April 14, 1970 D. R. VANDER MOLEN ET AL 3,505,828

CONTROL FOR REFRIGERATION APPARATUS

Filed June 20, 1968 2 Sheets-Sheet 1

FIG. 1

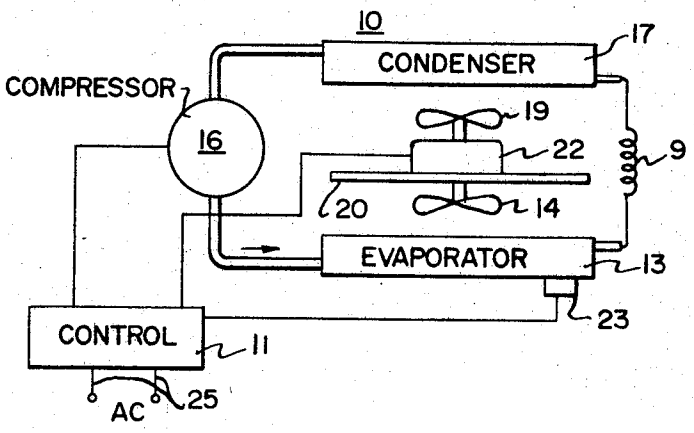
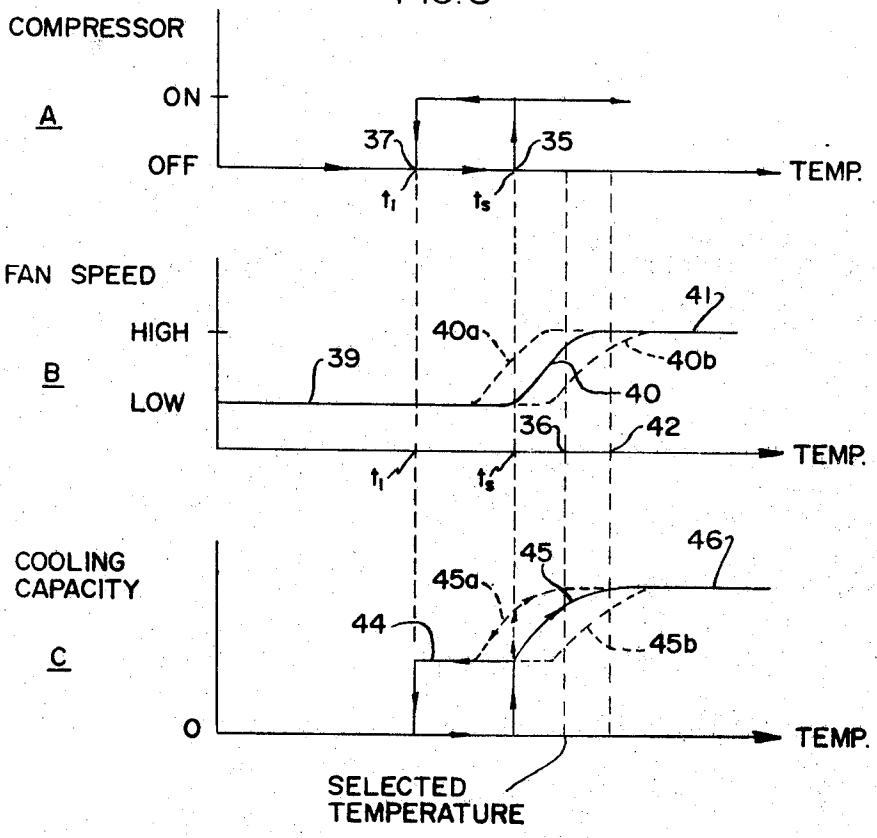


FIG. 3



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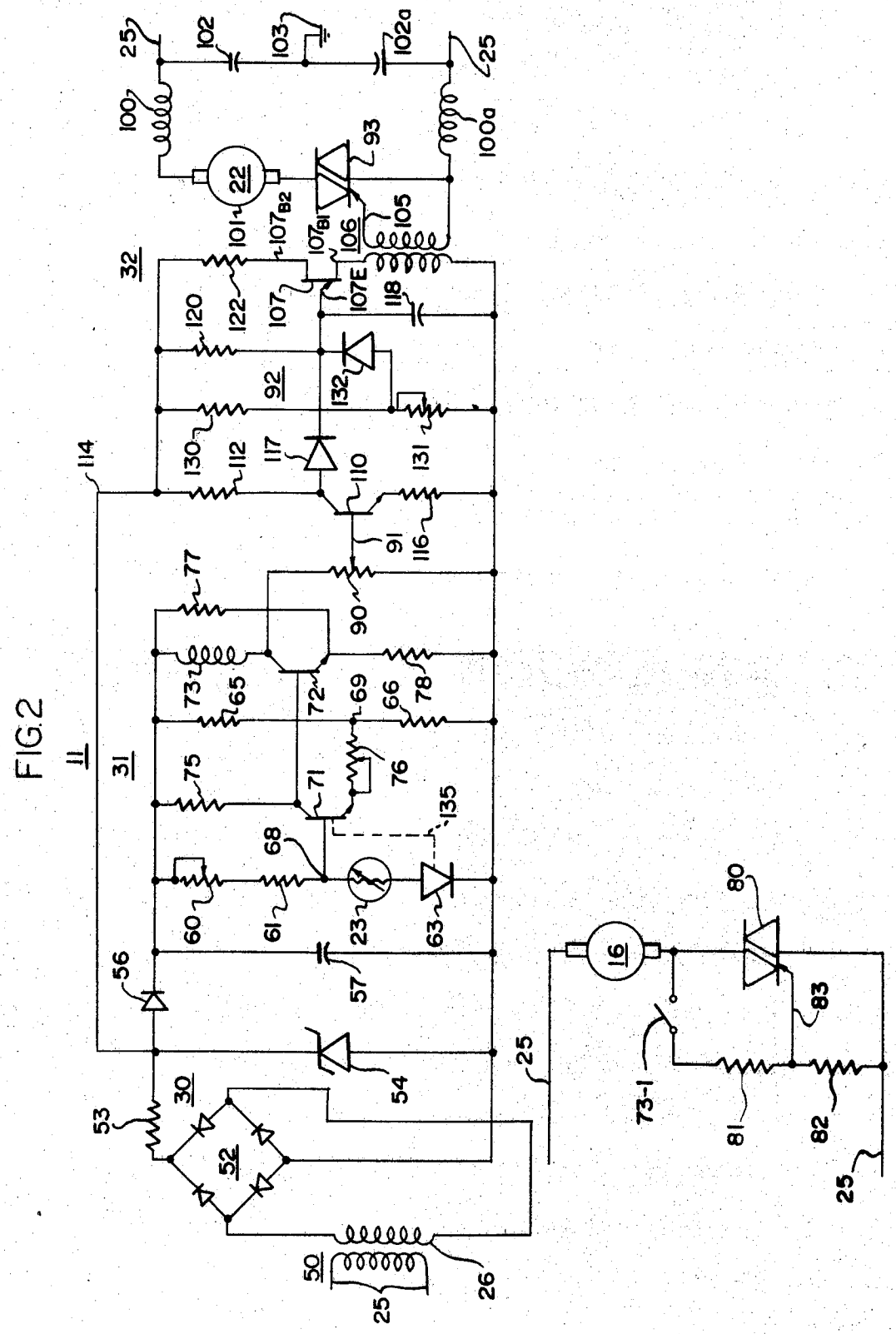
BY Hofgren, Wegner, Allen, Stellman & McCord.

ATTORNEYS.

CONTROL FOR REFRIGERATION APPARATUS

Filed June 20, 1968 2 Sheets-Sheet 2

FIG.2



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3,505,828

CONTROL FOR REFRIGERATION APPARATUS

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Int. Cl. F25d 17/00
U.S. Cl. 62—180 9 Claims

ABSTRACT OF THE DISCLOSURE

An air conditioning control having a two stage temperature compensated transistor amplifier connected to a thermistor temperature sensing bridge for cycling the compressor on and off. The speed of a fan for the evaporator is varied above a minimum speed in accordance with temperature when the compressor is operating.

This invention relates to a control for refrigeration apparatus, and more particularly to a refrigeration control for regulating the speed of a fan and the operation of a compressor unit.

A refrigeration apparatus, such as a conventional room type air conditioner, has an evaporator through which air is passed by a fan to effect a heat exchange for cooling the air. A refrigerant fluid is circulated through the evaporator by a compressor which is cycled on and off by a control unit. The control unit is connected to a temperature sensor arranged to initiate operation of the compressor when the room air temperature rises above a preselected high value, and to discontinue operation of the compressor when the room air temperature falls below a preselected low value.

It has been suggested that the speed of operation of the fan for the evaporator may be varied in proportion to temperature, independent of the operation of the compressor circuit to vary system capacity. While such a control represents an improvement over prior controls, it does not produce a system having the desired maximum efficiency at varying control settings.

In accordance with the invention, control of the evaporator fan speed is synchronized with control of energization and deenergization of the compressor unit, to produce a refrigeration system having improved cooling and dehumidifying efficiency over a wide range of control settings. The speed of the fan is preferably increased subsequent to the energization of the compressor to increase the cooling capacity of the refrigeration apparatus. A desired temperature is maintained by varying the speed of the fan and thus the system cooling capacity within a preselected controlled range. Since the compressor is continuously energized when the control calls for cooling, the evaporator remains cool in order to condense water vapor and hence dehumidify the air.

A principal object of this invention is to provide an improved refrigeration apparatus control which synchronizes control of the operation of the evaporator fan with control of the operation of the compressor.

One of the features of the invention is the provision of an air conditioner control in which evaporator fan speed is varied while the compressor is operating. While the compressor is deenergized, the evaporator fan is maintained at a constant minimum speed.

Another feature of this invention is the provision of an air conditioner control having a temperature sensor circuit for switching a compressor on and off. The temperature sensor circuit also controls the firing angle of a switching device connected between a fan motor and a source of alternating current.

Yet another feature of this invention is the provision of an air conditioner control in which a conduction device connected to a fan motor is controlled by a circuit including a voltage divider for maintaining a desired minimum voltage. The circuit is controlled by the same temperature sensor which cycles a compressor between energized and deenergized states.

Still another feature of the invention is the provision of a control for refrigeration apparatus employing temperature compensation for semiconductor devices used in the control.

Other features and advantages of the invention will be apparent from the following description of one embodiment taken in conjunction with the accompanying drawings. Of the drawings:

FIGURE 1 is a block diagram of refrigeration apparatus controlled by the invention;

FIGURE 2 is a schematic diagram of the control shown in block form in FIGURE 1; and

FIGURE 3 illustrates curves of the operating characteristics of the control over a limited range of temperatures.

While an illustrative embodiment of the invention is shown in the drawings and will be described in detail herein, the invention is susceptible of embodiment in many different forms and it should be understood that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the embodiment illustrated. Throughout the specification, values and type designations will be given for certain of the components in order to disclose a complete, operative embodiment of the invention. However, it should be understood that such values and type designations are merely representative and are not critical unless specifically so stated. The scope of the invention will be pointed out in the appended claims.

Turning to FIGURE 1, refrigeration apparatus in the form of an air conditioner **10**, which may be of the room air conditioner type adapted for use in a window or through-the-wall installation, is controlled by a unit **11** constructed in accordance with the invention. The air conditioner **10** is enclosed in a suitable housing (not shown) and has an evaporator **13** with refrigerant conducting tubes (not illustrated) which may have heat transfer fins thereon through which room air is circulated by means of a fan or blower **14**. A compressor **16** is connected with evaporator **13** for circulating a refrigerant fluid through the evaporator **13** and through a condenser **17** connected in a closed fluid path with a compressor **16** enclosed in a housing including a compressor motor. The refrigerant line connecting condenser **17** to vaporator **13** includes the usual restrictor, illustrated in the form of a capillary **9**. A second fan **19** is disposed adjacent condenser **17** for circulating cooling air thereto. Fan **19** is located behind a transverse partition **20** which separates fan **19** and condenser **17** from fan **14** and evaporator **13** in the air conditioner housing.

Control unit **11** maintains room air at the temperature selected by the user of the apparatus through control of the operation of both compressor motor **16** and a fan motor **22**, which may be arranged to drive both fans **14** and **19** as illustrated in FIGURE 1. It will be understood that fan **19** could also be operated by another control and another motor independent of control **11** and motor **22**. A temperature sensor illustrated in the form of a thermistor **23** is located in the path of air entering evaporator **13** for sensing the temperature of room air drawn through the air conditioner by fan **14**. When the sensed air temperature exceeds a predetermined value, control unit **11** energizes compressor motor **16**. The apparatus discussed above, except for the structure and operation of control unit **11** discussed in detail

hereafter, is generally known and will not be described in detail.

Turning now to FIGURE 2, control unit **11** is shown in schematic form. A pair of lines **25** from a conventional AC power source (not illustrated) provide power through a transformer **50** to a DC supply circuit **30** which provides operating power to a thermostat circuit **31**, which includes temperature sensor **23**, and a fan motor speed circuit **32**. Thermostat circuit **31** cycles compressor motor **16** between on and off states in accordance with a set point temperature selected by adjusting a control knob (not shown) associated with control unit **11**, and the relationship between set point temperature and the room temperature as monitored by sensor **23**. Fan speed circuit **32**, which is responsive to signals from thermostat circuit **31** when the compressor is energized, passes a variable amount of AC current to fan motor **22** for varying the speed of the fans driven thereby.

An understanding of the general operation of control unit **11** may be facilitated by referring to FIGURE 3, in which curves are illustrated of the operating characteristics of compressor **16** (FIGURE 3A), fan speed circuit **32** (FIGURE 3B), and the overall system (FIGURE 3C). The three curves have a common base which represents a limited range of temperatures near the temperature selected by the user.

In operation, thermostat circuit **31** turns the compressor on at a set point temperature indicated at **35**, as seen in FIGURE 3A. The compressor remains on for all temperatures in excess of temperature **35**, and will not turn off until a lower temperature indicated at **37** is reached. Once compressor **16** is off, the room temperature as monitored by sensor **23** must rise to the higher value indicated at **35** before the compressor will again be turned on. In the embodiment of FIGURES 1–3, the temperature differential between temperatures **35** and **37** is approximately 1° F.

Fan speed control circuit **32** normally maintains the fan at a low speed indicated at **39**, FIGURE 3B, for all temperatures below the temperature indicated at **35** at which the compressor is turned on. The operation of fan speed control circuit **32** is synchronized with the operation of thermostat circuit **31** so that when the compressor is turned on at temperature **35**, the speed of the fan may be modulated by being increased continuously over a range indicated at **40** until a maximum speed indicated at **41** is reached for all temperatures in excess of a temperature indicated at **42**, higher than the set point temperature indicated at **35**. As shown in FIGURE 3B, a temperature indicated at **36** falls within the range of continuous speed control of the fan motor **22**. If the air conditioner capacity has been properly matched with the required cooling load, fan speed control **32** will respond to maintain the room temperature at the temperature indicated at **36**. The temperature indicated at **36** may be called the control point temperature. The temperature differential between the temperature indicated at **42**, at which maximum fan speed indicated at **41** occurs, and the temperature indicated at **35**, at which the compressor is first energized, is approximately 1° F.

The resulting cooling capacity of the air conditioner when operated in the above manner can be seen in FIGURE 3C. The cooling capacity of the air conditioner has a constant value indicated at **44** when the compressor is on and the fan is driven at low speed. For temperatures in excess of the temperature indicated at **35**, however, the increase in fan speed has the effect of increasing the cooling capacity of the air conditioner, along a curve **45**, until a maximum cooling capacity indicated at **46** is reached which represents the compressor on and the fan operating at maximum speed. The control unit is effective to vary the fan speed to maintain a room temperature at a control point temperature indicated at **36** which falls within the variable cooling capacity curve **45** of the air conditioner. Depending on the cooling load, the control point temperature may not fall within the variable cooling capacity range. Thus under high load conditions, the control point temperature may be in excess of the temperature indicated at **42**.

By synchronizing the start of the fan speed modulation with the initial energization of the compressor, and continuously varying fan speed between minimum and maximum values over a narrow range of temperatures, several important operating advantages are achieved. The full range of fan speeds is available over a narrow temperature differential in order to control more precisely the capacity necessary to maintain a selected temperature. Furthermore, the compressor is maintained on for a maximum time, keeping the evaporator coils cool to condense water vapor and hence control the humidity of the air over a maximum period of time. Also, when the compressor is first turned on, indicating sensing of a rising temperature, a variable rather than a fixed cooling capacity is available to interrupt the sensed temperature rise. Furthermore, the air conditioner will always operate at the lowest fan speed consistent with the cooling load and thus provide quieter operation. This is particularly advantageous for room air conditioners used for cooling bedrooms where the night cooling load is typically low and where undue noise will interfere with sleeping. Also, legislation now in force establishing permissible noise levels for air conditioners sets lower levels for nighttime operation. Thus, it is desirable for the air conditioner to be quieter in operation during the nighttime hours while achieving the desired cooling capacity.

Returning to FIGURE 2, the control unit **11** which produces the above results will now be described in detail. Power supply circuit **30** consists of a power transformer **50** which drops the AC voltage input thereto from power lines **25** to 24 volts, which is coupled to a full wave diode rectifier bridge **52**. The output of bridge **52** is connected through a 100 ohm resistor **53** to a 20 volt Zener diode **54** for clipping the full wave AC voltage. The voltage across Zener diode **54** is coupled directly to fan speed circuit **32** and to a blocking diode **56** and a 175 microfarad smoothing capacitor **57** for powering thermostat circuit **31**.

Temperature sensor **23** in thermostat circuit **31** is a negative temperature coefficient thermistor, having 1,000 ohm resistance at 77° F., which is connected in a bridge type circuit across DC output capacitor **57**. One side of the bridge consists of a 10 kilohm potentiometer **60**, a 4.7 kilohm resistor **61**, thermistor **23**, and a diode **63** connected in series across the DC supply. The other side of the bridge consists of a 10 kilohm resistor **65** and a 1 kilohm resistor **66** connected in series across the DC supply. The output from the thermistor bridge is available at a junction **68** between resistor **61** and thermistor **23**, and a second junction **69** between resistor **65** and resistor **66**. The resistance of potentiometer **60** is varied by the user of the air conditioning system to select the desired set point temperature, as may be indicated by a suitably calibrated control knob (not illustrated) associated with control unit **11**.

A two stage transistor amplifier using NPN transistors **71** and **72** is connected between the thermistor bridge and a relay coil **73** for energizing compressor motor **16**. Transistor **71** has its base directly connected to junction **68**. The collector of transistor **71** is directly connected to the base of transistor **72**, and is connected to the DC power supply through a 100 kilohm resistor **75**. A 2 kilohm potentiometer **76** connects the emitter of transistor **71** to the junction **69** on the opposite side of the thermistor bridge.

The collector of transistor **72** is connected through relay coil **73** with the DC power source. Relay coil **73** has a 2.0 kilohm resistance with a 4.9 milliampere pull-in and a 2.9 milliampere drop-out rating. When the value of pull-in current is reached or exceeded, a normally open contact switch **73–1** is closed to energize compressor

motor **16**. The emitter of transistor **72** is connected to a voltage divider consisting of a 3.3 kilohm resistor **77** and a 680 ohm resistor **78** connected in series across the DC supply, with the junction therebetween being directly connected to the emitter of transistor **72**.

Compressor motor **16** is connected across the AC power lines **25** through a normally nonconducting semiconductor bidirectional triode switch or triac **80**. Triode switch **80** is shunted by relay contact **73–1** in series with a pair of resistors **81** and **82**. The junction between resistors **81** and **82** is connected to a gate terminal **83** of the triode switch.

In operation, transistor **71** is driven toward saturation at temperatures below that selected by potentiometer **60**. Transistor **71** diverts base current away from transistor **72**, tending to drive transistor **72** more nonconductive as transistor **71** becomes more conductive. As the temperature sensed by thermistor **23** increases, the thermistor resistance and corresponding voltage drop decreases, driving transistor **71** towards cut-off and increasing the conduction of transistor **72**. At the temperature indicated at **35** in FIGURE 3A, transistor **72** passes sufficient current to pull in relay **73**, thereby closing relay contact **73–1** and gating triac **80** into conduction. Triac **80** thereupon passes both half cycles of AC power to compressor motor **16** causing operation of the compressor. Since relay **73** has a smaller drop-out current than that required for pull-in, compressor motor **16** will not be turned off until a lower temperature **37** is sensed by temperature sensor **23**.

The operation of fan speed circuit **32** is synchronized with the operation of thermostat circuit **31**. More particularly, a 25 kilohm resistor **90** is connected in parallel with transistor **72** and resistor **78** so that voltage thereacross is approximately inversely proportional to the conduction of transistor **72**. Resistor **90** is in the form of a potentiometer having a variable tap **91** connected to a ramp and pedestal circuit **92** for controlling the firing angle of a second triac **93** which controls the current to fan motor **22**. Ramp and pedestal circuit **92**, to the extent described herein, operates in a known manner for circuits of this type, and reference may be made to a standard semiconductor control device manual for a more detailed description, as the General Electric Company "SCR Manual," third edition, 1964, pages 130 to 137.

Coils **100** and **100*a***, and capacitors **102** and **102*a*** form a radio frequency interference filter for eliminating radio interference generated by triac **93**. Triac **93** is in series with fan motor **22** in order to control the amount of each half cycle of AC which is passed to the motor. Triac **93** has a gate terminal **105** whch is connected through a pulse transformer **106** to a unijunction transistor (UJT) **107**. UJT **107**, in turn, is under control of ramp and pedestal circuit **92** for controlling the firing angle of triode switch **93**.

Ramp and pedestal circuit **92** includes an input NPN transistor **110** having its base directly connected to tap **91** of potentiometer **90**. The collector of transistor **110** is connected through a 1.5 kilohm resistor **112** to power supply line **114** which is connected to Zener diode **54**. As previously explained, line **114** provides a clipped or regulated full wave rectified DC voltage. The emitter of transistor **110** is connected through a one kiloohm resistor **116** to the opposite side of the DC power supply circuit **30**. UJT **107** has its emitter 107_E connected to a diode **117** and to one side of a 0.33 microfarad capacitor **118**, and its B1 terminal 107_{B1} connected through the primary side of pulse transformer **106** to the opposite side of capacitor **118**. UJT **107** is connected to power line **114** through a 22 kilohm resistor **120** connected with emitter 107_E and a 1.5 kilohm resistor **122** connected with B_2 terminal 107_{B2}.

When the voltage across capacitor **118** reaches a predetermined level, UJT **107** fires to discharge the capacitor, through pulse transformer **106**. After UJT **107** is turned off by the momentary drop of DC voltage on line **114**, capacitor **118** begins to charge again. The voltage across capacitor **118** increases rapidly to a pedestal level through the low resistance of resistor **112**, and thereafter increases more slowly along a ramp shaped curve as the capacitor is charged through the relatively higher resistance of resistor **120**. Thus, the firing voltage of UJT **107** is reached in a two step charging of capacitor **118**. When the voltage reaches a predetermined fraction of the total voltage across the terminals 107_{B2} and 107_{B1}, UJT **107** fires, discharging capacitor **118** through pulse transformer **106** and firing triac **93**.

As transistor **72** in thermostat circuit **31** is driven toward saturation, the voltage drop across resistor **90** decreases, causing transistor **110** to shunt less of the current passing through resistor **112**, and hence raising the pedestal. This advances the time of firing of UJT **107** thereby gating triac **93** sooner in each half cycle.

As previously explained, the fan motor **22** is maintained at a constant low speed when the compressor is not energized. For this purpose, a 1.5 kilohm resistor **130**, and a variable potentiometer **131**, having a maximum 5 kilohm resistance, are connected in series across the DC source. The junction between voltage dividing resistors **130** and **131** is connected through a diode **132** to the emitter 107_E of UJT **107**.

Capacitor **118** is charged to its initial pedestal level through resistor **112** and/or resistor **130**. Thus, although transistor **110** may shunt the current available from resistor **112**, capacitor **118** will rapidly charge to a fixed pedestal level determined by variable potentiometer **131**, establishing a minimum speed for the fan motor **101**. Accordingly, variable potentiometer **131** is adjusted to set the desired minimum speed for the fan motor.

The tap **91** on potentiometer **90** is adjusted to establish the temperature differential between the initiation of variable speed fan operation and the initial energization of compressor motor **16**. In FIGURE 3, the indicated temperature differential is zero, and fan motor speed increases with any increase in temperature above the set point temperature indicated at **35** at which compressor **16** is energized. However, potentiometer **90** may be set to initiate fan motor speed control at temperatures less than or in excess of the set point temperature indicated at **35**. If initiation of fan motor speed control is not concurrent with compressor energization, it is preferred that fan speed control be initiated at temperatures in excess of the set point temperature. In FIGURE 3B, the broken line **40*a*** indicates the speed change curve when speed changes are initiated below the set point temperature indicated at **35**, and the dotted line **40*b*** indicates the speed change curve when speed changes are initiated above the set point temperature indicated at **35**. The effect on capacity of changing the point at which fan speed change is initiated is indicated in FIGURE 3C. The broken lines **45*a*** show the below set point curve and the dotted lines **45*b*** the above set point curve. A comparison of the capacity curves will indicate the desirability of initiating fan speed changes at or above set point temperature indicated at **35**. When fan speed changes occur below set point temperature indicated at **35**, the air conditioner starts at an intermediate capacity, with a loss of modulation between the minimum capacity and the intermediate capacity when room temperature is rising. Full capacity modulation is available when the room temperature is decreasing because the compressor off temperature is less than the temperature at which the fan motor **22** reaches minimum speed.

When the fan speed changes are initiated at temperatures in excess of the set point temperature, the range of temperature between compressor off and full capacity is increased. This does not affect the capacity modulation characteristics of the control but becomes undesirable from a comfort standpoint in that the control reacts more slowly to rising temperatures and may allow room temperature to reach levels in excess of 2° F. above the set

point temperature. Some people are sensitive to temperature changes of as little as 1° F. and most people are sensitive to temperature changes of 3°–5° F. Thus if the control is caused to react too slowly to temperature rise above set point temperature, some people will be uncomfortable in the room being cooled by the air conditioner.

For a temperature differential of zero and with pull-in current flowing through relay **73**, tap **91** is adjusted to produce the same pedestal voltage at diode **117** as exists at diode **132**. Thereafter, as the relay current increases beyond the pull in value, due to an increasing temperature, the pedestal voltage is increased in proportion to temperature, aligning the beginning of curve **40** of FIGURE 3B with the temperature indicated at **35** at which the compressor is first energized. It will be readily understood that tap **91** may be adjusted to provide larger or smaller voltages at diode **117** and thus change the temperature at which initiation of fan motor speed changes occur. Once the tap **91** has been set, thus establishing the temperature differential between set point temperature indicated at **35** and the temperature at which fan motor speed change is initiated, the potentiometer **60** may be used to establish set point temperature indicated at **35** and synchronously the temperature at which fan motor speed change is initiated. The differential between these two temperatures will remain constant over the range of set point temperature settings permitted the user. In the illustrated embodiment of the invention the user can obtain any desired set point temperature within a range of 60°–90° F.

Regardless of the setting of minimum speed potentiometer **131**, UJT **107** is forced to fire at the end of each half cycle due to the momentary drop to zero of supply voltage on line **114**. As UJT **107** fires, capacitor **118** is discharged; insuring uniform performance on all half cycles since capacitor **118** will always be charged from a fully discharged condition.

Control circuit **11** also includes temperature compensation for the semiconductor devices used therein to insure repeatable performance regardless of the air temperatures surrounding the components. Potentiometer **76**, in series with the emitter of transistor **71**, provides temperature stability by reducing the sensitivity of thermostat circuit **31** to beta variations of transistor **71**, as well as providing a convenient adjustment of the sensitivity (deadband). As leakage currents through the transistor vary with changes in temperature, the voltage drop across potentiometer **76** is added as a feedback voltage to the fixed operating voltage established by resistors **65** and **66**. This feedback voltage may be in a positive or negative direction. Resistor **78** serves the same purpose for transistor **72** as potentiometer **76** serves for transistor **71**, thereby increasing temperature stability.

Diode **63** is preferably located in heat transfer relation with transistor **71**, as indicated by dashed lines **135**. By using the same type semiconductor material for diode **63** and transistor **71**, the voltage change in one device cancels the voltage change in the other for temperature variations. With the temperature compensation described herein, control unit **11** remains in calibration and synchronization regardless of the heating of the components used therein.

While we have shown and described certain embodiments of our invention, it is to be understood that it is capable of many modifications. Changes, therefore, in the construction and arrangement may be made without departing from the spirit and scope of the invention as defined in the appended claims.

The embodiment of the invention in which an exclusive property or privilege is claimed is defined as follows:

1. A control of refrigeration apparatus including an evaporator for chilling air, an evaporator fan for moving air over said evaporator, an evaporator fan motor for driving said evaporator fan and a compressor for circulating refrigerant to said evaporator, comprising:

first circuit means connected to said evaporator fan motor for operating said evaporator fan motor at a first speed;

means for sensing temperature;

second circuit means responsive to said means for sensing temperature for energizing said compressor when a predetermined temperature is sensed by said means for sensing temperature;

third circuit means including said first circuit means, connected to said second circuit means and responsive to said means for sensing temperature for varying the speed of said evaporator fan motor from said first speed in response to deviation of the temperature sensed by said means for sensing temperature from said predetermined temperature, thereby varying the cooling effect of said refrigeration apparatus by varying the rate of air flow moving over said evaporator;

said third circuit means further including a device switchable between conducting and nonconducting states under control of a gating signal, a source of alternating current for driving said fan motor, means connecting said device between said AC source and said fan motor, and firing angle control means for with respect to a phase of said alternating current to control the firing angle of said device in proportion to the sensed temperature deviation from said predetermined temperature; and

wherein said second circuit means includes a thermistor having resistance proportional to temperature, current operated switching means for energizing said compressor when a predetermined pull-in current is applied thereto, semiconductor means connected to said thermistor and to said current operated switching means for generating said pull-in current when said thermistor senses said predetermined temperature, said third circuit means includes an impedance device coupled to said second circuit means and having a voltage thereacross proportional to the current through said current operated switching means, and said firing angle control means is connected between said impedance device and said switchable device to vary the time of occurrence of said gating signal in proportion to the voltage across said impedance device.

2. The control of claim **1** wherein said second circuit means includes a temperature responsive voltage divider having in series a variable resistor and said thermistor, said semiconductor means including an output transistor having a current proportional to the voltage across said thermistor, said current operated switching means comprising a relay coil in series with said output transistor for actuating said compressor when pull-in current flows through said output transistor, and said firing angle control means includes a transistor responsive to the voltage across said impedance device when current in excess of pull-in current flows through said relay coil for varying the firing angle of said switching device.

3. The control of claim **2** wherein the transistor in said firing angle control means is connected in a ramp and pedestal circuit, and said first circuit means generates a minimum pedestal for maintaining said fan at a minimum speed corresponding to said first speed condition.

4. The control of claim **1** wherein said second circuit means includes means temperature compensating said semiconductor means to changes in ambient temperature.

5. The control of claim **4** wherein said temperature compensating means includes a semiconductor device connected in an electrical path with said thermistor, said device being formed of the same semiconductor material as said semiconductor means and disposed in heat transfer association with said semiconductor means.

6. The control of claim 4 wherein said semiconductor means includes at least one transistor having base, collector and emitter electrodes, means connecting said base electrode to said thermistor, a source of DC power, means connecting said DC power source in an electrical path including said collector and emitter electrodes for generating said pull-in current, and said temperature compensating means includes resistive means located in said electrical path to reduce the sensitivity of said second circuit means.

7. The control of claim 1 wherein said second circuit means includes means coupling said AC source to said compressor when said predetermined pull-in current is applied to said current operated switching means, said circuit means having no current path from said thermistor to said AC source, thereby isolating said thermistor from said AC source.

8. The control of claim 7 wherein said circuit means solely includes air gaps with magnetic fields therein for

signal transfer between said circuit means and the means connected to said AC source.

9. The control of claim 1 including a source of DC power, and means connecting said DC power source to said second circuit means for generating said pull-in current, thereby isolating said current operating switch-in means from said AC source.

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WILLIAM J. WYE, Primary Examiner

U.S. Cl. X.R.

62—207; 310—159

PO-1050
(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,505,828 Dated April 14, 1970

Inventor(s) Donald R. Vander Molen et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 7, line 73, in Claim 1, the word "of" should be --for--

Column 8, line 26, in Claim 1, after "for" should be inserted --varying the time of occurrence of said gating signal--

Column 10, lines 6-7, in Claim 9, the word "switchin" should be --switching--

SIGNED AND
SEALED
SEP 8 - 1970

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents