(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number : **0 488 775 A2**

(12) # EUROPEAN PATENT APPLICATION

(21) Application number : **91311098.7**

(51) Int. Cl.^{5} : **F25B 49/02,** F25B 41/00

(22) Date of filing : **29.11.91**

(30) Priority : **30.11.90 JP 337064/90**

(43) Date of publication of application : **03.06.92 Bulletin 92/23**

(84) Designated Contracting States : **DE FR GB IT**

(71) Applicant : **SANDEN CORPORATION
20 Kotobuki-cho
Isesaki-shi Gunma, 372 (JP)**

(71) Applicant : **JAPAN ELECTRONIC CONTROL SYSTEMS CO., LTD.
1671-1, Kasukawa-cho
Isesaki-shi Gunma-ken, 372 (JP)**

(72) Inventor : **Komatsu, Syunji
3408-5, Kasagake-machi Oaza Azami,
Nitta-gun Gunma, 379-23 (JP)**
Inventor : **Kuribara, Masaru
1778-2, Narushima
Tatebayashi-shi, Gunma 374 (JP)**
Inventor : **Kobayashi, Kazumitsu
4080-4, Oaza Moro
Isesaki-shi, Gunma 372 (JP)**

(74) Representative : **Jackson, Peter Arthur et al
Gill Jennings & Every, 53-64 Chancery Lane
London WC2A 1HN (GB)**

(54) **Detecting system for detecting an insufficient amount of refrigerant in a cooling apparatus and compressor control systemincorporating same.**

(57) A detecting system is provided for detecting an insufficient amount of refrigerant in a cooling apparatus having a refrigerant circuit (11) which includes a compressor (12), a condenser (13) and an evaporator (16). The system has a refrigerant state detecting sensor (19, 30) provided in a high-pressure side path of the refrigerant circuit (11) for detecting an insufficient amount of refrigerant in the circuit (11) by sensing a mixing state of refrigerant in a liquid phase and refrigerant in a vapor phase. The detecting system is incorporated into a compressor control system having a compressor deactivating circuit coupled to the refrigerant state detecting sensor (19, 30) for deactivating the compressor (12) in response to a signal provided by the refrigerant state detecting sensor (19, 30). The refrigerant state detecting sensor (19, 30) determines that an insufficient amount of refrigerant exists at an early stage by detecting the mixing state of refrigerant. Since the compressor (12) is stopped at an earlier stage than in conventional systems, undesirable drive of the compressor (12) and damage to the compressor (12) can be prevented.

EP 0 488 775 A2

The present invention relates to a detecting system for detecting an insufficient amount of refrigerant in a cooling apparatus, and more particularly to a compressor control system for stopping a compressor provided in a cooling apparatus when the system detects an unacceptably low level of refrigerant in a refrigerant circuit.

A typical conventional cooling apparatus is constituted, for example, as shown in FIG. 5. A refrigerant such as freon gas is circulated in refrigerant circuit 1 formed from pipe 7. Compressor 2, condenser 3, receiver dryer 4, expansion valve 5 and evaporator 6 are provided in refrigerant circuit 1 in this order in the circulation direction of the refrigerant shown by arrows. Usually, the refrigerant is circulated at a liquid phase in the high-pressure side path of refrigerant circuit 1, and circulated at a vapor phase in the low-pressure side path of the refrigerant circuit.

In the conventional cooling apparatus, pressure switch 8 is attached to pipe 7 of the high-pressure side path of refrigerant circuit 1 for detecting a lack of refrigerant in the refrigerant circuit. Pressure switch 8 is electrically connected to the power source circuit of compressor 2. Pressure switch 8 detects the pressure of refrigerant circulating in the high-pressure side path. As the amount of refrigerant in refrigerant circuit 1 drops, the pressure of refrigerant circulating in the high-pressure side path decreases. Pressure switch 8 sends a signal to the power source circuit of compressor 2 so that the compressor is deactivated when the detected pressure of refrigerant drops below a predetermined value.

In such a conventional system for detecting a drop in the refrigerant level in a cooling apparatus there are the following problems.

The operation pressure of pressure switch 8 is usually set to a low pressure, for example, 2 kg/cm^2. Therefore, pressure switch 8 operates only when very little or no liquefied refrigerant exists in refrigerant circuit 1. In a case where liquefied refrigerant remains but the amount of refrigerant is inadequate, compressor 2 continues to be driven. In such a state, not only is effective cooling due to the cooling apparatus impossible, but also compressor 2 may be damaged.

Accordingly, it would be desirable to provide a detecting system for detecting an insufficient amount of refrigerant in a cooling apparatus which can deactivate a compressor at an early stage when the refrigerant level in a refrigerant circuit drops below an acceptable level.

A detecting system for detecting an insufficient amount of refrigerant in a cooling apparatus according to the present invention is hereinafter described. The detecting system is incorporated into a cooling apparatus having a refrigerant circuit for circulating refrigerant, which includes a compressor, a condenser and an evaporator. Refrigerant state sensing means is provided in a high-pressure side path of the refrigerant circuit between the condenser and the evaporator, for determining a condition wherein an insufficient amount of refrigerant is in the circuit, by sensing a mixing state of refrigerant in a liquid phase and refrigerant in a vapor phase, and providing a signal indicative of this condition. The detecting system preferably forms part of a compressor control system for controlling the operation of the compressor responsive to the signal provided by the sensing means. Preferably, the compressor control system comprises compressor deactivating means coupled to the refrigerant state sensing means, for deactivating the compressor in response to the signal provided by the refrigerant state sensing means.

The refrigerant state sensing means comprises, for example, a photoelectric sensor which senses the mixing state of refrigerant by measuring transmittance of a light transmitted through the high-pressure side path, or a self-exothermic type temperature detecting element, for example, a self-exothermic type thermistor which senses the mixing state of refrigerant by measuring reduction of the temperature of the thermistor itself caused by thermal conduction from the thermistor to the refrigerant.

In the system according to the present invention, when amount of refrigerant in the refrigerant circuit decreases, this causes a decrease of the pressure of the refrigerant. There also occurs a mixing state of refrigerant in a liquid phase and refrigerant in a vapor phase in the high-pressure side path of the refrigerant circuit. If this mixing state of liquid phase and vapor phase occurs, the refrigerant state sensing means detects the state and sends a signal to the compressor deactivating means. The compressor deactivating means deactivates the compressor in response to the signal from the refrigerant state sensing means. Since the refrigerant state sensing means detects the mixing state of refrigerant in a liquid phase and in a vapor phase at an early stage, a lack of refrigerant can be immediately sensed and quickly recognized. Further, since the compressor is stopped at an early stage, undesirable drive of the compressor and consequential damage to the compressor can be prevented.

Preferred 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.

FIG. 1 is a schematic view of a detecting system for detecting an insufficient amount of refrigerant in a cooling apparatus, and a compressor control system incorporating the same, according to a first embodiment of the present invention.

FIG. 2 is an enlarged sectional view of refrigerant state sensing means of the system shown in FIG. 1.

FIG. 3 is a graph showing the relationship between remainder of refrigerant and pressure of refrigerant, and the operation area of the system shown in FIG. 1.

FIG. 4 is a sectional view of refrigerant state sensing means of a detecting system for detecting an insufficient amount of refrigerant in a cooling apparatus according to a second embodiment of the present invention.

FIG. 5 is a schematic view of a prior art system for detecting a lack of refrigerant in a cooling apparatus.

Referring to the drawings, FIGS. 1 and 2 illustrate a detecting system for detecting an insufficient amount of refrigerant in a cooling apparatus, incorporated into a compressor control system, according to a first embodiment of the present invention. In FIG. 1, a refrigerant such as freon gas is circulated in refrigerant circuit 11 formed from a pipe 17. Compressor 12, condenser 13, receiver dryer 14, expansion valve 15 and evaporator 16 are provided on refrigerant circuit 11 in this order in the circulation direction of the refrigerant shown by arrows. The endothermic surface of evaporator 16 is exposed to, for example, the interior of a vehicle (not shown).

After the refrigerant is compressed by compressor 12, the refrigerant is transformed in phase from a high-pressure gas to a high-pressure liquid in condenser 13 and further to a low-pressure gas in evaporator 16. When the refrigerant is transformed from liquid phase to gaseous phase (vapor phase) by evaporator 16, the refrigerant absorbs heat from, for example, the interior of a vehicle and the interior of the vehicle is thereby cooled. Expansion valve 15 is provided between receiver dryer 14 and evaporator 16. Expansion valve 15 reduces the pressure of the refrigerant to a relatively low pressure in order to facilitate vaporization of the liquefied high-pressure refrigerant when it passes through evaporator 16.

Compressor 12 is driven via power source circuit 23 for the compressor. Pressure switch 18 is provided on the high-pressure side path of refrigerant circuit 11 at a position between receiver dryer 14 and expansion valve 15, and is attached to pipe 17. Pressure switch 18 is coupled to power source circuit 23 for the compressor in which electromagnetic switch 20 is incorporated. Pressure switch 18 detects the pressure of the refrigerant circulating in the high-pressure side path of refrigerant circuit 11 and sends a signal to open electromagnetic switch 20 for deactivating compressor 12 when the pressure switch detects a pressure lower than a predetermined value. In this embodiment, pressure switch 18 is provided as a back up switch for refrigerant state detecting sensor 19.

Refrigerant state detecting sensor 19 is provided as refrigerant state detecting means. In this embodiment, refrigerant state detecting sensor 19 comprises a photoelectric sensor which senses the mixing state of refrigerant in a liquid phase and refrigerant in a vapor phase by measuring transmittance of a light transmitted through the high-pressure side path of refrigerant circuit 11. Referring to FIG. 2, refrigerant state detecting sensor 19 includes emitter 24 emitting a light towards the high-pressure side path of refrigerant circuit 11 and receiver 25 receiving the light transmitted through the path (through the refrigerant in the path). Sensor 19 is attached to pipe 17 so that emitter 24 and receiver 25 confront each other. O-rings 28 and 29 are interposed between sensor 19 and pipe 17 for sealing therebetween. The light emitted from emitter 24 is sent through sight glass 26 into the the high-pressure side path, and the light transmitted through the high-pressure side path is received by receiver 25 through sight glass 27. Refrigerant state detecting sensor 19 detects transmittance of the light received by receiver 25. The transmittance of the light transmitted through the high-pressure side path of refrigerant circuit 11 corresponds to the mixing ratio of refrigerant in a liquid phase and refrigerant in a vapor phase existing or flowing in the high-pressure side path. As the amount of refrigerant decreases, the ratio of refrigerant in a vapor phase to that in a liquid phase increases and the transmittance of the light decreases. Therefore, refrigerant state detecting sensor 19 can determine a decrease in the amount of refrigerant by measuring transmittance of the light transmitted through the high-pressure side path.

Refrigerant state detecting sensor 19 is coupled to amplifier 21, as shown in FIG. 1. Amplifier 21 is connected to coil 22 of electromagnetic switch 20 provided in power source circuit 23 for the compressor. One terminal end of refrigerant state detecting sensor 19 is coupled to a power source, and the other terminal end is grounded through amplifier 21 and coil 22 of electromagnetic switch 20. If refrigerant state detecting sensor 19 detects a transmittance of the light lower than a predetermined value, that is, determines that an insufficient amount of refrigerant remains, the sensor sends a signal to amplifier 21. The signal is amplified by amplifier 21, and the amplified signal excites coil 22 of electromagnetic switch 20. As a result, electromagnetic switch 20 is opened, and compressor 12 is deactivated.

FIG. 3 shows the relationship between remainder of refrigerant in refrigerant circuit 11 and pressure of the refrigerant, and the operation area of the above system. Refrigerant state detecting sensor 19 operates at point "A" to detect a drop in the amount of refrigerant. In contrast, pressure switch 18, used to detect a lack of refrigerant in the conventional system, operates at point "B" which is not reached until the amount of refrigerant has dropped considerably more. The pressure of refrigerant in refrigerant circuit 11 greatly varies depending on the variation of the temperature of atmosphere. Therefore, the characteristic line indicating the relationship between the remainder of refrigerant in refrigerant circuit 11 and the pressure of the refrigerant shifts on a function of temperature, for example, as shown by dashed lines in FIG. 3. Accordingly, in a conventional system which employs only pressure sensor 18, lack of refrigerant in refrigerant circuit 11 cannot be precisely determined. If the operative point of the pressure sensor may cause the deactivation of the compressor under a low temperature condition even though refrigerant circuit 11 is not lacking in refrigerant. Since this is not desirable, the operative point of the pressure sensor could not be adjusted upwardly in the conventional system. However, in the present invention, refrigerant state detecting sensor 19 can precisely detect the remainder of refrigerant, even if the temperature of atmosphere varies and the characteristic line shifts as a function of temperature as shown in FIG. 3. Refrigerant state detecting sensor 19 can detect refrigerant loss at its initial stage. Therefore, when refrigerant is lost from refrigerant circuit 11, compressor 12 can be deactivated more quickly and more adequately than in the conventional systems, and damage to the compressor can be prevented. Pressure switch 18 functions as a back up to refrigerant state detecting sensor 19 in this embodiment. If refrigerant state detecting sensor 19 does not operate properly for some reason, pressure switch 18 can operate for deactivating compressor 12 at a stage when the amount of refrigerant has dropped further.

FIG. 4 illustrates another refrigerant state detecting sensor according to a second embodiment of the present invention. In this embodiment, thermistor 30, a self-exothermic type thermistor, is employed as refrigerant state sensing means. Thermistor 30 is attached to pipe 32 via O-ring 31. Thermistor 30 mainly comprises an exothermic resistive body. Its electrical resistance becomes lower as its temperature elevates. The thermal conductivity of refrigerant has different values depending upon its phase, that is, depending upon whether it is in a liquid phase or vapor phase. For example, with freon-12, the thermal conductivity in liquid phase is 0.061 kcal/ m·hr·°C and the thermal conductivity in vapor phase is 0.0083 kcal/m ·hr·°C. If the refrigerant is in a mixed state of liquid phase and vapor phase, the thermal conductivity indicates an intermediate value therebetween. Therefore, the degree of reduction of the temperature of thermistor 30 exposed to refrigerant in a liquid phase is different from that of the thermistor exposed to refrigerant in a mixed phase. The output of thermistor 30 therefore corresponds to the phase state of the refrigerant. If the refrigerant circulating in the refrigerant circuit is insufficient as indicated by the refrigerant assuming mixed phase, thermistor 30 detects the state by variation of its electrical resistance caused by variation of the temperature of the thermistor itself. Compressor 12 can be deactivated by the signal from thermistor 30 in a similar manner to the case using photoelectric sensor 19 as aforementioned.

Claims

1. A detecting system for detecting an insufficient amount of refrigerant in a cooling apparatus having a refrigerant circuit (11) for circulating refrigerant, said refrigerant circuit (11) including a compressor (12), a condenser (13) and an evaporator (16), characterized in that said detecting system comprises refrigerant state sensing means (19, 30), provided in a high-pressure side path of said refrigerant circuit (11) at a position between said condenser (13) and said evaporator (16), for detecting a condition wherein an insufficient amount of refrigerant is in said circuit (11), by sensing a mixing state of refrigerant in a liquid phase and refrigerant in a vapor phase, and providing a signal indicative of said condition.

2. The detecting system according to claim 1, wherein said refrigerant state sensing means (19, 30) comprises a photoelectric sensor (19) which senses said mixing state of refrigerant by measuring transmittance of a light transmitted through said high-pressure side path.

3. The detecting system according to claim 2, wherein said photoelectric sensor (19) comprises an emitter (24) for emitting said light and a receiver (25) for receiving the light transmitted through said path.

4. The detecting system according to claim 1, wherein said refrigerant state sensing means (19, 30) comprises a self-exothermic type temperature detecting element (30).

5. The detecting system according to claim 4, wherein said self-exothermic type temperature detecting element is a self-exothermic type thermistor (30).

6. The detecting system according to any preceding claim, wherein said refrigerant circuit (11) further includes a receiver dryer (14) and an expansion valve (15), and said refrigerant state sensing means (19, 30) is provided at a position between said receiver dryer (14) and said expansion valve (15).

7. The detecting system according to any preceding claim further comprising a pressure sensor (18) provided in said high-pressure side path of said refrigerant circuit (11) at a position between said condenser (13) and said evaporator (16).

8. The detecting system according to claim 7, wherein said pressure sensor (18) is provided as a back up sensor of said refrigerant state sensing

means (19, 30).

9. A compressor control system for a cooling apparatus having a refrigerant circuit (11) for circulating refrigerant, said refrigerant circuit (11) including a compressor (12), a condenser (13) and an evaporator (16), characterized in that said control system comprises:

refrigerant state sensing means (19, 30), provided in a high-pressure side path of said refrigerant circuit (11) at a position between said condenser (13) and said evaporator (16), for detecting a condition wherein an insufficient amount of refrigerant is in said circuit (11), by sensing a mixing state of refrigerant in a liquid phase and refrigerant in a vapor phase, and providing a signal indicative of said condition; and

compressor control means, coupled to said refrigerant state sensing means (19, 30), for controlling operation of said compressor (12) in response to the signal provided by said refrigerant state sensing means (19, 30).

10. The compressor control system according to claim 9, wherein said refrigerant state sensing means (19, 30) comprises a photoelectric sensor (19) which senses said mixing state of refrigerant by measuring transmittance of a light transmitted through said high-pressure side path.

11. The compressor control system according to claim 10, wherein said photoelectric sensor (19) comprises an emitter (24) for emitting said light and a receiver (25) for receiving the light transmitted through said path.

12. The compressor control system according to claim 9, wherein said refrigerant state sensing means (19, 30) comprises a self-exothermic type temperature detecting element (30).

13. The compressor control system according to claim 12, wherein said self-exothermic type temperature detecting element is a self-exothermic type thermistor (30).

14. The compressor control system according to any of claims 9 to 13, wherein said refrigerant circuit (11) further includes a receiver dryer (14) and an expansion valve (15), and said refrigerant state sensing means (19, 30) is provided at a position between said receiver dryer (14) and said expansion valve (15).

15. The compressor control system according to any of claims 9 to 14 further comprising a pressure sensor (18) provided in said high-pressure side path of said refrigerant circuit (11) at a position between said condenser (13) and said evaporator (16).

16. The compressor control system according to claim 15, wherein said pressure sensor (18) is provided as a back up sensor of said refrigerant state sensing means (19, 30).

17. A compressor control system for a cooling apparatus having a refrigerant circuit (11) for circulating refrigerant, said refrigerant circuit (11) including a compressor (12), a condenser (13) and an evaporator (16), characterized in that said control system comprises:

refrigerant state sensing means (19, 30), provided in a high-pressure side path of said refrigerant circuit (11) at a position between said condenser (13) and said evaporator (16), for detecting a condition wherein an insufficient amount of refrigerant is in said circuit (11), by sensing a mixing state of refrigerant in a liquid phase and refrigerant in a vapor phase, and providing a signal indicative of said condition; and

compressor deactivating means, coupled to said refrigerant state sensing means (19, 30), for controlling operation of said compressor (12) in response to the signal provided by said refrigerant state sensing means (19, 30).

18. The compressor control system according to claim 17, wherein said refrigerant state sensing means (19, 30) comprises a photoelectric sensor (19) which senses said mixing state of refrigerant by measuring transmittance of a light transmitted through said high-pressure side path.

19. The compressor control system according to claim 18, wherein said photoelectric sensor (19) comprises an emitter (24) for emitting said light and a receiver (25) for receiving the light transmitted through said path.

20. The compressor control system according to claim 17, wherein said refrigerant state sensing means (19, 30) comprises a self-exothermic type temperature detecting element (30).

21. The compressor control system according to claim 20, wherein said self-exothermic type temperature detecting element is a self-exothermic type thermistor (30).

22. The compressor control system according to any of claims 17 to 21, wherein said compressor deactivating means comprises a switch (20) provided in a power source circuit (23) for said compressor (12) and an amplifier (21) connected to said refrigerant state sensing means (19, 30) and said switch (20).

23. The compressor control system according to claim 22, wherein said switch is an electromagnetic switch (20), and said amplifier (21) is connected to a coil (22) of said electromagnetic switch (20).

24. The compressor control system according to any of claims 17 to 23, wherein said refrigerant circuit (11) further includes a receiver dryer (14) and an expansion valve (15), and said refrigerant state sensing means (19, 30) is provided at a position between said receiver dryer (14) and said expansion valve (15).

25. The compressor control system according to any of claims 17 to 24 further comprising a pressure sensor (18) provided in said high-pressure side path of said refrigerant circuit (11) at a position between said condenser (13) and said evaporator (16).

26. The compressor control system according to claim 25, wherein said pressure sensor (18) is provided as a back up sensor of said refrigerant state sensing means (19, 30).

FIG. 1

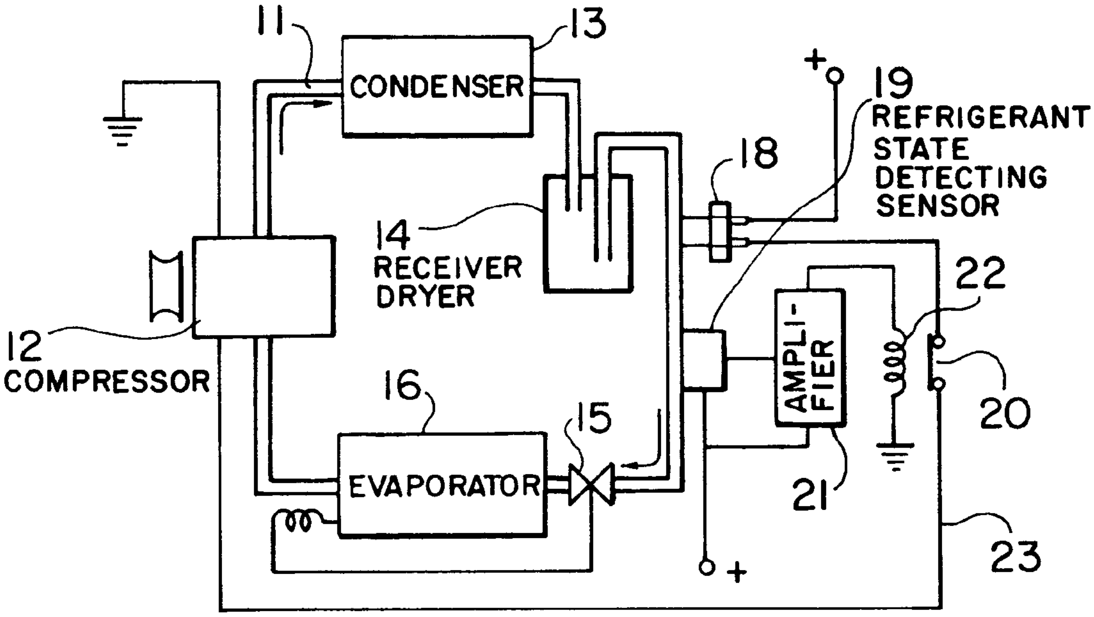
11
13
CONDENSER
+
19
REFRIGERANT
STATE
DETECTING
SENSOR
18
14
RECEIVER
DRYER
12
COMPRESSOR
AMPLI-
FIER
22
20
16
15
EVAPORATOR
21
23
+

FIG. 2

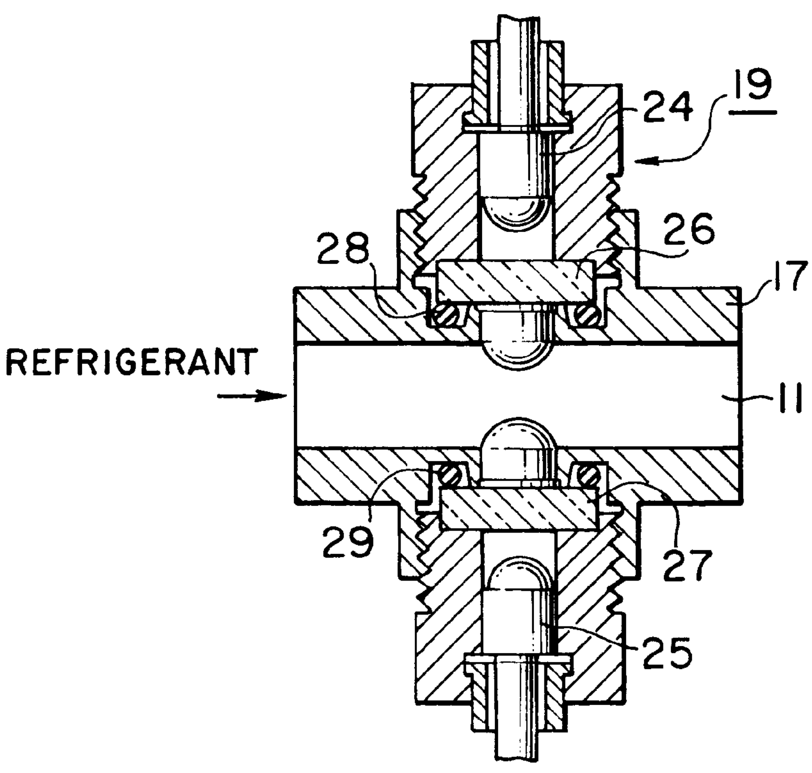
24
19
26
28
17
REFRIGERANT
11
29
27
25

FIG. 3

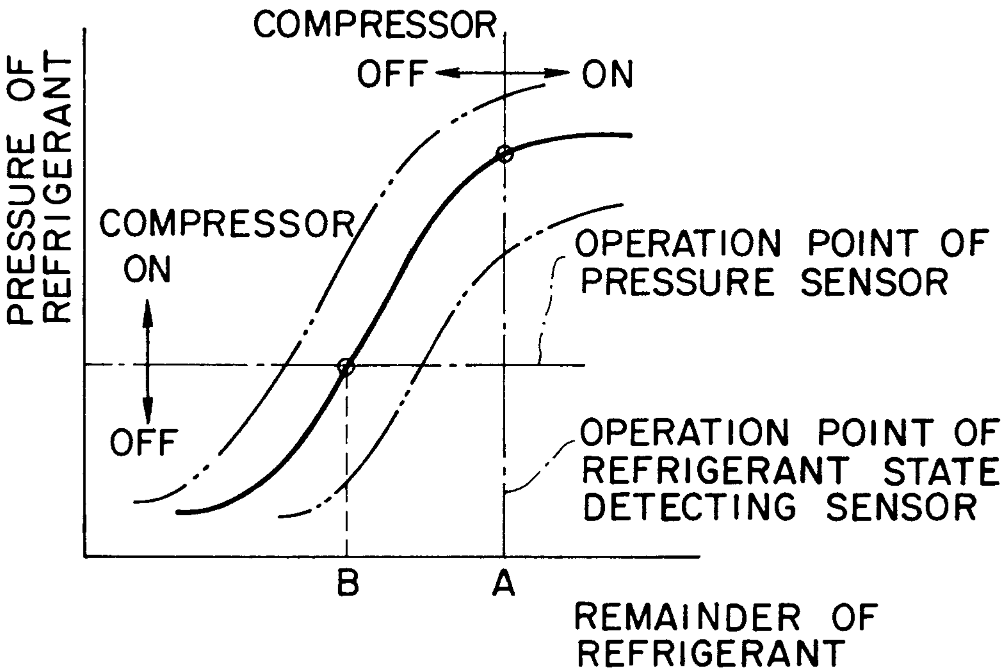
COMPRESSOR
OFF
ON
PRESSURE OF REFRIGERANT
COMPRESSOR
ON
OFF
OPERATION POINT OF PRESSURE SENSOR
OPERATION POINT OF REFRIGERANT STATE DETECTING SENSOR
B
A
REMAINDER OF REFRIGERANT

FIG. 4

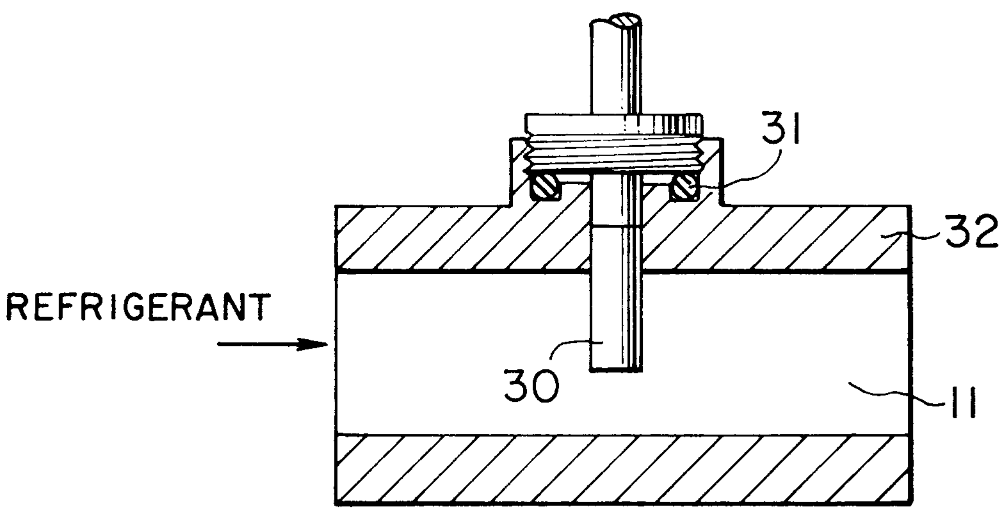
31
32
REFRIGERANT
30
11

FIG. 5
PRIOR ART