

[54] **AIR CONDITIONING SYSTEM WITH TEMPERATURE RESPONSIVE CONTROLS**

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[58] Field of Search **62/196, 197, 199, 200, 209, 62/90, 216, 173, 278**

[56] **References Cited**

UNITED STATES PATENTS

3,478,534	11/1969	Matthies	62/225
2,344,215	3/1944	Soling	62/196

2,403,818	7/1946	McGrath.....	62/200
2,614,394	10/1952	McGrath.....	62/199

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[57]

ABSTRACT

An air conditioning system comprising a compressor, condenser, and evaporator includes a refrigerant bypass line for passing a portion of the heat laden high-pressure refrigerant from the compressor output into the lower heat level reduced pressure refrigerant fed to the evaporator or the suction line of the compressor. A valve in the bypass line monitors the flow of the bypassed refrigerant as a function of room temperature to thereby continuously modulate the thermal capacity of the system in order to maintain room temperature relatively constant.

1 Claim, 4 Drawing Figures

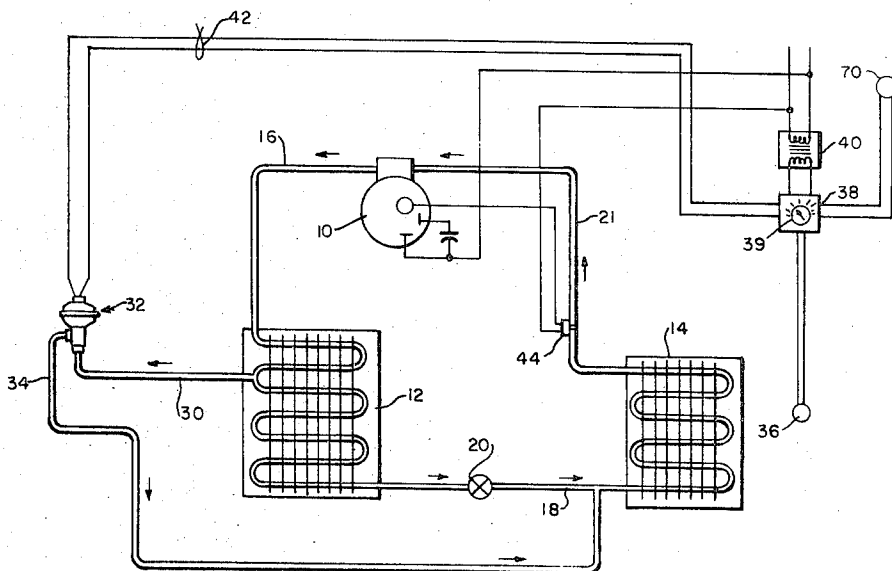
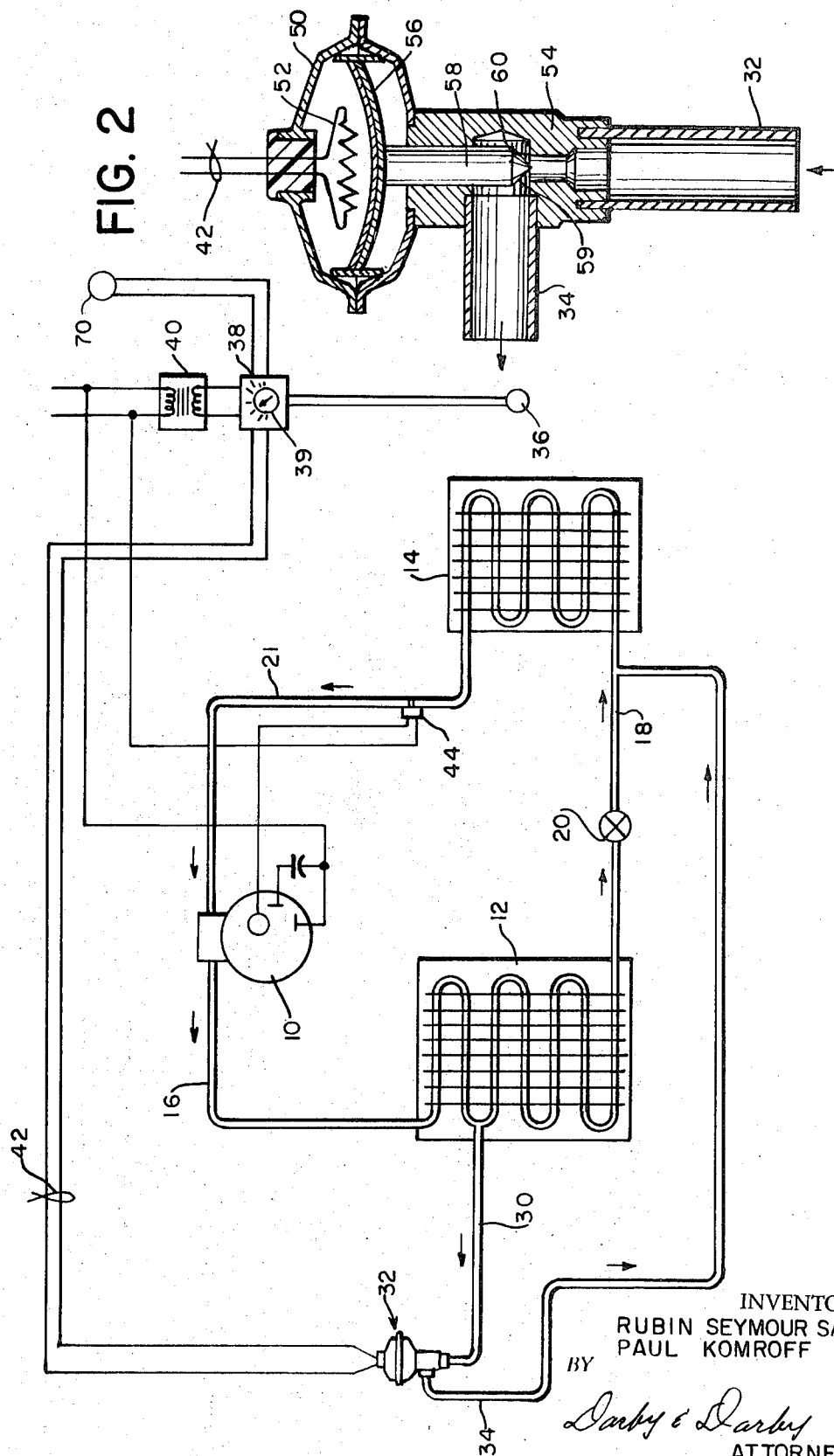


FIG. 1

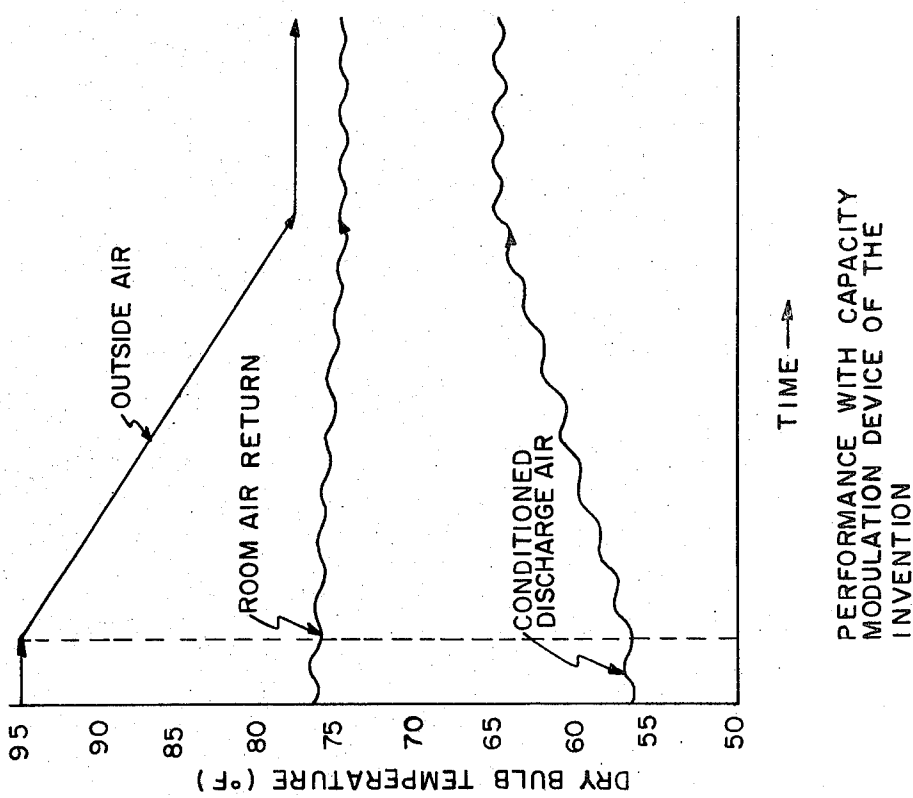


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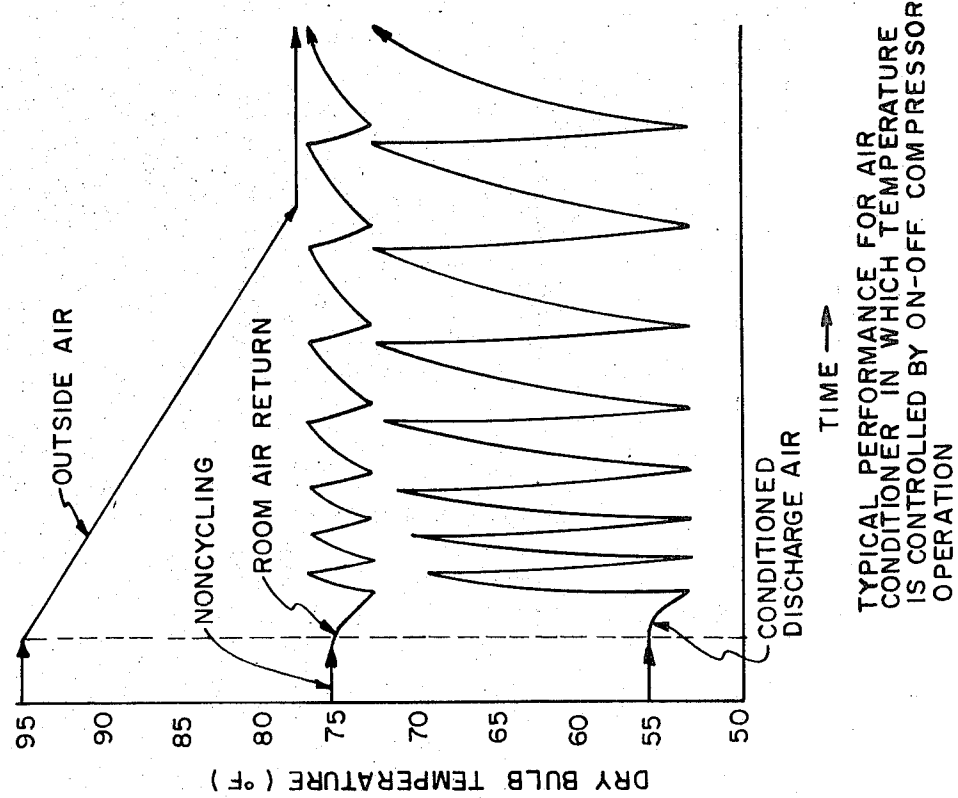
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FIG. 3B



PERFORMANCE WITH CAPACITY
MODULATION DEVICE OF THE
INVENTION

FIG. 3A



TYPICAL PERFORMANCE FOR AIR
CONDITIONER IN WHICH TEMPERATURE
IS CONTROLLED BY ON-OFF COMPRESSOR
OPERATION

AIR CONDITIONING SYSTEM WITH TEMPERATURE RESPONSIVE CONTROLS

The present invention relates to air conditioning systems, and, more particularly, to an air conditioner for maintaining the controlled temperature relatively constant without intermittent starting and stopping of the compressor.

Standard refrigeration air conditioners include an evaporator, compressor, and condenser. The compressor pumps a heat laden refrigerant under pressure to the condenser where the space heat and heat of compression are rejected to the outside. The resulting high-pressure but lower heat level liquid refrigerant from the output of the condenser is fed through suitable pressure reducing means to the evaporator. The air which is to be cooled is blown across the coils containing the evaporated refrigerant causing heat to be transferred from the air to the refrigerant. The low-pressure heat laden refrigerant from the evaporator is then returned to the compressor to close the cycle.

This type of air conditioning system is used in air conditioning units of all types. Since the system must be capable of cooling the occupied space to a comfortable temperature during extreme high outdoor temperature conditions, it is necessary to include adequate temperature control so that under less than extreme conditions, the room will not be uncomfortably cold.

Temperature control in air conditioners is usually provided by turning the compressor on and off in response to a sensed temperature condition. This is usually accomplished by a thermostatic switch responsive to space temperature, but can also be done manually. However, from a practical viewpoint, this type of control has serious drawbacks since, if the compressor is off for extended periods of time, room humidity may rise to an uncomfortable level. If the user, in attempting to compensate for this drawback, reduces the thermostat setting, the occupants are likely to become uncomfortably cold and, moreover, the coils of the evaporator may freeze resulting in nearly complete loss of cooling. In addition, typical small unitary air conditioners use thermostats which are insensitive enough to permit space temperatures to vary by plus or minus 2° F, or even 3° F. Consequently, for the majority of environmental conditions encountered, optimum comfort cannot be achieved either because of the excess humidity or the low temperature. Moreover, the required intermittent compressor operation materially reduces the operating life of the compressor.

The present invention provides an air conditioning system of the type used, for example, in small unitary air conditioners, which provides the desired temperature control without the foregoing disadvantages. Basically, this is done by modulating the thermal capacity of the air conditioner so that the compressor runs at all times to provide continuous humidity control. Capacity modulation is achieved by bypassing a suitable amount of the heat laden high-pressure uncondensed refrigerant around the condenser, and mixing the bypassed refrigerant with normal lower heat level cooling refrigerant at the inlet of the evaporator. The bypass line includes a valve which is responsive to room temperature to control the amount of bypassed refrigerant. Thus, a controlled amount of the heat removed from the space is recycled, and only the remaining portion of the heat removed is rejected from the system completely (in the

condenser). In this way, only that amount of heat required to maintain the desired space temperature is actually rejected from the air conditioning system.

The invention is described in detail below with reference to the attached drawings wherein

FIG. 1 is a diagrammatic illustration of a preferred embodiment of the invention; and

FIG. 2 is a side sectional view showing the construction of a preferred form of the refrigerant bypass valve.

FIG. 3A is a graphic illustration of air temperature variations for air conditioning unit using standard thermostatic "on-off" controls.

FIG. 3B is a graphic illustration of air temperature variations for an air conditioner using the capacity modulation means of the invention.

The preferred embodiment of the invention was designed specifically for use in a small unitary air conditioner and, in the following, reference is made to a small unitary air conditioner for purposes of explanation. The principles of the invention are equally applicable to central air conditioning systems and other non-unitary air conditioners.

In FIG. 1, the basic system is shown including a compressor 10, a condenser 12 and an evaporator 14. Since these elements are all well-known, they are shown only in diagrammatic form. Also, as is common, the output of compressor 10 is connected to the input of condenser 12 by a high-pressure line 16. The refrigerant is passed from condenser 12 to evaporator 14 through a high-pressure line 18 which contains a refrigerant flow control means 20. The liquid refrigerant from condenser 12 is under high pressure because of compressor 10 and flow control 20 (e.g., a flow restrictor) reduces the pressure of the liquid so that it will evaporate in evaporator 14. The low-pressure gaseous refrigerant from evaporator 14 is returned to compressor 10 through a suction line 21.

A fan (not shown) is used to blow the outside air across the coils of condenser 12. The heat of the condensed refrigerant within condenser 12 is transferred to this airstream which is then exhausted to the outside. A second fan or blower (not shown) pulls the room air across the evaporator coils which have been cooled by the evaporated refrigerant and recirculates the room air at substantially reduced temperature.

The operation of the system as described to this point is standard. Such systems, for example, may be capable of maintaining a room at 80° F when the outside air temperature is 95° F. If the outside temperature drops to, say, 85° F, the temperature of the room would become uncomfortably cold. As described above, satisfactory temperature and humidity control cannot be provided by merely shutting off the compressor 10 when the room air temperature drops below a preselected level. However, in accordance with the invention, compressor 10 can be kept on by selectively bypassing a predetermined amount of the heat laden uncondensed refrigerant (dependent upon room temperature) around condenser 12. For this purpose, an inlet bypass line 30 is connected directly from one of the first tube end turns of condenser 12 to a bypass valve 32. The outlet of bypass valve 32 is coupled by an outlet bypass line 34 to the inlet side of evaporator 14 as shown diagrammatically in FIG. 1.

The construction of valve 32 is explained in detail below in connection with FIG. 2. In its preferred embodiment, it is electrically operated in response to

room temperature as sensed by a probe 36. Where the invention is used in a small unitary air conditioner, the probe 36 may be positioned on the housing at a point which is at the approximate temperature of the space. Probe 36 may comprise a thermistor which is connected in a circuit including a signal converter 38 and a transformer 40 responsive to line voltage. The electrical output of the signal converter 38 is coupled by conductors 42 to valve 32 to maintain the valve in a condition dependent upon the space temperature. Thus, as room temperature decreases (or increases) the valve 32 is opened (or closed) to feed a controlled quantity of the heat laden high-pressure refrigerant directly into the inlet side of evaporator 14. A manual control 39 may be used by the occupant to vary the space temperature at which capacity modulation by bypassing will begin. Consequently, evaporation of the low-pressure liquid refrigerant in the evaporator is reduced (increased) and the temperature exchange between the room return air and the colder evaporator coils is reduced (increased).

As an example, under typical conditions, a room air conditioner operating at full capacity (i.e., with valve 32 closed) may be capable of reducing the space temperature to 77° F when outside air temperature is 93° F. The return air blown across the evaporator coil may, for example, be cooled 20° F (to about 57° F) under these circumstances. With the manual adjustment means 39 of the signal converter 38 set so that bypassing begins when the space temperature drops to 77° F, the following sequence takes place. A reduction in outside air temperature (say to 86° F) will result in a signal from the converter 38 which will cause the valve 32 to open partially. During this adjustment, the space temperature will drop to about 76° F, so the resulting discharge air temperature will be 61° F. Valve 32, in its partially open state, may cause the room return air to be cooled by only 15° F. If outside air temperature further drops to a temperature corresponding to the minimum load to which the valve 32 can adjust (say 78° F), the probe 36 may cause the valve 32 to open entirely permitting the space temperature to drop to 75° F. In this case the space return air will only be cooled 10° F with resulting discharge air temperature at about 65° F. Hence, in this hypothetical example, for a range of outside air temperature between 93° and 78° F, room temperature is maintained at a relatively constant range of 77°-75° F and discharge air temperature will actually rise from 57° and 65° F. Furthermore, the space will be continuously dehumidified in view of the continuous compressor operation. Accordingly, occupants of the room will detect no uncomfortable temperature or humidity changes despite the relatively wide variation of outside temperature.

The improvement provided by the invention is graphically depicted in FIGS. 3A and 3B. FIG. 3A shows typical performance characteristics of an air conditioning system in which temperature is controlled by turning the compressor on and off. As the outside air temperature decreases the room air temperature continuously fluctuates, and the intervals during which the compressor is off increase. During such intervals room humidity is not effectively controlled. With the invention, as shown in FIG. 3B, room air temperature variations are minimal since the average temperature of the discharge air increases gradually with decreasing environmental or outside air temperature.

Compressor 10 is operated directly from the line voltage which is also coupled to the primary winding of transformer 40. A temperature switch 44 may be series-connected in one of the lines to compressor 10.

This switch may operate on the suction line 21 to stop the compressor in the event of extremely low loads, which are beyond the bypassing capacity of valve 32, before evaporator coil freeze-up can occur. Alternatively, this function may be provided by a relay operated directly from the signal converter 38 in the event room air temperature drops below, for example, 65° F. Such protection means would not operate for the purpose of maintaining room temperature at a desired level but simply as a means for preventing evaporator coil freeze-up. Other means such as a suction pressure regulator in line 21 may be used to prevent evaporator coil freeze-up under extreme conditions. These protection means would only be operable where the bypass valve, in its fully opened condition, does not reduce the system capacity sufficiently, in which case continuous cooling may cause over-cooling or coil freeze-up. In practice, where the bypass valve 32 is capable of reducing the unit capacity by 50-60 percent, it is likely that the space occupant will manually turn off the unit before the protection means need be actuated.

FIG. 2 shows, in cross-sectional form, a preferred embodiment of valve 32. The valve includes a housing 50 in which an electrical heater element 52 (shown diagrammatically) is suitably positioned. The heater 52 is connected to line 42 from converter 38. Converter 38 transmits to valve 32 a voltage inversely proportional to the space temperature sensed by the probe 36. The lower the space temperature, the higher the voltage transmitted to heater 52 and vice versa. Converter 38 is equipped with a manual control 39 by means of which the magnitude of the voltage transmitted by 38 for a given sensed space temperature may be varied. Thus control 39 provides the occupant with a means of adjusting the space temperature to his needs. A cylinder 54 extends downwardly from the upper housing 50. A bi-metal element 56 is secured within housing 50 and will flex upwardly as its temperature increases and vice versa. In practice the coils comprising heater 52 may surround bi-metal element 56. A valve stem 58 including a lower valve plug 59 is rigidly attached to the bi-metal element 56. A fixed valve seat 60 which mates with the movable valve plug 59 is attached to the inside of valve housing cylinder 54. The bypass inlet 32 and outlet 34 are connected to the cylinder 54 as shown so that the position of valve plug 59 relative to valve seat 60 determines the amount of heat laden bypassed refrigerant gas passed to the evaporator 14. Besides metering the flow of bypassed refrigerant, the constriction provided by plug 59 and valve seat 60 allows for the reduction of the pressure of the heat laden uncondensed refrigerant in the bypass line to that existing in the evaporator 14.

In use, the occupant of the space to be cooled sets control 39 on the signal converter 38 to a desired point. This setting of control 39 determines the voltage transmitted to heater 52 for a given space temperature. An increase (decrease) in voltage to heater 52 increases (decreases) the heating rate and raises (lowers) the temperature of the bi-metal element 56, causing 56 to flex upward (downward). This in turn causes valve plug 59 to move upward (downward) away from (closer to) valve seat 60. As space temperature decreases (in-

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creases) heater 52 causes the bi-metal element 56 to flex upwardly (downwardly) thus opening (closing) valve seat 60 to increase (decrease) the flow of bypassed heat laden refrigerant between lines 32 and 34.

Although a preferred embodiment of the invention has been illustrated, numerous modifications thereof are contemplated within the scope of the invention. For example, the gas bypass line 34 may enter the low-pressure line 21 to compressor 10 so long as superheating of the suction gas is held within practical limits.

Similarly, although the preferred location for the inlet bypass line 30 is after the first tube pass as shown diagrammatically in FIG. 1, it is possible that this line may be coupled directly into the high-pressure gas discharge line 16 from compressor 10.

Also, the construction of valve 32 and the entire temperature sensing means may be varied considerably within the scope of the invention. In the preferred embodiment bypass valve 32 was a modified version of an electric expansion valve sold by Controls Company of America. With this type of valve, the signal converter could be electrical, electromagnetic, pneumatic-electric, electromechanical or any other adequate type. Moreover, the bypass valve does not have to be electrically operated and, for example, may be actuated by mechanical or pneumatic means.

It is further contemplated that a second temperature sensing probe 70 may be used to monitor outside air temperature. The signal from this second probe may be used to vary the space temperature set point of the signal converter 38 to provide automatic control of the outside-to-inside air temperature difference or to apply to anticipatory bypass effect in the event outside air temperatures vary rapidly.

We claim:

1. In an air conditioning system including a compressor, condenser, and evaporator wherein the compres-

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sor provides a heat laden refrigerant under relatively high pressure to the condenser which rejects heat from and condenses the refrigerant so that lower heat level liquid refrigerant can be supplied to the evaporator, there being a refrigerant flow control valve between the condenser outlet and evaporator inlet to reduce the pressure of the refrigerant fed to the evaporator, the improvement comprising

a refrigerant bypass line for passing the heat laden high-pressure refrigerant from the compressor output into the reduced-pressure lower heat level refrigerant between said flow control and the inlet to said compressor,

a bypass valve in said bypass line for controlling the flow of said heat laden refrigerant in said bypass line, said valve including a bimetallic element and an electrical heating element for flexing said bimetallic element,

a temperature responsive probe arranged outside of the direct flow of air across the evaporator and responsive to the room temperature of the space to be cooled,

means for coupling an electrical signal from said temperature responsive probe to said electrical heating element for controlling the condition of said valve to vary the temperature of the discharge air flowing across the evaporator to maintain said room temperature at a preselected level by varying the thermal capacity of the air conditioner,

a second temperature responsive probe responsive to the temperature of the outside air, and

means responsive to said second temperature responsive probe for varying the magnitude of the voltage applied to said heating element by said first-named temperature responsive probe.

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