March 1, 1966 T. O. PIHL ETAL 3,237,848

DEVICE FOR PREVENTING COMPRESSOR SLUGGING IN A REFRIGERATION SYSTEM

Filed Sept. 4, 1958

4 Sheets-Sheet 1

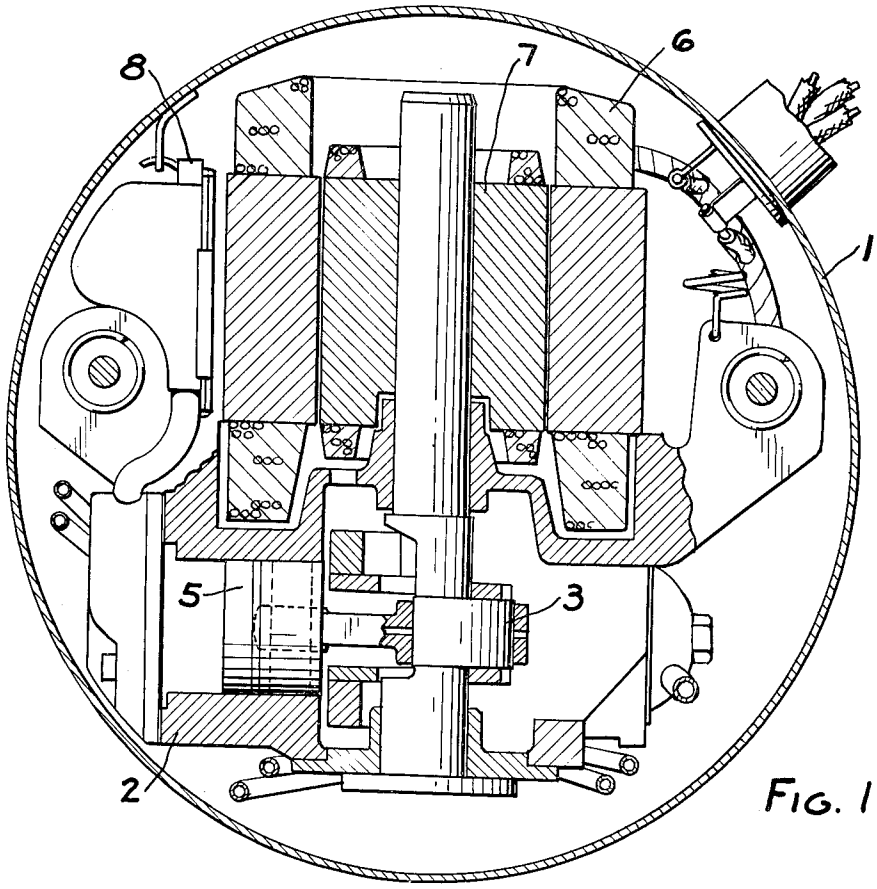


FIG. 1

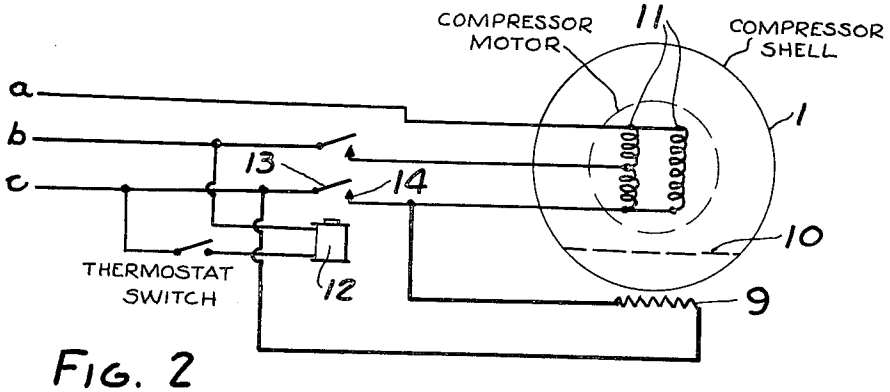


FIG. 2

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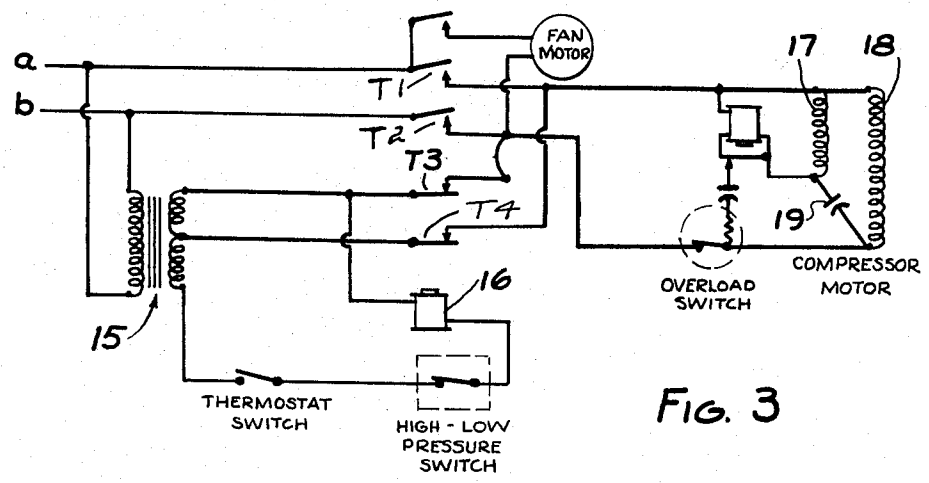


FIG. 3

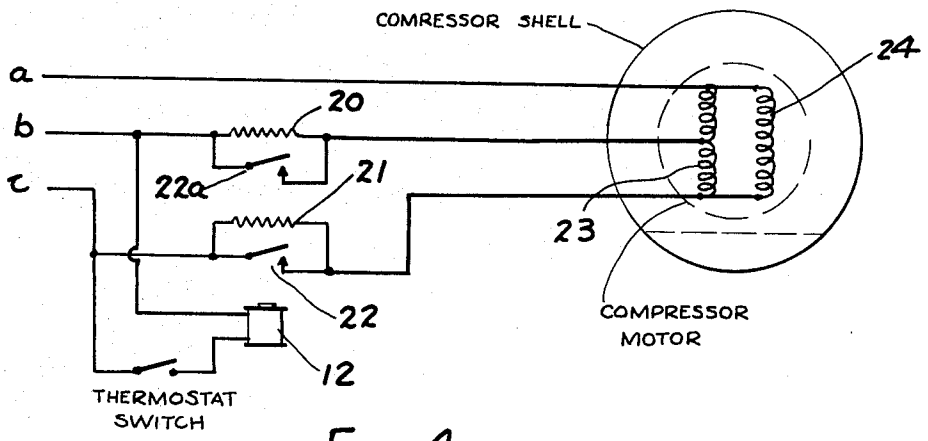


FIG. 4

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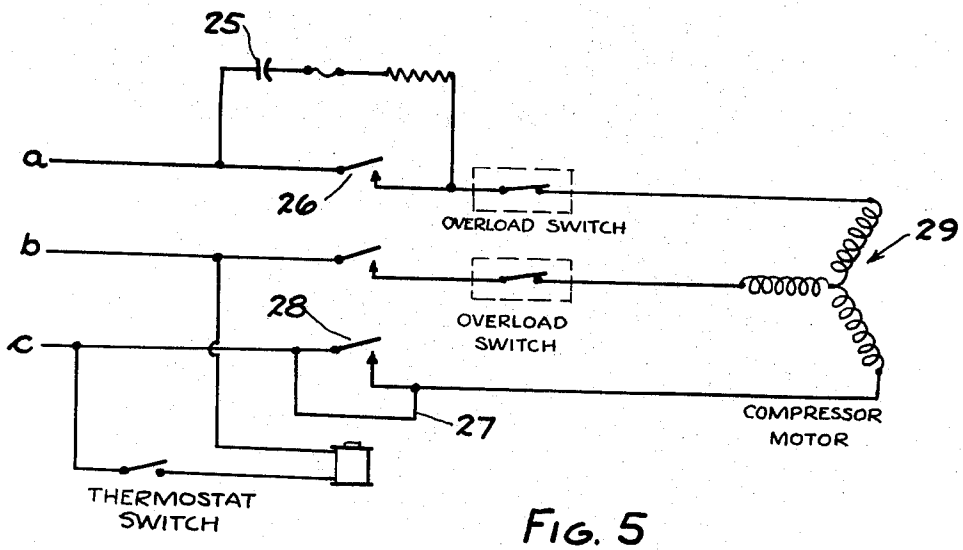


FIG. 5

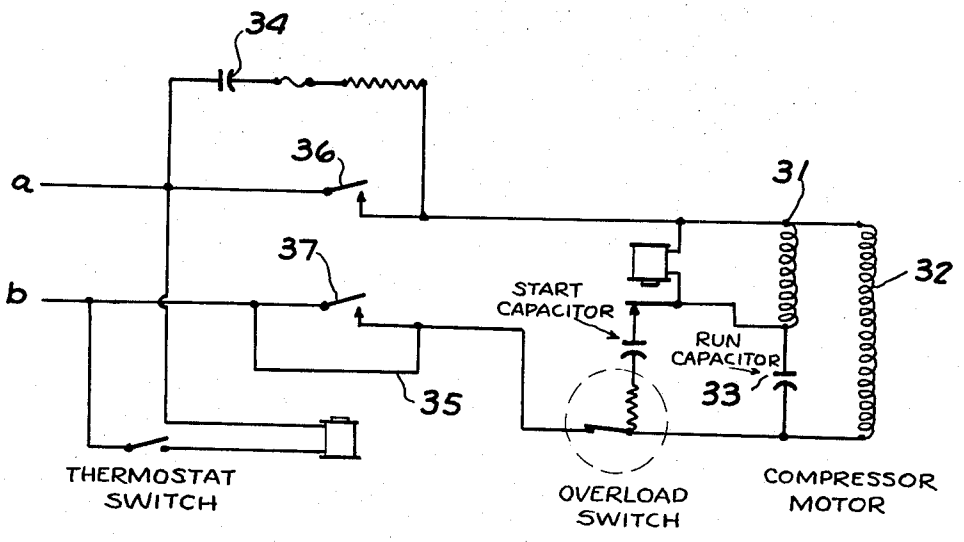


FIG. 6

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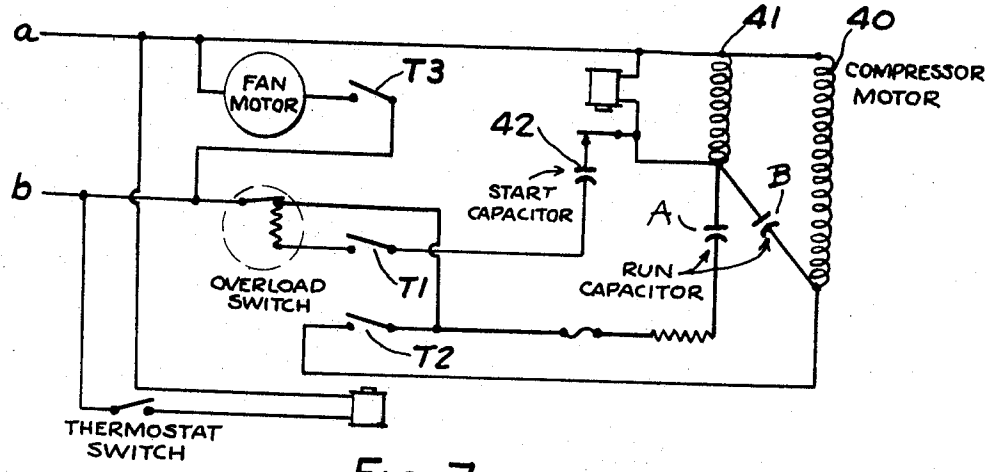


FIG. 7

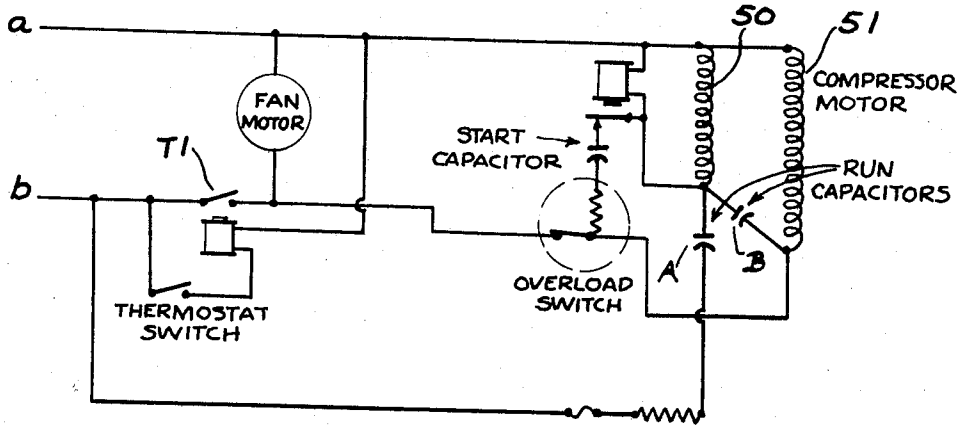


FIG. 8

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DEVICE FOR PREVENTING COMPRESSOR SLUGGING IN A REFRIGERATION SYSTEM

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Filed Sept. 4, 1958, Ser. No. 759,038
2 Claims. (Cl. 230—58)

This invention relates to a device for preventing compressor slugging in a refrigeration system.

The slugging of a compressor in a refrigeration system due to the accumulation of an excessive quantity of refrigerant in the compressor is a common occurrence. This condition arises during an off cycle where a refrigeration system is allowed to cool to surrounding ambient temperatures. If this cycle is long enough, all of the system components can reach a temperature equilibrium. With a rise in temperature, the compressor temperature usually lags behind the other system components since their temperatures follow the ambient rise. This is primarily due to the greater mass of the compressor. While the system is in this temperature unbalance, there will be an internal migration of refrigerant such, for example, as Freon due to a corresponding pressure unbalance to the coldest location in the system—usually the compressor housing. The added amount of refrigerant will mix with the crankcase oil until saturation is reached and then will continue to accumulate at the bottom of the compressor housing because it is heavier in this liquid state than the crankcase oil. Now, any rapid reduction of pressure exerted on this mixture will cause the liquid refrigerant to change state to a gas. When the compressor is started, the gas phase refrigerant is pumped from the compressor thereby reducing the pressure on the remaining oil-refrigerant mixture. The reduced pressure causes the refrigerant to expand and the oil to foam. This change of state can create violent oil foaming inside the compressor housing. The foam level rises until it reaches the suction pick-up tube and is taken into the cylinder. If a large enough quantity of this refrigerant and oil mixture is consumed into the cylinder, compressor slugging occurs. The result, regardless of the type of compressor, can be blown gaskets, broken valve leaves, broken pistons, rods, etc., any of which is fatal to compressor life.

It is an object of this invention to prevent a refrigeration system compressor from pumping liquid refrigerant or oil during a start-up period.

This object is achieved by maintaining the oil and compressor environmental temperatures above that of the other refrigeration system components thereby reducing the quantity of refrigerant in the oil and in the compressor.

In the drawings:

FIG. 1 is a vertical section through a conventional motor compressor unit for a refrigeration system.

FIG. 2 is a wiring diagram for an alternating current circuit for applying a small amount of power to the compressor motor windings during the refrigeration off cycle by means of an auxiliary heater dropping resistor placed either in the oil or on the compressor.

FIG. 3 is a wiring diagram for a conventional single phase alternating current motor for a compressor of a refrigeration system to which has been added a low voltage pilot duty circuit for applying a small amount of power to the motor windings during the refrigeration off cycle.

FIG. 4 shows an alternate wiring diagram for applying electric power to the compressor motor winding during the refrigeration off cycle in the form of dropping resistors or reactors of either capacitive or inductive reactance type connected in parallel with the contactor contacts.

FIG. 5 is an alternate wiring diagram for applying a small amount of power to the compressor motor windings of a three phase circuit during the refrigeration off cycle by means of an added series capacitor connected directly across one set of contactor contact points.

FIG. 6 is an alternate wiring diagram for applying a small amount of power to the windings of a single phase compressor motor with a two pole contactor during the refrigeration off cycle by means of an added series capacitor connected directly across one set of contactor contact points.

FIG. 7 is an alternate wiring diagram for applying a small amount of power to the windings of a single phase compressor motor with a three pole contactor during the refrigeration off cycle by utilizing the motor's own running duty capacitor.

FIG. 8 is an alternate wiring diagram for applying a small amount of power to the motor windings of a single phase motor with a single pole contactor during the refrigeration off cycle by utilizing the motor's own running duty capacitor.

FIG. 1 is a vertical section through a conventional compressor manufactured by Tecumseh Products Company, Tecumseh, Michigan. Although FIG. 1 shows a hermetically sealed unit compressor and motor assembly, it is understood that our invention is useful in any mechanical refrigeration system which utilizes a mechanical compressor in its cycle of evaporation, compression and liquefying the resultant gas and the return of this liquid refrigerant to the evaporator and wherein the lubricating oil and refrigerant mix.

In FIG. 1 the hermetically sealed housing or shell is designated **1**, the compressor cylinder **2**, the compressor eccentric **3**, the connecting rod **4**, the compressor piston **5**, the induction motor stator and windings **6**, the rotor **7**, and suction intake pipe **8**. Although not shown, the compressor is provided with the conventional valve controlled intake and discharge ports. The conventional liquid-oil refrigerant mixture level in the housing **1** is not shown. This level, of course, varies in the course of the operation of the system.

In the schematic wiring diagram shown in FIG. 2, the oil and compressor temperatures are maintained above the other system components such, for example, as the evaporator and condenser, by means of an auxiliary heater dropping resistor **9** placed on the compressor shell or housing **1**. If desired the resistor **9** can be placed in the oil within the housing **1**, the level of which is shown at **10**. The motor windings are designated **11**. The contactor coil is designated **12**. This method of heating the oil in the compressor shell is applicable to both single and three phase alternating current electric motor compressor units. Resistor **9** is connected in parallel with contactor contacts **13** and **14**. The resistor **9** is sized to provide in combination with the heat generated in the motor windings **11** sufficient heat to accomplish the purpose intended.

The circuit receives its energy from terminals *a*, *b* and *c* of an alternating current source appropriate for the purpose, for example, a 230 volt industrial supply network. When the contactor contacts **13** and **14** are open on the off cycle, current at a reduced voltage will flow through resistor **9** and the motor windings **11**, thus maintaining the oil and compressor environmental temperature above that of the other system components. The heat from the motor windings is carried by convection and conduction from the windings to the oil in the compressor shell. Preferably the oil temperature is maintained on the off cycle in a range of about 10° to 20° higher than the ambient temperature. The higher the temperature of the oil on the off cycle the less the amount of slugging that will occur during the start-up period of the compressor.

It is well known in the electric motor art that the windings of a motor will deteriorate rapidly above certain temperatures depending upon the make of the motor. An optimum or satisfactory temperature for motor windings on the off cycle is of the order of 140° to 150° F., although this temperature can be varied over wide limits. The amount of power delivered to the motor windings in any of the forms of the invention herein described will generate sufficient heat to accomplish the purpose intended but without raising the temperature of the motor windings high enough to damage the windings.

Referring to FIG. 3, here again the temperature of the compressor is maintained above the point at which refrigerant migration to the cylinder crankcase might occur by applying a low voltage current to the motor windings when the refrigeration unit is shut down. FIG. 3 shows a single phase compressor motor. The circuit receives its energy from the terminals *a* and *b* of an alternating current source appropriate for the purpose, for example, a 230 volt industrial supply network. The control transformer is designated **15**. The contactor pilot coil **16** is 24 volt and is connected in the secondary circuit of the transformer **15**. The contactor is provided with main contacts T–1 and T–2 and with an additional set of contacts T–3 and T–4 which connect two taps on the 24 volt transformer to the compressor terminals and provide the low voltage current to the compressor windings during the off cycle of the compressor. When the main contacts T–1 and T–2 are closed, the heater contacts T–3 and T–4 are open and vice versa. There is therefore no chance of the high voltage feeding back through the transformer. Also the heating voltage is automatically "on" when the unit is shut down. Contacts T–3 and T–4 are normally closed. The motor starting winding is designated **17** and the run winding **18**. The run capacitor **19** is not used in off cycle heating.

When the refrigerating unit is in the off cycle with main contacts T–1 and T–2 open, then heater contacts T–3 and T–4 are closed, thereby sending a low voltage current through the motor windings **17** and **18** for maintaining the temperature of the compressor and the oil therein higher than that of the other refrigeration system components so that the refrigerant will not migrate to the compressor.

By way of example, the specification of the transformer **15** can be as follows: With 200 volts applied to the primary winding and with the secondary winding being loaded by 4 amperes at 80% power factor, the secondary tap voltage preferably should be not less than 12 volts. With 250 volts applied to the primary winding and with the secondary winding being loaded by 6.5 amperes at 80% power factor, the secondary tap voltage should be 20 volts or less.

In the wiring diagram used in FIG. 4 dropping resistors or reactors **20** and **21** are connected in parallel with the contactor contacts **22** and **22***a* so that during the refrigeration off cycle a sufficient amount of power is delivered to the motor windings **23** and **24** that the oil and refrigerant temperature is maintained at an anti-slugging level. This system is applicable to both single and three phase systems with proper modifications for motor impedance. The reactors **20** and **21** in series with the motor winding **22**, **24** may be either inductive or capacitive.

In the alternate circuit shown in FIG. 5 the motor for the compressor is a three phase alternating current motor and the contactor is a three pole contactor. An added series capacitor **25** is connected directly across one set **26** of the contactor contact points. Capacitor **25** is preferably a continuous duty, oil filled capacitor. The circuit is completed by placing a jumper wire **27** across another set of contactor contacts **28**. The circuit receives its energy from terminals *a*, *b* and *c* of an alternating current source appropriate for the purpose, for example, a 230 volt industrial supply network. If only a two pole contactor is used in a three phase circuit, then, of course, the jumper wire is not required if the circuit is completed through the unbroken leg during the off cycle.

During the off cycle in the circuit shown in diagram, FIG. 5, the contactor contacts are open and the capacitor **25** located in one leg of the 230 volt line has a known and constant impedance which causes a very large voltage drop to appear across its terminals. This voltage drop causes a small voltage, for example, of the order of 24 volts to appear in the compressor motor terminals allowing a small current flow through the motor windings **29**. The capacitance of the capacitor **25** in the 230 volt circuit will be of the order of 20 microfarads (mfd.) when the motor **29** is of the order of one to two horsepower. If the motor is of two to three horsepower, then the capacitor will have a capacitance of the order of 30 mfd.

Referring to the wiring circuit shown in FIG. 6, there is shown a single phase motor having a start winding **31** and run winding **32**. The run capacitor is designated **33**. The added series capacitor **34** is connected directly across one set **36** of contactor contact points. The circuit is completed by placing a jumper wire **35** across the other set **37** of contacts. The contact shown is two pole but if a single pole contactor is used, a jumper wire **35** will not be needed.

During the off cycle, contacts **36** and **37** will be open. The circuit to the motor windings **31** and **32** will be completed through capacitors **34** and **33** and the jumper wire **35**. The compressor run capacitor **33** in conjunction with added series capacitor **34** impose a low voltage on the compressor windings during the off cycle. These capacitors are preferably continuous duty, oil filled capacitors and have a known and constant impedance which causes a very large voltage drop to appear across their terminals. This voltage drop causes a small voltage to appear at the compressor motor terminals allowing a small current to flow through the motor windings. The capacitors employed are sized to create and maintain a temperature differential between the compressor and the surrounding ambient temperature. Preferably the motor winding on the off cycle should be at a temperature of the order of 150° F. and the oil temperature maintained about 10° to 20° higher than the surrounding ambient temperature. Maintaining this higher crankcase temperature insures a higher internal pressure in the compressor crankcase than exists in other parts of the system and thus prevents the flow of refrigerant to the compressor housing.

FIG. 7 shows a single phase circuit with a three pole contactor. This system uses two run capacitors A and B. The motor run winding is designated **40** and the start winding **41**. The contactor contacts are designated T–1, T–2 and T–3. The contactor contacts T–3 control the fan circuit. During the off cycle when contactor contacts T–1 and T–2 are open, both the run winding **40** and the start capacitor **42** are out of the circuit. This leaves the run capacitors A and B in series with the start winding across the main power source line *a*, *b*. The impedance of run capacitors A and B causes a very large voltage drop to appear across their terminals. This voltage drop causes a small voltage of the order of 24 volts to appear at the compressor terminal allowing a small current flow through the motor windings. This small current flow maintains a temperature differential between the compressor and the surrounding ambient temperature.

FIG. 8 shows a single phase motor circuit with a single pole contactor. This system uses two run capacitors A and B. The start motor winding is designated **50** and the run winding **51**. The contactor contacts are designated T–1. During the off cycle when the contactor contacts T–1 are open, the circuit is completed from the alternating current power source terminals *a* and *b* through run capacitor A, start winding **50**, run capacitor B, run winding **51**. Here again the run capacitors A and B impose a low voltage on the compressor motor windings during the off cycle thereby allowing a small current flow through the motor windings which serve as resistance heaters dur-

ing the off cycle. The run capacitors A and B shown in FIGS. 7 and 8, like those referred to above, preferably are continuous duty, oil-filled capacitors.

We claim:

1. In a compressor, the combination of a casing, a compression mechanism in said casing, means in said casing for lubricating the compression mechanism including an oil sump, a motor operatively associated with said compression mechanism, said motor having a winding in heat exchange relation with the oil sump, a source of electrical current, circuit means including a switch coupling said motor winding to said source of electrical current causing operation of said motor when said switch is closed, and a resistance in heat exchange relation with said oil sump, said resistance being coupled across said switch to cause a reduced voltage to be impressed across said motor winding when said switch is open to heat the winding so that the heat which is produced by both the winding and the resistance is utilized to heat the oil sump to substantially reduce dilution of the oil with refrigerant.

2. In a refrigeration system wherein refrigerant is compressed, condensed and evaporated as it circulates in the system, a compressor for compressing the refrigerant preparatory to circulating the refrigerant in the system, an alternating current motor for driving said compressor, a source of alternating current for energizing the motor circuit, and means for establishing low amperage current flow through the motor winding during the off cycle of said motor whereby the motor winding serves as a heater for supplying heat to said compressor and migration of refrigerant in the system to said compressor is avoided, said means including switch means for interrupting the flow of current from said source directly to the motor winding and a dropping resistor located in heat exchange relation with said compressor for shunting the current around said open switch during the off cycle of the compressor motor.

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ROBERT A. O'LEARY, *Primary Examiner.*