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(54) MOTOR-COMPRESSOR DRIVE APPARATUS

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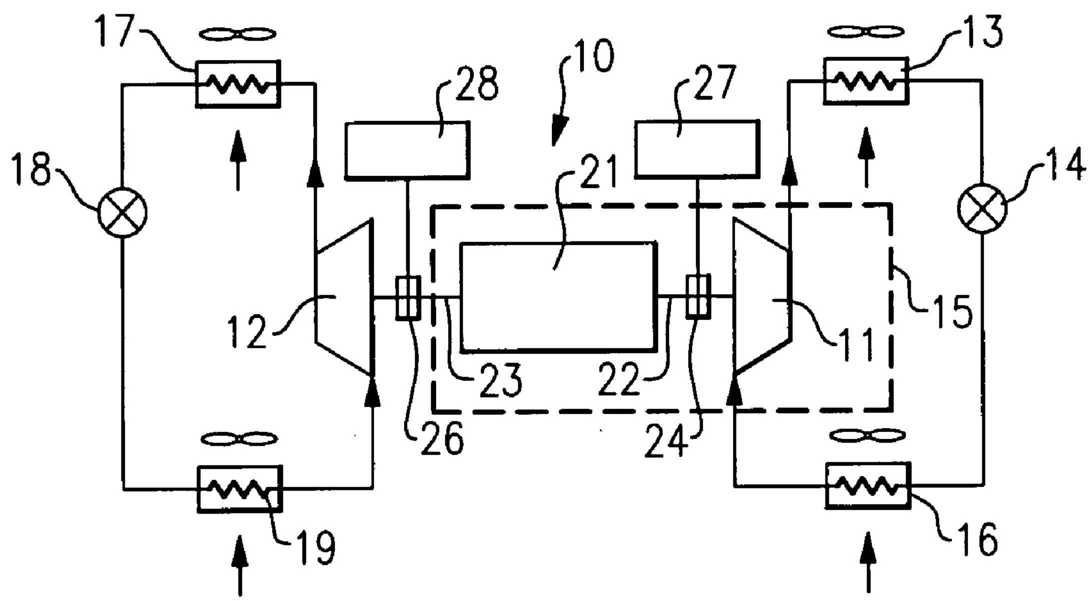
(57) **ABSTRACT**

Multiple compressors are connected to a common shaft of a drive motor. Provision may be made for selectively disengaging one or more of the compressors from its drive connection. The multiple compressors an preferably attached to opposite ends of a common motor shaft extending from both ends of the motor. Multiple compressors may be arranged to operate in parallel flow relationship or in series flow relationship in a single refrigerant circuit. The compressors may also be installed on separate refrigerant circuits. In a series flow relationship, a vapor or liquid injection function may be provided. Both compressors may be of an open-drive design, or one of the compressors nay share a common housing with the motor.



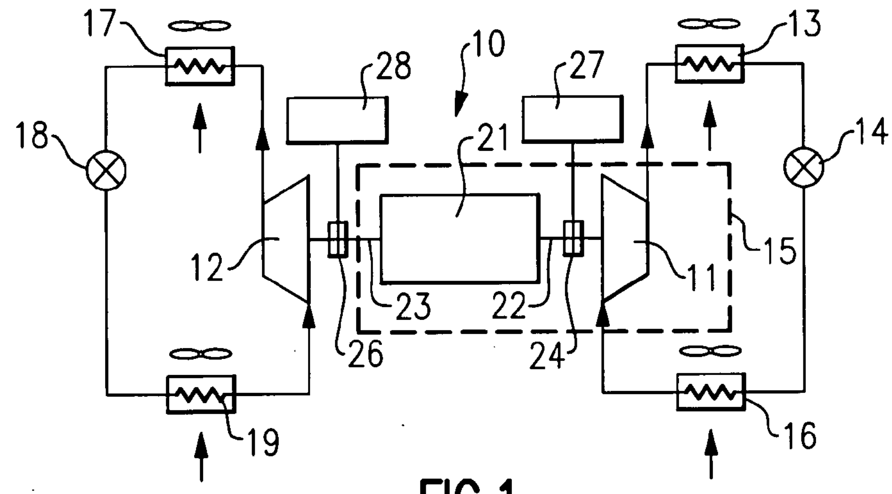


FIG.1

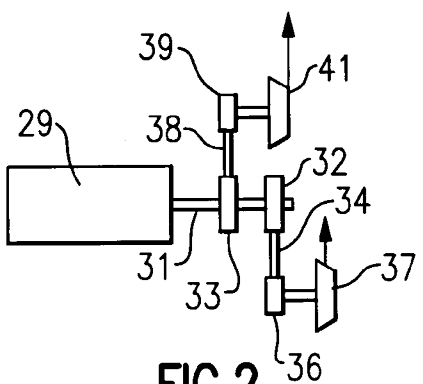


FIG.2

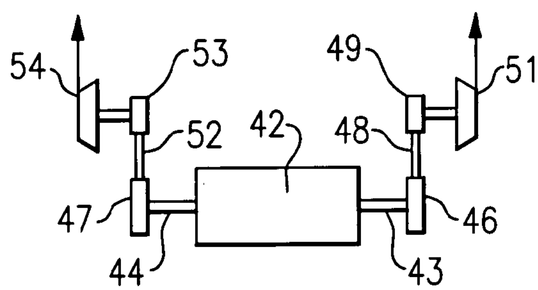


FIG.3

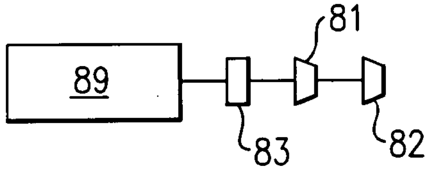


FIG.2A

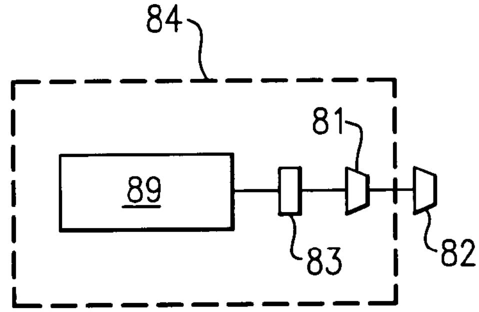


FIG.2B

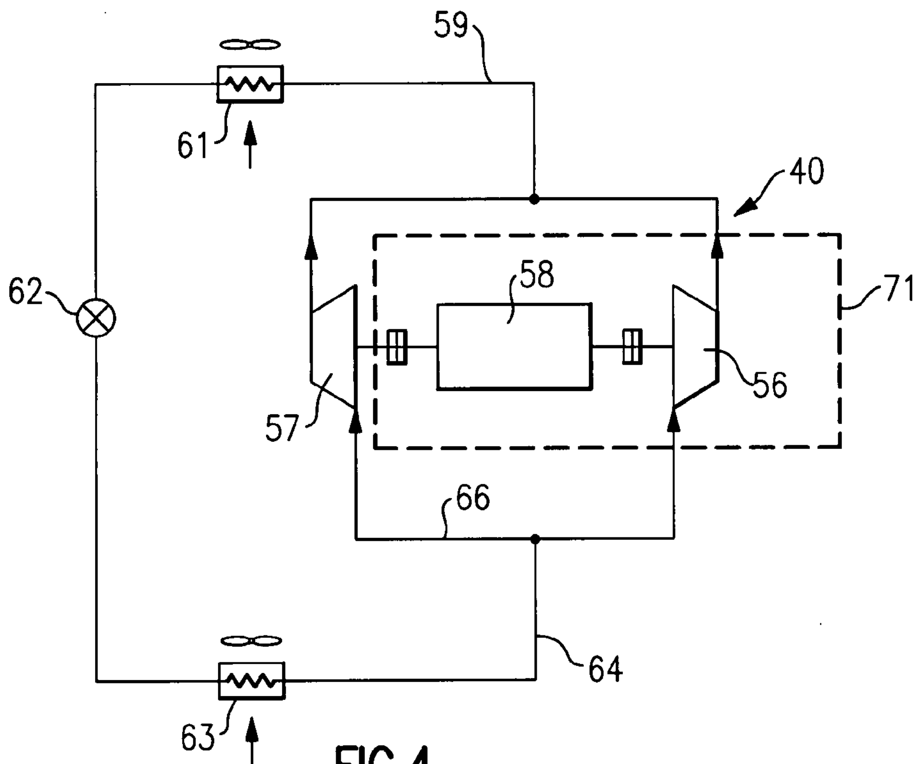


FIG.4

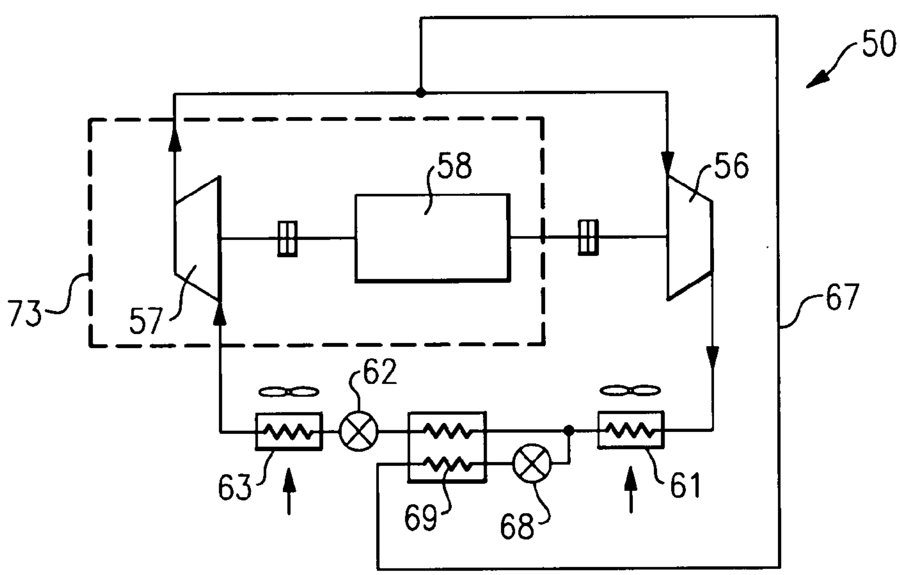


FIG.5

MOTOR-COMPRESSOR DRIVE APPARATUS

BACKGROUND OF THE INVENTION

[0001] This invention relates generally to refrigerant systems and, more particularly, to a method and apparatus for driving multiple compressors connected to a single motor.

[0002] Generally, there are two types of compressor drive arrangements for refrigerant systems. One design configuration encompasses a compressor unit and an electric motor in a single hermetically sealed housing, and is referred to as a hermetic or semi-hermetic compressor arrangement. Another design configuration consists of separated compressor and motor, where the motor is exposed to the ambient environment. This arrangement is referred to as an open-drive arrangement. In the latter configuration, the motor and compressor are connected by a shaft protruding through the compressor housing. Some sealing arrangement needs to be made to prevent refrigerant leakage to ambient environment or ambient air from entering into a refrigerant system.

[0003] In many HVAC&R (heating, ventilation, air conditioning and refrigeration) applications, there is a need for multiple compressors in a single system. The multiple compressors may be applied to a single refrigeration circuit or multiple refrigeration circuits, as well as connected serially or in tandem. in these applications, there is thus a need for a large number of drive motors associated with these compressors, i.e. one motor for each individual compressor. Each of the motors involves manufacturing cost, attendant costs associated with the motor itself, the necessary maintenance related thereto, and the associated space, weight and the installation cost. Therefore, there is a need to reduce a number of the driving motors, in comparison to a number of the refrigerant system compressors to be driven by these motors.

SUMMARY OF THE INVENTION

[0004] Briefly, in accordance with one aspect of the invention, a single motor is associated and mechanically connected to multiple compression elements (or compressors), where at least one compression element is an open-drive compressor. In case, where some of the compression elements is not an open-drive type, these compression elements and the motor share the same housing. The motor shaft, in this case, protrudes from the housing and the other compression elements are connected to that end of the shaft in the open-drive fashion. As a result, a hybrid arrangement is provided where some compression elements are a part of an open-drive compressor configuration and the other compression elements shares a common housing with the motor. In the case where all compression elements are of the open-drive type, the motor is located outside the compressor housing and is open to direct communication with the ambient environment.

[0005] In one aspect of the invention, the drive motor has a drive shaft extending from both ends thereof, with each end being associated and mechanically connected to one or more compression elements.

[0006] By another aspect of the invention, the drive connection between the drive motor and one or more of the open-drive compressors may be disengaged by the use of a clutch or the like.

[0007] By another aspect of the invention, the multiple compression elements (or compressors) may be fluidly connected to separate circuits of a refrigerant system.

[0008] In accordance with another aspect of the invention, the compressors may be connected in a parallel or so-called tandem, arrangement within a single circuit of a refrigerant system.

[0009] By yet another aspect of the invention, the multiple compressors may be connected in a series flow arrangement within a single circuit of a refrigerant system.

[0010] In the drawings as hereinafter described, preferred and modified embodiments are depicted; however, various other modifications and alternate constructions can be made thereto without departing from the spirit and scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. **1** is a schematic illustration of the present invention as incorporated into multiple compressors with independent circuits.

[0012] FIG. **2** is another embodiment thereof.

[0013] FIG. **2**A is another embodiment thereof.

[0014] FIG. **2**B is still another embodiment thereof.

[0015] FIG. **3** is yet another embodiment thereof.

[0016] FIG. **4** is a schematic illustration of the present invention as incorporated into multiple compressors operating in parallel flow relationship within the same circuit of a refrigerant system.

[0017] FIG. **5** is a schematic illustration of the present invention as incorporated into multiple compressors operating in serial flow relationship within the same circuit of a refrigerant system.

DETAILED DESCRIPTION OF THE INVENTION

[0018] The invention is shown generally in FIG. **1** at **10** as applied to a pair of open-drive compressors **11** and **12**, with the compressors **11** and **12** being fluidly connected in separate refrigerant circuits. That is, the open-drive compressor **11** is fluidly connected in serial flow relationship into a refrigerant circuit which includes a condenser **13**, an expansion device **14** and an evaporator **16**. Similarly, the open-drive compressor **12** is fluidly connected in serial flow relationship with a condenser **17**, an expansion device **18** and an evaporator **19**. It should be understood that the basic refrigerant circuits shown in FIG. **1** may include various options and enhancement features. All these refrigerant circuit arrangements can take advantage of and equally benefit from the invention.

[0019] The open-drive compressors **11** and **12** are both driven by a common motor **21** preferably having a common drive shaft that extends from both ends of the motor by shaft ends **22** and **23**. Shaft end **22** is thus extended to drive the open-drive compressor **11** by way of a mechanical coupling **24**, and open-drive compressor **12** is connected to shaft end **23** by a mechanical coupling **26**. The mechanical couplings **24** and **26** may be a simple female collar that receives the two male shafts at its ends. It may also be a more sophisticated connection device such as a gear or flexible coupling, a gear box, a friction drive or the like. Each of the mechanical couplings **24** and **26** may include an engaging-disengaging apparatus **27** and **28**, such as a clutch or the like, to allow an operator or system controls to selectively engage or disengage one or more of the drive connections.

[0020] It should be understood that each of the compressors **11** and **12** may encompass multiple units within a compressor system. All these configurations are also within the scope of the invention.

[0021] Alternatively, one of the compressors and the motor can be enclosed within a common housing. In this arrangement, the combination of the compressor element and the motor within, the common housing closely resembles a common hermetic or semi-hermitic compressor; with the exception that one end of the motor shaft protrudes from the housing to be connected to the open-drive compressor. To prevent refrigerant leakage from the gap created by the protruding shaft, the gap needs to be sealed off. This gap is normally sealed off by known means such as, for example, a face shaft seal. This alternative arrangement is exhibited in FIG. **1**, where the compressor **11** and the motor **26** are shown as being enclosed within a common housing **15**, as shown by the dashed line.

[0022] An alternative embodiment is shown in FIG. **2** wherein a drive motor **29** has a single shaft end **31**, and a pair of pulleys **32** and **33** is rigidly attached so as to be rotated by the shaft end **31**. The pulley **32** is mechanically connected by a belt **34** to a pulley **36** which drives an open-drive compressor **37**. Similarly, the pulley **33** is mechanically connected by a belt **38** to a pulley **39** for driving the open-drive compressor **41**.

[0023] In another alternative embodiment shown in FIG. **2**A, two compression elements **81** and **82** are attached to the same end of the shaft in a serial arrangement via a mechanical coupling **83**. Further, FIG. **2**B illustrates yet another embodiment, where one of the compression elements, such as the compression element **81**, and the motor **89** can be positioned within the same housing **84**. In both embodiments of FIGS. **2**A and **2**B, the mechanical coupling **83** may be positioned between two compression elements **81** and **82**.

[0024] A belt drive arrangement can also be applied to a double ended motor **42** as shown in FIG. **3**. Here, the motor **42** has shaft ends **43** and **44** with associated pulleys **46** and **47**. The pulley **46** is mechanically connected by a belt **48** to a pulley **49** which drives an open-drive compressor **51**. Similarly, the pulley **47** is mechanically connected by a belt **52** to a pulley **53** which drives an open-drive compressor **54**. Either of the two compressors can be selectively engaged or disengaged by being connected or disconnected from the belt drive.

[0025] It should be recognized that, in the FIG. **1** and FIG. **3** embodiments, wherein the motors are of the double ended type, there is an advantage provided by the loads being on the opposite ends of the shaft and thereby acting to balance each other and resulting in less wear on the bearings of the motor. Although the FIG. **1** and FIG. **3** embodiments are more balanced and preferred from the reliability perspective, the FIG. **2**, FIG. **2**A and FIG. **2**B configurations may be employed in cases where there are dimensional constraints or space limitations.

[0026] The single motor, common drive arrangement, in addition to being applicable for use with multiple compressors and separate refrigeration circuits, is also applicable to the use of multiple compressors within a single refrigerant circuit as shown in FIGS. **4** and **5**.

[0027] In FIG. **4**, embodiment **40** the two open-drive compressors **56** and **57** are driven by a common drive motor **58** and are fluidly connected in a parallel flow relationship wherein they discharge refrigerant to a common discharge line **59** leading to a condenser **61**, expansion device **62**, and evaporator **63**, connected in series, with the refrigerant vapor returning to a common suction line **64** for the two compressors **56** and **57**. As before, the compressors **56** and **57** may be selectively engaged and disengaged, depending on the thermal load requirements within the conditioned space. Further, as explained above, one of the compressors **56** and **57** may be of an open-drive type and another may be enclosed in the same housing with the driving motor **58**. This is shown schematically in FIG. **4** by the dashed line **71** that encompasses the compressor **56** and the motor **58** within the same housing.

[0028] In the FIG. **5** embodiment, **50** the two open-drive compressors **56** and **57** are driven by the common motor **58** and are connected in sequential, or series, flow relationship. Here, the open-drive compressor **57** discharges refrigerant into the suction side of the open-drive compressor **56** with the refrigerant then passing to the condenser **61**, expansion device **62** and evaporator **63**, after which it flows into the suction side of the open-drive compressor **57**.

[0029] Provision can also be made for the use of an economizer, or vapor injection, function wherein an economizer line **67** is connected at a point between the two compressors **56** and **57** and, upon the opening of the economizer expansion device **68**, a portion of refrigerant flow passes through the economizer heat exchanger **69** for the purpose of subcooling the refrigerant in the main circuit flowing to the evaporator **63**. General operation of the economizer function to enhance performance (efficiency and capacity) of the refrigerant system is known in the art. Also, various design configurations of the economizer circuit (including the flash tank option) are within the scope and can equally benefit from of the invention. Further, there may be more than two compression stages and more than one economizer circuit incorporated into a refrigerant system design.

[0030] As before, each compressor **56** or **57** may be selectively engaged and disengaged on demand, while a refrigerant bypass line may be provided to bypass refrigerant around the disengaged compressor (not shown). Similarly to the vapor injection function, the liquid injection feature may be employed to inject a portion of liquid refrigerant between the compression stages **56** and **57** to reduce the discharge temperature of the refrigerant. Again, one of the compressors **56** and **57** in FIG. **5** can share a common housing with the motor **58**. This is shown schematically in FIG. **5** by the dashed line **73** encompasses the compressor **57** and the motor **58** within the same housing. Preferably, the lower stage compressor **57** should share the same housing with the motor **58**, since the refrigerant suction vapor may simultaneously cool the motor.

[0031] It should also be understood that in the context of the above embodiments, a compressor can be selected from a variety of compressor types, including reciprocating, screw, scroll, centrifugal or axial compressor type. Each compressor or compression element type can be represented by multiple compressors or compression elements. For example, a compression element can consist of several centrifugal compressor stages. This invention can be applied to different refrigerant system types, including residential or commercial cooling and heating applications. It can also be used for providing cooling and refrigeration in supermarkets, truck-trailer and container applications.

[0032] While certain preferred and alternative embodiments of the present invention have been disclosed in detail, it is to be understood that various modifications in its structure and operation may be adopted without departing from the sprit and scope of the invention.

We claim:

1. A motor-compressor drive apparatus, comprising:

a motor having a drive shaft extending therefrom;

a first open-drive compressor having a shaft to be driven;

a second compressor having a shaft to be driven; and

said motor drive shaft being connected to both said first and second compressor.

2. A motor-compressor drive apparatus as set forth in claim **1** and disengaging apparatus for selectively disengaging one or more of said compressors from the connection to said motor drive shaft.

3. A motor-compressor drive apparatus as set forth in claim **1** wherein said second compressor is an open-drive compressor.

4. A motor-compressor drive apparatus as set forth in claim **1** wherein said second compressor shares a common housing with said motor.

5. A motor-compressor drive apparatus as set forth in claim **1** wherein said motor drive shaft extends from one end of said drive motor.

6. A motor-compressor drive apparatus as set forth in claim **5** wherein at least one of said first and second compressors is connected to said drive shaft by a mechanical coupling.

7. A motor-compressor drive apparatus as set forth in claim **5** wherein at least one of said first and second compressors is mechanically connected to said drive shaft by pulleys and belts.

8. A motor-compressor drive apparatus as set forth in claim **1** wherein said motor drive shaft extends from both ends of the motor with said first and second compressor shafts being connected to opposite ends of the motor drive shaft.

9. A motor-compressor drive apparatus as set forth in claim **8** wherein at least one of said connections is a mechanical coupling.

10. A motor-compressor drive apparatus as set forth in claim **8** wherein at least one of said first and second compressors is mechanically connected to said motor drive shaft by pulleys and belts.

11. A motor-compressor drive apparatus as set forth in claim **1** wherein each of said first and second compressors is fluidly connected in at least one refrigerant circuit which at least includes, in serial flow relationship, a condenser, an expansion device and an evaporator.

12. A motor-compressor drive apparatus as set forth in claim **11** wherein said at least one refrigerant circuit is a single circuit with said compressors operating in parallel flow relationship.

13. A motor-compressor drive apparatus as set forth in claim **11** wherein said at least one refrigerant circuit comprises a pair of refrigerant circuits with each said compressor being connected in a separate refrigerant circuit.

14. A motor-compressor drive apparatus as set forth in claim **11** wherein said compressors are connected in serial flow relationship.

15. A motor-compressor drive apparatus as set forth in claim **14** and including an economizer circuit with at least a portion of refrigerant flowing to a point between two said compressors.

16. A motor-compressor drive apparatus as set forth in claim **1** wherein at least one of said compressors comprises multiple compressors.

17. A method of driving a pair of compressors comprising the steps of:

providing a motor with a drive shaft extending therefrom; and

mechanically connecting said drive shaft to a first open-drive compressor and a second compressor.

18. A method as set forth in claim **17** wherein said second compressor is an open drive compressor.

19. A method as set forth in claim **17** wherein said second compressor shares a common housing with said motor.

20. A method as set forth in claim **17** and including the step of disengaging one or more of said compressors from the connection to the motor drive shaft.

21. A method set forth in claim **17** wherein said motor drive shaft is extended from one end of said drive motor.

22. A method as set forth in claim **21** wherein said at least one compressor is connected to said drive shaft by a mechanical coupling.

23. A method as set forth in claim **21** wherein at least one compressor is mechanically connected to said drive shaft by pulleys and belts.

24. A method as set forth in claim **17** wherein said motor drive shaft is extended from both ends of the motor with said first and second compressor shafts being connected to opposite ends of the motor drive shaft.

25. A method as set forth in claim **24** wherein at least one of said driving connections is made by a mechanical coupling.

26. A method as set forth in claim **24** wherein at least one compress mechanically connected to said drive shaft by pulleys and belts.

27. A method as set forth in claim **17** and including the step wherein each of said first and second compressor is fluidly connected in at least one refrigerant circuit which at least includes, in serial flow relationship, a condenser, an expansion device and an evaporator.

28. A method as set forth in claim **27** and including the step wherein said at least one refrigerant circuit is a single circuit and said compressors are connected to operate in parallel flow relationship.

29. A method as set forth in claim **27** and including the step wherein said at least one refrigerant circuit comprises a pair of refrigerant circuits and each said compressor is connected in a separate refrigerant circuit.

30. A method as set forth in claim **27** and including the step wherein said compressors are connected in serial flow relationship.

31. A method as set forth in claim **30** and including the step of including an economizer function with at least a portion of refrigerant flowing to a point between said two compressors.

32. A method as set forth in claim **17** wherein at least one of said two compressors comprises multiple compressors.

* * * * *