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[54] COMPRESSOR PROTECTOR RESPONSIVE TO LOW REFRERGERANT CHARGE

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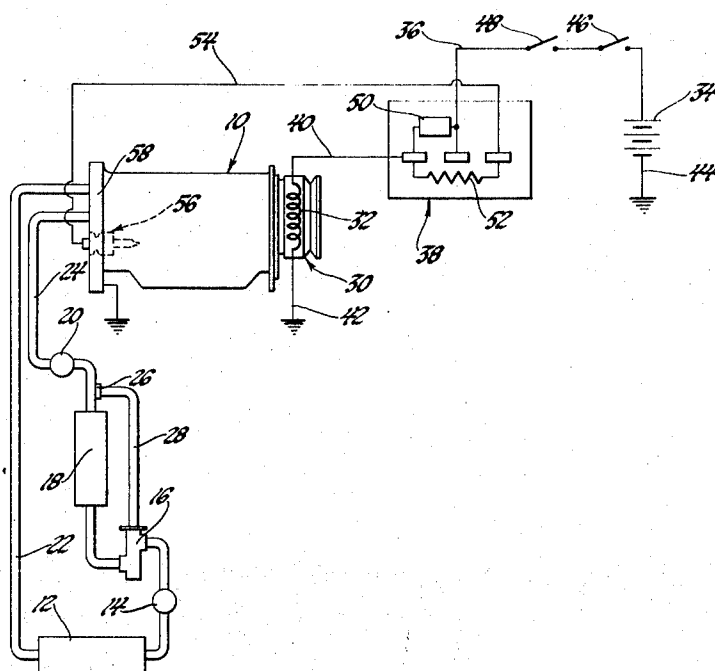
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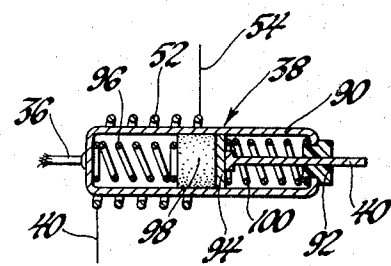
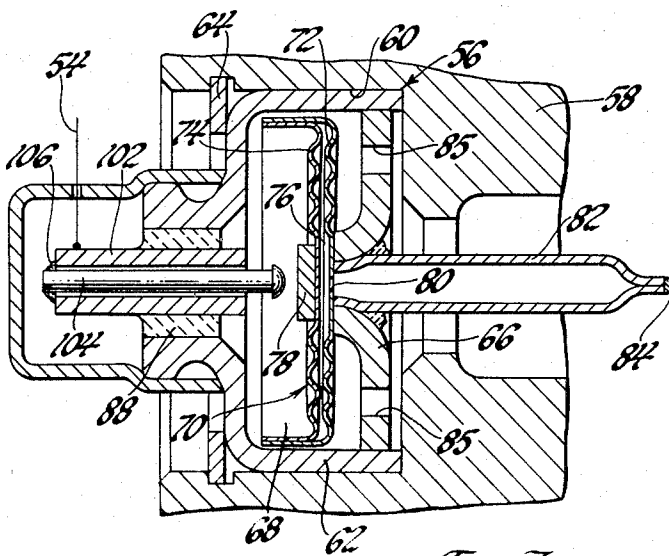
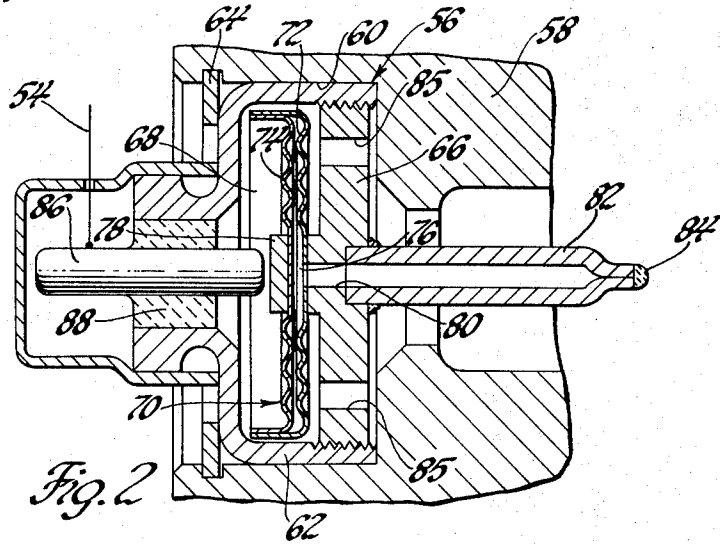
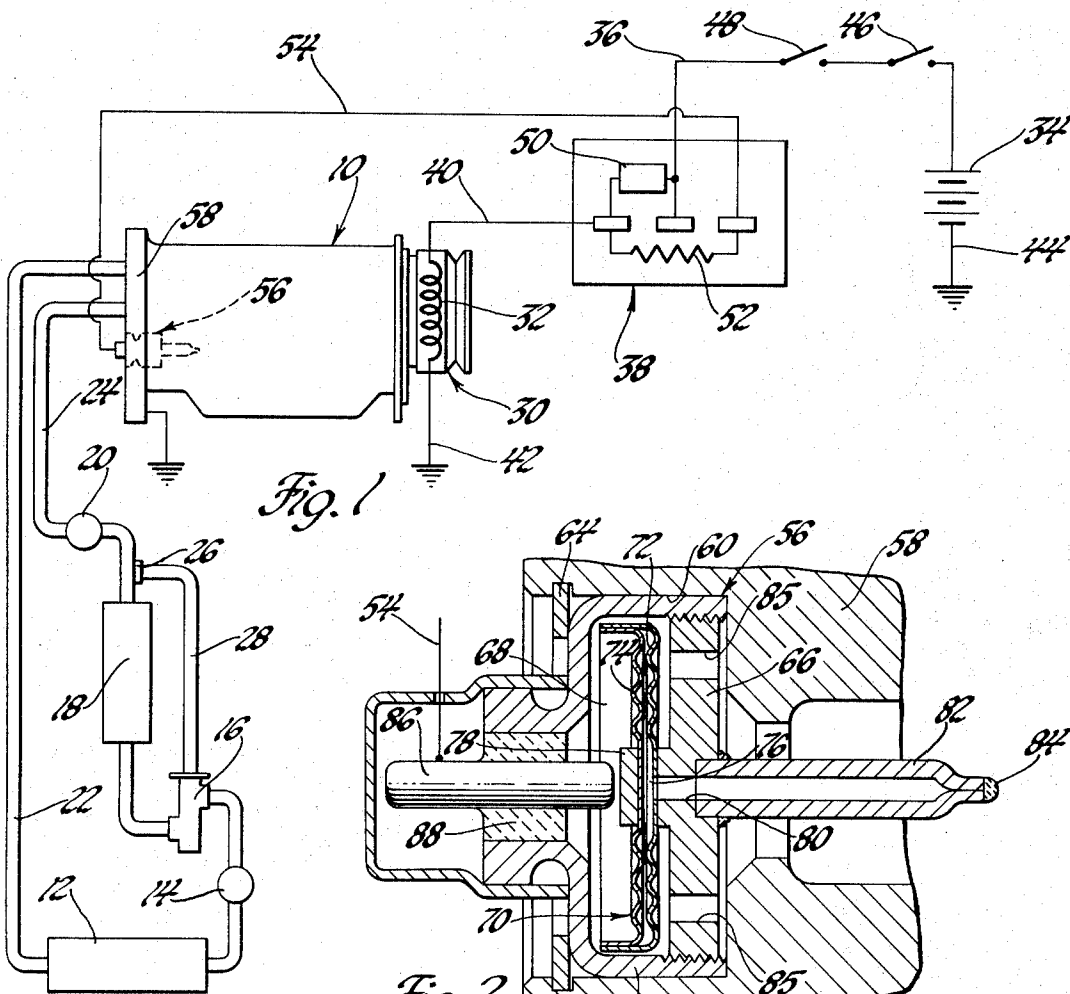
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[57] ABSTRACT

A compressor protector system for an air conditioning system having a compressor driven by an automobile engine through an electromagnetic clutch. When the refrigerant charge level falls below a level necessary for compressor cooling and lubrication, a thermally responsive fuse in the clutch energization circuit is made to open by a resistance wire heater. The wire heater is energized by the closing of a superheat switch responsive to the refrigerant temperature in the compressor inlet.

3 Claims, 4 Drawing Figures





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COMPRESSOR PROTECTOR RESPONSIVE TO LOW REFRERGERANT CHARGE

This invention relates to compressor protective systems for automobile air conditioning.

Automotive air conditioning systems with a refrigerant compressor utilize a quantity of oil mixed with the refrigerant for compressor lubrication and cooling. A portion of this lubricating oil flows with the refrigerant through the system's condenser, expansion means, and evaporator. A compressor sump portion is adapted to collect the oil when the compressor and system are operative. When the system's refrigerant charge level falls due to leakage, an insufficient quantity of refrigerant is in the system to supply oil to the compressor.

The present automotive air conditioner includes a compressor protector system which deactivates the compressor when the refrigerant charge level falls below a predetermined quantity which is insufficient for compressor cooling and lubrication. The compressor is driven by the automobile's engine through an electromagnetic clutch which is energized by a circuit having a fusible pellet type fuse. A resistance wire heater adjacent the fuse is connected in a circuit with a power source and a normally open switch mounted on the compressor. The switch includes a refrigerant filled bellows which expands to close in response to a predetermined refrigerant temperature in the compressor inlet. When the switch closes, the wire heater is energized and after a time delay the fuse opens to deenergize the magnetic clutch and render the compressor inoperative.

Because the fuse requires a certain amount of thermal input before opening, a time delay occurs between when the superheat switch closes and the fuse opens. This delay is desirable to prevent compressor deactivation during transient conditions during which the refrigerant temperature exceeds the switch closing temperature only temporarily. This, for example, may occur during rapid acceleration of the automobile. In contrast, when the refrigerant charge level is low, the refrigerant temperature is increased for a great enough time to melt the fusible pellet of the fuse and cause compressor deactivation until a new fuse is provided.

Therefore, an object of the invention is to provide a compressor protective system for automobile air conditioners utilizing a thermal fusible pellet type fuse in the electromagnetic clutch circuit having a resistance wire heater for heating the fuse which is energized by the closing of a superheat switch in response to a predetermined maximum temperature of refrigerant in the compressor inlet.

A further object of the invention is to provide a compressor protective system for sensing when the level of refrigerant charge in the air conditioning system is below that needed for compressor cooling and lubrication to deactivate the compressor until a full refrigerant charge is supplied.

Further objects and advantages of the present invention will be apparent from the following detailed description, reference being had to the accompanying drawings in which preferred embodiments of the invention are clearly shown.

In the drawings:

FIG. 1 is a schematic view of an automobile air conditioning system including a compressor and the subject protective device;

FIG. 2 is an enlarged sectioned view of the superheat switch shown in FIG. 1;

FIG. 3 is an enlarged sectioned view of another embodiment of the switch shown in FIG. 1; and

FIG. 4 is a sectioned view of the thermal fusible pellet type fuse shown schematically in FIG. 1.

In FIG. 1 of the drawings, an air conditioning system is shown including a compressor 10, a condenser 12, a drier-receiver assembly 14, an expansion valve 16, an evaporator 18 and a suction throttling valve 20. The compressor 10 is connected in refrigerant flow relation to the condenser 12 by a high pressure conduit or line 22. The evaporator 18 and throttling valve 20 are connected in refrigerant flow relation to compressor 10 by a suction conduit or line 24. A temperature bulb 26 and tube 28 sense evaporator outlet temperature to open and close the expansion valve 16.

The compressor 10 is driven by the automobile's internal combustion engine (not shown). An electromagnetic clutch 30 with a coil 32 transmits rotation of the engine to compressor 10 whenever its coil 32 is energized. Power is applied to coil 32 by a battery 34 through a conductor 36, a compressor protector fuse 38, and a conductor 40. The coil 32 and battery 34 are grounded respectively by conductors 42 and 44. An on-off switch 46 is manually operated by the automobile driver to activate the air conditioning system. Another switch 48 is responsive to ambient temperature to prevent operation of the air conditioning system whenever the temperature drops below a set minimum such as 35° F.

As previously indicated, it is desirable to deactivate the compressor whenever the system's refrigerant charge level falls below a minimum quantity needed for cooling and lubricating the compressor. The compressor protector 38 includes a fusible pellet type fuse 50 electrically connected between battery 34 and coil 32. When the fuse 50 is opened, coil 32 is deactivated until a new fuse is supplied and the refrigerant level is increased. The protector 38 includes a heater in the form of an electric resistance wire heater 52 to supply thermal energy to the fusible pellet of fuse 50. Heater 52 is connected by conductor 54 to a superheat switch 56 and to battery 34. The superheat switch 56 is mounted in the head 58 of compressor 10 to sense the temperature of refrigerant in the compressor inlet or suction line. When the inlet temperature of refrigerant exceeds a predetermined value, switch 56 closes to complete a circuit from the battery 34 through the heater 52. While the resistance heater 52 is energized, thermal energy is applied to the fusible pellet of fuse 50. After a predetermined time delay the pellet melts and the fuse is opened which deenergizes the clutch 30.

One embodiment of the superheat switch is shown in FIG. 2. A recess 60 formed in the compressor head 58 is adapted to accept cup-shaped member 62. The member 62 is held within the recess 60 by expansion ring 64. A collar 66 is threadable secured in the inner diameter of member 62 thus forming an interior space 68. A bellows member 70 within the interior space 68 is supported by collar 66. Bellows 70 is formed of two thin-walled, cup-shaped members 72 and 74 which are positioned one inside the other and joined at their edge portions and define an expandible chamber 76 therebetween. One of the members 72 is secured to collar 66 and the other member 74 has a contact pad

78 adapted to move with the member 74 as trapped refrigerant within the chamber 76 expands and contracts with temperature and pressure changes.

The chamber 76 is communicated by port 80 in collar 66 with a refrigerant-filled tube 82 which projects into the suction cavity of the compressor 10 and senses the inlet temperature of refrigerant. After filling chamber 76 with refrigerant, the tube 82 is sealed by a small amount of solder 84. Holes or ports 85 in collar 66 communicate space 68 with the inlet suction cavity. As refrigerant in the inlet of the compressor increases in temperature or decreases in pressure, the refrigerant within bulb 82 and chamber 76 expands causing the contact pad 78 to move toward a contact pin 86. Pin 86 is supported by the member 62 and mounted within a glass seal 88 to insulate it from the member 62 and the compressor. Pin 86 is electrically connected to one side of the wire heater 52 by conductor 54. When the trapped refrigerant within the bulb 82 and chamber 76 expands, pad 78 contacts pin 86 and completes a circuit from ground, through the pad 78 and pin 86, conductor 54, wire heater 52, fuse 50, and conductor 36 to battery 34. This energizes heater 52 and after a time delay melts the fusible pellet of fuse 50.

The fuse itself as shown in FIG. 4 consists of a hollow metal housing 90 to which the conductor 36 is connected. Another lead 40 is insulated from the housing 90 by a seal 92 and projects into the hollow interior of the housing 90. A metal piston 94 contacting the housing 90 at its peripheral edge is biased against the end of conductor 40 by a spring 96 and fusible pellet 98. The pellet 98 is fusible wax or other similar material and is pressed between the spring 96 and the piston 94. A second spring 100 between the housing 90 and the piston 94 presses against the piston 94 in an opposite direction than spring 96. When the fusible pellet 98 is melted by heat from resistance heater 52, the spring 96 expands toward piston 94 and consequentially the force exerted thereon decreases. Thereupon, the force of second spring 100 becomes greater than the force of spring 96 and moves the piston 94 away from conductor 40 which opens the connection between the conductors 36 and 40 thus deenergizing magnetic clutch coil 32.

FIG. 3 shows another embodiment of the superheat switch. This switch is similar to that shown in FIG. 2 and common parts are numbered alike. In FIG. 3, the collar 66 is secured to the member 62 by a press fit. Instead of a single pin 86, the second embodiment includes a sleeve member 102 which is secured to member 62 by a glass seal 88. A pin 104 is reciprocal within the sleeve 102 prior to calibration of the switch. The switch is calibrated by exposing it to an environment at a predetermined closing temperature and then securing the pin 104 in the cylinder 102 by placing a ring of solder at 106. This locates the pin 104 and pad 78 in a closing position at the predetermined temperature.

During operation of the air conditioning system with a low refrigerant charge, the inlet temperature of refrigerant increases due to insufficient cooling and lubricating capacity of the low charge. When the temperature of refrigerant at the inlet exceeds a predetermined maximum, a circuit is completed through the superheat switch 56 to energize the resistance heater 52.

After a delay, the wax pellet 98 is melted and the spring 96 expands. This allows the second spring 100 of the fuse to move the piston 94 away from conductor 40 and thus disconnect coil 32 from the power source 34. The resultant deactivation of the compressor prevents permanent damage from overheating caused by lack of lubrication. The clutch 30 can not be energized again until a new fuse 50 is installed and presumably more refrigerant is added. This positive cut-off protection for the compressor thus prevents use of the air conditioner until the charge is replenished.

A refrigerant used in the aforementioned air conditioning system is dichlorodifluoromethane with the chemical formula CCl_2F_2 . This refrigerant has a boiling point at atmospheric pressure of -21.6°F . The charge level in a typical General Motors automobile air conditioning system is four pounds of refrigerant. It has been determined that a charge of less than approximately one pound of refrigerant may result in insufficient cooling and lubrication of the compressor.

When the charge level of refrigerant is insufficient for cooling and lubricating the compressor, the superheat temperature of refrigerant in the compressor's suction cavity is significantly increased. Superheat temperature of refrigerant vapor is defined as the temperature increase of the refrigerant vapor above its boiling point for a given pressure. Thus refrigerant at -11.6°F . at atmospheric pressure has a superheat of 10°F . Under normal operation with a full refrigerant charge and a heat load on the evaporator, the throttling valve 20 of the air conditioning system maintains a refrigerant pressure of at least 30 psig which corresponds to 32°F . in the evaporator by restricting the suction line 24. These conditions represent approximately zero degrees superheat temperature in the evaporator. If the vapor in the suction cavity is at 40°F . at 30 psig, its superheat is about 8°F .

When operating the air conditioning system with a heat load on the evaporator such as produced by an ambient temperature of 70°F . and an insufficient refrigerant charge, the vapor temperature in the suction cavity may increase to 140°F . and thus be superheated about 108°F . The switch 56 is set to close at a superheat of 120°F . at 0 psig or a superheat of 141.6°F . Thus, under the aforementioned conditions the bellows will expand and cause pad 78 to engage pin 104 and energize the fuse heater.

When the heat load on the evaporator becomes relatively low such as with a low ambient temperature of about 32°F . and there is insufficient refrigerant in the system, the throttling valve may shut off vapor flow through the suction line. When this happens, the suction cavity pressure will drop to near zero psig at which pressure the refrigerant's boiling point is about -10°F . At 32°F . and zero pressure, the vapor has only a superheat of 42°F . Under normal 30 psig pressures this temperature would not close the superheat switch. However, because of the low pressure surrounding the bellows, the switch will close at the lower temperature to prevent further compressor operation. Thus the pressure responsive characteristics of the superheat switch assume importance as the throttling valve causes decreased suction pressure.

During some operating conditions of the air conditioning system, the suction or inlet refrigerant super-

heat may exceed the set closing superheat temperature of the superheat switch even when the system is at full charge. This can occur during rapid acceleration of the automobile or after consecutive stopping and starting of the compressor. The present protector system is insensitive to these transient temperature and pressure conditions because of a time delay between switch closing and fuse opening. Therefore, the clutch 30 is not deenergized during these periods. This time delay is caused by the lag between heating of the resistance wire heater and in melting the fusible pellet. As previously stated, it is dependent on material selection, heater capacity and heat transfer circumstances. By proper selection of the heater and fusible pellet material, a desirable time delay of two minutes may be achieved. This delay appears to be sufficient for preventing shut down during transient high superheat temperature conditions.

Once the fusible pellet 98 is melted and the circuit through the fuse is broken, the protector must be serviced in order to energize the clutch of the compressor. Normally, replacement of the protector would require professional service which would at the same time check and replenish the refrigerant charge. Subsequent operation then will be possible without danger of compressor failure.

While the embodiments of the invention described above are preferred embodiments, it should be understood that other embodiments may be adapted.

What is claimed is as follows:

1. In an automobile having an air conditioning system including a refrigerant compressor and an engine, a compressor protector comprising: an electromagnetic clutch for interconnecting said engine and said compressor for rotation together when said clutch is electrically energized; circuit means including a power source and a fuse for electrically energizing said clutch; said fuse having a fusible pellet which maintains a closed circuit through said fuse for energizing said clutch; spring means in said fuse for opening said closed circuit when said fusible pellet is melted by being heated; an electric resistance heater in heat transfer relation to said fusible pellet for selectively applying thermal energy to said pellet; a temperature responsive switch in heat transfer relation to refrigerant entering said compressor and in electrical connection with said resistance heater and said power source for energizing said resistance heater whenever the refrigerant temperature exceeds a predetermined value whereby after a delay during which said fusible pellet is heated and finally melted, said fuse is opened to disconnect said electromagnetic clutch from said power source and render said compressor inactive until said fuse is replaced.

2. In an automobile having an air conditioning system including a refrigerant compressor and an engine, a compressor protector comprising: an electromagnetic clutch for interconnecting said engine and said compressor for rotation together when said clutch is electrically energized; circuit means including a

power source and a fuse for electrically energizing said clutch; said fuse having a thin walled housing enclosing an elongated space; a reciprocal piston in said housing; a first spring and a fusible pellet on one side of said piston and a second spring on the other side of said piston; a conductor insulated from said housing and extending into said elongated space into contact with said piston and thereby completing a circuit from said housing through said piston to said conductor; an electric resistance heater in heat transfer relation to said housing and said fusible pellet for selectively applying thermal energy to said pellet; a temperature responsive switch in heat transfer relation to refrigerant entering said compressor and in electrical connection with said resistance heater and said power source for energizing said resistance heater whenever the refrigerant temperature exceeds a predetermined value and whereby after a delay during which said fusible pellet is heated and finally melted, said first spring relaxes by extension into the now liquefied pellet and said second spring moves said piston out of contact with said conductor to disconnect said electromagnetic clutch from said power source and render said compressor inactive until said fuse is replaced.

3. In an automobile having an air conditioning system including a refrigerant compressor and an engine, a compressor protector comprising: an electromagnetic clutch for interconnecting said engine and said compressor for rotation together when said clutch is electrically energized; circuit means including a power source and a fuse for electrically energizing said clutch; said fuse having a thin walled housing enclosing an elongated space; a reciprocal piston in said housing; a first spring and a fusible pellet on one side of said piston and a second spring on the other side of said piston; a conductor insulated from said housing and extending into said elongated space into contact with said piston and thereby completing a circuit from said housing through said piston to said conductor; an electric resistance heater in heat transfer relation to said housing and said fusible pellet for selectively applying thermal energy to said pellet; a temperature responsive switch in heat transfer relation to refrigerant entering said compressor and in electrical connection with said resistance heater and said power source for selectively energizing said resistance heater; said switch including a refrigerant filled expandable bellows portion of conductive material which expands with increases in refrigerant temperature in the inlet of the compressor to contact a conductor and energize said resistance heater whenever the refrigerant temperature exceeds a predetermined value and whereby after a delay during which said fusible pellet is heated and finally melted, said first spring relaxes by extension into the now liquified pellet and said second spring moves said piston out of contact with said conductor to disconnect said electromagnetic clutch from said power source and render said compressor inactive until said fuse is replaced.

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