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REFRIGERATION SYSTEM INCLUDING BYPASS CONTROL MEANS

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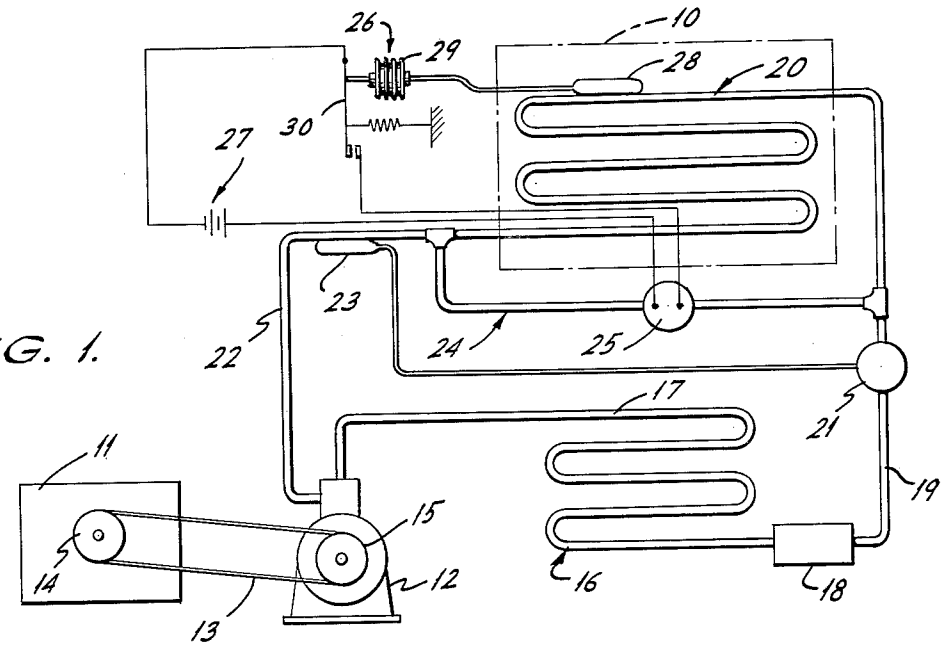


FIG. 1.

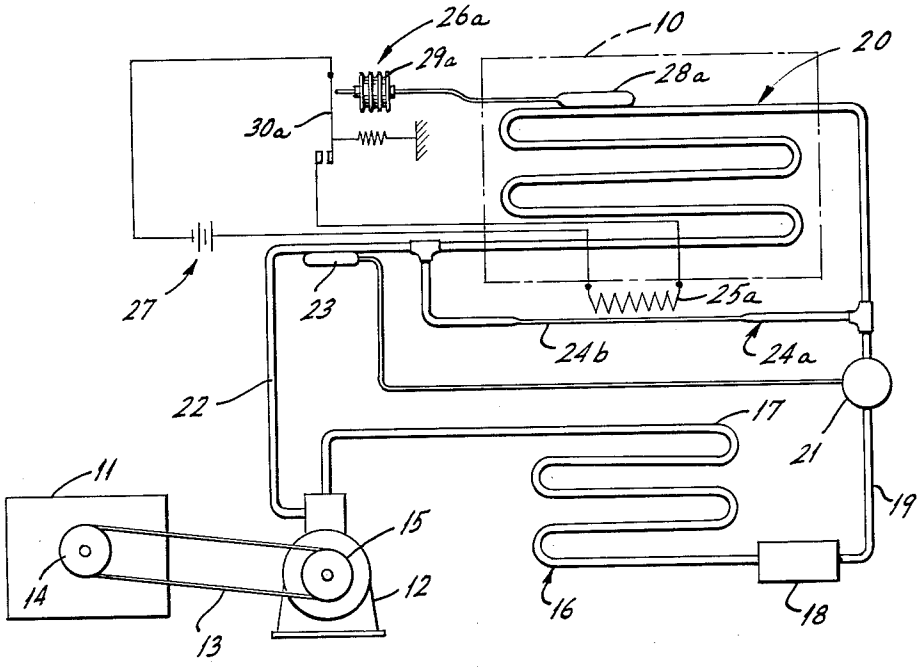


FIG. 2.

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REFRIGERATION SYSTEM INCLUDING BYPASS CONTROL MEANS

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This invention relates to refrigeration systems and, while of broader utility, is particularly useful in systems of a character adapted for conditioning air in passenger compartments of automotive vehicles.

In systems of this type it is common practice to provide a compressor driven by a power take-off from some rotating member of the vehicle engine, such as the crankshaft. This form of drive is characterized by obvious economical advantages. However, it presents certain operational difficulties arising from fluctation in compressor operation due to changes in engine speed.

Vehicle air conditioning systems of this type are designed to operate most efficiently at an engine speed calculated to balance the capacity of the driven compressor against the evaporator capacity, and are usually provided with some means to prevent engine speed variations from causing undesirable reduction in evaporator pressure, which reduction of course would result in a corresponding undesirable decrease in the temperature of the evaporator.

To compensate for variations in engine speeds, and by way of example, it has been a practise to provide bypass means that is selectively operable to regulate the cooling capacity of the evaporator in accordance with temperatures desired in the compartment of be cooled. However, using apparatus hitherto available, the structures have been subject to very high pressure differentials, with consequent leakage as well as the need for very strong mechanical linkages to operate the valves. Attempts to meet the problem have also been made by the use of clutch devices for coupling and decoupling the compressor and the drive motor. This arrangement is very costly.

It is a broad objective of this invention to provide improved refrigeration control means operating on the bypass principle, overcoming the above difficulties, and particularly adapted to vehicular cooling.

It is a specific objective of this invention to provide simple and effective refrigerant bypass means which minimizes the pressure differential across the bypass control means, thereby contributing to more effective operation of the control means.

It is a further specific objective of the invention to provide bypass means for the evaporator alone to regulate the cooling capacity of a refrigerator system powered by a variable speed compressor, and which bypass means is subject to the very low pressure drop across the evaporator and is controlled in substantial accordance with variations in speed of the compressor.

To the foregoing general ends, a preferred embodiment of the invention comprises—in a vehicular refrigeration system of the type including a compressor, a variable speed motor or engine to drive the compressor, and a thermostatic expansion valve for delivering expanded refrigerant directly to said evaporator—the provision of a conduit interconnecting the inlet of the evaporator, at a point downstream of the expansion valve, to the outlet of the evaporator. Flow through this conduit is controlled in accordance with evaporator temperature, and the temperature of the refrigerant flowing through the conduit, in turn, operates the expansion valve to decrease the flow rate of refrigerant pumped by the compressor through the system.

It will be appreciated that increased undesired cooling due to sustained compressor operation at high speeds is precluded by causing substantially all refrigerant to flow through the conduit bypassing the evaporator.

The manner in which the foregoing and other objectives of the invention may best be achieved will be more clearly understood from a consideration of the following detailed description, taken in light of the accompanying drawing in which:

FIGURE 1 is a diagrammatic showing of a refrigeration system embodying the invention; and

FIGURE 2 is a view similar to FIGURE 1, and illustrating a modified embodiment of the invention.

With more particular reference to the drawing, and first to FIGURE 1, the refrigeration system embodying the present invention is disposed and adapted to control the temperature within a space 10, for example the passenger compartment of a vehicle including a variable speed engine 11. A refrigerant compressor 12 is driven by the engine through a system comprising belt 13 and pulleys 14 and 15. Condenser 16 is connected to compressor 12 by suitable discharge conduit means 17 and a receiver 18 is connected to the outlet of the condenser. A liquid line 19 leads from receiver 18 to an evaporator 20 disposed for heat exchange with air within compartment 10. A thermostatic expansion valve 21 is connected in liquid line 19 between receiver 18 and evaporator 20, and is adapted to deliver expanded refrigerant directly to the evaporator. A suction line 22 connects evaporator 20 to compressor 12, and expansion valve 21 has a thermal sensing bulb 23 disposed in heat exchange relation with suction line 22 in the region of the outlet of the evaporator.

In particular accordance with the invention, a bypass conduit or line 24 interconnects the inlet of evaporator 20, which inlet is at a point downstream as respects expansion valve 21, to the outlet of the evaporator, which outlet is at a point upstream as respects the sensing bulb 23. Solenoid valve means 25 is disposed in conduit 24 and is operable to open and to close the latter. Thermostat means 26 is operable, in response to the temperatures of evaporator 20, to energize and to deenergize the valve means 25 by connecting or disconnecting its solenoid as respects a suitable source of power, such as electric battery 27. More particularly, thermostat means 26 includes a sensing bulb 28 disposed in heat exchange relation with evaporator 20 and connected with a bellows 29 operably connected with a switch 30. Battery 27 is disposed in series electric circuits with switch 30 and solenoid valve 25.

It will be noted that valve 21 comprises the sole expansion device controlling flow directly to the evaporator 20. This is of importance, since the bypass conduit connecting the inlet to the evaporator to its outlet as described is subject only to the very small pressure drop across the evaporator. Hence, the pressure drop across valve 25 is advantageously very small as will be hereinafter more fully appreciated.

Assuming first that switch 30 is closed and that engine 11 is running to operate compressor 12, construction and arrangement of the system is such that a rise in temperature in idle evaporator 20 will cause bellows 29 to expand and force switch 30 to open. This deenergizes valve 25 to close bypass conduit 24 causing refrigerant to flow through evaporator 20 where it is evaporated by heat absorbed from compartment 10. As compartment 10 becomes sufficiently cooled through absorption of heat by evaporator 20, bellows 29 contracts to close switch 30. Valve 25 is thereby energized and permits expanded refrigerant to bypass evaporator 20 by flowing from expansion valve 21 through conduit 24—where it absorbs relatively little heat—and into suction line 22.

As the relatively cold, expanded refrigerant flows

through suction line 22 past sensing bulb 23, thermostatic valve 21 is caused nearly to close, permitting a very low refrigerant flow rate. As a result, a substantial quantity of refrigerant is pumped, at a relatively low head pressure, into receiver 18 for storage therein until such time as the temperature within compartment 10 rises, closing valve 25 and again causing refrigerant to flow through the evaporator to absorb heat and cool the compartment.

Should the period of no refrigeration for the compartment 10 be for an extended length of time, it is possible that as lesser amounts of refrigerant flow through valve 21, its bulb 23 will sense a warmer suction line temperature and will cause valve 21 to open and pass more refrigerant. This, however, will not affect the temperature of evaporator 20 since valve 25 remains open, nor will it affect the very small pressure drop across valve 25. Instead, passage of this refrigerant will again cool bulb 23, causing valve 21 to close, or nearly so.

When the temperature of compartment 10 arises to a predetermined level, evaporator 20 also becomes warmer. Switch 30 is therfore caused to open, deenergizing valve 25 to close bypass conduit 24, and again causing refrigerant to flow through evaporator 20 and cool the compartment. Refrigerant flowing from the evaporator and through suction line 22 will be relatively warm and will first open valve 21 and thereafter cause it to control flow of refrigerant through the evaporator to cool the compartment.

Since expansion valve 21 is upstream of the inlet to bypass means 24, and provides a major portion of the pressure drop from the condenser to the evaporator, there is a minimal pressure drop across bypass conduit with valve 25 either opened or closed. The net result is, therefore, that valve 25 requires a minimum of force for its operation, and is not likely to leak when closed, due to the very small pressure drop. Also, in view of the substantial quantity of refrigerant withdrawn from the circuit when the bypass means is in operation and evaporator 20 is inoperative, the compressor 12 operates at a very low refrigerant flow rate.

With refernce to FIGURE 2, the same essential elements are illustrated and are indicated by the same reference characters as appear in FIGURE 1. Modification of the bypass circuit has been resorted to, however, in which connection it is seen that bypass conduit 24*a* comprises a capillary tube restrictor 24*b* and an electric resistance heater 25*a* disposed in heat exchange with the restrictor. Heater 25*a* is operable when energized to create a refrigerant vapor block in restrictor 24*b* preventing substantial flow of refrigerant through bypass conudit 24*a*. When de-enegized, heater 25*a* ceases to maintain a vapor block in the capillary tube and permits substantial flow of refrigerant through the bypass conduit, with little or no flow of refrigerant through the evaporator. Selective energization and deenergization of heater 25*a* to control refrigerant flow though the bypass conduit, is provided by operation of switch 30*a* in series electrical circuit with battery 27 and the heater. Swtch 30*a* is actuated by bellows 29*a* and sensing bulb 28*a* of thermostat 26*a* adapted to sense the temperature of evaporator 20 disposed for heat exchange with air within passenger compartment 10.

As in the embodiment illustrated in FIGURE 1, the pressure drop across bypass conduit 24*a* is relatively low. Therefore, even though restrictor 24*b* is continuously open, leakage of refrigerant therethrough is minimal and does not detract from the operating efficiency of the system in carrying out its cooling function. Also, the flow restricting characteristics of the restrictor 24*b* are selected to permit substantially full flow of the bypassed refrigerant, with little or no resultant flow through the evaporator.

From the foregoing it will be appreciated that the invention affords simple and effective means for controlling a refrigeration system without need for cyclically energizing and deenergizing the compressor. Such a system is particularly advantageous in a vehicular system where it obviates the need for clutches or intricate refrigerant flow modulating devices to prevent over-cooling of, for example, an automobile passenger compartment.

I claim:

1. In a refrigeration system, elements including compressor means, motor means for driving said compressor means, condenser means, evaporator means, conduit means connecting said elements in conventional series refrigerant flow circuit, a thermostatic valve interposed in said conduit means between said condenser means and said evaporator means and serving as the expansion element operable to deliver refrigerant directly to said evaporator means, said valve being the sole expansion element and including a sensing bulb disposed in heat exchange relation with said conduit means between said evaporator means and said compressor means, means for regulating the capacity of said evaporator means comprising a bypass line for said evaporator means connecting to said conduit means at a point after said evaporator means and upstream as respects said sensing bulb and before said evaporator means at a point downstream as respects said valve, and means selectively operable to control the flow of expanded refrigerant through said bypass line.

2. A refrigeration system according to claim 1 and characterized in that said last recited means includes a solenoid actuated valve interposed in said bypass line and operable upon selective energization and deenergization of the solenoid to open and to close the bypass line.

3. In a refrigeration system, compressor means, normally variable speed motor means for driving said compressor means, condenser means connected to said compressor means, means defining a liquid line leading from said condenser means to said evaporator means, a thermostatic expansion valve interposed in said liquid line for delivering expanded refrigerant directly to said evaporator means, a suction line connecting said evaporator means to said compressor means, said thermostatic expansion valve having a sensing bulb disposed for heat exchange with said suction line in the region of the outlet of said evaporator means, bypass conduit means leading from said liquid line in a region downstream as respects said expansion valve and immediately upstream as respects said evaporator means, to said suction line in a region upstream as respects said sensing bulb, and means selectively operative to control the flow of expanded refrigerant through said bypass conduit means.

4. In a refrigeration system including a compressor, a normally variable speed motor for driving said compressor, a condenser connected to said compressor, a receiver connected to the outlet of said condenser, a liquid line leading from said receiver, an evaporator including an inlet and an outlet, a thermostatic expansion valve connected to said liquid line and said evaporator for delivering expanded refrigerant directly to the inlet of said evaporator, and a suction line connecting the outlet of said evaporator to the compressor, said expansion valve having a thermal sensing bulb adjacent the suction line at the outlet of said evaporator, control means comprising: a conduit interconnecting the inlet of the evaporator, after the expansion valve, to the outlet of the evaporator prior to the sensing bulb, valve means in said conduit operable to control flow of refrigerant through the latter, and means operable to control operation of said valve means.

5. A refrigeration system according to claim 4 and characterized in that said valve means comprises a valve operable to open and to close said conduit.

6. A refrigeration system according to claim 4 and characterized in that said valve means comprises a capillary tube restrictor interposed in series refrigerant flow circuit with said conduit, and a heater disposed in heat exchange relation with said restrictor and selectively energizable to control refrigerant flow through said restrictor.

7. In a refrigeration system, elements including compressor means, motor means for driving said compressor means, condenser means, evaporator means, conduit means connecting said elements in conventional series flow circuit, a thermostatic valve interposed in said conduit means between said condenser means and said evaporator means and serving as the expansion element delivering refrigerant directly to said evaporator means, said valve including a sensing bulb disposed in heat exchange relation with said conduit means between said evaporator means and said compressor means, means for regulating the capacity of said evaporator means comprising a capillary tube restrictor for bypassing said evaporator and connecting said conduit means at a point upstream as respects said sensing bulb and downstream as respects said valve, and means selectively operable to control the flow of expanded refrigerant through said capillary tube restrictor comprising heater means disposed in heat exchange relation with said restrictor, said heater means being selectively energizable to control refrigerant flow through said restrictor.

8. In a refrigeration system, compressor means, variable speed motor means for driving said compressor means, condenser means connected to said compressor means, means defining a liquid line leading from said compressor means to said evaporator means, a thermostatic expansion valve interposed in said liquid line for

delivering expanded refrigerant directly to the evaporator means, a suction line connecting said evaporator means to said compressor means, said thermostatic expansion valve having a sensing bulb disposed for heat exchange relation with said suction line in the region of the outlet of said evaporator means, bypass conduit means comprising a capillary tube restrictor leading from said liquid line, in a region downstream as respects said expansion valve and immediately upstream as respects said evaporator means, to said suction line, in a region upstream as respects said sensing bulb, and means selectively operative to control the flow of expanded refrigerant through said bypass conduit means comprising heater means disposed in heat exchange relation with said restrictor and selectively energizable and de-energizable in response to temperatures sensed in the region of said evaporator means, thereby selectively to vapor block and to permit refrigerant flow through said bypass conduit means.

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