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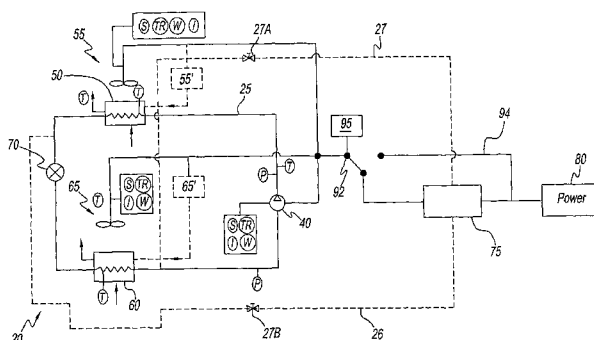
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(54) Title: REFRIGERANT SYSTEM WITH VARIABLE SPEED DRIVE



(57) Abstract: A refrigerant system (10, 100, 200) is provided with a power control system (30, 130, 230). The power control system adjusts the speed of the motors driving the refrigerant system components such as a compressor, a fan or a pump via a variable speed device (75, 175, 275) or bypasses the variable speed device (75, 175, 275) for normal operating speeds. A single power control system may be provided for the entire refrigerant system or each component may be independently controlled.

REFRIGERANT SYSTEM WITH VARIABLE SPEED DRIVE

BACKGROUND OF THE INVENTION

1 Field of the Invention

[0001] This invention generally relates to machinery driven by variable speed drives and, more particularly, to systems for heating, ventilation, air-conditioning and refrigeration applications with variable speed components

2 Description of the Related Art

[0002] In machinery that is driven by variable speed drives, there is approximately a five to ten percent penalty in power and efficiency due to losses associated with the operation of the variable speed drive. This efficiency loss or additional power draw is one of the drawbacks that has limited the application of variable speed drives in industrial or other installations. This limitation is especially significant where the need to slow down or speed up the machinery from its normal operating speed is infrequent.

[0003] Further, variable speed drive electronics generate heat and are frequently required to be cooled with an external source and/or by diverting a portion of refrigerant circulating through the refrigerant system. Therefore, additional efficiency and power draw penalties are paid to operate variable speed drives within the specified temperature limits. Also, variable speed drives often present a source of unreliability reducing overall system maintenance and uninterrupted service intervals.

[0004] Accordingly, there is a need for heating, ventilation, air-conditioning

and refrigeration systems with the components driven at variable speeds (or incorporating variable speed drives) with enhanced efficiency of the operation and improved reliability. The method and apparatus of the present invention reduces losses associated with the operation of variable speed drives.

[0005] It is an object of the present invention to provide a system for heating, ventilation, air-conditioning and refrigeration applications with an enhanced operational efficiency and improved reliability.

[0006] It is a further object of the present invention to provide such a system with an increased service life and maintenance intervals for the components of the variable speed drive system.

[0007] It is yet a further object of the present invention to provide a configuration that allows for selective operation of the variable speed drive system.

SUMMARY OF THE INVENTION

[0008] In one aspect, a power control system for a refrigerant system having an AC motor with a normal operating speed is provided. The power control system comprises a variable frequency drive connected to the AC motor, and a bypass device connected to the AC motor and connectable to a power source. The bypass device is selectively switchable between first and second positions. The first position provides connection from the power source to the variable frequency drive thereby causing the AC motor to run at lower or higher than the normal operating speed. The second position provides connection from the power source to the AC motor by bypassing the variable frequency drive thereby causing the AC motor to run at the normal operating speed.

[0009] In another aspect, a refrigerant system is provided, which comprises a vapor compression system and a power control system. The vapor compression system includes a compressor with a compressor motor. The power control system includes a variable speed drive device and a bypass device. The bypass device is connected to the compressor motor and is connectable to a power source. The bypass device is selectively switchable between first and second positions. The first position provides connection from the power source to the variable speed drive device thereby causing the compressor motor to run at lower or higher than a normal operating speed. The second position provides connection from the power source to the compressor motor by bypassing the variable speed drive device thereby causing the compressor motor to run at the normal operating speed.

[0010] In yet another aspect, a method of operating a refrigerant system to meet space thermal load demands is provided. The method comprises providing a vapor compression system having a compressor with an AC motor, determining if the AC motor need to run at below or above a normal operating speed to satisfy the space thermal load demands, reducing or increasing a speed of the AC motor accordingly below or above the normal operating speed to satisfy the space thermal load demands, wherein the speed is varied by adjusting the frequency and/or voltage of power supplied to the AC motor via a variable frequency drive, and providing power to the AC motor by bypassing the variable frequency drive if the space thermal load demands are to be satisfied by running the AC motor at the normal operating speed.

[0011] The variable speed drive device can be a variable frequency drive and the motor may be an AC motor. The variable speed drive device can be a voltage control module and the motor may be a DC motor. The bypass device can comprise a two-position switch and a bypass circuit. The bypass circuit may be connected between the variable speed drive device and the power source for providing the connection directly to the motor. The vapor

compression system typically has at least a condenser, an expansion device, and evaporator, where a condenser and evaporator have fans with fan motors. The fan motors may be connected to the bypass device, wherein the first position of the bypass device provides connection from the power source to the variable speed drive device thereby causing the fan motor to run at lower or higher than a normal operating speed, and wherein the second position of the bypass device provides connection from the power source to the fan motor by bypassing the variable speed drive device thereby allowing the fan motor to run at the normal operating speed. The method can further comprise monitoring parameters of the refrigerant system to determine the space thermal load imposed upon the refrigerant system. Also, each of the fans may have a separate power control system increasing operational flexibility, if desired. Further, variable speed liquid pumps may be used in place of fans in a similar manner but to circulate liquid (instead of air) through condensers and evaporators.

[0012] The above-described and other features and advantages of the present disclosure will be appreciated and understood by those skilled in the art from the following detailed description, drawings, and appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Figure 1 is a schematic illustration of a refrigerant system with an exemplary embodiment of a power control system of the present invention,

[0014] Figure 2 is a schematic illustration of a refrigerant system with an alternative exemplary embodiment of a power control system of the present invention, and

[0015] Figure 3 is a schematic illustration of a refrigerant system with another

alternative exemplary embodiment of a power control system of the present invention

DETAILED DESCRIPTION OF THE INVENTION

[0016] Referring to FIG. 1, an exemplary embodiment of a system having machinery driven by variable speed drives is illustrated and generally referred to by reference numeral 10. The exemplary embodiment of system 10 is a refrigerant system. It should be understood by a person of ordinary skill in the art that the particular type of the refrigerant system 10 can be varied including (but not limited to) heating, ventilation, air-conditioning and refrigeration systems, and the particular components of the system can be changed to accomplish the specific space conditioning objective. Such refrigerant system components are known by a person of ordinary skill in the art. For instance, fans moving air across the condenser and evaporator could be replaced by pumps circulating liquid, such as, for example, water or brine, for heat transfer purposes.

[0017] Refrigerant system 10 has a vapor compression system 20 and a power/control system 30. The vapor compression system 20 includes typical components for achieving desired characteristics in the conditioned space including a refrigerant circuit 25 with various valves and interconnected pipes. The vapor compression system 20 includes a compressor 40, a condenser 50, and an evaporator 60 interconnected in the circuit 25. In the exemplary embodiment, fans 55 and 65 are in fluid communication with the condenser 50 and the evaporator 60, respectively, and an expansion device 70 is positioned between the condenser and evaporator within the circuit 25. However, the particular configuration and components of the vapor compression system 20 (including the configuration of refrigerant circuit 25) can be varied according to particular requirements imposed on system 10.

[0018] The power/control system 30 provides electric power for driving the components, e g , compressor 40 and/or fans 55 and 65, as well as control over one or more of the components of vapor compression system 20. Power/control system 30 has a variable frequency drive 75 ("VFD") that is connected to the AC motor of compressor 40 and which is also connected to a power source 80 via electric circuit 35. A power bypass device 90 is provided between VFD 75 and power source 80. In the exemplary embodiment of system 10, the power bypass device 90 is a two-position switch 92 and a bypass circuit 94. However, the present disclosure contemplates the use of other structures, devices, circuits and/or methods for selectively providing power to VFD 75 or alternatively bypassing the VFD 75 and providing the power directly to the motor of compressor 40.

[0019] VFD 75 adjusts the speed of the motor of compressor 40 by varying the frequency and/or voltage of the power provided to the motor. The power electronics used to adjust or control the frequency and voltage via VFD 75 are known in the art, such as, for example, rectifiers and inverter bridges, and can be varied according to the particular needs of system 10. This adjustment allows the motor of compressor 40 to run at lower or higher than normal operating speed. For instance, such a speed adjustment will improve system performance under circumstances when thermal load in the conditioned space or environmental conditions for the refrigerant system change or a user alters the conditioned space setpoint. However, when compressor 40 is required to operate at its normal speed to meet sensible and latent capacity demands, then the use of VFD 75 incurs efficiency losses and additional power draw, e g , the above-mentioned losses associated with operation of the VFD power electronics and losses associated with cooling of VFD to operate within specified temperature limits. For use of compressor 40 at the normal operating speed, power bypass device 90 provides the power directly to the compressor motor, thus excluding VFD 75 from an electric circuit and improving operational efficiency and reliability of the refrigerant system.

[0020] The selective control or switching of the bypass device 90 can be accomplished by various methods and/or devices including both automatic and manual bypassing. In an exemplary embodiment, bypass device 90 is operated by a control system 95 that determines whether the motor of compressor 40 is, or will be, operating at its normal operating speed to satisfy the space thermal load demands, and opens or closes the two-position switch 92 or other bypass device based upon that determination. The opening or closing of the two-position switch 92 or other bypass device can be done by various actuators, devices and methods known in the art, and control system 95 can be a subsystem or subroutine of the overall control system for refrigerant system 10. Alternatively, the opening or closing of the two-position switch 92 can be done manually, and control system 95 can provide a readable indication that compressor 40 will be operating at a normal operating speed to satisfy the space thermal load demands.

[0021] Sensors are disposed in various positions throughout the vapor compression system 20 to monitor operational parameters of the system. The data or information gathered by the sensors can be utilized for the control or switching of the bypass device 90, e.g., by control system 95 for the opening or closing of the two-position switch 92. The sensors include, but are not limited to, temperature sensors T (e.g., temperature transducers), pressure sensors P (e.g., pressure transducers), electric current sensors I, power sensors W, torque sensors TR, slip sensors S, transducers for each of these operational parameters, and the like. The use of pressure sensors and saturation temperature sensors are generally interchangeable for refrigerant system 10, since there is a direct relationship between pressure and corresponding saturation temperature. Further, the discharge of the compressor may have a temperature sensor for more refined measurements. The corresponding operational parameters monitored by the sensors can include, but are not limited to, the outdoor and indoor fan motor current, power, torque or slip, the compressor motor current, power, torque or slip, the condenser saturation discharge temperature, evaporator saturation suction

temperature, the compressor suction and discharge pressure, and the compressor discharge temperature. The connection or method of communication between the sensors and the bypass device 90, e.g., control system 95, is not shown but is known to a person of ordinary skill in the art. The decision when to switch from variable frequency drive to constant speed operation would depend on the information gathered from these sensors. Bypassing of the variable speed device can be based, at least in part, on the efficiency of running at a line frequency as compared to operating at a speed other than provided by the line frequency where there are additional inverter losses. Other considerations such as power limitations, safety concerns and operational reliability may be included into the control logic of control system 95 for making a switching decision. Control system 95 can include other sensors for determining whether the motor of compressor 40 will need to run at normal operating speed to satisfy a space thermal load. Such sensors can monitor various parameters of the system 10, including the ambient temperature and the temperature of the conditioned space.

[0022] In the exemplary embodiment of system 10, fans 55 and 65 are also connected to, and controlled via, bypass device 90. This allows for selective variable speed control of the fan motors in the same way that the speed of the motor of compressor 40 is adjusted by VFD 75. The fans 55 and 65 can also be directly provided with power via bypass device 90 when they are operating at, or will be operating at, normal operating speed to avoid the efficiency losses associated with the VFD 75.

[0023] Due to the heat generated by the power electronics of VFD 75, vapor compression system 20 can also provide cooling to the VFD via refrigerant lines 27 (as shown by the dashed lines). Refrigerant line 26 taps a portion of refrigerant from the main refrigerant circuit 25 downstream of the condenser 50 and returns it through line 27 downstream of the evaporator 60 and may include valves 27A and 27B each of which could be of an adjustable type. The refrigerant lines 26 and 27 supply a portion of the refrigerant from the

main refrigerant circuit 25 to the VFD 75 for removal of heat from the electronics of the VFD and then return the refrigerant to the main refrigerant circuit 25. Other locations of lines 26 and 27 in relation to the main refrigerant circuit 25 are also feasible. Additionally, variations can be made to the particular configuration and components of the power-control system 30 (including the configuration of electric circuit 35) according to the particular requirements imposed on refrigerant system 10. Analogously, similar design and control methodology can be applied if a liquid pump 55' or 65' (shown in phantom) is used for heat transfer interaction in vapor compression system 20 instead of fan 55 or fan 65 respectively. The VFD of each of the liquid pumps 55' and 65' as well as for fans 55 and 65 could be independently bypassed as well.

[0024] Referring to FIG. 2, an alternative exemplary embodiment of a refrigerant system generally referred to by reference numeral 100 is illustrated. Again, it should be understood by one of ordinary skill in the art that the particular type of the refrigerant system 100 can be varied including (but not limited to) heating, ventilation, air-conditioning and refrigeration, and the particular components of the system can be changed to accomplish the particular objective.

[0025] Refrigerant system 100 has components and systems that are similar to the components and systems of refrigerant system 10 of FIG. 1 and which are similarly labeled, such as vapor compression system 20 and its components. Refrigerant system 100 also has a power/control system 130 with components that are similar to the components of power/control system 30 of FIG. 1 and which are similarly labeled. Power/control system 130 provides electric power for driving the components, e.g., compressor 40 and fans 55 and 65, as well as control over one or more of the components of the vapor compression system 20. Analogously, identical design and control methodology can be applied if a fluid pump is used instead of fan 55 or fan 65.

[0026] Power/control system 130 has a voltage control module 175 ("VCM") that is connected to a DC motor of compressor 40 and also to a power source 80 via electric circuit 35. The power bypass device 90 is provided between VCM 175 and power source 80, which in this alternative exemplary embodiment of system 100 is the two-position switch 92 and the bypass circuit 94. Although, the present disclosure contemplates the use of other structures, devices and/or methods for selectively providing power to VCM 175 or alternatively bypassing the VCM and providing the power directly to the motor of compressor 40.

[0027] VCM 175 adjusts the speed of the motor of compressor 40 by varying the voltage of the power provided to the motor. The power electronics used to adjust or control the voltage via VCM 175 are known in the art and can be varied according to the particular needs of system 100. The voltage adjustment by VCM 175 allows the motor of compressor 40 to run at speeds different than its normal operating speed and improve system performance during off-design conditions. The VCM 175 is bypassed when compressor 40 is operating at the normal speed, and electric power is provided directly to the motor of the compressor. This selective control or switching via the bypass device 90 can be accomplished as described above with respect to the exemplary embodiment of system 10, including, but not limited to, the use of control system 95.

[0028] The present disclosure contemplates the use of other variable speed drive devices and/or power electronic circuits instead of VFD 75 or VCM 175 which can adjust the speed of AC or DC motors for the compressor 40 and/or other components of the vapor compression system 20, but which can also be bypassed via the bypass device 90 to provide power directly to the motors and avoid efficiency losses when normal operating speed is contemplated. Analogously, similar design and control methodology can be applied if a liquid pump 55' or 65' (shown in phantom) is used with a heat exchanger in vapor

compression system 20 instead of fan 55 or fan 65. The VCM of each of the liquid pumps 55' and 65' as well as for fans 55 and 65 could be independently bypassed.

[0029] Referring to FIG. 3, another alternative exemplary embodiment of a refrigerant system generally referred to by reference numeral 200 is illustrated. Again, it should be understood by a person of ordinary skill in the art that the particular type of the refrigerant system 200 can be varied including (but not limited to) heating, ventilation, air-conditioning and refrigeration, and the particular components of the system can be changed to accomplish the particular objective.

[0030] Refrigerant system 200 has components and systems that are similar to the components and systems of refrigerant system 10, as described above, and which are similarly labeled, such as vapor compression system 20 and its components. Refrigerant system 200 also has a power/control system 230 with components that are similar to the components of power/control system 30 and which are similarly labeled. Power/control system 230 provides electric power for driving the components, e.g., compressor 40 and fans 55 and 65, as well as control over one or more of the components of the vapor compression system 20.

[0031] Power/control system 230 has a plurality of variable frequency drives 275 that are operated by the system controller. Each of the VFD's are connected to the various components of refrigerant system 20, such as, for example, the motor of compressor 40 and the motors of each of the fans 55 and 65. The power bypass device 90 is provided between VFD's 275 and power source 80, which in this alternative exemplary embodiment of system 200 is the two-position switches 92 and the bypass circuit 94. Although, the present disclosure contemplates the use of other structures, devices and/or methods for selectively providing power to VFD's 275 or alternatively

bypassing the VFD's and providing the power directly to the motor of compressor 40 and the motors of fans 55 and 65

[0032] Power/control system 230 can utilize a voltage control module ("VCM"), similar to that described with respect to power/control system 130, that is connected to a DC motor of compressor 40. As mentioned before, system flexibility is increased by providing for independent control of each of the VFD's or VCM's for the various components of the refrigerant system 20. The VFD's or VCM's (or a combination of the two) of each of the components can be independently bypassed or directly powered to increase system operational efficiency and flexibility. Analogously, similar design and control methodology can be applied if a liquid pump 55' or 65' (shown in phantom) is used with a heat exchanger in vapor compression system 20 instead of fan 55 or fan 65. The VFD or VCM of each of the liquid pumps 55' and 65' could be independently bypassed as well.

[0033] While the instant disclosure has been described with reference to one or more 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 thereof. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the disclosure without departing from the scope thereof. Therefore, it is intended that the disclosure not be limited to the particular embodiment(s) disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.

What is claimed is

1 A power control system (30) for a system (10, 100, 200) including an electric motor with a normal operating speed, the power control system (30) comprising

a variable speed drive (75, 175, 275) connected to the electric motor, and

a bypass device (90) connected to the electric motor and connectable to a power source (80), wherein said bypass device (90) is selectively switchable between first and second positions, wherein said first position provides electric power from the power source (80) to said variable speed drive (75, 175, 275) thereby causing the electric motor to run at speeds different from the normal operating speed, and wherein said second position provides electric power from the power source (80) to the electric motor by bypassing said variable speed drive (75, 175, 275) thereby causing the electric motor to run at the normal operating speed

2 The system (10, 100, 200) of claim 1, wherein said bypass device (90) comprises a two-position switch (92) and a bypass circuit (94), and wherein said bypass circuit (94) is connected between said variable speed drive (75, 175, 275) and the power source (80)

3 The system (10, 100, 200) of claim 1, wherein said variable speed device (75, 175, 275) is a variable frequency drive (75, 275), and wherein said electric motor is an AC motor

4 The system (10, 100, 200) of claim 1, wherein said variable speed device (75, 175, 275) is a voltage control module (175, 275), and wherein said motor is a DC motor

5 A refrigerant system (10, 100, 200) comprising

a vapor compression system (20) having a compressor (40) with a compressor motor, and

a power control system (30, 130, 230) having a variable speed device (75, 175, 275) and a bypass device (90), wherein said bypass device (90) is connected to said compressor motor and is connectable to a power source (80), wherein said bypass device (90) is selectively switchable between first and second positions, wherein said first position provides electric power from the power source (80) to said variable speed device (75, 175, 275) thereby causing said compressor motor to run at speeds different from a normal operating speed, and wherein said second position provides electric power from the power source (80) to said compressor motor by bypassing said variable speed device (75, 175, 275) thereby causing said compressor motor to run at said normal operating speed

6 The system (10, 100, 200) of claim 5, wherein said variable speed device (75, 175, 275) is a variable frequency drive (75, 275), and wherein said compressor motor is an AC motor

7 The system (10, 100, 200) of claim 5, wherein said variable speed device (75, 175, 275) is a voltage control module (175, 275), and wherein said compressor motor is a DC motor

8 The system (10, 100, 200) of claim 5, wherein said bypass device (90) comprises a two-position switch (92) and a bypass circuit (94), and wherein said bypass circuit (94) is connected between said variable speed device (75, 175, 275) and the power source (80)

9 The system (10, 100, 200) of claim 5, wherein said vapor compression system (20) further comprises a condenser (50) and an evaporator (60), wherein said condenser (50) has either a condenser fan (55) with a first fan motor or a condenser pump (55') with a first pump motor, wherein said evaporator (60) has either an evaporator fan (65) with a second fan motor or an evaporator pump (65') with a second pump motor, wherein at least one of said first fan motor, said second fan motor, said first pump motor or said second pump motor is connected to said bypass device (90), wherein said first position of said bypass device (90) provides electric power from the power source (80) to said variable speed device (75, 175, 275) thereby causing said at least one of said first fan motor, said second fan motor, said first pump motor or said second pump motor to run at speeds different from a normal operating speed, and wherein said second position of said bypass device (90) provides electric power from the power source (80) to said at least one of said first fan motor, said second fan motor, said first pump motor or said second pump motor by bypassing said variable speed device (75, 175, 275) thereby allowing said at least one of said first fan motor, said second fan motor, said first pump motor or said second pump motor to run at said normal operating speed

10 The system (10, 100, 200) of claim 9, wherein said variable speed device (75, 175, 275) is a variable frequency drive (75, 275), and wherein said at least one of said first fan motor, said second fan motor, said first pump motor or said second pump motor is an AC motor

11 The system (10, 100, 200) of claim 9, wherein said variable speed device (75, 175, 275) is a voltage control module (175, 275), and wherein said at least one of said first fan motor, said second fan motor, said first pump motor or said second pump motor is a DC motor

12 The system (10, 100, 200) of claim 9, wherein said bypass device (90) comprises a two-position switch (92) and a bypass circuit (94), and wherein

said bypass circuit (94) is connected between said variable speed device (75, 175, 275) and the power source (80)

13 A method of operating a refrigerant system (10, 100, 200) to meet a conditioned space thermal load comprising

providing a vapor compression system (20) having an electric motor,
determining if said electric motor is to be run at speeds different from a normal operating speed to satisfy the conditioned space thermal load,

adjusting a speed of said electric motor to satisfy the conditioned space thermal load, wherein said speed is adjusted by a variable speed device (75, 175, 275), and

providing power to said electric motor by bypassing said variable speed device (75, 275, 275) if the space conditioning load can be satisfied by running said electric motor at said normal operating speed

14 The method of claim 13, further comprising

monitoring operational parameters of the refrigerant system (10, 100, 200) and bypassing said variable speed device (75, 275, 275) based at least in part on efficiency of running at line frequency as compared to operating at a speed other than provided by line frequency where there are additional inverter losses

15 The method of claim 14, further comprising

monitoring said operational parameters of the refrigerant system (10, 100, 200) via at least one transducer that is selected from a group consisting of temperature transducer, pressure transducer, current transducer, power transducer, torque transducer, slip transducer or any combination thereof

16 The method of claim 13, further comprising

adjusting frequency or voltage of power supplied to said electric motor to adjust said speed, wherein said electric motor is a plurality of electric motors, and wherein each of said plurality of electric motors drives a refrigerant component selected from the group consisting essentially of a compressor, a condenser fan, a condenser pump, an evaporator fan, an evaporator pump and any combinations thereof, and

independently and selectively bypassing said variable speed devices (75, 275, 275) of at least one of said plurality of electric motors

17 A device, system or method for controlling one or more motors in a refrigerant system (10, 100, 200) as herein before described with reference to any one of Figures 1 through 3 of the accompanying drawings

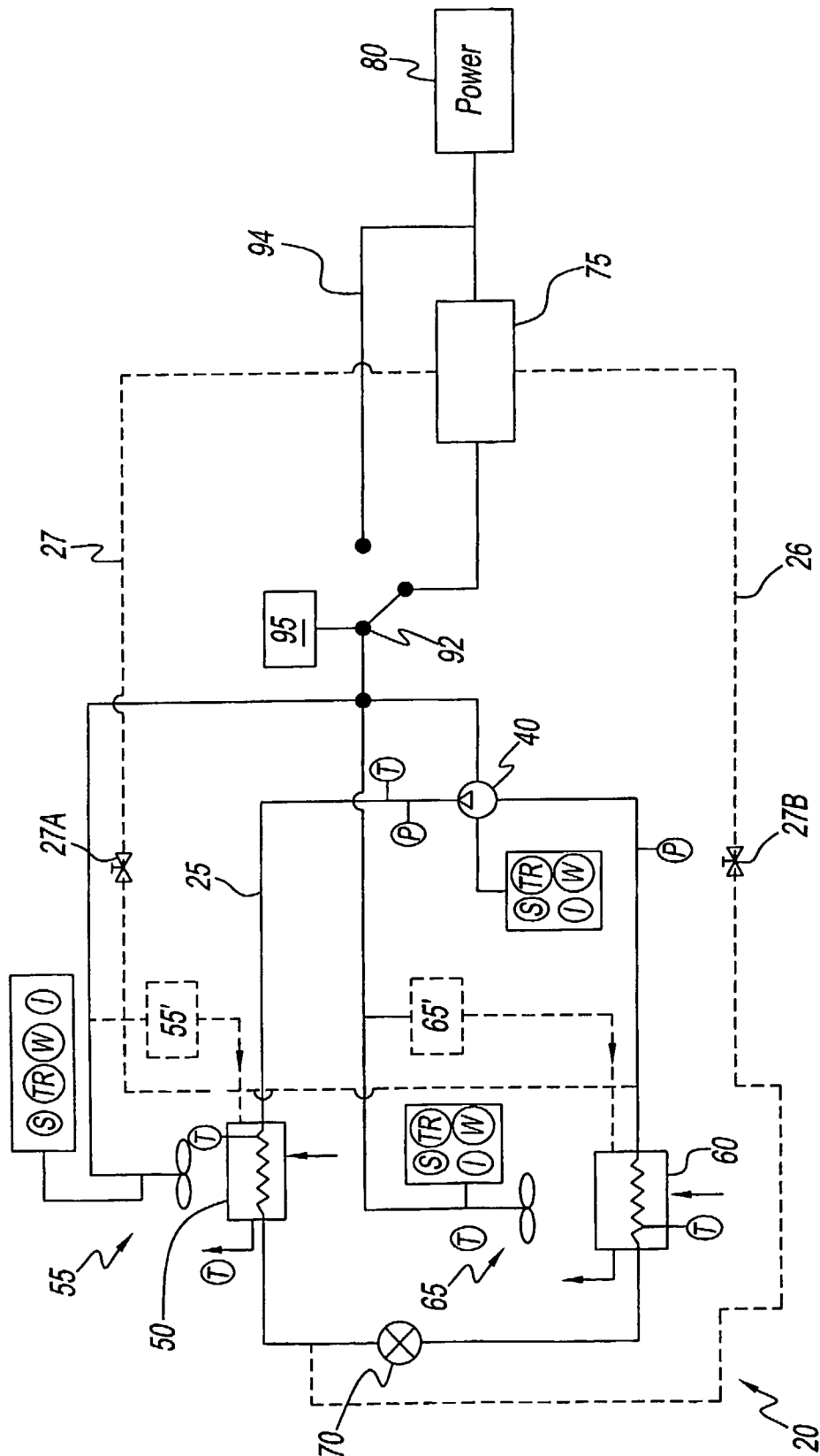


Fig. 1

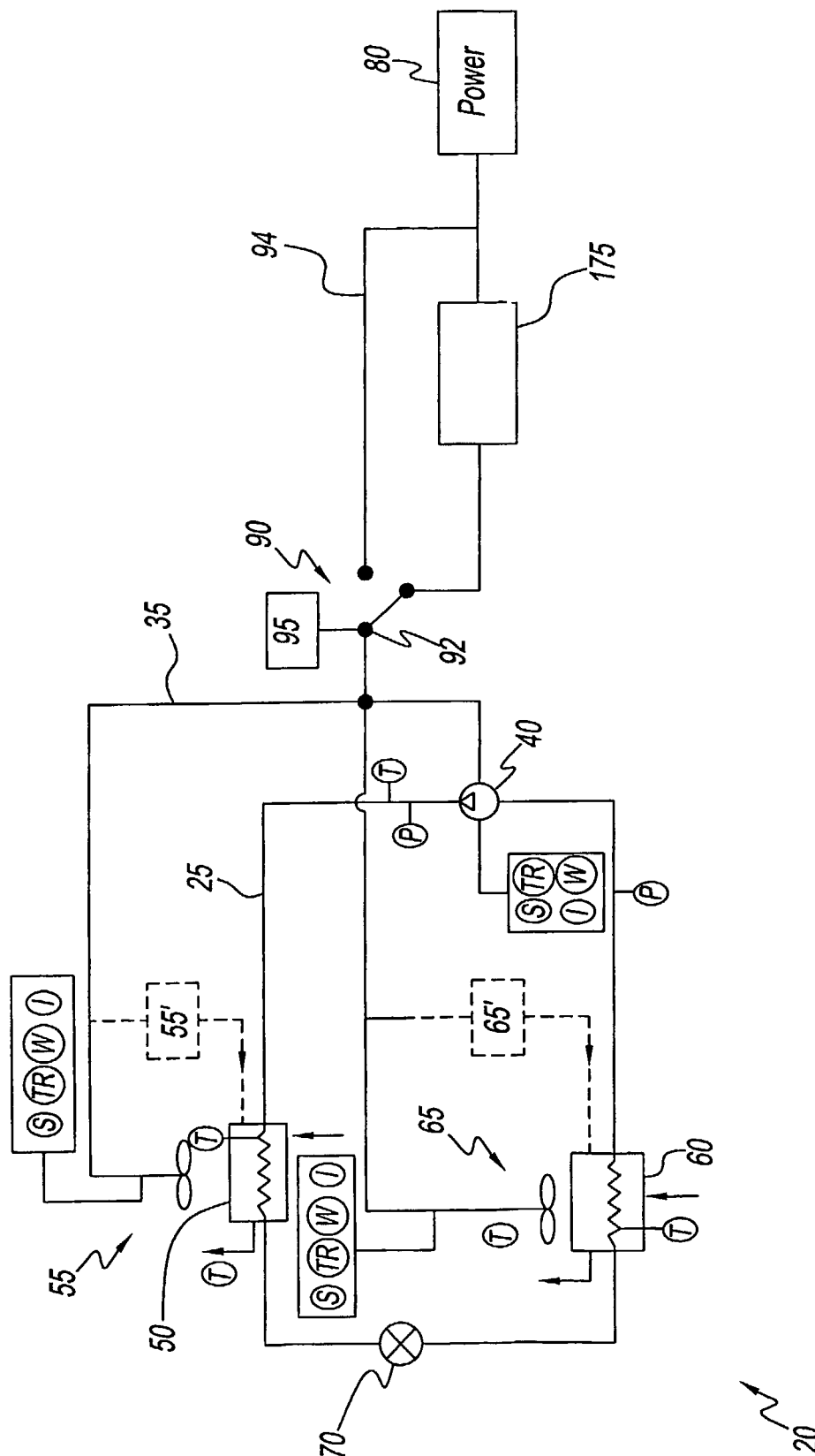


Fig. 2

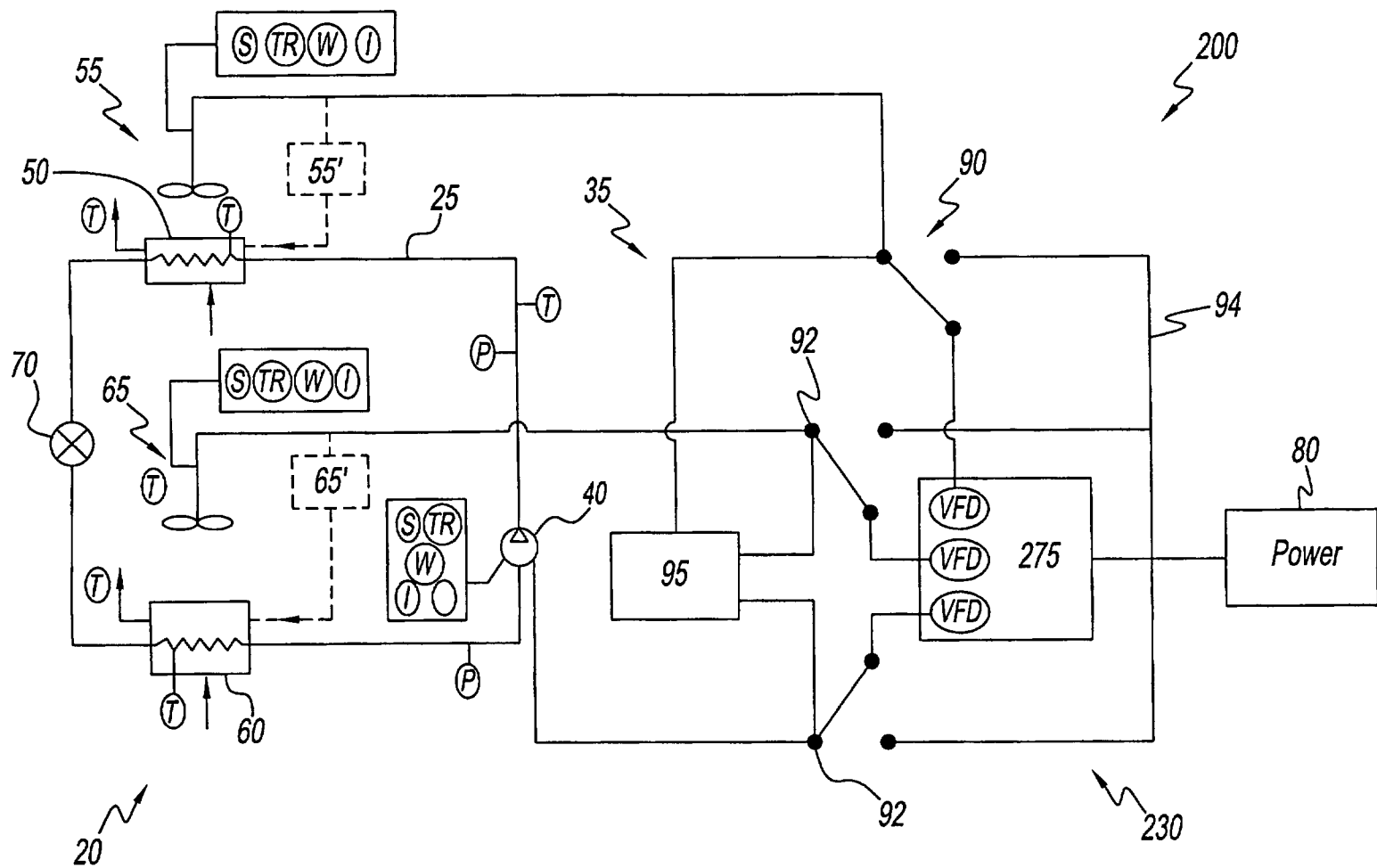


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No

PCT/US05/37464

A CLASSIFICATION OF SUBJECT MATTER

IPC(7) F25B 1/00, 27/00, 49/00, F25D 17/00

US CL 62/179, 180, 228 1, 228 4, 236

According to International Patent Classification (IPC) or to both national classification and IPC

B FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U S 62/179, 180, 228 1, 228 4, 236

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EAST search terms compressor, variable speed drive, vsd, bypass, motor

C DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
X	US 6,370,888 B1 (GRABON) 16 April 2002 (16 04 2002), Figures 1-3	1-3, 5, 6, 8, and 13
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Y		4, 7
Y	US 5,746,062 A (BEAVERSON et al) 05 May 1998 (05 05 1998), Figure 1	4 and 7

☐ Further documents are listed in the continuation of Box C



See patent family annex

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Date of the actual completion of the international search

06 February 2006 (06 02 2006)

Date of mailing of the international search report

15 MAR 2006

Name and mailing address of the ISA/US

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Authorized officer

For
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INTERNATIONAL SEARCH REPORT

International application No

PCT/US05/37464

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons

- 1 ☒ Claims Nos 17
because they relate to subject matter not required to be searched by this Authority, namely
The metes and bounds of the claim are unclear One cannot simply refer to the drawings in order to define the
limitations of the claim
- 2 ☐ Claims Nos
because they relate to parts of the international application that do not comply with the prescribed requirements to such
an extent that no meaningful international search can be carried out, specifically
- 3 ☐ Claims Nos
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6 4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows

- 1 ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all
searchable claims
- 2 ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment
of any additional fees
- 3 ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report
covers only those claims for which fees were paid, specifically claims Nos
- 4 ☐ No required additional search fees were timely paid by the applicant Consequently, this international search report is
restricted to the invention first mentioned in the claims, it is covered by claims Nos

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the
payment of a protest fee
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee
was not paid within the time limit specified in the invitation
- ☐ No protest accompanied the payment of additional search fees