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(54) **Refrigeration circuit comprising a turbine for driving a rotary member.**

(57) A turbine (6) arranged in the refrigeration circuit of a refrigerator so as to be driven by refrigerant fluid is connected into the circuit at a position such that the enthalpy of the refrigerant fluid driving the turbine is substantially at a maximum. The turbine (6) comprises a rotor (11) which is driven by means of injected refrigerant fluid. The turbine (6) drives a fan impeller (16) which is preferably coupled to the turbine (11) rotor by a magnetic coupling.

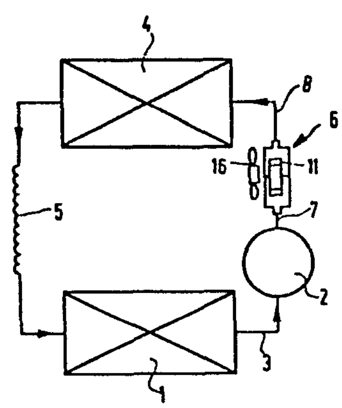

FIG. 1

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Refrigeration circuit comprising a turbine for driving a rotary member.

This invention relates to a refrigeration circuit of a refrigerating appliance, which circuit comprises a turbine for driving a rotary member of the appliance, for example, a fan impeller, the turbine comprising a casing of substantially cylindrical form, a rotor supported by a shaft inside the casing, a nozzle for injecting refrigerant fluid into the casing so as to cause the rotor to rotate, and an aperture for discharging the refrigerant fluid from the casing. U.S.A. patent 4,442,682 describes such a turbine connected into a compression refrigeration circuit at a position downstream of at least a part of the refrigerant fluid expansion device, which is constituted by at least one capillary tube. The turbine serves for driving a rotary member which is mounted on the turbine rotor shaft but is disposed outside the casing of the turbine. This known construction gives rise to a number of drawbacks, which limit the turbine performance and which result in uncertain operational reliability of the refrigerator appliance, which should be able to operate for many years without supervision or maintenance.

A first drawback arises by virtue of the fact that the turbine can be said to be of the "hydraulic" type in that it operates by utilising the kinetic energy of a refrigerant fluid in a very wet vapour state. Consequently, the casing comprises one outlet for discharging the gazeous part of the refrigerant fluid and another outlet for discharging the liquid part of said fluid. Thus the refrigeration circuit comprises at least one portion of piping which is not present in a conventional refrigeration circuit. This results at least in an increased manufacturing cost.

A further drawback derives from the fact that the turbine rotor is mounted on the same shaft as the rotary member which is driven by the turbine but is disposed outside the casing. Consequently the shaft passes through the casing wall and must therefore be provided with seals which, because of the small dimensions concerned, are inevitably delicate, costly and subject to wear during their operational life. The reliability of the system therefore cannot be particularly high.

The object of the present invention is to provide an arrangement which does not suffer from these drawbacks and which, in particular, is of relatively simple and economical construction but of high reliability. The refrigeration circuit according to the present invention is characterized in that the turbine is connected into the refrigeration circuit at a position such that the enthalpy of the refrigerant fluid injected into the casing is substantially at its maximum value within the entire refrigeration circuit.

If the refrigeration circuit is of the compression type the turbine may be connected to the compressor delivery pipe.

In an embodiment of the invention in which a fan impeller constitutes the rotary to be driven by the turbine, the shaft of the turbine rotor is entirely enclosed within the casing of the turbine and a ferromagnetic body is fixed on a face of the rotor which is perpendicular to said shaft. This body cooperates with a second ferromagnetic body which is fixed to a shaft to which the fan impeller is fixed, the impeller and the shaft being located entirely outside the turbine casing. The invention will be more apparent from the description given hereinafter of non-limiting embodiments thereof, with reference to the accompanying drawings, in which:

Figure 1 is a block diagram of a compression refrigeration circuit comprising a turbine in accordance with the invention;

Figure 2 is a Mollier diagram of the refrigeration circuit of Figure 1;

Figure 3 is a sectional elevation showing the turbine arranged to drive the impeller of the refrigerant air fan of a so-called "no frost" domestic refrigerator; and

Figure 4 is a sectional elevation showing the turbine arranged to drive the impeller of a fan for cooling those circuits components which are disposed on the outside of the refrigerating appliance, in particular the condenser and/or compressor.

The refrigeration circuit shown in Figure 1 comprises an evaporator 1, a compressor 2 connected to the evaporator by a suction pipe 3, a condenser 4 and a capillary tube 5. A turbine, indicated generally by 6, is connected to the delivery pipe 7 of the compressor 2 and to the upstream end of a pipe 8 through which the refrigerant fluid is fed into the condenser 4.

In the simplified Mollier diagram of Figure 2,

A-B represents evaporation of the refrigerant fluid with superheating,

B-C represents isentropic compression,

C-D represents condensation,

D-A represents expansion.

Also a zone E-F can be seen which corresponds to the work produced by the turbine. For practical purposes the point E is to be considered as more or less coinciding with the point C at which the enthalpy of the refrigerant fluid is at its maximum value within the entire refrigeration circuit. In other words, the turbine in the present invention uses superheated vapour as its operating fluid rather than wet vapour as in the case of the turbine described in the cited U.S.A. patent 4,442,682.

Figure 3 shows the constructional details of the turbine 6, which comprises a casing 10 of substantially cylindrical form and constructed of a non-magnetic material (e.g. aluminium or plastics) and a rotor 11 which is of similar design to the rotor of a gas turbine and which is supported by a shaft 12. This shaft does not pass through the walls of the casing 10 and is therefore entirely housed within the casing, journalled in suitable bearings - not shown - provided in the inner faces of said walls. In its inlet side the casing 10 has a nozzle 13 which is connected to the delivery pipe 7 of the compressor 2 (see also Figure 1), and in its outlet side the casing 10 has an aperture 14 through which the refrigerant fluid, after turning the rotor 11, discharges into the pipe 8 which leads to the condenser 4. A permanent magnet 15 in the form of a disc, the poles of which are indicated respectively by N' and S', is fixed on a face of the rotor 11 which is perpendicular to the axis of the shaft 12. A fan impeller 16 is disposed outside the casing 10 and is supported by way of a hub 17 on its own shaft 18, which does not pass through the wall of the casing 10 but is journalled in a suitable bearing - not shown - provided in the outer face of said wall. That face of the hub 7 which faces the casing 10 carries a second permanent magnet 19, also of disc form, its poles being indicated respectively by N and S.

The operation of the turbine is as follows. The refrigerant fluid in the superheated vapour state is injected into the casing 10 through the nozzle 13. By virtue of its slight expansion in the casing 10 before leaving through the aperture 14, a fraction of the very high enthalpy of the fluid is transformed into mechanical energy, which causes the rotor 11 to rotate together with the shaft 12 and the permanent magnet 15. By magnetic entrainment (the lines of force of the magnetic field produced by the permanent magnet 15 being practically undisturbed by the constituent material of the casing 10), the second permanent magnet 19 is also rotated, together with the fan impeller 16 and the shaft 18. In the present case the turbine is positioned in the lower rear zone of a domestic refrigerator and the fan impeller 16 is used for blowing (relatively fresh) atmospheric air on to the outer surfaces of the compressor 2 and/or condenser 4, so improving their efficiency and reliability.

In the modified embodiment shown in Figure 4 the component parts of the turbine 6 are substantially the same as in Figure 3, and consequently the respective reference numerals are unchanged. In this case, however, the turbine is positioned behind the (thermally insulated) rear wall 26 of the casing of a two-door domestic refrigerator of the type commonly known as a "no frost" refrigerator. In this refrigerator there is a forced circulation of cooling air through a finned bank 20, which constitutes the evaporator of the refrigerator and is disposed within a horizontal wall which separates two food preservation compartments 21 and 22. The forced circulation is produced by a fan 23, the impeller 24 of which is carried by a shaft 25 which does not pass through the wall 26 but instead is journalled in a suitable bearing - not shown - provided in the wall 26. A second permanent magnet 27 in the form of a disc is fixed on the shaft 25 and is rotated by the permanent magnet 15 which forms part of the turbine 6. The materials of construction of the wall 26 are obviously non-magnetic.

From the aforegoing description it can be seen that the present invention obviates the drawbakcs of the construction described in the cited U.S.A. patent 4,442,682.

The present invention offers a further advantage deriving from the fact that the turbine uses refrigerant fluid of very high enthalpy, namely that as only a fraction of the enthalpy difference between points C and D of the Mollier diagram (see Figure 2) is used in the turbine, it is possible to improve the thermodynamic efficiency of the condenser or reduce its heat transfer surface compared with a similar refrigerator which is not provided with the turbine.

CLAIMS

1. A refrigeration circuit of a refrigerating appliance, which circuit comprises a turbine for driving a rotary member of the appliance, for example, a fan impeller, the turbine comprising a casing of substantially cylindrical form, a rotor supported by a shaft inside the casing, a nozzle for injecting refrigerant fluid into the casing so as to cause the rotor to rotate and an aperture for discharging the refrigerant fluid from the casing, characterized in that the turbine is connected into the refrigeration circuit at a position such that the enthalpy of the refrigerant fluid injected into the casing is substantially at its maximum value within the entire refrigeration circuit.

2. A refrigeration circuit of the compression type as claimed in Claim 1, characterized in that the turbine is connected into the circuit between the delivery pipe of the compressor and the upstream side of at least one portion of the condenser.

3. A refrigeration circuit as claimed in Claim 3, characterized in that a permanent magnet is fixed to the rotor shaft, the magnet being mounted on a face of the rotor which is perpendicular to the axis of the shaft.

4. A refrigeration circuit as claimed in Claim 4, characterized in that the rotary member which is to be driven by the turbine, and also a supporting shaft to which this rotary member is fixed, are located entirely outside the casing of the turbine, and a second permanent magnet is fixed to said supporting shaft.

5. A refrigeration circuit as claimed in any of the preceding Claims, characterized in that the rotary member which is to be driven by the turbine forms part of a cooling means for the condenser and/or for the compressor.

6. A refrigeration circuit as claimed in any of Claims 1 to 5, characterized in that the rotary member which is to be driven by the turbine is located inside the refrigerating appliance and forms part of the system for the forced circulation of cooling air through the evaporator of said appliance.

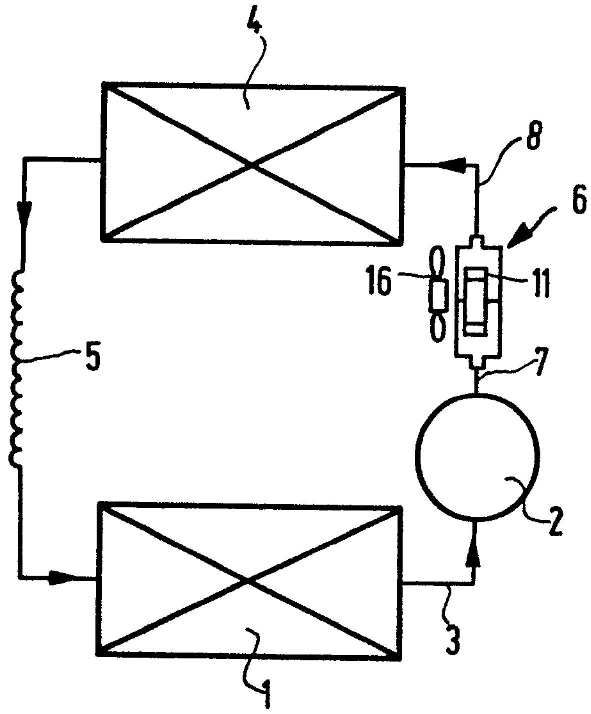

FIG. 1

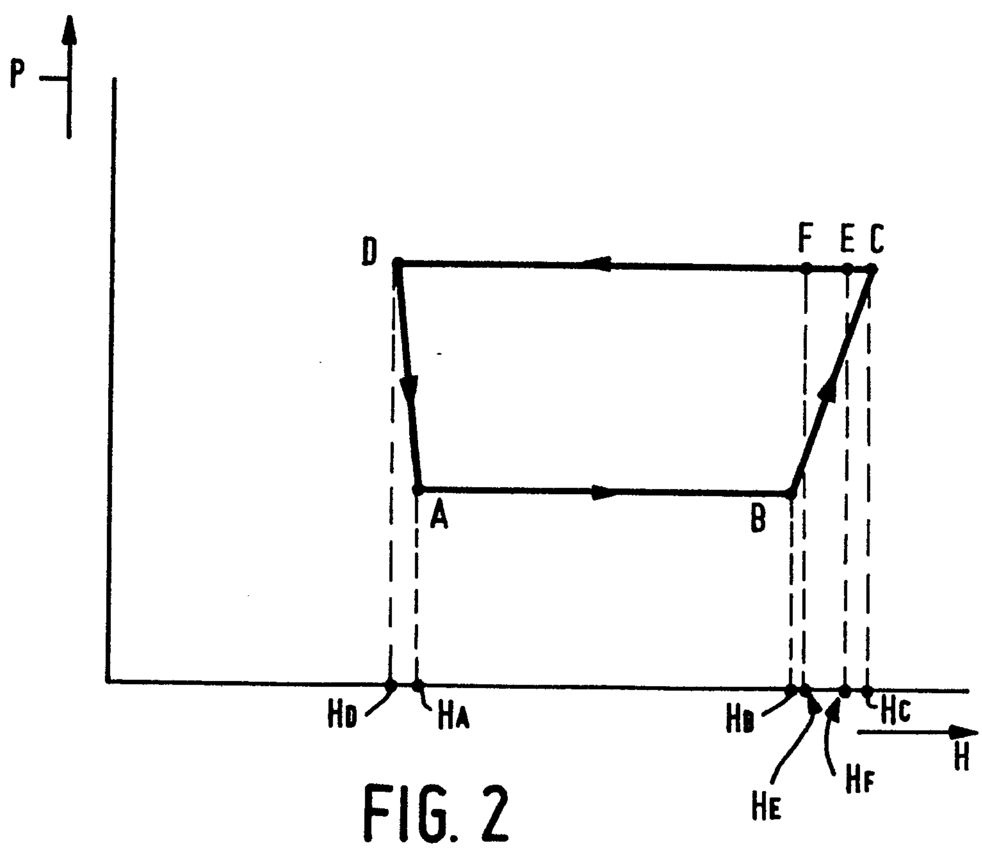

FIG. 2

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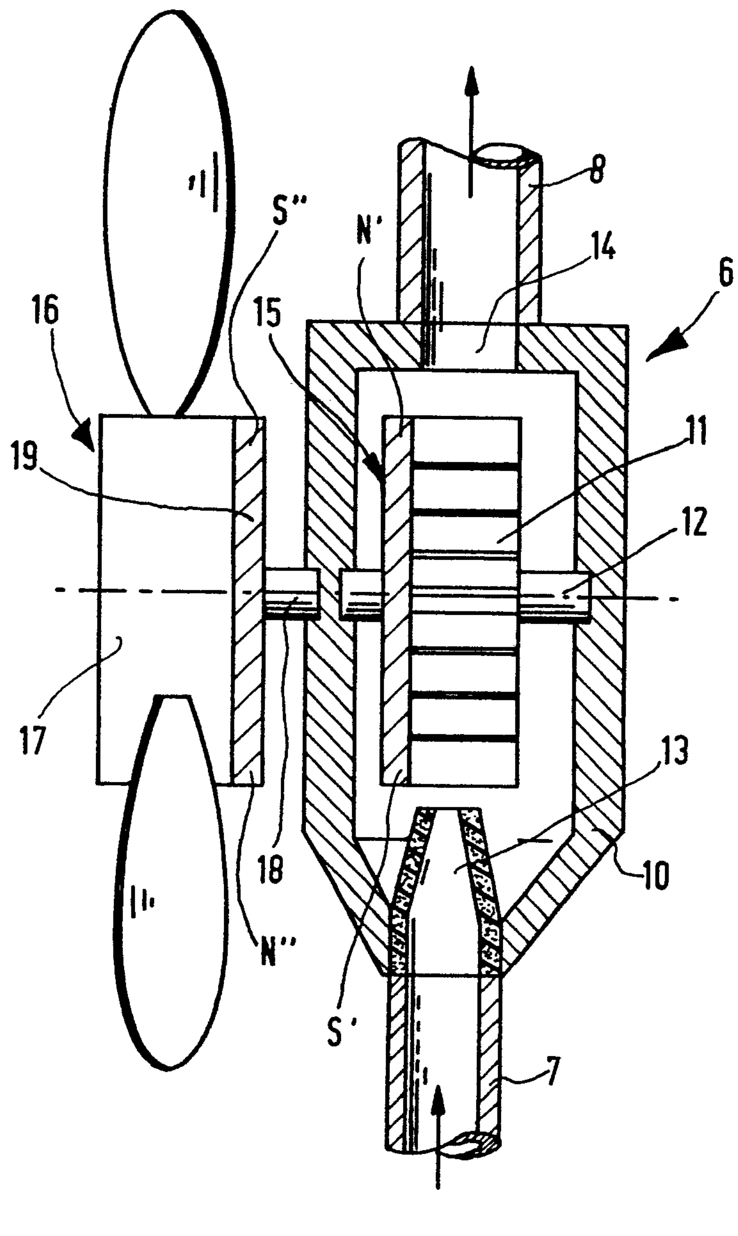

FIG. 3

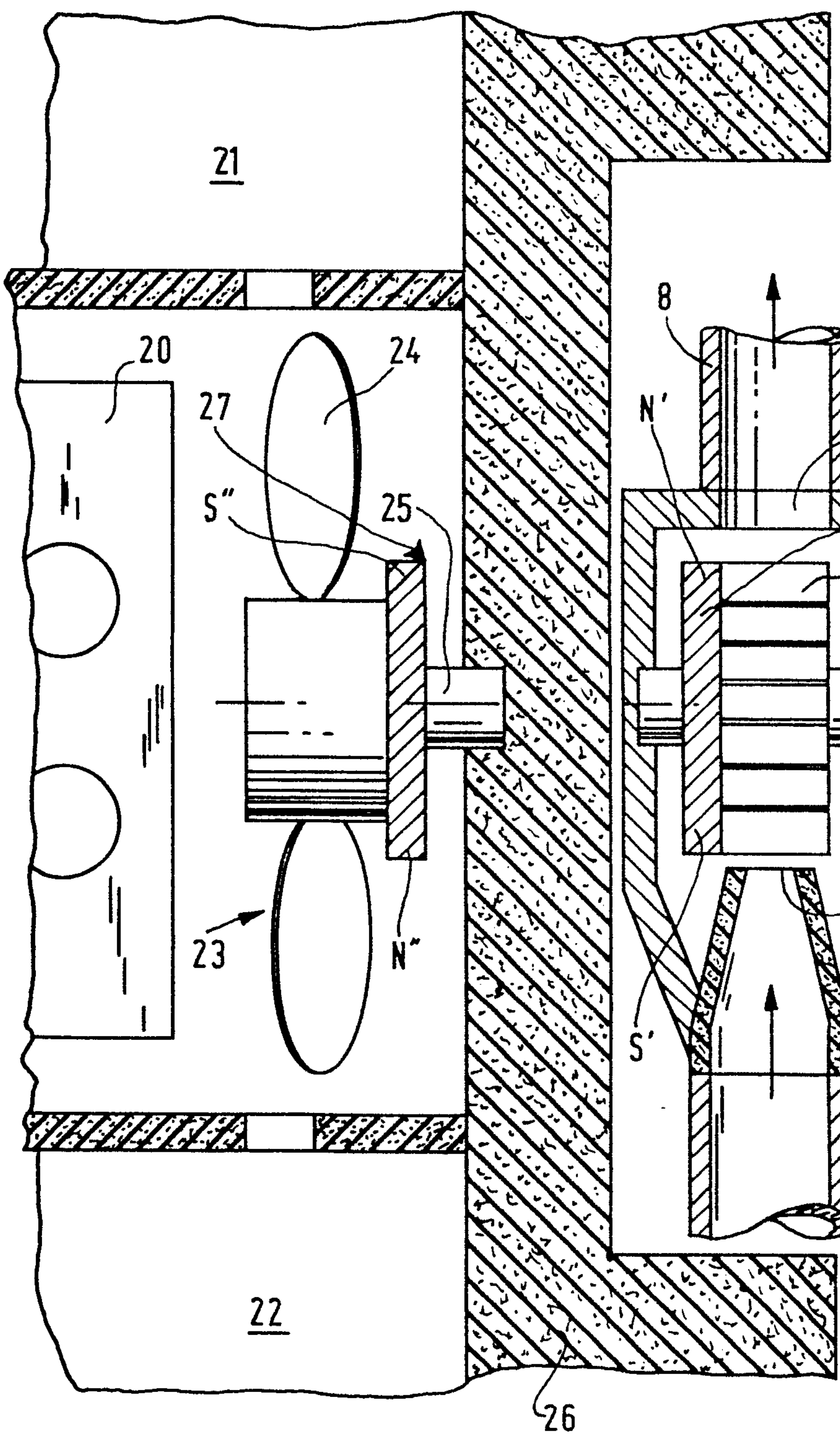

FIG. 4