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Ramsey

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[54] **AIR CONDITIONER CONDENSING SYSTEM CONTROL**

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Related U.S. Application Data

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[52] **U.S. Cl.** **236/49,** 62/184, 62/507, 318/345

[51] **Int. Cl.** **F24f 7/00**

[58] **Field of Search** 62/180, 181, 183, 184, 62/507; 165/39; 236/49; 318/334, 345

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[57] **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

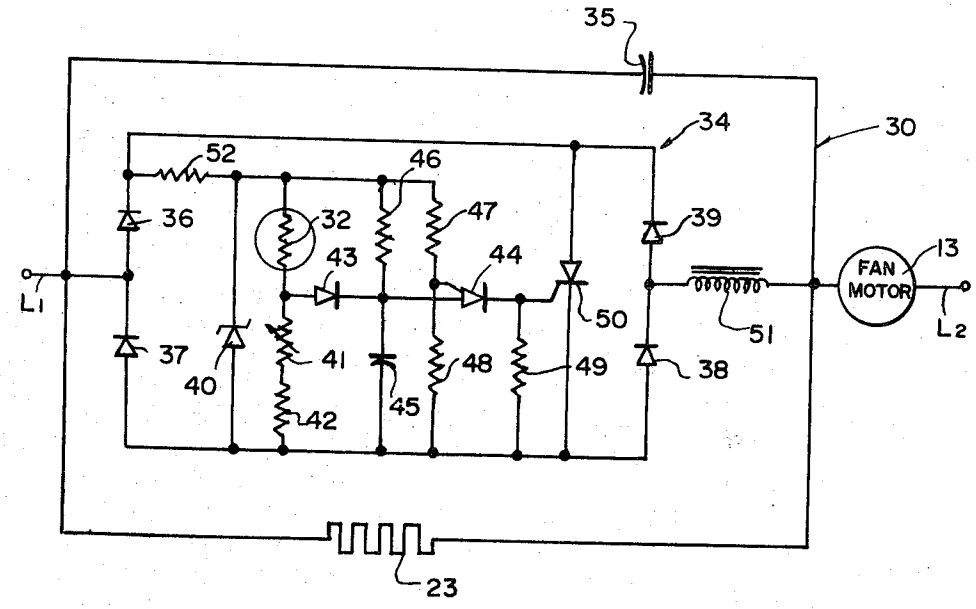


FIG.1

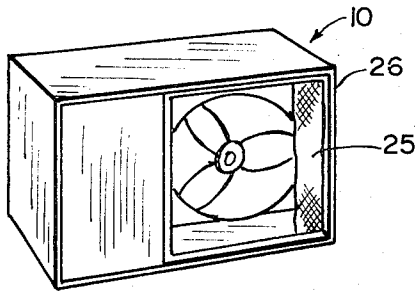


FIG.2

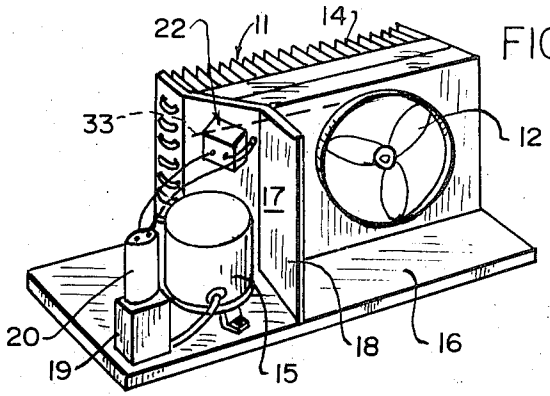


FIG.3

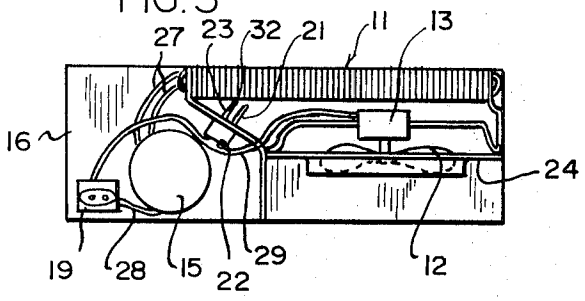


FIG.5

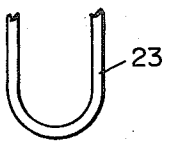


FIG.4

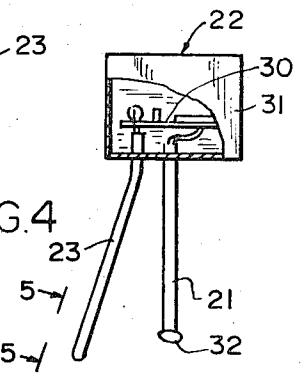
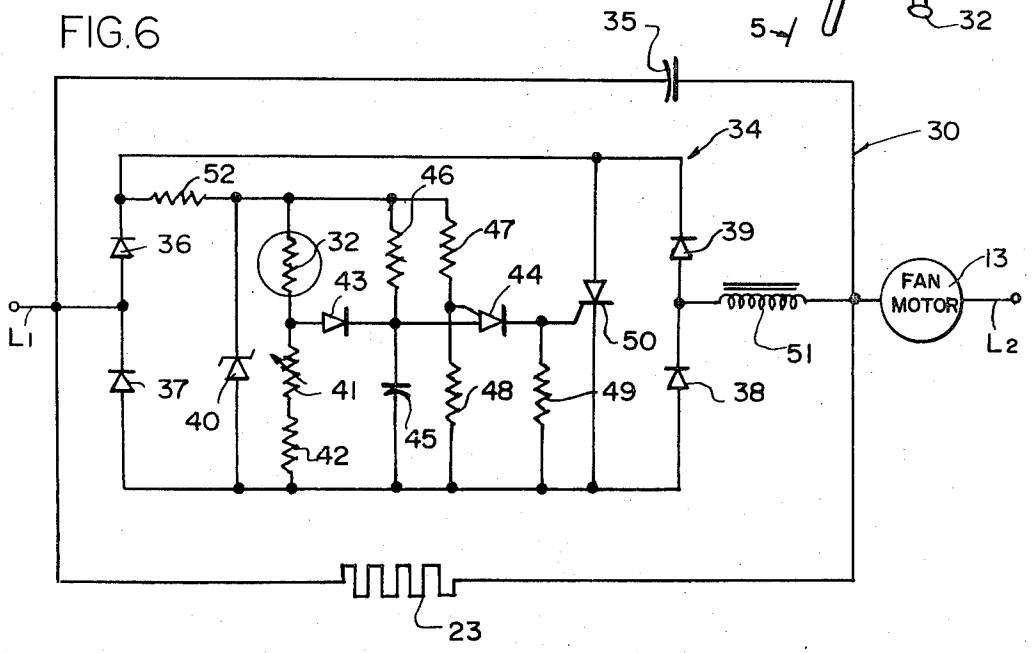


FIG.6



AIR CONDITIONER CONDENSING SYSTEM CONTROL

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 drawing 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 discharge 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 control **34** 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 refrigerant 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 L_1 and L_2, through the fan motor **13.** When L_1 is positive with respect to L_2, current flows through diode **36,** SCR **50,** diode **38,** choke **51** and fan motor **13.** During the negative half wave, i.e., when L_2 is positive with respect to L_1, 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 it 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 conduit 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

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 therethrough.

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.

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