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(54) **REFRIGERANT SYSTEM WITH FUEL CELL FOR ELECTRICITY GENERATION**

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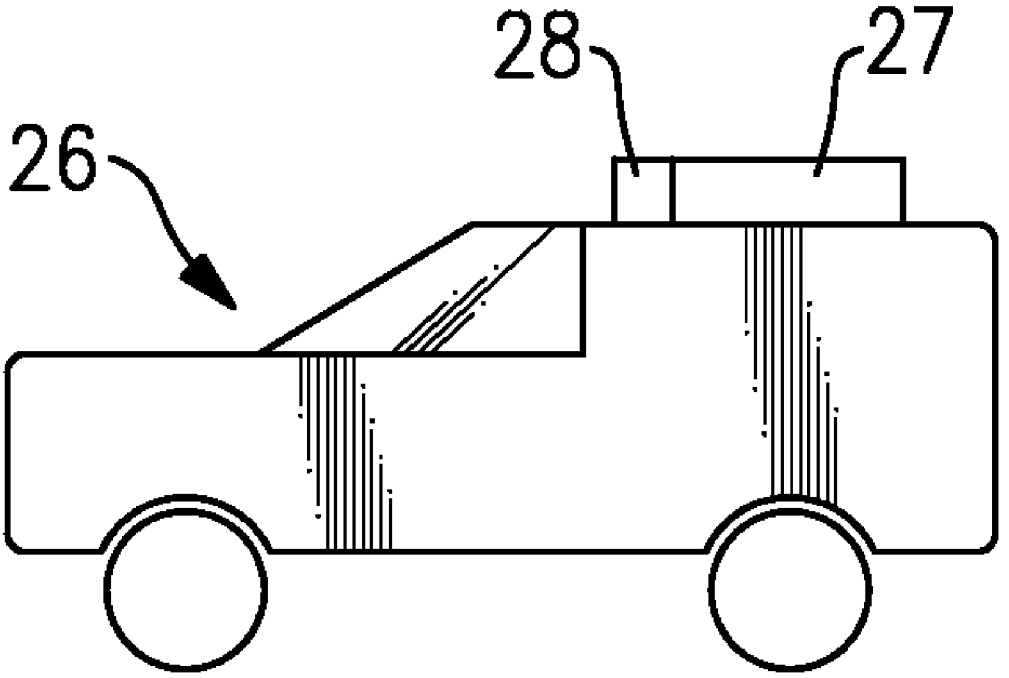
(57) **ABSTRACT**

A transport refrigeration/air conditioning system includes a fuel cell which is electrically connected to at least one of the compressor drive motor, evaporator fan motor or condenser fan motor to provide electrical power thereto.



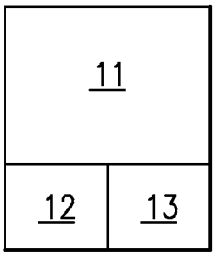


FIG.1

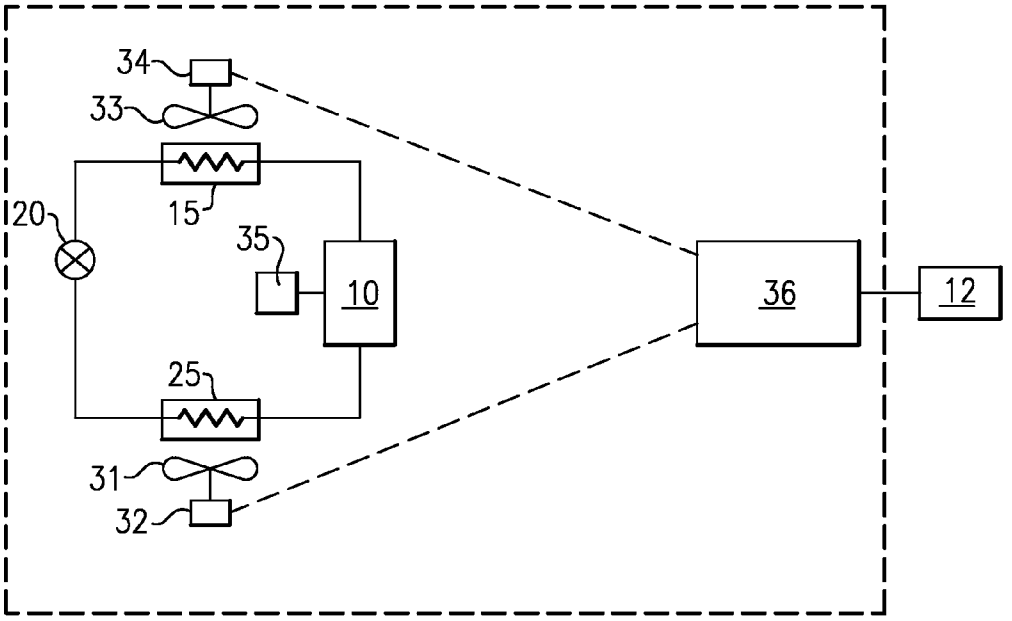


FIG.1a

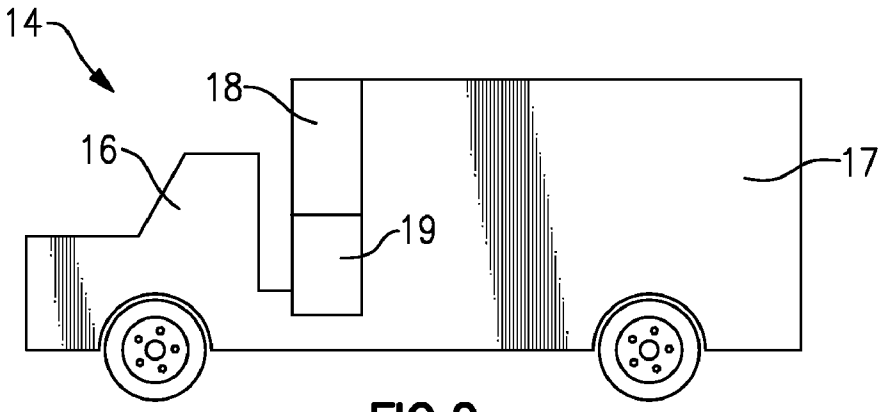


FIG.2

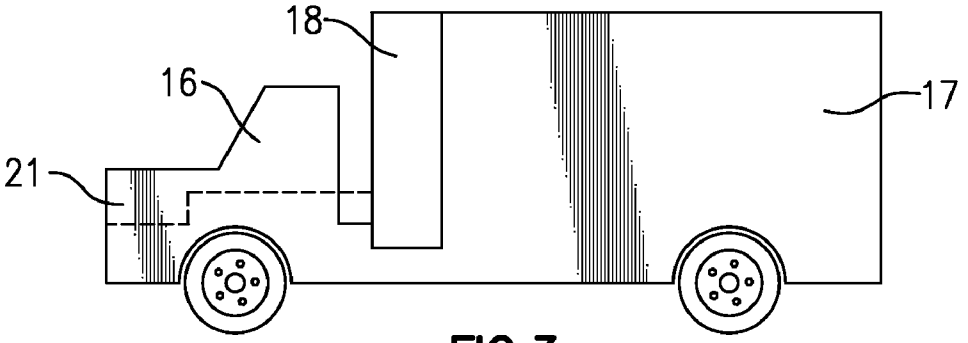


FIG.3

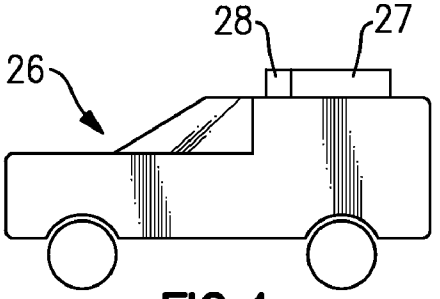


FIG.4

REFRIGERANT SYSTEM WITH FUEL CELL FOR ELECTRICITY GENERATION

TECHNICAL FIELD

[0001] This invention relates generally to refrigerant systems and more particularly, to such systems powered by fuel cells.

BACKGROUND OF THE INVENTION

[0002] There are various types of dedicated refrigerant systems, such as refrigeration air conditioning. systems used in mobile or tray applications. That is, trucks/trailer refrigerated compartments, as well as refrigerated containers, which include associated dedicated refrigeration systems for maintaining a required temperature condition in the confines of the storage space of the vehicle or container. Similarly, buses and recreational vehicles often include associated dedicated air conditioning systems, most often located on the roofs of the vehicles, for conditioning the air Within the interior of the vehicles.

[0003] The truck trailer refrigeration systems may be of the two main types. in one arrangement, the truck trailer includes an engine, such as a diesel engine, which is drivingly connected, by a belt, a clutch, gears or the like, to the compressor, and to the evaporator and condenser (or gas cooler) fans. In another arrangement, a diesel engine may be drivingly connected to a generator/alternator which, in turn, provides electrical power to the compressor and the fans.

[0004] In refrigerated container systems, the refrigeration units are adapted to be plugged into an electrical power source, such as on land or aboard a ship, to thereby provide electrical power to The compressor and fans of the refrigeration system. However, to allow the container refrigeration system to operate when there is no direct source of electricity present, such as aboard a trailer or rail platform, or on a remote dock, a diesel engine is provided to drive a generator which, in turn provides a required source of electricity to the compressor and fans.

[0005] If no source of electricity is available, then normally an internal combustion engine is required to drive at least the generator, and possibly the compressor and the fans. Quite often, this engine would be a stand alone engine that is exclusively dedicated to run an air conditioning or refrigeration system. In this regard, there are various undesirable aspects to the use of the internal combustion engine in this manner. Firstly, it produces exhaust gases which are harmful to the environment. Secondly, it generates substantial noise during operation. As known, both issues are becoming more important in environmental considerations and are governed by various regulations and legislation requirements.

DISCLOSURE OF THE INVENTION

[0006] In accordance with one aspect of the invention, the generator and/or dedicated engine for a transport refrigeration/air conditioning system is replaced with a fuel cell for providing the electrical power needed for the refrigeration/air conditioning system.

[0007] In accordance with another aspect of invention, a fuel cell replaces a direct source of electric power for a transport refrigeration/air conditioning system.

[0008] In the drawings as hereinafter described, a preferred embodiment and a modified embodiment 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

[0009] FIG. **1** is a simplified illustration of the general concept of the present invention.

[0010] FIG. **1**A is a simplified refrigerant system schematic that relies on the use of a fuel cell as a power supply.

[0011] FIG. **2** is a schematic illustration of one embodiment thereof as incorporated into a truck/trailer.

[0012] FIG. **3** is an alternative embodiment thereof.

[0013] FIG. **4** is a schematic illustration of the present invention as incorporated into a recreational vehicle air conditioning system.

DETAILED DESCRIPTION OF THE INVENTION

[0014] FIG. **1** is a simplified illustration of a transport refrigeration/air conditioning system **11** connected to a fuel cell **12** incorporated therein. A transport refrigeration/air conditioning system may be a refrigeration system for a truck/trailer or container, or it may be an air conditioning system for a bus or recreational vehicle, most likely located on its roof.

[0015] In any case, as shown in FIG. **1**A, a basic refrigeration/air conditioning system includes, in a serial flow relationship, a compressor **10** driven by an electric motor **35**, a heat rejection heat exchanger **15**, an expansion device **20** and an evaporator **25**. An evaporator fan **31** blows air over the external surfaces of the evaporator **25** and a heat rejection heat exchanger fan **33** blows air over the external surfaces of the heat rejection heat exchanger **15**, The evaporator fan **31** is driven by an electric motor **32** and the heat rejection heat exchanger fan **33** is driven by an electric motor **34**. The electric motors **32**, **34** and **35** would normally be connected to an electric DC bus **36** that converts the DC current from the fuel cell **12** into the AC current. However, motors **32**, **34** and **35** can also be of the DC type, such that no DC bus would be required. Any of the motors **32**, **34** and **35** can also be connected to a variable speed drive to operate the motors at variable speeds.

[0016] It should be understood that in the context of this invention, the heat rejection heat exchanger **15** can be of a condenser type, if it operates in a two-phase regime typical of subcritical cycles, or a gas cooler type, if it operates in a single phase gas regime typical of transcritical cycles. The transcritical cycles are common when, for example, CO_2 is used as a refrigerant. The schematic shown in FIG. **1**A is simplified, and as known in the art, may also include additional components such as, for example, receivers, accumulators, economizer heat exchanger, liquid injection and vapor injection lines, intercooler heat exchanger, liquid-suction, heat exchanger, etc. The compressor **10** can be a single or Multi-Stage type compressor. The compressor **10** can have special provisions for vapor injection or liquid injection. The compressor can be of a different type such as, for example, a reciprocating compressor, a screw compressor, a scroll compressor or a rotary compressor. The compressor can also include several compressors connected in series or in parallel (or so-called tandem) arrangement, as known in the art.

[0017] Further, as shown in FIG. **1**, the fuel cell **12** can be providing the entire electrical power needs for the transport refrigeration/air conditioning system. However, there may be some systems configurations where an alternate electrical

power source or dedicated engine (with associated components) **13**, may also he included. In such cases, one of the two systems **12** or **13** can act as the primary electrical energy source while the other acts as a standby system or a backup system used in emergencies. One example of such an auxiliary system operation is a standby operation where an electric motor plugged into an electric grid outlet was previously used to temporarily provide power to the components of a refrigeration/air conditioning system. Switching to such mode of operation may be required, for instance, due to noise level limitations exceeding by a combustion engine during nighttime in urban areas. Another example may be related to a combustion engine failure. Further, in many locations, such an electric grid power supply may not be available, therefore the benefits of the fuel cell providing power during standby or backup emergency systems become apparent.

[0018] In FIG. **2** there is schematically shown a truck/trailer **14** which includes a tractor **16** which is attached to a trailer **17** in a conventional manner. This truck/trailer **14** may also take the form of a smaller truck wherein the tractor **16** forms an integral part of the trailer **17**, with such a combination simply being referred to as a truck.

[0019] In the case of either a truck or a truck/trailer arrangement, the internal cargo space is cooled by way of a refrigeration system **18** which is commonly attached to the front of the trailer in a conventional manner as shown. The refrigeration system **18** has components similar to the components of the refrigeration/air conditioning system **11** described hereinabove. A fuel cell **19** is installed adjacent the refrigeration system **18** and is electrically connected thereto such that the fuel cell provides electrical power to the compressor, evaporator fan and condenser fan motors within the refrigeration unit **18**. In this manner, the refrigerant system **18** can be made to be fully independent of an engine, thus allowing for quiet and environmental friendly operation of the system.

[0020] An alternative embodiment is shown in FIG. **3**, wherein a fuel cell **21** is provided in the tractor **16** portion of the unit rather than being associated directly with the refrigeration unit. In this case, the same fuel **21** can be used to provide the source of power to operate the tractor/trailer as well as power the refrigeration system **18**.

[0021] In FIG. **4** there is shown a recreational vehicle **26** with an associated dedicated air conditioning unit **27** located on the roof thereof. The air conditioning unit **27**, which has the same basic components as the earlier described refrigeration/air conditioning system **11**. Again, a fuel cell **28** is electrically connected to the air conditioning unit **27** so as to provide the required power for the electric motors of the air conditioning unit **27**.

[0022] While the present invention has been particularly shown and described with reference to preferred and modified embodiments as illustrated in the drawings, it will be understood by one skilled in the art that various changes in detail may be made thereto without departing from the spirit and scope of the invention as defined by the claims.

We claim:

1. A transport closed-loop refrigeration/air conditioning system ha mg a compressor with an associated electrical drive motor, an evaporator with an associated electrical motor driven an moving device and a heat rejection heat exchanger with an associated electrical motor driven air moving device, and further comprising:

a fuel cell electrically connected to at least one of said associated electrical drive motors for supplying electrical power thereto.

2. A transport closed-loop refrigeration/air conditioning system as set forth in claim **1** wherein said fuel cell is a primary power source.

3. A transport closed-loop refrigeration/air conditioning system as set forth in claim **1** wherein said fuel cell is an auxiliary power source.

4. A transport closed-loop refrigeration/air conditioning system as set forth in claim **3** wherein said fuel cell provides power to the electrical drive motors simultaneously with a primary source of power.

5. A transport closed-loop refrigeration/air conditioning system as set forth in claim **1** wherein said fuel cell is at least one of a backup power source and as standby power source.

6. A transport closed-loop refrigeration/air conditioning system as set forth in claim **1** wherein said fuel cell is connected to a DC bus to convert DC current to AC current.

7. A transport closed-loop refrigeration/air conditioning system as set forth in claim **1** wherein said heat rejection heat exchanger is one of a condenser type or a gas cooler type.

8. A transport dosed-loop refrigeration/air conditioning system as set forth in claim **1** further comprising at least one of the following components: a receiver, an accumulator, an economizer heat exchanger, a liquid injection line, a vapor injection line, a liquid-suction heat exchanger and an intercooler heat exchanger.

9. A transport closed-loop refrigeration/air conditioning system as set forth in claim **1** wherein said closed-loop refrigeration/air conditioning system is part of one of a truck/trailer or a refrigerated container.

10. A transport closed-loop refrigeration/air conditioning system as set forth in claim **9** wherein said fuel cell is also located on said one of a truck/trailer or a refrigerated container.

11. A transport closed-loop refrigeration/air conditioning system as set forth in claim **10** wherein said truck/trailer includes a tractor for moving said trailer and further wherein said fuel cell is also used to power said tractor.

12. A transport closed-loop refrigeration/air conditioning system as set forth in claim **1** wherein said closed-loop refrigeration/air conditioning system is located on the roof or at the rear of the vehicle for purposes of conditioning the air within the vehicle.

13. A transport closed-loop refrigeration/air conditioning system as set forth in claim **12** wherein said fuel cell is also located on vehicle.

14. A method of providing, electrical power to a transport closed-loop refrigeration/air conditioning system having a compressor with an associated electrical drive motor, an evaporator with an associated electrical motor driven fan and a heat rejection heat exchanger with an associated electrical motor driven tan, comprising the steps of:

providing a fuel cell; and

electrically connecting said fuel cell to at least one of said associated electrical drive motors for supplying electrical power thereto.

15. A method as set forth in claim **14** wherein said fuel cell is a primary power source.

16. A method as set forth in claim **14** wherein said fuel cell is an auxiliary power source.

17. A method as set forth in claim **16** wherein said fuel cell provides power to the electrical drive motors simultaneously with a primary source of power.

18. A method as set forth in claim **14** wherein said fuel cell is at least one of as backup power source and a standby power source.

19. A method as set forth in claim **14** wherein said fuel cell is connected to a DC bus to convert DC current to AC current.

20. A method as set forth in claim **14** wherein said heat rejection heat exchanger is one of as condenser type or a gas cooler type.

21. A method as set forth in claim **14** wherein the closed-loop refrigerant system is a part of one of a truck/trailer or a refrigerated container.

22. A method as set forth in claim **21** wherein said fuel cell is also a part of said one of a truck/trailer or a refrigerated container.

23. A method as set forth in claim **22** wherein said truck/trailer includes a tractor for moving said trailer and further wherein said fuel cell is also used to power said tractor.

24. A method as set forth in claim **14** wherein said closed-loop refrigerant system is located on the roof or at the rear of the vehicle for purposes of conditioning the air within the vehicle.

25. A method as set forth in claim **24** wherein said fuel cell is also located on the vehicle.

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