United States Patent

Harter

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[54] REFRIGERANT COMPRESSOR CONTROL-RELAY TO CONTROL TWO TIME DELAYS

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[52] **U.S. Cl.**.....**307/141.4**, 62/158, 307/117

[51] **Int. Cl.**.....**F25b 1/00**

[58] **Field of Search**.....307/141, 141.4, 117; 317/132, 317/141 S; 62/158

[56] **References Cited**

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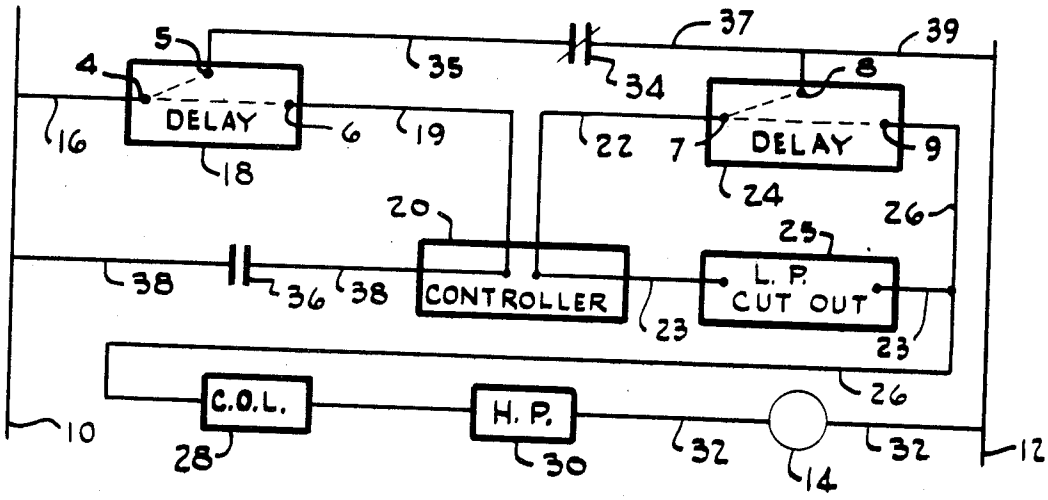
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[57] **ABSTRACT**

An air conditioner refrigerant compressor control having a first time delay means automatically keeping the compressor deenergized for a predetermined period after each stop cycle, a second time delay means operable under certain conditions to keep the compressor energized for at least a predetermined period at initiation of each start cycle, and a single relay means operable to correctly program the two time delay means.

7 Claims, 4 Drawing Figures



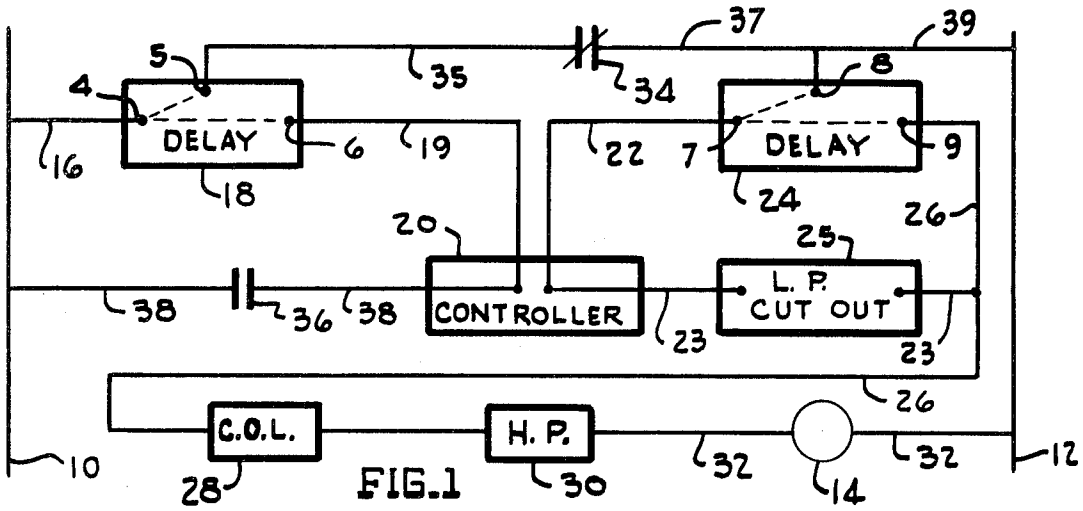


FIG. 1

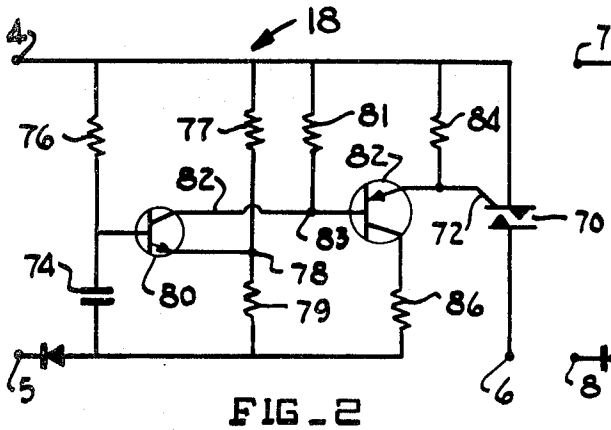


FIG. 2

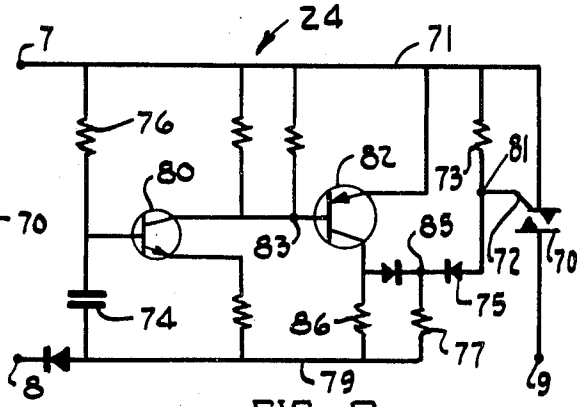


FIG. 3

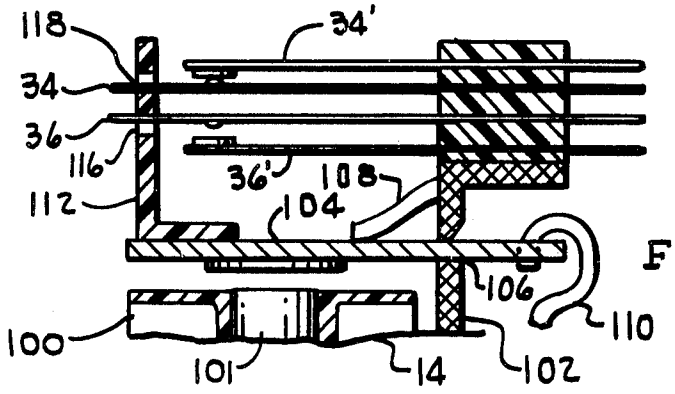


FIG. 4

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REFRIGERANT COMPRESSOR CONTROL-RELAY TO CONTROL TWO TIME DELAYS

THE DRAWINGS

FIG. 1 is a diagram of a refrigerant compressor control circuit that can be used in practice of the invention.

FIG. 2 is a circuit diagram for a time delay means employable in the FIG. 1 circuit.

FIG. 3 is a circuit diagram of a second time delay means employable in the FIG. 1 circuitry.

FIG. 4 is a fragmentary view through a relay structure that can be used in the FIG. 1 circuitry.

REFRIGERATION SYSTEM—GENERAL OPERATION

This invention relates to the type of air-conditioning system which may include a motor-driven refrigerant compressor, an air-cooled refrigerant condenser located outdoors, and a heat-absorbing refrigerant evaporator located indoors. In operation of such a system the compressor delivers hot refrigerant gas to the condenser at relatively high pressure. The condenser fan moves outdoor air across the condenser fins to thus condense the refrigerant. Condensed refrigerant is then delivered across a flow restrictor (capillary or expansion valve) to the indoor evaporator. A motor-driven fan moves room air across the evaporator fins so that the air gives up heat to the refrigerant; the refrigerant is thus vaporized and subsequently drawn back into the compressor for recycle.

COMPRESSOR FIVE-MINUTE TIME DELAY

In the above type of system the compressor is usually lubricated with lubricant pumped or withdrawn from a small sump; the sump also acts as a refrigerant supply chamber for the compressor. During the first moments of each run cycle all bearing surfaces may not receive an optimum quantity of lubricant. If the run cycle continues for a sufficient time period the lubrication will become adequate to prevent any scoring or premature wear. However if the compressor is caused to operate on very short run and stop cycles there may not be enough continuous run time to provide an adequate lubricating action.

During each run cycle some of the lubricant becomes entrained with the system refrigerant; eventually the lubricant separates out in the sump, given sufficient time. However, with very short run-stop cycles the refrigerant-oil emulsion in the sump does not have sufficient time to break up, and under these circumstances the sump fluid is foamlike in character. This foam has very inadequate lubrication properties.

At the start of each run cycle the motor current is relatively high. If the run-stop cycles are very short the heat incident to each initial current inrush is not fully dissipated, and local hot-spots sometimes develop in the windings, thereby shortening motor life.

Because of the above circumstances, and possibly others, it has been a practice to equip air conditioners with control devices which insure a few minutes time delay (usually about 5 minutes) between the end of each run cycle and the beginning of the next run cycle. This lengthens the off periods and indirectly tends to lengthen the run periods because the longer off periods increase the cooling load.

LOW-PRESSURE CUTOUT

Conventional systems usually include a low-pressure cutout switch which responds to pressure conditions in the suction line between the evaporator and compressor. The purpose of this cutout is to prevent the compressor from operating at a suction pressure so low that refrigerant flow path is insufficient to carry excess heat away from the motor windings. This cutout switch unfortunately has a disadvantageous affect at startup under wintertime operation.

During winter periods room cooling may be required even though the outdoor temperature is quite low, for example 40° or less. Under such conditions the condenser may condense refrigerant so effectively that the compressor is unable to maintain a satisfactory hot gas pressure for delivering sufficient refrigerant across the restriction between the high and low sides of the system. As a result the evaporator may be semistarved of refrigerant, especially at startup. At startup the compressor may draw more refrigerant from the evaporator than can be replaced by the condenser, thus causing the suction line pressure to suddenly drop, thereby actuating the low-pressure cutout. The result is a short on-off-on cycling of the compressor which interferes with operation and sometimes necessitates nuisance restarts or maintenance calls.

Because of this circumstance it has become the practice to equip air conditioners with control devices which override the low-pressure cutout during the first moments of each run cycle. Such control devices keep the compressor energized for the initial one or two minutes of the cycle, even though the low-pressure cutout switches to the off position. After the initial two minutes the low-pressure cutout assumes control.

FIG. 1 illustrates by block diagram a control circuit of the present invention. As shown the circuit comprises power lines **10** and **12** for supplying an AC voltage to a compressor relay coil **14**. At normal startup the compressor relay coil is energized through a circuit which includes line **16**, time delay **18**, line **19**, the contacts of a controller **20** (which may be a thermostat or relay contacts controlled by a thermostat), line **22**, time delay **24**, line **26**, compressor overload control **28**, high-pressure cutout **30** (responsive to excessively high gas pressures in the high side of the refrigerant system), and line **32**.

TIME DELAY 18

Time delay **18** **18** is preferably a solid-state circuit having three terminals **4**, **5** and **6**. When energizer current begins to flow between terminals **4** and **5** the time delay period (e.g., 5 minutes) starts. During the delay period the circuit between terminals **4** and **6** is interrupted. At the end of the delay period a solid-state AC switch in device **18** is in condition to conduct load current between terminals **4** and **6**. Such current flow automatically ceases in response to current interruption in the circuit going through terminals **4** and **5**. FIG. **2** illustrates the rudiments of one solid-state circuit that can be used to provide the desired operation.

It will be noted from FIG. **1** that the so-called energizer circuit for delay device **18** includes line **16**, terminals **4** and **5**, line **35**, normally closed contacts **34**, and lines **37** and **39**. When contacts **34** close the 5-minute delay period begins; the delay period is halted either by the expiration of 5 minutes or the opening of contacts **34**.

TIME DELAY 24

Time delay **24** is preferably a solid-state circuit having three terminals **7**, **8** and **9**. When energizer current begins to flow between terminals **7** and **8** the 2-minute delay period begins; during this delay period the load circuit between terminals **7** and **9** is fully conductive. At the end of the 2-minute delay period an AC switch in device **24** is biased to the nonconducting state, thereby interrupting current flow between terminals **7** and **9** even through energizer current continues to flow between terminals **7** and **8**. FIG. **3** illustrates the rudiments of one solid-state circuit that can be used to provide the desired operation.

RELAY OPERATION

The illustrated coil **14** controls two auxiliary sets of contacts **34** and **36** physically arranged so that contacts **36** make before contacts **34** break (FIG. **4** illustrates one way this can be accomplished). Prior to normal startup contacts **34** and **36** are as shown in FIG. **1**, coil **14** is deenergized, and delay devices **18** and **24** have both timed out; the load circuit between terminals **4** and **6** is conductive, and the load circuit between terminals **7** and **9** is conductive. Startup is accomplished by closing the contacts in controller **20**, as by thermosensitive means

(not shown). At startup coil **14** is energized through the aforementioned circuit comprising the series-connected mechanisms **16, 18, 19, 20, 22, 24, 26, 28, 30** and **32**. As coil **14** is energized the contacts **36** close to complete a circuit through line **38**. A few milliseconds later contacts **34** open to break the energizer circuit for the time delay **18**; one purpose in thus breaking the energizer circuit at this time is to interrupt the load current through time delay **18** i.e., through lines **16** and **19**). Load current is instead carried by line **38**, so that time delay **18** is not subjected to transients caused by lightning, motor surges or other surge conditions. Another purpose in breaking the energizer circuit (at **34**) is to halt or prevent the 5-minute delay period; it is intended that switch **34** close at the end of the run cycle to start the 5-minute delay period.

During the initial 2 minutes of the run cycle the current may flow between controller **20** and line **26** through either or both of two separate paths. One path comprises line **22** and time delay **24**, and the other path comprises line **23** and low-pressure cutout **25** (responsive to suction line pressures in the refrigerant system). Should the low side of the system be too low the cutout **25** will open the circuit through line **23**, and the load current will take the path through time delay **24**.

At the end of the initial 2-minute run time the delay device **24** will time out, and low-pressure cutout **25** will assume sole control over the compressor (in conjunction with other safety controls such as the illustrated controls **28** and **30**). Normal stop cycle is initiated by opening the contacts in controller **20**. This action deenergizes coil **14** which stops the compressor and returns contacts **34** and **36** to their illustrated positions. As contacts **34** close they start a current flow between terminals **4** and **5** which thereby starts the 5-minute delay period. During such delay period the compressor cannot be restarted by coil **14** even though controller **20** closes its contacts to call for cooling. At the end of the 5-minute period the circuit between terminals **4** and **6** becomes conductive so that the controller contacts can thereafter energize the coil **14** in a normal run cycle.

As will be noted from previous remarks, the general purpose of the FIG. **1** circuit is to provide a 2-minute delay period during the initial portion of each run cycle so that the low-pressure cutout **25** is prevented from tripping out the compressor during this 2-minute period. A further purpose of the circuitry is to provide a 5-minute delay at the end of each run cycle so that the compressor cannot be reenergized during the 5-minute period, thus achieving the aforementioned advantages in regard to compressor lubrication and compressor motor life, among others. The circuitry is designed so that a single relay coil **14** can be used to energize the compressor (through contacts not shown) and also to program or control the time delays **18** and **24**, as by means of the auxiliary contacts **34** and **36**.

It is believed that time delay **18** can take various forms. However for illustration purposes there is shown in FIG. **2** the rudiments of a suitable time delay circuit. As shown, the circuit comprises terminals **4, 5** and **6** numbered to correspond with the same terminals in FIG. **1**. The circuit comprises a solid-state AC switch **70** which may for example be a switch marketed by General Electric Company under the trade name Triac. The switch will conduct AC current between terminals **4** and **6** only when a sufficient negative potential is applied to its gate **72**.

Assuming contacts **34** are closed to apply an AC voltage across terminals **4** and **5**, the capacitance **74** will slowly charge on the half-cycles while terminal **4** is positive; charging will be through the resistance **76**. Resistances **76, 77** and **79** are so chosen that initially the emitter potential of transistor **80** is greater than the base potential, thereby producing a reverse bias which holds the transistor off. As the capacitance **74** becomes fully charged the base potential for transistor **80** increases so that the transistor is fired on, thereby producing a collector-emitter current through a circuit which includes resistance **81** and line **82**.

The collector-emitter current flow through transistor **80** lowers the positive potential at junction **83**, thereby permitting the second transistor **82** to fire through a circuit that includes resistance **84**, the emitter-collector of the transistor, and resistance **86**. This action makes the gate **72** more negative so that switch **70** fires to permit load current to flow between terminals **4** and **6**. The resistances and capacitance may be chosen to obtain a 5-minute delay time between initial triggering voltage across terminals **4** and **5** (closing of contacts **34** at the end of the run cycle) and conduction across terminals **4** and **6** (start of the next run cycle).

Time delay **24** can be similar in general character to time delay **18**; therefore similar numerals are used where applicable. Delay **24** differs from delay **18** in that the load circuit is on during the delay period, not off. When a voltage is initially applied across terminals **7** and **8** (as when the controller **20** contacts close) a trigger voltage is applied to the gate **72** of AC switch **70** through a circuit which includes line **71**, and resistance **73**. Current flow on alternate half-cycles takes a path that includes line **71**, resistance **73**, diode **75**, resistance **77**, and line **79**. This flow lowers the potential at junction **81**, (see FIG. **3**, thereby causing the gate to become more positive for thus firing the AC switch to the conducting mode.

During the initial 2-minute period capacitance **74** slowly charges, after which the transistors **80** and **82** are fired on, as by the action previously outlined in connection with FIG. **2**. As transistor **82** fires its collector becomes more positive, thereby raising the positive potential at junction **85**. This causes the gate **72** to go more positive, thereby biasing the switch **70** into the nonconducting mode.

FIG. **4** illustrates a portion of a relay coil **14** which includes winding **100**, core **101** and flux-conducting frame **102** having a pivotal plate-type armature **104** hingedly mounted on pivot **106** for upward movement against a stop **108** (struck out of the frame) under the urging of a tension spring **110**. Energization of the coil causes armature **104** to swing downwardly so that its attached arm **112** moves the spring leaf contact elements **34** and **36** downwardly. Suitable length slots **116** and **118** are formed in arm **112** so that leaf **36** engages the subjacent leaf **36'** before leaf **34** leaves the superjacent leaf **34'**. This make-before-break action is advantageous in that it eliminates a time race problem that can occur when the relay is used in the FIG. **1** circuit.

RELAY ACTION

Assuming the contacts **36** and **34** are in the FIG. **1** conditions, the energization of coil **14** causes contacts **36** to close and contacts **34** to open. As noted above, contacts **36** should be closed before contacts **34** start to open. If contacts **34** were allowed to open before contacts **36** closed the load circuit through terminals **4** and **6** might open before contacts **36** could take over as the holding contacts; in that event the relay coil **14** might be prematurely deenergized. With the make-before-break action shown in FIG. **4** this situation is prevented.

I claim:

1. An air conditioner refrigerant compressor control comprising a controller for initiating the compressor start and stop actions on a substantially nondelayed basis; first time delay means keeping the compressor deenergized for a predetermined period after each stop action; a compressor cutout responsive to low side conditions in the refrigerant system; second time delay means keeping the compressor energized for a predetermined period after each start action irrespective of the condition of the compressor cutout; and a single relay means controlled by the start and stop actions for electrically programming both time delay means.

2. The control of claim **1** wherein the compressor cutout and second time delay means are in electrical parallelism with one another and in series circuit connection with the controller.

3. The control of claim **1** wherein the relay means comprises a set of normally closed contacts effective to energize the first time delay means at each compressor stop action.

4. The control of claim 1 wherein the relay means comprises a set of normally open contacts arranged in electrical parallelism with the first time delay means; said first time delay means and the normally open contacts forming alternate energizer connections for the compressor during the startup period.

5. The control of claim 1 wherein the controller is series-connected with the first and second time delay means so that an open circuit at the controller deenergizes the compressor irrespective of the condition of the time delay means.

6. The control of claim 1 wherein the first time delay means comprises a solid-state device operable to provide an open load circuit when initially provided with an input energizer signal by the relay means.

7. The control of claim 1 wherein the second time delay means comprises a solid-state device operable to provide a closed load circuit when initially provided with an input energizer signal by the relay means.

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