \leq LP2$ is a determination condition. The target discharge temperature value a of the second fixed capacity compressor

(40c) is set to a value which is different between a case where the determination condition is satisfied ($LP1 \leq LP2$) and a case where the determination condition is not satisfied ($LP1 > LP2$). Note that, at step ST26, $LP1 < LP2$ may be a determination condition, and the target discharge temperature value a of the second fixed capacity compressor (40c) may be set to a value which is different between a case where the determination condition is satisfied ($LP1 < LP2$) and a case where the determination condition is not satisfied ($LP1 \geq LP2$).

[0183] At step ST29, a change amount $dpls$ of an opening degree value of the third injection motor-operated valve (64c) is used, which is calculated at step ST23, ST24, or ST28. At step ST29, a value obtained by adding the change amount $dpls$ to a current opening degree value EV5pls of the third injection motor-operated valve (64c) is set as a new opening degree value EV5pls. The degree of opening of the third injection motor-operated valve (64c) is set to the new opening degree value EV5pls.

[0184] In addition, at step ST29, a lower limit of the new opening degree value EV5pls is set to a value which is different between a case where a determination parameter F is "1" and a case where the determination parameter F is "0." Specifically, if the determination parameter $F = 0$, the lower limit of the opening degree value EV5pls of the third injection motor-operated valve (64c) is set to "43." On the other hand, if the determination parameter $F = 1$, the lower limit of the opening degree value EV5pls of the third injection motor-operated valve (64c) is set to "200."

[0185] In the opening degree control operation of the third injection motor-operated valve (64c) by the controller (200), a sequence from step ST 25 to step ST29 through step ST26 corresponds to the oil distribution operation. A sequence from step ST25 to step ST29 through step ST27 corresponds to the normal operation.

Advantages of First Embodiment

[0186] In the present embodiment, the controller (200) serving as the opening degree control section of the flow rate adjusting mechanism (250) intermittently performs the oil distribution operation. Based on the determination condition in which the detection value LP1 of the first low-pressure sensor (71) is equal to or less than the detection value LP2 of the second low-pressure sensor (72) ($LP1 \leq LP2$), the controller (200) performs the operation which is different between the case where the determination condition is satisfied and the case where the determination condition is not satisfied, as the oil distribution operation.

[0187] As described above, if the determination condition is satisfied, it can be assumed that it is more likely that refrigeration oil returns to the second fixed capacity compressor (40c) than to the variable capacity compressor (40a). In such a state, the controller (200) intermittently performs the operation in which the refrigerant flow

rate in the first injection pipe (62a) is increased as compared to that during the normal operation, and the refrigerant flow rate in the third injection pipe (62c) is decreased as compared to that during the normal operation, as the oil distribution operation. During the oil distribution operation, the flow rate of refrigeration oil flowing into the variable capacity compressor (40a) through the first injection pipe (62a) is increased as compared to that during the normal operation. Thus, if the oil distribution operation is performed when the determination condition is satisfied, the amount of refrigeration oil stored in the variable capacity compressor (40a) and decreased during the normal operation can be recovered.

[0188] In addition, if the determination condition is not satisfied, it can be assumed that it is more likely that refrigeration oil returns to the variable capacity compressor (40a) than to the second fixed capacity compressor (40c). The controller (200) intermittently performs the operation in which the refrigerant flow rate in the first injection pipe (62a) is decreased as compared to that during the normal operation, and the refrigerant flow rate in the third injection pipe (62c) is increased as compared to that during the normal operation, as the oil distribution operation. During the oil distribution operation, the flow rate of refrigeration oil flowing into the second fixed capacity compressor (40c) through the third injection pipe (62c) is increased as compared to that during the normal operation. Thus, if the oil distribution operation is performed when the determination condition is not satisfied, the amount of refrigeration oil stored in the second fixed capacity compressor (40c) and decreased during the normal operation can be recovered.

[0189] As described above, according to the present embodiment, the controller (200) performs the oil distribution operation to ensure a sufficient amount of refrigeration oil stored in both of the variable capacity compressor (40a) and the second fixed capacity compressor (40c). Thus, according to the present embodiment, damage of the variable capacity compressor (40a) and the second fixed capacity compressor (40c) due to inadequate lubrication can be avoided in advance, thereby improving reliability of the refrigerating apparatus (10).

[0190] In the present embodiment, the controller (200) sets the target control value to the normal target value T_{dm} to adjust the degrees of opening of the first injection motor-operated valve (64a) and the third injection motor-operated valve (64c) during the normal operation, and sets the target control value to the value different from the normal target value T_{dm} to adjust the degrees of opening of the first injection motor-operated valve (64a) and the third injection motor-operated valve (64c) during the oil distribution operation. Thus, according to the present embodiment, a change in opening degree of the first injection motor-operated valve (64a) and the third injection motor-operated valve (64c) during the oil distribution operation from the value during the normal operation can be ensured, and an increase/decrease in refrigerant flow rate in the first injection pipe (62a) and the

third injection pipe (62c) during the oil distribution operation from the value during the normal operation can be ensured.

[0191] The refrigerant circuit (20) of the present embodiment is switchable between the first and second modes in each of the cooling operation and the normal heating operation. For example, in the first mode of the cooling operation, the variable capacity compressor (40a) and the first fixed capacity compressor (40b) suck refrigerant evaporated in the chilling heat exchanger (91), and the second fixed capacity compressor (40c) sucks refrigerant evaporated in the air-conditioning heat exchanger (81). In the second mode of the cooling operation, the variable capacity compressor (40a) sucks refrigerant evaporated in the chilling heat exchanger (91), and the first fixed capacity compressor (40b) and the second fixed capacity compressor (40c) suck refrigerant evaporated in the air-conditioning heat exchanger (81). The controller (200) of the present embodiment selects either one of an operation suitable for the first mode and an operation suitable for the second mode, and performs the selected operation as the oil distribution operation for the second injection motor-operated valve (64b). Thus, according to the present embodiment, a sufficient amount of refrigeration oil stored in the first fixed capacity compressor (40b) selectively sucking refrigerant evaporated in the chilling heat exchanger (91) and refrigerant evaporated in the air-conditioning heat exchanger (81) can be ensured, thereby avoiding damage of the first fixed capacity compressor (40b) due to inadequate lubrication in advance.

[0192] The controller (200) of the present embodiment extends the duration time of the oil distribution operation as the difference between the detection value LP of the first low-pressure sensor (71) and the detection value LP2 of the second low-pressure sensor (72) increases. Thus, according to the present embodiment, the duration time of the oil distribution operation can be extended as a difference between the amount of refrigeration oil stored in the variable capacity compressor (40a) and the amount of refrigeration oil stored in the second fixed capacity compressor (40c) increases. Consequently, the sufficient amount of refrigeration oil stored in both of the variable capacity compressor (40a) and the second fixed capacity compressor (40c) can be ensured.

<<Second Embodiment of the Invention>>

[0193] A second embodiment of the present invention will be described. A refrigerating apparatus (10) of the present embodiment has a configuration of a controller (200), which is changed from the configuration of the controller (200) of the first embodiment. The controller (200) of the present embodiment will be described herein.

[0194] As illustrated in FIG. 11, the controller (200) of the present embodiment includes an motor-operated valve control section (220) and an intermediate-pressure control section (225). The motor-operated valve control

section (220) includes a determination parameter setting section (221). In the present embodiment, the motor-operated valve control section (220) serves as an opening degree control section. In addition, the motor-operated valve control section (220) and injection motor-operated valves (64a, 64b, 64c) provided in an injection circuit (60) together form a flow rate adjusting mechanism (250).

[0195] The motor-operated valve control section (220) uses the degree of superheating of refrigerant discharged from a compressor (40a, 40b, 40c) as a physical amount for control, and separately adjusts the degrees of opening of the injection motor-operated valves (64a, 64b, 64c) so that the degree of superheating of refrigerant discharged from the compressor (40a, 40b, 40c) reaches a predetermined target control value. Specifically, the motor-operated valve control section (220) calculates the degree of superheating of refrigerant discharged from the variable capacity compressor (40a) by using detection values of a first discharge pipe temperature sensor (74a) and a high-pressure sensor (70), and adjusts the degree of opening of the first injection motor-operated valve (64a) so that the calculated degree of superheating of discharged refrigerant reaches the target control value. In addition, the motor-operated valve control section (220) calculates the degree of superheating of refrigerant discharged from the first fixed capacity compressor (40b) by using detection values of a second discharge pipe temperature sensor (74b) and the high-pressure sensor (70), and adjusts the degree of opening of the second injection motor-operated valve (64b) so that the calculated degree of superheating of discharged refrigerant reaches the target control value. Further, the motor-operated valve control section (220) calculates the degree of superheating of refrigerant discharged from the second fixed capacity compressor (40c) by using detection values of a third discharge pipe temperature sensor (74c) and the high-pressure sensor (70), and adjusts the degree of opening of the third injection motor-operated valve (64c) so that the calculated degree of superheating of discharged refrigerant reaches the target control value.

[0196] Furthermore, the motor-operated valve control section (220) adjusts the degree of opening of the injection motor-operated valve (64a-64c) while operating the corresponding compressor (40a-40c), and maintains the injection motor-operated valve (64a-64c) at a completely-closed state while stopping the corresponding compressor (40a-40c). That is, the motor-operated valve control section (220) performs an opening degree control operation of the first injection motor-operated valve (64a) while operating the variable capacity compressor (40a), and maintains the first injection motor-operated valve (64a) at the completely-closed state while stopping the variable capacity compressor (40a). The motor-operated valve control section (220) performs an opening degree control operation of the second injection motor-operated valve (64b) while operating the first fixed capacity compressor (40b), and maintains the second injection motor-operated valve (64b) at the completely-closed state while

stopping the first fixed capacity compressor (40b). The motor-operated valve control section (220) performs an opening degree control operation of the third injection motor-operated valve (64c) while operating the second fixed capacity compressor (40c), and maintains the third injection motor-operated valve (64c) at the completely-closed state while stopping the second fixed capacity compressor (40c).

[0197] The determination parameter setting section (221) alternately sets "0" and "1" as a determination parameter F. Specifically, the determination parameter setting section (221) repeats an operation in which the determination parameter F is changed to "1" after a lapse of 17 minutes since the determination parameter F is set to "0," and the determination parameter F is changed back to "0" after a lapse of 3 minutes since the determination parameter F is set to "1." That is, the determination parameter setting section (221) repeatedly performs the operation in which the determination parameter F is maintained at "0" for 17 minutes, followed by maintaining the determination parameter F at "1" for 3 minutes.

[0198] Although will be described in detail later, if the determination parameter F = 0, the motor-operated valve control section (220) performs a normal operation in which a target value of a discharge superheating degree of the compressor (40a, 40b, 40c) is set to a normal target value. If the determination parameter F = 1, the motor-operated valve control section (220) performs an oil distribution operation in which the target value of the discharge superheating degree of the compressor (40a, 40b, 40c) is set to a value different from the normal target value.

[0199] The intermediate-pressure control section (225) performs an opening degree control operation of a subcooling expansion valve (63). The intermediate-pressure control section (225) selectively performs an operation in which the degree of opening of the subcooling expansion valve (63) is adjusted based on a detection value MP of an intermediate pressure sensor (73), and an operation in which the degree of opening of the subcooling expansion valve (63) is adjusted based on a superheating degree SHm of intermediate-pressure refrigerant flowing out through a second flow path (67) of a subcooling heat exchanger (65).

Control Operation of Motor-operated Valve Control Section

[0200] An operation performed by the motor-operated valve control section (220) of the controller (200) will be described. As described above, the motor-operated valve control section (220) separately adjusts the degree of opening of the injection motor-operated valve (64a, 64b, 64c). Note that values for a temperature and a superheating degree described below are set forth merely for purposes of examples in nature.

<Opening Degree Control of First Injection Motor-operated Valve>

[0201] An opening degree control of the first injection motor-operated valve (64a) by the motor-operated valve control section (220) will be described with reference to control flowcharts of FIGS. 12 and 13. Although will be described in detail below, as illustrated in the control flowchart of FIG. 13, the motor-operated valve control section (220) uses the degree of superheating of refrigerant discharged from the variable capacity compressor (40a) as a physical amount for control, and adjusts the degree of opening of the first injection motor-operated valve (64a) so that such a superheating degree reaches a predetermined target control value.

[0202] At step ST31 of FIG. 12, the motor-operated valve control section (220) determines whether or not all of three conditions are satisfied. A first condition at step ST31 is a condition in which the degree of superheating (discharge superheating degree T_{dsh1}) of refrigerant discharged from the variable capacity compressor (40a) is less than 15°C ($T_{dsh1} < 15^{\circ}\text{C}$). A second condition at step ST31 is a condition in which the temperature (discharge temperature T_{d1}) of refrigerant discharged from the variable capacity compressor (40a) is less than 60°C ($T_{d1} < 60^{\circ}\text{C}$). A third condition at step ST31 is a condition in which a superheating degree SH_m of intermediate-pressure refrigerant flowing out through the second flow path (67) of the subcooling heat exchanger (65) is less than 5°C ($SH_m < 5^{\circ}\text{C}$). Note that the superheating degree SH_m of intermediate-pressure refrigerant is calculated by using detection values of the injection pipe temperature sensor (77) and the intermediate pressure sensor (73).

[0203] At step ST31, if all of the first, second, and third conditions are satisfied, it can be assumed that the degree of wetness of refrigerant sucked into the variable capacity compressor (40a) is too high. In such a case, the process proceeds to step ST32, and the motor-operated valve control section (220) forcibly decreases the degree of opening of the first injection motor-operated valve (64a). As a result, a flow rate of intermediate-pressure refrigerant flowing into the variable capacity compressor (40a) through a first injection pipe (62a) is decreased, thereby rising the discharge temperature T_{d1} of the variable capacity compressor (40a).

[0204] On the other hand, at step ST31, if at least one of the first, second, and third conditions is not satisfied, it can be assumed that the degree of wetness of refrigerant sucked into the variable capacity compressor (40a) is not so high. In such a case, the process proceeds to step ST33, and the motor-operated valve control section (220) performs the process at step ST33.

[0205] At step ST33, the motor-operated valve control section (220) determines whether or not a condition is satisfied, in which the discharge temperature T_{d1} of the variable capacity compressor (40a) exceeds 100°C ($T_{d1} > 100^{\circ}\text{C}$). If such a condition is satisfied, it is determined

that the discharge temperature T_{d1} of the variable capacity compressor (40a) is extremely risen. In such a case, the process proceeds to step ST34, and the motor-operated valve control section (220) forcibly increases the degree of opening of the first injection motor-operated valve (64a). As a result, the flow rate of intermediate-pressure refrigerant flowing into the variable capacity compressor (40a) through the first injection pipe (62a) is increased, thereby dropping the discharge temperature T_{d1} of the variable capacity compressor (40a).

[0206] On the other hand, at step ST33, if the condition ($T_{d1} > 100^{\circ}\text{C}$) is not satisfied, it is determined that it is not necessary to forcibly drop the discharge temperature T_{d1} of the variable capacity compressor (40a), and therefore the process proceeds to step ST35.

[0207] At step ST35, the motor-operated valve control section (220) determines whether or not a condition is satisfied, in which both of the variable capacity compressor (40a) and the second fixed capacity compressor (40c) are in operation. If such a condition is satisfied, the process proceeds to step ST36, and the motor-operated valve control section (220) performs an opening degree control for an oil distribution, which is illustrated in the control flowchart of FIG. 13. The opening degree control for the oil distribution will be described later.

[0208] On the other hand, if the foregoing condition is not satisfied at step ST35, it is determined that the variable capacity compressor (40a) is in operation, and the second fixed capacity compressor (40c) is stopped. The motor-operated valve control section (220) performs the opening degree control of the first injection motor-operated valve (64a) because only the variable capacity compressor (40a) is in operation. When the second fixed capacity compressor (40c) is stopped, the third injection motor-operated valve (64c) is completely closed, and refrigeration oil does not flow into the second fixed capacity compressor (40c) from an oil return circuit (49). In such a case, the motor-operated valve control section (220) adjusts the degree of opening of the first injection motor-operated valve (64a) so that the discharge superheating degree T_{dsh1} of the variable capacity compressor (40a) reaches a predetermined target value (in this case, 25°C).

[0209] The opening degree control for the oil distribution, which is performed at step ST36 will be described with reference to the control flowchart of FIG. 13.

[0210] At step ST41 of FIG. 13, the motor-operated valve control section (220) compares a detection value $LP1$ of a first low-pressure sensor (71) (i.e., an actual measured value of the pressure of a first suction pipe (51)) and a detection value $LP2$ of a second low-pressure sensor (72) (i.e., an actual measured value of the pressure of a third suction pipe (53)) to each other. The motor-operated valve control section (220) determines whether or not a determination condition is satisfied, in which the detection value $LP1$ of the first low-pressure sensor (71) is greater than the detection value $LP2$ of the second low-pressure sensor (72) ($LP1 > LP2$). Note that, at step

ST41, a condition in which the detection value LP1 of the first low-pressure sensor (71) is equal to or greater than the detection value LP2 of the second low-pressure sensor (72) ($LP1 \geq LP2$) may be the determination condition.

[0211] If the determination condition is satisfied at step ST41 (i.e., if $LP1 > LP2$), the process proceeds to step ST42, and the motor-operated valve control section (220) performs the process at step ST42. At step ST42, the motor-operated valve control section (220) determines whether or not the determination parameter $F = 1$. If the determination parameter $F = 1$, the process proceeds to step ST43, and the motor-operated valve control section (220) performs the oil distribution operation. On the other hand, if the determination parameter $F \neq 1$ (i.e., the determination parameter $F = 0$), the process proceeds to step ST44, and the motor-operated valve control section (220) performs the normal operation.

[0212] At step ST44, the motor-operated valve control section (220) sets the target control value of the discharge superheating degree Tdsh1 of the variable capacity compressor (40a) to "25°C" which is the normal target value, and adjusts the degree of opening of the first injection motor-operated valve (64a) so that the discharge superheating degree Tdsh1 reaches 25°C. The motor-operated valve control section (220) performs such an operation as the normal operation.

[0213] On the other hand, at step ST43, the motor-operated valve control section (220) sets the target control value of the discharge superheating degree Tdsh1 of the variable capacity compressor (40a) to "20°C" which is lower than the normal target value, and adjusts the degree of opening of the first injection motor-operated valve (64a) so that the discharge superheating degree Tdsh1 reaches 20°C. The motor-operated valve control section (220) performs such an operation as the oil distribution operation. When the target control value of the discharge superheating degree Tdsh1 is decreased as compared to the normal target value by the oil distribution operation, the degree of opening of the first injection motor-operated valve (64a) is increased as compared to that during the normal operation, and a flow rate of intermediate-pressure refrigerant in the first injection pipe (62a) is increased as compared to that during the normal operation.

[0214] If the determination condition is not satisfied at step ST41 (i.e., if $LP1 \leq LP2$), the process proceeds to step ST45, and the motor-operated valve control section (220) performs the process at step ST45. At step ST45, the motor-operated valve control section (220) determines whether or not the determination parameter $F = 1$. If the determination parameter $F = 1$, the process proceeds to step ST46, and the motor-operated valve control section (220) performs the oil distribution operation. On the other hand, if the determination parameter $F \neq 1$ (i.e., the determination parameter $F = 0$), the process proceeds to step ST47, and the motor-operated valve control section (220) performs the normal operation.

[0215] At step ST47, the motor-operated valve control

section (220) sets the target control value of the discharge superheating degree Tdsh1 of the variable capacity compressor (40a) to "25°C" which is the normal target value, and adjusts the degree of opening of the first injection motor-operated valve (64a) so that the discharge superheating degree Tdsh1 reaches 25°C. The motor-operated valve control section (220) performs such an operation as the normal operation. That is, the motor-operated valve control section (220) performs the same process as that of step ST44.

[0216] On the other hand, at step ST46, the motor-operated valve control section (220) sets the target control value of the discharge superheating degree Tdsh1 of the variable capacity compressor (40a) to "30°C" which is higher than the normal target value, and adjusts the degree of opening of the first injection motor-operated valve (64a) so that the discharge superheating degree Tdsh1 reaches 30°C. The motor-operated valve control section (220) performs such an operation as the oil distribution operation. When the target control value of the discharge superheating degree Tdsh1 is increased as compared to the normal target value by the oil distribution operation, the degree of opening of the first injection motor-operated valve (64a) is decreased as compared to that during the normal operation, and the flow rate of intermediate-pressure refrigerant in the first injection pipe (62a) is decreased as compared to that during the normal operation.

[0217] After the process at step ST32, ST34, ST36, or ST37 in the control flowchart of FIG. 12 is completed, the process returns to step ST31, and the motor-operated valve control section (220) performs the process at step ST31 again. The motor-operated valve control section (220) repeatedly performs the process illustrated in the control flowcharts of FIGS. 12 and 13, e.g., every 10-20 seconds.

<Opening Degree Control of Third Injection Motor-operated Valve>

[0218] An opening degree control of the third injection motor-operated valve (64c) by the motor-operated valve control section (220) will be described with reference to control flowcharts of FIGS. 16 and 17. Although will be described in detail below, as illustrated in the control flowchart of FIG. 17, the motor-operated valve control section (220) uses the degree of superheating of refrigerant discharged from the second fixed capacity compressor (40c) as a physical amount for control, and adjusts the degree of opening of the third injection motor-operated valve (64c) so that such a superheating degree reaches a predetermined target control value.

[0219] At step ST81 of FIG. 16, the motor-operated valve control section (220) performs a process similar to that of step ST31 of FIG. 12 for the second fixed capacity compressor (40c). That is, the motor-operated valve control section (220) determines whether or not a first condition in which a discharge superheating degree Tdsh3

of the second fixed capacity compressor (40c) is less than 15°C ($T_{dsh3} < 15^\circ\text{C}$), a second condition in which a discharge temperature T_{d3} of the second fixed capacity compressor (40c) is less than 60°C ($T_{d3} < 60^\circ\text{C}$), and a third condition in which a superheating degree SH_m of intermediate-pressure refrigerant flowing out from the subcooling heat exchanger (65) is less than 5°C ($SH_m < 5^\circ\text{C}$) are satisfied.

[0220] At step ST81, if all of the first, second, and third conditions are satisfied, it can be assumed that the degree of wetness of refrigerant sucked into the second fixed capacity compressor (40c) is too high. In such a case, the process proceeds to step ST82, and the motor-operated valve control section (220) forcibly decreases the degree of opening of the third injection motor-operated valve (64c). As a result, a flow rate of intermediate-pressure refrigerant flowing into the second fixed capacity compressor (40c) through a third injection pipe (62c) is decreased, thereby rising the discharge temperature T_{d3} of the second fixed capacity compressor (40c).

[0221] On the other hand, at step ST81, if at least one of the first, second, and third conditions is not satisfied, it can be assumed that the degree of wetness of refrigerant sucked into the second fixed capacity compressor (40c) is not so high. In such a case, the process proceeds to step ST83, and the motor-operated valve control section (220) performs the process at step ST83.

[0222] At step ST83, the motor-operated valve control section (220) determines whether or not a condition is satisfied, in which the discharge temperature T_{d3} of the second fixed capacity compressor (40c) exceeds 100°C ($T_{d3} > 100^\circ\text{C}$). If such a condition is satisfied, it is determined that the discharge temperature T_{d3} of the second fixed capacity compressor (40c) is extremely risen. In such a case, the process proceeds to step ST84, and the motor-operated valve control section (220) forcibly increases the degree of opening of the third injection motor-operated valve (64c). As a result, the flow rate of intermediate-pressure refrigerant flowing into the second fixed capacity compressor (40c) through the third injection pipe (62c) is increased, thereby dropping the discharge temperature T_{d3} of the second fixed capacity compressor (40c).

[0223] On the other hand, at step ST83, if the condition ($T_{d3} > 100^\circ\text{C}$) is not satisfied, it is determined that it is not necessary to forcibly drop the discharge temperature T_{d3} of the second fixed capacity compressor (40c), and therefore the process proceeds to step ST85.

[0224] At step ST85, the motor-operated valve control section (220) determines whether or not a condition is satisfied, in which both of the variable capacity compressor (40a) and the second fixed capacity compressor (40c) are in operation. If such a condition is satisfied, the process proceeds to step ST86, and the motor-operated valve control section (220) performs an opening degree control for an oil distribution, which is illustrated in the control flowchart of FIG. 17. The opening degree control for the oil distribution will be described later.

[0225] On the other hand, if the foregoing condition is not satisfied at step ST85, it is determined that the second fixed capacity compressor (40c) is in operation, and the variable capacity compressor (40a) is stopped. The motor-operated valve control section (220) performs the opening degree control of the third injection motor-operated valve (64c) because only the second fixed capacity compressor (40c) is in operation. When the variable capacity compressor (40a) is stopped, the first injection motor-operated valve (64a) is completely closed, and refrigeration oil does not flow into the variable capacity compressor (40a) from the oil return circuit (49). In addition, an operational capacity of the second fixed capacity compressor (40c) is fixed to the maximum capacity. In such a case, the motor-operated valve control section (220) sets the third injection motor-operated valve (64c) to a completely-opened state.

[0226] The opening degree control for the oil distribution, which is performed at step ST86 will be described with reference to the control flowchart of FIG. 17.

[0227] At step ST91 of FIG. 17, the motor-operated valve control section (220) compares a detection value $LP1$ of the first low-pressure sensor (71) and a detection value $LP2$ of the second low-pressure sensor (72) to each other. The motor-operated valve control section (220) determines whether or not a determination condition is satisfied, in which the detection value $LP1$ of the first low-pressure sensor (71) is greater than the detection value $LP2$ of the second low-pressure sensor (72) ($LP1 > LP2$). Note that, at step ST91, a condition in which the detection value $LP1$ of the first low-pressure sensor (71) is equal to or greater than the detection value $LP2$ of the second low-pressure sensor (72) ($LP1 \geq LP2$) may be the determination condition.

[0228] If the determination condition is satisfied at step ST91 (i.e., if $LP1 > LP2$), the process proceeds to step ST92, and the motor-operated valve control section (220) performs the process at step ST92. At step ST92, the motor-operated valve control section (220) determines whether or not the determination parameter $F = 1$. If the determination parameter $F = 1$, the process proceeds to step ST93, and the motor-operated valve control section (220) performs the oil distribution operation. On the other hand, if the determination parameter $F \neq 1$ (i.e., the determination parameter $F = 0$), the process proceeds to step ST94, and the motor-operated valve control section (220) performs the normal operation.

[0229] At step ST94, the motor-operated valve control section (220) sets the target control value of the discharge superheating degree T_{dsh3} of the second fixed capacity compressor (40c) to "25°C" which is a normal target value, and adjusts the degree of opening of the third injection motor-operated valve (64c) so that the discharge superheating degree T_{dsh3} reaches 25°C. The motor-operated valve control section (220) performs such an operation as the normal operation.

[0230] On the other hand, at step ST93, the motor-operated valve control section (220) sets the target con-

trol value of the discharge superheating degree Tdsh3 of the second fixed capacity compressor (40c) to "30°C" which is higher than the normal target value, and adjusts the degree of opening of the third injection motor-operated valve (64c) so that the discharge superheating degree Tdsh3 reaches 30°C. The motor-operated valve control section (220) performs such an operation as the oil distribution operation. When the target control value of the discharge superheating degree Tdsh3 is increased as compared to the normal target value by the oil distribution operation, the degree of opening of the third injection motor-operated valve (64c) is decreased as compared to that during the normal operation, and a flow rate of intermediate-pressure refrigerant in the third injection pipe (62c) is decreased as compared to that during the normal operation.

[0231] If the determination condition is not satisfied at step ST91 (i.e., if $LP1 \leq LP2$), the process proceeds to step ST95, and the motor-operated valve control section (220) performs the process at step ST95. At step ST95, the motor-operated valve control section (220) determines whether or not the determination parameter $F = 1$. If the determination parameter $F = 1$, the process proceeds to step ST96, and the motor-operated valve control section (220) performs the oil distribution operation. On the other hand, if the determination parameter $F \neq 1$ (i.e., the determination parameter $F = 0$), the process proceeds to step ST97, and the motor-operated valve control section (220) performs the normal operation.

[0232] At step ST97, the motor-operated valve control section (220) sets the target control value of the discharge superheating degree Tdsh3 of the second fixed capacity compressor (40c) to "25°C" which is the normal target value, and adjusts the degree of opening of the third injection motor-operated valve (64c) so that the discharge superheating degree Tdsh3 reaches 25°C. The motor-operated valve control section (220) performs such an operation as the normal operation. That is, the motor-operated valve control section (220) performs the same process as that of step ST94.

[0233] On the other hand, at step ST96, the motor-operated valve control section (220) sets the target control value of the discharge superheating degree Tdsh3 of the second fixed capacity compressor (40c) to "20°C" which is lower than the normal target value, and adjusts the degree of opening of the third injection motor-operated valve (64c) so that the discharge superheating degree Tdsh3 reaches 20°C. The motor-operated valve control section (220) performs such an operation as the oil distribution operation. When the target control value of the discharge superheating degree Tdsh3 is decreased as compared to the normal target value by the oil distribution operation, the degree of opening of the third injection motor-operated valve (64c) is increased as compared to that during the normal operation, and the flow rate of intermediate-pressure refrigerant in the third injection pipe (62c) is increased as compared to that during the normal operation.

[0234] After the process at step ST82, ST84, ST86, or ST87 in the control flowchart of FIG. 16 is completed, the process returns to step ST81, and the motor-operated valve control section (220) performs the process at step ST81 again. The motor-operated valve control section (220) repeatedly performs the process illustrated in the control flowcharts of FIGS. 16 and 17, e.g., every 10-20 seconds.

<Opening Degree Control of Second Injection Motor-operated Valve>

[0235] An opening degree control of the second injection motor-operated valve (64b) by the motor-operated valve control section (220) will be described with reference to control flowcharts of FIGS. 14 and 15. Although will be described in detail below, as illustrated in the control flowchart of FIG. 15, the motor-operated valve control section (220) uses the degree of superheating of refrigerant discharged from the first fixed capacity compressor (40b) as a physical amount for control, and adjusts the degree of opening of the second injection motor-operated valve (64b) so that such a superheating degree reaches a predetermine target control value.

[0236] A process from steps ST51-ST54 of FIG. 14 corresponds to the process from steps ST31-ST34 of FIG. 12. That is, at step ST51, the motor-operated valve control section (220) performs a process similar to that of step ST31 of FIG. 12 by using a discharge superheating degree Tdsh2 and a discharge temperature Td2 of the first fixed capacity compressor (40b). In addition, at step ST52, the motor-operated valve control section (220) performs a process similar to that of step ST32 of FIG. 12, which is intended for the second injection motor-operated valve (64b). Further, at step ST53, the motor-operated valve control section (220) a process similar to that of step ST33 of FIG. 12 by using the discharge temperature Td2 of the first fixed capacity compressor (40b). Furthermore, at step ST54, the motor-operated valve control section (220) performs a process similar to that of step ST34 of FIG. 12, which is intended for the second injection motor-operated valve (64b).

[0237] If a condition ($Td2 > 100^\circ\text{C}$) is not satisfied at step ST53, the process proceeds to step ST55, and the motor-operated valve control section (220) performs the process at step ST55. At step ST55, the motor-operated valve control section (220) determines whether or not a condition is satisfied, in which both of the variable capacity compressor (40a) and the second fixed capacity compressor (40c) are in operation. If such a condition is satisfied, the process proceeds to step ST56, and the motor-operated valve control section (220) performs an opening degree control for an oil distribution, which is illustrated in the control flowchart of FIG. 15. The opening degree control for the oil distribution will be described later. On the other hand, if the foregoing condition is not satisfied at step ST55, the process proceeds to step ST57, and the motor-operated valve control section (220) sets the

second injection motor-operated valve (64b) to a completely-opened state.

[0238] The opening degree control for the oil distribution, which is performed at step ST56 will be described with reference to the control flowchart of FIG. 15.

[0239] At step ST61 of FIG. 15, the motor-operated valve control section (220) compares a detection value LP1 of the first low-pressure sensor (71) and a detection value LP2 of the second low-pressure sensor (72) to each other. The motor-operated valve control section (220) determines whether or not a determination condition is satisfied, in which the detection value LP1 of the first low-pressure sensor (71) is greater than the detection value LP2 of the second low-pressure sensor (72) ($LP1 > LP2$). Note that, at step ST61, a condition in which the detection value LP1 of the first low-pressure sensor (71) is equal to or greater than the detection value LP2 of the second low-pressure sensor (72) ($LP1 \geq LP2$) may be the determination condition.

[0240] If the determination condition is satisfied at step ST61 (i.e., if $LP1 > LP2$), the process proceeds to step ST62, and the motor-operated valve control section (220) performs the process at step ST62. At step ST62, the motor-operated valve control section (220) determines whether or not the determination parameter $F = 1$. If the determination parameter $F = 1$, the process proceeds to step ST63, and the motor-operated valve control section (220) performs the oil distribution operation. On the other hand, if the determination parameter $F \neq 1$ (i.e., the determination parameter $F = 0$), the process proceeds to step ST66, and the motor-operated valve control section (220) performs the normal operation.

[0241] At step ST66, the motor-operated valve control section (220) sets the target control value of the discharge superheating degree $Tdsh2$ of the first fixed capacity compressor (40b) to "25°C" which is a normal target value, and adjusts the degree of opening of the second injection motor-operated valve (64b) so that the discharge superheating degree $Tdsh2$ reaches 25°C. The motor-operated valve control section (220) performs such an operation as the normal operation.

[0242] On the other hand, at step ST63, the motor-operated valve control section (220) determines whether or not the refrigerating apparatus (10) is in the first mode. If the refrigerating apparatus (10) is in the first mode, the process proceeds to the step ST64, and the motor-operated valve control section (220) performs the process at step ST64. If the refrigerating apparatus (10) is not in the first mode (i.e., the refrigerating apparatus (10) is in the second mode), the process proceeds to step ST65, and the motor-operated valve control section (220) performs the process at step ST65.

[0243] During the first mode, the first fixed capacity compressor (40b) sucks refrigerant through the first suction pipe (51). That is, the pressure of refrigerant sucked into the first fixed capacity compressor (40b) is substantially equal to the pressure of refrigerant sucked into the variable capacity compressor (40a). At step ST64, the

motor-operated valve control section (220) performs a process similar to that of step ST43 of FIG. 13. That is, the motor-operated valve control section (220) sets the target control value of the discharge superheating degree $Tdsh2$ of the first fixed capacity compressor (40b) to "20°C" which is lower than the normal target value, and adjusts the degree of opening of the second injection motor-operated valve (64b) so that the discharge superheating degree $Tdsh2$ reaches 20°C. When the target control value of the discharge superheating degree $Tdsh2$ is decreased as compared to the normal target value by the oil distribution operation, the degree of opening of the second injection motor-operated valve (64b) is increased as compared to that during the normal operation, and a flow rate of intermediate-pressure refrigerant in a second injection pipe (62b) is increased as compared to that during the normal operation.

[0244] On the other hand, during the second mode, the first fixed capacity compressor (40b) sucks refrigerant through the third suction pipe (53). That is, the pressure of refrigerant sucked into the first fixed capacity compressor (40b) is substantially equal to the pressure of refrigerant sucked into the second fixed capacity compressor (40c). At step ST65, the motor-operated valve control section (220) performs a process similar to that of step ST93 of FIG. 17. That is, the motor-operated valve control section (220) sets the target control value of the discharge superheating degree $Tdsh2$ of the first fixed capacity compressor (40b) to "30°C" which is higher than the normal target value, and adjusts the degree of opening of the second injection motor-operated valve (64b) so that the discharge superheating degree $Tdsh2$ reaches 30°C. When the target control value of the discharge superheating degree $Tdsh2$ is increased as compared to the normal target value by the oil distribution operation, the degree of opening of the second injection motor-operated valve (64b) is decreased as compared to that during the normal operation, and the flow rate of intermediate-pressure refrigerant in the second injection pipe (62b) is decreased as compared to that during the normal operation.

[0245] If the determination condition is not satisfied at step ST61 (i.e., if $LP1 \leq LP2$), the process proceeds to step ST67, and the motor-operated valve control section (220) performs the process at step ST67. At step ST67, the motor-operated valve control section (220) determines whether or not the determination parameter $F = 1$. If the determination parameter $F = 1$, the process proceeds to step ST68, and the motor-operated valve control section (220) performs the oil distribution operation. On the other hand, if the determination parameter $F \neq 1$ (i.e., the determination parameter $F = 0$), the process proceeds to step ST71, and the motor-operated valve control section (220) performs the normal operation.

[0246] At step ST71, the motor-operated valve control section (220) sets the target control value of the discharge superheating degree $Tdsh2$ of the first fixed capacity compressor (40b) to "25°C" which is the normal

target value, and adjusts the degree of opening of the second injection motor-operated valve (64b) so that the discharge superheating degree T_{dsh2} reaches 25°C. That is, at step ST71, the motor-operated valve control section (220) performs the same process as that of step ST66. The motor-operated valve control section (220) performs such an operation as the normal operation.

[0247] On the other hand, at step ST68, the motor-operated valve control section (220) determines whether or not the refrigerating apparatus (10) is in the first mode. If the refrigerating apparatus (10) is in the first mode, the process proceeds to step ST69, and the motor-operated valve control section (220) performs the process at step ST69. If the refrigerating apparatus (10) is not in the first mode (i.e., the refrigerating apparatus (10) is in the second mode), the process proceeds to step ST70, and the motor-operated valve control section (220) performs the process at step ST70.

[0248] During the first mode, the first fixed capacity compressor (40b) sucks refrigerant through the first suction pipe (51). That is, the pressure of refrigerant sucked into the first fixed capacity compressor (40b) is substantially equal to the pressure of refrigerant sucked into the variable capacity compressor (40a). At step ST69, the motor-operated valve control section (220) performs a process similar to that of step ST46 of FIG. 13. That is, the motor-operated valve control section (220) sets the target control value of the discharge superheating degree T_{dshs2} of the first fixed capacity compressor (40b) to "30°C" which is higher than the normal target value, and adjusts the degree of opening of the second injection motor-operated valve (64b) so that the discharge superheating degree T_{dsh2} reaches 30°C. When the target control value of the discharge superheating degree T_{dsh2} is increased as compared to the normal target value by the oil distribution operation, the degree of opening of the second injection motor-operated valve (64b) is decreased as compared to that during the normal operation, and the flow rate of intermediate-pressure refrigerant in the second injection pipe (62b) is decreased as compared to that during the normal operation.

[0249] On the other hand, during the second mode, the first fixed capacity compressor (40b) sucks refrigerant through the third suction pipe (53). That is, the pressure of refrigerant sucked into the first fixed capacity compressor (40b) is substantially equal to the pressure of refrigerant sucked into the second fixed capacity compressor (40c). At step ST70, the motor-operated valve control section (220) performs a process similar to that of step ST96 of FIG. 17. That is, the motor-operated valve control section (220) sets the target control value of the discharge superheating degree T_{dsh2} of the first fixed capacity compressor (40b) to "20°C" which is lower than the normal target value, and adjusts the degree of opening of the second injection motor-operated valve (64b) so that the discharge superheating degree T_{dsh2} reaches 20°C. When the target control value of the discharge superheating degree T_{dsh2} is decreased as compared

to the normal target value by the oil distribution operation, the degree of opening of the second injection motor-operated valve (64b) is increased as compared to that during the normal operation, and the flow rate of intermediate-pressure refrigerant in the second injection pipe (62b) is increased as compared to that during the normal operation.

[0250] After the process at step ST52, ST54, ST56, or ST57 in the control flowchart of FIG. 14 is completed, the process returns to step ST51, and the motor-operated valve control section (220) performs the process at step ST51 again. The motor-operated valve control section (220) repeatedly performs the process illustrated in the control flowcharts of FIGS. 14 and 15, e.g., every 10-20 seconds.

<Advantages Obtained by Oil Return Operation of Motor-operated Valve Control Section>

[0251] First, e.g., when the normal heating operation is performed during midwinter during which an outdoor temperature drops below freezing, the evaporation temperature of refrigerant in the outdoor heat exchanger (44) may be lower than that in the chilling heat exchanger (91). In such a case, the detection value LP 1 of the first low-pressure sensor (71) is higher than the detection value LP2 of the second low-pressure sensor (72). That is, the pressure of refrigerant sucked into the variable capacity compressor (40a) is higher than the pressure of refrigerant sucked into the second fixed capacity compressor (40c). A pressure in the compression chamber of the variable capacity compressor (40a) in the middle of the compression process, which is communicated with the first injection pipe (62a) is higher than a pressure in the compression chamber of the second fixed capacity compressor (40c) in the middle of the compression process, which is communicated with the third injection pipe (62c). In addition, a compression ratio in the variable capacity compressor (40a) is smaller than that in the second fixed capacity compressor (40c).

[0252] On the other hand, if the determination parameter $F = 0$, the motor-operated valve control section (220) performs the normal operation. That is, in such a case, the motor-operated valve control section (220) adjusts the degree of opening of the first injection motor-operated valve (64a) so that the discharge superheating degree T_{dsh1} of the variable capacity compressor (40a) reaches the normal target value (25°C) (see step ST44 of FIG. 13), and adjusts the degree of opening of the third injection motor-operated valve (64c) so that the discharge superheating degree T_{dsh3} of the second fixed capacity compressor (40c) reaches the normal target value (25°C) (see step ST94 of FIG. 17). Thus, the flow rate of intermediate-pressure refrigerant flowing into the variable capacity compressor (40a) through the first injection pipe (62a) is smaller than the flow rate of intermediate-pressure refrigerant flowing into the second fixed capacity compressor (40c) through the third injection pipe (62c).

As a result, during the normal operation, the flow rate of refrigeration oil flowing into the variable capacity compressor (40a) through the first injection pipe (62a) is smaller than the flow rate of refrigeration oil flowing into the second fixed capacity compressor (40c) through the third injection pipe (62c), thereby decreasing the amount of refrigeration oil stored in the variable capacity compressor (40a).

[0253] When the normal operation is continued for a predetermined period of time (in the present embodiment, for 17 minutes) in a state in which the detection value LP1 of the first low-pressure sensor (71) is higher than the detection value LP2 of the second low-pressure sensor (72), the motor-operated valve control section (220) temporarily stops the normal operation and performs the oil distribution operation in order to increase the amount of refrigeration oil stored in the variable capacity compressor (40a). Specifically, the motor-operated valve control section (220) decreases the target control value of the discharge superheating degree Tdsh1 of the variable capacity compressor (40a) from the normal target value (25°C) to 20°C (see step ST43 of FIG. 13), and increases the target control value of the discharge superheating degree Tdsh3 of the second fixed capacity compressor (40c) from the normal target value (25°C) to 30°C (see step ST93 of FIG. 17).

[0254] The determination parameter setting section (221) of the motor-operated valve control section (220) maintains the value for the determination parameter F at "1" for a predetermined period of time (in the present embodiment, for 3 minutes). Thus, the motor-operated valve control section (220) of the present embodiment performs the oil distribution operation for three minutes, and then stops the oil distribution operation to restart the normal operation.

[0255] When the target control value of the discharge superheating degree Tdsh1 of the variable capacity compressor (40a) is decreased to 20°C, the degree of opening of the first injection motor-operated valve (64a) is increased as compared to that during the normal operation. On the other hand, when the target control value of the discharge superheating degree Tdsh3 of the second fixed capacity compressor (40c) is increased to 30°C, the degree of opening of the third injection motor-operated valve (64c) is decreased as compared to that during the normal operation. Thus, the flow rate of intermediate-pressure refrigerant and refrigeration oil supplied to the variable capacity compressor (40a) through the first injection pipe (62a) is increased, and the flow rate of intermediate-pressure refrigerant and refrigeration oil supplied to the second fixed capacity compressor (40c) through the third injection pipe (62c) is decreased. As a result, the amount of refrigeration oil stored in the variable capacity compressor (40a) is increased, thereby maintaining the amount of refrigeration oil stored in the second fixed capacity compressor (40c) at an appropriate value.

[0256] Next, when performing the cooling operation, the evaporation temperature of refrigerant in the air-con-

ditioning heat exchanger (81) is higher than that in the chilling heat exchanger (91), and therefore the detection value LP2 of the second low-pressure sensor (72) is higher than the detection value LP1 of the first low-pressure sensor (71). That is, the pressure of refrigerant sucked into the second fixed capacity compressor (40c) is higher than the pressure of refrigerant sucked into the variable capacity compressor (40a). Thus, the pressure in the compression chamber of the second fixed capacity compressor (40c) in the middle of the compression process, which is communicated with the third injection pipe (62c) is higher than the pressure in the compression chamber of the variable capacity compressor (40a) in the middle of the compression process, which is communicated with the first injection pipe (62a). In addition, the compression ratio in the second fixed capacity compressor (40c) is smaller than that in the variable capacity compressor (40a).

[0257] On the other hand, if the determination parameter $F = 0$, the motor-operated valve control section (220) performs the normal operation. That is, in such a case, the motor-operated valve control section (220) adjusts the degree of opening of the first injection motor-operated valve (64a) so that the discharge superheating degree Tdsh1 of the variable capacity compressor (40a) reaches the normal target value (25°C) (see step ST47 of FIG. 13), and adjusts the degree of opening of the third injection motor-operated valve (64c) so that the discharge superheating degree Tdsh3 of the second fixed capacity compressor (40c) reaches the normal target value (25°C) (see step ST97 of FIG. 17). Thus, the flow rate of intermediate-pressure refrigerant flowing into the second fixed capacity compressor (40c) through the third injection pipe (62c) is smaller than the flow rate of intermediate-pressure refrigerant flowing into the variable capacity compressor (40a) through the first injection pipe (62a). As a result, during the normal operation, the flow rate of refrigeration oil flowing into the second fixed capacity compressor (40c) through the third injection pipe (62c) is smaller than the flow rate of refrigeration oil flowing into the variable capacity compressor (40a) through the first injection pipe (62a), thereby decreasing the amount of refrigeration oil stored in the second fixed capacity compressor (40c).

[0258] When the normal operation is continued for a predetermined period of time (in the present embodiment, for 17 minutes) in a state in which the detection value LP2 of the second low-pressure sensor (72) is higher than the detection value LP1 of the first low-pressure sensor (71), the motor-operated valve control section (220) temporarily stops the normal operation and performs the oil distribution operation in order to increase the amount of refrigeration oil stored in the second fixed capacity compressor (40c). Specifically, the motor-operated valve control section (220) increases the target control value of the discharge superheating degree Tdsh1 of the variable capacity compressor (40a) from the normal target value (25°C) to 30°C (see step ST46 of FIG.

13), and decreases the target control value of the discharge superheating degree Tdsh3 of the second fixed capacity compressor (40c) from the normal target value (25°C) to 20°C (see step ST96 of FIG. 17).

[0259] When the target control value of the discharge superheating degree Tdsh1 of the variable capacity compressor (40a) is increased to 30°C, the degree of opening of the first injection motor-operated valve (64a) is decreased as compared to that during the normal operation. On the other hand, when the target control value of the discharge superheating degree Tdsh3 of the second fixed capacity compressor (40c) is decreased to 20°C, the degree of opening of the third injection motor-operated valve (64c) is increased as compared to that during the normal operation. Thus, the flow rate of intermediate-pressure refrigerant and refrigeration oil supplied to the second fixed capacity compressor (40c) through the third injection pipe (62c) is increased, and the flow rate of intermediate-pressure refrigerant and refrigeration oil supplied to the variable capacity compressor (40a) through the first injection pipe (62a) is decreased. As a result, the amount of refrigeration oil stored in the second fixed capacity compressor (40c) is increased, thereby maintaining the amount of refrigeration oil stored in the variable capacity compressor (40a) at an appropriate value.

[0260] The motor-operated valve control section (220) performs the oil distribution operation for the second injection motor-operated valve (64b).

[0261] During the first mode, the first fixed capacity compressor (40b) sucks refrigerant through the first suction pipe (51) as in the variable capacity compressor (40a). Thus, when performing the normal operation in a state in which the detection value LP1 of the first low-pressure sensor (71) is higher than the detection value LP2 of the second low-pressure sensor (72) during the first mode, the refrigerant flow rate in each of the first injection pipe (62a) and the second injection pipe (62b) is smaller than that in the third injection pipe (62c), and the amount of refrigerant stored in each of the variable capacity compressor (40a) and the first fixed capacity compressor (40b) is decreased. In such a case, the motor-operated valve control section (220) temporarily performs the operation in which the target control value of the discharge superheating degree Tdsh2 of the first fixed capacity compressor (40b) is decreased from the normal target value (25°C) to 20°C (see step ST64 of FIG. 15), as the oil distribution operation. Then, the motor-operated valve control section (220) increases the amount of refrigerant stored in the first fixed capacity compressor (40b).

[0262] When performing the normal operation in a state in which the detection value LP2 of the second low-pressure sensor (72) is higher than the detection value LP1 of the first low-pressure sensor (71) during the first mode, the refrigerant flow rate in the third injection pipe (62c) is smaller than the refrigerant flow rate in each of the first injection pipe (62a) and the second injection pipe (62b), thereby decreasing the amount of refrigerant

stored in the second fixed capacity compressor (40c). In such a case, the motor-operated valve control section (220) temporarily performs the operation in which the target control value of the discharge superheating degree Tdsh2 of the first fixed capacity compressor (40b) is increased from the normal target value (25°C) to 30°C (see step ST69 of FIG. 15), as the oil distribution operation. As a result, the refrigerant flow rate in the second injection pipe (62b) is decreased, and the refrigerant flow rate in the third injection pipe (62c) is increased. Thus, the amount of refrigerant stored in the second fixed capacity compressor (40c) is increased.

[0263] On the other hand, during the second mode, the first fixed capacity compressor (40b) sucks refrigerant through the third suction pipe (53) as in the second fixed capacity compressor (40c). Thus, when performing the normal operation in a state in which the detection value LP1 of the first low-pressure sensor (71) is higher than the detection value LP2 of the second low-pressure sensor (72) during the second mode, the refrigerant flow rate in the first injection pipe (62a) is smaller than that in each of the second injection pipe (62b) and the third injection pipe (62c), and the amount of refrigerant stored in the variable capacity compressor (40a) is decreased. In such a case, the motor-operated valve control section (220) temporarily performs the operation in which the target control value of the discharge superheating degree Tdsh2 of the first fixed capacity compressor (40b) is increased from the normal target value (25°C) to 30°C (see step ST65 of FIG. 15), as the oil distribution operation. As a result, the refrigerant flow rate in the second injection pipe (62b) is decreased, and the refrigerant flow rate in the first injection pipe (62a) is increased. Thus, the amount of refrigerant stored in the variable capacity compressor (40a) is increased.

[0264] When performing the normal operation in a state in which the detection value LP2 of the second low-pressure sensor (72) is higher than the detection value LP1 of the first low-pressure sensor (71) during the second mode, the refrigerant flow rate in each of the second injection pipe (62b) and the third injection pipe (62c) is smaller than the refrigerant flow rate in the first injection pipe (62a), thereby decreasing the amount of refrigerant stored in the first fixed capacity compressor (40b). In such a case, the motor-operated valve control section (220) temporarily performs the operation in which the target control value of the discharge superheating degree Tdsh2 of the first fixed capacity compressor (40b) is decreased from the normal target value (25°C) to 20°C (see step ST70 of FIG. 15), as the oil distribution operation. As a result, the refrigerant flow rate in the second injection pipe (62b) is increased, and the amount of refrigerant stored in the first fixed capacity compressor (40b) is increased.

Control Operation of Intermediate-Pressure Control Section

[0265] An operation performed by the intermediate-pressure control section (225) of the controller (200) will be described. As described above, the intermediate-pressure control section (225) adjusts the degree of opening of the subcooling expansion valve (63). A control operation performed by the intermediate-pressure control section (225) will be described with reference to a control flowchart of FIG. 18.

[0266] At step ST101, the intermediate-pressure control section (225) determines whether or not a condition is satisfied, in which both of the variable capacity compressor (40a) and the second fixed capacity compressor (40c) are in operation. Then, if such a condition is satisfied, the process proceeds to step ST102, and the intermediate-pressure control section (225) performs the process at step ST102. If the condition is not satisfied, the process proceeds to step ST103, and the intermediate-pressure control section (225) performs the process at step ST103.

[0267] At step ST102, the intermediate-pressure control section (225) adjusts the degree of opening of the subcooling expansion valve (63) so that a detection value MP of the intermediate pressure sensor (73) (i.e., an actual measured value of the pressure of intermediate-pressure refrigerant flowing through the main injection pipe (61)) reaches a predetermined target intermediate pressure MPs.

[0268] In a state in which both of the variable capacity compressor (40a) and the second fixed capacity compressor (40c) are in operation, it is necessary to supply intermediate-pressure refrigerant to both of the variable capacity compressor (40a) and the second fixed capacity compressor (40c). For the foregoing reason, it is necessary that the pressure of intermediate-pressure refrigerant flowing through the main injection pipe (61) is set to a value higher than both of a pressure in the compression chamber of the variable capacity compressor (40a) in the middle of the compression process, which is communicated with the first injection pipe (62a), and a pressure in the compression chamber of the second fixed capacity compressor (40c) in the middle of the compression process, which is communicated with the third injection pipe (62c).

[0269] The pressure in the compression chamber of the variable capacity compressor (40a) in the middle of the compression process can be estimated based on the pressure of refrigerant sucked into the variable capacity compressor (40a), and the pressure in the compression chamber of the second fixed capacity compressor (40c) in the middle of the compression process can be estimated based on the pressure of refrigerant sucked into the second fixed capacity compressor (40c). The intermediate-pressure control section (225) uses a detection value LP1 of the first low-pressure sensor (71) and a detection value LP2 of the second low-pressure sensor

(72) to calculate the target intermediate pressure MPs which allows intermediate-pressure refrigerant to flow into both of the variable capacity compressor (40a) and the second fixed capacity compressor (40c), and adjusts the degree of opening of the subcooling expansion valve (63) by using the calculated target intermediate pressure MPs. Thus, during the operation of both of the variable capacity compressor (40a) and the second fixed capacity compressor (40c), supply of intermediate-pressure refrigerant from the injection circuit (60) to both of the variable capacity compressor (40a) and the second fixed capacity compressor (40c) can be ensured.

[0270] At step ST103, the intermediate-pressure control section (225) adjusts the degree of opening of the subcooling expansion valve (63) so that a superheating degree SHm of intermediate-pressure refrigerant flowing out from the second flow path (67) of the subcooling heat exchanger (65) reaches a predetermined target value (in the present embodiment, 5°C). In a state in which either one of the variable capacity compressor (40a) and the second fixed capacity compressor (40c) is in operation, it is inevitable that the pressure of intermediate-pressure refrigerant flowing through the main injection pipe (61) is higher than the pressure in the compression chamber of the operated one of the variable capacity compressor (40a) and the second fixed capacity compressor (40c) in the middle of the compression process, which is communicated with the injection pipe (62a, 62c). That is, in such a state, it is not necessary to adjust the degree of opening of the subcooling expansion valve (63) considering the pressure of intermediate-pressure refrigerant flowing through the main injection pipe (61).

[0271] In such a case, the intermediate-pressure control section (225) adjusts the degree of opening of the subcooling expansion valve (63) so that the superheating degree SHm of intermediate-pressure refrigerant reaches the target value. As a result, a flow rate of intermediate-pressure refrigerant supplied to the second flow path (67) of the subcooling heat exchanger (65) is maintained at a required and sufficient value, and therefore cooling of high-pressure refrigerant flowing through the first flow path (66) of the subcooling heat exchanger (65) can be ensured.

<<Other Embodiment>>

First Variation

[0272] In each of the foregoing embodiments, the operation in which the degree of opening of one of the first injection motor-operated valve (64a) and the third injection motor-operated valve (64c) is increased as compared to that during the normal operation, and the degree of opening of the remaining one of the first injection motor-operated valve (64a) and the third injection motor-operated valve (64c) is decreased as compared to that during the normal operation is performed as the oil distribution operation.

[0273] On the other hand, in each of the foregoing embodiments, an operation in which only the degree of opening of one of the first injection motor-operated valve (64a) and the third injection motor-operated valve (64c) is increased as compared to that during the normal operation, and the degree of opening of the remaining one of the first injection motor-operated valve (64a) and the third injection motor-operated valve (64c) is maintained at the same value as that during the normal operation may be performed as the oil distribution operation. For example, if only the degree of opening of the first injection motor-operated valve (64a) is increased, and the degree of opening of the third injection motor-operated valve (64c) is maintained at the same value as that during the normal operation, the refrigerant flow rate in the first injection pipe (62a) is increased, thereby decreasing the refrigerant flow rate in the third injection pipe (62c).

[0274] In addition, in each of the foregoing embodiments, an operation in which only the degree of opening of one of the first injection motor-operated valve (64a) and the third injection motor-operated valve (64c) is decreased as compared to that during the normal operation, and the degree of opening of the remaining one of the first injection motor-operated valve (64a) and the third injection motor-operated valve (64c) is maintained at the same value as that during the normal operation may be performed as the oil distribution operation. For example, if the degree of opening of the first injection motor-operated valve (64a) is maintained at the same value as that during the normal operation, and only the degree of opening of the third injection motor-operated valve (64c) is decreased, the refrigerant flow rate in the third injection pipe (62c) is decreased, thereby increasing the refrigerant flow rate in the first injection pipe (62a).

Second Variation

[0275] In each of the foregoing embodiments, the injection motor-operated valve (64a, 64b, 64c) having the variable degree of opening is provided in the injection pipe (62a-62c), and the degree of opening of the injection motor-operated valve (64a, 64b, 64c) is adjusted to adjust the refrigerant flow rate in the injection pipe (62a-62c). On the other hand, an openable solenoid valve may be provided in the injection pipe (62a-62c), and the refrigerant flow rate in the injection pipe (62a-62c) may be adjusted by the solenoid valve. In such a case, the refrigerant flow rate in the injection pipe (62a-62c) is adjusted by changing a time period for which the solenoid valve is maintained at an opened state. That is, in order to increase the refrigerant flow rate in the injection pipe (62a-62c), the time period for which the solenoid valve is maintained at the opened state is extended. Conversely, in order to decrease the refrigerant flow rate in the injection pipe (62a-62c), the time period for which the solenoid valve is maintained at the opened state is shortened.

Third Variation

[0276] In each of the foregoing embodiments, the injection motor-operated valves (64a, 64b, 64c) are provided in all of the injection pipes (62a, 62b, 62c) of the injection circuit (60). However, in some cases, an injection motor-operated valve may be provided only in one of injection pipes. That is, if it can be determined in advance which one of the first suction pipe (51) and the third suction pipe (53) has a lower pressure as in, e.g., a case where only the cooling operation of the second embodiment is performed, the first injection motor-operated valve (64a) may be provided only in the injection pipe (62a) connected to the compressor (40a) sucking refrigerant through the first suction pipe (51) having the lower pressure.

INDUSTRIAL APPLICABILITY

[0277] As described above, the present invention is useful for the refrigerating apparatus in which refrigeration oil separated from refrigerant discharged from the compressor is supplied to the compressor together with intermediate-pressure refrigerant.

DESCRIPTION OF REFERENCE CHARACTERS

[0278]

10	Refrigerating Apparatus
20	Refrigerant Circuit
40a	Variable Capacity Compressor (First Compressor)
40b	First Fixed Capacity Compressor (Third Compressor)
40c	Second Fixed Capacity Compressor (Second Compressor)
44	Outdoor Heat Exchanger (Condenser, Second Evaporator)
49	Oil Return Circuit
60	Injection Circuit
61	Main Injection Pipe
62a	First Injection Pipe (First Branched Pipe)
62b	Second Injection Pipe (Third Branched Pipe)
62c	Third Injection Pipe (Second Branched Pipe)
63	Subcooling Expansion Valve (Intermediate-Pressure Expansion Valve)
64a	First Injection Motor-operated Valve (First Flow Rate Adjusting Valve)
64b	Second Injection Motor-operated Valve (Third Flow Rate Adjusting Valve)
64c	Third Injection Motor-operated Valve (Second Flow Rate Adjusting Valve)
65	Subcooling Heat Exchanger
81	Air-Conditioning Heat Exchanger (Second Evaporator, Condenser)
91	Chilling Heat Exchanger (First Evaporator)
220	Motor-operated Valve Control Section (Opening

Degree Control Section)
 225 Intermediate-Pressure Control Section
 250 Flow Rate Adjusting Mechanism

Claims

1. A refrigerating apparatus, comprising:

a refrigerant circuit (20) in which a refrigeration cycle is performed,
 wherein the refrigerant circuit (20) includes

a first evaporator (91),
 a second evaporator (81, 44),
 a first compressor (40a) sucking refrigerant evaporated in the first evaporator (91),
 a second compressor (40c) sucking refrigerant evaporated in the second evaporator (81, 44),
 a condenser (44, 81) into which refrigerant discharged from the first compressor (40a) and the second compressor (40c) flows,
 an injection circuit (60) having a main injection pipe (61) through which intermediate-pressure refrigerant flows, a first branched pipe (62a) connecting the main injection pipe (61) to the first compressor (40a), and a second branched pipe (62c) connecting the main injection pipe (61) to the second compressor (40c), and
 an oil return circuit (49) in which refrigeration oil separated from refrigerant discharged from the first compressor (40a) and the second compressor (40c) is supplied to the main injection pipe (61),

the refrigerating apparatus further includes

a flow rate adjusting mechanism (250) configured to perform a normal operation in which a refrigerant flow rate in each of the first branched pipe (62a) and the second branched pipe (62c) is adjusted so that a physical amount for control reaches a predetermined target control value, and

the flow rate adjusting mechanism (250)

makes determination using either one of a condition in which a pressure of refrigerant sucked into the first compressor (40a) is greater than a pressure of refrigerant sucked into the second compressor (40c), and a condition in which the pressure of refrigerant sucked into the first compressor (40a) is equal to or greater than the pressure of refrigerant sucked into the second com-

pressor (40c), as a determination condition, intermittently performs an operation in which the refrigerant flow rate in the first branched pipe (62a) is increased as compared to that during the normal operation, and the refrigerant flow rate in the second branched pipe (62c) is decreased as compared to that during the normal operation, as an oil distribution operation when the determination condition is satisfied, and intermittently performs an operation in which the refrigerant flow rate in the first branched pipe (62a) is decreased as compared to that during the normal operation, and the refrigerant flow rate in the second branched pipe (62c) is increased as compared to that during the normal operation, as the oil distribution operation when the determination condition is not satisfied.

2. The refrigerating apparatus of claim 1, wherein the flow rate adjusting mechanism (250) includes

a first flow rate adjusting valve (64a) provided in the first branched pipe (62a),
 a second flow rate adjusting valve (64c) provided in the second branched pipe (62c), and
 an opening degree control section (220) configured to control a degree of opening of each of the first flow rate adjusting valve (64a) and the second flow rate adjusting valve (64c) so that the physical amount for control reaches a predetermined target control value, and

the opening degree control section (220)

performs one or both of an operation in which the degree of opening of the first flow rate adjusting valve (64a) is increased as compared to that during the normal operation, and an operation in which the degree of opening of the second flow rate adjusting valve (64c) is decreased as compared to that during the normal operation, as the oil distribution operation when the determination condition is satisfied, and performs one or both of an operation in which the degree of opening of the first flow rate adjusting valve (64a) is decreased as compared to that during the normal operation, and an operation in which the degree of opening of the second flow rate adjusting valve (64c) is increased as compared to that during the normal operation, as the oil distribution operation when the determination condition is not satisfied.

3. The refrigerating apparatus of claim 2, wherein the opening degree control section (220)

uses a temperature or a superheating degree of refrigerant discharged from the first compressor (40a) as a first physical amount for control and adjusts the degree of opening of the first flow rate adjusting valve (64a) so that the first physical amount for control reaches a first target control value,

uses a temperature or a superheating degree of refrigerant discharged from the second compressor (40c) as a second physical amount for control and adjusts the degree of opening of the second flow rate adjusting valve (64c) so that the second physical amount for control reaches a second target control value,

in the normal operation, sets the first and second target control values to a predetermined normal target value to adjust the degree of opening of each of the first flow rate adjusting valve (64a) and the second flow rate adjusting valve (64c), if the degree of opening of the first flow rate adjusting valve (64a) is increased as compared to that during the normal operation in the oil distribution operation, sets the first target control value to a value lower than the normal target value, if the degree of opening of the first flow rate adjusting valve (64a) is decreased as compared to that during the normal operation in the oil distribution operation, sets the first target control value to a value higher than the normal target value,

if the degree of opening of the second flow rate adjusting valve (64c) is increased as compared to that during the normal operation in the oil distribution operation, sets the second target control value to a value lower than the normal target value, and

if the degree of opening of the second flow rate adjusting valve (64c) is decreased as compared to that during the normal operation in the oil distribution operation, sets the second target control value to a value higher than the normal target value.

4. The refrigerating apparatus of claim 1, wherein the flow rate adjusting mechanism (250)

uses a temperature or a superheating degree of refrigerant discharged from the first compressor (40a) as a first physical amount for control and adjusts the refrigerant flow rate in the first branched pipe (62a) so that the first physical amount for control reaches a first target control value, and

uses a temperature or a superheating degree of refrigerant discharged from the second compressor (40c) as a second physical amount for control and adjusts the refrigerant flow rate in the second branched pipe (62c) so that the sec-

ond physical amount for control reaches a second target control value.

5. The refrigerating apparatus of claim 1, wherein the refrigerant circuit (20) further includes a third compressor (40b) configured to selectively suck either one of refrigerant evaporated in the first evaporator (91) and refrigerant evaporated in the second evaporator (81, 44), the injection circuit (60) further includes a third branched pipe (62b) connecting the main injection pipe (61) to the third compressor (40b), the oil return circuit (49) supplies refrigeration oil which is separated from refrigerant discharged from the first compressor (40a), the second compressor (40c), and the third compressor (40b), to the main injection pipe (61), the flow rate adjusting mechanism (250) includes

a first flow rate adjusting valve (64a) provided in the first branched pipe (62a),
a second flow rate adjusting valve (64c) provided in the second branched pipe (62c),
a third flow rate adjusting valve (64b) provided in the third branched pipe (62b), and
an opening degree control section (220) configured to control a degree of opening of each of the first flow rate adjusting valve (64a), the second flow rate adjusting valve (64c), and the third flow rate adjusting valve (64b) so that the physical amount for control is a predetermined target control value,

the opening degree control section (220), in a state in which the third compressor (40b) sucks refrigerant evaporated in the first evaporator (91),

performs one or both of an operation in which the degree of opening of each of the first flow rate adjusting valve (64a) and the third flow rate adjusting valve (64b) is increased as compared to that during the normal operation, and an operation in which the degree of opening of the second flow rate adjusting valve (64c) is decreased as compared to that during the normal operation, as the oil distribution operation when the determination condition is satisfied, and performs one or both of an operation in which the degrees of opening of the first flow rate adjusting valve (64a) and the third flow rate adjusting valve (64b) are decreased as compared to that during the normal operation, and an operation in which the degree of opening of the second flow rate adjusting valve (64c) is increased as compared to that during the normal operation, as the oil distribution operation when the determination condition is not satisfied, and

the opening degree control section (220), in a state in which the third compressor (40b) sucks refrigerant evaporated in the second evaporator (81, 44),

performs one or both of an operation in which the degree of opening of the first flow rate adjusting valve (64a) is increased as compared to that during the normal operation, and an operation in which the degree of opening of each of the second flow rate adjusting valve (64c) and the third flow rate adjusting valve (64b) is decreased as compared to that during the normal operation, as the oil distribution operation when the determination condition is satisfied, and performs one or both of an operation in which the degree of opening of the first flow rate adjusting valve (64a) is decreased as compared to that during the normal operation, and an operation in which the degree of opening of each of the second flow rate adjusting valve (64c) and the third flow rate adjusting valve (64b) is increased as compared to that during the normal operation, as the oil distribution operation when the determination condition is not satisfied.

6. The refrigerating apparatus of any one of claims 1-5, wherein the flow rate adjusting mechanism (250) extends a duration time of the oil distribution operation as a difference between the pressure of refrigerant sucked into the first compressor (40a) and the pressure of refrigerant sucked into the second compressor (40c) increases.
7. The refrigerating apparatus of any one of claims 1-5, wherein the injection circuit (60) is connected to

an intermediate-pressure expansion valve (63) configured to expand high-pressure refrigerant into intermediate-pressure refrigerant and provided in the main injection pipe (61), and a subcooling heat exchanger (65) configured to cool high-pressure liquid refrigerant flowing from the condenser (44, 81) to at least one of the first evaporator (91) and the second evaporator (81, 44) by exchanging heat between the high-pressure liquid refrigerant and intermediate-pressure refrigerant flowing through the main injection pipe (61), and

the injection circuit (60) further includes an intermediate-pressure control section (225) which, if both of the first compressor (40a) and the second compressor (40c) are in operation, adjusts a degree of opening of the intermediate-pressure expansion valve (63) so that a pressure of intermediate-pressure refrigerant flowing through the main injection pipe (61)

reaches a predetermined target pressure, and which, if either one of the first compressor (40a) and the second compressor (40c) is in operation, and the remaining one of the first compressor (40a) and the second compressor (40c) is stopped, adjusts the degree of opening of the intermediate-pressure expansion valve (63) so that a degree of superheating of intermediate-pressure refrigerant flowing out from the subcooling heat exchanger (65) reaches a predetermined target superheating degree.

FIG.1

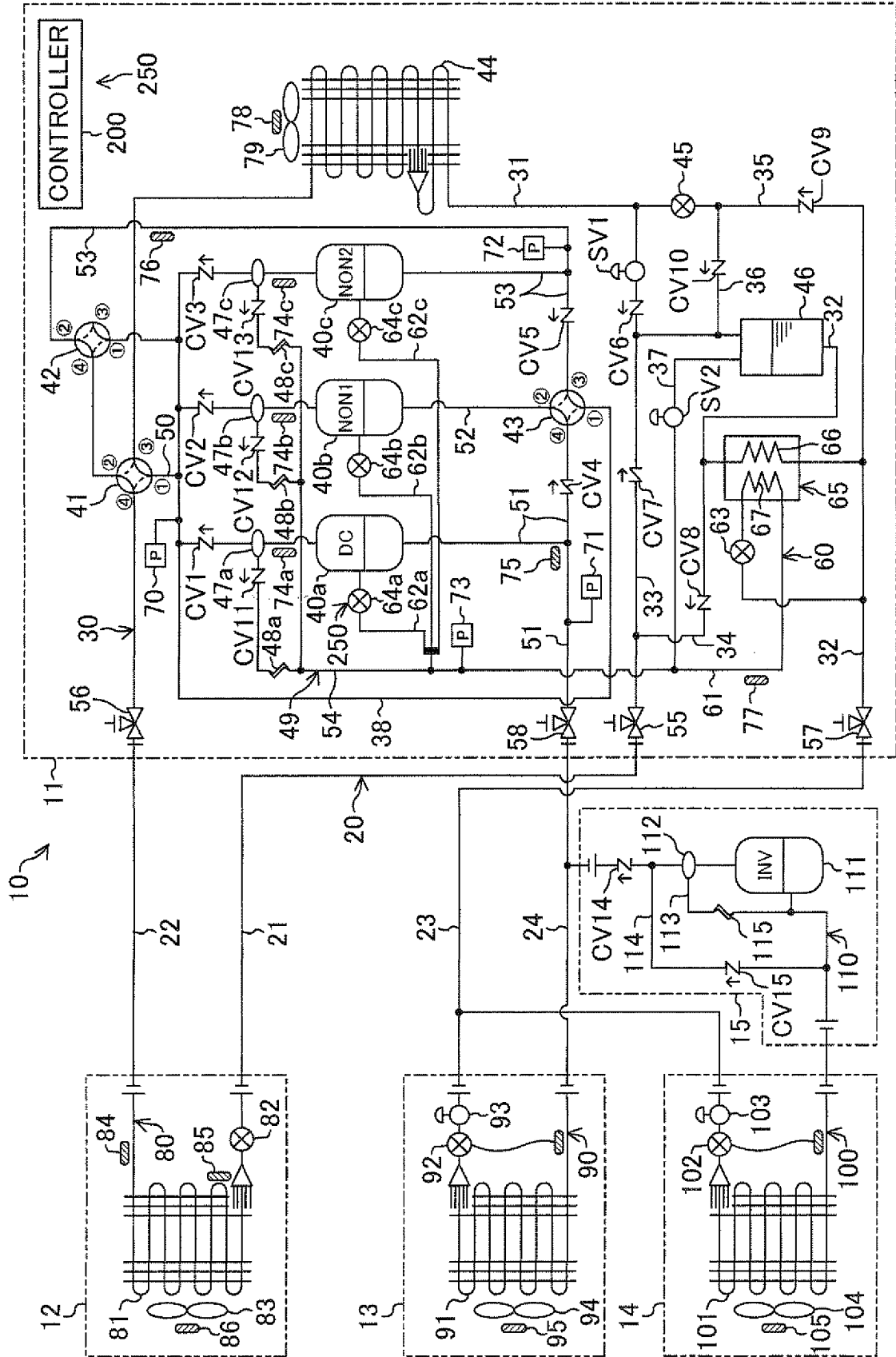
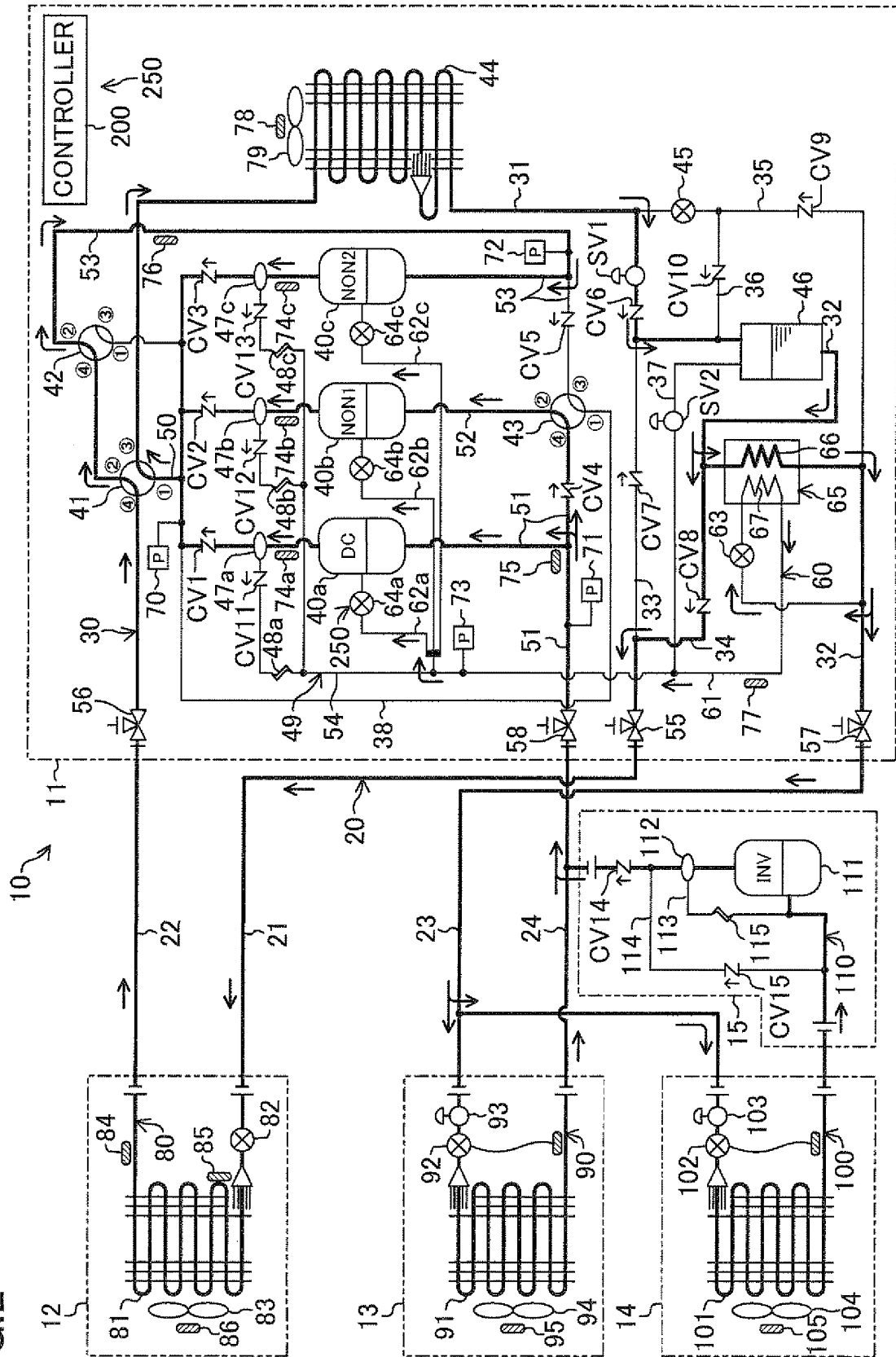


FIG. 2



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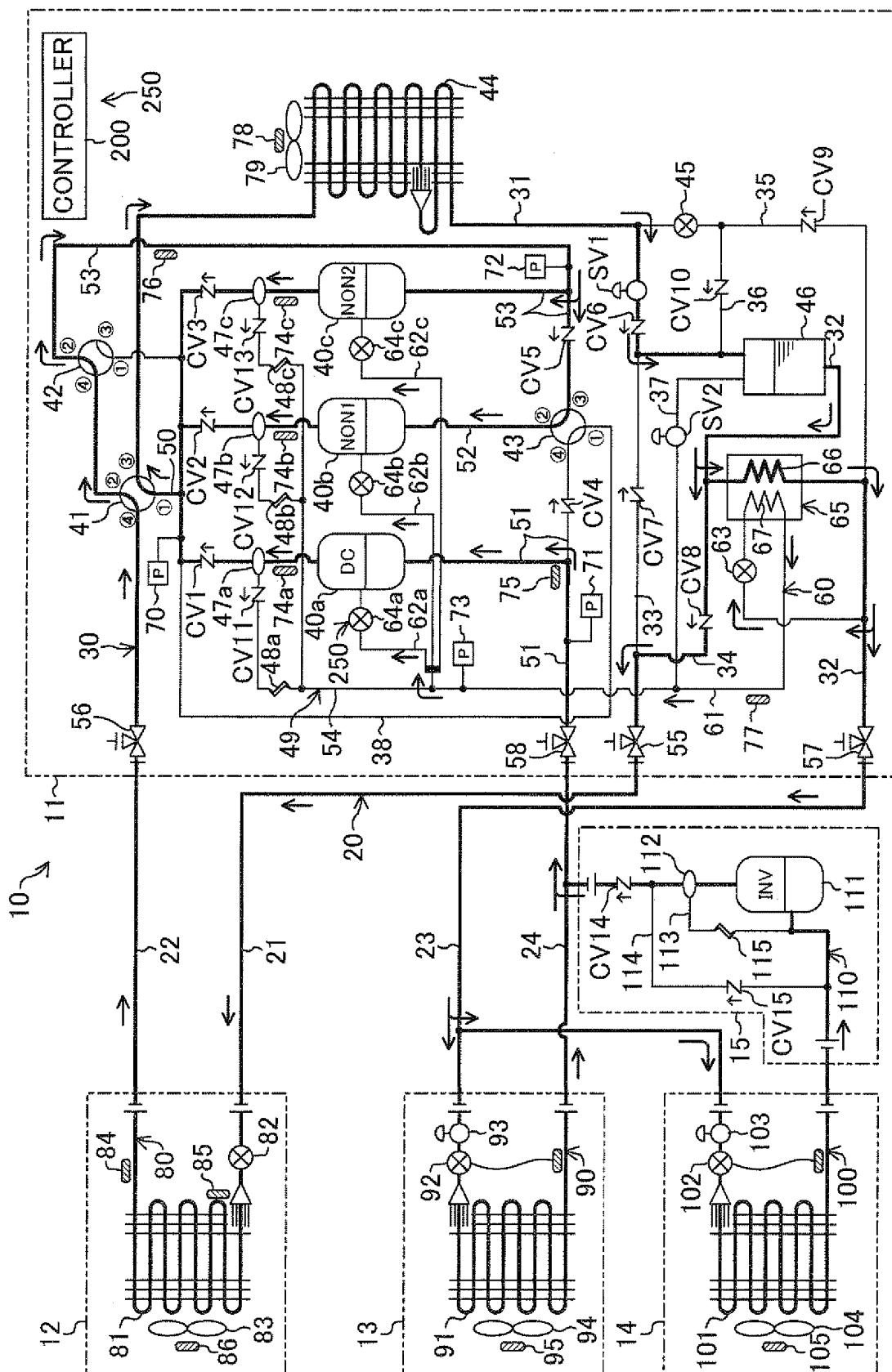
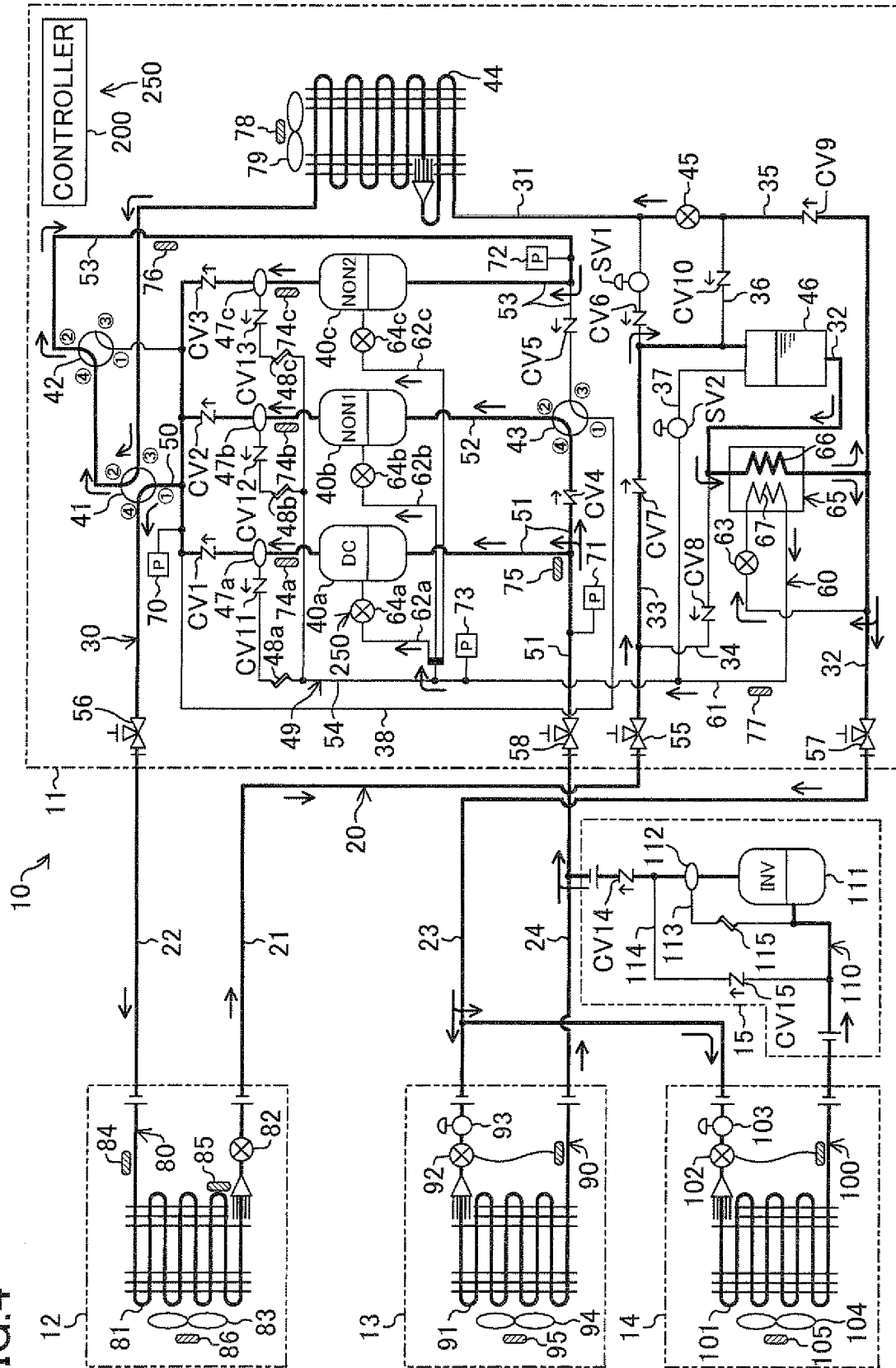


FIG. 4



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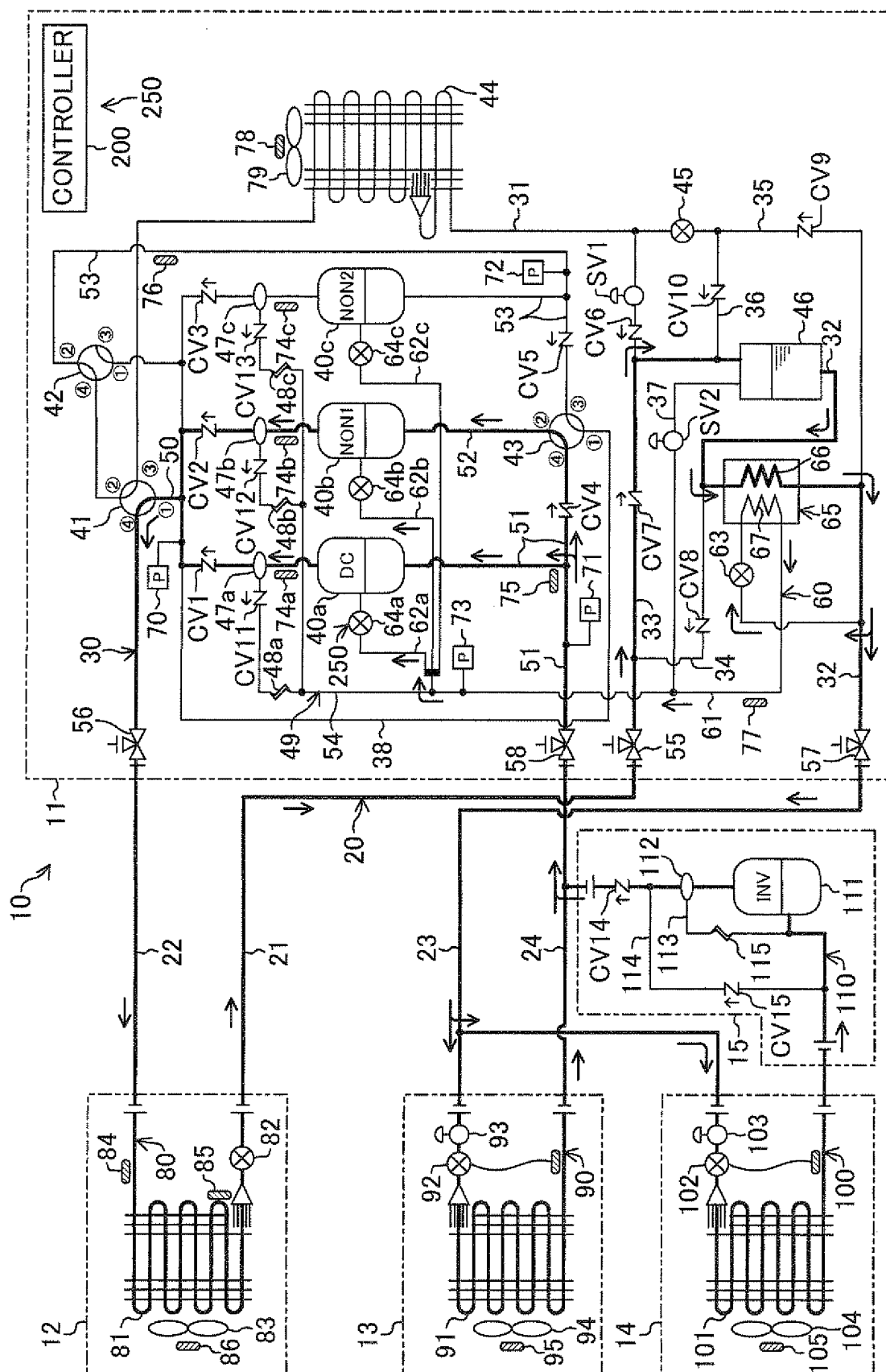


FIG. 6

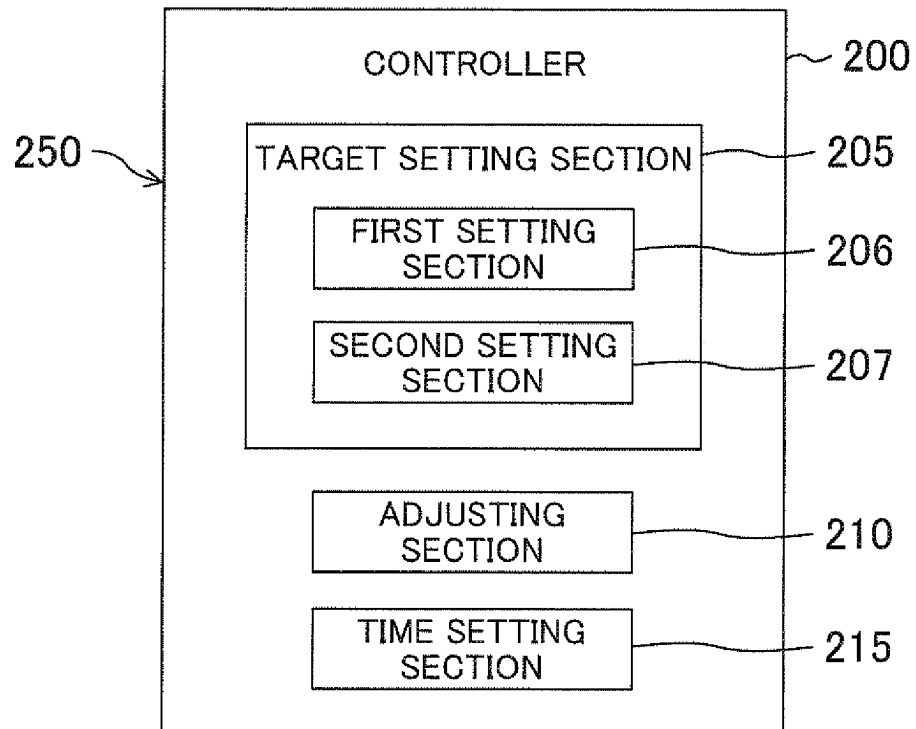


FIG. 7

$\Delta LP = \text{ABS}(LP1 - LP2)$	$\Delta LP \geq 2.25$	$1.5 \leq \Delta LP < 2.25$	$0.75 \leq \Delta LP < 1.5$	$0 \leq \Delta LP < 0.75$
DURATION TIME OF OIL DISTRIBUTION OPERATION (SECONDS)	$1.75 \times t1$	$1.5 \times t1$	$1.25 \times t1$	$t1$
CONTROL CYCLE (SECONDS)	$10 \times t1$			

FIG.8

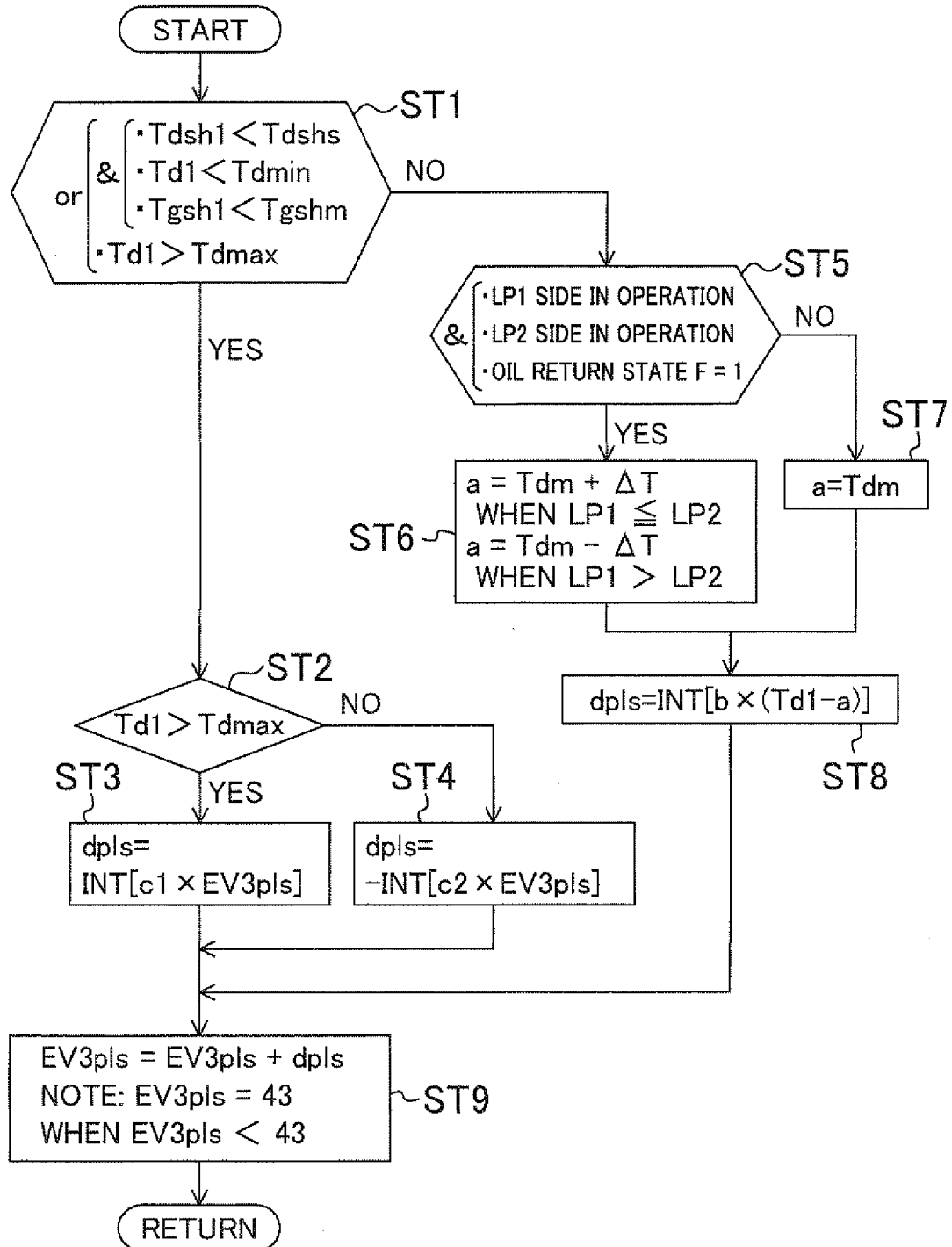


FIG.9

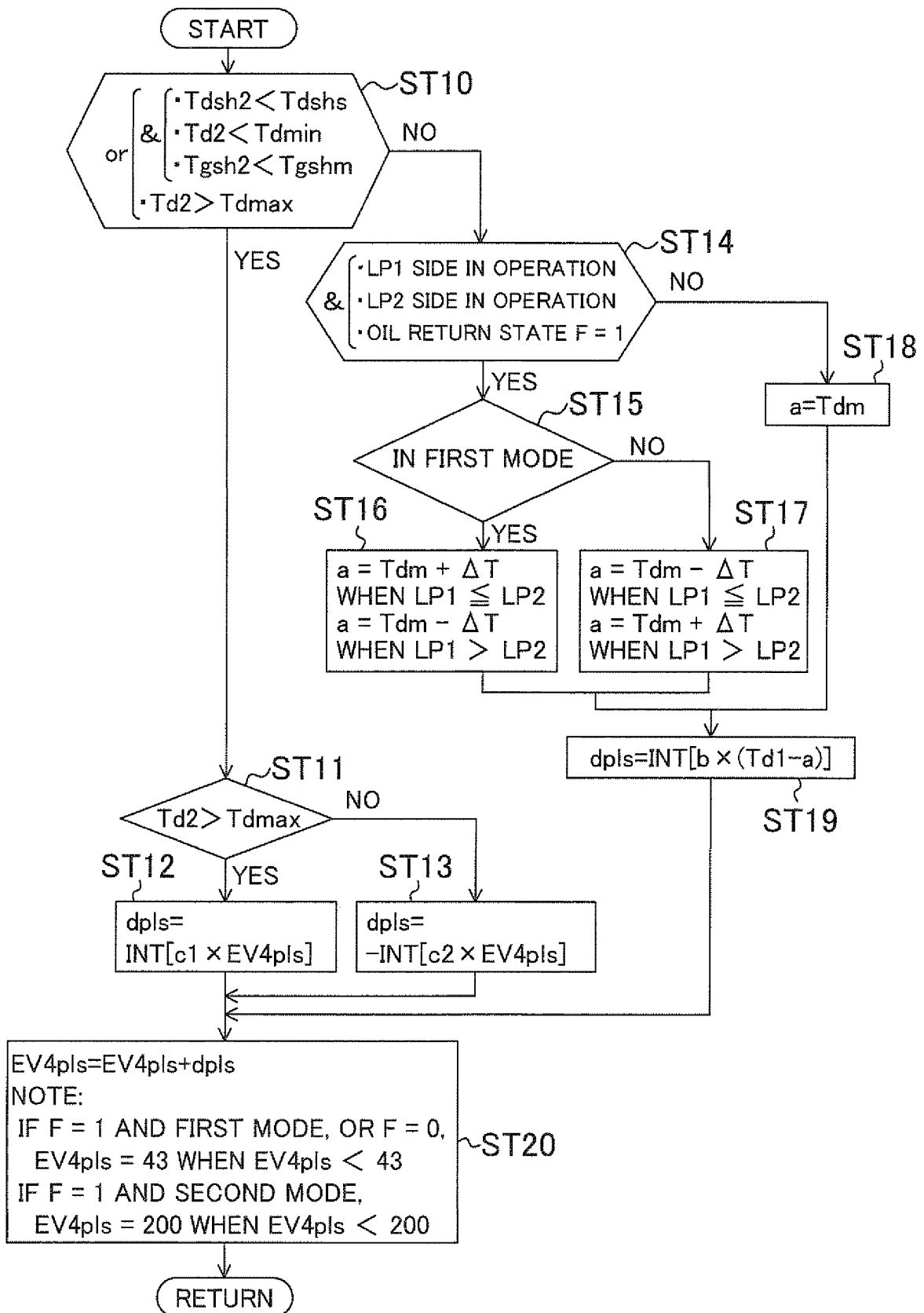


FIG.10

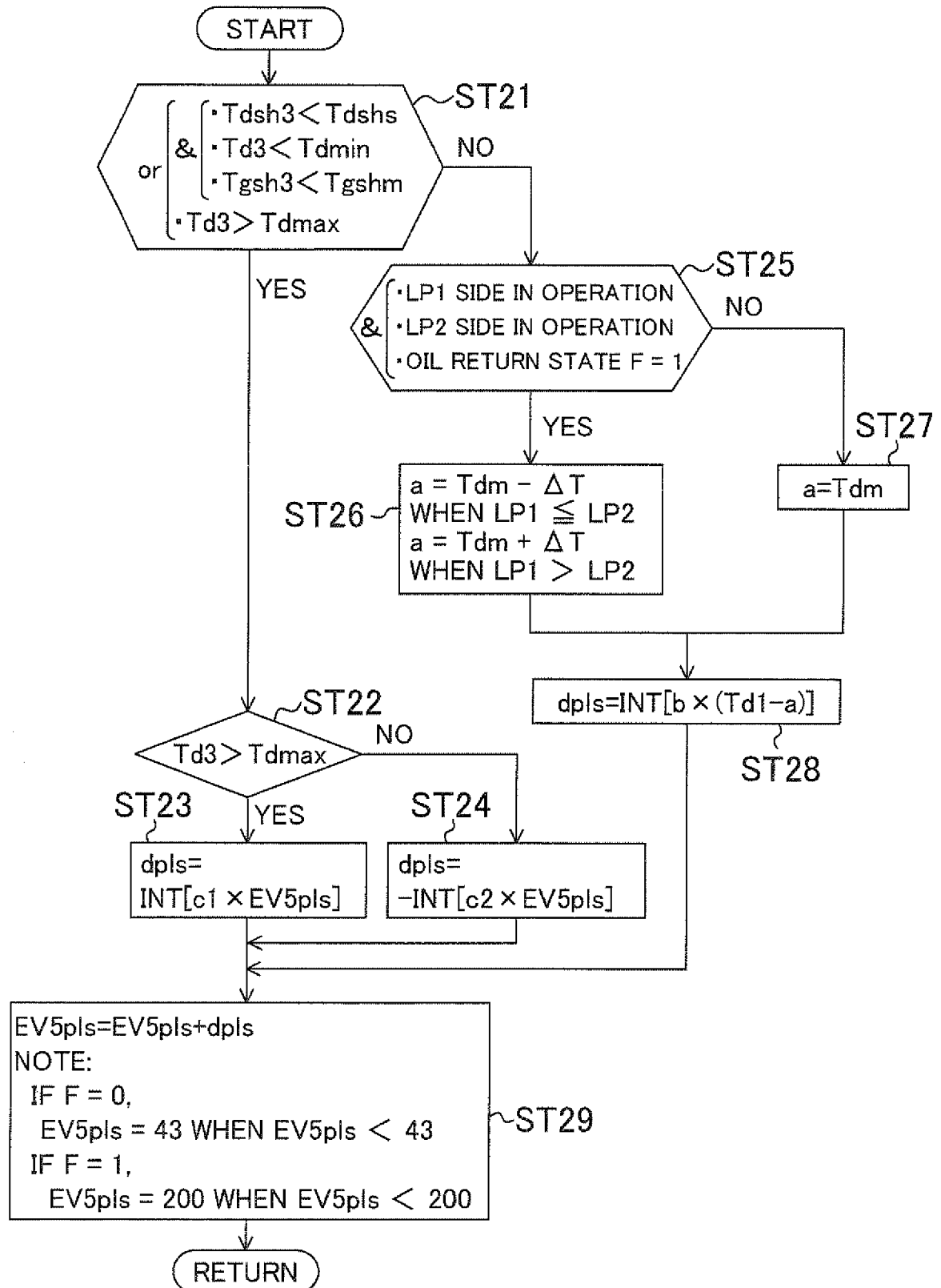


FIG.11

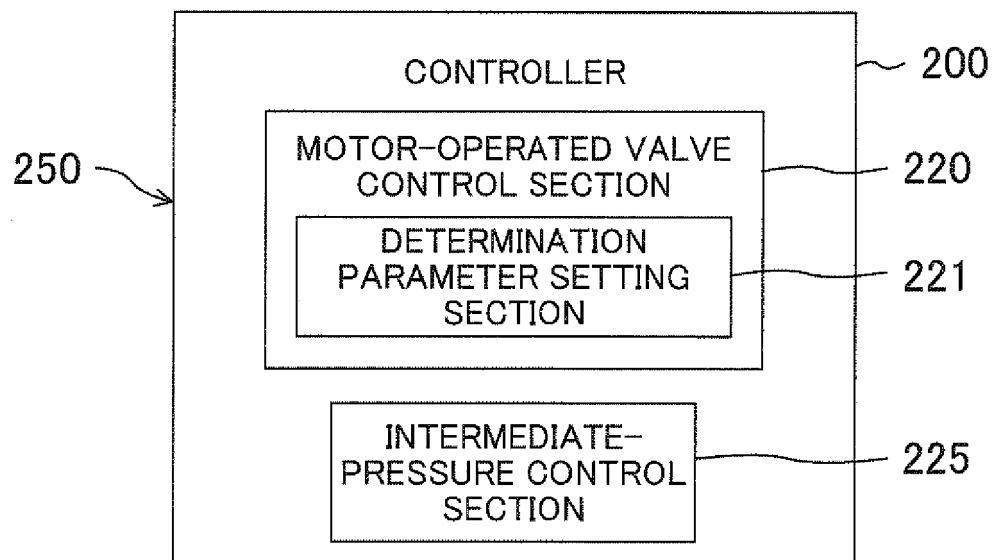


FIG.12

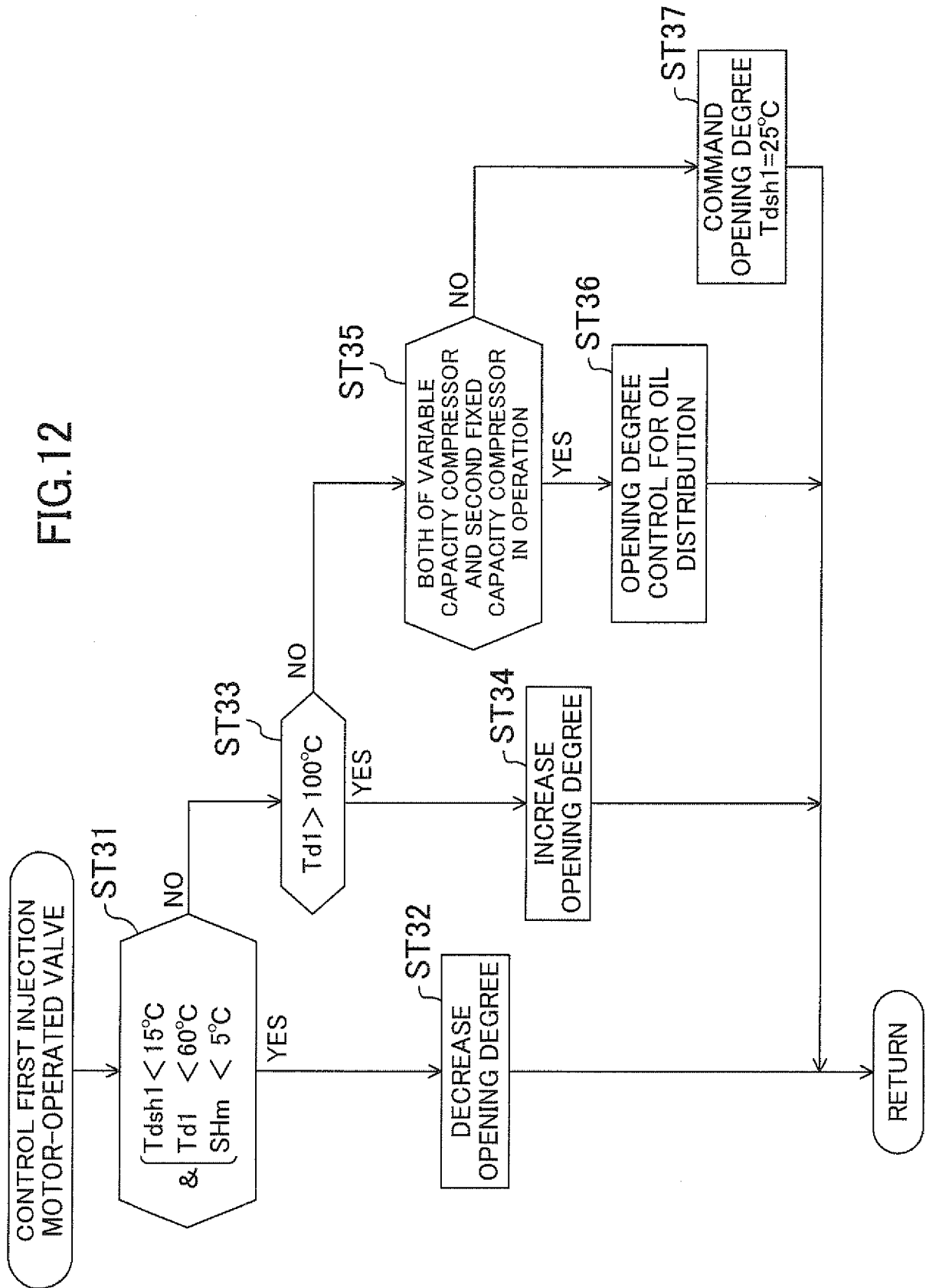


FIG. 13

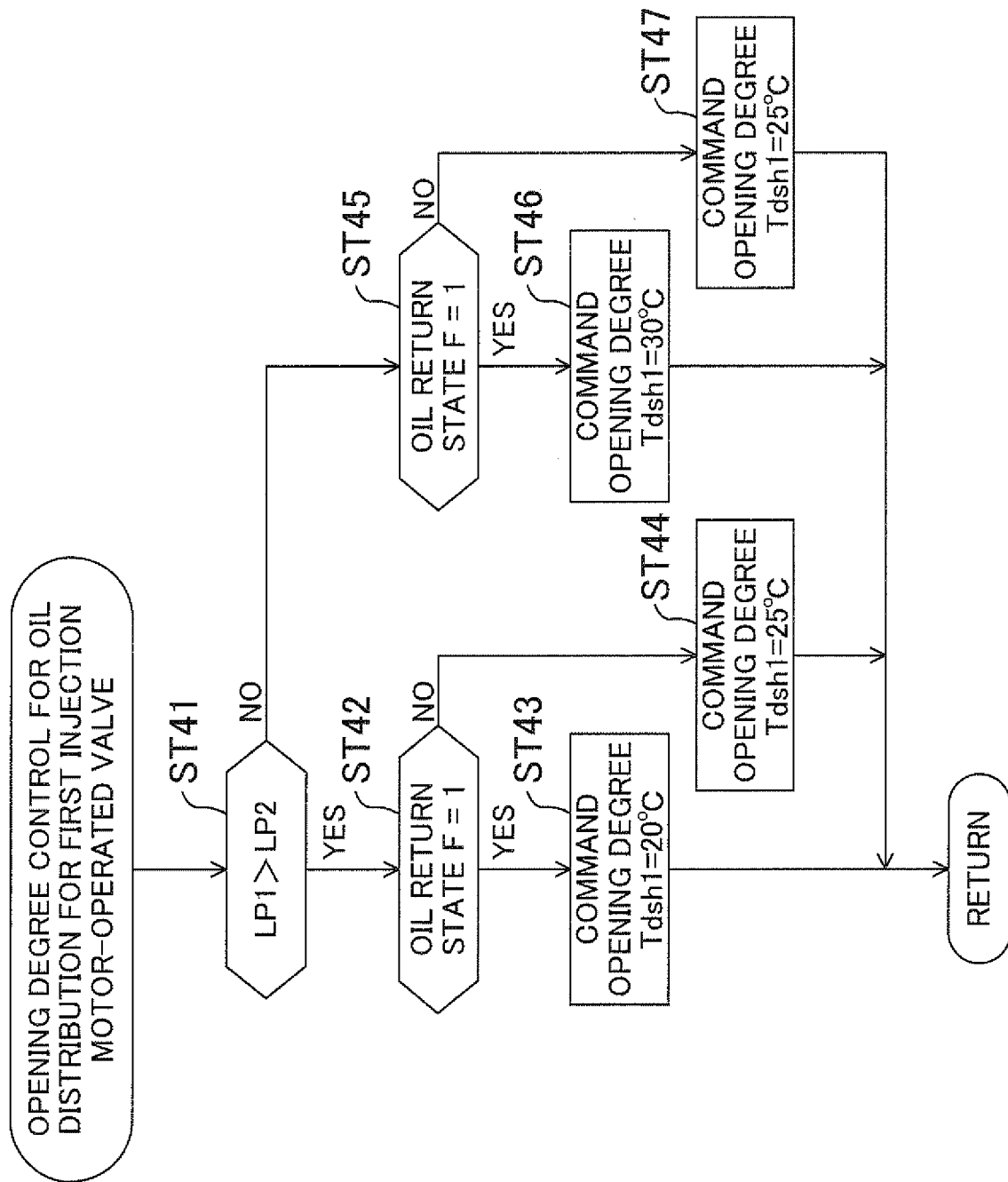
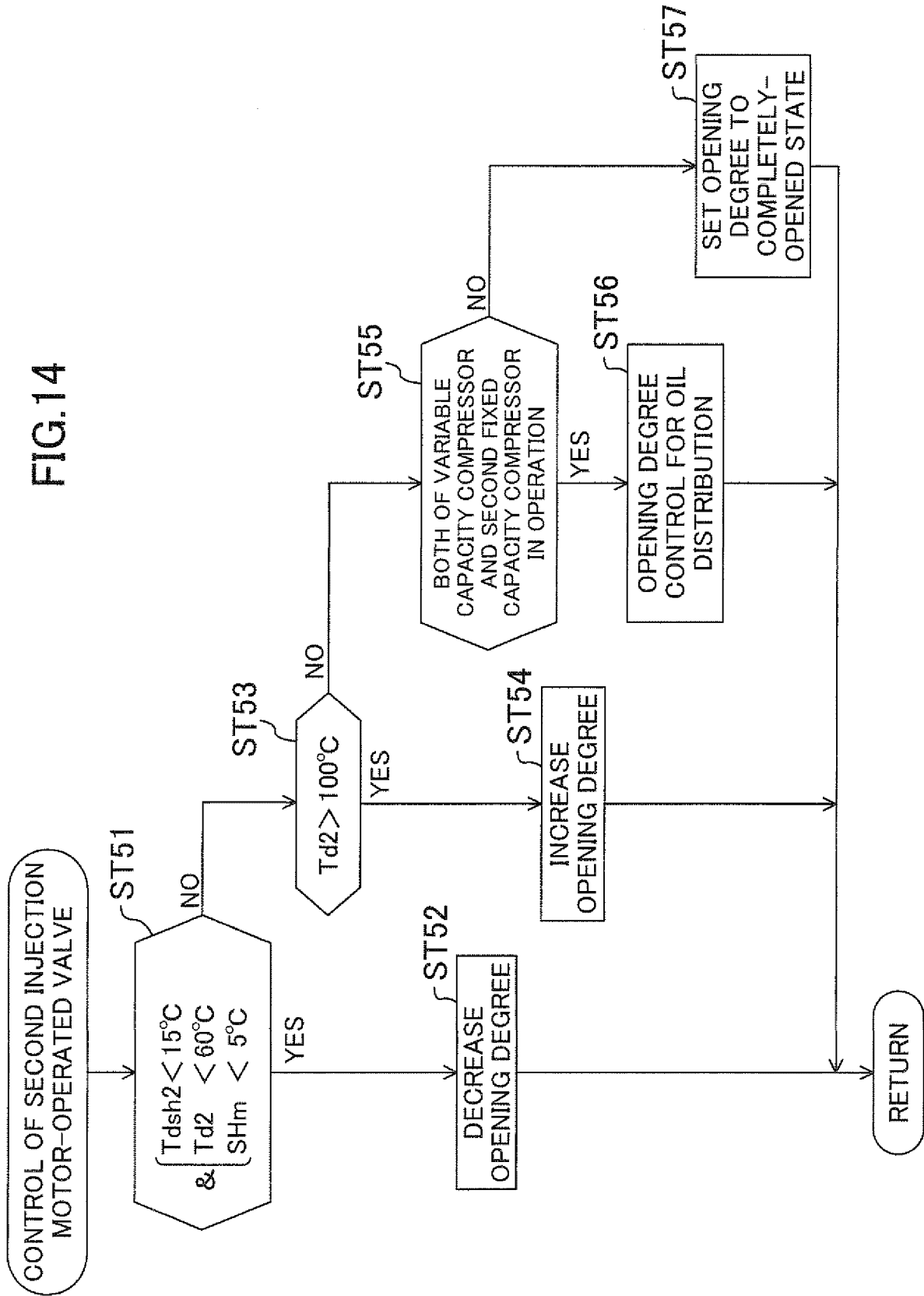


FIG. 14



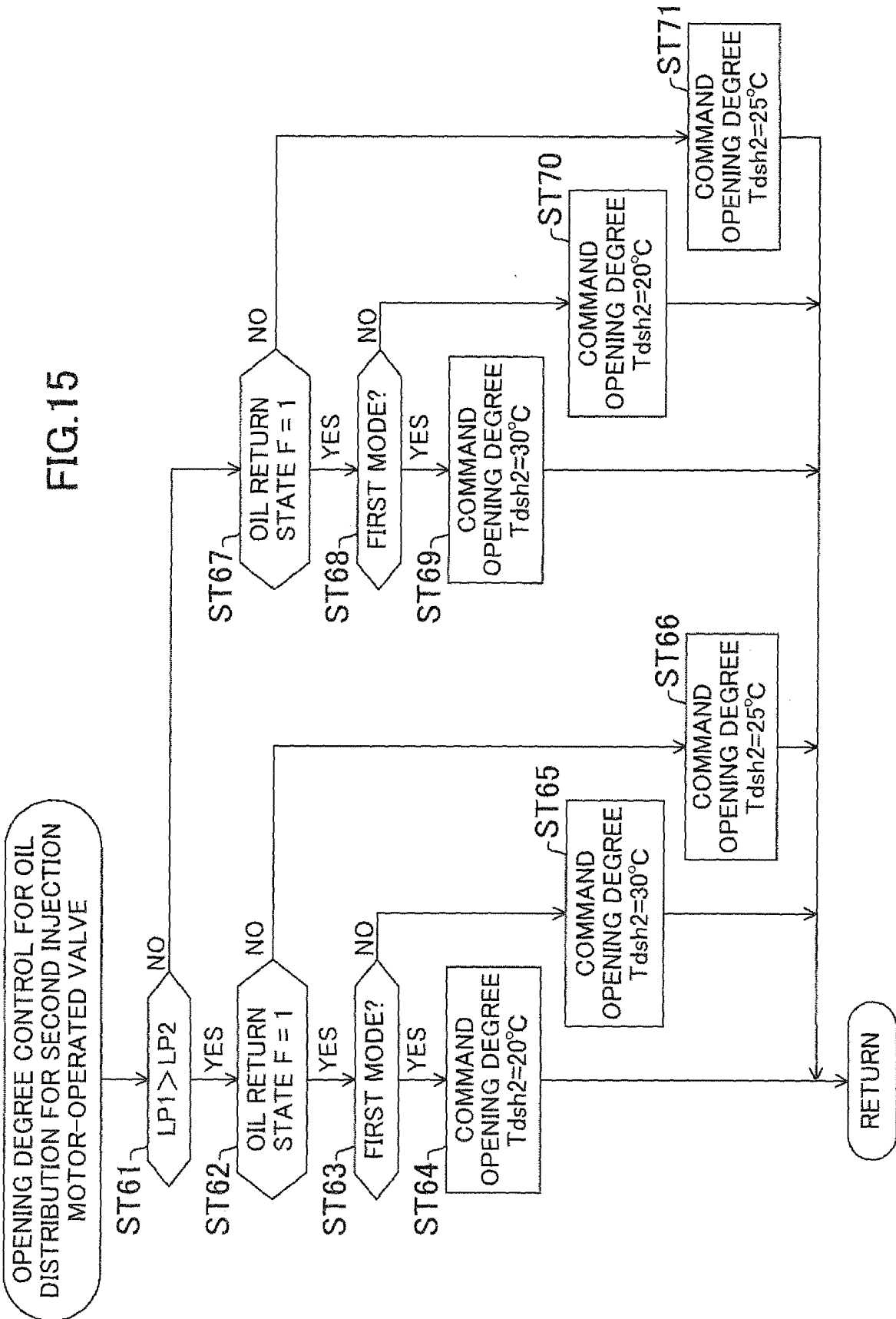


FIG.16

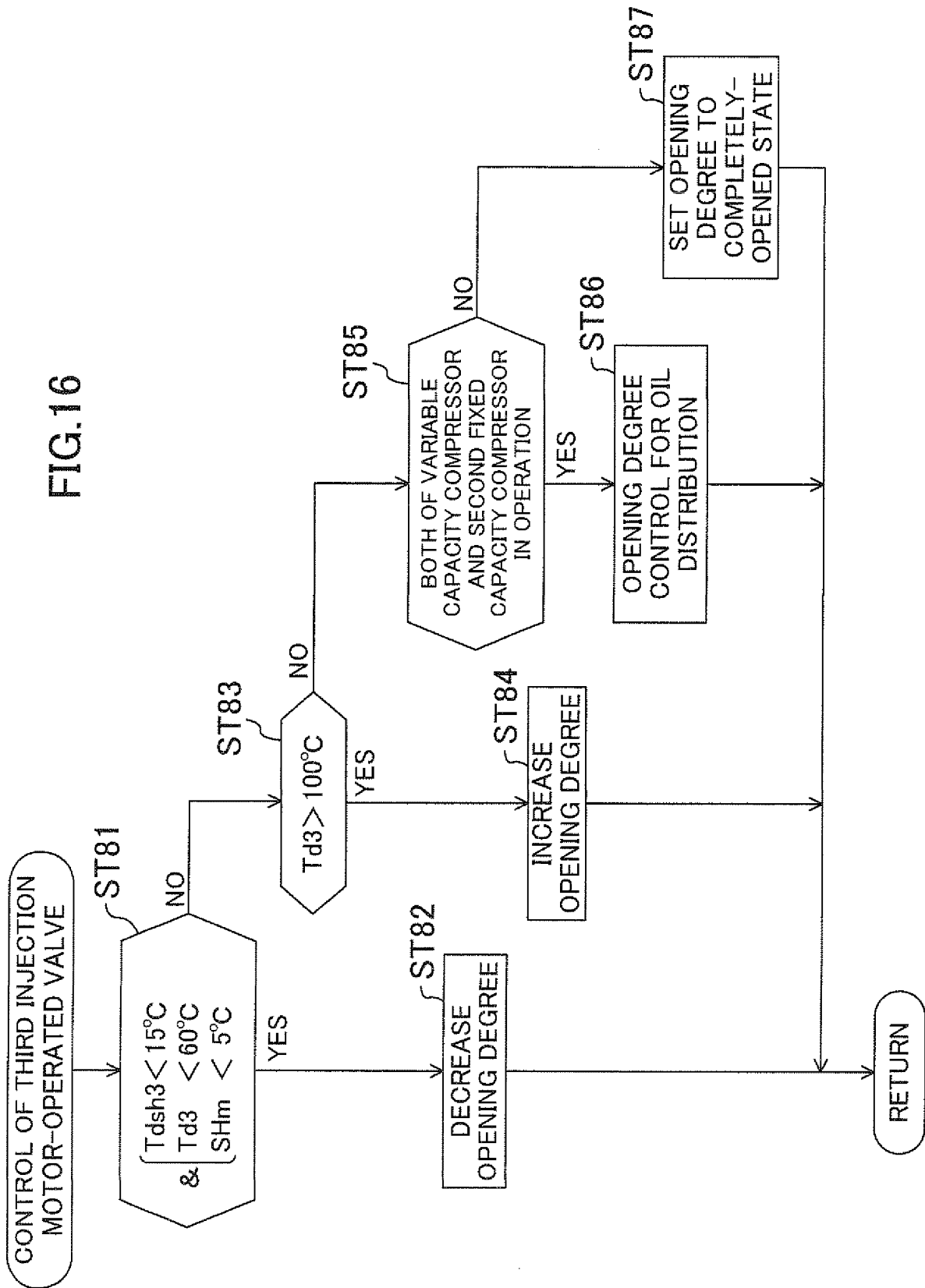


FIG.17

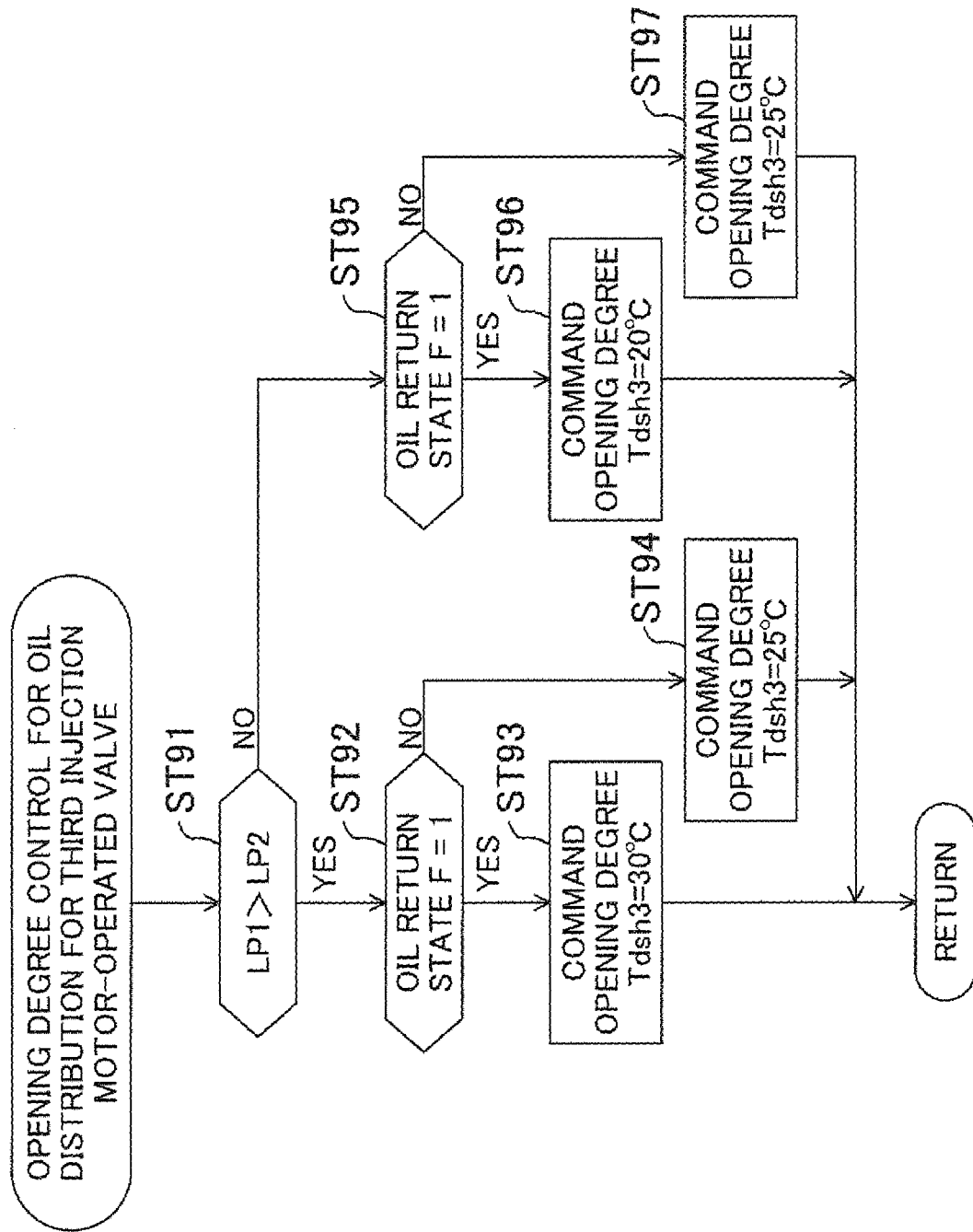
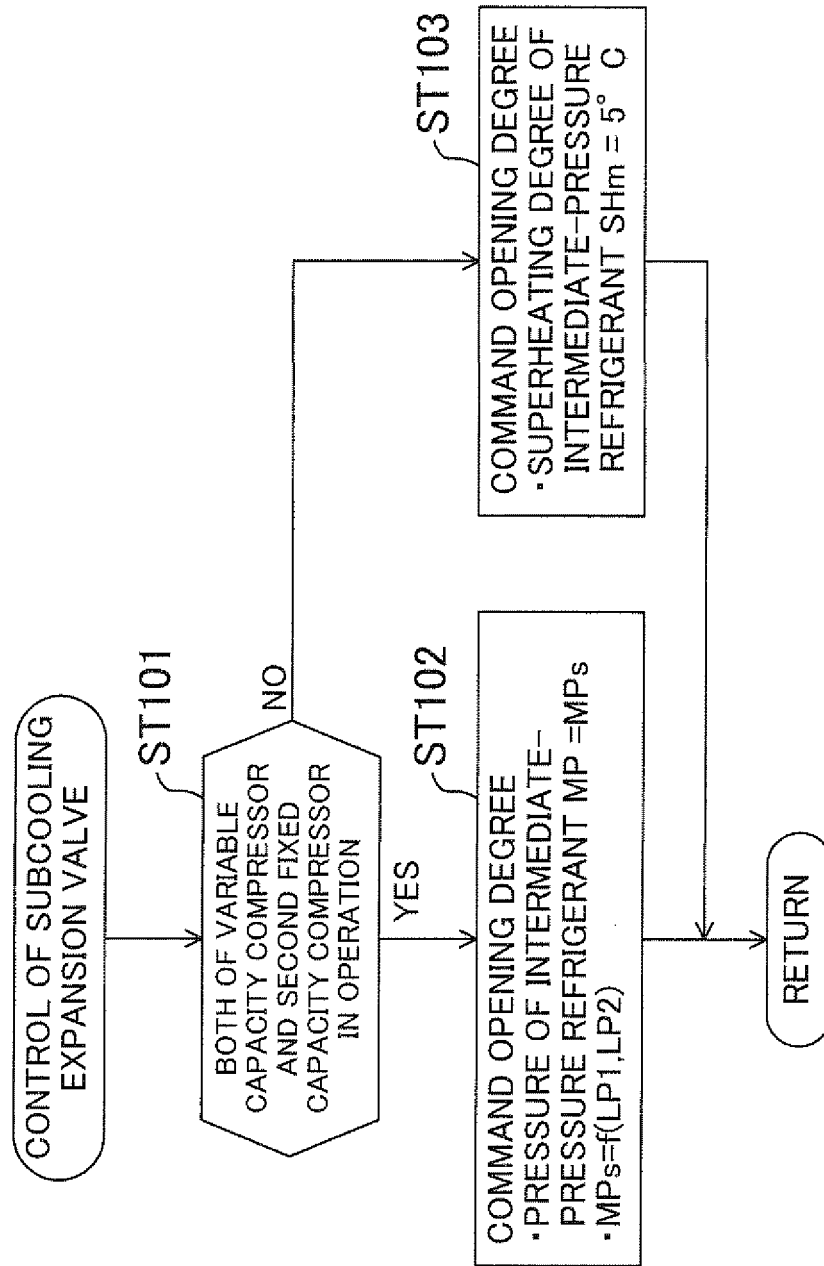


FIG.18



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2009/006486

A. CLASSIFICATION OF SUBJECT MATTER

F25B1/00 (2006.01) i

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)

F25B1/00

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2010

Kokai Jitsuyo Shinan Koho 1971-2010 Toroku Jitsuyo Shinan Koho 1994-2010

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.
A	JP 2008-76017 A (Daikin Industries, Ltd.), 03 April 2008 (03.04.2008), entire text; all drawings (Family: none)	1-7
A	WO 2007/139093 A1 (Daikin Industries, Ltd.), 06 December 2007 (06.12.2007), entire text; all drawings & JP 2007-322048 A & US 2009/0229301 A & EP 2023060 A1 & KR 10-2009-0018971 A & CN 101454623 A & AU 2007268608 A1	1-7
A	JP 2007-178052 A (Daikin Industries, Ltd.), 12 July 2007 (12.07.2007), entire text; all drawings (Family: none)	1-7

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

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Date of the actual completion of the international search

18 January, 2010 (18.01.10)

Date of mailing of the international search report

02 February, 2010 (02.02.10)

Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

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Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2009/006486

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 4-222351 A (Daikin Industries, Ltd.), 12 August 1992 (12.08.1992), entire text; all drawings (Family: none)	1-7

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2008076017 A [0007]