United States Patent [19]
Newton

[11] **3,797,266**

[45] **Mar. 19, 1974**

[54] **AIR CONDITIONING CONTROL SYSTEM**

[75] Inventor: **Alwin B. Newton,** York, Pa.

[73] Assignee: **Borg-Warner Corporation,** Chicago, Ill.

[22] Filed: **July 7, 1972**

[21] Appl. No.: **269,638**

[52] U.S. Cl. **62/223,** 62/224

[51] Int. Cl. **F25b 41/04**

[58] Field of Search 62/204, 210, 211, 222, 62/225

[56] **References Cited**

UNITED STATES PATENTS

1,408,744	3/1922	Keen	62/224
1,618,815	2/1927	Cory	62/223

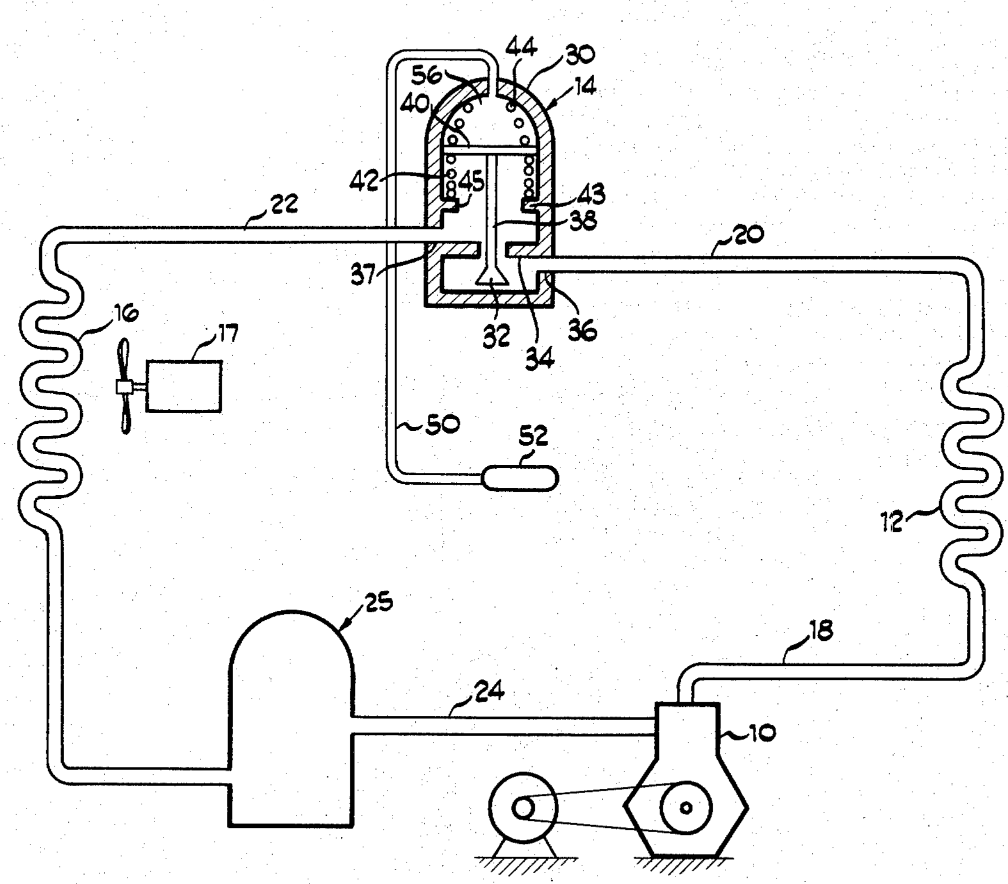
Primary Examiner—Meyer Perlin

Attorney, Agent, or Firm—Donald W. Banner

[57] **ABSTRACT**

A refrigerant control system, particularly useful for air conditioning apparatus, including means for operating the system with a relatively high evaporator pressure during the time the temperature within the cooled space is being reduced to its desired level. The constant pressure expansion device, at system start up, is operated at a relatively high pressure to maximize the refrigeration effect and increase cooling capacity. A temperature sensing element, which is sensitive to a variable indicative of air temperature within the cooled space, is operative to reset the control point of the expansion device to reduce the temperature and pressure of the evaporator. The improvement of the subject invention is directed to a system in which the temperature sensing element comprises a temperature responsive bulb and capillary charged with a fluid having a pressure difference over its temperature range which approximately matches the pressure difference of the system refrigerant over its range of operating conditions.

3 Claims, 2 Drawing Figures



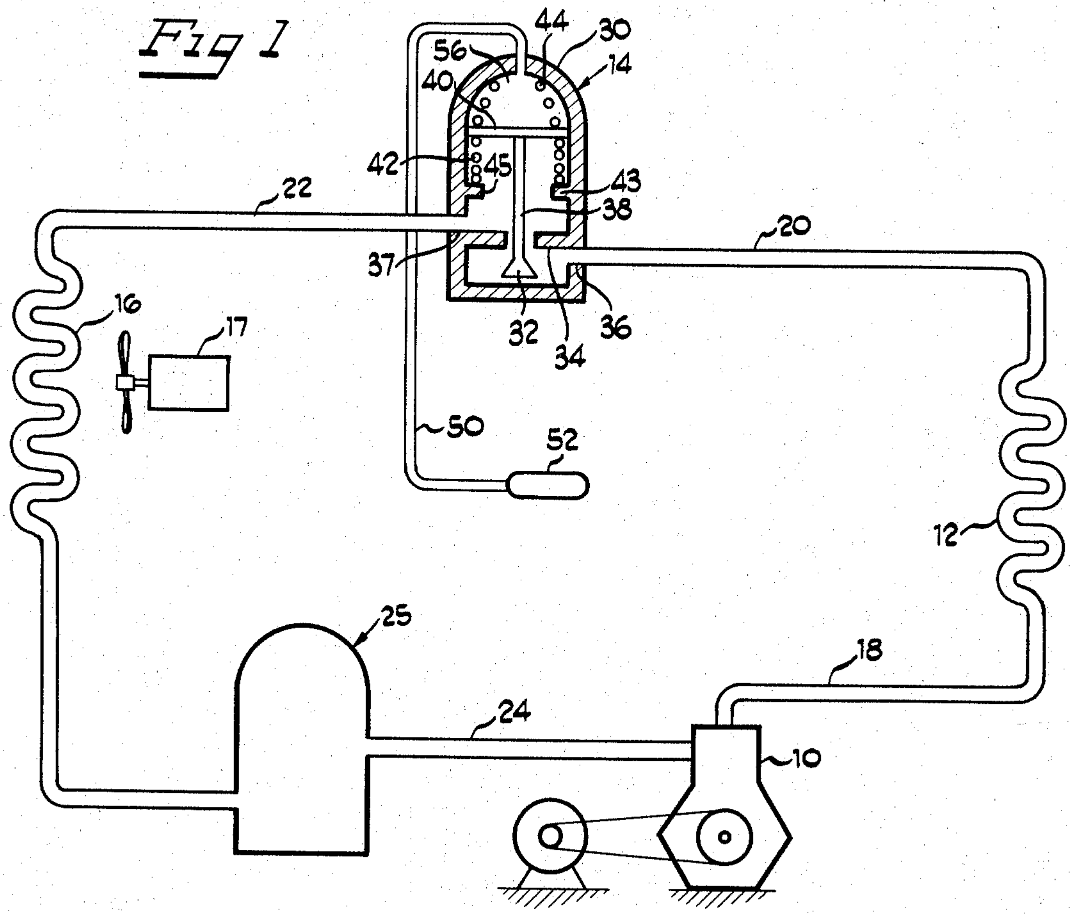


Fig 1
44
30
56
14
40
42
45
43
38
22
20
37
16
17
32
36
34
50
52
12
25
18
24
10

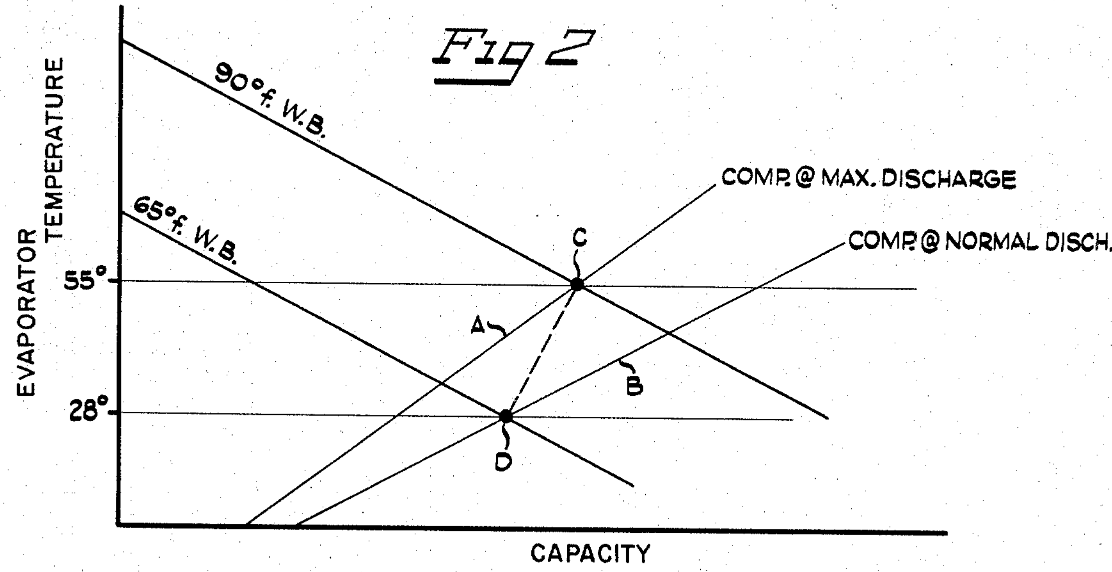


Fig 2
EVAPORATOR TEMPERATURE
90°f. W.B.
65°f. W.B.
COMP. @ MAX. DISCHARGE
COMP. @ NORMAL DISCH.
55°
28°
C
A
B
D
CAPACITY

AIR CONDITIONING CONTROL SYSTEM

BACKGROUND AND SUMMARY OF THE INVENTION

In U. S. Pat. No. 3,260,064 issued to A. B. Newton on July 12, 1966 there is described an air conditioning system including a compressor, a condenser, an expansion device, and an evaporator, all connected in a closed, vapor cycle refrigeration circuit. An important feature described and claimed in the aforementioned patent is the use of means for sensing the superheat of gas leaving the evaporator and means varying the capacity of the compressor operated in response to the amount of superheat to maintain the correct balance between the compressor capacity and the refrigeration load. This system also uses a constant pressure expansion device between the condenser and evaporator to maintain the evaporator pressure at a predetermined value.

In certain automotive air conditioning applications, especially in the larger size vehicles, which are conventionally furnished with adequately sized evaporator coils, the critical part of the system is in the compressor. At low suction pressures the efficiency of the compressor is materially reduced in that the refrigeration taken in the suction side of the compressor is in a smaller quantity and less work can be performed on the refrigerant. Automotive applications also present a problem with respect to start-up conditions. For example, the temperature of the air in an enclosed vehicle space, if the auto is parked in the sun with the air conditioning off, is often 145° F. and may be as high as 180° F. During the time which is required to bring this temperature down to the desired level, commonly referred to as "pull-down," the system should be operated in such a manner as to reduce this temperature as fast as possible to minimize discomfort of the occupants. On the other hand, it is desirable to operate the system to provide adequate dehumidification of the air being circulated within the vehicle space.

In order to satisfy the first objective, i.e., rapid pull down, the evaporator pressure should be kept relatively high. This allows more refrigerant to be taken into the compressor suction and provides for effective use of the entire evaporator coil surface. In other words, during pull-down under normal conditions the refrigerant will completely evaporate in the first section of the evaporator coil. Beyond this point the temperature of the refrigerant vapor rises (is superheated) and then passes to the compressor suction port. With an adequately sized evaporator coil the pressure can be raised to effectively increase the capacity of the compressor and utilize most of the evaporator coil surface. To satisfy the requirement of dehumidification after pull-down has been completed, the evaporator pressure should then be lowered to a point slightly above the temperature at which coil freeze up can occur.

In the related copending application Ser. No. 269,637 by Kenneth W. Cooper filed July 7, 1972, there is described an automatic control for adjusting the balance point of the automatic expansion device which permits the evaporator to operate at a substantially higher temperature (and pressure) during the pull-down phase of operation. When the temperature of the air within the controlled space reaches its desired level, the balance point of the expansion device is reset to produce a pressure and temperature in the evaporator slightly above the temperature at which coil freeze up could occur. Actually, the readjusting of the balance point is a continuous process as the pressure opposing the evaporator pressure control force rises continuously throughout the pull-down period. In the present invention, it has been found that it is very desirable to utilize a fluid in the thermal bulb capillary system which, for the pull-down temperature range, matches the pressure-temperature characteristics of the refrigerant employed in the system. For example, if it is desired to operate the evaporator at 55° F. upon initiation of the refrigeration system and at 28° F. after the desired air temperature in the control space has been reached, this is effectively a 15.2 psi difference in refrigeration pressure. If the thermal bulb is placed in contact with the air circulating in the passenger compartment, the temperature drop from 145° to 75° F. should be about equal to the previously mentioned pressure difference i.e., 15.2 psi. One advantage flowing from this is that further decrease in the temperature of air within the vehicle space would have very little effect on the thermal bulb-capillary system.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic or diagrammatic view of the air conditioning system constructed in accordance with the present invention; and

FIG. 2 is a graph in which refrigeration system capacity (Q) is plotted against evaporator temperature (T).

DETAILED DESCRIPTION OF THE INVENTION

As shown in FIG. **1**, the air conditioning system of the present invention includes a compressor **10**, a condenser **12**, an expansion device **14** and an evaporator **16** all connected to provide a closed circuit refrigeration system. Refrigerant compressed by the compressor **10** is delivered to the condenser through line **18**. The liquified refrigerant is then passed through line **28** to expansion device **14**, which will be discussed in more detail below. After the refrigerant passes through the expansion device from high pressure side to low pressure side, it flows through line **22** to the evaporator **16** which cools the air circulated over it by fan **17**. The refrigerant then flows through line **24**, commonly referred to as the suction gas line, to the suction connection of compressor **10**.

As previously described in copending application Ser. No. 99,806, A. B. Newton filed Dec. 21, 1970, now U.S. Pat. No. 3,688,517 issued Sept. 5, 1972, a superheat regulating valve **25** is located between the evaporator and the compressor in line **24**. Since the construction and operation is described in detail in the above-identified Newton application it is incorporated by reference.

Expansion device **14** comprises a valve having a casing **30**, a valve member **32** adapted to be seated on valve seat **34**, inlet **36** and outlet **37**. Valve member **32** is connected to a stem **38** which is secured at its opposite end to an actuating diaphragm **40**. Spring **42** is seated upon a spring support member **43** and tends to urge the valve member toward a closed position against seat **34**. Spring **44** located in the upper portion of the casing **30** engages the diaphragm **40** and biases the same in a downward position tending to open the valve by urging valve member **32** away from the seat.

As noted above, an important feature of the invention is the provision of means for establishing a control signal indicative of the interior air temperature and using such signal to vary the control point of the expansion device **14.** At the upper portion of the casing **30** there is provided a fluid connection, by means of capillary tube **50,** to thermal bulb **52.** The chamber **56** formed between the casing **30** and diaphragm **40** together with the capillary and bulb form a closed system.

Referring now to FIG. **2,** which shows a plot of temperature in the evaporator vs. capacity of a system using refrigerant R-**12,** the two lines running across the graph with a downward slope indicate the characteristics of the 90° F. wet bulb condition and the 65° F. wet bulb condition, as indicated by the legends. The two curves with the positive slope identified as A and B respectively indicate the compressor capacity pressure conditions at maximum discharge pressure and at normal discharge pressure. The intersection (C) of the 90° F. wet bulb line and capacity curve A approximates the conditions at initiation of the pull-down phase and results in a 55° F. evaporator pressure. The intersection (D) of line B and the 65° F. wet bulb line is the desired operating point on the assumption that the air temperature and humidity have been adjusted to this value after several minutes of operation. This produces the desired evaporator temperature of about 28° F. It is obvious from inspection of FIG. **2** that the compressor must shift operation between points C and D along the dashed line C-D. In order to establish this shift it is desirable to use a fluid in the thermal bulb-capillary system which has the same pressure drop between an assumed high interior vehicle space condition, about 145° F. and the desired air temperature, about 75° F. It can be seen that while the evaporator pressure is being shifted from 66.7 psia (corresponding to 55° F.) and 41.5 psia (corresponding to 28° F.) the bulb-capillary system must operate over an appreciably larger temperature range. In this case, a desirable fluid for use in the bulb-capillary system would be refrigerant R-**113.** At 145° F., this refrigerant has a pressure of 23.9 psia and at 75° F. a pressure of 6.2 psia resulting in a difference of 17.7 psi. Corresponding relationships can be found for the other refrigerant systems. For example, if the system is utilizing R-**22,** then R-**11** or R-**216** can be used in the bulb-capillary system. The net result of this matching of pressures within the control system forces the shift of operating conditions along a line approximating line C-D on FIG. **2.**

Assuming that the vehicle is in a condition where the interior space is relatively warm, the bulb **50** which as previously noted may be located in a position to sense interior air temperature, will be relatively warm. Accordingly, the fluid charge in the bulb and capillary will be at a high pressure, tending to establish a relatively high pressure not only within the bulb itself but also in chamber **56** which is part of the same closed system. This pressure acting against the upper surface of diaphragm **40** will tend to bias the valve member to its open position and establish a control point effecting a relatively high pressure on the downstream side of the valve, and in the evaporator itself. After the system has been operating for a few minutes the pressure on the downstream side will be maintained constant by the pressure acting against the under side of the diaphragm **40.** For example, if the load is changed so as to increase the downstream pressure this pressure will be applied through channel **45** to the under side of the diaphragm **40** tending to close the valve. If the pressure is reduced for some reason, the opposite result occurs. After the system has been operating for a while at the higher evaporator pressure, the bulb temperature will be reduced tending to reduce the pressure in chamber **56** to relieve the pressure on the upper surface of the diaphragm. This will gradually shift control point at lower and lower pressures until such time as the pull-down phase has been completed. At this point, the evaporator pressure will be established at a point slightly above the temperature at which freeze up can occur but at a low enough temperature to effect the desired dehumidification of air passing through the evaporator coil.

In the selection of the fluid to be used for the thermal bulb fill, it is preferred that such fluid have a pressure change between 145° and 75° F. of between 75 and 125 percent of the pressure change of the system refrigerant between 55° and 28° F. As noted above in the preliminary remarks, it is also desirable to select a fluid for the thermal bulb-capillary system which exhibits little pressure change upon further change in the temperature of the compartment. The choice of refrigerant R-**113** for a system utilizing refrigerant R-**12** meets this need. The average pressure change from 145° F. bulb temperature to 75° F. bulb temperature is approximately 0.25 psi/° F., whereas for the next 10° F. (down to 65° F.) there would be only 0.12 psi/° F. pressure change for further reduction in temperature.

Likewise, with refrigerant R-**11** as the thermal bulb fill, the average change in pressure for bulb temperature decreases from 145° to 75° F. is 0.48 psi/° F., whereas the change in the next 10° F. below 75° F. is 0.26 psi/° F. Even if an operator should set the temperature control in his car as low as 70° F., he would affect the evaporator temperature by only about 0.5° F., which is an acceptable deviation.

While this invention has been described in connection with a certain specific embodiment thereof, it is to be understood that this is by way of illustration and not by way of limitation; and the scope of the appended claims should be construed as broadly as the prior art will permit.

What is claimed is:

1. An air conditioning system comprising a compressor, a condenser, a constant pressure expansion device, and an evaporator all connected to provide a closed, vapor cycle refrigeration circuit through which a refrigerant is circulated; means for circulating air within a cooled space through said evaporator; a control system including a thermal bulb-capillary unit for establishing a control signal which is a function of the temperature of air within said cooled space; means for applying said signal to said constant pressure expansion device to vary the control point thereof, and the corresponding evaporator pressure, whereby the evaporator pressure is established at a lower value when the temperature of the cooled space is below some predetermined value, said thermal bulb-capillary unit being filled with an expansible, halocarbon fluid having a pressure change in the range of 145° and 75° F of between 75 and 125 percent of the pressure change of said refrigerant in the range between 55° and 28° F, whereby the temperature range of air within the controlled space during normal operation matches the temperature-pressure characteristics of said refrigerant over the range of its operating pressure.

2. A system as defined in claim **1** wherein said expansible fluid is refrigerant R-**113** and said system refrigerant is refrigerant R-**12.**

3. A system as defined in claim **1** wherein said expansible fluid is refrigerant R-**11** and said system refrigerant is refrigerant R-**22.**

* * * * *