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(54) **Compressor motor preheat control**

(57) A method of controlling a vapor cycle system (10) having first and second compressors (14,16) includes operating the first compressor (14) to compress refrigerant while the second compressor (16) is idle, sensing a motor temperature of the second compressor (16), activating a preheating mode in which the motor (16-1) of the second compressor (16) is powered to generate heat when the motor temperature of the second compressor is below a lower temperature threshold, turning off the preheating mode when the sensed motor temperature of the second compressor (16) is above an upper temperature threshold, and limiting the maximum duration of the preheating mode to a preheating time period, such that the preheating mode is turned off after being activated for the preheating time period.

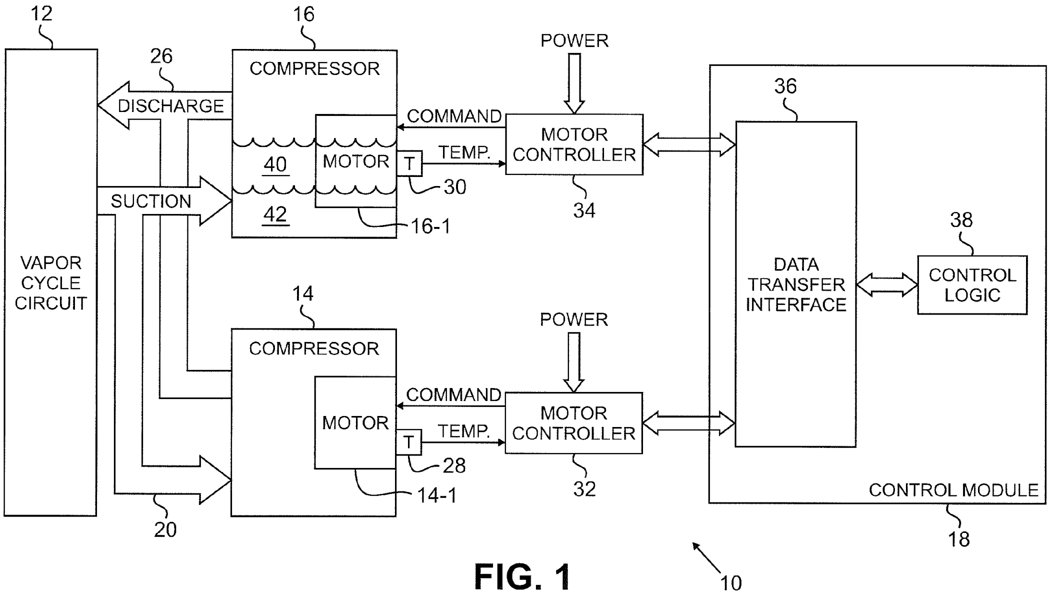

FIG. 1

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Description

BACKGROUND

[0001] The present invention relates to vapor cycle systems having a compressor, and more particularly to vapor cycle systems and methods of operating the same to reduce flooded compressor startup conditions and/or lubrication accumulation in the idle compressors of multi-compressor systems.

[0002] Vapor cycle systems (VCSs) are known for providing cooling in a variety of contexts. In general, a refrigerant is compressed and expanded in a cyclical manner to transfer thermal energy and help cool a given airspace or fluid. Some VCSs have a dual compressor configuration, with two compressors operable within the same overall refrigerant circuit.

[0003] It is desired to reduce fluid migration issues in dual compressor VCSs, and to provide a cold-start procedure for VCSs with any number of compressors.

SUMMARY

[0004] A method of controlling a vapor cycle system having first and second compressors according to the present invention includes operating the first compressor to compress refrigerant while the second compressor is idle, sensing a motor temperature of the second compressor, activating a preheating mode in which the motor of the second compressor is powered to generate heat when the motor temperature of the second compressor is below a lower temperature threshold, turning off the preheating mode when the sensed motor temperature of the second compressor is above an upper temperature threshold, and limiting the maximum duration of the preheating mode to a preheating time period, such that the preheating mode is turned off after being activated for the preheating time period.

[0005] Viewed from a first aspect, the present invention provides a method of controlling a vapor cycle system having first and second compressors, the method comprising: operating the first compressor to compress refrigerant while the second compressor is idle; sensing a motor temperature of the second compressor; activating a preheating mode in which the motor of the second compressor is powered to generate heat when the motor temperature of the second compressor is below a lower temperature threshold; turning off the preheating mode when the sensed motor temperature of the second compressor is above an upper temperature threshold; and limiting the maximum duration of the preheating mode to a preheating time period, such that the preheating mode is turned off after being activated for the preheating time period.

[0006] Viewed from a second aspect, the present invention provides a vapor cycle system comprising: a first compressor having an electric motor, a motor temperature sensor, and a motor controller; a second compressor having an electric motor, a motor temperature sensor, and a motor controller; a refrigerant circuit, wherein the first compressor and the second compressor are connected in fluid communication with the refrigerant circuit in parallel; and a control module operatively connected to the motor controller of each of the first and second compressors, wherein the control module is configured to command the motor controllers of each of the first and second compressors to operate only one of the first and second compressors to compress refrigerant and to operate the other, idle one of the first and second compressors in a preheat mode, wherein the preheat mode is activated to generate heat with the motor of the idle one of the first and second compressors to a preheat temperature range, and wherein the control module is further configured to limit a duration of the preheat mode to a preheating time period.

[0007] Viewed from a third aspect, the present invention provides a method of operating a dual compressor vapor cycle system, the method comprising: operating a first compressor to compress refrigerant; selectively activating a preheating mode of a second compressor connected in parallel with the first compressor to reduce migration of refrigerant, lubricant or a combination thereof from the first compressor to the second compressor, wherein the preheating mode comprises supplying power to an electric motor of the second compressor to generate heat, wherein the preheating mode is activated when the second compressor is idle; controlling the preheating mode of the second compressor according to sensed motor temperature by default; and limiting a duration of the preheating mode of the second compressor to a preheating time period to provide failsafe protection against overheating.

[0008] Viewed from a fourth aspect, the present invention provides a method of operating a vapor cycle system having a compressor with an electric motor, the method comprising: sensing a motor temperature of the electric motor when the compressor idle; determining if the motor temperature is below a lower temperature threshold; when the motor temperature is below the lower temperature threshold, supplying current to the electric motor to generate heat while the compressor remains idle; and ceasing to generate heat with the electric motor when the sensed motor temperature is above an upper temperature threshold.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 is a block diagram schematically illustrating a dual compressor vapor cycle system (VCS) according to the present invention.

[0010] FIG. 2 is a flow chart illustrating an embodiment of a method of controlling a VCS according to the present invention.

[0011] FIG. 3 is a flow chart illustrating an alternative embodiment of a method of controlling a VCS according to the present invention.

DETAILED DESCRIPTION

[0012] In general, one embodiment the present invention relates to multi-compressor vapor cycle system (VCS) and associated control logic. The present inventors have discovered a problem with dual compressor VCSs when one compressor is idle, that is not operating to compress refrigerant, whereby liquid state refrigerant and/or lubricant can migrate to the idle compressor. Migrating fluid can undesirably starve the active compressor of lubricant and negatively impact system performance, resulting in reduced cooling effectiveness as well as potential failure of the operating compressor. Furthermore, the idle compressor flooded with liquid refrigerant and/or lubricant can experience difficulties at startup when requested to operate (called a "flooded start"), which can lead to reliability issues. In one embodiment of a multi-compressor VCS according to the present invention, the compressors are connected in parallel, which allows fluid to pass between the compressors and into the idle compressor. Each compressor can be selectively activated based on desired cooling capacity, such that both compressors or only one of them are operating simultaneously to compress refrigerant. When only a single compressor is active, the control logic provides heating to an idle compressor to reduce or eliminate migration of refrigerant and/or lubricant in a liquid state into the idle compressor. The idle compressor has an electric motor that can be used to generate heat that reduces migration of liquids and tends to drive out or evaporate any liquids that may be present. By default, a preheat mode of the idle compressor generates heat with windings of the idle compressor motor to a given motor temperature range (e.g., 48.9°C (120°F) to 54.4°C (130°F)), controlled by sensing the motor temperature with a suitable sensor, such as a thermistor. The system can further optionally provide a failsafe timer mechanism to prevent overheating in the event of a failure of the temperature sensor. The preheating mode of the idle compressor is cycled on (i.e., operated) for a given time period (e.g., 14 minutes), and can then by cycled off for a given delay period (e.g., 30 minutes) before the preheating time period is reactivated, thereby providing the optional failsafe time functionality. By heating the idle compressor according to the present invention, an active (non-idle) compressor is not starved of refrigerant during operation due to migration of fluid to the idle compressor. Furthermore, the preheat mode helps reduce a risk of a flooded start when the idle compressor is activated to begin compressing refrigerant. In another embodiment of the present invention, a preheating mode is provided that is controlled based on sensed motor temperature, such as using sensed resistance through a thermistor, and can be implemented in single or multi-compressor VCSs. Other features and benefits of the present invention will be appreciated in view of the discussion that follows.

[0013] FIG. 1 is a block diagram schematically illustrating one embodiment of a dual compressor VCS 10 that includes a vapor cycle circuit 12, a compressor 14, a compressor 16, and a control module 18.

[0014] Each compressor 14 and 16 includes an electric motor 14-1 and 16-1, respectively, and can be of any suitable type (e.g., scroll, reciprocating, etc.). The electric motors 14-1 and 16-1 can include suitable windings, etc., and can have a conventional configuration. The compressors 14 and 16 can each be connected to a common suction port manifold 20 and a common discharge port manifold 26, with each manifold 20 and 26 connected in fluid communication with the vapor cycle circuit 12. In the illustrated embodiment, the compressors 14 and 16 are connected to the vapor cycle circuit 12 in parallel. Common discharge and suction manifolds can be omitted in alternative embodiments, with separate discharge and suction ports for each compressor 14 and 16. A temperature sensor 28 and 30 is provided for each compressor 14 and 16, respectively, to sense a motor temperature of the compressor 14 or 16. In one embodiment, the sensors 28 and 30 are thermistors that allow temperature sensing by changing resistance as a function of temperature. A motor controller 32 and 34 is provided from each compressor 14 and 16, respectively. The motor controllers 32 and 34 each accept power, send operational commands to the motors 14-1 and 16-1 of the compressors 14 and 16, and receive temperature signals from the sensors 28 and 30. Signals sent between the motor controllers 32 and 34 and the compressors 14 and 16 can all be analog. The sensors 28 and 30 and the motor controllers 32 and 34 can be part of a common assembly with the compressors 14 and 16, respectively, in some embodiments.

[0015] The control module 18 is operatively connected to each motor controller 32 and 34, and communication between the motor controllers 32 and 34 and the control module 18 can be in the form of digital signals. The control module 18 includes a data transfer interface 36 and control logic 38, which can be implemented through suitable circuitry and/or software (e.g., suitable processor(s), computer-readable memory, etc.). The data transfer interface 36 facilitates communication between all of the motor controllers 32 and 34 and the control logic 38 of the control module 18. The control logic 38 provides high level decision making for the VCS 10, while the motor controllers 32 and 34 handle lower-level tasks such and providing operational commands to the motors 14-1 and 16-1 of the compressors 14 and 16.

[0016] A refrigerant 40 (e.g., R134A refrigerant) and a lubricant 42 are present within the VCS 10. In the illustrated embodiment, which shows the compressor 14 in an active state and the compressor 16 in an idle state, portions of the refrigerant 40 and the lubricant 42 in liquid phases are present in the compressor 16. Vapor phase portions of the refrigerant 40 and the lubricant 42 are also present in the vapor cycle circuit 12 and the compressors 14 and 16.

[0017] During operation, the VCS 10 can activate one or both of the compressors 14 and 16 to move and compress fluid (e.g., the refrigerant 40). Cooling can be provided by the VCS 10 in a conventional manner. The basic operation of VCSs to provide cooling is well-known, and will be understood by those of ordinary skill in the art. Further discussion here is unnecessary. Depending upon cooling demand, both compressors 14 and 16 can be operated simultaneously to provide relatively high levels of cooling, or only one of the compressors 14 or 16 can be operated while the other compressor 14 or 16 remains idle (i.e., not moving or compressing fluid) to provide a lower level of cooling. Operation of only a single one of the compressors 14 and 16 can alternate between the two, to provide relatively even usage of each compressor 14 and 16 over time.

[0018] FIG. 2 is a flow chart illustrating one embodiment of a method of controlling the VCS 10. Initially, the VCS 10 is operated in a mode with only one compressor 14 or 16 active to move or compress fluid (step 100). As discussed above, the VCS 10 can also operate both compressors 14 and 16 active simultaneously, and, further, in single compressor operation the particular compressor 14 or 16 that is active can alternate. By default, a motor temperature of the motor 14-1 or 16-1 of the idle compressor 14 or 16 is sensed using the corresponding sensor 28 or 30 (step 102). The temperature of fluid in the idle compressor 14 or 16 need not be sensed directly, only the temperature of motor windings of the motor 14-1 or 16-1 of the idle compressor 14 or 16. Temperature of the motor windings can be sensed by delivering a current and measuring resistance through a thermistor, or using other methods as desired. The sensed temperature is communicated to the control logic 38 of the control module 18. The control logic 38 analyzes the sensed data and determines if the motor temperature of the idle compressor 14 or 16 is above a lower threshold (also called a lower temperature threshold) (step 104). In the illustrated embodiment the lower threshold is approximately 48.9°C (120°F), though other temperatures can be selected for the lower threshold in alternative embodiments. For instance, the lower threshold can be selected to be sufficiently high to ensure that the refrigerant 40 is vaporized. If the motor temperature is above the lower threshold, then it is okay to start (i.e., activate) the idle compressor motor if desired (step 106). If the sensed motor temperature is below the lower threshold, then a preheating mode can be activated (step 108). The preheating mode can generate thermal energy by delivering power from the motor controller 32 or 34 to windings of the motor 14-1 or 16-1 of the idle compressor 14 or 16, thereby using the idle motor windings as a heater, without activating the motor 14-1 or 16-1 of the idle compressor 14 or 16 to generate a motive force to move or compress fluid. Thermal energy created by motor windings can vaporize liquid, such as the refrigerant 40 and/or the lubricant 42, that may be present in the idle compressor 14 or 16, and can help drive out refrigerant 40 or other liquid from the idle compressor 14 or 16 to help prevent migration of fluid from the active compressor 14 or 16 through the vapor cycle circuit 12 that may starve the active compressor 14 or 16 of such fluid used for operation.

[0019] It is desirable to maintain the motor temperature of the idle compressor 14 or 16 within a given range between the lower threshold and an upper threshold (also called an upper temperature threshold). After the preheating mode has been activated at step 108, it is determined whether the sensed motor temperature of the idle compressor 14 or 16 is above the upper threshold (step 110). The upper threshold can be approximately 54.4°C (130°F), or other temperatures in alternative embodiments. If the motor temperature is above the upper threshold, then the preheating mode of the idle compressor 14 or 16 can be turned off (step 112), and then it is okay to start the motor of the idle compressor 14 or 16 at step 106. In this way, sensed motor temperature controls the preheat mode by default, and turns on or off preheating of the idle compressor 14 or 16 as a function of sensed motor temperature. If the motor temperature of the idle compressor 14 or 16 is below the upper threshold, it is determined whether the motor temperature is above the lower threshold and there is a command to turn the idle compressor 14 or 16 on (i.e., activate the idle compressor 14 or 16) (step 114). If the motor temperature is above the lower threshold and the idle compressor 14 or 16 is commanded on, then the preheat mode is turned off at step 112 and it is okay to start the motor 14-1 or 16-1 of the idle compressor 14 or 16 at step 106.

[0020] If the motor temperature of the idle compressor 14 or 16 is either below the lower threshold or the motor 14-1 or 16-1 of the idle compressor 14 or 16 is not commanded on, then the preheat mode is maintained on for a preheat time period (step 116). The preheat time period can be 14 minutes, or another time period in alternative embodiments. After the preheat time period, the preheat mode is turned off (step 118) and thermal energy is no longer generated by the motor of the idle compressor 14 or 16. The preheat time period thus provides a failsafe to limit the maximum duration of the preheating and the amount of time that heat is generated with the motor of the idle compressor 14 or 16, which helps prevent a risk of overheating in the event of a failure of the sensor 28 or 30. After the preheat time period has expired and the preheat mode is turned off at step 118, then a determination is made as whether the idle compressor 14 or 16 has been commanded on (step 120). If there is a command to turn on the idle compressor after step 118, then it is okay to start the motor at step 106. If the preheat time period has lapsed, in effect overriding the default sensed temperature control of the preheating mode, then the motor 14-1 or 16-1 of the idle compressor 14 or 16 can be started regardless of the actual motor temperature. The preheat time period can selected to help promote a suitable motor temperature of the idle compressor 14 or 16 even without the benefit of temperature sensing. If the preheat time period has lapsed at step 118 but there is no command to turn on the idle compressor 14 or 16, then a delay period is triggered (step 122). In one embodiment the delay period can be 30 minutes, or other periods in alternative embodiments. During the delay period the preheat mode of the idle compressor 14 or 16 is maintained in an off condition. The delay period helps prevent overheating and provides further failsafe protection. After expiration of the delay period, the preheat mode of the idle compressor 14 or 16 can be reactivated at step 116.

[0021] At any time it is determined it is okay to start the motor 14-1 or 16-1 of the idle compressor 14 or 16 at step 106, the idle compressor 14 or 16 can be started (i.e., activated) to move or compress fluid. After step 106, a determination can be made as to whether single compressor mode is desired (step 124). At this point, the single compressor mode using the same active compressor 14 or 16 can be maintained or the active and idle compressors 14 and 16 can alternate roles. If single compressor mode is desired, then the method can proceed to step 100 and begin again. If single compressor mode is not desired and all compressors 14 and 16 are activated, then the method is finished because preheating is not needed when all compressors 14 and 16 are active.

[0022] FIG. 3 is a flow chart illustrating an alternative embodiment of a method of controlling a VCS to provide a "cold start" routine. In the embodiment illustrated in FIG. 3, a time fail-safe procedure, as provided in the embodiment illustrated in FIG. 2, is omitted. It should be appreciated that the method illustrated in FIG. 3 can readily be applied to single-compressor VCSs, or to multi-compressor systems such as VCS 10 shown in FIG. 1.

[0023] Initially, a motor temperature of the motor 14-1 or 16-1 of an idle compressor 14 or 16 is sensed using a corresponding sensor 28 or 30 (step 202). The temperature of fluid in the idle compressor 14 or 16 need not be sensed directly, only the temperature of the motor windings of the motor 14-1 or 16-1 of the idle compressor 14 or 16. Temperature of the motor windings can be sensed by delivering a current and measuring resistance through a thermistor, or using other methods as desired. The sensed temperature is communicated to the control logic 38 of the control module 18. The control logic 38 analyzes the sensed data and determines if the motor temperature of the idle compressor 14 or 16 is above a lower threshold (also called a lower temperature threshold) (step 204). In the illustrated embodiment the lower threshold is approximately 29.4°C (85°F), though other temperatures can be selected for the lower threshold in alternative embodiments. For instance, the lower threshold can be selected to be sufficiently high to ensure that the refrigerant 40 is vaporized. If the motor temperature is above the lower threshold, then it is okay to start (i.e., activate) the idle compressor motor 14-1 or 16-1 if desired (step 206). If the sensed motor temperature is below the lower threshold, then a preheating mode can be activated (step 208). The preheating mode can generate thermal energy by delivering power from the motor controller 32 or 34 to windings of the motor 14-1 or 16-1 of the idle compressor 14 or 16, thereby using the idle motor windings as a heater, without activating the motor 14-1 or 16-1 of the idle compressor 14 or 16 to generate a motive force to move or compress fluid. Thermal energy created by motor windings can vaporize liquid, such as the refrigerant 40 and/or the lubricant 42, that may be present in the idle compressor 14 or 16, and can help drive out refrigerant 40 or other liquid from the idle compressor 14 or 16.

[0024] It is desirable to maintain the motor temperature of the idle compressor 14 or 16 within a given range between the lower threshold and an upper threshold (also called an upper temperature threshold). After the preheating mode has been activated at step 208, it is determined whether the sensed motor temperature of the idle compressor 14 or 16 is above the upper threshold (step 210). The upper threshold can be approximately 32.2°C (90°F), or other temperatures in alternative embodiments. If the motor temperature is above the upper threshold, then the preheating mode of the idle compressor 14 or 16 can be turned off (step 212), and then it is okay to start the motor 14-1 or 16-1 of the idle compressor 14 or 16 at step 206. In this way, sensed motor temperature controls the preheat mode by default, and turns on or off preheating of the idle compressor 14 or 16 as a function of sensed motor temperature. If the motor temperature of the idle compressor 14 or 16 is below the upper threshold, then it is determined if there has been a motor temperature sensor failure (step 215). This can be accomplished through built-in-testing processes, or any other suitable method. If the sensor is operating normally, preheating can continue at step 208. If the sensor has failed, preheating is turned on for a time period (e.g., 18 minutes) (step 216), then preheating is turned off (step 218). At this point it is determined if the idle compressor 14 or 16 is commanded on (step 220). If the idle compressor 14 or 16 is commanded on, then it is okay to start the motor 14-1 or 16-1 at step 206. If there is no on command, then a delay period (e.g., 30 minutes) is begun (step 222). During the delay period, it is determined if there is an on command (step 224). If there is an on command any time during the delay period, then it is okay to start the motor 14-1 or 16-1 at step 206. If there is no on command after the expiration of the delay period, then a preheating period can be cycled on for a new time period (e.g., 14 minutes) (step 226), which returns to step 218 to continue the method.

[0025] At any time it is determined it is okay to start the motor 14-1 or 16-1 of the idle compressor 14 or 16 at step 206, the idle compressor 14 or 16 can be started (i.e., activated) to move or compress fluid.

[0026] It should be noted that the method illustrated in FIG. 3 can be limited only to use in relatively cold environments or climates. For instance, use of the method shown in FIG. 3 can be used only when a sensed ambient temperature is below a suitable temperature threshold.

[0027] While the invention has been described with reference to exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention, which is defined by the claims. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiments disclosed, but that the invention will include all embodiments falling within the scope of the appended claims. For example, although certain embodiments of the present invention have been described with respect to a dual compressor VCS, the present invention could be used with VCSs having a different number of compressors. Moreover, temperature thresholds for preheating control can vary as desired for particular applications, such as to accommodate particular refrigerants or other fluids used by a VCS.

Claims

1. A method of operating a compressor (14,16) with an electric motor (14-1,16-1) in a vapor cycle system (10), the method comprising:

sensing a motor temperature of the compressor when the compressor is idle;
determining if the motor temperature is below a lower temperature threshold;
activating a preheat mode when the motor temperature is below the lower temperature threshold by supplying current to the electric motor to generate heat while the compressor remains idle; and
turning off the preheat mode when the sensed motor temperature is above an upper temperature threshold.

2. The method of claim 1 and further comprising:

activating the compressor when the motor temperature is above the lower temperature threshold and after turning off the preheat mode.

3. The method of claim 1 or 2, wherein the lower temperature threshold is approximately 29.4°C (85°F), and wherein the upper temperature threshold is approximately 32.2°C (90°F).

4. The method of claim 1, 2 or 3, wherein the motor temperature is sensed by sensing a resistance with a thermistor (28,30).

5. A method of controlling a vapor cycle system (10) having first and second compressors (14,16), the method comprising:

operating the first compressor (14) to compress refrigerant while the second compressor (16) is idle;
operating the second compressor by the method of any preceding claim; and
limiting the maximum duration of the preheating mode to a preheating time period, such that the preheating mode is turned off after being activated for the preheating time period.

6. The method of claim 5, wherein the preheating time period is approximately 14 minutes.

7. The method of claim 5 or 6 and further comprising:

maintaining the second compressor preheat mode in an off condition for a delay period; and
reactivating the preheating mode for the second compressor for the preheating time period following the delay period.

8. The method of claim 7 wherein the delay period is approximately 30 minutes.

9. The method of claim 5, 6, 7 or 8 and further comprising:

starting the second compressor to compress refrigerant after the preheat mode is turned off.

10. A vapor cycle system (10) comprising:

a first compressor (14) having an electric motor (14-1), a motor temperature sensor (28), and a motor controller (32);
a second compressor (16) having an electric motor (16-1), a motor temperature sensor (30), and a motor controller (34);
a refrigerant circuit, wherein the first compressor and the second compressor are connected in fluid communication with the refrigerant circuit in parallel; and
a control module (18) operatively connected to the motor controller of each of the first and second compressors, wherein the control module is configured to command the motor controllers of each of the first and second compressors to operate only one of the first and second compressors to compress refrigerant and to operate the other, idle one of the first and second compressors in a preheat mode, wherein the preheat mode is activated to generate heat with the motor of the idle one of the first and second compressors to a preheat temperature range, and wherein the control module is further

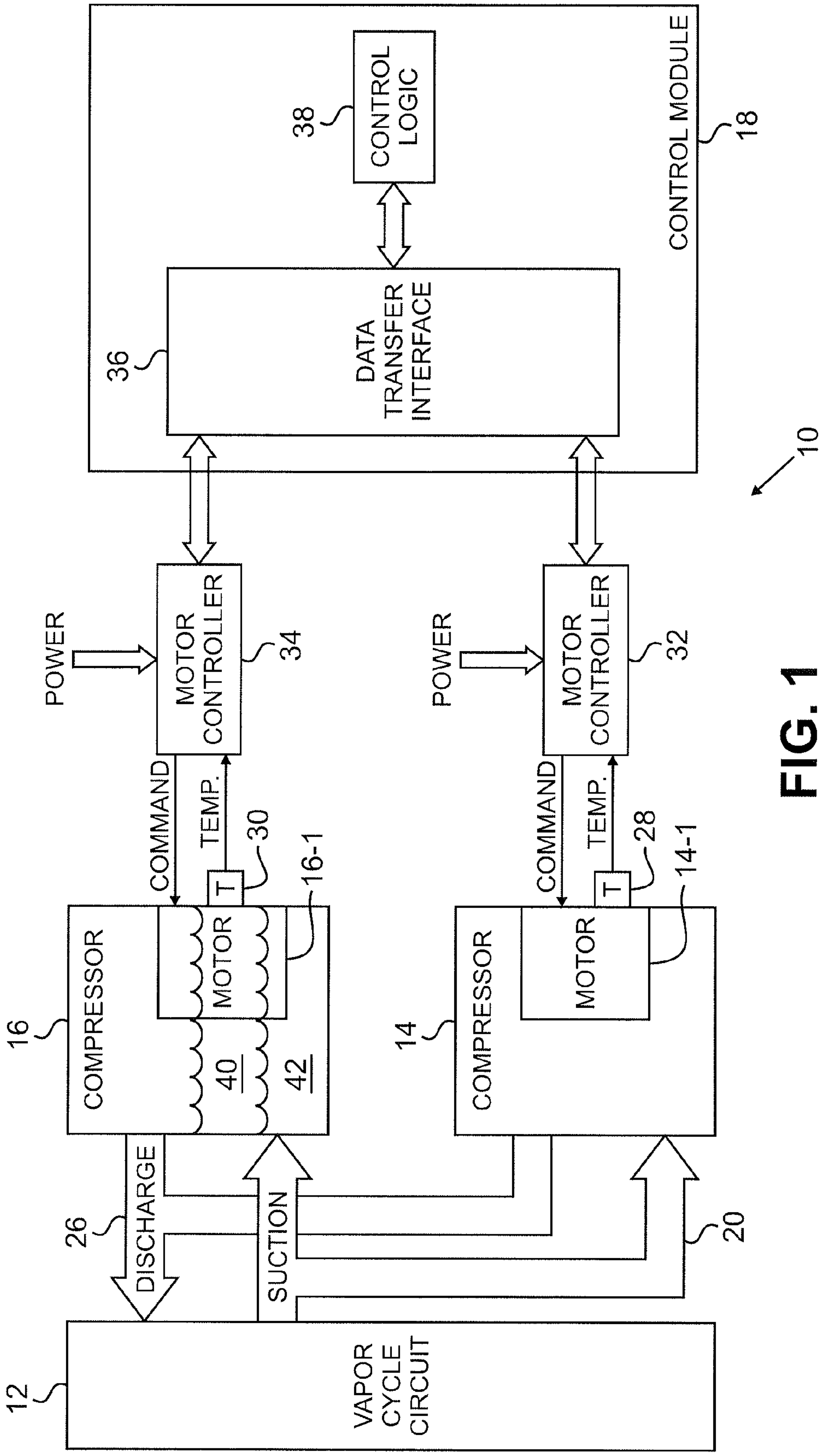
configured to limit a duration of the preheat mode to a preheating time period.

11. The vapor cycle system of claim 10, wherein the preheat temperature range is approximately 48.9°C (120°F) to approximately 54.4°C (130°F).

12. The vapor cycle system of claim 10 or 11, wherein the motor temperature sensors of each of the first and second compressors is a thermistor.

13. The vapor cycle system of claim 10, 11 or 12, wherein the control module is further configured to maintain the preheat mode of the idle one of the first and second compressors in an off condition for a delay period and then reactivate the preheating mode for the idle one of the first and second compressors for the preheating time period following the delay period.

14. The vapor cycle system of claim 13, wherein the preheating time period is approximately 14 minutes, and wherein the delay period is approximately 30 minutes.



CONTROL LOGIC
38
DATA TRANSFER INTERFACE
36
CONTROL MODULE
18
10
POWER
MOTOR CONTROLLER
34
POWER
MOTOR CONTROLLER
32
COMMAND
TEMP.
30
T
16-1
COMMAND
TEMP.
28
T
14-1
COMPRESSOR
16
MOTOR
40
42
COMPRESSOR
14
MOTOR
DISCHARGE
26
SUCTION
20
VAPOR CYCLE CIRCUIT
12

FIG. 1

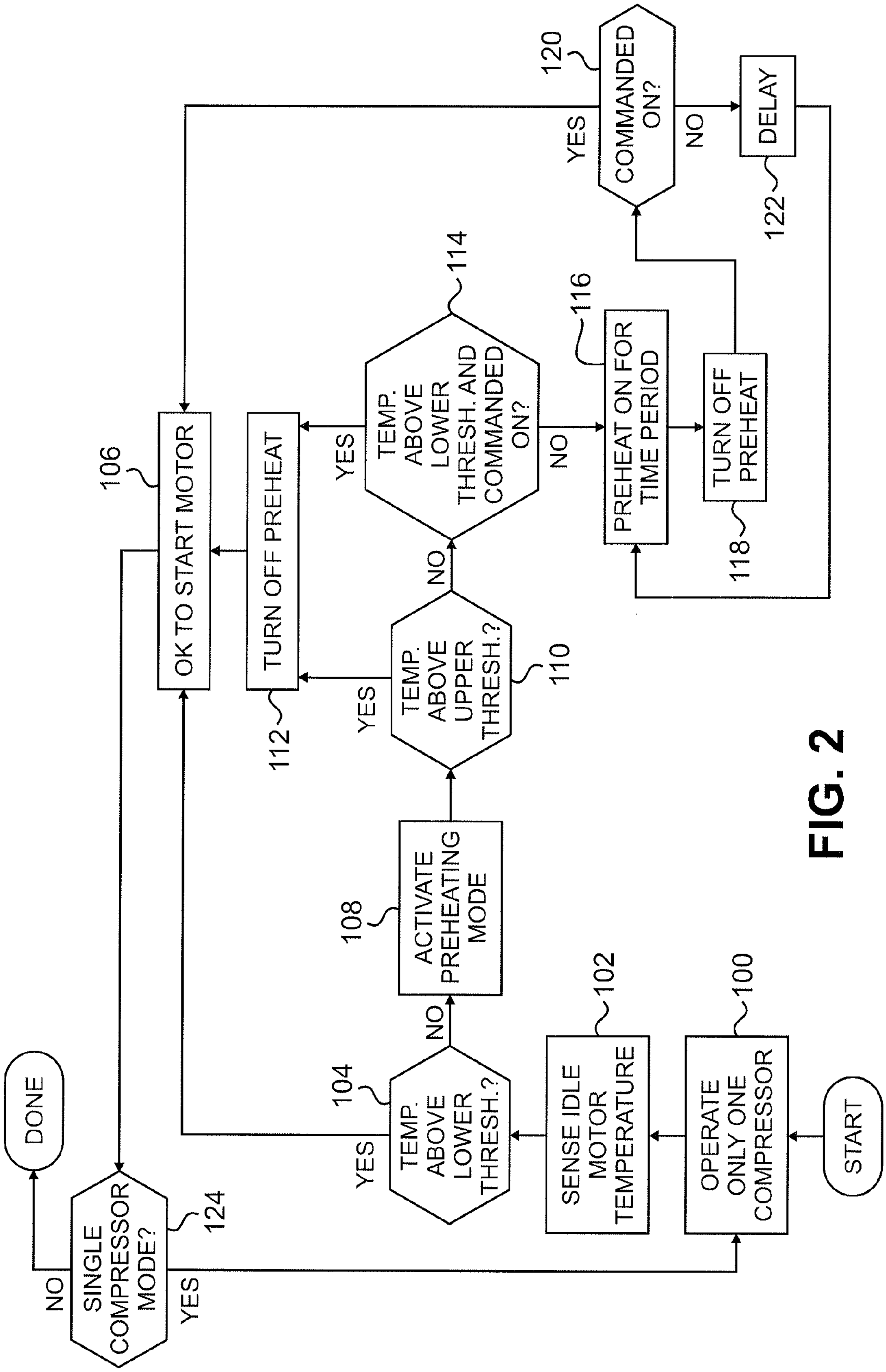

START
OPERATE ONLY ONE COMPRESSOR
100
SENSE IDLE MOTOR TEMPERATURE
102
TEMP. ABOVE LOWER THRESH.?
104
YES
NO
OK TO START MOTOR
106
ACTIVATE PREHEATING MODE
108
TEMP. ABOVE UPPER THRESH.?
110
YES
NO
TURN OFF PREHEAT
112
TEMP. ABOVE LOWER THRESH. AND COMMANDED ON?
114
YES
NO
PREHEAT ON FOR TIME PERIOD
116
TURN OFF PREHEAT
118
COMMANDED ON?
120
YES
NO
DELAY
122
SINGLE COMPRESSOR MODE?
124
YES
NO
DONE

FIG. 2

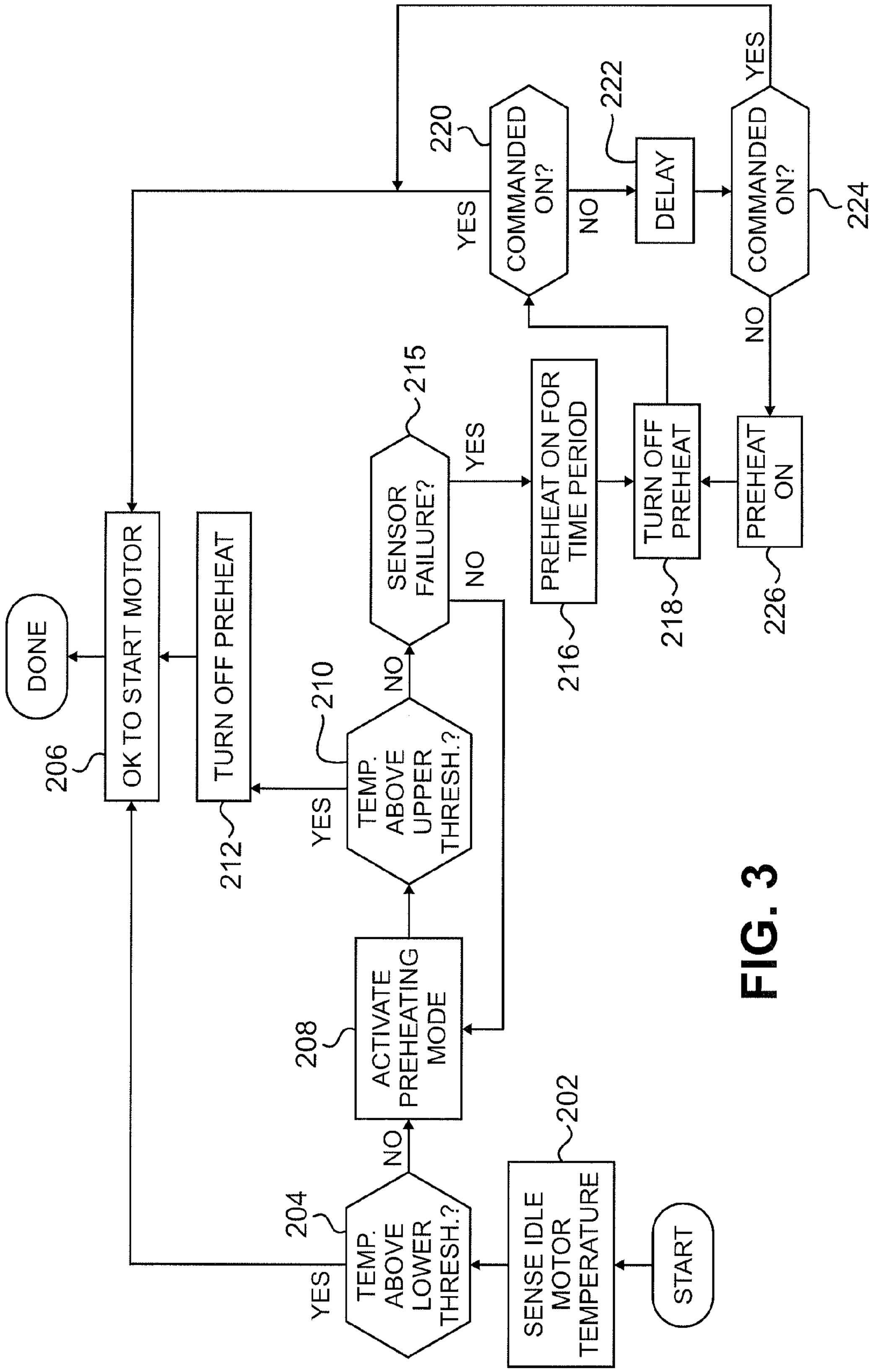

START
SENSE IDLE MOTOR TEMPERATURE
202
TEMP. ABOVE LOWER THRESH.?
204
YES
NO
ACTIVATE PREHEATING MODE
208
TEMP. ABOVE UPPER THRESH.?
210
YES
NO
TURN OFF PREHEAT
212
OK TO START MOTOR
206
DONE
SENSOR FAILURE?
215
YES
NO
PREHEAT ON FOR TIME PERIOD
216
TURN OFF PREHEAT
218
PREHEAT ON
226
COMMANDED ON?
220
YES
NO
DELAY
222
COMMANDED ON?
224
YES
NO

FIG. 3