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(54) **Method and apparatus for controlling vehicle air conditioner**

Verfahren und Vorrichtung zum Steuern einer Klimaanlage in einem Fahrzeug

Méthode et dispositif de commande d'une installation de conditionnement d'air montée sur un véhicule

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- **PATENT ABSTRACTS OF JAPAN vol. 9, no. 152 (M-391)(1875) 27 June 1985 & JP-A-60 029 319 (NISSAN JIDOSHA) 14 February 1985**
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Description

[0001] The invention relates to a method of controlling a vehicle air conditioner according to the preamble of claim 1 and an apparatus for controlling a vehicle air conditioner according to the preamble of claim 10, as already known from EP-A-0 363 038, which discloses a vehicle air conditioner comparing a calculated value for the function of blower speed and power with preselected value for said function, said preselected value may be determined on comfortable feeling of the passengers.

[0002] As described in Japanese Patent Publication No. 62-8327, in a control method for a vehicle air conditioner, the outlet air flow rate and the outlet air temperature of air-conditioning air are controlled while balancing between the heat amount supplied from an air conditioner into a passenger room, and the heat load acting on a vehicle. As will be described in detail later, the fundamental equation of air-conditioning control during an unstable period is given by:

$$C_p \cdot \gamma \cdot V_a(T_o - T_{SET}) = K \cdot S(T_{SET} - T_a) - K_s \cdot T_s - C + K_i \cdot (T_{SET} - T_r)$$

In this control equation, the left-hand side represents the heat amount to be supplied from the air conditioner into the passenger room, and the right-hand side represents the vehicle heat load. In the equation, T_{SET} is the setting temperature, T_a is the atmospheric temperature, and T_r is the passenger room temperature.

[0003] In the air-conditioning control, the outlet air flow rate V_a and the outlet air temperature T_o are set on the basis of the above-mentioned heat balance equation. In this case, however, two unknowns V_a and T_o cannot be uniquely obtained from a single equation.

[0004] In the technique described in the above-mentioned patent publication (Japanese Patent Publication No. 62-8327), the relationship between an environmental condition such as the atmospheric temperature, and the like, and the outlet air flow rate V_a is determined in advance, and an outlet air flow rate V_a corresponding to the detected environmental condition is preferentially determined. The determined outlet air flow rate V_a is substituted in the heat balance equation to obtain the outlet air temperature T_o.

[0005] On the other hand, Japanese Patent Laid-Open No. 2-120117 describes the following technique. That is, the outlet air temperature T_o is set by a passenger, and is substituted in the heat balance equation to obtain the outlet air flow rate V_a.

[0006] In the air-conditioning control, air-conditioning air is controlled, so that the passenger room temperature T_r eventually becomes equal to the setting temperature T_{SET}. For example, in terms of comfort, air-conditioning air is controlled to be lower than the setting temperature T_{SET} in the summer, and contrary to this, air-conditioning air is controlled to be higher than the setting temperature T_{SET} in the winter. From this viewpoint, Japanese Patent Laid-Open No. 57-77216 discloses a technique for changing a target temperature in air-conditioning control according to the atmospheric temperature under a condition that the air-conditioning control is made based on the above-mentioned heat balance equation.

[0007] The ultimate object of an air conditioner is to provide comfort to passengers, and the comfort felt by a passenger is a combination of various factors. Therefore, when the outlet air flow rate V_a is preferentially determined according to an environmental condition, and then, the outlet air temperature T_o is determined like in the above-mentioned prior art, it is unknown whether or not a combination of the determined outlet air flow rate V_a and outlet air temperature T_o can give the best comfort to a passenger in that specific case.

[0008] Similarly, when the outlet air temperature T_o is set by a passenger, it is not always certain whether or not the outlet air temperature T_o set as a desirable temperature by the passenger can give the best comfort in association with the outlet air flow rate V_a. Of course, when the set outlet air temperature T_o is not desirable in association with the outlet air flow rate V_a, the passenger need only change the outlet air temperature T_o. However, this forces an extra operation load on a passenger.

[0009] Furthermore, when the target temperature of air-conditioning control is changed according to the atmospheric temperature, it is unknown whether or not the changed target temperature can give the best comfort to a passenger in association with the outlet air flow rate V_a.

[0010] The above-mentioned problems are always posed during air-conditioning control. Besides these problems, various other problems are posed when an engine is started from a state wherein the engine stands still, and air-conditioning control is initiated.

[0011] For example, as a method of solving the problems posed when air-conditioning control is started, as described in Japanese Patent Publication No. 62-5371, the operation of a blower is started when the temperature of an evaporator is decreased to a predetermined temperature, i.e., the outlet operation of air-conditioning air is delayed, so as to prevent hot air in a duct from being exhausted from an outlet port into a passenger room when a cooling operation is started.

[0012] For example, assume a vehicle under the blazing sun. A passenger who gets on such a vehicle wants wind at once in any case. However, when air-conditioning air is output upon start of the cooling operation, hot air in a duct

is output from the outlet port, as described above, thus enhancing discomfort.

[0013] On the other hand, in addition to the problem posed when the cooling operation is started, a problem is also posed when a heating operation is started in the winter.

[0014] For example, a water-cooled engine normally uses engine cooling water as a heat source of heating. For this reason, sufficiently warm air cannot be supplied into the passenger room in heating control during a warm-up operation before the engine cooling water is sufficiently warmed.

[0015] In association with heating control during the warm-up operation, Japanese Patent Laid-Open No. 60-29319 discloses the following technique. That is, an air outlet mode is changed according to the temperature of engine cooling water. Japanese Patent Publication No. 1-20084 discloses the following technique. That is, when the temperature of engine cooling water is low, a defrosting mode is set, so that cold air-conditioning air does not directly blow against a passenger. On the other hand, when the temperature of engine cooling temperature is increased to a medium temperature, a defrosting/heating mode is set. When the temperature of engine cooling water is increased to a high temperature, a heating mode is set. Japanese Patent Publication No. 60-21082 discloses a technique wherein the outlet air flow rate is increased according to the temperature of engine cooling water.

[0016] Comfort felt by a passenger upon blowing of air-conditioning air into the passenger room does not always depend on only the temperature of air-conditioning air. More specifically, if the passenger room temperature is extremely low, even when the defrosting/heating mode is set after the temperature of engine cooling water is considerably increased, cold air in the passenger room is stirred by air-conditioning air output from both a defroster outlet port and a foot outlet port, and for this reason, the passenger may feel rather cold.

SUMMARY OF THE INVENTION

[0017] The present invention has been made in consideration of the above situation, and has as its object to provide a method and apparatus for controlling a vehicle air conditioner, which can obtain a combination of an outlet air flow rate V_a and an outlet air temperature T_o desirable for passenger's comfort under a condition that air-conditioning control is made on the basis of the heat balance equation.

[0018] According to the invention, this object is achieved by the method and apparatus defined in independent claims 1 and 10. Further advantageous embodiments of the invention are disclosed in dependent claims, respectively.

[0019] Advantageously, the present invention provides a method and apparatus for controlling a vehicle air conditioner, which can obtain a combination of an outlet air flow rate V_a and an outlet air temperature T_o desirable for passenger's comfort, and quickly attain a comfortable air-conditioned state during a stable period under a condition that air-conditioning control is made on the basis of the heat balance equation.

[0020] Further, advantageously, the present invention provides a method and apparatus for controlling a vehicle air conditioner, which adjusts the outlet timing of air-conditioning air so as not to enhance discomfort felt by a passenger when he or she gets in a vehicle assuming a cooling operation.

[0021] A further advantage of the present invention is that it provides a method and apparatus for controlling a vehicle air conditioner, which can desirably switch an outlet mode in consideration of passenger's comfort in heating control during a warm-up operation.

[0022] Advantageously, the present invention provides a method and apparatus for controlling a vehicle air conditioner, which can prevent cold air in a passenger room from being stirred by output air-conditioning air, and a passenger from feeling cold, assuming heating control during a warm-up operation.

[0023] Other objects and advantages besides those discussed above shall be apparent to those skilled in the art from the description of a preferred embodiment of the invention which follows. In the description, reference is made to accompanying drawings, which form a part hereof, and which illustrate an example of the invention. Such example, however, is not exhaustive of the various embodiments of the invention, and therefore reference is made to the claims which follow the description for determining the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024]

Fig. 1 is a view showing the overall structure of an air conditioner;
Fig. 2 is a block diagram showing the overall arrangement of the air conditioner;
Fig. 3 is a schematic flow chart of the overall control content of air-conditioning control;
Fig. 4 is a flow chart showing an example of ventilation mode control;
Fig. 5 is a flow chart showing details of target temperature change control in the ventilation mode control;
Fig. 6 is a flow chart showing an example of B/L1 mode control;
Fig. 7 is a flow chart showing details of target temperature change control in the B/L1 mode control;

Fig. 8 is a flow chart showing an example of B/L2 mode control;
Fig. 9 is a flow chart showing details of target temperature change control in the B/L2 mode control;
Fig. 10 is a flow chart showing an example of B/L3 mode control;
Fig. 11 is a flow chart showing details of target temperature change control in the B/L3 mode control;
Fig. 12 is a flow chart showing an example of heating mode control;
Fig. 13 is a flow chart showing details of target temperature change control in the heating mode control;
Fig. 14 is a graph showing the relationship between the outlet air flow rate and the outlet air temperature which can be set on the basis of the heat balance equation, and also showing the relationship between the outlet air flow rate and the outlet air temperature which can be selected on the basis of a comfort index F;
Fig. 15 is a flow chart showing details of a subroutine for calculating a target temperature, i.e., the control content for predicting a target temperature;
Fig. 16 is a flow chart showing the details of the subroutine for calculating a target temperature, i.e., the control content for predicting a target temperature together with Fig. 15;
Fig. 17 is a graph showing the relationship between the outlet air temperature of air-conditioning air output from a foot outlet port, and the outlet air temperature of air-conditioning air output from a ventilation outlet port in the B/L1 mode;
Fig. 18 is a graph showing the relationship between the outlet air temperature of air-conditioning air output from the foot outlet port, and the outlet air temperature of air-conditioning air output from the ventilation outlet port in the B/L2 mode;
Fig. 19 is a graph showing the relationship between the outlet air temperature of air-conditioning air output from the foot outlet port, and the outlet air temperature of air-conditioning air output from the ventilation outlet port in the B/L3 mode;
Fig. 20 shows a control map used in region discrimination in the B/L1 mode;
Fig. 21 shows a control map used in region discrimination in the B/L2 mode;
Fig. 22 shows a control map used in region discrimination in the B/L3 mode;
Fig. 23 is a flow chart showing an example of air-conditioning air outlet control in a cooling operation;
Fig. 24 is a flow chart showing an example of warm-up control;
Fig. 25 is a flow chart showing the warm-up control together with Fig. 24;
Fig. 26 is a flow chart showing the warm-up control together with Figs. 24 and 25;
Fig. 27 is a flow chart showing the warm-up control together with Figs. 24, 25, and 26;
Fig. 28 is a control characteristic graph showing a control content when a comfort index F_5 is small at the beginning of warm-up control (e.g., when the passenger room temperature is low);
Fig. 29 is a control characteristic graph showing a control content when the comfort index F_5 is relatively large at the beginning of warm-up control (e.g., when the passenger room temperature is relatively high);
Fig. 30 is a control characteristic graph showing a control content when the comfort index F_5 is considerably large at the beginning of warm-up control (e.g., when the passenger room temperature is considerably high);
Fig. 31 is a graph showing a control content of warm-up control according to a first modification of the third embodiment; and
Fig. 32 is a graph showing a control content of warm-up control according to a second modification of the third embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0025] The preferred embodiments of the present invention will now be described with reference to the accompanying drawings.

(First Embodiment)

[0026] In Fig. 1, reference numeral 1 denotes a ventilation duct for supplying air-conditioning air to a passenger room. The ventilation duct 1 is provided with an outer air inlet 2 for introducing outer air, and an inner air inlet 3 for circulating air in the passenger room at its upstream end side. These outer and inner air inlets 2 and 3 are selectively opened/closed by an inner/outer air switching damper 4.

[0027] On the other hand, at the downstream end side of the ventilation duct 1, a ventilation outlet port 5 open toward a passenger's bust, a foot outlet port (heating outlet port) 6 open toward passenger's feet, and defroster outlets 7 open toward a front glass or door glass are provided. These outlets 5 to 7 are opened/closed by corresponding mode switching dampers 8 to 10.

[0028] In the ventilation duct 1, a blower 11, a cooling heat exchanger 12, an air mixing damper 13, and a heating heat exchanger 14 are arranged in the order named from the upstream side toward the downstream side. By controlling

an opening degree θ of the air mixing damper 13, the ratio of the air flow rate passing through the heating heat exchanger 14 and the air flow rate bypassing the heating heat exchanger 14 (air mixing ratio) is adjusted, thereby adjusting the temperature (outlet air temperature T_o) of air-conditioning air.

[0029] More specifically, assume that the opening degree θ of the air mixing damper 13 when the air flow rate ratio to the heating heat exchanger 14 is "100%" is expressed as "θ = 1", and the opening degree θ when the air flow rate ratio is "0%" is expressed as "θ = 0". In this case, the outlet air temperature T_o is adjusted stepless between the highest temperature obtained when "θ = 1" and the lowest temperature obtained when "θ = 0".

[0030] The opening degree θ of the air mixing damper 13 is calculated based on the following equation:

$$\theta = (T_o - T_e) / (K_w \cdot T_w - T_e)$$

where

T_e : exit temperature of cooling heat exchanger 12
T_w : temperature of engine cooling water
T_o : outlet air temperature
K_w : coefficient for converting temperature of engine cooling water into exit temperature of heating heat exchanger 14

[0031] The cooling heat exchanger 12 comprises an evaporator inserted in a coolant circuit X including a compressor 15, a condenser 16, and a receiver 17, and the operation of the evaporator 12 is controlled by turning "on" or "off" an electromagnetic clutch 31 (Fig. 2) inserted between the compressor 15 and an engine 18.

[0032] The heating heat exchanger 14 comprises a heater core through which the cooling water of the engine 18 passes. The amount of the engine cooling water passing through the heater core 14 is adjusted by an opening/closing valve (not shown) interlocked with the air mixing damper 13.

[0033] In Fig. 1, reference numeral 19 denotes a motor serving as an actuator for the inner/outer air switching damper 4. Reference numeral 20 denotes a motor serving as an actuator for the mode switching dampers 8 to 10. Reference numeral 21 denotes a servo motor serving as an actuator for the air mixing damper 13. These motors 19 to 21, and the like are controlled based on a signal output from a control circuit 22.

[0034] The control circuit 22 is constituted by, e.g., a microcomputer, and comprises, e.g., a CPU 30 (Fig. 2), a ROM, a RAM, and the like, as is well known. The control circuit 22 receives signals from various manual switches 23a to 23e arranged on a console panel 23 and from sensors 24 to 29.

[0035] The switch 23a is an auto switch for turning on/off an automatic air-conditioning control mode. The switch 23b is used for setting a passenger room temperature (i.e., a set switch of the setting temperature T_{SET}). The switch 23c is used for switching between an inner air circulation mode and an outer air introduction mode. The switch 23d is an outlet mode switch for switching the outlet ports. The switch 23e is a defroster switch for selecting an open/closed state of the defroster outlet ports 7. The sensor 24 is a room temperature sensor for detecting the passenger room temperature T_r, and is arranged inside the ventilation duct 1 in this embodiment. The sensor 25 is an atmospheric temperature sensor for detecting the atmospheric temperature T_a. The sensor 26 is a solar radiation sensor for detecting a solar radiation amount T_s. The sensor 27 is a duct sensor for detecting the exit temperature T_e of the cooling heat exchanger 12. The sensor 28 is a water temperature sensor for detecting the temperature T_w of the engine cooling water. The sensor 29 comprises a potentiometer for detecting the opening degree θ of the air mixing damper 13.

[0036] Note that the blown air flow rate (in other words, the outlet air flow rate) V_a of the blower 11 is controlled by changing an application voltage to a blower motor 11a as the driving source of the blower 11. On the other hand, the opening degree θ of the air mixing damper 13 is feedback-controlled on the basis of the opening degree θ detected by the potentiometer 29.

[0037] The air-conditioning control system will be described in detail below. As shown in Fig. 2, the control circuit 22 receives signals from the above-mentioned sensors 24 to 29 and switch signals from the console panel 23. On the other hand, the motors 19, 20, and 21, the blower motor 11a, and the electromagnetic clutch 31 inserted between the compressor 15 and the engine 18 are controlled on the basis of an output signal from the control circuit 22. In Fig. 2, reference numeral 32 denotes a stabilized power supply; 33, a D/A converter; and 34 to 38, drivers.

[0038] The outline of air-conditioning control performed by the control circuit 22 will be described below.

[0039] Conventional air-conditioning control based on the heat balance equation will be explained first. The air-conditioning control is attained by balancing between the heat load acting on a vehicle and the heat amount supplied from the air conditioner into the passenger room. This control will be described in detail below.

[0040] The heat load acting on the vehicle will be referred to as a vehicle heat load, and is represented by "Q_L". The vehicle heat load Q_L includes the following parameters.

1) Heat Transfer Load Q_u

[0041] The heat transfer load Q_u is a heat load based on the difference between the passenger room temperature and the atmospheric temperature, and is given by:

$$Q_u = K \cdot S(T_r - T_a)$$

where

T_r : passenger room temperature
T_a : atmospheric temperature
S : heat transfer area
K : coefficient

2) Solar Radiation Load Q_s

[0042] The solar radiation load Q_s is a heat load based on solar radiation received by the entire vehicle body, and is given by:

$$Q_s = K_s \cdot T_s$$

where

T_s : solar radiation amount (kcal/h • m^2) detected by solar radiation sensor
K_s : conversion coefficient (m^2)

3) Heat Load Q_m from Passenger

[0043] The heat load Q_m is a heat amount generated by a passenger.

4) Heat Load Q_e Conducted from Engine Room to Passenger Room

[0044] The heat load Q_e is a heat amount of heat generated by, e.g., the engine conducted to the passenger room.

5) Vehicle Body Heat Capacity Q_n

[0045] The vehicle body heat capacity Q_n is a heat amount of interior equipment such as seats, an instrument panel, and the like, and is given by:

$$Q_n = (m \cdot c/h) \cdot (T_{SET} - T_r)$$

where

m : mass of interior equipment
c : specific heat of interior equipment
h : time required until temperature of interior equipment reaches setting temperature T_{SET}

[0046] Note that the vehicle body heat capacity Q_n becomes "$Q_n = 0$" when the passenger room temperature T_r becomes equal to the setting temperature T_{SET}. More specifically, in a stable period wherein the air-conditioned state is stabilized, the vehicle body heat capability Q_n becomes zero.

[0047] In consideration of the above-mentioned parameters, the vehicle heat load Q_L during an unstable period can be expressed by the following equation:

$$Q_L = Q_u - Q_s - Q_m - Q_e + Q_n$$

$$= K \cdot S(T_r - T_a) - K_s \cdot T_s - C + K_i \cdot (T_{SET} - T_r)$$

where

C : constant obtained when Q_m and Q_e are considered to be constant
K_i : constant equal to m • c/h

[0048] On the other hand, the vehicle heat load Q_L in a stable period can be expressed by the following equation:

$$Q_L = Q_u - Q_s - Q_m - Q_e$$

$$= K \cdot S(T_r - T_a) \cdot K_s \cdot T_s - C$$

[0049] On the other hand, the heat amount supplied from the air conditioner into the passenger room will be referred to as heat exchange capability, and is represented by "Qa". The heat exchange capability Q_a is given by:

$$Q_a = Cp \cdot \gamma \cdot V_a(T_o - T_r)$$

where

Cp : specific heat at constant pressure of air
γ : specific gravity of air
V_a : outlet air flow rate of air-conditioning air (blown air flow rate of blower)
T_o : outlet air temperature of air-conditioning air
T_r : passenger room temperature

[0050] Note that the above Q_a equation is employed in the inner air circulation mode, and in the outer air introduction mode, the following equation is employed.

$$Q_a = C_p \cdot \gamma \cdot V_a(T_o - T_a)$$

where Ta is the atmospheric temperature, as described above.

[0051] When the heat exchange capability Q_a and the vehicle heat load Q_L are balanced ($Q_a = Q_L$), air-conditioning control can be properly made to attain the setting temperature T_{SET}. More specifically, the fundamental equation of air-conditioning control is expressed by the following balance equation during an unstable period:

$$Cp \cdot \gamma \cdot V_a(T_o - T_{SET}) = K \cdot S(T_{SET} - T_a) - K_s \cdot T_s - C + K_i \cdot (T_{SET} - T_r)$$

[0052] On the other hand, during a stable period, the fundamental equation of air-conditioning control is expressed by the following balance equation:

$$Cp \cdot \gamma \cdot V_a(T_o - T_{SET}) = K \cdot S(T_{SET} - T_a) - K_s \cdot T_s - C$$

[0053] The air-conditioning control according to the present invention will be described below.

[0054] In the embodiment according to the present invention, control is made using the stable period control equation: $Cp \cdot \gamma \cdot V_a(T_o - T_{SET}) = K \cdot S(T_{SET} - T_a) - K_s \cdot T_s - C$ even during an unstable period. The optimal combination of the outlet air flow rate V_a and the outlet air temperature T_o as variables in this control equation is selected on the basis of a comfort index F defined by the following equation:

$$F = K_1 \cdot V_a + K_2 \cdot T_o + K_3 \cdot T_a + K_4 \cdot T_r + K_5 \cdot T_s$$

where V_a, and the like have the same meanings as those in equation (1), and are as follows:

V_a : outlet air flow rate of air-conditioning air
T_o : outlet air temperature of air-conditioning air
T_a : atmospheric temperature
T_r : passenger room temperature
T_s : solar radiation amount

[0055] Also, K_1 to K_5 are weighting coefficients, and these coefficients K_1 to K_5 are experimentally obtained.

[0056] That is, the comfort index F is obtained by converting a comfort level felt by a passenger into an index on the basis of various parameters which influence the passenger's comfort level. In this case, the coefficients K_1 to K_5 are set so that the most comfortable state is represented by F = 5. Therefore, as the index F deviates more from F = 5, the discomfort level is increased. For example, when the comfort index F is larger than "F = 5" (e.g., F = 7), this means, as an example of discomfort, a state wherein a passenger feels hot. When the comfort index is smaller than "F = 5" (e.g., F = 3), this means, as an example of discomfort, a state wherein a passenger feels cold.

[0057] In this manner, when the comfort index F is "$F \cong 5$" calculated based on the outlet air temperature T_o and the outlet air flow rate V_a obtained by the above-mentioned balance equation, it is determined that this combination of the outlet air temperature T_o and the outlet air flow rate V_a can form the most comfortable air-conditioned state in a future stable period, and the control is made to attain the outlet air temperature T_o and the outlet air flow rate V_a.

[0058] On the other hand, when the comfort index F obtained based on the selected outlet air temperature T_o and outlet air flow rate V_a has a value deviated from "F = 5", a more preferred combination of the outlet air temperature T_o and the outlet air flow rate V_a is searched.

[0059] This search operation is realized by changing a target temperature T_{TRG} in air-conditioning control. More specifically, the search operation in the above-mentioned first stage is performed using the setting temperature T_{SET} as the target temperature T_{TRG} ($T_{TRG} = T_{SET}$). As a result of the search operation in the first stage, when it is determined based on the comfort index F that a combination of the outlet air temperature T_o and the outlet air flow rate V_a does not provide comfort (when the value F largely deviated from F = 5 can only be obtained), the target temperature T_{TRG} is increased or decreased by a predetermined amount (ΔT_{TRG}), and another combination of the outlet air temperature T_o and the outlet air flow rate V_a, which can provide comfort, is searched using the value F. The target temperature T_{TRG} is repetitively changed until "$F \cong 5$" is obtained as the value of the comfort index F.

[0060] In this embodiment, the outlet ports, i.e., an outlet mode is selected on the basis of the comfort index F. More specifically, an optimal combination of the outlet air temperature T_o and the outlet air flow rate V_a is selected in association with the outlet mode.

[0061] The contents of the air-conditioning control premised on the above description will be described in detail below with reference to the flow charts shown in Figs. 3 to 13.

[0062] Fig. 3 shows the outline of the overall flow of air-conditioning control. More specifically, in step S1, initialization is performed. Thereafter, in step S2, data from the various sensors are input. In step S3, a target temperature T_{TRG} is calculated. In step S4, a comfort index F is calculated on the basis of the outlet air temperature T_o and the outlet air flow rate V_a obtained based on the target temperature T_{TRG}. In step S5, the outlet air temperature T_o and the outlet air flow rate V_a, which are determined based on the value of the comfort index F (value F) to attain a comfortable state, are set (a combination of the outlet air temperature T_o and the outlet air flow rate V_a, which yields the value F closest to F = 5). In addition, an outlet mode (outlet ports) is set on the basis of the comfort index F. Thereafter, in step S6, the ON/OFF state of the compressor is controlled. In step S7, air-conditioning control is executed.

[0063] The control contents according to this embodiment will be described in detail below with reference to the flow charts shown in Fig. 4 and subsequent drawings.

Ventilation Mode

[0064] Figs. 4 and 5 show a routine for setting the ventilation outlet port 5 (ventilation mode). After it is confirmed in step S11 in Fig. 4 that an air-conditioning switch is turned on, the flow advances to step S12 to calculate a target temperature T_{TRG}, as will be described in detail later. In step S13, a vehicle heat load Q_L is calculated. The vehicle heat load Q_L is calculated by $Q_L = K \cdot S(T_r - T_a) - K_s \cdot T_s - C + K_i \cdot (T_{SET} - T_r)$ using the equation in the unstable period.

[0065] The processing in steps S14 to S24 is executed to obtain a combination of the outlet air temperature T_o and the outlet air flow rate V_a. The outline of this processing will be described below.

[0066] The combination of the outlet air temperature T_o and the outlet air flow rate V_a is obtained as follows under a condition that the vehicle heat load Q_L is constant. More specifically, when the vehicle heat load Q_L is assumed to be constant, the relationship between the outlet air temperature and the outlet air flow rate can be expressed by an inverse proportionality curve having $T_o = T_{SET}$ and $V_a = 0$ as asymptotic lines, as shown in Fig. 14. Based on this

relationship, in this embodiment, assuming that a low air flow rate $V_a1(V_{a1})$ is set as the outlet air flow rate V_a, a corresponding outlet air temperature T_{o1} is calculated, and a comfort index F based on the low air flow rate V_{a1} and the outlet air temperature T_{o1} is then calculated.

[0067] As the comfort index F, a comfort index F_2 for a cooling operation is used. The comfort index F_2 is obtained by converting (by setting the weighting coefficients K_1 to K_5), into an index, a comfort level felt by a passenger upon output of air-conditioning air from the ventilation outlet port 5 when a cooling operation is performed (by selecting the ventilation outlet port 5; by setting the ventilation mode). Therefore, the comfort index F_2 mainly represents the comfort level left at the bust of a passenger.

[0068] Subsequently, assuming that an air flow rate V_{a2} obtained by adding a predetermined value ΔV to the low air flow rate V_{a1} is set, a corresponding outlet air temperature T_{o2} is obtained (see Fig. 14). In addition, a comfort index F_2 based on V_{a2} and T_{o2}, and the absolute value of a value obtained by subtracting 5 from the value F_2 are calculated. Thereafter, up to a maximum air flow rate V_{ah} (V_{a7}), an outlet air temperature $T_{o(n)}$, a comfort index F_2, and the absolute value of a deviation between the value F_2 and 5 are calculated on the basis of an air flow rate $V_{a(n)}$ obtained by adding the predetermined value ΔV to an air flow rate $V_{a(n-1)}$. These air flow rates $V_{a(n)}$, $T_{o(n)}$, the values F_2, and the absolute values of the deviations are stored in the RAM.

[0069] Referring back to the flow chart shown in Fig. 4, in step S14, the outlet air flow rate V_a is set to be a low air flow rate V_a1 (V_{a1}). Thereafter, in step S16, an outlet air temperature T_{o1} corresponding to the low air flow rate V_{a1} is calculated. In step S17, the opening degree θ of the air mixing damper 13 is calculated on the basis of the outlet air temperature T_{o1}. In step S18, it is checked if the opening degree θ obtained in step S17 is equal to or smaller than zero. If YES in step S18, it is determined that the air flow rate ratio to the heating heat exchanger 14 becomes 0%, and the flow advances to step S20. In step S20, the exit temperature T_e of the cooling heat exchanger 14 is set to be the outlet air temperature T_o. On the other hand, if NO ($\theta > 0$) in step S18, it is determined that the air mixing operation is performed, and the outlet air temperature T_{o1} is set to be the outlet air temperature T_o in step S19. In step S21, a comfort index F_2 is calculated, and in step S22, a deviation (F_2 - 5) between the value F_2 and 5 is calculated. In step S23, the absolute value of the deviation is calculated. Thereafter, in step S24, ΔV is added to the outlet air flow rate V_{a1}, and the processing in steps S15 to S24 is repeated until the maximum air flow rate V_{ah} (V_{a7}) is reached. With this series of processing operations, the outlet air temperatures and the values F corresponding to the outlet air flow rates are obtained like (V_{a1}, T_{o1}, and the absolute value of the deviation), (V_{a2}, T_{o2}, and the absolute value of the deviation)

[0070] Upon completion of the processing for obtaining the combinations, the flow advances from step S15 to step S25, and a combination of the outlet air flow rate V_a and the outlet air temperature T_o, which has the minimum absolute value of the deviation between the value F_2 and 5, is selected. More specifically, a combination of the outlet air flow rate and the outlet air temperature, which exhibits a value F closest to $F_2 = 5$ (a state wherein a passenger feels most comfortable), is selected. The selected outlet air flow rate V_a is represented by "V_{ao}", and the outlet air temperature T_o paired with the outlet air flow rate V_{ao} is represented by "T_{oo}" (selection of V_{ao} and T_{oo}).

[0071] In step S26, it is checked if an air-conditioned state has reached a stable state. More specifically, it is checked if ΔT (= T_r - T_{TRG}) falls within a predetermined range. If NO in step S26, it is determined that the passenger room temperature T_r deviates from the target temperature T_{TRG} (e.g., the deviation is 2°C or more), and an unstable period is determined. The flow then advances to step S27 to check if the value (F_2 - 5) is equal to or larger than a predetermined value (-α; e.g., $\alpha = 1$). If YES in step S27 (F_2 based on V_{ao} and T_{oo} is 4 or more), the flow advances to step S28 to check if the value F_2 is equal to or smaller than 5. If NO in step S28 ($F_2 > 5$), it is determined that a state wherein a passenger feels that his or her bust is hot is set, and the flow then advances to step S30. In step S30, the ventilation outlet port 5 is set, and the combination (V_{ao} and T_{oo}) of the outlet air flow rate and the outlet air temperature is set. Thus, air-conditioning air is blown from the ventilation outlet port 5 toward the bust of the passenger (ventilation mode). In this air-conditioned state, the air flow rate is set to be V_{ao}, and the temperature is set to be T_{oo}.

[0072] If YES in step S28, it is determined that the comfort index F_2 based on V_{ao} and T_{oo} is 5 or less, i.e., that a state a passenger feels that his or her bust is comfortable or cold is set. The flow advances to step S29 to check if the selected outlet air temperature T_o is smaller than a predetermined value α_o (e.g., 30°C). If YES in step S29, the flow advances to step S30. On the other hand, if NO in step S27, i.e., if F_2 is smaller than 4, it is determined that a state wherein a passenger feels that his or her bust is cold is set, and the control enters a B/L1 mode (to be described later). If NO in step S29, i.e., if the selected outlet air temperature T_o is 30°C or more, it is determined that a passenger feels discomfort since hot air blows against his or her face, and the control enters the B/L1 mode (to be described later).

[0073] If YES in step S26, i.e., if the difference between the passenger room temperature T_r and the target temperature T_{TRG} is small, it is determined that an air-conditioned state has nearly reached a stable period, and the flow advances to step S31 and subsequent steps (Fig. 5).

[0074] The processing in step S31 and subsequent steps is performed to correct the target temperature T_{TRG} in a stable period. It is checked in step S31 if the value (F_2 - 5) is equal to or larger than the predetermined value (e.g., $\alpha = 1$). If YES in step S31 ($F_2 \geq 6$), it is determined that a state wherein a passenger feels hot is set, and the flow advances to step S32. In step S32, the target temperature T_{TRG} is changed, i.e., is decreased by the predetermined value ΔT.

In step S33, it is checked if the target temperature T_{TRG} is 18°C. If NO in step S33, the flow returns to step S13, and an optimal outlet air temperature, and the like are calculated again on the basis of the changed target temperature T_{TRG}.

[0075] When the value of the comfort index F_2 obtained by the optimal outlet air temperature T_{oo} and the optimal outlet air flow rate V_{ao} calculated based on the changed target temperature T_{TRG} becomes "value $F \cong 5$", it is determined that an optimal air-conditioned state has been found by changing the target temperature T_{TRG}, and the flow advances to step S30. On the other hand, if YES is determined again in step S31 based on the changed target temperature T_{TRG}, the flow advances to step S32 again, and the target temperature T_{TRG} is changed. The change operation of the target temperature is performed up to 18°C as a minimal value in the ventilation mode.

[0076] If NO in step S31, the flow advances to step S34 to check if the value (F_2 - 5) is equal to or smaller than the predetermined value ($-\alpha$). If YES in step S34 (e.g., $F_2 \leq 4$), it is determined that a state wherein a passenger feels cold is set, and the flow advances to step S35 to check if the value F_2 is equal to or smaller than 3. If NO in step S35, it is determined that although a rather cold state is set, this state can be adjusted by changing the target temperature T_{TRG}. Thus, in step S36, the target temperature T_{TRG} is changed, i.e., is increased by the predetermined value ΔT. In step S37, it is checked if the changed target temperature T_{TRG} is equal to 27°C as a maximal value in the ventilation mode. If NO in step S37, the flow returns to step S13, and an optimal outlet air temperature, and the like are calculated again on the basis of the changed target temperature T_{TRG}.

[0077] If YES is determined in step S35 or S37, it is determined that it is impossible to form an air-conditioned state having "$F_2 \cong 5$" in the ventilation mode, and the control enters the B/L1 mode (to be described below).

B/L1 Mode

[0078] Figs. 6 and 7 show a routine for setting the B/L1 mode. In the B/L1 mode, 75% air-conditioning air is output from the ventilation outlet port 5, and 25% air-conditioning air is output from the foot outlet port 6. More specifically, when an outlet air flow rate V_a is set, ait is output from the ventilation outlet port 5 at a flow rate $V_{av} = 0.75 \times V_a$, and air is output from the foot outlet port 6 at a flow rate $V_{af} = 0.25 \times V_a$. The outlet air temperature of air-conditioning air output from the ventilation outlet port 5 is represented by "T_{ov}", and the outlet air temperature of air-conditioning air output from the foot outlet port 6 is represented by "T_{of}". In this case, the relationship between T_{ov} and T_{of} is as shown in Fig. 17. More specifically, when an outlet air temperature T_o is set, air-conditioning air at the temperature T_{ov} is output from the ventilation outlet port 5, and air-conditioning air at the temperature T_{of} is output from the foot outlet port 6 according to the opening degree θ_o of the air mixing damper 13 corresponding to this outlet air temperature T_o. Upon comparison between T_{ov} and T_{of}, as can be seen from Fig. 17, air-conditioning air output from the ventilation outlet port 5 is set at a lower temperature than that output from the foot outlet port 6, thus realizing the effect of keeping the head cold and the feet warm.

[0079] The B/L1 mode premised on the above description will be described in detail below.

[0080] In step S38, the setting temperature T_{SET} is set to be the target temperature T_{TRG}, and thereafter, in step S39, a vehicle heat load Q_L is calculated using the equation in the unstable period.

[0081] Steps S40 to S50 are basically the same as the above-mentioned processing in steps S14 to S24 (Fig. 4), and are executed to obtain a combination of the outlet air temperature T_o and the outlet air flow rate V_a.

[0082] More specifically, after the outlet air flow rate V_a is set to be the low air flow rate V_{a1} in step S38, an outlet air temperature T_{o1} corresponding to the low air flow rate V_{a1} is calculated in step S42. In step S43, an opening degree θ of the air mixing damper 13 is calculated based on T_{o1}. In step S44, the outlet air temperature T_{ov} of the ventilation outlet port 5 and the outlet air temperature T_{of} of the foot outlet port 6 corresponding to the opening degree θ are read from the map shown in Fig. 17. In step S45, an outlet air flow rate V_{av} of air-conditioning air output from the ventilation outlet port 5 and an outlet air flow rate V_{af} of air-conditioning air output from the foot outlet port 6 are calculated.

[0083] In step S46, a comfort index F is calculated, as will be described later. In this case, as the comfort index F, the above-mentioned index F_2, and a second index F_4 as a comfort index for the foot outlet port 6 are used. The second comfort index F_4 is obtained by converting, into an index, a comfort level felt by a passenger when air-conditioning air is output from the foot outlet port 6. More specifically, in an equation expressing the comfort index F ($F = K_1 \cdot V_a + K_2 \cdot T_o + K_3 \cdot T_a + K_4 \cdot T_r + K_5 \cdot T_s$), the weighting coefficients K_1 to K_5 are set on the basis of air-conditioning air output from the foot outlet port 6. Therefore, the foot comfort index F_4 mainly represents the comfort level at the legs of the passenger.

[0084] Premised on the above description, in calculation of the value F in step S46, the ventilation index F_2 is calculated on the basis of the outlet air flow rate V_{av} and the outlet air temperature T_{ov} of the ventilation outlet port 5, and the foot index F_4 is calculated on the basis of the outlet air flow rate V_{af} and the outlet air temperature T_{of} of the foot outlet port 6.

[0085] In step S47, a deviation (F_2 - 5) between the value F_2 and 5, and a deviation (F_4 - 5) between the value F_4 and 5 are calculated. In this case, since the total comfort level felt by a passenger is evaluated using the two indices F_2 and F_4, a point where both F_2 and F_4 indicate "5" is represented by "O", as shown in Fig. 18, and a point indicated

by the values (F_2 - 5) and (F_4 - 5) is represented by "P". In this case, the total comfort level is evaluated by a distance L between the point "P" and the most comfortable point "O".

[0086] For this reason, in step S49, the distance L is calculated by an equation $L^2 = (F_2 - 5)^2 + (F_4 - 5)^2$. Thereafter, in step S50, ΔV is added to the outlet air flow rate V_{a1}, and the above-mentioned processing in steps S39 to S50 is repeated until the maximum air flow rate V_{ah} (V_{a7}) is reached. With this series of processing operations, the outlet air temperatures and the values L corresponding to the outlet air flow rates are obtained like (V_{a1}, T_{o1}, and the distance L), (V_{a2}, T_{o2}, and the distance L),....

[0087] Upon completion of the processing for obtaining the combinations, the flow advances from step S41 to step S51, and an optimal combination of the outlet air flow rate V_{ao} and the outlet air temperature T_{oo} having the minimum distance L is selected.

[0088] In step S52, it is checked based on the above-mentioned ΔT (= T_r - T_{TRG}) if an air-conditioned state has reached a stable period. If NO in step S52, it is determined that an air-conditioned state is still in an unstable period, and the flow advances to step S53 to check based on the optimal outlet air flow rate V_{ao} and outlet air temperature T_{oo} if both the values (F_2 - 5) and (F_4 - 5) are equal to or smaller than the predetermined value α (e.g., α = 1). If YES in step S53 (both F_2 and F_4 are 6 or less), it is checked in step S54 if both the values (F_2 - 5) and (F_4 - 5) based on the optimal outlet air flow rate V_{ao} and outlet air temperature T_{oo} are equal to or larger than the predetermined value (-α). If YES in step S54 (both F_2 and F_4 are 4 or more), it is determined that both the comfort index F_2 obtained by air-conditioning air output from the ventilation outlet port 5, and the comfort index F_4 obtained by air-conditioning air output from the foot outlet port 6 are equal to or closer to "5". In step S55, it is confirmed if the outlet air temperature T_{ov} of the ventilation outlet port 5 is lower than the predetermined temperature α_o (e.g., α_o = 30°C). In step S56, it is checked if the outlet air temperature T_{of} of the foot outlet port 6 is higher than a predetermined temperature β (e.g., β = 20°C). If YES in both steps S55 and S56, the combination of the optimal outlet air flow rate V_{ao} and the optimal outlet air temperature T_{oo}, and the B/L1 mode are set in step S57.

[0089] If NO in step S53, it is determined that a passenger feels that both his or her bust and legs are hot, and the control returns to the above-mentioned ventilation mode (step S12 in Fig. 4). If NO in step S56, it is determined that cold air-conditioning air is output from the foot outlet port 6, and a passenger feels that his or her legs are cold. Thus, the control also returns to the ventilation mode (step S12 in Fig. 4).

[0090] If NO in step S54, it is determined that a passenger feels that both his or her bust and legs are cold, and the control enters a B/L2 mode (Fig. 8; to be described later). If NO in step S55, it is determined that a passenger feels discomfort since hot air-conditioning air blows against his or her face, and the control also enters the B/L2 mode.

[0091] If YES in step S52, i.e., if the difference between the passenger room temperature T_r and the target temperature T_{TRG} is small, it is determined that an air-conditioned state has nearly reached a stable period, and the flow advances to step S58 and subsequent steps shown in Fig. 7.

[0092] The processing in step S58 and subsequent steps is executed for correcting the target temperature T_{TRG}. In step S58, region discrimination is performed based on the map shown in Fig. 20. If it is determined that the point P falls within a region I shown in Fig. 20 (YES in step S58), the flow returns to step S57 in Fig. 6, and the B/L1 mode, the outlet air temperature T_{oo}, and the like are set.

[0093] On the other hand, if NO in step S58, the flow advances to step S59 to check if the point P falls within a region II shown in Fig. 20. If YES in step S59, it is determined that a state wherein a passenger feels that his or her bust is hot although he or she feels that his or her legs are comfortable, or vice versa is set, and the flow advances to step S60. In step S60, the target temperature T_{TRG} is changed, i.e., is decreased by the predetermined value ΔT. In step S61, it is checked if the changed target temperature T_{TRG} is equal to 20°C. If NO in step S61, an optimal outlet air temperature, and the like are calculated again on the basis of the changed target temperature T_{TRG}.

[0094] When both the values of the indices F_2 and F_4 obtained by the optimal outlet air temperature T_{oo} and the optimal outlet air flow rate V_{ao} calculated based on the changed target temperature T_{TRG} become substantially equal to " $\cong$ 5" (region I), it is determined that the optimal air-conditioned state has been found by changing the target temperature T_{TRG}, and the flow advances from step S58 to step S57 (Fig. 6).

[0095] On the other hand, if it is determined in step S59 regardless of the changed target temperature T_{TRG} that the point P falls within the region II (YES in step S59), the target temperature T_{TRG} is changed again (T_{TRG} - ΔT) in step S60. The target temperature is changed up to 20°C as a minimal value of the target temperature in the B/L1 mode.

[0096] If NO in step S59, the flow advances to step S62 to check if the point P falls within a region III shown in Fig. 20. If YES in step S62 (region III), it is determined that a state wherein a passenger feels that his or her bust is cold although he or she feels that his or her legs are comfortable, or vice versa is set. In step S63, the target temperature T_{TRG} is changed, i.e., is increased by the predetermined value ΔT. In step S64, it is checked if the changed target temperature T_{TRG} is equal to 30°C as a maximal value in the B/L1 mode. If NO in step S64, the flow returns to step S39 (Fig. 6), and an optimal outlet air temperature, and the like are calculated based on the changed target temperature T_{TRG}.

[0097] If NO in step S62, the flow advances to step S65 to check if the point P falls within a region IV. If YES in step

S65 (region IV), it is determined that a state wherein a passenger feels that both his or her bust and legs are hot is set, and the control returns to the ventilation mode (step S12 in Fig. 4). On the other hand, if NO in step S65, the flow advances to step S66 to check if the point P falls within a region V. If YES in step S66 (region V), it is determined that a state wherein a passenger feels that both his or her bust and legs are cold is set, and the control enters the B/L2 mode (step S68 in Fig. 8; to be described later). On the other hand, if NO in step S66, the flow advances to step S57 described above.

B/L2 Mode

[0098] Figs. 8 and 9 show a routine for setting the B/L2 mode. In the B/L2 mode, 60% air-conditioning air is output from the ventilation outlet port 5, and 40% air-conditioning air is output from the foot outlet port 6. More specifically, when an outlet air flow rate V_a is set, air is output from the ventilation outlet port 5 at a flow rate $V_{av} = 0.60 \times V_a$, and air is output from the foot outlet port 6 at a flow rate $V_{af} = 0.40 \times V_a$. The relationship between the outlet air temperature T_{ov} output from the ventilation outlet port 5 and the outlet air temperature T_{of} output from the foot outlet port 6 is as shown in Fig. 18.

[0099] The B/L2 mode premised on the above description will be described in detail below.

[0100] Steps S68 to S80 shown in Fig. 8 correspond to steps S38 to S50 (B/L1 mode; see Fig. 6) described above. In these steps, since steps having common numerals at the one's digit of their step numbers execute the same processing, a description thereof will be omitted. Note that the equation in step S75 corresponds to the fact that the outlet ratio of air-conditioning air of the ventilation outlet port 5 is 60%, and that of the foot outlet port 6 is 40%.

[0101] Steps S81 to S87 shown in Fig. 8 correspond to steps S51 to S57 in the B/L1 mode. In these steps, since steps having common numerals at the one's digit of their step numbers execute the same processing, a description thereof will be omitted. In step S87, of course, the B/L2 mode is set.

[0102] If NO is determined in step S83, it is determined that a state wherein a passenger feels that both his or her bust and legs are hot is set, and the control returns to the above-mentioned B/L1 mode (step S38 in Fig. 6). If NO is determined in step S86, it is determined that a state wherein a passenger feels that his or her legs are cold is set since cold air-conditioning air is output from the foot outlet port 6, and the control also returns to the B/L1 mode (step S38 in Fig. 6).

[0103] Furthermore, if NO is determined in step S84, it is determined that a state wherein a passenger feels that both his or her bust and legs are cold is set, and the control enters a B/L3 mode (Fig. 10; to be described later). If NO is determined in step S85, it is determined that a passenger feels discomfort since hot air-conditioning air blows against his or her face, and the control also enters the B/L3 mode.

[0104] If YES is determined in step S82, i.e., if the difference between the passenger room temperature T_r and the target temperature T_{TRG} is small, it is determined that an air-conditioned state has nearly reached a stable period, and the flow advances to step S88 and subsequent steps shown in Fig. 9.

[0105] In the processing in step S88 and subsequent steps, the target temperature T_{TRG} is corrected by the same technique as in the B/L1 mode. Steps S88 to S96 correspond to steps S58 to S66 (B/L1 mode; see Fig. 7) described above. In these steps, since steps having common numerals at the one's digit of their step numbers execute basically the same processing, a description thereof will be omitted.

[0106] In step S88, region discrimination is performed based on a map shown in Fig. 21. If it is determined that the point P falls within a region I shown in Fig. 21 (YES in step S88), the flow returns to step S87 shown in Fig. 8, and the B/L2 mode, the outlet air temperature T_{oo}, and the like are set.

[0107] On the other hand, if NO in step S88, the flow advances to step S89 to check if the point P falls within a region II shown in Fig. 21. If YES in step S89, it is determined that a state wherein a passenger feels that his or her bust is hot although he or she feels that his or her legs are comfortable, or vice versa is set, and the flow advances to step S90. In step S90, the target temperature T_{TRG} is changed, i.e., is decreased by the predetermined value ΔT. In step S91, it is checked if the changed target temperature T_{TRG} is equal to 20°C. If NO in step S91, an optimal outlet air temperature, and the like are calculated again on the basis of the changed target temperature T_{TRG}.

[0108] When both the values of the indices F_2 and F_4 obtained by the optimal outlet air temperature T_{oo} and the optimal outlet air flow rate V_{ao} calculated based on the changed target temperature T_{TRG} become substantially equal to " $\cong$ 5" (region I), it is determined that an optimal air-conditioned state has been found by changing the target temperature T_{TRG}, and the flow advances from step S88 to step S87 (Fig. 8).

[0109] On the other hand, if it is determined in step S89 regardless of the changed target temperature T_{TRG} that the point P falls within the region II (YES in step S89), the target temperature T_{TRG} is changed again ($T_{TRG} - \Delta T$) in step S90. The target temperature is changed up to 20°C as a minimal value of the target temperature in the B/L2 mode.

[0110] If NO in step S89, the flow advances to step S92 to check if the point P falls within a region III shown in Fig. 21. If YES in step S92 (region III), it is determined that a state wherein a passenger feels that his or her bust is cold although he or she feels that his or her legs are comfortable, or vice versa is set. In step S93, the target temperature

T_{TRG} is changed, i.e., is increased by the predetermined value ΔT. In step S94, it is checked if the changed target temperature T_{TRG} is equal to 30°C as a maximal value in the B/L2 mode. If NO in step S94, the flow returns to step S69 (Fig. 8), and an optimal outlet air temperature, and the like are calculated based on the changed target temperature T_{TRG}.

[0111] If NO in step S92, the flow advances to step S95 to check if the point P falls within a region IV. If YES in step S95 (region IV), it is determined that a state wherein a passenger feels that his or her bust is hot, and his or her legs are cold is set, and the control returns to the B/L1 mode (step S38 in Fig. 6). On the other hand, if NO in step S95, the flow advances to step S96 to check if the point P falls within a region V. If YES in step S96 (region V), it is determined that a state wherein a passenger feels that both his or her bust and legs are cold is set, and the control enters a B/L3 mode (step S108 in Fig. 10; to be described later). On the other hand, if NO in step S96, the flow advances to step S87 described above.

B/L3 Mode

[0112] Figs. 10 and 11 show a routine for setting the B/L3 mode. In the B/L3 mode, 45% air-conditioning air is output from the ventilation outlet port 5, and 55% air-conditioning air is output from the foot outlet port 6. More specifically, when an outlet air flow rate V_a is set, air is output from the ventilation outlet port 5 at a flow rate $V_{av} = 0.45 \times V_a$, and air is output from the foot outlet port 6 at a flow rate $V_{af} = 0.55 \times V$ The relationship between the outlet air temperature T_{ov} output from the ventilation outlet port 5 and the outlet air temperature T_{of} output from the foot outlet port 6 is as shown in Fig. 19.

[0113] The B/L3 mode premised on the above description will be described in detail below.

[0114] Steps S108 to S120 shown in Fig. 10 correspond to steps S38 to S50 (B/L1 mode; see Fig. 6) described above. In these steps, since steps having common numerals at the one's digit of their step numbers execute the same processing, a description thereof will be omitted. Note that the equation in step S115 corresponds to the fact that the outlet ratio of air-conditioning air of the ventilation outlet port 5 is 45%, and that of the foot outlet port 6 is 55%.

[0115] Steps S121 to S127 shown in Fig. 10 correspond to steps S51 to S57 in the B/L1 mode. In these steps, since steps having common numerals at the one's digit of their step numbers execute the same processing, a description thereof will be omitted. In step S127, of course, the B/L3 mode is set.

[0116] If NO is determined in step S123, it is determined that a state wherein a passenger feels that both his or her bust and legs are hot is set, and the control returns to the above-mentioned B/L2 mode (step S68 in Fig. 8). If NO is determined in step S126, it is determined that a state wherein a passenger feels that his or her legs are cold is set since cold air-conditioning air is output from the foot outlet port 6, and the control also returns to the B/L2 mode (step S68 in Fig. 8).

[0117] Furthermore, if NO is determined in step S124, it is determined that a state wherein a passenger feels that both his or her bust and legs are cold is set, and the control enters a heating mode (Fig. 12; to be described later). If NO is determined in step S125, it is determined that a passenger feels discomfort since hot air-conditioning air blows against his or her face, and the control also enters the heating mode.

[0118] If YES is determined in step S122, i.e., if the difference between the passenger room temperature T_r and the target temperature T_{TRG} is small, it is determined that an air-conditioned state has nearly reached a stable period, and the flow advances to step S128 and subsequent steps shown in Fig. 11.

[0119] In the processing in step S128 and subsequent steps, the target temperature T_{TRG} is corrected by the same technique as in the B/L1 mode. Steps S128 to S136 correspond to steps S58 to S66 (B/L1 mode; see Fig. 7) described above. In these steps, since steps having common numerals at the one's digit of their step numbers execute basically the same processing, a description thereof will be omitted.

[0120] In step S128, region discrimination is performed based on a map shown in Fig. 22. If it is determined that the point P falls within a region I shown in Fig. 22 (YES in step S128), the flow returns to step S127 shown in Fig. 10, and the B/L3 mode, the outlet air temperature T_{oo}, and the like are set.

[0121] On the other hand, if NO in step S128, the flow advances to step S129 to check if the point P falls within a region II shown in Fig. 22. If YES in step S129, it is determined that a state wherein a passenger feels that his or her bust is hot although he or she feels that his or her legs are comfortable, or vice versa is set, and the flow advances to step S130. In step S130, the target temperature T_{TRG} is changed, i.e., is decreased by the predetermined value ΔT. In step S131, it is checked if the changed target temperature T_{TRG} is equal to 20°C. If NO in step S131, an optimal outlet air temperature, and the like are calculated again on the basis of the changed target temperature T_{TRG}.

[0122] When both the values of the indices F_2 and F_4 obtained by the optimal outlet air temperature T_{oo} and the optimal outlet air flow rate V_{ao} calculated based on the changed target temperature T_{TRG} become substantially equal to " $\cong$ 5" (region I), it is determined that an optimal air-conditioned state has been found by changing the target temperature T_{TRG}, and the flow advances from step S128 to step S127 (Fig. 10).

[0123] On the other hand, if it is determined in step S129 regardless of the changed target temperature T_{TRG} that

the point P falls within the region II (YES in step S129), the target temperature T_{TRG} is changed again (T_{TRG} - ΔT) in step S130. The target temperature is changed up to 20°C as a minimal value of the target temperature in the B/L3 mode.

[0124] If NO in step S129, the flow advances to step S132 to check if the point P falls within a region III shown in Fig. 22. If YES in step S132 (region III), it is determined that a state wherein a passenger feels that his or her bust is cold although he or she feels that his or her legs are comfortable, or vice versa is set. In step S133, the target temperature T_{TRG} is changed, i.e., is increased by the predetermined value ΔT. In step S134, it is checked if the changed target temperature T_{TRG} is equal to 30°C as a maximal value in the B/L3 mode. If NO in step S134, the flow returns to step S109 (Fig. 10), and an optimal outlet air temperature, and the like are calculated based on the changed target temperature T_{TRG}.

[0125] If NO in step S132, the flow advances to step S135 to check if the point P falls within a region IV. If YES in step S135 (region IV), it is determined that a state wherein a passenger feels that his or her bust is hot, and his or her legs are cold is set, and the control returns to the B/L2 mode (step S68 in Fig. 8). On the other hand, if NO in step S135, the flow advances to step S136 to check if the point P falls within a region V. If YES in step S136 (region V), it is determined that a state wherein a passenger feels that both his or her bust and legs are cold is set, and the control enters the heating mode (Fig. 12; to be described later). On the other hand, if NO in step S136, the flow advances to step S127 described above.

Heating Mode

[0126] Figs. 12 and 13 show a routine for setting the foot outlet port 6 (heating mode).

[0127] In step S142, the setting temperature T_{SET} is set to be the target temperature T_{TRG}. In step S143, a vehicle heat load Q_L is calculated using the equation in the unstable period. In step S144, the outlet air flow rate V_a is set to be a low air flow rate V_a1 (V_{a1}). In step S146, an outlet air temperature T_{o1} corresponding to the low air flow rate V_{a1} is calculated. In step S147, an opening degree θ of the air mixing damper 13 is calculated on the basis of T_{o1}. In step S148, it is checked if the opening degree θ obtained in step S147 is equal to or larger than "1". If NO in step S148 (θ < 1), it is determined that an air mixing operation is performed, and in step S149, the outlet air temperature T_{o1} is set as the outlet air temperature T_o. On the other hand, if YES in step S148 ($\theta \geq$ "1"), it is determined that the air flow rate ratio to the heating heat exchanger 14 becomes 100% (full hot), and in step S150, the temperature T_w of the engine cooling water is set as the outlet air temperature T_o. In the equation shown in step S150, the coefficient K_w is used for converting the temperature T_w of the engine cooling water into the exit temperature of the heating heat exchanger 14.

[0128] In step S151, an outlet air flow rate V_{af} of air to be output from the foot outlet port 6 is calculated. More specifically, when the heating mode is set, air-conditioning air is output from the defroster outlet ports 7 in addition to the foot outlet port 6. In this case, the outlet air flow rate ratio of the foot outlet port 6 is set to be 75%, and that of the defroster outlet ports 7 is set to be 25%. More specifically, when an outlet air flow rate V_a is set, air is output from the foot outlet port 6 at a flow rate $V_{at} = 0.75 \times V_a$. In step S152, a comfort index F_4 (as described above, the comfort index F_4 represents the comfort level obtained by air-conditioning air output from the foot outlet port 6) is calculated. In step S153, a deviation (F_4 - 5) between the value F_4 and 5 is calculated. In step S154, the absolute value of the deviation is calculated. Thereafter, in step S155, ΔV is added to the outlet air flow rate V_{a1}, and the processing in steps S146 to S154 is repeated until the maximum air flow rate V_{ah} (V_{a7}) is reached. With this series of processing operations, the outlet air temperatures and the values F corresponding to the outlet air flow rates are obtained like (V_{a1}, T_{o1}, and the absolute value of the deviation), (V_{a2}, T_{o2}, arid the absolute value of the deviation),....

[0129] Upon completion of the processing for obtaining the combinations, the flow advances from step S145 to step S156, and a combination of the outlet air flow rate V_a and the outlet air temperature T_o, which has the minimum absolute value of the deviation between the value F_4 and 5, is selected. More specifically, a combination of the outlet air flow rate and the outlet air temperature, which exhibits a value F closest to "F_4 = 4" (a state wherein a passenger feels most comfortable), is selected (selection of V_{ao} and T_{oo}).

[0130] It is checked in step S157 if an air-conditioned state has reached a stable state. More specifically, it is checked if ΔT (= T_r = T_{TRG}) falls within a predetermined range. If NO in step S157, it is determined that the passenger room temperature T_r deviates from the target temperature T_{TRG} (e.g., the deviation is 2°C or more), and the air-conditioned state is in an unstable period. Thus, the flow advances to step S158 to check if the value (F_4 - 5) is equal to or smaller than the predetermined value (e.g., α = 1). If YES in step S158 (F_4 based on V_{ao} and T_{oo} is 6 or less), the flow advances to step S159 to check if the value (F_4 - 5) is equal to or larger than zero ($F_4 \geq 5$). If NO in step S159 (F_4 < 5), it is determined that a state wherein a passenger feels that his or her legs are cold is set, and the flow advances to step S161. In step S161, the foot outlet port 6, and the combination (V_{ao} and T_{oo}) of the outlet air flow rate and the outlet air temperature are set. In this manner, air-conditioning air is output from the foot outlet port 6 toward the legs of the passenger (heating mode). In this air-conditioned state, the air flow rate is set to be V_{ao}, and the temperature is set to be T_{oo}.

[0131] If YES in step S159, it is determined that the comfort index F_4 based on V_{ao} and T_{oo} is equal to or larger than

5, i.e., a state wherein a passenger feels that his or her legs are comfortable or hot is set. Thus, the flow advances to step S160 to check if the selected outlet air temperature T_o is larger than the predetermined value β (e.g., 20°C). If YES in step S160, the flow advances to step S161. On the other hand, if NO in step S158, i.e., if F_4 is larger than 6, it is determined that a state wherein a passenger feels that his or her legs are hot is set, and the control enters the B/L3 mode. If NO in step S160, i.e., if the selected outlet air temperature T_o is 20°C or less, it is determined that it is not preferable that cold air blows against the feet of the passenger, and the control enters the B/L3 mode.

[0132] If YES in step S157, i.e., if the difference between the passenger room temperature T_r and the target temperature T_{TRG} is small, it is determined that an air-conditioned state has nearly reached a stable period, and the flow advances to step S162 and subsequent steps (see Fig. 13).

[0133] In the processing in step S162 and subsequent steps, the target temperature T_{TRG} is corrected. In step S163, it is checked if the value (F_4 - 5) is equal to or smaller than the predetermined value (-α; e.g., α = 1). If YES in step S163 ($F_4 \leq 4$), it is determined that a state wherein a passenger feels cold is set, and the flow advances to step S163 to change, i.e., increase the target temperature T_{TRG} by the predetermined value ΔT. In step S164, it is checked if the target temperature. T_{TRG} is equal to 32°C. If NO in step S164, the flow returns to step S143, and an optimal outlet air temperature, and the like are calculated on the basis of the changed target temperature T_{TRG}.

[0134] If the value of the comfort index F_4 obtained by the optimal outlet air temperature T_{oo} and the optimal outlet air flow rate V_{ao} calculated based on the changed target temperature T_{TRG} becomes "the value $F \cong 5$", it is determined that an optimal air-conditioning controlled state has been found by changing the target temperature T_{TRG}, and the flow advances to step S161. On the other hand, if YES is determined in step S162 regardless of the changed target temperature T_{TRG}, the flow advances to step S163 again to change the target temperature T_{TRG}. The target temperature is changed up to 32°C as a maximal value in the heating mode.

[0135] If NO in step S162 ($F_4 > 4$), the flow advances to step S165 to check if the value (F_4 - 5) is equal to or larger than the predetermined value α. If YES in step S165 (e.g., $F \geq 6$), it is determined that a state wherein a passenger feels hot is set, and the flow advances to step S166 to check if the value F_4 is 7 or more. If NO in step S166, it is determined that a state wherein a passenger feels rather hot is set, and this state can be adjusted by changing the target temperature T_{TRG}. Thus, in step S167, the target temperature T_{TRG} is changed, i.e., is decreased by the predetermined value ΔT. In step S168, it is checked if the changed target temperature T_{TRG} is equal to 23°C as a minimal value in the heating mode. If NO in step S168, the flow returns to step S143, and an optimal outlet air temperature, and the like are calculated again on the basis of the changed target temperature T_{TRG}.

[0136] If YES in step S166, it is determined that too hot a state is set, and the control enters the B/L3 mode. If YES in step S168, it is determined that it is impossible to form an air-conditioned state having "$F_2 \cong 5$" in the heating mode, and the control enters the B/L3 mode.

[0137] Figs. 15 and 16 show a subroutine showing the details of a calculation of the target temperature T_{TRG} in step S12 (Fig. 4). In this subroutine, an optimal target temperature T_{TRG} when an air-conditioned state reaches a stable period is predicted. More specifically, in step S200, the setting temperature T_{SET} is set to be "25" since a comfortable setting temperature T_{SET} is determined with reference to 25°C. The passenger room temperature T_r becomes equal to the setting temperature T_{SET} when a stable period is reached. For this reason, in step S201, the passenger room temperature T_r is set to be "25" which is equal to the setting temperature T_{SET}. In steps S202 to S208, a combination of the outlet air flow rate V_a and the outlet air temperature T_o is searched on the basis of the value of the above-mentioned comfort index F (corresponding to, e.g., steps S14 to S24 in Fig. 4).

[0138] The outline of this search operation will be described below. In step S203, a vehicle heat load Q_L is calculated on the basis of the equation in the stable period ($Q_L = K \cdot S(T_r - T_a) - K_s \cdot T_s - C$). In this case, the passenger room temperature T_r is not an actual room temperature, but a temperature set in, e.g., step S201. In step S206, a comfort index F_2 is calculated. In the calculation of the comfort index F_2, the passenger room temperature T_r is not an actual room temperature, but a temperature set in, e.g., step S201. Therefore, the search operation of the combination of the outlet air flow rate V_a and the outlet air temperature T_o based on the value of the comfort index F_2 in steps S202 to S208 is performed independently of the current air-conditioned state under an assumption that the stable period has been reached (the passenger room temperature T_r is equal to the setting temperature T_{SET} (target temperature T_{TRG})).

[0139] Upon completion of the search operation of the combination of the outlet air flow rate V_a and the outlet air temperature T_o based on the value F_2, the flow advances from step S204 to S209, and a combination having a comfort index F_2 closest to "5" is selected. In step S210, it is checked if the deviation (F_2 - 5) between the comfort index F_2 obtained by the selected combination of the outlet air flow rate V_a and the outlet air temperature T_o, and "5" is smaller than a predetermined value (-α). If NO in step S210, it is determined that the value F_2 is, e.g., equal to or larger than "4", and the flow advances to step S211 to check if the deviation (F_2 - 5) between the value F_2 and "5" is equal to or smaller than a predetermined value α. If YES in step S211, it is determined that the value F_2 is almost equal to "5", and the setting temperature T_{SET} (25°C) is set to be the target temperature T_{TRG} in step S212.

[0140] If NO in step S211, it is determined that the value F_2 is equal to or larger than "6", and a state wherein a passenger feels hot is set. Thus, the flow advances to step S213, and the setting temperature T_{SET} is decreased by

a predetermined value. In step S214, the passenger room temperature T_r is similarly decreased by the predetermined value. In step S215, it is checked if the setting temperature T_{SET} is equal to or higher than "18°C". If YES in step S215, the flow returns to step S202, and an optimal combination of the outlet air flow rate V_a and the outlet air temperature T_o is searched again on the basis of the changed setting temperature T_{SET} and the changed passenger room temperature T_r. When a combination of the outlet air flow rate V_a and the outlet air temperature T_o having a value $F_2 \cong$ "5" can be found, the changed setting temperature T_{SET} is set as the target temperature T_{TRG} in step S212.

[0141] If YES in step S210, it is determined that the value F_2 is, e.g., equal to or smaller than "4", and a state wherein a passenger feels cold is set. Thus, the flow advances to step S217, and the setting temperature T_{SET} is increased by a predetermined value. In step S218, the passenger room temperature T_r is similarly increased by the predetermined value. It is checked in step S219 if the setting temperature T_{SET} is equal to or lower than "27°C". If YES in step S219, the flow returns to step S202, and an optimal combination of the outlet air flow rate V_a and the outlet air temperature T_o is searched again on the basis of the changed setting temperature T_{SET} and the changed passenger room temperature T_r. When a combination of the outlet air flow rate V_a and the outlet air temperature T_o having a value $F_2 \cong$ "5" can be found, the changed setting temperature T_{SET} is set as the target temperature T_{TRG} in step S212.

[0142] If NO in step S219, it is determined that an optimal combination of the outlet air flow rate V_a and the outlet air temperature T_o cannot be found in the ventilation mode, and the flow advances to step S220, and the target temperature T_{TRG} in the B/L1 mode is predicted. The target temperature T_{TRG} in the B/L1 mode is predicted by basically the same scheme as that in the ventilation mode although its flow chart is omitted. Of course, as described above (see Figs. 6 and 7), the comfort index F_2 for the ventilation mode and the comfort index F_4 for the heating mode are used as the comfort index F. Also, the maps shown in Figs. 17 and 20 are used. When an optimal combination of the outlet air flow rate V_a and the outlet air temperature T_o cannot be found in the B/L1 mode, the target temperature T_{TRG} is similarly predicted in the B/L2 mode, B/L3 mode, and heating mode.

[0143] In this manner, since the target temperature T_{TRG} is predicted in step S12 shown in Fig. 4 assuming a stable period, the outlet air flow rate V_a, and the like set in, e.g., step S30 (Fig. 4) in an unstable period are based on the predicted target temperature T_{TRG}. When the air-conditioned state actually enters a stable period, the predicted target temperature T_{TRG} is directly used, and air-conditioning control based on this target temperature T_{TRG} is executed. Therefore, since the control is made in an unstable period based on the target temperature T_{TRG} in a future stable period from the beginning, the air-conditioned state can reach the stable period earlier than that in a case wherein such prediction is not performed.

[0144] Upon setting of the outlet air flow rate and the outlet air temperature based on the heat balance equation in air-conditioning control, a combination of the outlet air flow rate and the outlet air temperature, which has a comfort index F close to "value F = 5" is set, and in addition, an outlet mode is set based on the comfort index F. Since the comfort index F includes parameters which influence the comfort level actually felt by a passenger, a combination desirable for comfort of a passenger can be systematically set on the basis of the comfort index F.

[0145] When the air-conditioned state actually reaches a stable period, the target temperature T_{TRG} is adjusted, so that the comfort index F becomes closer to "value F = 5". Thus, a combination of the outlet air flow rate and the outlet air temperature, which can more satisfactorily improve the comfort of a passenger, can be set.

[0146] As can be seen from the above description, according to the first embodiment, since air-conditioning control in an unstable period is executed on the basis of a target temperature, which is predicted based on a comfort index in a future stable period, the air-conditioned state can enter the stable period early.

(Second Embodiment)

[0147] The control content of the first embodiment described above is applied as long as a vehicle is operating. However, the control content of the second embodiment is applied to a short period of time immediately after the engine of a vehicle is started.

[0148] In the second embodiment, the arrangement of a vehicle air-conditioner is the same as that of the first embodiment shown in Figs. 1 and 2, and the control content of the control circuit 22 is the principal characteristic feature of the second embodiment. Therefore, a description about the arrangement of the vehicle air conditioner will be omitted here.

[0149] The content of air-conditioning control of the second embodiment premised on a cooling operation will be described hereinafter. The outline of the control will be described below. After the operation of the compressor 15 is started when the air-conditioning switch (auto switch 23a) is turned on, an outlet start timing of air-conditioning air is determined upon comparison between a comfort index F_1 and a discomfort index F_o (to be described later). More specifically, only after an air-conditioned state that does not worsen the discomfort level felt by a passenger when the air-conditioning switch 23a is turned on can be realized, the outlet operation of air-conditioning air (the operation of the blower 11) is started. Discrimination of this state uses the following comfort index F_1 and discomfort index F_o.

[0150] The comfort index F_1 will be described below. The comfort index F_1 is defined by the following equation:

$$F_1 = K_1 \cdot V + K_2 \cdot T_e + K_3 \cdot T_r + K_4 \cdot T_a + K_5 \cdot T_s + C_1$$

where

V : outlet air flow rate
T_e : evaporator temperature
T_r : passenger room temperature
T_a : atmospheric temperature
T_s : solar radiation amount
C_1 : constant

[0151] In the F_1 equation, K_1 to K_5 are weighting coefficients, and these coefficients K_1 to K_5 are experimentally obtained. More specifically, the comfort index F_1 is obtained by converting a comfort level felt by a passenger into an index on the basis of various parameters that influence the comfort of the passenger. In this case, the coefficients K_1 to K_5 are set so that the most comfortable state corresponds to $F_1 = 5$. Therefore, as the index F_1 deviates further from $F_1 = 5$, the discomfort level felt by a passenger increases. For example, when the value of the comfort index F_1 is considerably larger than "5", this means, as an example of discomfort, a state wherein a passenger feels hot.

[0152] On the other hand, the discomfort index F_o will be described below. The discomfort index F_o is defined by the following equation:

$$F_o = K_6 \cdot T_e + K_7 \cdot T_r + K_s \cdot T_a + K_9 \cdot T_s + C_2$$

where C_2 is a constant.

[0153] In the F_o equation, K_5 to K_9 are weighting coefficients, and these coefficients are experimentally obtained. More specifically, the discomfort index F_o is obtained by converting a discomfort level felt by a passenger into an index on the basis of various parameters that influence the comfort of the passenger like in the comfort index F_1. In this case, the coefficients K_5 to K_9 are set, so that the least discomfort level state corresponds to "$F_o = 5$". In other words, the same comfort level state as the comfort level of "$F_1 = 5$" corresponds to "$F_o = 5$". Therefore, as the discomfort index F_o deviates further from "$F_o = 5$", this means that the discomfort level felt by a passenger increases. For example, when the value of the discomfort index F_o is considerably larger than "5", this means, as an example of discomfort, a state wherein a passenger feels hot.

[0154] The functions of the comfort index F_1 and the discomfort index F_o will be described in detail below. The comfort index F_1 represents a comfort level, which will be felt by a passenger assuming that air-conditioning air is output after the air-conditioning switch is turned on. The comfort index F_1 is sequentially updated. On the other hand, the discomfort index F_o represents a discomfort level in a passenger room when the air-conditioning switch is turned on. For example, the discomfort index F_o represents a discomfort level when a passenger gets in a vehicle under the blazing sun, and starts an engine.

[0155] When the comfort index F_1 is larger than the discomfort index F_o, the operation of the blower 11 is inhibited, and hence, the outlet operation of air-conditioning air is inhibited. When the comfort index F_1 becomes equal to or smaller than the discomfort index F_o along with an elapse of time, the operation of the blower 11 is started, and air-conditioning air is output.

[0156] This operation will be described in detail below with reference to the flow chart shown in Fig. 23.

[0157] In step S1, it is checked if the air-conditioning switch is turned on. If YES in step S1, the flow advances to step S2 to calculate a discomfort index F_o. In addition, the calculated value of the discomfort index F_o is stored in a memory (RAM). Upon calculation of the discomfort index F_o, the evaporator temperature T_e indicates the temperature of air staying in the duct 1 since the compressor 15 is just started.

[0158] In step S3, the comfort index F_1 is calculated. The outlet air flow rate V necessary for calculating the comfort index F_1 will be explained below. When a minimum outlet air flow rate V_{LOW} (gentle air state) is set as the air flow rate at the beginning of the air outlet operation, as will be described later, the comfort index F_1 is calculated using the minimum outlet air flow rate V_{LOW} as the outlet air flow rate V. For example, when a vehicle is parked under the blazing sun, the temperature of air staying in the duct 1 becomes high. Thus, when the high-temperature air is blown to a passenger, he or she feels very uncomfortable. That is, the value of the comfort index F_1 is larger than the discomfort index F_o when a passenger gets in a vehicle.

[0159] In step S4, it is checked if the comfort index F_1 is larger than the discomfort index F_o. If YES in step S4 ($F_1 > F_o$), it is determined that a passenger feels more uncomfortable if air-conditioning air is output (the blower 11 is started). Thus, the flow advances to step S5 to inhibit the blower 11 from being started (to inhibit air-conditioning air

from being output). Thereafter, the flow returns to step S3, and the comfort index F_1 is calculated again.

[0160] As time elapses, the evaporator temperature T_e is decreased, and the comfort index F_1 then becomes equal to or lower than the discomfort index F_o. That is, when a state wherein the discomfort level currently felt by a passenger is not worsened any more even when air-conditioning air is output (the blower 11 is started) is determined, control for delaying the start timing of the blower 11 is ended.

[0161] With the above-mentioned control, when the outlet operation of air-conditioning air is started, the discomfort level felt by a passenger can be at least prevented from being worsened by starting the outlet operation of air-conditioning air. When the value of the discomfort index F_o when a passenger gets in a vehicle is not so large, i.e., when the value of the discomfort index F_o is close to $F_o = 5$, the outlet operation of air-conditioning air is started at an early timing. In other words, the outlet timing of air-conditioning air is automatically adjusted according to the discomfort index F_o.

[0162] Thereafter, the blower 11 is started, and a cooling operation is actually executed. At the beginning of this cooling control, it is preferable to set the outlet air flow rate V to be the minimum outlet air flow rate V_{LOW}, and to gradually increase the outlet air flow rate V. The increase in outlet air flow rate V can be easily attained by utilizing, e. g., a timer. As the discomfort index F_o indicates a larger value, the rate of increase in outlet air flow rate V may be increased to perform a quick cooling operation. More specifically, whether or not the quick cooling operation is necessary can be determined according to the value of the discomfort index F_o. In addition, the degree of the quick cooling operation can be changed according to the value of the discomfort index F_o.

[0163] As the outlet mode, the outlet operation may be started from the defroster outlet ports 7, or may be started from the ventilation outlet port 5. Of course, when the outlet operation of air-conditioning air is started from the defroster outlet ports 7, the coefficients K_1 to K_5 in the F_1 equation are set under an assumption that air-conditioning air is output from the defroster outlet ports 7. On the other hand, when the outlet operation of air-conditioning air is started from the ventilation outlet port 5, the coefficients K_1 to K_5 in the F_1 equation are set under an assumption that air-conditioning air is output from the ventilation outlet port 5.

[0164] As can be apparent from the above description, according to the second embodiment, the outlet timing of air-conditioning air can be automatically adjusted according to the discomfort level at the beginning of the cooling operation without increasing the discomfort level felt by a passenger at the beginning of the cooling operation.

(Third Embodiment)

[0165] The control content of the first embodiment described above is applied as long as a vehicle is operating. However, the control content of the second embodiment is applied to a short period of time immediately after the engine of a vehicle is started like in the second embodiment.

[0166] In the third embodiment, the arrangement of a vehicle air-conditioner is the same as that of the first embodiment shown in Figs. 1 and 2, and the control content of the control circuit 22 is the principal characteristic feature of the third embodiment. Therefore, a description about the arrangement of the vehicle air conditioner will be omitted here.

[0167] Heating control in a warm-up operation (warm-up control) of the air-conditioning control executed by the control circuit 22 will be described hereinafter.

[0168] The outline of the warm-up control will be explained below. Selection of an outlet air flow rate and an outlet air temperature, and mode control are made with reference to a comfort index F_5.

[0169] The comfort index F_5 will be described below. The comfort index F_5 is defined by the following equation.

$$F_5 = - K_1 \cdot V_a + K_2 \cdot T_o + K_3 \cdot T_r + K_4 \cdot T_a + C_1$$

where

V_a : outlet air flow rate
T_o : outlet air temperature
T_r : passenger room temperature
T_a : atmospheric temperature

[0170] In addition, in the F_5 equation, C_1 is a constant, and K_1 to K_4 are weighting coefficients. The constant C_1 and the coefficients K_1 to K_4 are experimentally obtained. More specifically, the comfort index F_5 is obtained by converting a comfort level felt by a passenger in a heating operation during a warm-up operation into an index. In this case, the constant C_1 and the coefficients K_1 to K_4 are set, so that the most comfortable state corresponds to "$F_5 = 5$". Therefore, as the comfort index F_5 deviates further from "$F_5 = 5$", the discomfort level is increased. For example, when the outlet air temperature T_o is constant, if the outlet air flow rate V_a is increased, a passenger feels cold. At this time, the value

F_5 is smaller than "5".

[0171] Warm-up control premised on the above description will be described in detail below with reference to the flow charts shown in Figs. 24 to 27.

[0172] In step S1, it is checked if the control is made for the first time. If YES in step S1, the flow advances to step S2, and the flow rate of air to be output from the foot outlet port 6 when the minimum air flow rate V_{aL} is set is calculated based on an equation $V_a = 0.75 \times V_a$.

[0173] More specifically, when the foot outlet port 6 is selected as the outlet port of air-conditioning air, i.e., when the heating mode is selected, air is output from the foot outlet port 6 at a flow rate 75% of the flow rate V_a of air supplied from the ventilation duct 1, and air is output from the defroster outlet ports 7 at a flow rate 25% of the flow rate V_a. In step S3, an engine cooling water temperature T_w is set as an outlet air temperature T_o. In step S4, the comfort index F_5 is calculated based on these values.

[0174] In step S5, it is checked if the value of the comfort index F_5 is smaller than "3". If YES in step S5, it is determined that the current cooling water temperature T_w is considerably low. Thus, the flow advances to step S6 to set a flag "00". On the other hand, if NO in step S5, the flow advances to step S7 to check if the value of the comfort index F_5 is smaller than "4". If YES in step S7, it is determined that the cooling water temperature T_w is in a medium state. Thus, the flow advances to step S8 to set a flag "01". However, if NO in step S7, it is determined that the cooling water temperature T_w is considerably high. Thus, the flow advances to step S9 to set a flag "10".

[0175] In steps S10 to S17 shown in Fig. 25, a combination of the outlet air flow rate V_a and the outlet air temperature T_o is searched. The content of this search operation will be explained below.

[0176] More specifically, in step S10, the outlet air flow rate V_a is set to be the minimum air flow rate V_{aL}. Thereafter, the outlet air temperature T_o is set to be the engine cooling water temperature T_w in step S12 via step S11 (to be described later). In step S13, the outlet air flow rate V_a is converted into an outlet air flow rate of air to be output from the foot outlet port 6. Based on these values, a comfort index F_5 for the warm-up control is then calculated. In step S15 a comfort index F_4 upon completion of the warm-up operation is calculated. The comfort index F_4 will be described below. The comfort index F_4 is defined by the following equation:

$$F_4 = K_5 \cdot V_a - K_6 \cdot T_o + K_7 \cdot T_r + K_8 \cdot T_a + C_2$$

[0177] Note that the meanings of V_a, and the like are the same as those in the above equation associated with F_5, and will be explained again.

V_a : outlet air flow rate
T_o : outlet air temperature
T_r : passenger room temperature
T_a : atmospheric temperature

[0178] In the F_4 equation, C_2 is a constant, and K_5 to K_8 are weighting coefficients. The constants C_2 and the coefficients K_5 to K_8 are experimentally obtained. More specifically, the comfort index F_4 is obtained by converting a comfort level felt by a passenger in a heating operation upon completion of the warm-up operation into an index. That is, the constants C_2 and the coefficients K_5 to K_8 are set on the basis of the heated air-conditioning air output from the foot outlet port 6 upon completion of the warm-up operation, so that the most comfortable state corresponds to "$F_4 = 5$". For example, when the value F_4 is smaller than "5", this means a state wherein a passenger feels cold. Note that the comfort felt by a passenger when $F_4 = 5$ is set to be the same as that felt by a passenger when $F_5 = 5$.

[0179] In step S16 the absolute value of a deviation between the warm-up comfort index F_5 and a predetermined value α_o is calculated. The predetermined value α_o is set to be an initial value $\alpha_o = 2$. In step S17, the outlet air flow rate V_a is increased by a predetermined amount ΔV_a. The above-mentioned processing in steps S13 to S16 is repeated until a maximum air flow rate V_{aH} is reached. With this series of processing operations, after the engine cooling water temperature T_w is set as the outlet air temperature T_o, the outlet air flow rates V_a, which are increased stepwise from the minimum air flow rate V_{aL} to the maximum air flow rate V_{aH}, and pairs of comfort indices F_4 and F_5 obtained based on combinations of the outlet air temperatures T_o and the outlet air flow rates V_a are obtained.

[0180] If NO is determined in step S11 it is determined that the search operation is performed up to the maximum air flow rate V_{aH}, and the flow advances to step S18. An outlet air flow rate selected in step S18 based on the absolute value of $(F_5 - \alpha_o)$ in step S16 is represented by "V_{ao}", and an outlet air temperature selected in step S18 is represented by "T_{oo}".

[0181] In step S19, it is checked if the flag is "00". If YES in step S19, the flow advances to step S20 to check if the selected outlet air flow rate V_{ao} is lower than a "medium low air flow rate V_{aML}" as a predetermined value. If YES in step S20, the selected outlet air flow rate V_{ao} and outlet air temperature T_{oo}, and a defroster mode are output. More

specifically, when the engine cooling water temperature T_w is low, the outlet air flow rate V_{ao} having the comfort index F_5 = "2" is set, and the defroster outlet ports 7 are selected as the outlet port.

[0182] In step S22, it is checked if the difference between the values F_5 and F_4 is smaller than "0.5". If NO in step S22, it is too early to start heating control after the completion of the warm-up operation. The flow then returns to step S10 to search a combination of the outlet air flow rate V_a and the outlet air temperature T_o again, thereby selecting a combination of the outlet air flow rate V_{ao} and the outlet air temperature T_{oo} closest to F_5 = 2 (S18).

[0183] Since the engine cooling water temperature T_w is increased along with an elapse of time, the selected outlet air flow rate V_{ao} is gradually increased. If NO is determined in step S20 via step S19, the flow advances to step S25 to check if the value of the comfort index F_5 serving as a reference for selecting the outlet air flow rate V_{ao}, and the like in step S18 is smaller than "3". If YES in step S25, the flow advances to step S26 to set the outlet air flow rate to be a "medium low air flow rate V_{aML}" as a predetermined value, and to set the outlet air temperature to be a "medium low temperature T_{oML}" as a predetermined value. In addition, as an outlet mode, the defroster mode is set.

[0184] More specifically, when the engine cooling water temperature T_w is increased along with an elapse of time, and the comfort index F_5 is gradually increased but does not reach "3", the outlet air flow rate and the outlet air temperature are controlled to have the predetermined values (V_{aML} and T_{oML}) in the defroster mode.

[0185] Thereafter, when the value of the comfort index F_5 becomes equal to or larger than "3" along with an elapse of time, the flow advances from step S25 to step S27 to check if the selected outlet air flow rate V_{ao} is lower than a "medium high air flow rate V_{aMH}" as a predetermined value. If YES in step S27, the predetermined value α_o is changed to "α_o = 3" in step S28, and thereafter, the outlet air flow rate V_{ao} and the outlet air temperature T_{oo} selected in step S18, and a defroster/heating mode are set and output in step S29.

[0186] In the defroster/heating mode, air-conditioning air is output from both the defroster outlet ports 7 and the foot outlet port 6. Since α_o is changed to "3" in step S28, the subsequent calculation of the absolute value (F_5 - α_o) in step S16 is performed using α_o = 3. In step S18, a combination of the outlet air flow rate V_{ao} and the outlet air temperature T_{oo}, which has a minimum absolute value of (F_5 - 3), is selected.

[0187] Thereafter, when the selected outlet air flow rate V_{ao} becomes equal to or higher than the "medium high air flow rate V_{aMH}" as the predetermined value since the cooling water temperature T_w is increased along with an elapse of time, the flow advances from step S27 to step S30 to check if the value of the comfort index F_5 serving as a reference for selecting the outlet air flow rate V_{ao}, and the like in step S18 is smaller than "4". If YES in step S30, the flow advances to step S31. In step S31, the outlet air flow rate is set to be the "medium high air flow rate V_{aMH}" as the predetermined value, the outlet air temperature is set to be a "medium high temperature T_{oMH}" as a predetermined value, and the defroster/heating mode is set as the outlet mode.

[0188] Thus, when the engine cooling water temperature T_w is increased along with an elapse of time, and the comfort index F_5 is gradually increased but does not reach "4", the outlet air flow rate and the outlet air temperature are controlled to have the predetermined values (V_{aMH} and T_{oMH}) in the defroster/heating mode.

[0189] Thereafter, when the value of the comfort index F_5 becomes equal to or larger than "4" along with an elapse of time, the flow advances from step S30 to step S32 to change the predetermined value α_o to "α_o = 4". In step S33, the outlet air flow rate V_{ao} and the outlet air temperature T_{oo} selected in step S18, and the heating mode are set and output.

[0190] Since α_o is changed to "4" in step S32, the subsequent calculation of the absolute value (F_5 - α_o) in step S16 is performed using α_o = 4. In step S18, a combination of the outlet air flow rate V_{ao} and the outlet air temperature T_{oo}, which has a minimum absolute value of (F_5 - 4), is selected.

[0191] Thereafter, when the value of the warm-up comfort index F_5 is increased, and the value (F_5 - F_4) becomes smaller than "0.5", the flow advances from step S22 to S23 to end the above-mentioned warm-up control, and in step S24, the flag is reset.

[0192] On the other hand, when the flag "01" is set, it is determined that the engine cooling water temperature T_w at the beginning of the warm-up control is medium, and the flow advances from step S34 (Fig. 27) to step S35 to check if the outlet air flow rate V_{ao} selected in step S18 is lower than the "medium high air flow rate V_{aMH}" as the predetermined value. If YES in step S35, the flow advances to step S36, and the outlet air flow rate V_{ao} and the outlet air temperature T_{oo} selected in step S18, and the defroster/heating mode are set and output.

[0193] Thereafter, when the selected outlet air flow rate V_{ao} becomes equal to or higher than the "medium high air flow rate V_{aMH}" as the predetermined value since the cooling water temperature T_w is increased along with an elapse of time, the flow advances from step S35 to step S37 to check if the value of the comfort index F_5 serving as a reference for selecting the outlet air flow rate V_{ao}, and the like in step S18 is smaller than "4". If YES in step S37, the flow advances to step S38. In step S38, the outlet air flow rate is set to be the "medium high air flow rate V_{aMH}" as the predetermined value, the outlet air temperature is set to be a "medium high temperature T_{oMH}" as a predetermined value, and the defroster/heating mode is set as the outlet mode.

[0194] Thus, when the engine cooling water temperature T_w is increased along with an elapse of time, and the comfort index F_5 is gradually increased but does not reach "4", the outlet air flow rate and the outlet air temperature are controlled

to have the predetermined values (V_{aMH} and T_{oMH}) in the defroster/heating mode.

[0195] Thereafter, when the value of the comfort index F_5 becomes equal to or larger than "4" along with an elapse of time, the flow advances from step S37 to step S39 to change the predetermined value α_o to "α_o = 4". In step S40, the outlet air flow rate V_{ao} and the outlet air temperature T_{oo} selected in step S18, and the heating mode are set and output. Since α_o is changed to "4" in step S39, the subsequent calculation of the absolute value (F_5 - α_o) in step S16 is performed using α_o = 4. In step S18, a combination of the outlet air flow rate V_{ao} and the outlet air temperature T_{oo}, which has a minimum absolute value of (F_5 - 4), is selected.

[0196] Thereafter, when the value of the warm-up comfort index F_5 is increased, and the value (F_5 - F_4) becomes smaller than "0.5", the flow advances from step S22 to S23 to end the above-mentioned warm-up control, and in step S24, the flag is reset.

[0197] On the other hand, when the flag "10" is set, it is determined that the engine cooling water temperature T_w at the beginning of the warm-up control is considerably high, and the flow advances from step S34 (Fig. 27) to step S41. In step S41, the outlet air flow rate V_{ao} and the outlet air temperature T_{oo} selected in step S18, and the heating mode are set and output. When the value (F_5 - F_4) becomes smaller than "0.5" along with an elapse of time, the flow advances to step S22 to end the warm-up control.

[0198] The above-mentioned control contents can be illustrated as graphs shown in Figs. 28 to 31.

[0199] More specifically, when the engine cooling water temperature T_w at the beginning of the warm-up control is low (when flag = "00"), as shown in Fig. 28, air-conditioning control is performed under a condition that the comfort index F_5 = 2. When the outlet air flow rate reaches the "medium low air flow rate V_{aML}", the outlet temperature is increased toward the index F_5 = 3 in the state of the "medium low air flow rate V_{aML}".

[0200] After the comfort index F_5 becomes "3", air-conditioning control is performed under a condition that the index F_5 = 3. When the outlet air flow rate reaches the "medium high air flow rate V_{aMH}", the outlet temperature is increased toward the index F_5 = 4 in the state of the "medium high air flow rate V_{aMH}". After the comfort index F_5 becomes "4", air-conditioning control is performed under a condition that the index F_5 = 4.

[0201] On the other hand, when the engine cooling water temperature T_w at the beginning of the warm-up control is medium (when flag = "01"), as shown in Fig. 29, air-conditioning control is performed under a condition that the comfort index F_5 = 3. When the outlet air flow rate reaches the "medium high air flow rate V_{aMH}", the outlet temperature is increased toward the index F_5 = 4 in the state of the "medium high air flow rate V_{aMH}". After the comfort index F_5 becomes "4", air-conditioning control is performed under a condition that the index F_5 = 4.

[0202] When the engine cooling water temperature T_w at the beginning of the warm-up control is considerably high (when flag = "10"), as shown in Fig. 30, air-conditioning control is performed under a condition that the comfort index F_5 = 4.

[0203] In the above-mentioned warm-up control, since the outlet air flow rate, and the like are controlled on the basis of the comfort index F_5 including the passenger room temperature T_r as a parameter, for example, when the passenger room temperature T_r is low, the rate of increase in air flow rate is decreased as compared to a case wherein the passenger room temperature T_r is high. More specifically, when the passenger room temperature T_r is low, a passenger should feel cold regardless of the engine cooling water temperature, and the comfort index F_5 representing this state has a small value such as "2". That is, as long as the passenger room temperature T_r is low, the comfort index F_5 cannot be increased to "3", and air-conditioning control under the "medium low air flow rate V_{aML}" continues for a long period of time.

[0204] Therefore, a passenger can be prevented from feeling cold when cold air in the passenger room is stirred due to an increase in outlet air flow rate V_a regardless of the fact that the low passenger room temperature T_r is low.

[0205] Fig. 31 shows a modification of the third embodiment. The control content shown in Fig. 31 will be described below. A minimum air flow rate $_{VaL}$ is maintained until the comfort index F_5 becomes "4", and after the comfort index F_5 becomes "4", air-conditioning control is performed under a condition that the comfort index F_5 = 4.

[0206] According to this modification, after the engine cooling water temperature T_w is sufficiently increased, and the passenger room temperature T_r is increased to some extent, the outlet air flow rate is increased. For this reason, stirring of cold air in the passenger room can be minimized.

[0207] Fig. 32 shows the second modification of the third embodiment. The control content shown in Fig. 32 will be described below. Air-conditioning control is performed in the defroster mode under a condition that the comfort index F_5 = 2, and when the outlet air flow rate becomes a maximum air flow rate V_{aH}, the outlet air temperature is increased toward the comfort index F_5 = 5. Thus, as the value of the index F_5 is increased, the defroster/heating mode is selected when F_5 = 3, and the heating mode is selected when F_5 = 4. According to the second modification, the passenger room temperature T_r can be increased quickly although the comfort of a passenger is sacrificed.

[0208] As can be apparent from the above description, according to the third embodiment, since an increase in outlet air flow rate is suppressed while the passenger room temperature is low, stirring of cold air in the passenger room due to an outlet operation of air-conditioning air can be suppressed, and a passenger can be prevented from feeling cold.

[0209] Not only control of the outlet mode depending on only the engine cooling water temperature but also control

of the outlet mode in consideration of the comfort of a passenger can be realized.

Claims

1. A method of controlling a vehicle air conditioner, which controls an outlet air flow rate and an outlet air temperature of air-conditioning air while balancing between a heat amount supplied from an air conditioner for adjusting the air-conditioning air into a passenger room, and a heat load acting on a vehicle,
characterized by comprising:

   the first step of detecting information which is necessary for calculating a comfort index representing a comfort level of a passenger and obtaining, from a heat balance equation, a plurality of combinations of the outlet air flow rates and the outlet air temperatures necessary for maintaining a passenger room temperature to be a predetermined target temperature;
   the second step of calculating the comfort index F on the basis of the outlet air flow rate, the outlet air temperature, the passenger room temperature, an atmospheric temperature, and a solar radiation amount Ts;
   the third step of selecting a combination of the outlet air flow rate and the outlet air temperature so that the comfort index becomes closest to an optimal value, and
   the fourth step of changing the target temperature when the comfort index calculated based on the combination of the outlet air flow rate and the outlet air temperature searched in the third step is a numerical value falling within a range that is not preferable for comfort of the passenger.

2. The method according to claim 1, wherein the comfort index is calculated as a total sum of products obtained by multiplying at least the outlet air flow rate, the outlet air temperature, the passenger room temperature, and the atmospheric temperature with predetermined constants, and the constants are set on the basis of signs of heat loads generated in the passenger room.

3. The method according to claim 2, wherein the constants are set on the basis of a selected outlet mode of air-conditioning air output into the passenger room.

4. The method according to claim 1, further comprising:

   the fourth step of executing air-conditioning control so that the outlet air flow rate and the outlet air temperature searched in the third step are realized.

5. The method according to claim 1, wherein the first to fourth steps are repeated until the comfort index becomes a numerical value falling within a range that is preferable for the comfort of the passenger.

6. The method according to claim 1, wherein the fourth step is executed in a stable period wherein a control state of the air-conditioning control is stabilized.

7. The method according to claim 1, further comprising:

   the fifth step of changing the outlet mode of air-conditioning air when the comfort index preferable for the comfort of the passenger cannot be obtained by only changing the target temperature in the fourth step.

8. The method according to claim 1, wherein the first step having a step of predicting an optimal target temperature on the basis of the comfort index obtained under an assumption that a control state of air-conditioning control is in a stable period, and a heat balance equation, and
   the second step having a step of selection an outlet air flow rate and an outlet air temperature on the basis of the target temperature predicted in the first step and a comfort index, as parameters, factors which influence comfort actually felt by the passenger in the passenger room.

9. The method according to claim 8, wherein the first step includes the step of predicting an optimal outlet mode with reference to the comfort index, and the third step includes the step of executing the air-conditioning control on the basis of the outlet mode predicted in the first step as well as the outlet air flow rate and the outlet air temperature.

10. An apparatus for controlling a vehicle air conditioner, which controls an outlet air flow rate and an outlet air tem-

perature of air-conditioning air while balancing between a heat amount supplied from an air-conditioner for adjusting the air-conditioning air into a passenger room, and a heat load acting on a vehicle, **characterized by** comprising:

calculation means for calculating a comfort index (F) representing a comfort level of a passenger on the basis of the outlet air flow rate (Va), the outlet air temperature (To), the passenger room temperature (Tr), an atmospheric temperature (Ta) and a solar radiation amount, and obtaining, from a heat balance equation, a plurality of combinations of the outlet air flow rates (Va) and the outlet air temperatures (To) necessary for maintaining a passenger room temperature (Tr) to be a predetermined target temperature;
detection means for detecting information which is necessary for calculating the comfort index (F); and
selecting means for selecting a combination of the outlet air flow rate (Va) and the outlet air temperature (To) so that the comfort index (F) becomes closest to an optimal value, for selecting a combination of the outlet air flow rate and the outlet air temperature, which can provide a comfort index (F) closest to an optimal value of the comfort index, from the plurality of combinations of the outlet air flow rates and the outlet air temperatures, and for changing the target temperature when the comfort index calculated based on the combination of the outlet air flow rate and the outlet air temperature searched in the third step is a numerical value falling within a range that is not preferable for comfort of the passenger.

11. The apparatus according to claim 10, wherein said second calculation means calculates the comfort index as a total sum of products obtained by multiplying at least the outlet air flow rate (Va), the outlet air temperature (To), the passenger room temperature (Tr), and the atmospheric temperature (Ta) with predetermined constants which are set on the basis of signs of heat loads generated in the passenger room.

12. The apparatus according to claim 11, wherein said second calculation means calculates the comfort index (F) as a total sum of products obtained by multiplying at least the outlet air flow rate (Va), the outlet air temperature (To), the passenger room temperature (Tr), and the atmospheric temperature (Ta) with predetermined constants which are set on the basis of a selected outlet mode of air-conditioning air output into the passenger room.

13. The apparatus according to claim 10, further comprising:

control means for executing air-conditioning control so that the outlet air flow rate (Va) and the outlet air temperature (To) searched by a search means are realized.

14. The apparatus according to claim 10, comprising:

a comfort index calculation means for calculating a comfort index (F) having, as parameters, factors which influence comfort felt by a passenger at the beginning of an operation of the air conditioner;
a detection means for detecting information which is necessary for calculating the comfort index (F) ; and a control means for controlling the air conditioner in accordance with the comfort index (F) at the beginning of the operation of the air conditioner so as to reduce a discomfort felt by a passenger.

15. The apparatus according to claim 14, wherein the beginning of the operation of the air conditioner is the beginning of a warming operation.

16. The apparatus according to claim 15, further comprising:

comfort index calculation means for calculating a comfort index (F) including, as parameters, factors which influence comfort of a passenger in heating control during a warm-up operation;
detection means for detecting information necessary for calculating the comfort index (F); and
outlet mode control means for changing an outlet mode in the heating control during the warm-up operation in accordance with a value of the comfort index (F) calculated by said comfort index calculation means.

17. The apparatus according to claim 16, wherein the parameters of the comfort index include a passenger room temperature (Tr).

18. The apparatus according to claim 17, wherein the parameters of the comfort index include an outlet air flow rate (Va) and an outlet air temperature (To) of air-conditioning air.

19. The apparatus according to claim 14, wherein the beginning of the operation of the air conditioner is the beginning

of a cooling operation.

20. The apparatus according to claim 19, further comprising:

a calculation means for calculating a discomfort level felt by a passenger before a temperature of an evaporator is decreased at the beginning of a cooling operation, and a comfort level which will be the passenger under an assumption that air-conditioning air is output after the temperature of said evaporator begins to fall at the beginning of the cooling operation;
a comparing means for comparing the discomfort level with the comfort level; and
a control means for controlling the air conditioner so that when the comfort level represents a state more comfortable than that represented by the discomfort level, an outlet operation of air-conditioning air is started.

21. The method according to claim 1, wherein the comfort index calculation includes, as parameters, factors which influence comfort felt by a passenger at the beginning of an operation of the air conditioner; and wherein
the air conditioner is controlled in accordance with the comfort index at the beginning of the operation of the air conditioner so as to reduce the discomfort felt by the passenger.

22. The method according to claim 1, wherein a discomfort level felt by a passenger before a temperature of an evaporator is decreased at the beginning of a cooling operation, and a comfort level which will be felt by the passenger under an assumption that air-conditioning air is output after the temperature of said evaporator begins to fall at the beginning of the cooling operation are compared with each other, and when the comfort level represents a state more comfortable than that represented by the discomfort level, an outlet operation of air-conditioning air is started.

23. The apparatus according to claim 10, wherein said calculation means calculate a comfort index, including, as a parameter, a passenger room temperature (Tr) at the beginning of the heating control during the warm-up operation; and wherein
air flow rate control means is provided for decreasing in accordance with the comfort index a rate of increase in outlet air flow rate (Va) as compared to a case wherein the passenger room temperature (Tr) is high and the comfort index has a large value, when the passenger room temperature (Tr) is low and the comfort index has a small value.

24. The method according to claim 1, wherein the comfort index, including, as a parameter, a passenger room temperature (Tr) at the beginning of the heating control during the warm-up operation, is calculated by using detected information which is necessary for calculating this comfort index, and wherein, when the passenger room temperature (Tr) is low and the comfort index has a small value, a rate of increase in outlet air flow rate (Va) is decreased as compared to a case wherein the passenger room temperature (Tr) is high and the comfort index has a large value, in accordance with the comfort index.

Patentansprüche

1. Verfahren zur Regelung einer Fahrzeugklimaanlage, bei dem eine Auslaßluft-Strömungsrate und eine Auslaßluft-Temperatur einer klimatisierten Luft geregelt werden, wobei zwischen einer Wärmemenge, die von einer Klimaanlage in einen Fahrgastraum hinein zum Einstellen der klimatisierten Luft geliefert wird, und einer auf das Fahrzeug wirkenden Wärmebelastung ausgeglichen wird,
gekennzeichnet durch
einen ersten Verfahrensschritt, bei dem die Information ermittelt wird, die zur Berechnung eines Behaglichkeitsindex nötig ist, der einen Behaglichkeitspegel eines Passagiers darstellt und mit dem aus einer Wärmegleichgewichtsgleichung zahlreiche Kombinationen von Auslaßluft-Strömungsraten und Auslaßluft-Temperaturen ermittelt werden, die notwendig sind, um eine. Fahrgastraum-Temperatur auf einer vorbestimmen Soll-Temperatur zu halten;
einen zweiten Schritt, bei dem der Behaglichkeitsindex F auf der Grundlage der Auslaßluft-Strömungsrate, der Auslaßluft-Temperatur, der Fahrgastraum-Temperatur, einer Atmosphären-Temperatur und einer Sonnenstrahlungsmenge Ts berechnet wird;
einen dritten Schritt, bei dem die Kombination aus Auslaßluft-Strömungsrate und Auslaßluft-Temperatur so gewählt wird, dass der Behaglichkeitsindex einem optimalen Wert am nächsten kommt, und
einen vierten Schritt, bei dem die Soll-Temperatur geändert wird, wenn der auf der Kombination der Auslaßluft-Strömungsrate und der Auslaßluft-Temperatur, die im dritten Verfahrensschritt gesucht wurde, berechnete Behag-

lichkeitsindex ein numerischer Wert ist, der innerhalb eines Bereichs fällt, der für das Behagen des Passagiers nicht günstig ist.

2. Verfahren nach Anspruch 1, bei dem der Behaglichkeitsindex als Gesamtsumme von Produkten berechnet wird, die durch Multiplizieren von wenigstens der Auslaßluft-Strömungsrate, der Auslaßluft-Temperatur, der Fahrgastraum-Temperaturen und der Atmosphären-Temperatur mit vorbestimmten Konstanten ermittelt werden, und wobei die Konstanten auf der Grundlage von Anzeichen von Wärmebelastungen eingestellt werden, die in dem Fahrgastraum erzeugt werden.

3. Verfahren nach Anspruch 2, bei dem die Konstanten auf der Grundlage eines ausgewählten Auslaßmodus von klimatisierter Luft in den Fahrgastraum hinein eingestellt werden.

4. Verfahren nach Anspruch 2, weiterhin mit dem vierten Schritt, bei dem eine Klimatisierungsregelung so durchgeführt wird, dass die Auslaßluft-Strömungsrate und die Auslaßluft-Temperatur, die in dem dritten Schritt gesucht wurden, verwirklicht werden.

5. Verfahren nach Anspruch 1, bei dem die ersten vier Schritte wiederholt werden bis der Behaglichkeitsindex einen numerischen Wert erreicht, der innerhalb eines Bereichs fällt, welcher für das Behagen des Passagiers günstig ist.

6. Verfahren nach Anspruch 1, bei dem der vierte Schritt in einer stabilen Phase durchgeführt wird, in der ein Regelungszustand der Klimatisierungsregelung stabilisiert ist.

7. Verfahren nach Anspruch 1, zu dem weiterhin ein fünfter Schritt gehört, bei dem die Art des Auslaß von klimatisierter Luft geändert wird, wenn der für das Behagen des Passagiers günstige Behaglichkeitsindex nicht allein durch Änderung der Soll-Temperatur im vierten Schritt erreicht werden kann.

8. Verfahren nach Anspruch 1, bei dem zu dem ersten Schritt ein Schritt gehört, bei dem eine optimale Soll-Temperatur auf der Grundlage des Behaglichkeitsindex, welcher unter einer Annahme erhalten wird, dass ein Regelungszustand der Klimatisierungssteuerung sich in einer stabilen Phase befindet, und einer Wärmebilanzgleichung vorgegeben wird, und
wobei zu dem zweiten Schritt ein Schritt gehört, bei dem eine Auslaßluft-Strömungsrate und eine Auslaßluft-Temperatur auf der Grundlage der im ersten Schritt vorgegebenen Soll-Temperatur und ein Behaglichkeitsindex als Parameter hinsichtlich Faktoren ausgewählt werden, die die aktuelle Behaglichkeit beeinflussen, welche von einem Passagier in dem Fahrgastraum empfunden wird.

9. Verfahren nach Anspruch 8, bei dem zu dem ersten Schritt der Schritt gehört, einen optimalen Auslaßmodus bzgl. des Behaglichkeitsindex vorzugeben, und wobei zu dem dritten Schritt der Schritt gehört, die Klimatisierungsregelung auf der Grundlage des in dem ersten Schritt vorgegebenen Auslaßmodus sowie der Auslaßluft-Strömungsrate und der Auslaßluft-Temperatur durchzuführen.

10. Vorrichtung zur Regelung einer Fahrzeugklimaanlage, welche eine Auslaßluft-Strömungsrate und eine Auslaßluft-Temperatur einer klimatisierten Luft regelt, wobei zwischen einer Wärmemenge, die von einer Klimaanlage zur Einstellung der klimatisierten Luft in einen Fahrgastraum hinein geliefert wird und einer auf das Fahrzeug wirkenden Wärmebelastung ausgeglichen wird, **gekennzeichnet durch**
eine Berechnungseinrichtung zum Berechnen eines Behaglichkeitsindex (F), der einen Behaglichkeitspegel eines Passagiers auf der Grundlage der Auslaßluft-Strömungsrate (Va), der Auslaßluft-Temperatur (To), der Fahrgastraum-Temperatur (Tr), einer Atmosphären-Temperatur (Ta) und einer Sonnenstrahlungsmenge berechnet und mit dem aus einer Wärmegleichgewichtsgleichung zahlreiche Kombinationen von Auslaßluft-Strömungsraten (Va) und Auslaßluft-Temperaturen (To) ermittelt werden, die notwendig sind, um eine Fahrgastraum-Temperatur (Tr) auf einer vorbestimmen Soll-Temperatur zu halten;
eine Ermittlungseinrichtung zum Erfassen von Informationen, die nötig zur Berechnung des Behaglichkeitsindex (F) sind; und
eine Auswahleinrichtung zur Selektion einer Kombination aus der Auslaßluft-Strömungsrate (Va) und der Auslaßluft-Temperatur (To) derart, dass der Behaglichkeitsindex (F) sich einem optimalen Pegel weitest möglich nähert, zur Selektion einer Kombination aus Auslaßluft-Strömungsrate und Auslaßluft-Temperatur, welche einen Behaglichkeitsindex (F) weitest gehend nahe an einem optimalen Pegel des Behaglichkeitsindex erzeugen kann aus zahlreichen Kombinationen von Auslaßluft-Strömungsraten und Auslaßluft-Temperaturen und zum Verändern der Soll-Temperatur, wenn der auf der Kombination der Auslaßluft-Strömungsrate und der Auslaßluft-Temperatur,

die im dritten Verfahrensschritt gesucht wurde, berechnete Behaglichkeitsindex ein numerischer Wert ist, der innerhalb eines Bereichs fällt, der für das Behagen des Passagiers nicht günstig ist.

11. Vorrichtung nach Anspruch 10, bei der die zweite Berechnungseinrichtung den Behaglichkeitsindex als Gesamtsumme von Produkten berechnet, die durch Multiplizieren von wenigstens der Auslaßluft-Strömungsrate (Va), der Auslaßluft-Temperatur (To), der Fahrgastraum-Temperatur (Tr) und der Atmosphären-Temperatur (Ta) mit vorbestimmten Konstanten erhalten werden, welche auf der Basis von Anzeichen von in dem Fahrgastraum erzeugten Wärmebelastungen eingestellt sind.

12. Vorrichtung nach Anspruch 11, bei der die zweite Berechungseinrichtung dem Behaglichkeitsindex (F) als Gesamtsumme von Produkten berechnet, die durch Multiplizieren von wenigstens der Auslaßluft-Strömungsrate (Va), der Auslaßluft-Temperatur (To), der Fahrgastraum-Temperatur (Tr) und der Atmosphären-Temperatur (Ta) mit vorbestimmten Konstanten ermittelt wird, die auf der Grundlage eines ausgewählten Auslaßmodus der klimatisierten Luftabgabe in den Fahrgastraum hinein eingestellt sind.

13. Vorrichtung nach Anspruch 10, weiterhin **gekennzeichnet durch** eine Regelungseinrichtung, **durch** die die Klimatisierungsregelung derart durchführbar ist, dass die Auslaßluft-Strömungsrate (Va) und die Auslaßluft-Temperatur (To), welche von einer Sucheinrichtung gesucht wurden, realisiert werden.

14. Vorrichtung nach Anspruch 10, bestehend aus:

einer Behaglichkeitsindexberechnungseinrichtung zur Berechnung eines Behaglichkeitsindex (F), der als Parameter Faktoren besitzt, die die von einem Passagier zu Beginn eines Betriebs der Klimaanlage empfundene Behaglichkeit beeinflussen;

eine Ermittlungseinrichtung zur Erfassung von Informationen, die nötig für die Berechnung des Behaglichkeitsindex (F) sind; und einer Regelungseinrichtung zur Regelung der Klimaanlage in Übereinstimmung mit dem Behaglichkeitsindex (F) zu Beginn des Betriebs der Klimaanlage zur Verringerung einer von einem Passagier empfundenen Unbehaglichkeit.

15. Vorrichtung nach Anspruch 14, bei der der Beginn des Betriebs der Klimaanlage der Beginn eines Heizbetriebs ist.

16. Vorrichtung nach Anspruch 15, weiterhin bestehend aus:

einer Behaglichkeitsindexberechnungseinrichtung zur Berechnung eines Behaglichkeitsindex (F), der als Parameter Faktoren enthält, welche die Behaglichkeit eines Passagiers bei der Heizungsregelung während eines Aufwärmvorgangs beeinflussen;

eine Ermittlungseinrichtung zum Erfassen von Information, die für die Berechnung des Behaglichkeitsindex (F) erforderlich sind; und

einer Auslaßmodusregeleinrichtung zur Veränderung eines Auslaßmodus bei der Wärmeregelung während des Aufwärmvorgangs entsprechend einem Pegel des Behaglichkeitsindex (F), der durch die Behaglichkeitsindexberechnungseinrichtung berechnet worden ist.

17. Vorrichtung nach Anspruch 16, bei der zu den Parametern des Behaglichkeitsindex eine Fahrgastraum-Temperatur (Tr) gehört.

18. Vorrichtung nach Anspruch 17, wobei zu den Parametern des Behaglichkeitsindex eine Auslaßluft-Strömungsrate (Va) und eine Auslaßluft-Temperatur (To) der klimatisierten Luft gehören.

19. Vorrichtung nach Anspruch 14, bei der Beginn des Betriebs der Klimaanlage der Beginn des Kühlvorgangs ist.

20. Vorrichtung nach Anspruch 19, weiterhin bestehend aus:

einer Berechnungseinrichtung, durch die ein Unbehaglichkeitspegel, der von einem Passagier vor Absenken der Temperatur eines Verdampfers zu Beginn eines Kühlvorgangs empfunden wird, und ein Behaglichkeitspegel berechenbar sind, der von dem Passagier unter der Annahme empfunden wird, dass klimatisierte Luft

abgegeben wird, nachdem die Temperatur des Verdampfers zu Beginn des Kühlvorgangs zu fallen beginnt;

einer Vergleichseinrichtung zum Vergleichen des Unbehaglichkeitspegels mit dem Behaglichkeitspegel; und

einer Regeleinrichtung, durch die die Klimaeinlage derart regelbar ist, dass ein Auslaßvorgang der klimatisierten Luft begonnen wird, wenn der Behaglichkeitspegel einen Zustand darstellt, der behaglicher als derjenige ist, welcher von dem Unbehaglichkeitspegel dargestellt ist.

21. Verfahren nach Anspruch 1, bei dem die Behaglichkeitsindexberechnung als Parameter Faktoren enthält, die die von einem Passagier zu Beginn eines Klimaanlagenbetriebs empfundene Behaglichkeit beeinflussen; und wobei die Klimaanlage in Übereinstimmung mit dem Behaglichkeitsindex zu Beginn des Betriebs der Klimaanlage in der Form geregelt wird, dass die vom Passagier empfundene Unbehaglichkeit verringert wird.

22. Verfahren nach Anspruch 1, bei dem ein Unbehaglichkeitspegel, der von einem Passagier empfunden wird, ehe eine Temperatur eines Verdampfers zu Beginn des Kühlvorgangs abgesenkt wird, und ein Behaglichkeitspegel, der von dem Passagier unter einer Annahme empfunden wird, dass die klimatisierte Luft abgegeben wird, nachdem die Temperatur des Verdampfers zu Beginn des Kühlvorgangs zu fallen beginnt, miteinander verglichen werden, und bei dem dann, wenn der Behaglichkeitspegel einen Zustand darstellt, der behaglicher ist als derjenige, der von dem Unbehaglichkeitspegel repräsentiert wird, einen Auslaßvorgang von klimatisierter Luft begonnen wird.

23. Vorrichtung nach Anspruch 10, bei der die Berechnungseinrichtung einen Behaglichkeitsindex berechnet, zu dem als Parameter eine Fahrgastraum-Temperatur (Tr) zu Beginn der Heizungssteuerung während des Aufwärmvorgangs gehört; und bei der
eine Luftströmungsraten-Regelungseinrichtung vorgesehen ist, durch die in Abhängigkeit von dem Behaglichkeitsindex eine Zunahmerate der Auslaßluft-Strömungsrate (Va) verringerbar ist, wenn die Fahrgastraum-Temperatur (Tr) niedrig und der Behaglichkeitsindex einen kleinen Wert hat im Vergleich zu einem Fall, bei dem die Fahrgastraum-Temperatur (Tr) hoch ist und der Behaglichkeitswert einen großen Wert hat.

24. Verfahren nach Anspruch 1, bei dem der Behaglichkeitsindex, der als Parameter eine Fahrgastraum-Temperatur (Tr) zu Beginn der Aufheizsteuerung während des Aufheizbetriebes aufweist, unter Verwendung ermittelter Informationen berechnet wird, die zur Berechnung dieses Behaglichkeitsindex erforderlich sind, und wobei dann, wenn die Fahrgastraum-Temperatur (Tr) niedrig ist und der Behaglichkeitsindex einen kleinen Wert aufweist, eine Zunahmerate der Auslaßluft-Strömungsrate (Va) in Übereinstimmung mit dem Behaglichkeitsindex im Vergleich zu einem Fall verringert wird, bei dem die Fahrgastraum-Temperatur (Tr) hoch ist und der Behaglichkeitsindex einen großen Wert besitzt.

Revendications

1. Procédé de commande d'une installation de conditionnement d'air d'un véhicule, qui commande un débit de sortie et une température de sortie de l'air du conditionnement d'air tout en assurant un équilibre entre la quantité de chaleur délivrée par une installation de conditionnement d'air, pour ajuster l'air du conditionnement d'air dans un espace de passagers, et une charge thermique agissant sur un véhicule,
caractérisé en ce qu'il comprend :

une première étape de détection d'informations nécessaires pour calculer un indice de confort représentant un niveau de confort d'un passager, et obtenir, à partir d'une équation d'équilibre thermique, une série de combinaisons des débits d'air de sortie et des températures d'air de sortie nécessaires pour maintenir la température de l'espace de passagers à une température cible prédéterminée,
une deuxième étape de calcul de l'indice de confort F sur la base du débit d'air de sortie, de la température d'air de sortie, de la température de l'espace de passagers, d'une température atmosphérique, et d'une quantité de rayonnement solaire T_{Δ} ; et
une troisième étape de sélection d'une combinaison du débit d'air de sortie et de la température d'air de sortie de telle sorte que l'indice de confort devienne le plus proche d'une valeur optimale, et
une quatrième étape de modification de la température cible lorsque l'indice de confort calculé basé sur la combinaison du débit d'air de sortie et de la température d'air de sortie recherchée dans la troisième étape est une valeur numérique qui se situe dans une plage qui n'est pas préférable pour le confort du passager.

2. Procédé selon la revendication 1, dans lequel l'indice de confort est calculé sous la forme de la somme totale des produits obtenus en multipliant au moins le débit d'air de sortie, la température d'air de sortie, la température de l'espace de passagers et la température atmosphérique par des constantes prédéterminées, et dans lequel les constantes sont établies sur la base de signes de charges thermiques générées dans l'espace de passagers.

3. Procédé selon la revendication 2, dans lequel les constantes sont établies sur la base d'un mode de sortie sélectionné de l'air du conditionnement d'air délivré à l'espace de passagers.

4. Procédé selon la revendication 1, comprenant par ailleurs une quatrième étape qui consiste à effectuer une commande du conditionnement d'air de manière à atteindre le débit d'air de sortie et la température d'air de sortie recherchés dans la troisième étape.

5. Procédé selon la revendication 1, dans lequel les première à quatrième étapes sont répétées jusqu'à ce que l'indice de confort atteigne une valeur numérique qui se situe dans une plage qui est préférable pour le confort du passager.

6. Procédé selon la revendication 1, dans lequel la quatrième étape est réalisée dans une période stable dans laquelle l'état de commande du conditionnement d'air est stabilisé.

7. Procédé selon la revendication 1, comprenant par ailleurs une cinquième étape qui consiste à modifier le mode de sortie de l'air du conditionnement d'air lorsque l'indice de confort préférable pour le confort du passager ne peut être obtenu en changeant uniquement la température cible dans la quatrième étape.

8. Procédé selon la revendication 1, qui consiste à prédire une température cible optimale sur la base de l'indice de confort obtenu dans l'hypothèse où l'état de commande du conditionnement d'air se trouve dans une période stable, et d'une équation d'équilibre thermique, et dans lequel la deuxième étape comporte une étape de sélection d'un débit d'air de sortie sur la base de la température cible prédite dans la première étape et d'un indice de confort ayant, en tant que paramètres; des facteurs qui influencent le confort réellement ressenti par le passager dans l'espace de passagers.

9. Procédé selon la revendication 8, dans lequel la première étape comprend l'étape de prédiction d'un mode de sortie optimal en se référant à l'indice de confort, et dans lequel la troisième étape comprend l'étape d'exécution de la commande du conditionnement d'air sur la base du mode de sortie prédit dans la première étape, ainsi que du débit d'air de sortie et de la température d'air de sortie.

10. Appareil de commande d'une installation de conditionnement d'air d'un véhicule, qui commande un débit d'air de sortie et une température d'air de sortie de l'air du conditionnement d'air tout en assurant un équilibre entre la quantité de chaleur délivrée par une installation de conditionnement d'air, pour ajuster l'air du conditionnement d'air dans un espace de passagers, et une charge thermique agissant sur le véhicule,
caractérisé en ce qu'il comprend :

des moyens de calcul pour calculer un indice de confort (F) représentant le niveau de confort d'un passager sur la base du débit d'air de sortie (Va), de la température d'air de sortie (To), de la température de l'espace de passagers (Tr), d'une température atmosphérique (Ta) et d'une quantité de rayonnement solaire, et obtenir, à partir d'une équation d'équilibre thermique, une série de combinaisons des débits d'air de sortie (Va) et des températures d'air de sortie (To) nécessaires au maintien de la température (Tr) de l'espace de passagers à une température cible prédéterminée,
des moyens de détection pour détecter les informations nécessaires au calcul de l'indice de confort (F), et
des moyens de sélection pour sélectionner une combinaison du débit d'air de sortie (To) de telle sorte que l'indice de confort (F) devienne le plus proche d'une valeur optimale, pour sélectionner une combinaison du débit d'air de sortie et de la température d'air de sortie qui peut assurer un indice de confort (F) le plus proche d'une valeur optimale de l'indice de confort, à partir de la série de combinaisons des débits d'air de sortie et des températures d'air de sortie, et pour changer la température cible lorsque l'indice de confort calculé sur la base de la combinaison du débit d'air de sortie et de la température d'air de sortie recherchée dans la troisième étape est une valeur numérique qui se situe dans une plage qui n'est pas préférable pour le confort du passager.

11. Appareil selon la revendication 10, dans lequel lesdits deuxièmes moyens de calcul calculent l'indice de confort sous la forme de la somme totale des produits obtenus en multipliant au moins le débit d'air de sortie (Va), la

température d'air de sortie (To), la température (Tr) de l'espace de passagers et la température atmosphérique (Ta) par des constantes prédéterminées qui sont établies sur la base de signes de charges thermiques générées dans l'espace de passagers.

12. Appareil selon la revendication 11, dans lequel lesdits deuxièmes moyens de calcul calculent l'indice de confort (F) sous la forme de la somme totale des produits obtenus en multipliant au moins le débit d'air de sortie (Va), la température d'air de sortie (To), la température (Tr) de l'espace de passagers et la température atmosphérique (Ta) par des constantes prédéterminées qui sont établies sur la base d'un mode de sortie sélectionné de l'air du conditionnement d'air délivré à l'espace de passagers.

13. Appareil selon la revendication 10, comprenant par ailleurs des moyens de commande pour effectuer une commande du conditionnement d'air de manière à atteindre le débit d'air de sortie (Va) et la température d'air de sortie (To) recherchés par des moyens de recherche.

14. Appareil selon la revendication 10, comprenant :

un moyen de calcul de l'indice de confort pour calculer un indice de confort (F) ayant, comme paramètres, des facteurs qui influencent le confort ressenti par le passager au début du fonctionnement de l'installation de conditionnement d'air ;
un moyen de détection pour détecter les informations nécessaires au calcul de l'indice de confort (F) ; et un moyen de commande pour commander l'installation de conditionnement d'air en fonction de l'indice de confort (F) au début du fonctionnement de l'installation de conditionnement d'air, de manière à réduire l'inconfort ressenti par un passager.

15. Appareil selon la revendication 14, dans lequel le début du fonctionnement de l'installation de conditionnement d'air est le début d'une opération de chauffage.

16. Appareil selon la revendication 15, comprenant par ailleurs :

des moyens de calculs de l'indice de confort pour calculer un indice de confort (F) comprenant, à titre de paramètres, des facteurs qui influencent le confort d'un passager lors de la commande de chauffage au cours d'une opération de chauffage,
des moyens de détection pour détecter les informations nécessaires au calcul de l'indice de confort (F), et
des moyens de commande du mode de sortie pour modifier le mode de sortie de la commande de chauffage au cours de l'opération de chauffage en fonction d'une valeur de l'indice de confort (F) calculée par lesdits moyens de calcul de l'indice de confort.

17. Appareil selon la revendication 16, dans lequel les paramètres de l'indice de confort comprennent la température (Tr) de l'espace de passagers.

18. Appareil selon la revendication 17, dans lequel les paramètres de l'indice de confort comprennent le débit d'air de sortie (Va) et la température d'air de sortie (To) de l'air du conditionnement d'air.

19. Appareil selon la revendication 14, dans lequel le début du fonctionnement de l'installation de conditionnement d'air est le début d'une opération de refroidissement.

20. Appareil selon la revendication 19, comprenant par aiileurs :

un moyen de calcul pour calculer le niveau d'inconfort ressenti par un passager avant que la température d'un évaporateur ne soit réduite au début de l'opération de refroidissement, et le niveau de confort ressenti par le passager dans l'hypothèse où l'air du conditionnement d'air est délivré après que la température dudit évaporateur a commencé à descendre au début de l'opération de refroidissement ;
un moyen de comparaison pour comparer le niveau d'inconfort au niveau de confort ; et
un moyen de commande pour commander l'installation de conditionnement d'air de telle sorte que, lorsque le niveau de confort représente un état plus confortable que celui représenté par le niveau d'inconfort, une opération de sortie de l'air du conditionnement d'air soit démarrée.

21. Procédé selon la revendication 1, dans lequel le calcul de l'indice de confort comprend, à titre de paramètres, des

facteurs qui influencent le confort ressenti par un passager au début du fonctionnement de l'installation de conditionnement d'air, et dans lequel l'installation de conditionnement d'air est commandée en fonction de l'indice de confort au début du fonctionnement de l'installation de conditionnement d'air de manière à réduire l'inconfort ressenti par le passager.

22. Procédé selon la revendication 1, dans lequel on compare l'un à l'autre le niveau d'inconfort ressenti par un passager avant que la température d'un évaporateur ne soit réduite au niveau d'une opération de refroidissement, et le niveau de confort qui sera ressenti par le passager dans l'hypothèse où l'air du conditionnement d'air est délivré après que la température dudit évaporateur a commencé à descendre au début de l'opération de refroidissement, et dans lequel, le niveau de confort représente un état plus confortable que celui représenté par le niveau d'inconfort, une opération de sortie de l'air du conditionnement d'air est démarrée.

23. Appareil selon la revendication 10, dans lequel lesdits moyens de calcul calculent un indice de confort comprenant, à titre de paramètre, la température (Tr) de l'espace de passagers au début de la commande de chauffage au cours de l'opération de chauffage, et dans lequel

des moyens de commande du débit d'air sont prévus, pour réduire, en fonction de l'indice de confort, le taux d'augmentation du débit d'air de sortie (Va) en comparaison du cas où la température (Tr) de l'espace de passagers est élevée et où l'indice de confort a une valeur élevée, lorsque la température (Tr) de l'espace de passagers est basse et que l'indice de confort a une valeur basse.

24. Procédé selon la revendication 1, dans lequel l'indice de confort comprenant, à titre de paramètre, la température (Tr) de l'espace de passagers au début de la commande de chauffage pendant l'opération de chauffage, est calculé en utilisant les informations détectées nécessaires au calcul de cet indice de confort, et dans lequel, lorsque la température de l'espace de passagers est basse et que l'indice de confort a une valeur basse, le taux d'augmentation du débit d'air de sortie (Va) est réduit en comparaison du cas où la température (Tr) de l'espace de passagers est élevée et que l'indice de confort a une valeur élevée, en fonction de l'indice de confort.

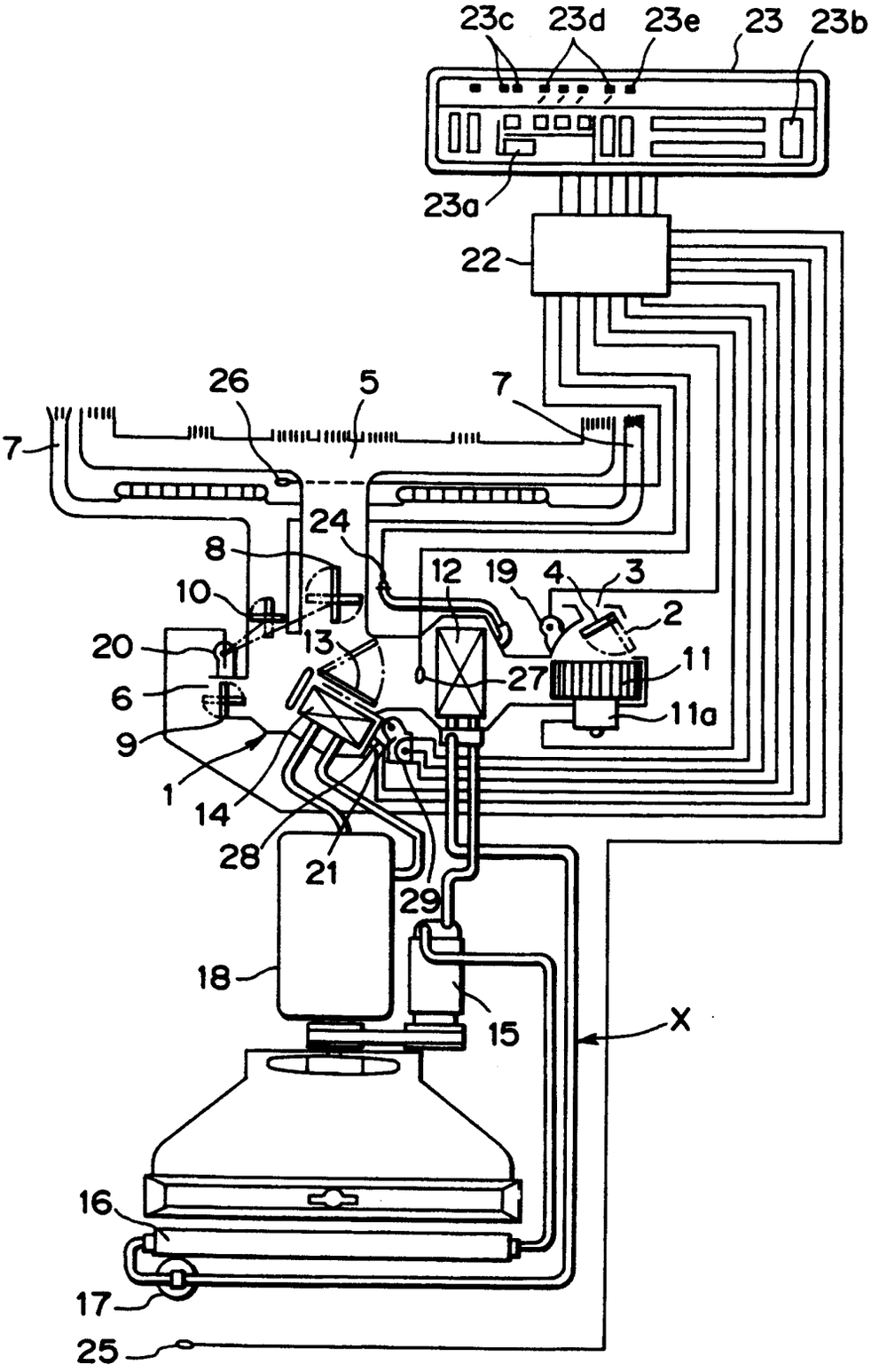
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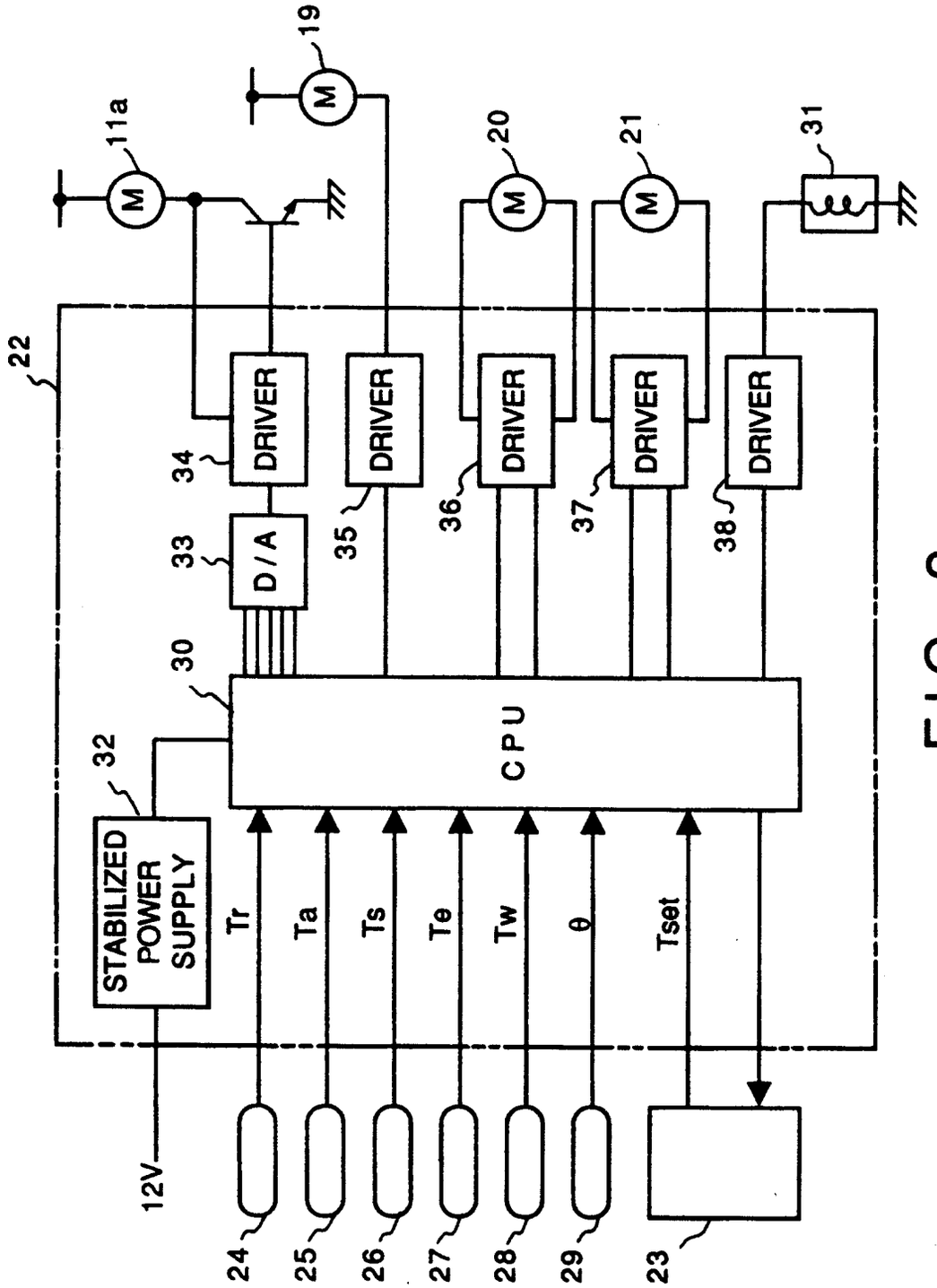
FIG. 1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STABILIZED POWER SUPPLY
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FIG. 2

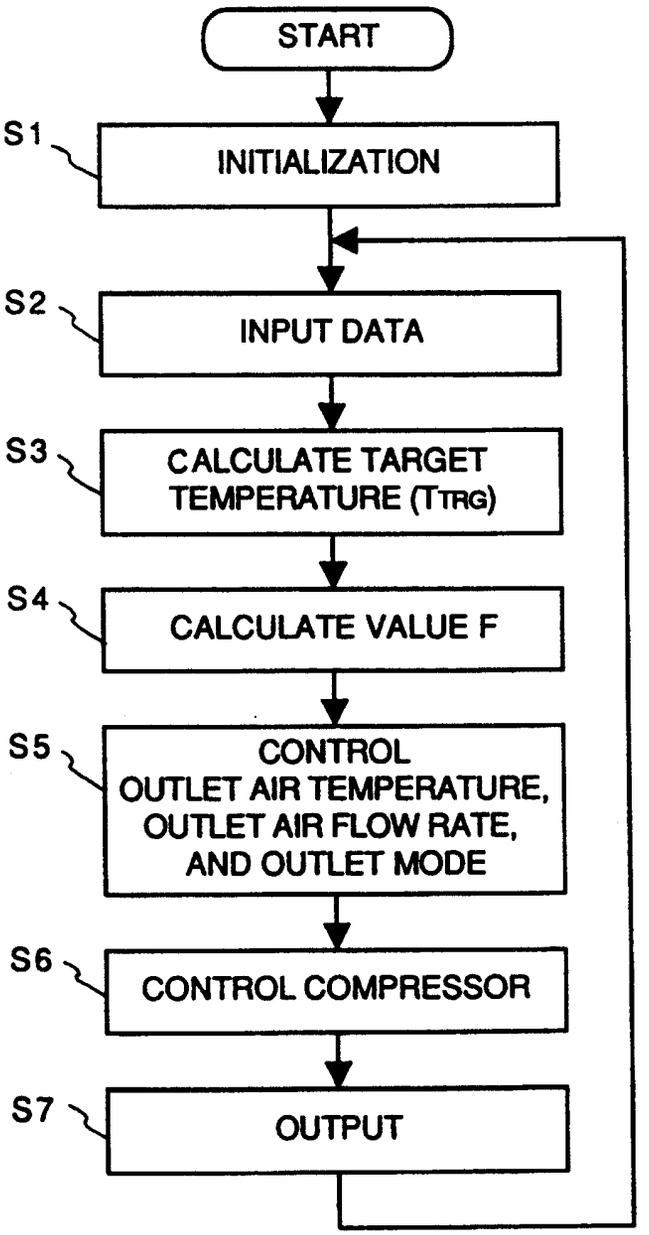
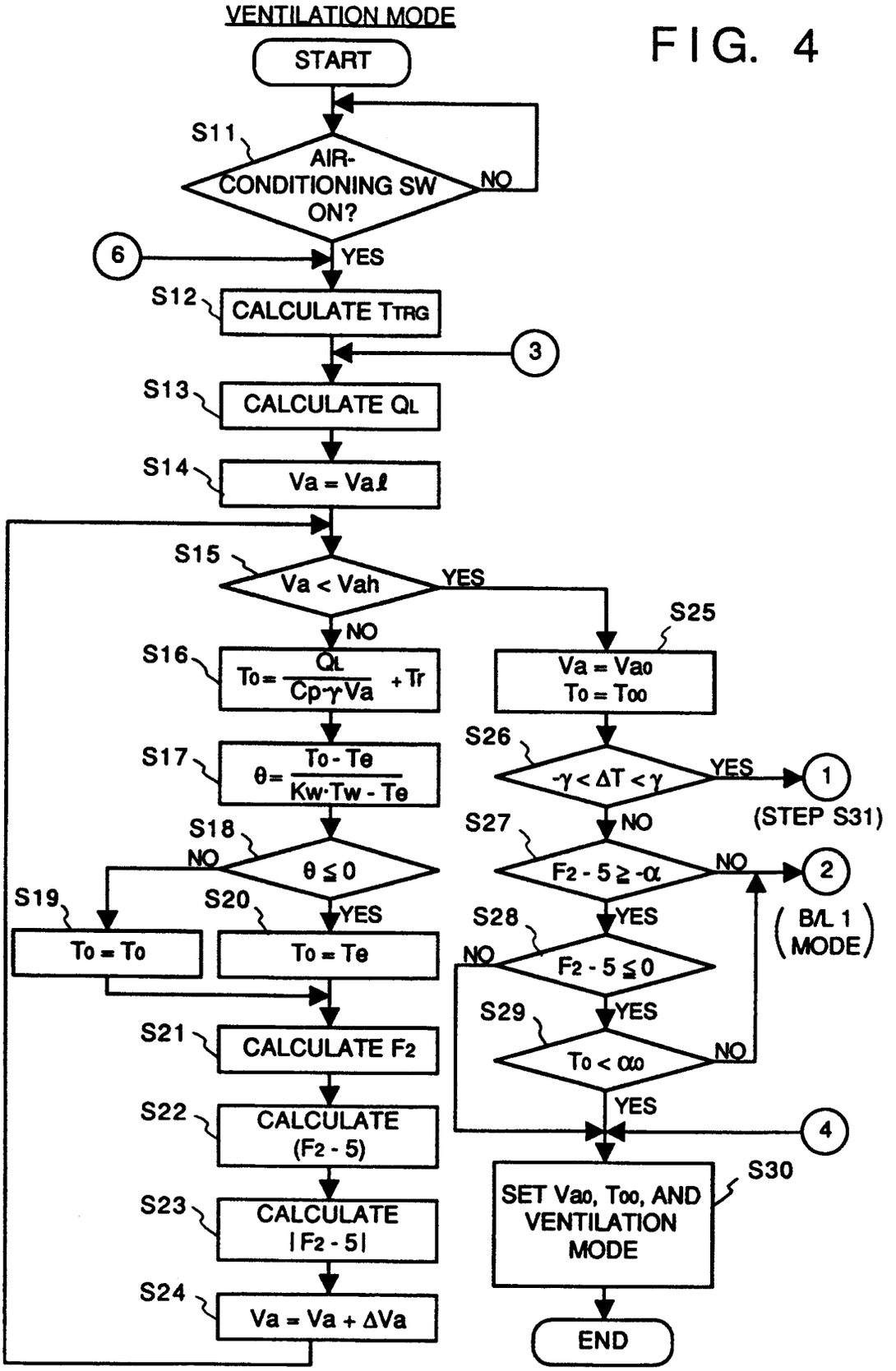

START
S1
INITIALIZATION
S2
INPUT DATA
S3
CALCULATE TARGET TEMPERATURE (TTRG)
S4
CALCULATE VALUE F
S5
CONTROL OUTLET AIR TEMPERATURE, OUTLET AIR FLOW RATE, AND OUTLET MODE
S6
CONTROL COMPRESSOR
S7
OUTPUT

FIG. 3

FIG. 4


VENTILATION MODE
START
S11
AIR-CONDITIONING SW ON?
NO
YES
6
S12
CALCULATE TTRG
3
S13
CALCULATE QL
S14
Va = Vaℓ
S15
Va < Vah
YES
NO
S16
To = QL / (Cp·γVa) + Tr
S17
θ = (To - Te) / (Kw·Tw - Te)
S18
NO
θ ≤ 0
S19
To = To
S20
YES
To = Te
S21
CALCULATE F2
S22
CALCULATE (F2 - 5)
S23
CALCULATE |F2 - 5|
S24
Va = Va + ΔVa
S25
Va = Vao
To = Too
S26
-γ < ΔT < γ
YES
1
(STEP S31)
S27
NO
F2 - 5 ≥ -α
NO
2
(B/L 1 MODE)
S28
YES
NO
F2 - 5 ≤ 0
S29
YES
To < αo
NO
YES
4
S30
SET Vao, Too, AND VENTILATION MODE
END

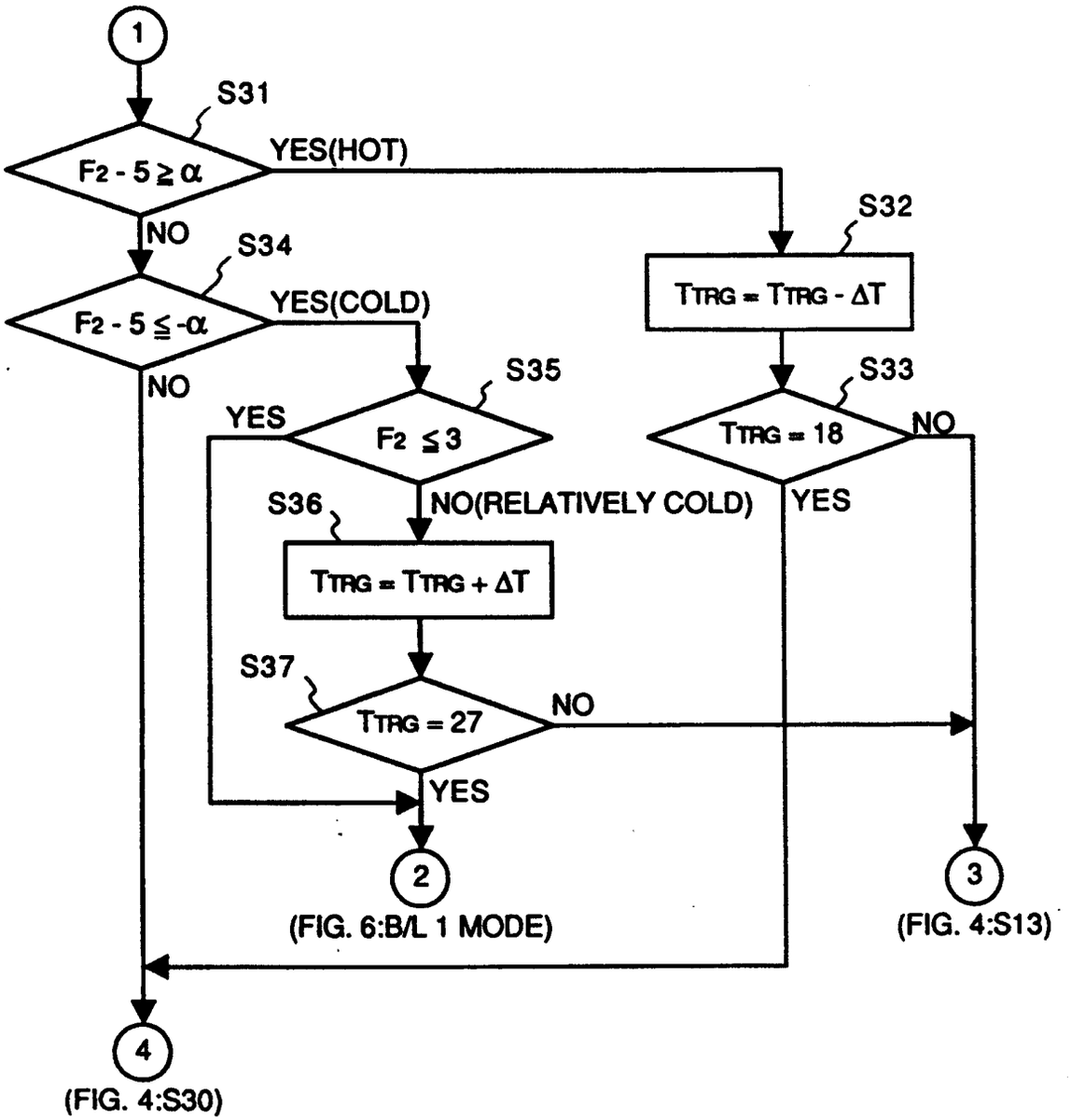
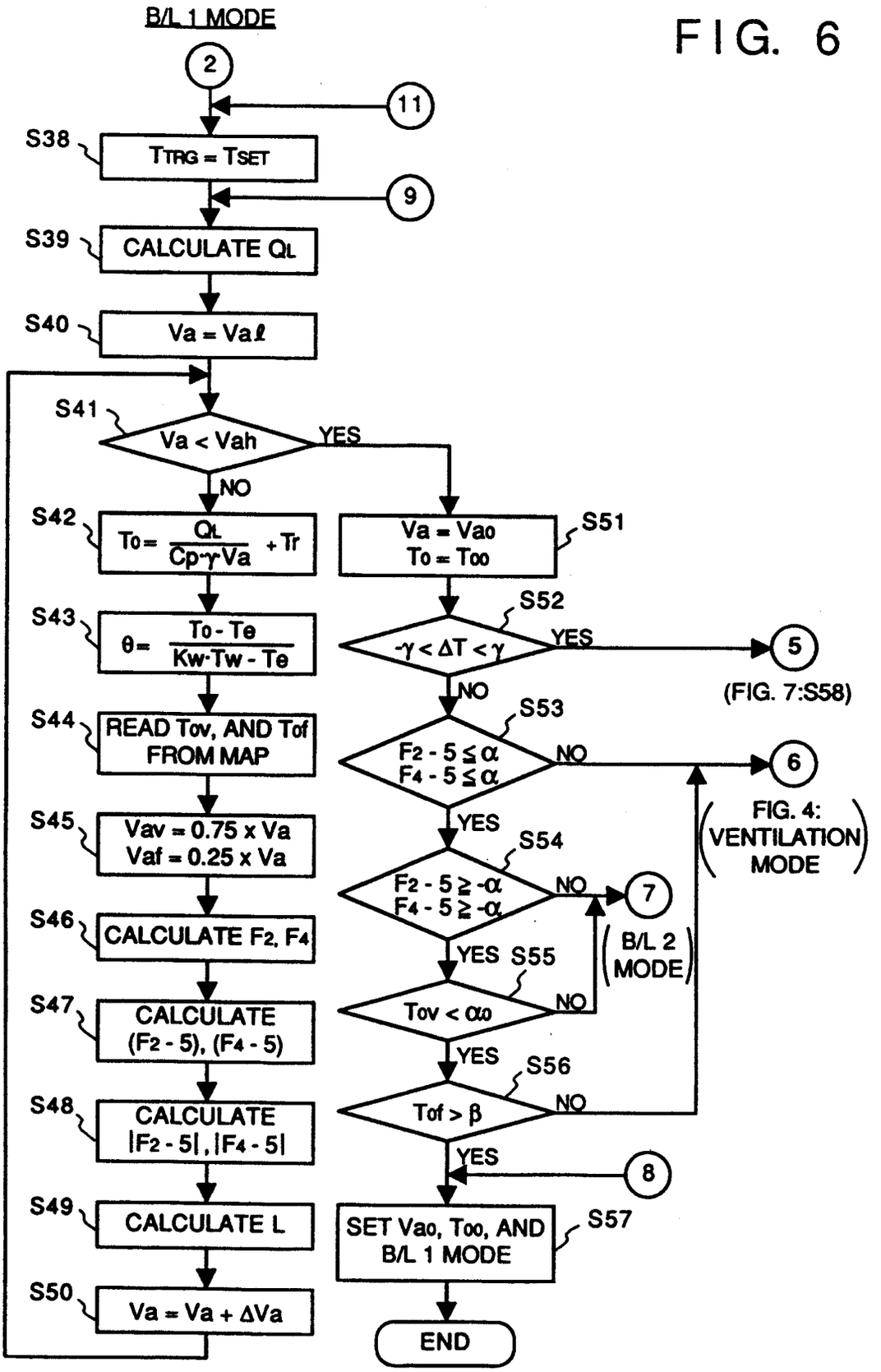

1
S31
F2 - 5 ≧ α
YES(HOT)
NO
S34
F2 - 5 ≦ -α
YES(COLD)
NO
S32
TTRG = TTRG - ΔT
S33
TTRG = 18
NO
YES
S35
YES
F2 ≦ 3
NO(RELATIVELY COLD)
S36
TTRG = TTRG + ΔT
S37
TTRG = 27
NO
YES
2
(FIG. 6:B/L 1 MODE)
3
(FIG. 4:S13)
4
(FIG. 4:S30)

FIG. 5

FIG. 6


B/L 1 MODE
2
11
S38
TTRG = TSET
9
S39
CALCULATE QL
S40
Va = Vaℓ
S41
Va < Vah
YES
NO
S42
To = QL / (Cp·γVa) + Tr
S43
θ = (To - Te) / (Kw·Tw - Te)
S44
READ Tov, AND Tof FROM MAP
S45
Vav = 0.75 x Va
Vaf = 0.25 x Va
S46
CALCULATE F2, F4
S47
CALCULATE (F2 - 5), (F4 - 5)
S48
CALCULATE |F2 - 5|, |F4 - 5|
S49
CALCULATE L
S50
Va = Va + ΔVa
S51
Va = Vao
To = Too
S52
-γ < ΔT < γ
YES
5
(FIG. 7:S58)
NO
S53
F2 - 5 ≦ α
F4 - 5 ≦ α
NO
6
FIG. 4: VENTILATION MODE
YES
S54
F2 - 5 ≧ -α
F4 - 5 ≧ -α
NO
7
B/L 2 MODE
YES
S55
Tov < αo
NO
YES
S56
Tof > β
NO
YES
8
SET Vao, Too, AND B/L 1 MODE
S57
END

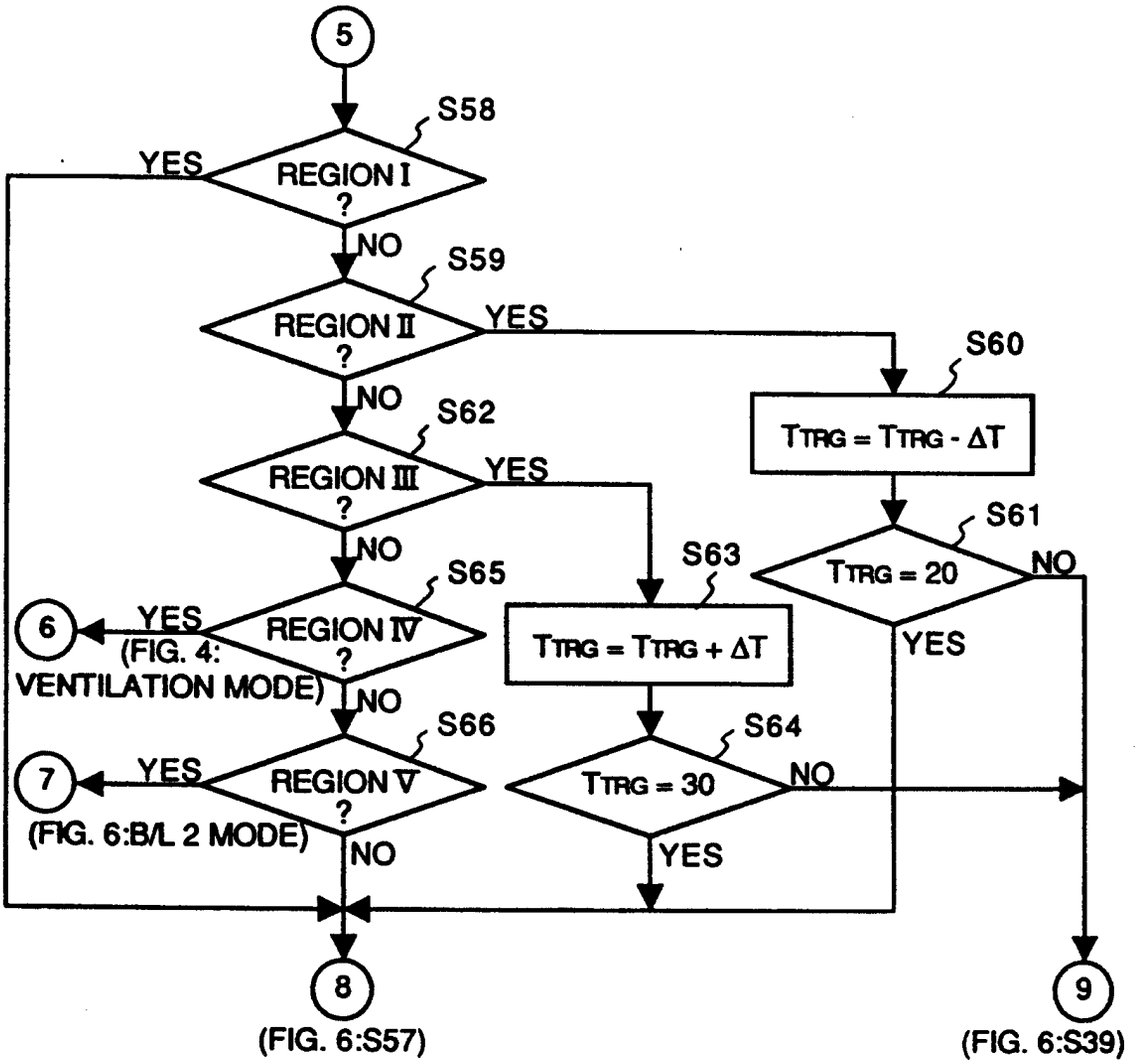
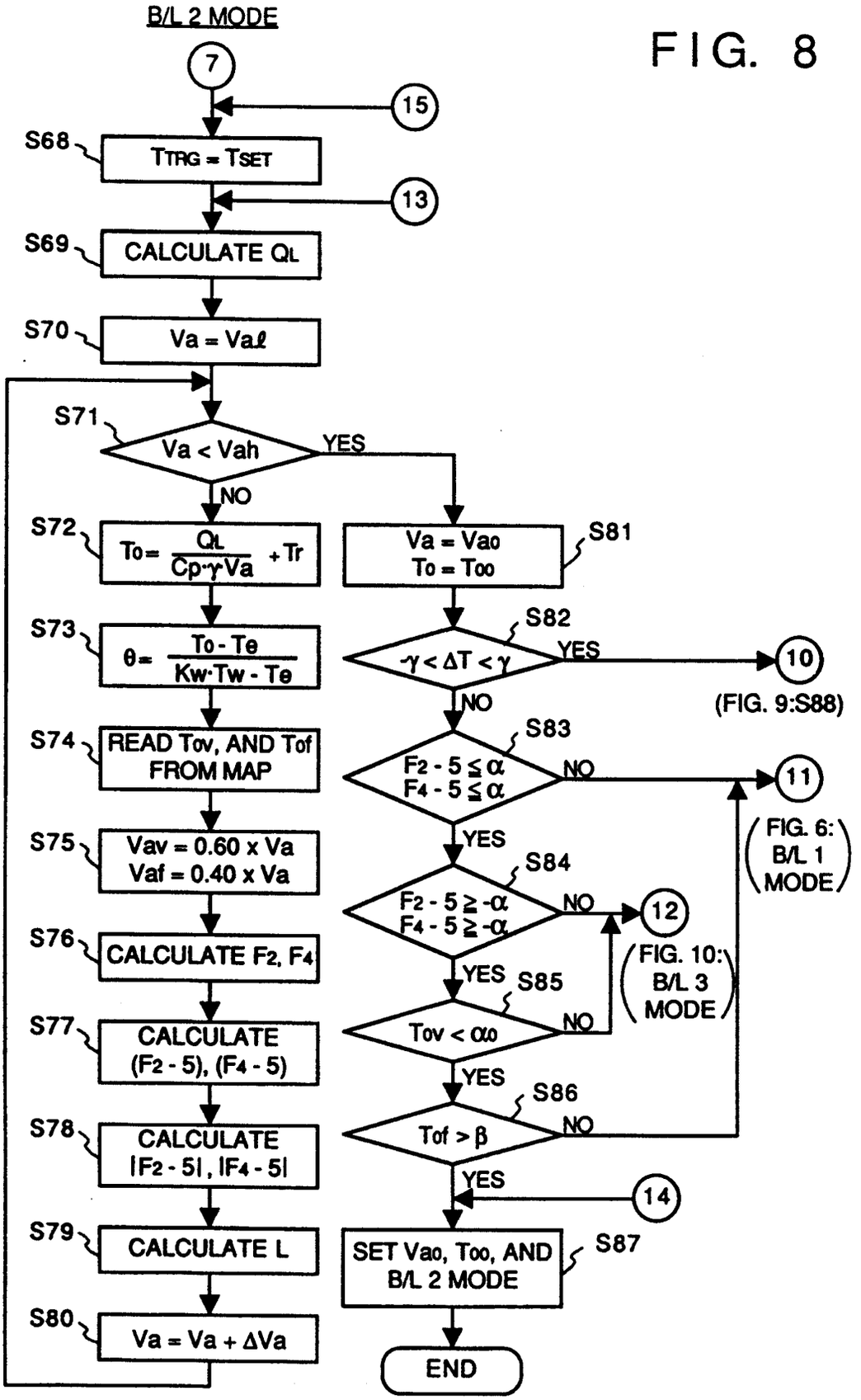

5
S58
YES
REGION I ?
NO
S59
REGION II ?
YES
S60
NO
S62
TTRG = TTRG - ΔT
REGION III ?
YES
S61
NO
S63
S65
TTRG = 20
NO
6
YES
REGION IV ?
TTRG = TTRG + ΔT
YES
(FIG. 4: VENTILATION MODE)
NO
S66
S64
7
YES
REGION V ?
TTRG = 30
NO
(FIG. 6:B/L 2 MODE)
NO
YES
8
9
(FIG. 6:S57)
(FIG. 6:S39)

FIG. 7

FIG. 8


B/L 2 MODE
7
15
S68
TTRG = TSET
13
S69
CALCULATE QL
S70
Va = Vaℓ
S71
Va < Vah
YES
NO
S72
To = QL / (Cp·γVa) + Tr
S73
θ = (To - Te) / (Kw·Tw - Te)
S74
READ Tov, AND Tof FROM MAP
S75
Vav = 0.60 x Va
Vaf = 0.40 x Va
S76
CALCULATE F2, F4
S77
CALCULATE (F2 - 5), (F4 - 5)
S78
CALCULATE |F2 - 5|, |F4 - 5|
S79
CALCULATE L
S80
Va = Va + ΔVa
S81
Va = Vao
To = Too
S82
-γ < ΔT < γ
YES
10
(FIG. 9:S88)
NO
S83
F2 - 5 ≦ α
F4 - 5 ≦ α
NO
11
(FIG. 6: B/L 1 MODE)
YES
S84
F2 - 5 ≧ -α
F4 - 5 ≧ -α
NO
12
(FIG. 10: B/L 3 MODE)
YES
S85
Tov < αo
NO
YES
S86
Tof > β
NO
YES
14
S87
SET Vao, Too, AND B/L 2 MODE
END

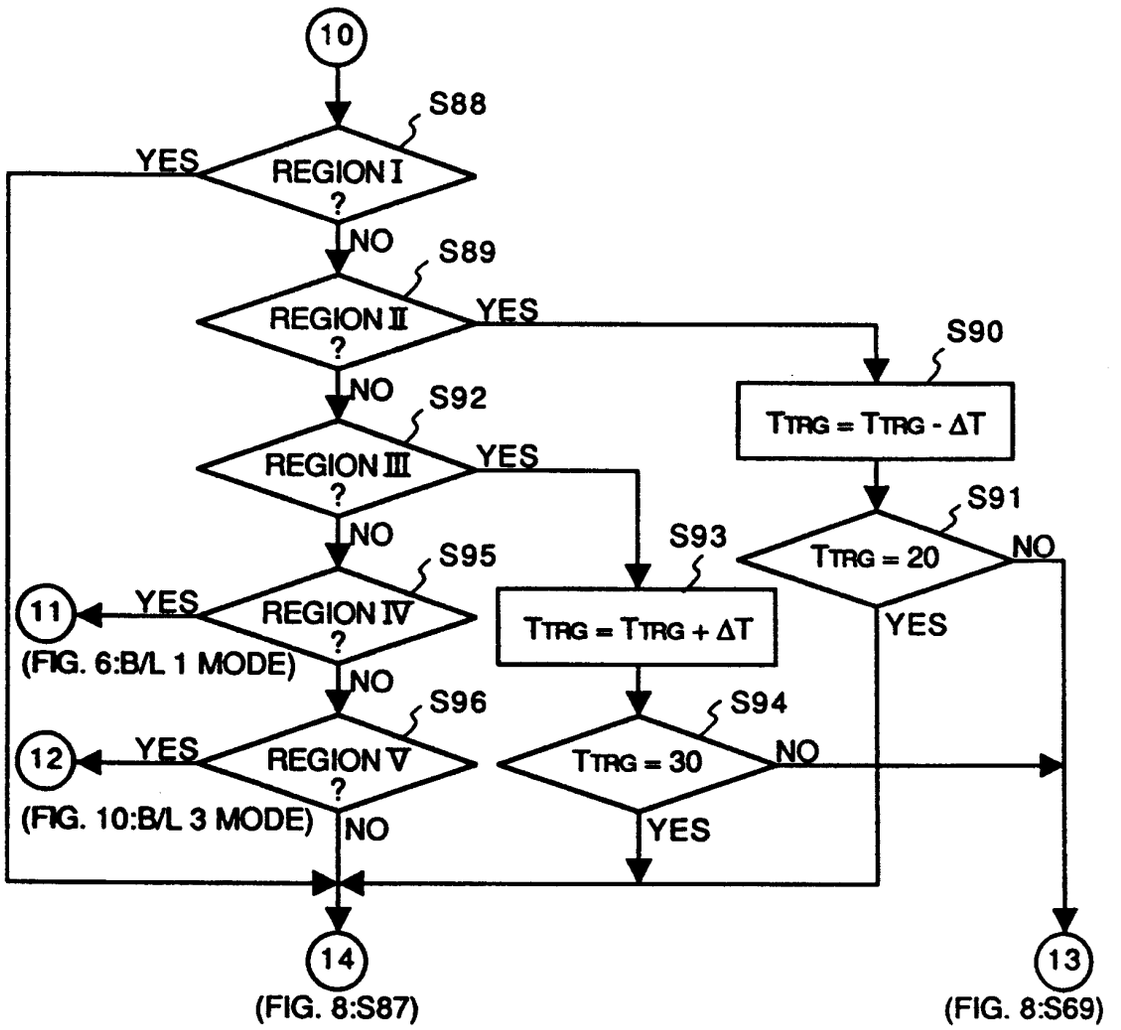
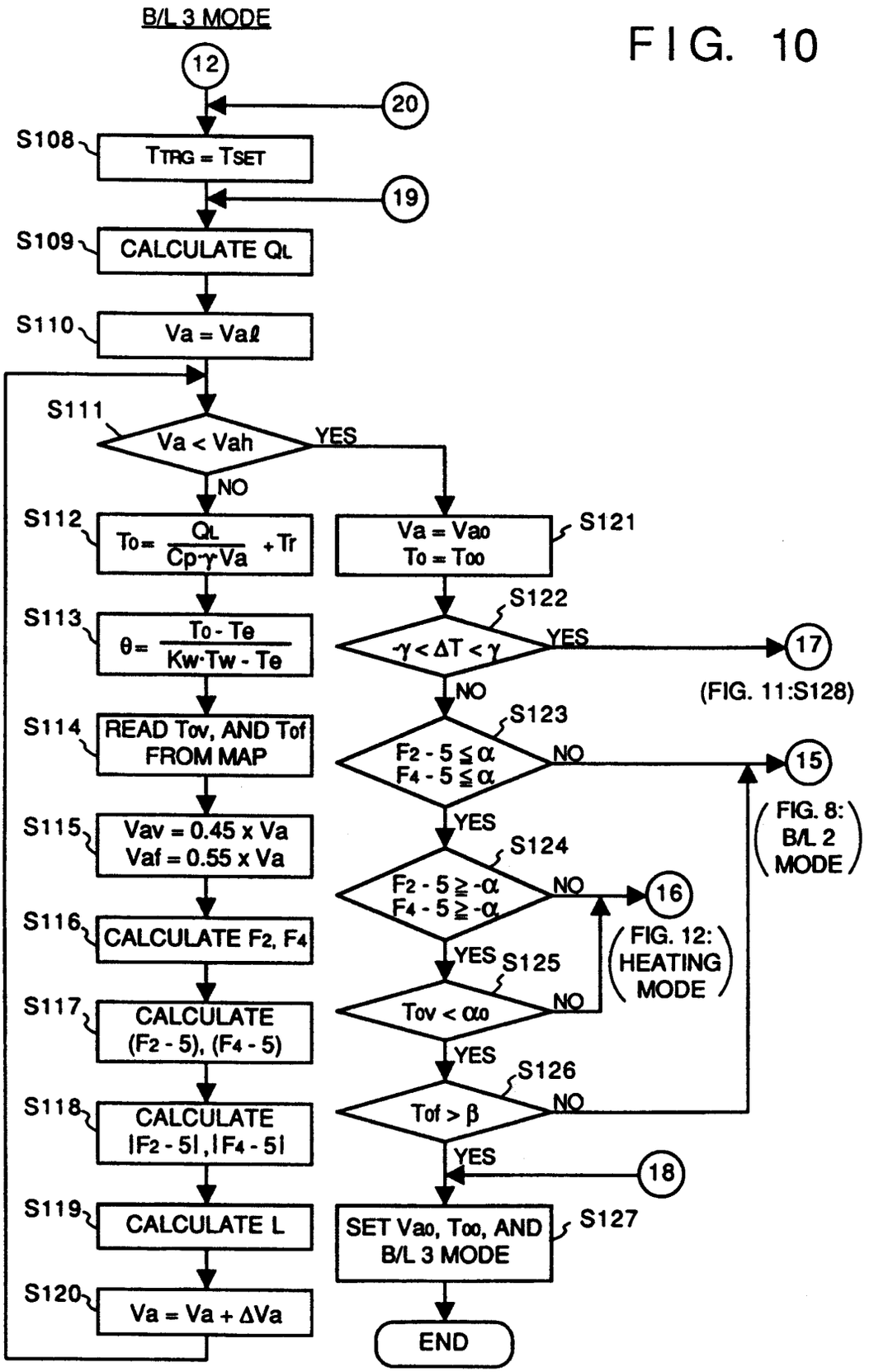

10
S88
YES
REGION I ?
NO
S89
REGION II ?
YES
S90
NO
S92
TTRG = TTRG - ΔT
REGION III ?
YES
S91
NO
S93
S95
TTRG = 20
NO
11
YES
REGION IV ?
TTRG = TTRG + ΔT
YES
(FIG. 6:B/L 1 MODE)
NO
S96
S94
12
YES
REGION V ?
TTRG = 30
NO
(FIG. 10:B/L 3 MODE)
NO
YES
14
13
(FIG. 8:S87)
(FIG. 8:S69)

FIG. 9

FIG. 10


B/L 3 MODE
12
20
S108
TTRG = TSET
19
S109
CALCULATE QL
S110
Va = Vaℓ
S111
Va < Vah
YES
NO
S112
To = QL / (Cp·γ·Va) + Tr
S113
θ = (To - Te) / (Kw·Tw - Te)
S114
READ Tov, AND Tof FROM MAP
S115
Vav = 0.45 x Va
Vaf = 0.55 x Va
S116
CALCULATE F2, F4
S117
CALCULATE (F2 - 5), (F4 - 5)
S118
CALCULATE |F2 - 5|, |F4 - 5|
S119
CALCULATE L
S120
Va = Va + ΔVa
S121
Va = Vao
To = Too
S122
-γ < ΔT < γ
YES
17
(FIG. 11:S128)
NO
S123
F2 - 5 ≦ α
F4 - 5 ≦ α
NO
15
(FIG. 8: B/L 2 MODE)
YES
S124
F2 - 5 ≧ -α
F4 - 5 ≧ -α
NO
16
(FIG. 12: HEATING MODE)
YES
S125
Tov < αo
NO
YES
S126
Tof > β
NO
YES
18
S127
SET Vao, Too, AND B/L 3 MODE
END

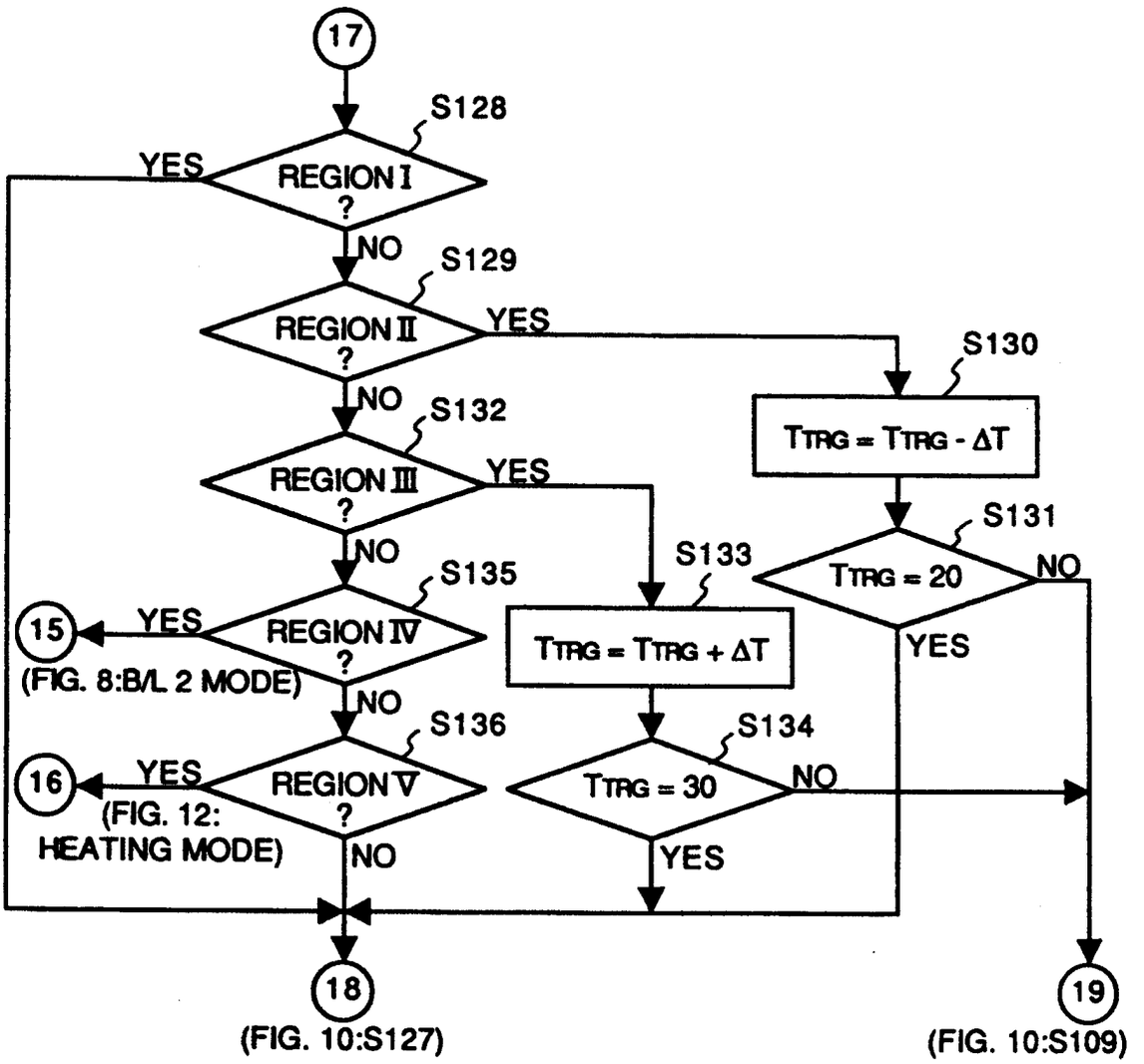
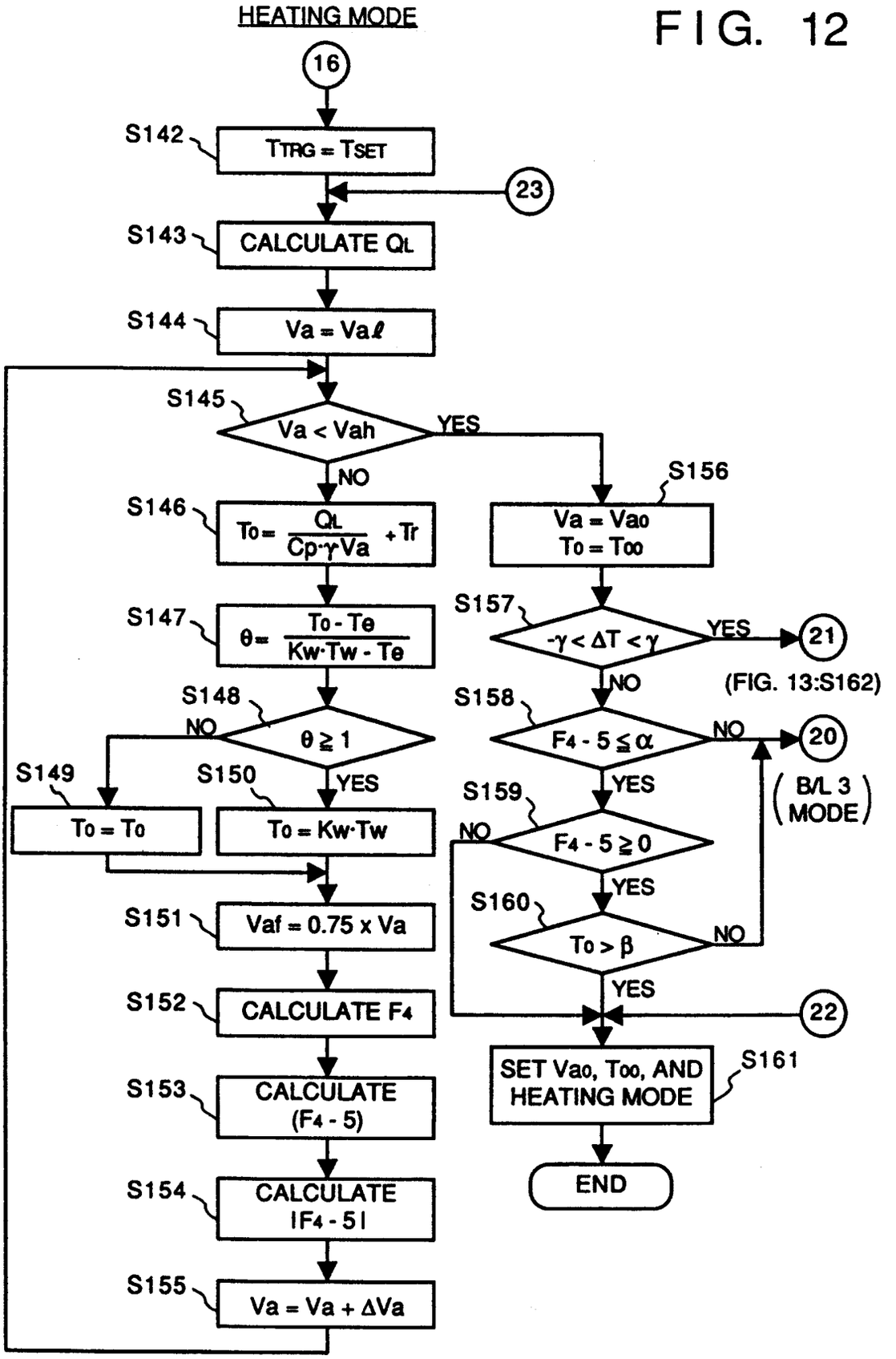

17
S128
YES
REGION I ?
NO
S129
REGION II ?
YES
S130
NO
S132
TTRG = TTRG - ΔT
REGION III ?
YES
S131
NO
S133
S135
TTRG = 20
NO
15
YES
REGION IV ?
TTRG = TTRG + ΔT
YES
(FIG. 8:B/L 2 MODE)
NO
S136
S134
16
YES
REGION V ?
TTRG = 30
NO
(FIG. 12: HEATING MODE)
NO
YES
18
19
(FIG. 10:S127)
(FIG. 10:S109)

FIG. 11

FIG. 12


HEATING MODE
16
S142
TTRG = TSET
23
S143
CALCULATE QL
S144
Va = Vaℓ
S145
Va < Vah
YES
NO
S146
To = QL / (Cp·γVa) + Tr
S147
θ = (To - Te) / (Kw·Tw - Te)
S148
θ ≧ 1
NO
YES
S149
To = To
S150
To = Kw·Tw
S151
Vaf = 0.75 x Va
S152
CALCULATE F4
S153
CALCULATE (F4 - 5)
S154
CALCULATE |F4 - 5|
S155
Va = Va + ΔVa
S156
Va = Vao
To = Too
S157
-γ < ΔT < γ
YES
21
NO
(FIG. 13:S162)
S158
F4 - 5 ≦ α
NO
20
YES
(B/L 3 MODE)
S159
F4 - 5 ≧ 0
NO
YES
S160
To > β
NO
YES
22
S161
SET Vao, Too, AND HEATING MODE
END

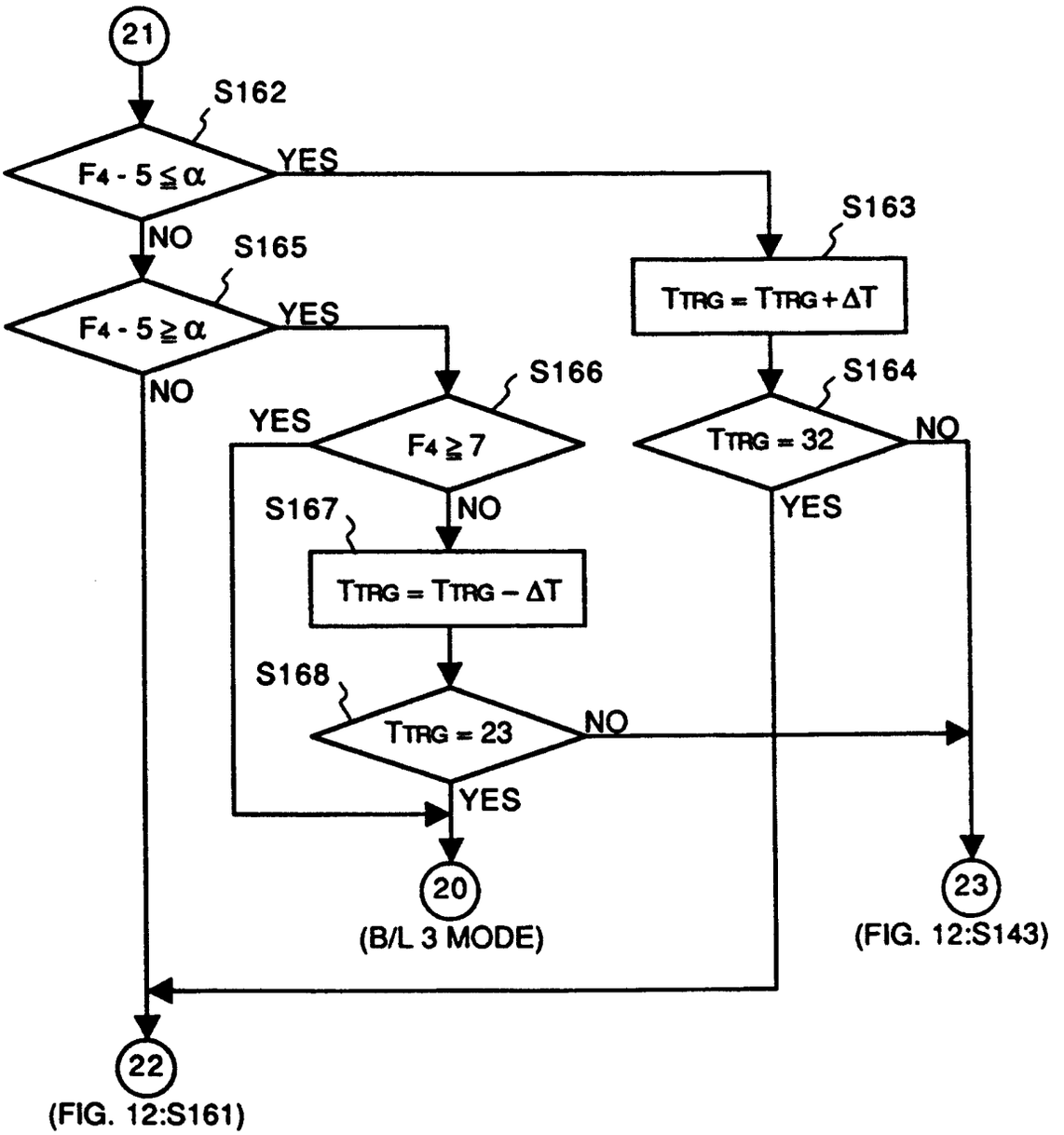

21
S162
F4 - 5 ≦ α
YES
NO
S165
F4 - 5 ≧ α
YES
NO
S163
TTRG = TTRG + ΔT
S164
TTRG = 32
NO
YES
S166
YES
F4 ≧ 7
NO
S167
TTRG = TTRG – ΔT
S168
TTRG = 23
NO
YES
20
(B/L 3 MODE)
23
(FIG. 12:S143)
22
(FIG. 12:S161)

FIG. 13

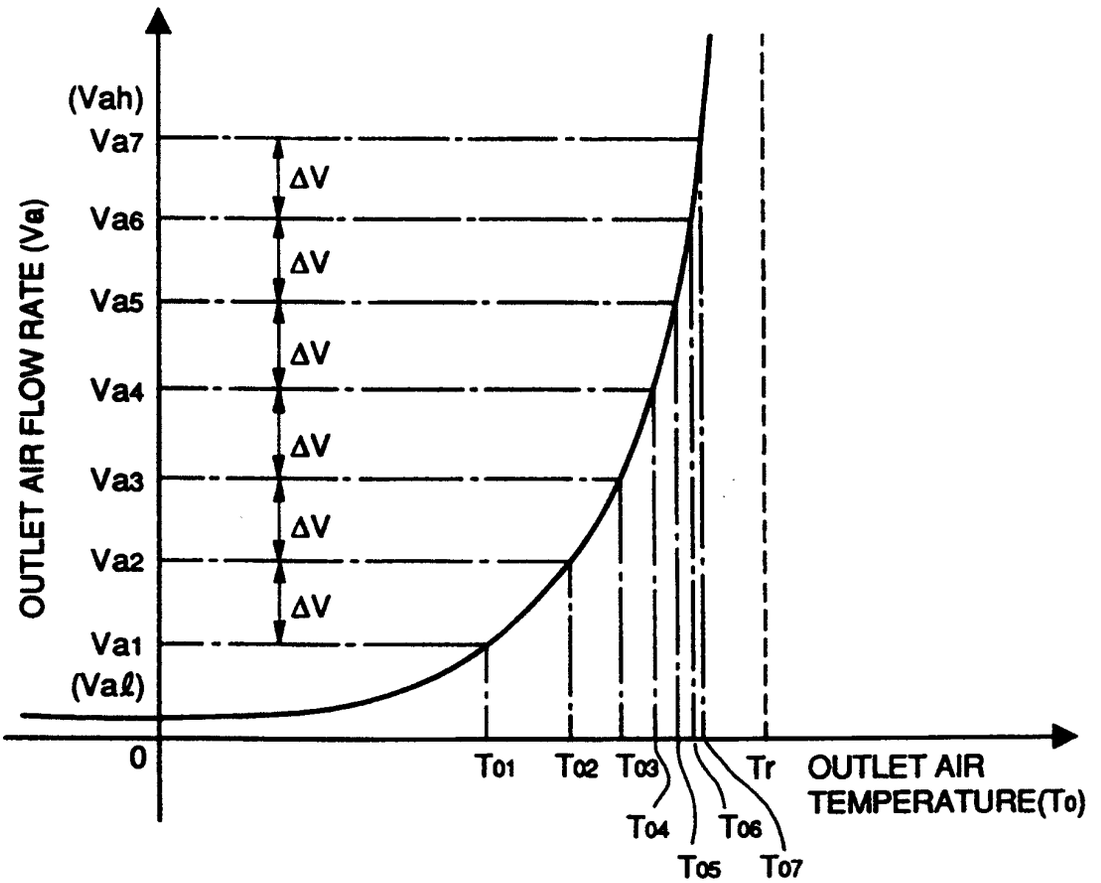

(Vah)
Va7
Va6
Va5
Va4
Va3
Va2
Va1
(Val)
ΔV
ΔV
ΔV
ΔV
ΔV
ΔV
OUTLET AIR FLOW RATE (Va)
0
To1
To2
To3
To4
To5
To6
To7
Tr
OUTLET AIR TEMPERATURE(To)

FIG. 14

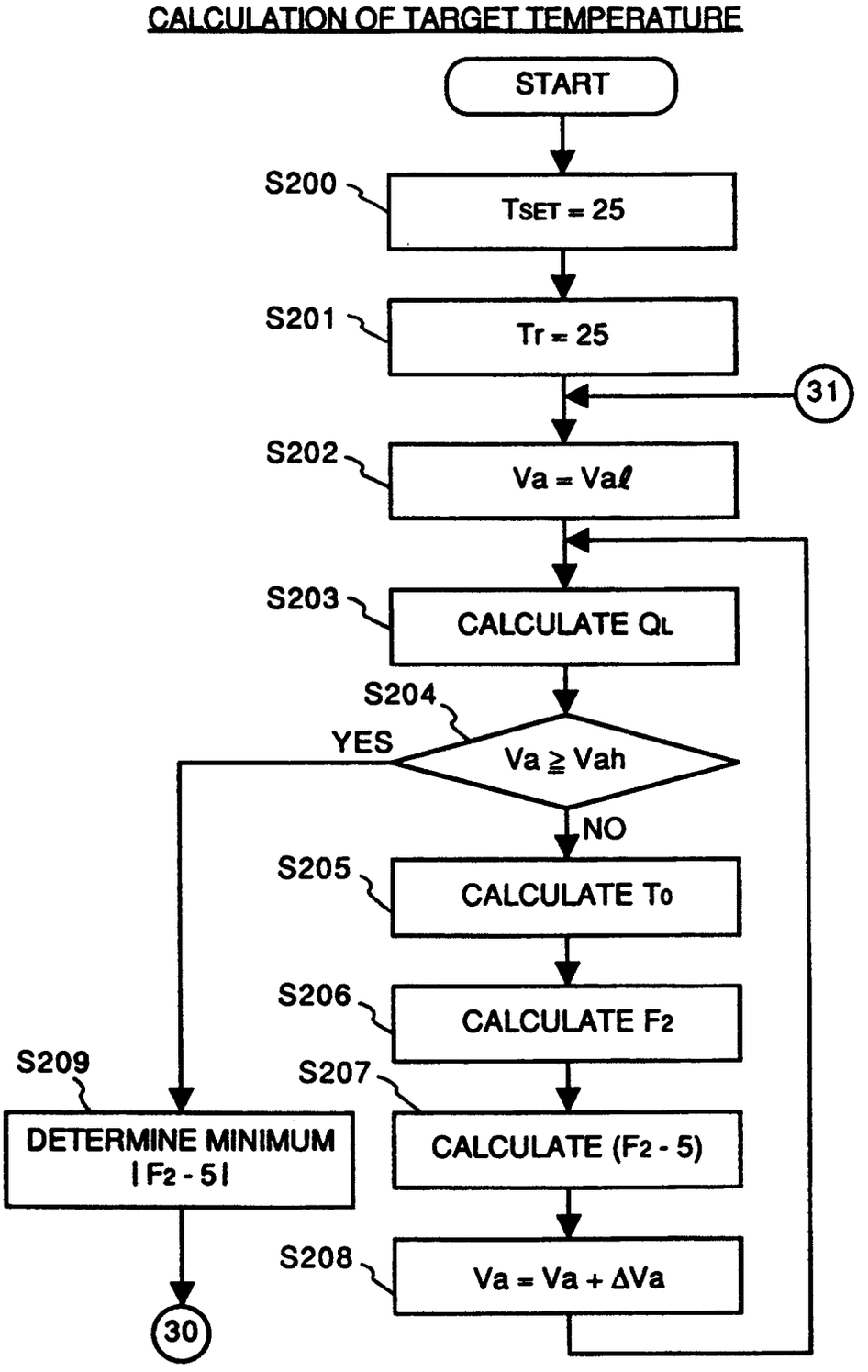

CALCULATION OF TARGET TEMPERATURE
START
S200
TSET = 25
S201
Tr = 25
31
S202
Va = Vaℓ
S203
CALCULATE QL
S204
YES
Va ≧ Vah
NO
S205
CALCULATE To
S206
CALCULATE F2
S209
S207
DETERMINE MINIMUM
| F2 - 5 |
CALCULATE (F2 - 5)
S208
Va = Va + ΔVa
30

FIG. 15

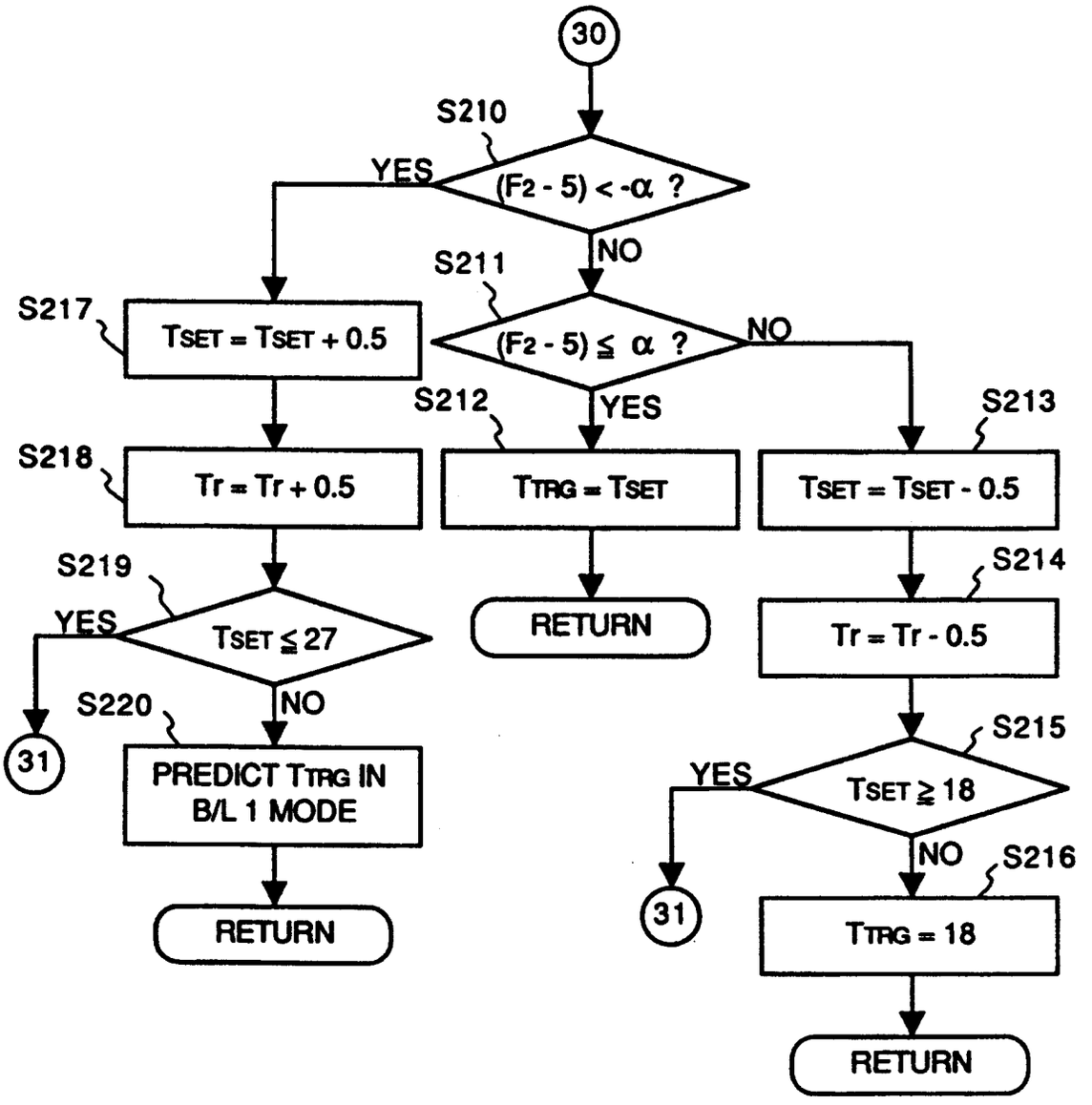

30
S210
YES
(F2 - 5) < -α ?
NO
S211
S217
TSET = TSET + 0.5
(F2 - 5) ≦ α ?
NO
S212
YES
S213
S218
Tr = Tr + 0.5
TTRG = TSET
TSET = TSET - 0.5
S219
S214
YES
TSET ≦ 27
RETURN
Tr = Tr - 0.5
S220
NO
S215
31
PREDICT TTRG IN B/L 1 MODE
YES
TSET ≧ 18
NO
S216
31
TTRG = 18
RETURN
RETURN

FIG. 16

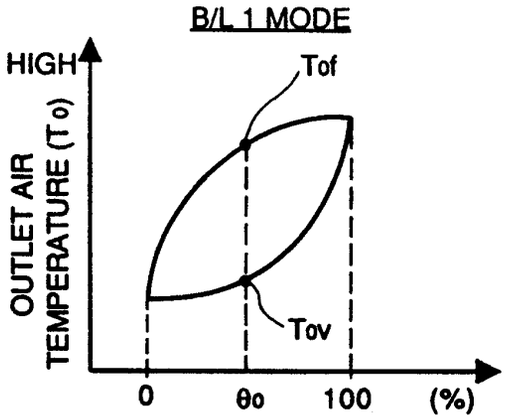


FIG. 17

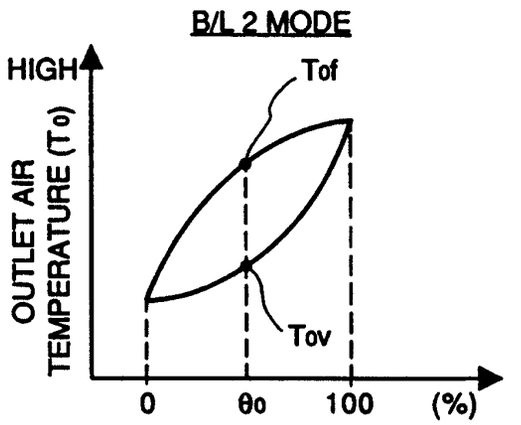


FIG. 18

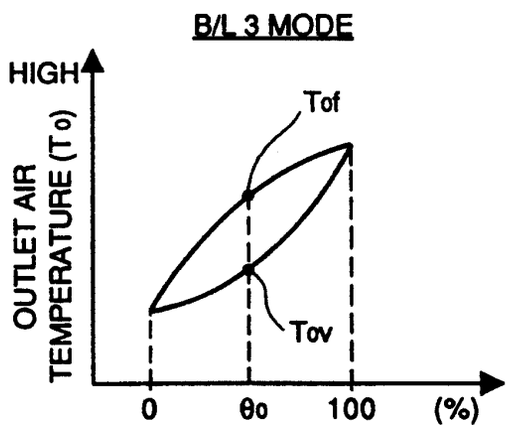


FIG. 19

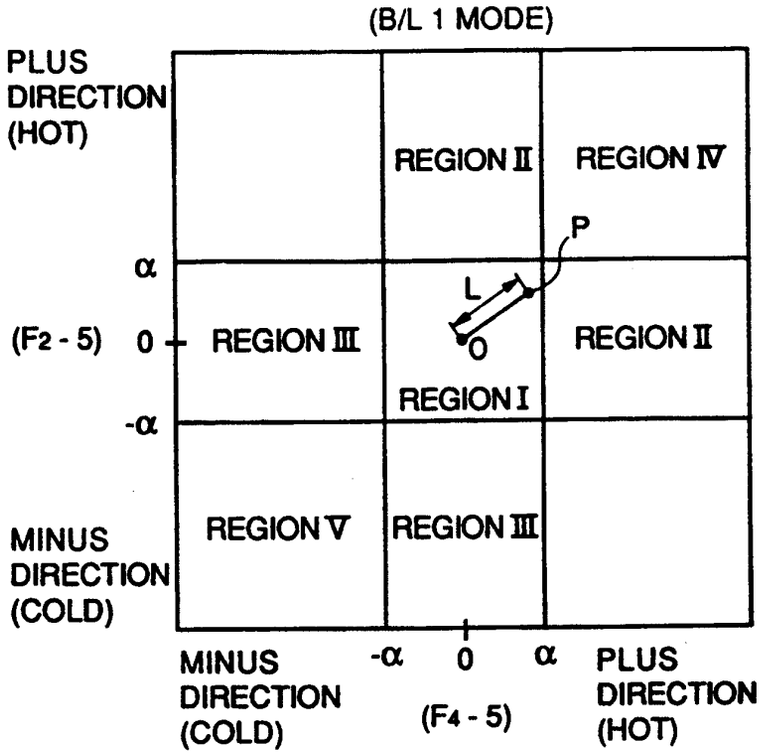

(B/L 1 MODE)
PLUS DIRECTION (HOT)
REGION II
REGION IV
P
α
L
(F2 - 5)
0
REGION III
O
REGION II
REGION I
-α
REGION V
REGION III
MINUS DIRECTION (COLD)
MINUS DIRECTION (COLD)
-α
0
α
(F4 - 5)
PLUS DIRECTION (HOT)

FIG. 20

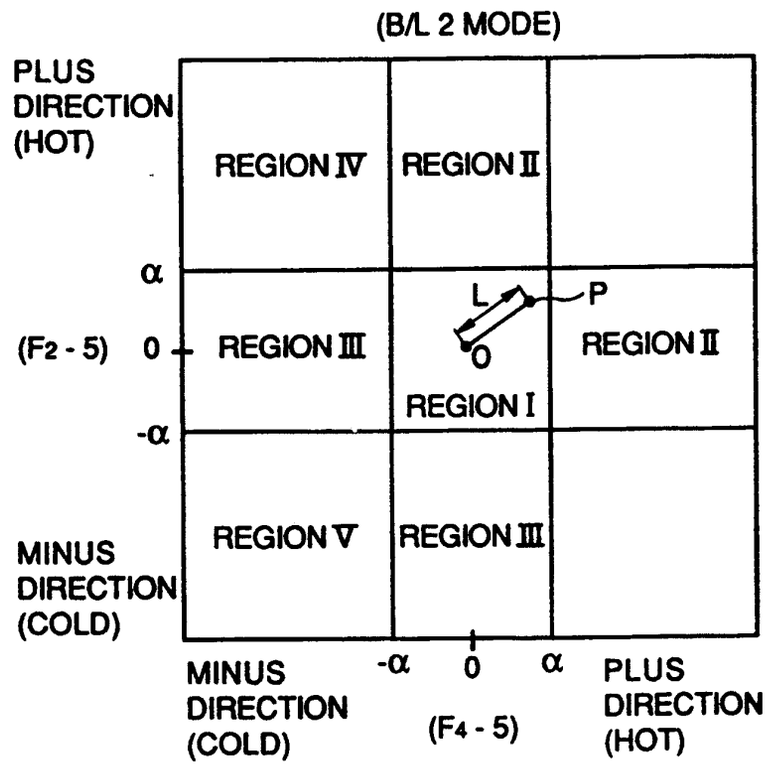

(B/L 2 MODE)
PLUS DIRECTION (HOT)
REGION IV
REGION II
α
L
P
(F2 - 5)
0
REGION III
O
REGION II
REGION I
-α
REGION V
REGION III
MINUS DIRECTION (COLD)
MINUS DIRECTION (COLD)
-α
0
α
(F4 - 5)
PLUS DIRECTION (HOT)

FIG. 21

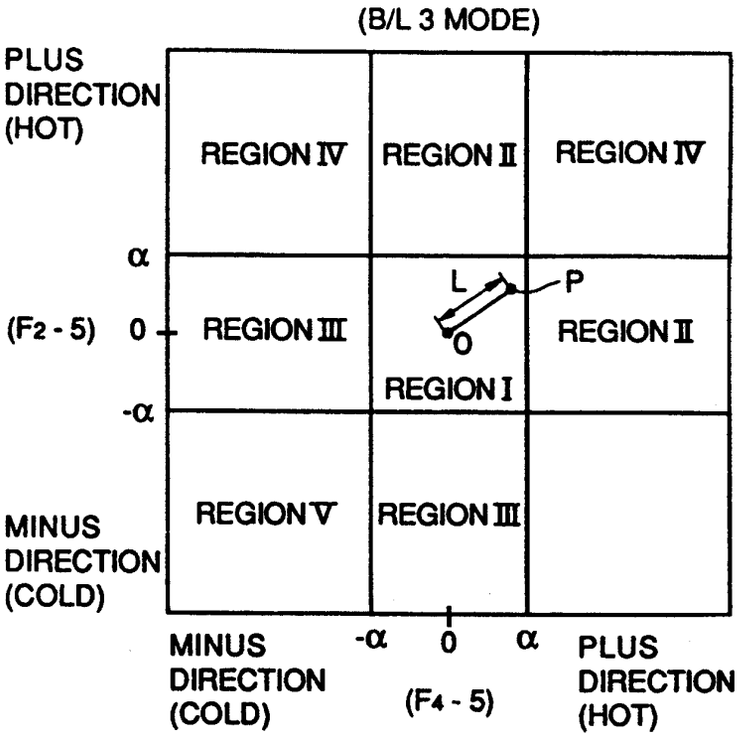

(B/L 3 MODE)
PLUS DIRECTION (HOT)
REGION IV
REGION II
REGION IV
α
L
P
(F2 - 5)
0
REGION III
REGION II
O
REGION I
-α
REGION V
REGION III
MINUS DIRECTION (COLD)
MINUS DIRECTION (COLD)
-α
0
α
(F4 - 5)
PLUS DIRECTION (HOT)

FIG. 22

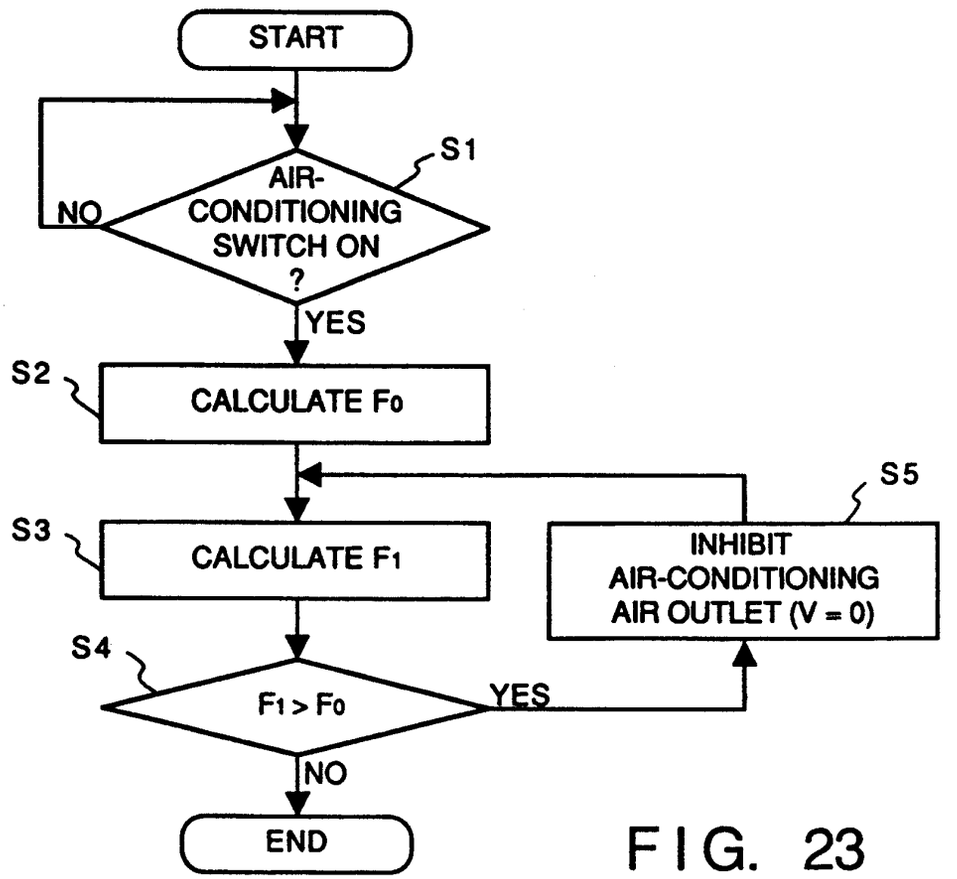

START
S1
AIR-CONDITIONING SWITCH ON ?
NO
YES
S2
CALCULATE F0
S3
CALCULATE F1
S4
F1 > F0
YES
NO
S5
INHIBIT AIR-CONDITIONING AIR OUTLET (V = 0)
END

FIG. 23

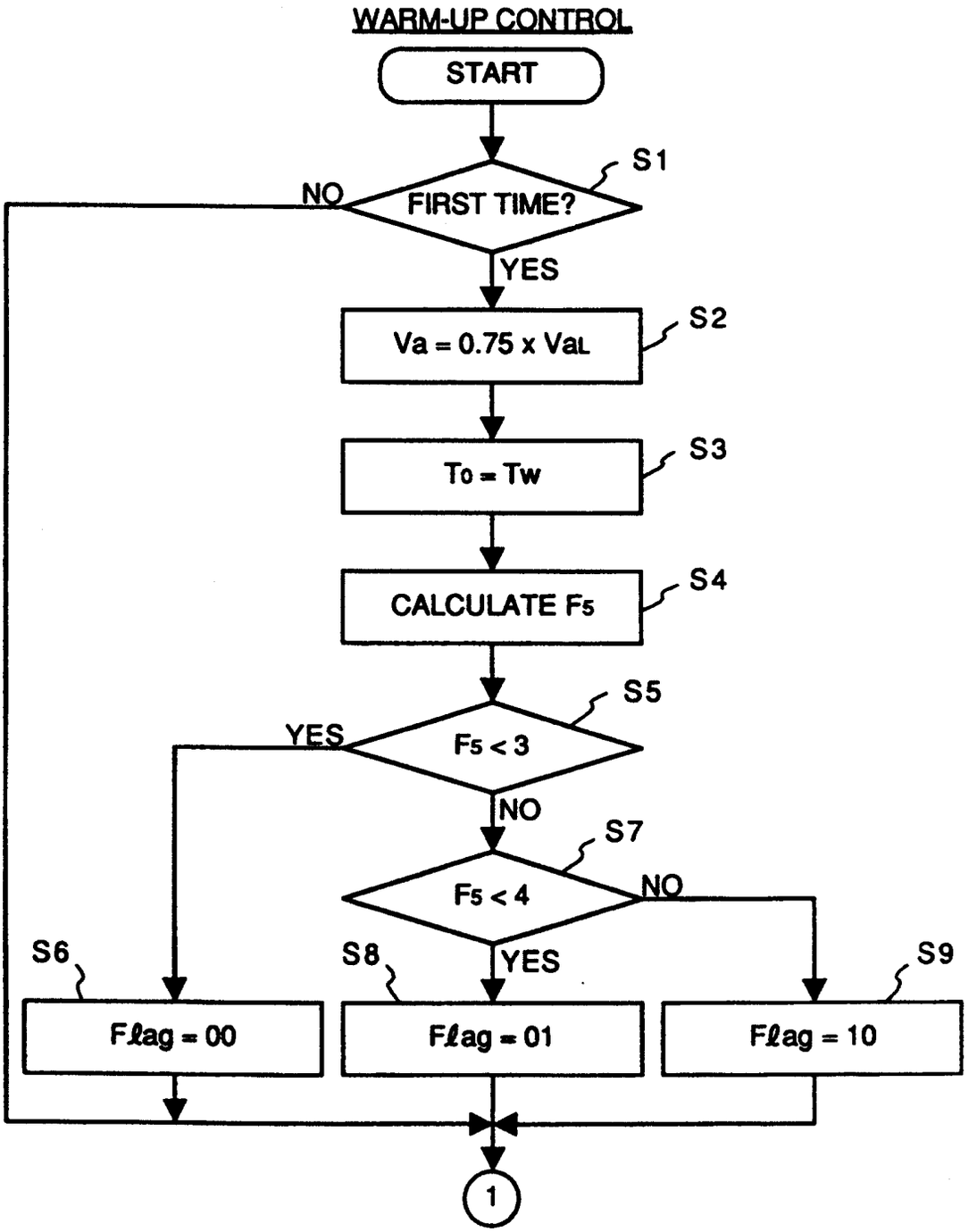

WARM-UP CONTROL
START
S1
FIRST TIME?
NO
YES
S2
Va = 0.75 x VaL
S3
To = Tw
S4
CALCULATE F5
S5
F5 < 3
YES
NO
S7
F5 < 4
NO
YES
S6
S8
S9
Flag = 00
Flag = 01
Flag = 10
1

FIG. 24

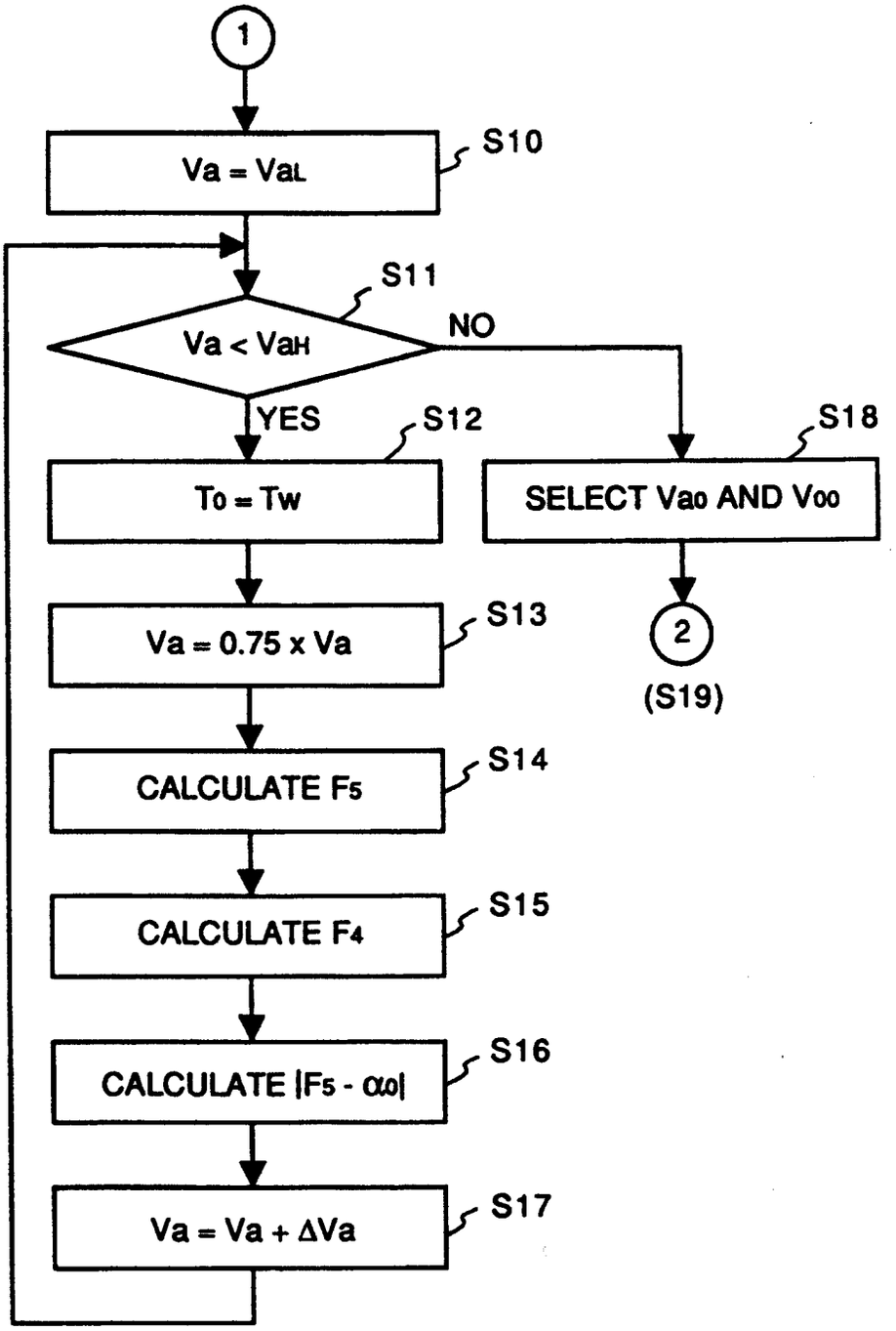
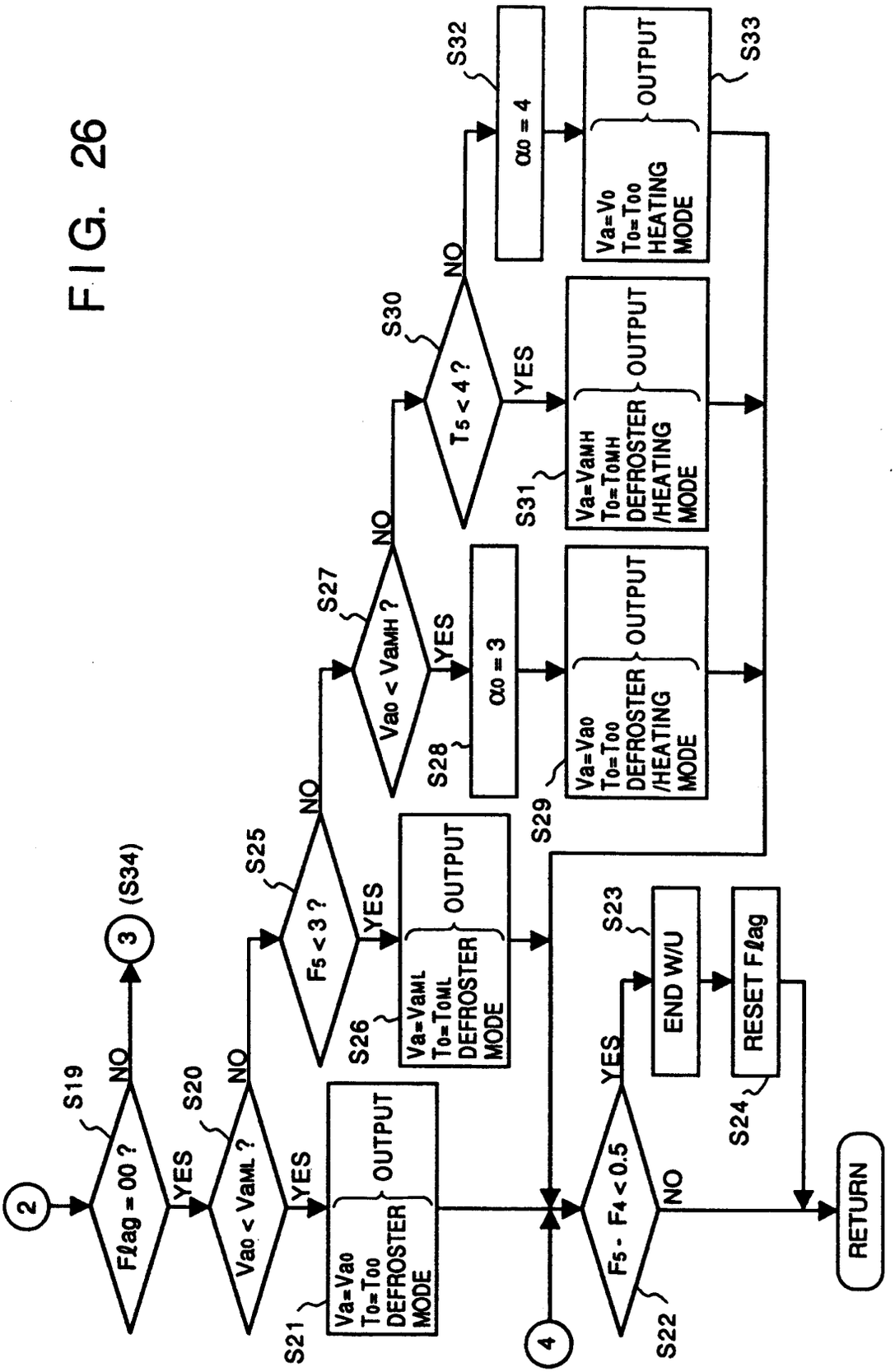

1
Va = VaL
S10
S11
Va < VaH
NO
YES
S12
S18
To = Tw
SELECT Vao AND Voo
Va = 0.75 x Va
S13
2
(S19)
CALCULATE F5
S14
CALCULATE F4
S15
CALCULATE |F5 - αo|
S16
Va = Va + ΔVa
S17

FIG. 25

FIG. 26


2
S19
Flag = 00 ?
NO
3
(S34)
YES
S20
Vao < VaML ?
NO
YES
S21
Va=Vao
To=Too
DEFROSTER
MODE
OUTPUT
S25
F5 < 3 ?
NO
YES
S26
Va=VaML
To=ToML
DEFROSTER
MODE
OUTPUT
S27
Vao < VaMH ?
NO
YES
S28
αo = 3
S29
Va=Vao
To=Too
DEFROSTER
/HEATING
MODE
OUTPUT
S30
T5 < 4 ?
NO
YES
S31
Va=VaMH
To=ToMH
DEFROSTER
/HEATING
MODE
OUTPUT
S32
αo = 4
Va=Vo
To=Too
HEATING
MODE
OUTPUT
S33
4
S22
F5 - F4 < 0.5
YES
NO
S23
END W/U
S24
RESET Flag
RETURN

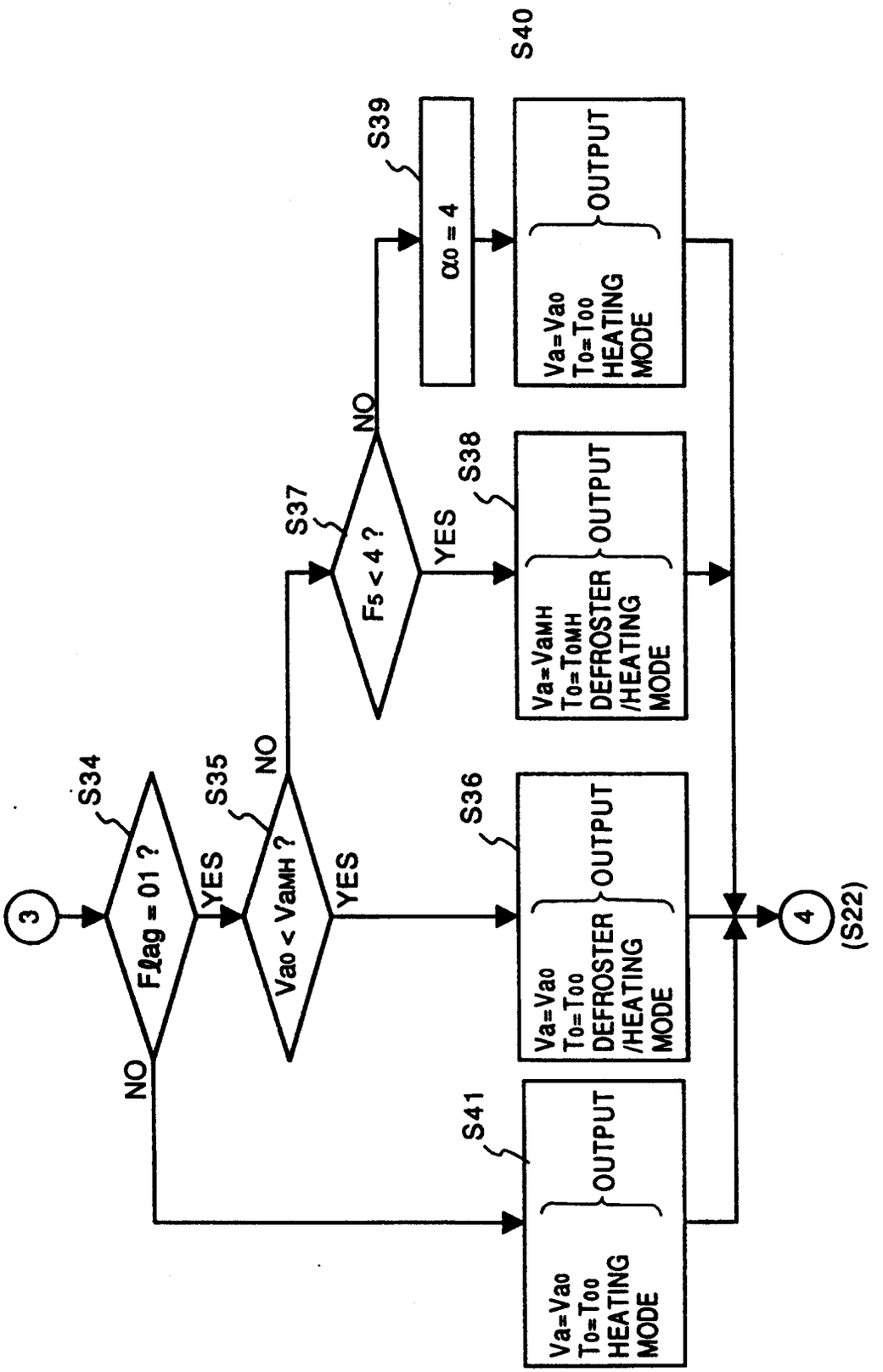

3
S34
Flag = 01 ?
YES
NO
S35
Vao < VaMH ?
YES
NO
S36
Va=Vao
To=Too
DEFROSTER
/HEATING
MODE
OUTPUT
S37
F5 < 4 ?
YES
NO
S38
Va=VaMH
To=ToMH
DEFROSTER
/HEATING
MODE
OUTPUT
S39
αo = 4
S40
Va=Vao
To=Too
HEATING
MODE
OUTPUT
S41
Va=Vao
To=Too
HEATING
MODE
OUTPUT
4
(S22)

FIG. 27

FIG. 28

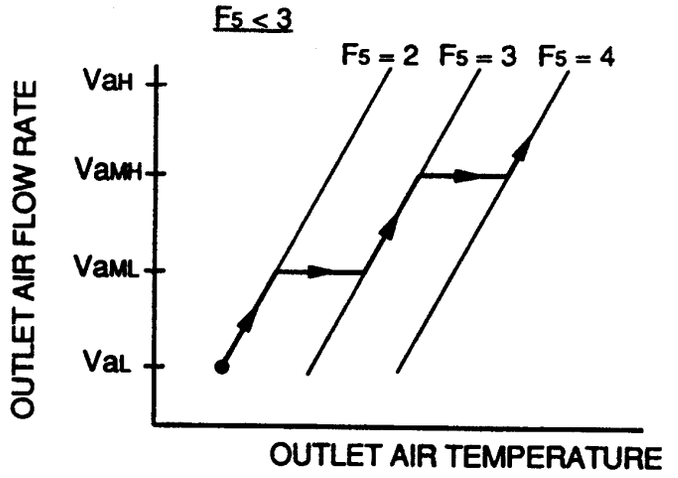


FIG. 29

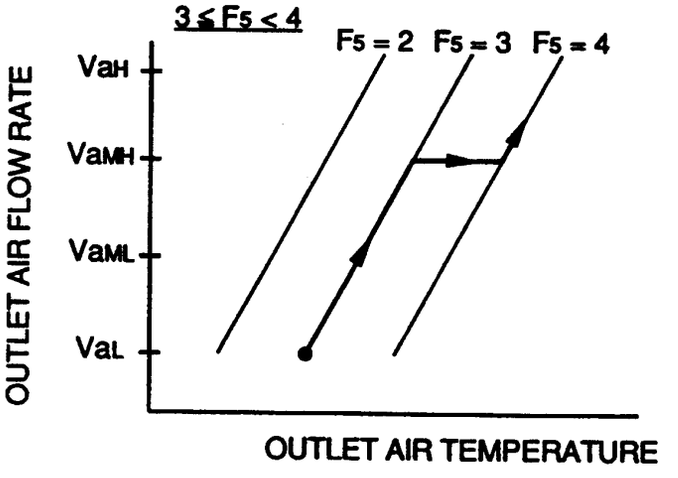
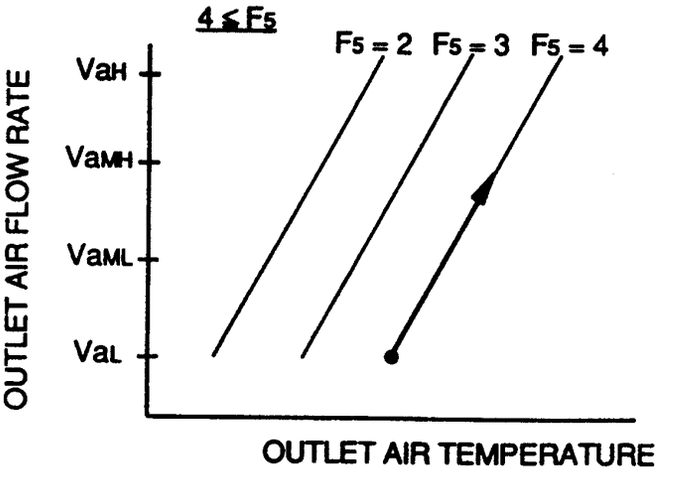


FIG. 30



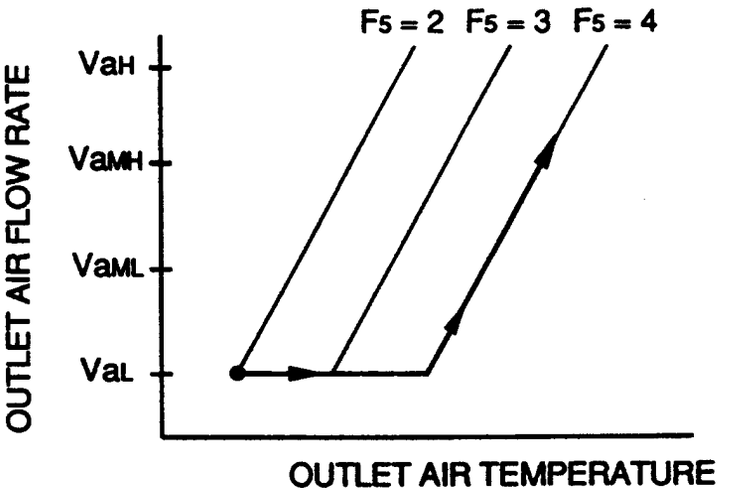

F5 = 2
F5 = 3
F5 = 4
VaH
VaMH
VaML
VaL
OUTLET AIR FLOW RATE
OUTLET AIR TEMPERATURE

FIG. 31

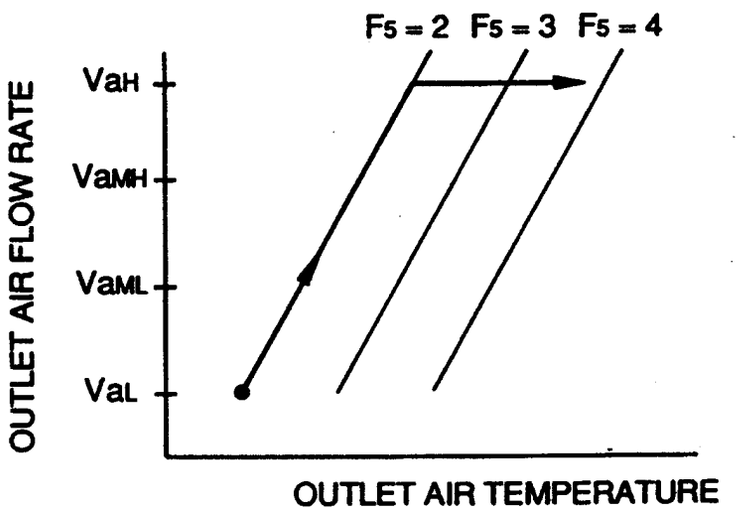

F5 = 2
F5 = 3
F5 = 4
VaH
VaMH
VaML
VaL
OUTLET AIR FLOW RATE
OUTLET AIR TEMPERATURE

FIG. 32