AIR CONDITIONER CONDENSING SYSTEM CONTROL

Inventor: Robert W. Ramsey, Nashville, Tenn.

Assignee: Heil-Quaker Corporation, Lewisburg, Tenn.

Filed: Jan. 15, 1972

Appl. No.: 323,436

Related U.S. Application Data

Division of Ser. No. 133,276, April 12, 1971, Pat. No. 3,735,602.

U.S. Cl. .................. 236/49, 62/184, 62/507, 318/345

Int. Cl. .......................... F24I 7/00

Field of Search ............... 62/180, 181, 183, 184, 62/507, 165/39, 236/49, 318/334, 345

References Cited

UNITED STATES PATENTS

1,779,116 10/1930 Davenport ............................. 62/184
2,342,657 2/1944 Grabau ................................ 318/331
2,703,404 4/1955 Malistich .............................. 62/184
3,122,695 3/1964 Woods.................................. 62/184
3,196,629 7/1965 Wood .................................. 62/183
3,359,751 12/1967 Stevens .............................. 62/186

Abstract

An air conditioner condensing system control having a motor driven means for flowing cooling air in heat transfer association with a condenser thereof. The operation of the motor is controlled by a resistance means in series therewith and disposed in heat transfer association with the air flowed by the air flowing means. The control means further includes means for providing an adjustable additional voltage to the motor for modulating the speed thereof. The additional voltage supply means may comprise an inexpensive gated control element adapted to control only a portion of the total maximum power supply voltage to the motor. Means are provided for sensing the temperature of the condenser at a liquid-gas interface therein for controlling the gated control element.

8 Claims, 6 Drawing Figures
REFERENCE TO RELATED APPLICATIONS

This application comprises a division of my copending application Ser. No. 133,276 filed Apr. 12, 1971 for an Air Conditioner Condensing System Control, now U.S. Pat. No. 3,735,602.

BACKGROUND OF THE INVENTION

1. Field of the Invention
This invention relates to air conditioning apparatus and in particular to means for controlling the operation of a condenser fan in such an air conditioning apparatus.

2. Description of the Prior Art
In the conventional air conditioning apparatus utilizing condensers for cooling the compressed refrigerant fluid prior to the delivery thereof to the evaporator, a fan is provided for cooling the hot compressed refrigerant by heat exchange relationship therewith in the condenser. It is desirable to adjust the speed of the fan to vary the cooling effect, such as in accordance with the variations in temperature of the refrigerant fluid and/or in accordance with the variations in the ambient temperature conditions. It has been found that in conventional refrigeration systems of this type, a liquid-gas interface level appears in the condenser at a point intermediate the top and bottom of the condenser during normal operation of the system. It is desirable to vary the cooling effect of the air for regulation of the refrigeration as by varying the speed of the motor driving the air moving means. Conventionally, temperature sensing devices have been placed in thermal transfer contact with the condenser for sensing the temperature of the condenser and controlling the speed of the air moving means motor. The known control systems for this purpose have the serious disadvantage of requiring that the electrical control gated devices used therein handle the full motor current as well as switch the full supply voltage. Another disadvantage of the known control devices is the relatively high noise level produced thereby as a result of the chopped wave characteristics of the electrical output provided for controlling the motor speed. Such chopped wave controls further cause radio frequency interference and disturbances and provide substantial losses in the operation of the motor.

Another problem found with such conventional control systems is the relative insensitivity of the temperature sensing device resulting from the direct thermal contact thereof with the condenser. The provision of the sensing element in physical contact with the condenser raises the further problem of difficulty of electrical insulation. Still further, it is difficult to preselect the parameters of such a system, thereby necessitating the adjustment of the system for proper operation only after the system is installed in the field. Such field adjustment is costly and relatively inefficient.

A further disadvantage of the conventional systems is the inability thereof to respond directly to variations in ambient air temperatures which would effect the required control of the motor speed to produce the desired cooling effect. Still further, the conventional systems are relatively complicated and expensive. Illustratively, where gated control devices are utilized for regulating the full load current and supply voltage of the motor, the cost of the control may be $25.00 or more.

SUMMARY OF THE INVENTION

The present invention comprehends an improved control for a condenser fan motor eliminating the disadvantages of the above-discussed prior art devices in a novel and simple manner.

More specifically, the invention comprehends the provision of a motor speed control system for such use having a voltage reducing resistor in parallel with a gated device for cooperatively delivering desired operating voltage to the condenser fan motor. The resistor may be placed in the path of flow of the air moved by the condenser fan so as to provide improved efficiency in the operation of the system. The gated device may comprise a relatively inexpensive electronic gated device such as a silicon controlled rectifier adapted to switch only a portion of the full supply voltage, thereby permitting the use of a relatively inexpensive device while yet providing accurate modulation of the fan motor to provide accurate control of the condenser cooling effect.

The invention further comprehends the provision of the temperature sensing means in spaced relationship to the condenser adjacent the level of the liquid-gas interface of the refrigerant fluid within the condenser. Thus, the temperature sensing device is able to respond to variations in the liquid-gas interface level quickly and accurately to provide improved control of the fan induced cooling effect. Further, the sensing means may be disposed in thermal transfer association with the airstream drawn by the fan so as to be responsive to the ambient temperature conditions as well as the refrigerant temperature conditions in the condenser providing further improved accuracy in the control of the cooling effect to maintain the desired head pressure of the refrigerant fluid in the refrigerant system.

The sensing element may be positioned accurately at the factory avoiding the necessity for adjustment of the system in the field upon installation.

Thus, the control of the present invention is extremely simple and economical of construction while yet providing highly desirable advantages over the known condenser fan control devices.

BRIEF DESCRIPTION OF THE DRAWING

Other features and advantages of the invention will be apparent from the following description taken in connection with the accompanying drawings wherein:

FIG. 1 is a perspective view of a refrigeration unit having a condenser fan control embodying the invention;
FIG. 2 is an enlarged perspective view thereof with the cabinet removed;
FIG. 3 is a top plan view of the apparatus of FIG. 2;
FIG. 4 is an enlarged top plan view of the resistor and sensing element means of the control with a portion thereof broken away for facilitated illustration of the arrangement; FIG. 5 is a fragmentary side elevation taken substantially along the line 5-5 of FIG. 4; and
FIG. 6 is a schematic wiring diagram of the electrical control.
DESCRIPTION OF THE PREFERRED EMBODIMENT

In the exemplary embodiment of the invention as disclosed in the drawing, a refrigeration unit generally designated 10 is shown to comprise a condensing unit of a separate condenser-evaporator air conditioning system wherein the condensing unit and compressor are mounted externally of the space to be cooled. Illustratively, such a unit may be installed exteriorly of a residence on a suitable pad (not shown). The condensing unit includes a condenser 11 adapted to be cooled by a suitable air moving means herein comprising a fan 12 driven by an electric motor 13 for flowing coolant air in heat exchange relationship with the fins 14 of the condenser. A compressor 15 may be mounted on the base 16 of the apparatus 10 in a separate space 17 defined by an upright baffle wall 18 at one end of the condenser. A suitable control 19 may be provided having a capacitor 20 for controlling the operation of the motor compressor 15 and the fan motor 13. A speed control package generally designated 22 includes means for adjustably regulating the speed of fan motor 13 in response to the temperature conditions sensed by a probe 21 carried on baffle wall 18 adjacent condenser 11. Speed control package 22 further includes a resistor 23 disposed in the path of flow of the air drawn by fan 12 through the condenser. As best seen in FIG. 3, fan 12 is mounted in a suitable shroud 24 for drawing a stream of air inwardly through condenser 11 for discharging through outlet grill 25 to the ambient atmosphere. Unit 10 further includes suitable refrigerant lines 27 extending between compressor 15 and condenser 11 and suitable electrical wiring harnesses 28 and 29 for electrically interconnecting control 19, control package 22, condenser fan motor 13, motor compressor 15, and the capacitor 20.

Speed control package 22 includes a circuit board 30 mounted in a suitable housing 31 electrically connected to prove 21 and resistor 23, as shown in FIG. 4. Probe 21 includes at the distal end thereof a sensing element, herein a thermistor 32 which, as shown in FIGS. 2 and 3, is juxtaposed to the rear face of the condenser adjacent the normal liquid-gas interface 33 of the refrigerant fluid in the system. As resistor 23 and thermistor 32 are disposed in the path of air flow from condenser 11 to fan 12, resistor 23 is effectively cooled by the air flow and thermistor 32 is made effectively responsive to variations in the refrigerant liquid-gas interface temperature and the ambient temperature in providing a temperature-responsive signal to the control 30 of the speed control package 22.

Referring now to FIG. 6, control 30 includes a parallel arrangement of resistor 23, a variable voltage control portion 34, a capacitor 35 and a RF choke 51 provided for eliminating radio frequency interference. A minimum voltage for fan motor 13 is provided through resistor 23 and variable voltage 24 provides additional voltage to the fan motor to modulate the speed thereof in response to the temperature conditions sensed by thermistor 32 thereby to regulate the operating conditions of the refrigeration system. More specifically, the regulation of the fan motor 13 is a function of the ambient temperature and the load on the refrigeration system represented by the load on the condensing unit. The control is, therefore, a closed loop control regulating the head pressure of the refrigeration system over the desired range. By making the control responsive to the ambient air temperature, control of the head pressure as a result of the operation of control 34 during relatively low ambient temperature conditions provides improved operation of the refrigeration system by reducing problems associated with liquid return to the compressor. Resultingly, a substantial increase in the compressor life and reliability is obtained.

Thermistor 32 is spaced rearwardly of the condenser to permit a more direct response to the ambient air temperature and to provide a more accurate sensing of the temperature in the condenser as compared to those prior art arrangements wherein the temperature sensing device is mounted directly on the condenser coil surface by virtue of avoiding changes in thermal conductivity due to installation procedures and subsequent aging of the contacting surface materials.

By way of example only, control 34 includes two pairs of diodes 36, 37, 38 and 39, a 16 volt avalanche diode 40, a 2.5 kilohm variable resistor 41, a 0.1 kilohm fixed resistor 42, a diode 43, a programmable, unijunction, or PUT, transistor 44, a 0.10 microfarad capacitor 45, a 470 kilohm fixed resistor 46, 16 kilohm resistors 47 and 48, 47 ohm resistors 49 and 52, a gated device, herein comprising a conventional silicon controlled rectifier, or SCR, 50 and a 150 microhenry RF choke 51. It is to be appreciated that the values of the circuit components can be varied to suit specific applications or conditions.

The operation of modulating control 34 is extremely simple. Current to the control is provided between power supply leads L1 and L2, through the fan motor 13. When L1 is positive with respect to L2, current flows through diode 36, SCR 50, diode 38, choke 51 and fan motor 13. During the negative half wave, i.e., when L2 is positive with respect to L1, current flows through fan motor 13, choke 51, diode 39, SCR 50, and diode 37. Thus, a positive full wave voltage is developed across avalanche diode 40. The avalanche diode 40 functions such that voltage thereacross, which is applied to the remaining circuitry, will not exceed the volt breakdown voltage thereof. As the voltage increases from zero toward a positive value, current flows through resistors 47 and 48 which causes the voltage at the junction therebetween, which is coupled to the gate of the PUT transistor 44, to increase. At the same time, current through resistor 46 charges capacitor 45 and after a period of time determined by the RC time constant of resistor 46 and capacitor 45, the anode of PUT 44 reaches its saturation voltage. PUT 44, in response thereto, assumes a low impedance state to allow current to flow from capacitor 25 through PUT 44 and resistor 49. The junction between PUT 44 and resistor 49 is coupled to the gate of SCR 50 and when the voltage at this gate reaches the breakdown voltage of SCR 50, SCR 50 assumes a low impedance state to conduct current in parallel with resistor 23 thereby shunting resistor 23.

As the temperature sensed by thermistor 32 increases, the resistance value of thermistor 32 decreases to conduct current through diode 43 to charge capacitor 45. This reduces the effective RC time constant determined by capacitor 45 and, thus, the saturation voltage or PUT 44 is reached earlier in the half cycle. The turning on earlier in the half cycle of PUT 44 causes SCR 50, in turn, to also turn on earlier in the half cycle which provides increased shunt current thereby raising
3,817,451

the voltage to the fan motor 13 and causes fan motor 13 to increase in speed. Variable resistor 41 is provided to vary the conduction angle of SCR 50. Resistor 42, in series with variable resistor 41, is provided to insure that this conduction angle can never be decreased below a preselected value. Resistor 52 coupled between diode 36 and avalanche diode 40 isolates the AC voltage applied to the motor from the limited breakdown voltage of avalanche diode 40.

Thus, control 34 and thermistor 32 may be built and calibrated as a unit independently of condensing unit 11 effectively eliminating the need for calibration after assembly to condenser 11 or field calibration. As the thermistor is spaced from the condenser, electrical insulation problems are effectively eliminated and the need for maintained characteristics of the surfaces of the condenser and probe is eliminated. The thermistor operation is controlled by variable resistor 41 so as to provide a desired set point temperature to maintain the head pressure of the refrigeration system within a desired operating range notwithstanding a wide variation in load and ambient temperature conditions.

Control of the speed of fan motor 13 is substantially instantaneous in response to load or ambient temperature conditions so as to provide an accurate closed loop control of the refrigeration system and maintaining the desired head pressure and back pressure conditions in the system at substantially all times.

The thermistor may be caused to have a relatively long time constant by utilization of a relatively large size thermistor to effectively preclude instability while yet providing effective following accurate fast response to variations in conditions of the system.

Control 30 is simple and economical of construction while yet providing the highly desirable features discussed above. By virtue of switching only a portion of the voltage by means of control 30 being connected in parallel with fixed resistor 23, radio frequency interference is effectively reduced and acoustic noise in the fan motor and fan blades is reduced as a result of the reduction of audio frequency energy. Transient effects on the solid state control 34 are reduced by virtue of absorption of energy by resistor 23 thus effectively reducing vulnerability of control 30 to failure. The power factor relative to control 34 is increased by virtue of the resistor 23 connected in series with the fan motor inductance to provide improved operation of the control and speed variations of motor 13 which might be caused by nonsymmetrical firing of the gated control device 50 are effectively minimized by resistor 23. Further, failure of control 34 does not cause discontinuation of the operation of fan motor 13 as reduced voltage may continue to be supplied to the fan motor 13 by resistor 23. As the waveform applied to fan motor 13 has low harmonic content and improved symmetry, heating of motor 13 is effectively minimized.

The foregoing disclosure of specific embodiments is illustrative of the broad inventive concepts comprehended by the invention.

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

1. In a system for modifying the temperature of a space and having a heat exchange element and motor driven fan for flowing air in heat transfer association with said heat exchange element, means for controlling the operation of the fan motor from a power supply, comprising: resistance means in series with said motor directly across said power supply for reducing the voltage to the motor to reduce the speed thereof, said resistance means being disposed to dissipate heat to said system; and control means responsive to a temperature condition of the system in parallel with said resistance means for providing an adjustable additional voltage to said motor for modulating the speed thereof, said resistance means having a value preselected to permit operation of the fan motor solely by current flow there through.

2. The system of claim 1 wherein said control means includes a temperature sensing element disposed adjacent a preselected portion of said heat exchange element for response to temperature conditions in said heat exchange element at the preselected portion thereof, and means for modulating said additional voltage to the motor to control said level.

3. The system of claim 2 wherein said sensing element comprises a thermistor.

4. The system of claim 2 wherein said sensing element is disposed in the air flow path downstream of said heat exchange element whereby said sensing element responds to ambient air temperature as well as temperature conditions in said heat exchange element.

5. The system of claim 1 wherein said control means is arranged to shunt said resistance means to provide a full speed operation of said fan.

6. The system of claim 1 wherein said control means provides an additional voltage as a variably chopped waveform voltage.

7. The system of claim 1 wherein said control means includes a thermistor sensing element electrically insulated from the heat exchange element by said flowed air.

8. The system of claim 1 wherein said control means includes a temperature sensing element spaced from the heat exchange element for response to temperature conditions in said heat exchange element at the preselected portion thereof.