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METHOD FOR CONTROLLING THE ROTATIONAL SPEED OF A MOTOR-COMPRESSOR USED IN AN AIR CONDITIONER

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(71) Applicant(s)
SANDEN CORPORATION

(72) Inventor(s)
SUSUMU IKEDA

(74) Attorney or Agent
GRIFFITH HACK & CO , GPO Box 1285K, MELBOURNE VIC 3001

(56) Prior Art Documents
US 5119071
US 4901534
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(57) Claim

1. A method for controlling the rotational speed of a motor-compressor used in an air conditioner for vehicles, said motor-compressor driven by a motor and the rotational speed of said motor-compressor controlled via an inverter circuit, said method comprising the steps of:

sending a plurality of signals for determining the driving condition of said air conditioner to said inverter circuit, one of the plurality of signals being a constant rotational speed command signal for controlling the rotational speed of said motor-compressor to a predetermined constant rotational speed; and

driving said motor-compressor at said predetermined constant rotational speed only when said constant rotational speed command signal is sent to said inverter circuit.

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COMPLETE SPECIFICATION

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Applicant(s):

SANDEN CORPORATION

Invention Title:

METHOD FOR CONTROLLING THE ROTATIONAL SPEED OF A MOTOR-COMPRESSOR USED IN AN AIR CONDITIONER

The following statement is a full description of this invention, including the best method of performing it known to me/us:

METHOD FOR CONTROLLING THE ROTATIONAL SPEED OF A MOTOR-COMPRESSOR USED IN AN AIR CONDITIONER

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a method for controlling the rotational speed of a motor-compressor used in an air conditioner for vehicles, and more particularly to a method for controlling the rotational speed of a motor-compressor via an inverter.

Description of the Prior Art

There are two types of systems which are used as air conditioners for vehicles. One is a system using a compressor driven by an engine of a vehicle via a belt, etc. The other is a system using a motor-compressor driven by an electric motor. In either type of system, refrigerant is not charged in the refrigerant circuit constituting the air conditioner before the air conditioner is attached to a vehicle. Refrigerant is charged into the refrigerant circuit after the air conditioner is attached to a vehicle and the refrigerant circuit is vacuumed.

When refrigerant is charged, in the case of the system using a compressor driven by an engine, the rotational speed of the compressor can be controlled to an appropriate rotational speed by controlling the rotational speed of the engine. In the case of the system using a motor-compressor, however, since the

rotational speed of the compressor is controlled in accordance with the ambient temperature of the vehicle, an atmospheric condition, a set temperature of the air blown into the interior of the vehicle and so forth, the rotational speed of the compressor is not controlled to a constant speed. Therefore, the condition of the refrigerant charge is not stable.

In the system using a compressor driven by an engine, a proper amount of charged refrigerant can be determined by recognizing the amount of charged refrigerant through a sight glass provided in the refrigerant circuit. However, in the system using a motor-compressor, in a case where the system is started under a condition that the temperature of the interior of the vehicle is relatively high and the temperature of the air blown into the interior to be controlled is set to a relatively low temperature, the motor-compressor is driven at a high rotational speed. As a result, there is a concern that the refrigerant may be over charged.

Moreover, at a time immediately after charge of refrigerant is started, the refrigerant is sent into the refrigerant circuit, not by the motor-compressor, but by the pressure difference between the pressure in the refrigerant circuit and the pressure in a bottle of refrigerant so that the pressure in the refrigerant circuit reaches a saturated pressure. Therefore, if the motor-compressor is driven at a high rotational speed under a condition where the amount of

refrigerant existing in the refrigerant circuit is small, the compressor portion of the motor-compressor may be damaged. On the contrary, if the motor-compressor is driven at a very low rotational speed or under a condition where the motor-compressor may be stopped from the relationship with various setting temperatures, it becomes impossible to charge refrigerant.

SUMMARY OF THE INVENTION

Accordingly, an object of the present invention is to provide a method for controlling the rotational speed of a motor-compressor used in an air conditioner for vehicles, which can freely control the rotational speed of the motor-compressor to an optimum speed without being influenced by the temperature of the interior of the vehicle, the atmosphere condition and the set temperature of the air blown into the interior.

Another object of the present invention is to provide a method for controlling the rotational speed of a motor-compressor used in an air conditioner for vehicles, which can control the drive of the motor-compressor such that the motor-compressor is not driven under a condition where the amount of refrigerant existing in a refrigerant circuit is small, thereby preventing damage of the compressor portion of the motor-compressor.

To achieve these objects, a method for controlling the

rotational speed of a motor-compressor used in an air conditioner for vehicles is herein provided. The motor-compressor is driven by a motor and the rotational speed of the motor-compressor is controlled via an inverter circuit. The method for controlling the rotational speed of the motor-compressor comprises the steps of sending a plurality of signals for determining the driving condition of the air conditioner to the inverter circuit, one of the plurality of signals being a constant rotational speed command signal for controlling the rotational speed of the motor-compressor to a predetermined constant rotational speed, and driving the motor-compressor at the predetermined constant rotational speed only when the constant rotational speed command signal is sent to the inverter circuit.

Alternatively, the method for controlling the rotational speed of the motor-compressor comprises the steps of sending a plurality of signals for determining the driving condition of the air conditioner to the inverter circuit, one of the plurality of signals being a constant rotational speed command signal for controlling the rotational speed of the motor-compressor to a predetermined constant rotational speed; sending a plurality of sensor signals from a plurality of sensors for sensing the state of the air conditioner and the environmental state thereof to the inverter circuit, one of the plurality of sensor signals being a pressure signal sent from a

pressure sensor provided in a refrigerant circuit forming the air conditioner; and determining whether to drive the motor-compressor at the predetermined constant rotational speed in accordance with the constant rotational speed command signal and the pressure signal.

In the control method according to the present invention, after the motor-compressor is attached to the air conditioner for vehicles, the motor-compressor can be driven at an optimum rotational speed regardless of conditions set in a driving condition setting unit of the air conditioner. Therefore, it is not necessary to adjust the rotational speed of the motor-compressor when refrigerant is charged. Further, a failure to charge refrigerant does not occur.

Moreover, in the control method according to the present invention, over charge of refrigerant, which occurs by driving the motor-compressor at a rotational speed more than a necessary speed, can be effectively prevented.

Furthermore, when the amount of refrigerant present in the refrigerant circuit is smaller than a predetermined amount, the motor-compressor can be controlled not to be driven by the control for driving the motor-compressor at the predetermined constant rotational speed only when the pressure signal from the pressure sensor represents a pressure not lower than a predetermined pressure and the constant rotational speed command signal is sent to the inverter circuit. Therefore,

damage to the motor-compressor, which occurs when the motor-compressor is driven under a condition where refrigerant does not exist in the refrigerant circuit or the amount of refrigerant present in the refrigerant circuit is very small, can be prevented.

Preferred exemplary embodiments of the invention will now be described with reference to the accompanying drawings which are given by way of example only, and are not intended to limit the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram of a system for carrying out a control method according to an embodiment of the present invention.

FIG. 2 is a circuit diagram of a part of a control unit of the system shown in FIG. 1.

FIG. 3 is a time chart showing the control operation of the system shown in FIG. 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

FIG. 1 illustrates a system for an air conditioner for vehicles which uses a motor-compressor, for carrying out a control method according to an embodiment of the present invention. In FIG. 1, refrigerant circuit 1 for an air

conditioner for vehicles comprises a motor-compressor 2 driven by a motor (not shown), a condenser 3 and a pressure sensor 4. Inverter circuit 5 for controlling the rotational speed of motor-compressor 2 is coupled to the motor-compressor 2. Inverter circuit 5 comprises a DC power source circuit 10, a switching element module 20 having a plurality of switching elements 21, a base driver 40 and a control unit 30 for controlling the switching timing of the switching elements. DC power source circuit 10 includes a DC power source 11 and a capacitor 12. DC power source circuit 10 is coupled to switching element module 20, and the switching element module is coupled to motor-compressor 2. Control unit 30 is coupled to switching element module 20 via base driver 40.

Control unit 30 has a signal processing circuit 31, a micro computer 32 and a control signal output circuit 33. Control unit 30 outputs a signal for controlling the switching timing of switching elements 21 in switching element module 20. Signal processing circuit 31 comprises a filter 34, an A/D converter 35 and a logic circuit 36. Control unit 30 is coupled to motor-compressor 2, pressure sensor 4, driving condition setting unit 50 and a group of sensors 60 other than the pressure sensor. The group of sensors 60 includes various sensors such as temperature sensor 61 for the interior of the vehicle, temperature sensor 62 for the atmosphere, evaporator sensor 63, solar radiation sensor 64, etc. Driving condition

setting unit 50 has a switch 51 for a constant rotational speed command signal and various switches 52 for setting the signals sent to control unit 30 for comparing them with the signals sent from the plurality of sensors 61, 62, 63, 64, ... A constant rotational speed of motor-compressor 2 is preset in driving condition setting unit 50. In a time when a refrigerant charge into the refrigerant circuit is required, constant rotational speed command signal switch 51 is turned on. When constant rotational speed command signal switch 51 is turned on, the signal of the constant rotational speed representing the preset constant rotational speed of motor-compressor 2 is generated at driving condition setting unit 50. Since the signal of the constant rotational speed is set to override the signals which are also generated at driving condition setting unit 50 by means of turning on various switches 52, only the signal of the constant rotational speed is output from driving condition setting unit 50 to control unit 30 to be processed therein. As a result, inverter circuit 5 controls operation of motor-compressor 2 to be driven at the preset constant rotational speed or to be not driven in accordance with an operational result of control unit 30 described in detail below.

On the other hand, in a situation where the air conditioner operates to condition the air in the vehicle, constant rotational speed command signal switch 51 is maintained so as to be turned off. As long as constant rotational speed command signal switch 51 is turned off, only the signals which are generated at driving condition setting unit 50 by means of turning on various switches 52 are output from driving condition setting unit 50 to control unit 30 to be compared with the signals sent from the plurality of sensors 61, 62, 63, 64, ... thereat. As a result, inverter circuit 5 controls operation of motor-compressor 2 to be driven at the various rotational speeds in accordance with the comparing results at control unit

30. That is, in the situation where the air conditioner operates to condition the air in the vehicle, inverter circuit 5 controls operation of motor-compressor 2 to be driven at the various rotational speeds in response to the results of comparing the signals set by various switches 52 with the signals sent from the plurality of sensors 61, 62, 63, 64,...

Pressure sensor 4 senses a pressure in refrigerant circuit 1, and sends the signal to control unit 30 as a pressure sensor signal. When the pressure sensor signal and the constant rotational speed command signal are sent to control unit 30, the control unit determines whether to carry out the control of driving motor-compressor 2 at the constant rotational speed. After the determination, control unit 30 sends a driving signal of motor-compressor 2 to base driver 40. Base driver 40 drives switching element module 20 in accordance with the driving signal sent from control unit 30. Switching element module 20 switches each of switching elements 21 based upon the signal sent from the base driver 40, and controls the rotational speed of motor-compressor 2.

FIG. 2 illustrates a part of the circuit of control unit 30. Constant rotational speed command signal 71 sent from driving condition setting unit 50 is sent to AND circuit 361 through

filter 34. Pressure sensor signal 72 sent from pressure sensor 4 is sent to comparator 351 through filter 34. In comparator 351, the voltage level of pressure sensor signal 72 is compared with the voltage level of a predetermined pressure signal which is preset by dividing a base voltage Vcc by resistances R1 and R2. The result of the comparison is sent to AND circuit 361. Comparator 351 outputs a logical signal "1" when pressure sensor signal 72 sent from pressure sensor 4 is not less than the predetermined pressure signal, and outputs a logical signal "0" for other conditions. AND circuit 361 outputs a logical signal "1" only when constant rotational speed command signal 71 is sent (i.e., the logical signal is "1") and the logical signal from comparator 351 is "1".

In the above system, only when constant rotational speed command signal 71 is sent and the amount of refrigerant present in refrigerant circuit 1 indicated by pressure sensor signal 72 sent from pressure sensor 4 is not less than a predetermined amount, control unit 30 outputs the driving signal for driving motor-compressor 2 at a predetermined constant rotational speed. When constant rotational speed command signal 71 is not output, the driving of motor-compressor 2 at a predetermined constant rotational speed is not carried out. Further, when the amount of refrigerant present in refrigerant circuit 1 is smaller than the predetermined amount, the logical signal output from comparator 351 is "0" and AND circuit 361 outputs a logical

signal "0". In such a case, control unit 30 controls base driver 40 so as not to drive motor-compressor 2.

FIG. 3 illustrates a time chart showing the control operation described above. In FIG. 3, at a time t1, since the constant rotational speed command signal is output but the the pressure sensor signal indicates that the amount of refrigerant present in refrigerant circuit 1 has not reached a predetermined value and comparator 351 does not output logical signal "1", the control of constant rotational speed is not carried out. At a time t2, since the amount of refrigerant present in refrigerant circuit 1 has reached a predetermined value and comparator 351 outputs logical signal "1" but the constant rotational speed command signal is not output, the control of constant rotational speed is not carried out. At a time t3, since the constant rotational speed command signal is output and the amount of refrigerant present in refrigerant circuit 1 has reached a predetermined value and comparator 351 outputs logical signal "1", the control of constant rotational speed is carried out. Thus, when the amount of refrigerant present in refrigerant circuit 1 is small, motor-compressor 2 is not driven, and damage to the compression portion of the motor-compressor can be prevented.

Although the pressure sensor signal from pressure sensor 4 is utilized for the control for driving motor-compressor 2 in the above embodiment, the control for driving motor-compressor 2

at a constant rotational speed can be conducted even without the pressure sensor signal. In this embodiment, constant rotational speed command signal switch 51 must be turned on after the refrigerant charge into the refrigerant circuit by means of pressure difference between the pressure in the bottle of the refrigerant and the pressure in the refrigerant circuit is terminated. Furthermore, the refrigerant circuit is evacuated before the above refrigerant charge into the refrigerant circuit is carried out. The evacuation of the refrigerant circuit is terminated at a time when degree of vacuum of the refrigerant circuit reaches a desired value. The degree of vacuum of the refrigerant circuit is read by a pressure gauge (not shown) equipped at an evacuating apparatus (not shown). In addition, in this embodiment, pressure sensor 4 illustrated in Figure 1 is eliminated from the air conditioner, and therefore AND circuit 361 and comparator 351 illustrated in Figure 2 are eliminated from control unit 30.

According to this embodiment, in a situation where the refrigerant charge into the refrigerant circuit is required, constant rotational speed command signal switch 51 is turned on after the refrigerant charge into the refrigerant circuit by means of pressure difference between the pressure in the bottle of the refrigerant and the pressure in the refrigerant circuit is terminated. When constant rotational speed command signal switch 51 is turned on, inverter circuit 5 controls operation of motor-compressor 2 to be driven at the preset constant rotational speed in accordance with only the signal of the constant rotational speed.

Since motor-compressor 2 operates at the preset constant rotational speed, the refrigerant charge by means of pressure differential between the pressure in the bottle of the refrigerant and the pressure in the refrigerant circuit is smoothly taken over the refrigerant charge by

operation of motor-compressor 2. Therefore, the operational defects described in the description of the prior art section of the present application can be effectively eliminated. In addition, the refrigerant is stably drawn into the refrigerant circuit from the bottle by operation of motor-compressor 2.

When an amount of the refrigerant charge into the refrigerant circuit becomes a predetermined value, the refrigerant charge from the bottle into the refrigerant circuit is terminated by means of turning off the constant rotational speed command signal switch 51.

In a situation where the air conditioner operates to condition the air in the vehicle, the constant rotational speed command signal switch 51 is maintained so as to be turned off. Thus, motor-compressor 2 is driven at the various rotational speeds as described in the aforementioned embodiment.

When an amount of the refrigerant charge into the refrigerant circuit becomes a predetermined value, the refrigerant charge from the bottle into the refrigerant circuit is terminated by means of turning off the constant rotational speed command signal switch 51.

In a situation where the air conditioner operates to condition the air in the vehicle, the constant rotational speed command signal switch 51 is maintained so as to be turned off. Thus, motor-compressor 2 is driven at the various rotational speeds as described in the aforementioned embodiment.

Furthermore, in case of erroneous ON-OFF operation of constant rotational speed command signal switch 51, the aforementioned first embodiment may be prepared in order to effectively eliminate the operational defects of the air conditioner caused thereby.

Although several preferred embodiments of the present invention have been described in detail herein, it will be appreciated by those skilled in the art that

various modifications can be made without materially departing from the novel and advantageous teachings of the invention. Accordingly, the embodiments disclosed herein are by way of example. The scope of the invention is defined by the claims annexed hereto and which form a part of this application.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method for controlling the rotational speed of a motor-compressor used in an air conditioner for vehicles, said motor-compressor driven by a motor and the rotational speed of said motor-compressor controlled via an inverter circuit, said method comprising the steps of:

sending a plurality of signals for determining the driving condition of said air conditioner to said inverter circuit, one of the plurality of signals being a constant rotational speed command signal for controlling the rotational speed of said motor-compressor to a predetermined constant rotational speed; and

driving said motor-compressor at said predetermined constant rotational speed only when said constant rotational speed command signal is sent to said inverter circuit.

2. The method as recited in claim 1 wherein said inverter circuit comprises a DC power source, a plurality of switching elements and a control unit for controlling the switching timing of said switching elements.

3. The method as recited in claim 2 wherein said plurality of signals for determining the driving condition of said air conditioner are provided to said control unit of said inverter circuit.

4. A method for controlling the rotational speed of a motor-compressor used in an air conditioner for vehicles, said motor-compressor driven by a motor and the rotational speed of said motor-compressor controlled via an inverter circuit, said method comprising the steps of:

sending a plurality of signals for determining the driving condition of said air conditioner to said inverter circuit, one of the plurality of signals being a constant rotational speed command signal for controlling the rotational speed of said motor-compressor to a predetermined constant rotational speed;

sending a plurality of sensor signals from a plurality of sensors for sensing the state of said air conditioner and environmental state thereof to said inverter circuit, one of the plurality of sensor signals being a pressure signal sent from a pressure sensor provided in a refrigerant circuit forming said air conditioner; and

determining whether to drive said motor-compressor at said predetermined constant rotational speed in accordance with said constant rotational speed command signal and said pressure signal.

5. The method as recited in claim 4 wherein said motor-compressor is driven at said predetermined constant rotational speed only when said pressure signal represents a pressure not

lower than a predetermined pressure and said constant rotational speed command signal is sent to said inverter circuit.

6. The method as recited in claim 4 wherein said inverter circuit comprises a DC power source, a plurality of switching elements and a control unit for controlling the switching timing of said switching elements.

7. The method as recited in claim 6 wherein said plurality of signals for determining the driving condition of said air conditioner and said plurality of sensor signals are provided to said control unit of said inverter circuit.

DATED THIS 7TH DAY OF OCTOBER 1992
SANDEN CORPORATION
By its Patent Attorneys:
GRIFFITH HACK & CO
Fellows Institute of Patent
Attorneys of Australia

METHOD FOR CONTROLLING THE ROTATIONAL SPEED OF A MOTOR-COMPRESSOR USED IN AN AIR CONDITIONER

ABSTRACT OF THE DISCLOSURE

A method for controlling the rotational speed of a motor-compressor used in an air conditioner for vehicle is disclosed. The rotational speed of the motor-compressor is controlled via an inverter circuit. The motor-compressor is driven at a predetermined constant rotational speed only when a constant rotational speed command signal for controlling the rotational speed of the motor-compressor to the predetermined constant rotational speed is sent to the inverter circuit. When refrigerant is charged to the refrigerant circuit of the air conditioner, the rotational speed of the motor-compressor can be controlled to an optimum speed without being influenced by other unnecessary conditions.

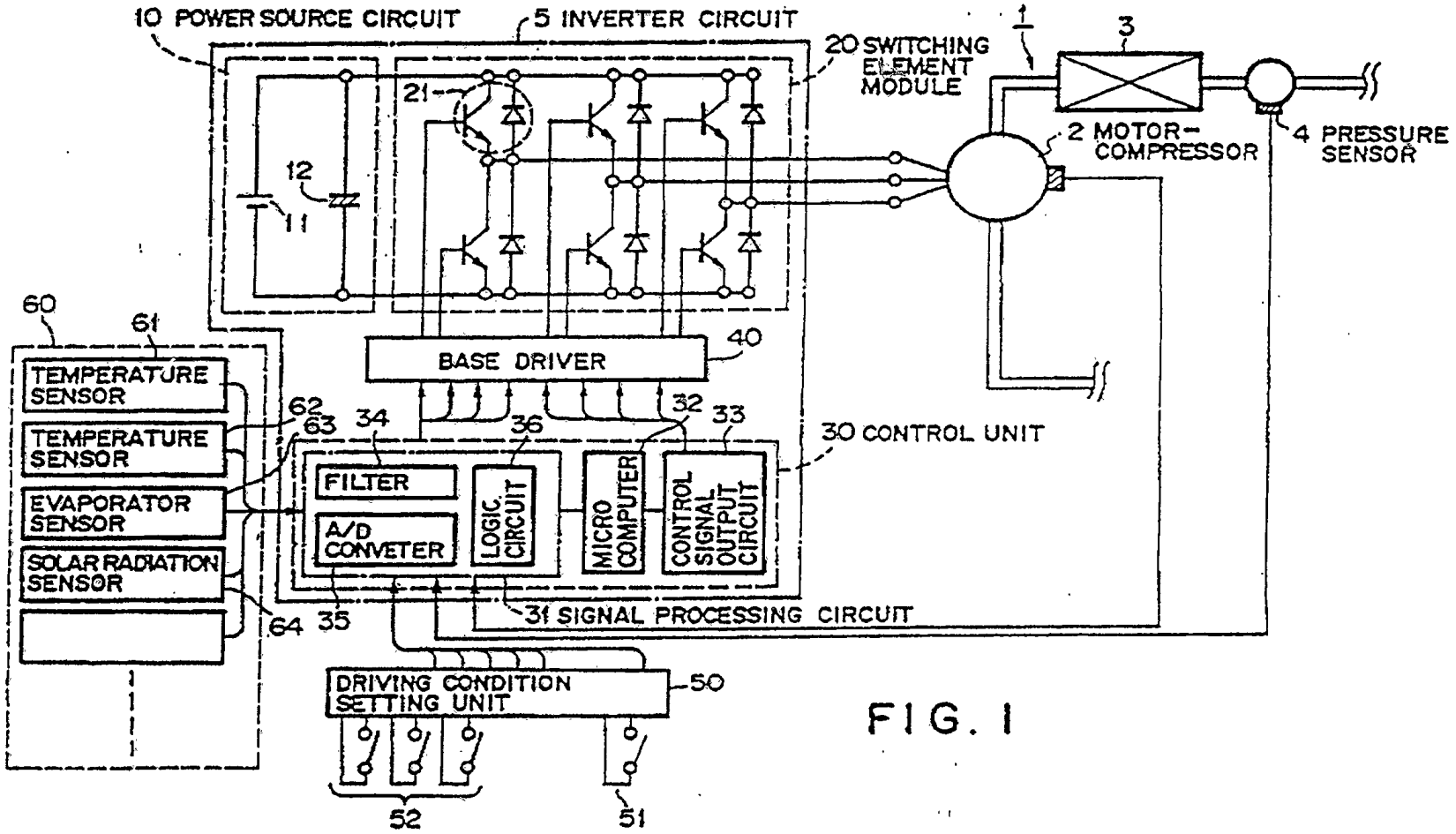


FIG. 1

FIG. 2

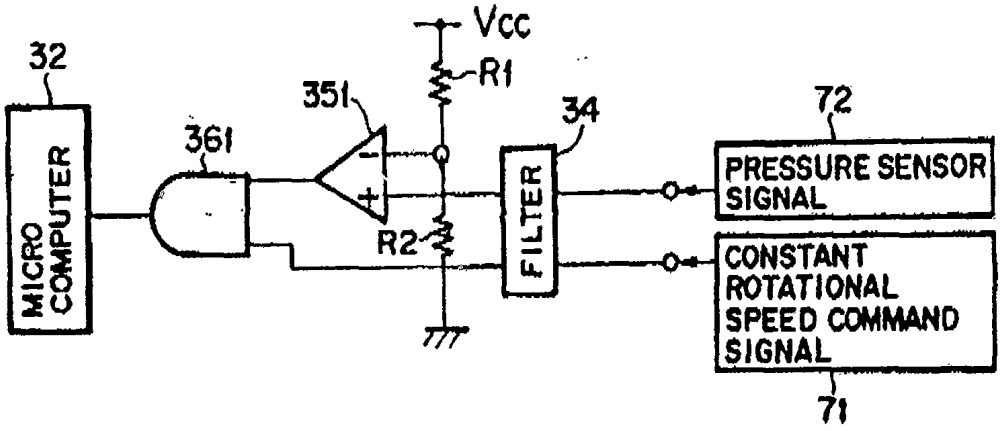
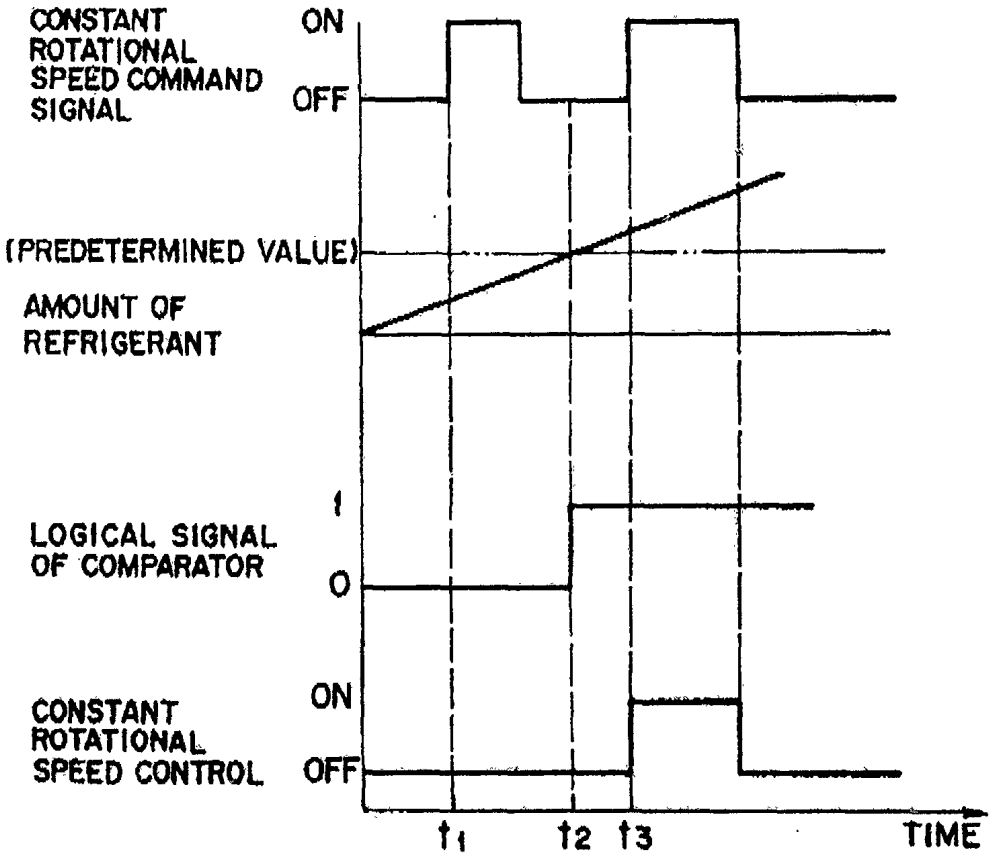

32
MICRO COMPUTER
361
351
Vcc
R1
R2
34
FILTER
72
PRESSURE SENSOR SIGNAL
CONSTANT ROTATIONAL SPEED COMMAND SIGNAL
71

FIG. 3


CONSTANT ROTATIONAL SPEED COMMAND SIGNAL
ON
OFF
(PREDETERMINED VALUE)
AMOUNT OF REFRIGERANT
LOGICAL SIGNAL OF COMPARATOR
1
0
CONSTANT ROTATIONAL SPEED CONTROL
ON
OFF
t1
t2
t3
TIME