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[54] REFRIGERATION APPARATUS
2 Claims, 2 Drawing Figs.

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[51] Int. Cl. F25b 43/02
[50] Field of Search 62/192, 193, 84, 468, 469, 230

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ABSTRACT: A refrigeration circuit comprising a motor-driven compressor, a condenser, an evaporator, and expansion means. The compressor includes an oil reservoir, where a supply of oil is disposed for lubricating the compressor during normal operation thereof. Associated with the compressor is a heating element, operable to heat the oil when the compressor is inoperable. A safety switch prevents the compressor from becoming energized if the heating element has not functioned while the compressor was inoperable.

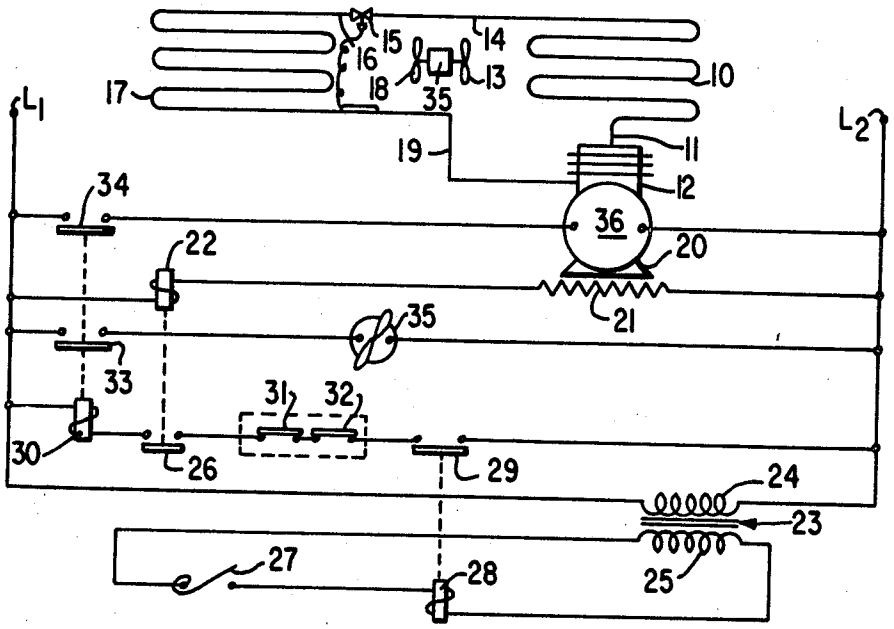


FIG. 1

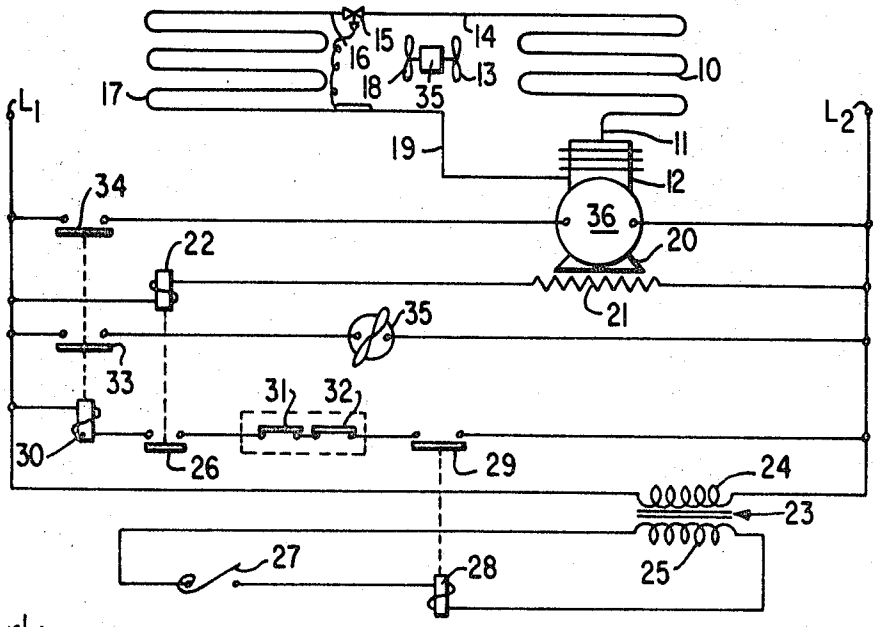
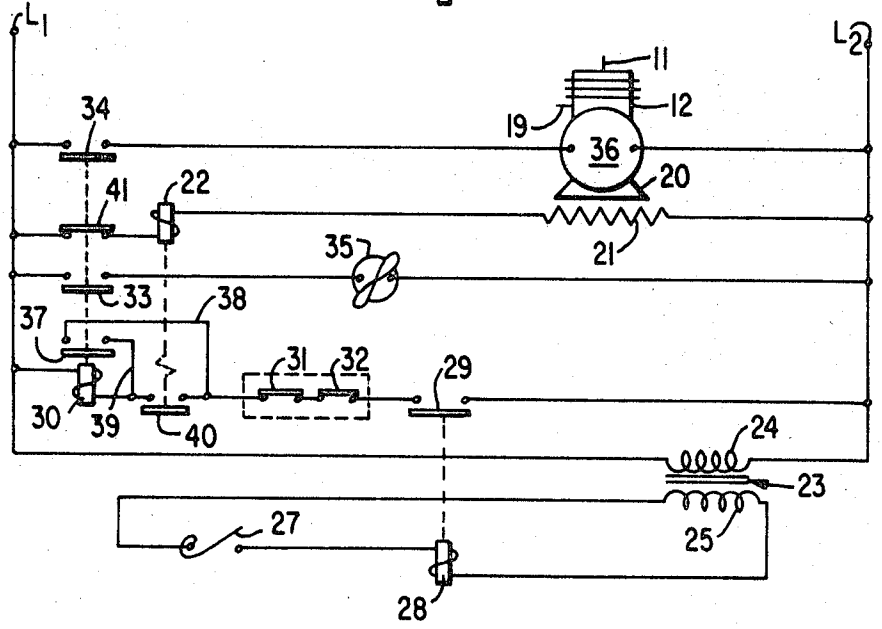


FIG. 2



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REFRIGERATION APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to a refrigeration circuit, and more particularly to refrigeration circuits including motor-driven compressors.

It is well known that under certain conditions, some refrigerants and oil used as a lubricant for the motor compressor unit are freely miscible. During normal operation of the refrigeration circuit, because of operating pressures and temperatures, the oil in the sump of a compressor will be substantially free of refrigerant. However, on shutdown when the circuit reaches ambient temperature and the pressure equalizes within the circuit, the refrigerant vapor and oil in the sump of the compressor will mix to form a substantially homogenous solution.

This phenomenon is not localized, and it is possible that the entire liquid refrigerant charge within the circuit may be absorbed by the oil charge in the sump. When the ambient temperature at the compressor sump approaches the evaporator temperature, liquid refrigerant will boil off in the evaporator and will condense in the compressor sump and thereby go into solution with the oil.

Upon startup of the compressor, the oil sump which is usually a part of the crankcase of the compressor drops to suction pressure and the compressor mechanism may agitate the solution. The combination of the drop in suction pressure and possible mechanical agitation causes the refrigerant in solution to attempt to return to its vapor state. Since the refrigerant at shutdown is in a substantially homogenous solution, the flashing of admixed liquid refrigerant to vapor may carry therewith a substantial amount of the oil charge and may even result in the entire solution turning into a foam.

Foaming of the oil will materially increase the amount of oil carried over into the refrigerant discharge line. Foaming may become so severe that all the oil is pumped out of the sump. Not only will this leave the compressor without lubrication, which may produce bearing failure in a short period of operation, but there is also the possibility that noncompressible slugs of liquid refrigerant and oil will enter the compressor cylinders and cause serious damage to the compressor in the form of broken valves and pistons and bent or broken rods and shafts.

To avoid the problem of crankcase oil dilution, crankcase heaters are generally employed. On shutdown of the compressor, temperature throughout the inactive refrigeration unit eventually equalizes with the prevailing ambient temperature, with the exception of the compressor crankcase which is suitably heated, a satisfactory temperature being approximately 40° F. to 60° F. above ambient temperature. At this temperature, a small amount of refrigerant will be absorbed by the oil charge; however, this mixture of oil and refrigerant will have a sufficient vapor pressure to discourage further refrigerant from passing into the vapor state and being absorbed into the crankcase solution.

The crankcase heater may be an electrical resistance element. The resistance element may either be installed directly in the crankcase, in direct contact with the oil, or may be wrapped around the outer surface of the compressor casing in heat transfer relation with the oil stored in the crankcase.

If the heating element were to become inoperable due to burning out, becoming disconnected, or the like, while the compressor was inoperable, the problem sought to be overcome may return upon startup of the compressor.

Therefore, the object of this invention is a control operable to prevent the compressor from starting up if the crankcase heater has failed.

SUMMARY OF THE INVENTION

The novel control herein disclosed is utilized with refrigeration circuits having refrigerant compressors employing crankcase heaters.

The primary purpose of the crankcase heater as explained heretofore, is to maintain the oil at a sufficiently warm temperature to minimize absorption of refrigerant during shutdown of the refrigeration circuit. However, in applications where costs to operate the heating element are relatively low when compared to manufacturing costs of installing components to automatically cycle the heating element in response to the cycle of the refrigeration circuit, the heating element may be operable at all times without introducing any problems. If the operating costs are higher than the installation costs, then the additional components required to cycle the heating element will be installed. In either case, the refrigeration control herein disclosed will prevent the compressor from becoming operable if the crankcase-heating element has failed during the shutdown period of the refrigeration unit.

The control includes a relay disposed in the circuit supplying power to the heating element. The relay controls the position of a normally open switch disposed in the circuit controlling the energization of the compressor.

Assume the refrigeration circuit is employed in an application where it is preferable to operate the crankcase-heating element only when the refrigeration circuit is inoperable. If the crankcase heater has not functioned during the shutdown period, for example, the element may have burnt out, the relay in the element control circuit will be deenergized. With the relay inoperable, the switch controlled thereby is in its normally open position and thus prevents the compressor from becoming operable.

A bypass arrangement or holding circuit prevents the switch from deenergizing the compressor, once the refrigeration unit is operable and the heating element is inoperable.

Alternatively, if the crankcase-heating element is always operable, the normally open switch in the compressor control circuit may be opened during compressor operation or during shutdown, by the failure of the heater and the concurrent deenergization of the relay controlling the switch.

If the compressor stops during a period of time when it should be operating, or if the compressor fails to start, the operator will then "trouble-shoot" to determine the problem and will then be able to repair the crankcase heater before the serious problems previously noted occur. To expedite the "-trouble-shooting" operation, indicator lights may be installed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates schematically a type of refrigeration apparatus to which the present invention applies, and a wiring diagram of a preferred form of the refrigeration circuit control serving as the subject of the invention; and

FIG. 2 illustrates an alternative embodiment of the invention of this patent.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, and in particular to FIG. 1, there is schematically shown an air-conditioning system employing a refrigeration circuit embodying the invention herein disclosed.

The refrigeration circuit or unit disclosed is representative of a circuit utilized in window mounted room air conditioners. The refrigeration unit includes an outdoor heat exchange coil or condenser **10**. The condenser **10** is connected by means of line **11** with the discharge side of a suitable refrigerant compression mechanism, for example, a reciprocating-type compressor **12**. The gaseous refrigerant produced in compressor **12** subsequently flows through condenser **10** and is condensed by ambient air routed over the surface of the condenser by outdoor fan **13**. Liquid refrigerant formed in the condenser **10**, flows through line **14**, thermal expansion valve **15** and line **16** to indoor coil or evaporator **17**. It is understood other suitable expansion devices, as a capillary tube, may be employed in lieu of expansion valve **15**. The thermal expansion valve **15** in conjunction with the compressor **12** separates the

refrigeration unit into a high-pressure side and a low-pressure side.

Liquid refrigerant in evaporator **17** is converted to vaporous refrigerant as it extracts heat from the medium, for example, room air passed over its surface by indoor fan **18**. The cooled air is thereafter passed to the area being conditioned by suitable means, such as grilles or vents (not shown). Vaporous refrigerant from coil **17** flows via suction line **19** to compressor **12** to complete the refrigerant flow cycle.

The compressor **12** includes a crankcase **20** which functions as a reservoir or sump for storing a supply of oil for lubricating the various parts of the compressor during normal operation. Associated with the compressor **12** is heating element **21**, shown as a resistance coil. The heating element **21** may be disposed directly in the crankcase of the compressor may be wrapped around the outer surface of the casing of the compressor in heat transfer relation with the oil stored in the sump. The heating element **21** is utilized to prevent the problems discussed hereinabove.

Again referring to FIG. **1**, a preferred form of the control circuit for the refrigeration unit hereinabove described is schematically shown. A suitable source of electrical power is represented by lines L_1 and L_2 connected to a primary winding **24** of a transformer **23**. It is understood that a polyphase source of electrical power may be employed if the circuit is suitably modified.

As is apparent from referring to FIG. **1**, the heating element **21** is directly connected to the source of electrical power. Thus, heating element **21** is operable at all times when a source of electrical power is available. Connected in series with heating element **21** is relay **22** controlling the operation of normally open switch **26**. The purpose of relay **22** and switch **26** will be described more fully hereinafter.

The secondary winding **25** of the transformer **23** is connected in series with a switch **27**, responsive to the temperature of air circulating in the area being served by the equipment. When switch **27** is closed, current is supplied to control relay **28**. Energization of relay **28** closes normally open switch **29**. Connected in series with switch **29** are normally closed switches **31** and **32**. Normally closed switches **31** and **32** are safety devices, respectively a high-pressure cutout and a motor overload cutout. Other safety devices known to the art, such as a low-pressure cutout and a low oil pressure cutout, may also be used. The occurrence of the condition protected against will open the particular switch, thereby either preventing the refrigeration unit from becoming operable or stopping the unit during the normal operation thereof.

Assuming switches **31** and **32** are in their normally closed position and relay **22** has closed switch **26**, relay **30** is then energized. Energization of relay **30** will close normally open switches **33** and **34**. Closure of switch **33** actuates fan motor **35**, operating fans **13** and **18**. Closure of switch **34** connects compressor motor **36** across lines L_1 and L_2, thereby starting the compressor **12**.

As heretofore explained, heating element **21** is used to warm the lubricating oil stored in the crankcase **20** of the compressor during shutdown periods of the refrigeration unit. As shown in FIG. **1**, the heating element **21** may also be energized during the operating time of the unit without introducing any problems. Heating element **21** will be used continuously in applications where the initial costs of adding components to the compressor to automatically deenergize the heating element **21** in response to the refrigeration cycle are relatively large when compared to the costs involved in operating the heating element during operation of the unit. The heating element will maintain the oil at a relatively warm temperature during shutdown of the unit to minimize absorption of the refrigerant, and to thereby prevent the concomitant problems discussed heretofore.

If the heating element were to burn out, become disconnected, or to otherwise become inoperative during the unit shutdown period, relay **22** will then be deenergized. Deenergization of relay **22** will place switch **26** in its normally open position, thereby preventing energization of relay **30**. With relay **30** deenergized, switch **34** will be maintained in its normally open position, thereby preventing the compressor motor from becoming operable as desired.

Referring now to FIG. **2**, there is disclosed a modified embodiment of the invention. In particular, the heating element **21** is inoperable during operation of the refrigeration unit. The circuit schematically represented by FIG. **2** may be particularly useful in applications where the cost of operating the element **21** is relatively high when compared to the cost of installing components to automatically deenergize the element **21** when the refrigeration unit is in operation.

Connected in series with heating element **21** and relay **22** is normally closed switch **41**, the position thereof being controlled by relay **30**. Relay **30** additionally controls the position of normally open switch **37**. The closure of the latter switch will establish a bypass or holding circuit through lines **38** and **39** around normally open switch **40**. The reason for the bypass circuit will be explained more fully hereinafter.

In lieu of switch **26**, relay **22** now controls the position of normally open switch **40**. Switch **40** has a sufficiently delayed opening after deenergization of relay **22** for a reason that will be explained hereinafter.

Assume heating element **21** has been operable during the unit's shutdown period, and thermally responsive switch **27** now senses the area being served requires cooling and closes.

As noted hereinabove, closure of switch **27** will energize relay **28** thereby closing switch **29**. Since we have assumed heating element **21** has been operable, relay **22** is therefore energized and switch **40** is closed. With switches **29** and **40** in their closed positions, relay **30** is then energized, thereby closing switches **33**, **34**, and **37** and opening switch **41**. The opening of switch **41** will deenergize relay **22** and heating element **21**. In addition, switch **40** is also opened when relay **22** is deenergized. However, the opening of switch **40** at this time will not prevent operation of the unit, since the time delay provided for the opening of the latter switch will have allowed switch **37** to be closed, thereby creating the bypass or holding circuit through lines **38** and **39** about the switch **40**.

In case the heating element had failed to function during the unit's shutdown, deenergization of relay **22** will have opened switch **40**, thus preventing energization of the compressor motor **36** as desired.

The control circuit hereinabove discussed will prevent compressor failure and costly repairs in case the crankcase heater has not functioned in the designed manner.

While I have described and illustrated a preferred embodiment of my invention, it will be understood that my invention is not limited thereto, since it may be otherwise embodied within the scope of the following claims.

I claim:

1. A control for a refrigeration circuit including a motor-driven compressor, a condenser, an evaporator, and expansion means, comprising:

A. a supply circuit for providing electrical energy to said compressor motor including a controller including a first switch for connecting said motor to said supply circuit, said controller further including an energizing coil;

B. a lubricant reservoir in said compressor having a supply of the lubricant disposed therein for lubricating said compressor;

C. heating means associated with said compressor, operable to heat said lubricant; and

D. switch means operable to prevent said compressor motor from being connected to said supply circuit if said heating means has been inoperable while said compressor motor has been deenergized.

2. A method of operating a refrigeration system including a motor-driven compressor, a condenser, an evaporator and expansion means, said compressor having an oil reservoir with oil disposed therein for lubricating said compressor, said compressor further having heating means associated therewith, operable to warm said oil, comprising the steps of:

A. circulating a refrigerant through said refrigeration system by energization of said compressor, in response to a predetermined thermal condition;

B. terminating the operation of said refrigeration system upon satisfaction of a predetermined thermal condition;

C. operating said heating means to warm said oil while said compressor is deenergized; and

D. preventing the compressor from becoming operable in response to a predetermined condition, if said heating means has been inoperable while said compressor has been deenergized.