CLAIMS

What is claimed is:

1. A cascade refrigeration system having at least two refrigeration loops, each circulating a refrigerant therethrough, comprising:

   (a) a first expansion device for reducing the pressure and temperature of a first refrigerant liquid;

   (b) an evaporator having an inlet and an outlet, wherein the first refrigerant liquid from the first expansion device enters the evaporator through the evaporator inlet and is evaporated in the evaporator to form a first refrigerant vapor, thereby producing cooling, and circulates to the outlet;

   (c) a first compressor having an inlet and an outlet, wherein the first refrigerant vapor from the evaporator circulates to the inlet of the first compressor and is compressed, thereby increasing the pressure and the temperature of the first refrigerant vapor, and the compressed first refrigerant vapor circulates to the outlet of the first compressor;

   (d) a cascade heat exchanger system having:

      (i) a first inlet and a first outlet, wherein the first refrigerant vapor circulates from the first inlet to the first outlet and is condensed in the heat exchanger system to form a first refrigerant liquid, thereby rejecting heat, and

      (ii) a second inlet and a second outlet, wherein a second refrigerant liquid circulates from the second inlet to the second outlet and absorbs the heat rejected by the first refrigerant and forms a second refrigerant vapor;

   (e) a second compressor having an inlet and an outlet, wherein the second refrigerant vapor from the cascade heat exchanger system is drawn into the

compressor and is compressed, thereby increasing the pressure and temperature of the second refrigerant vapor;

(f) a condenser having an inlet and an outlet for circulating the second refrigerant vapor therethrough and for condensing the second refrigerant vapor from the compressor to form a second refrigerant liquid, wherein the second refrigerant liquid exits the condenser through the outlet; and

(g) a second expansion device for reducing the pressure and temperature of the second refrigerant liquid exiting the condenser and entering the second inlet of the cascade heat exchanger system;

wherein the first refrigerant is CO_2 and the second refrigerant comprises HFO-1234yf; wherein the total equivalent warming impact of the system is a value lower than that for a system with CO_2 as the first refrigerant and CO_2 as the second refrigerant..

2. The system of claim 1, wherein the second refrigerant consists essentially of HFO-1234yf.

3. The system of claim 1, wherein the second refrigerant also comprises R134a.

4. The system of claim 1, wherein the second refrigerant also comprises HFC-32.

5. The system of claim 1, wherein the second refrigerant comprises trans-HFO-1234ze.

6. A cascade refrigeration system having at least two refrigeration loops, each circulating a refrigerant therethrough, comprising:
a first refrigeration loop, including:

(a) a first expansion device for reducing the pressure and temperature of a first refrigerant liquid;

(b) an evaporator having an inlet and an outlet, wherein the first refrigerant liquid from the first expansion device enters the evaporator through the

evaporator inlet and is evaporated in the evaporator to form a first refrigerant vapor, thereby producing cooling, and circulates to the outlet;

(c) a first compressor having an inlet and an outlet, wherein the first refrigerant vapor from the evaporator circulates to the inlet of the first compressor and is compressed, thereby increasing the pressure and the temperature of the first refrigerant vapor, and the compressed first refrigerant vapor circulates to the outlet of the first compressor;

(d) a cascade heat exchanger system comprising:

(i) a first cascade heat exchanger having:

(A) a first inlet and a first outlet, wherein the first refrigerant vapor from the evaporator circulates from the first inlet to the first outlet and is condensed in the first heat exchanger to form a first refrigerant liquid, thereby rejecting heat, and

(B) a second inlet and a second outlet, wherein a heat transfer fluid circulates from the second inlet to the second outlet, wherein the heat rejected by the first refrigerant vapor as it is condensed is absorbed by the heat transfer fluid,

(ii) a second cascade heat exchanger having:

(A) a first inlet and a first outlet, wherein the heat transfer fluid from the first cascade heat exchanger circulates from the first inlet to the first outlet and rejects the heat absorbed in the first cascade heat exchanger, and

(B) a second inlet and a second outlet, wherein a second refrigerant liquid circulates from the second inlet to the second outlet and absorbs the heat rejected by the heat transfer fluid and forms a second refrigerant vapor;

(e) a second compressor having an inlet and an outlet, wherein the second refrigerant vapor from the second cascade heat exchanger is drawn into the compressor and is compressed, thereby increasing the pressure and temperature of the second refrigerant vapor;

(f) a condenser having an inlet and an outlet for circulating the second refrigerant vapor therethrough and for condensing the second refrigerant vapor from the compressor to form a second refrigerant liquid, wherein the second refrigerant liquid exits the condenser through the outlet; and

(g) a second expansion device for reducing the pressure and temperature of the second refrigerant liquid exiting the condenser and entering the second inlet of the second cascade heat exchanger;

wherein the first refrigerant is CO_2 and the second refrigerant comprises HFO-1234yf; wherein the total equivalent warming impact of the system is a value lower than that for a system with CO_2 as the first refrigerant and CO_2 as the second refrigerant.

7. A method of exchanging heat between at least two refrigeration loops, comprising:

(a) absorbing heat from a body to be cooled in a first refrigeration loop and rejecting this heat to a second refrigeration loop; and

(b) absorbing the heat from the first refrigeration loop in the second refrigeration loop and rejecting this heat to ambient, wherein the refrigerant in the first refrigeration loop is CO_2 and the refrigerant in the second refrigerant loop comprises HFO-1234yf; wherein the total equivalent warming impact of the system is a value lower than that for a system with CO_2 as the first refrigerant and CO_2 as the second refrigerant.

8. The method of claim 7, wherein the second refrigerant also comprises R134a.

9. The method of claim 7, wherein the second refrigerant also comprises HFC-32.

CLAIMS

What is claimed is:

1. A cascade refrigeration system having at least two refrigeration loops, each circulating a refrigerant therethrough, comprising:

(a) a first expansion device for reducing the pressure and temperature of a first refrigerant liquid;

(b) an evaporator having an inlet and an outlet, wherein the first refrigerant liquid from the first expansion device enters the evaporator through the evaporator inlet and is evaporated in the evaporator to form a first refrigerant vapor, thereby producing cooling, and circulates to the outlet;

(c) a first compressor having an inlet and an outlet, wherein the first refrigerant vapor from the evaporator circulates to the inlet of the first compressor and is compressed, thereby increasing the pressure and the temperature of the first refrigerant vapor, and the compressed first refrigerant vapor circulates to the outlet of the first compressor;

(d) a cascade heat exchanger system having:

(i) a first inlet and a first outlet, wherein the first refrigerant vapor circulates from the first inlet to the first outlet and is condensed in the heat exchanger system to form a first refrigerant liquid, thereby rejecting heat, and

(ii) a second inlet and a second outlet, wherein a second refrigerant liquid circulates from the second inlet to the second outlet and absorbs the heat rejected by the first refrigerant and forms a second refrigerant vapor;

(e) a second compressor having an inlet and an outlet, wherein the second refrigerant vapor from the cascade heat exchanger system is drawn into the compressor and is compressed,

thereby increasing the pressure and temperature of the second refrigerant vapor;

(f) a condenser having an inlet and an outlet for circulating the second refrigerant vapor therethrough and for condensing the second refrigerant vapor from the compressor to form a second refrigerant liquid, wherein the second refrigerant liquid exits the condenser through the outlet; and

(g) a second expansion device for reducing the pressure and temperature of the second refrigerant liquid exiting the condenser and entering the second inlet of the cascade heat exchanger system;

wherein the first refrigerant is CO_2 and the second refrigerant comprises HFO-1234yf.

2. The system of claim 1, wherein the second refrigerant consists essentially of HFO-1234yf.

3. The system of claim 1, wherein the second refrigerant also comprises R134a.

4. The system of claim 1, wherein the second refrigerant also comprises HFC-32.

5. The system of claim 1, wherein the second refrigerant comprises trans-HFO-1234ze.

6. A cascade refrigeration system having at least two refrigeration loops, each circulating a refrigerant therethrough, comprising:

a first refrigeration loop, including:

(a) a first expansion device for reducing the pressure and temperature of a first refrigerant liquid;

(b) an evaporator having an inlet and an outlet, wherein the first refrigerant liquid from the first expansion device enters the evaporator through the evaporator inlet and is evaporated in the evaporator to form a first refrigerant vapor, thereby producing cooling, and circulates to the outlet;

(c) a first compressor having an inlet and an outlet, wherein the first refrigerant vapor from the evaporator circulates to the inlet of the first compressor and is compressed, thereby increasing the pressure and the temperature of the first refrigerant vapor, and the compressed first refrigerant vapor circulates to the outlet of the first compressor;

(d) a cascade heat exchanger system comprising:

(i) a first cascade heat exchanger having:

(A) a first inlet and a first outlet, wherein the first refrigerant vapor from the evaporator circulates from the first inlet to the first outlet and is condensed in the first heat exchanger to form a first refrigerant liquid, thereby rejecting heat, and

(B) a second inlet and a second outlet, wherein a heat transfer fluid circulates from the second inlet to the second outlet, wherein the heat rejected by the first refrigerant vapor as it is condensed is absorbed by the heat transfer fluid,

(ii) a second cascade heat exchanger having:

(A) a first inlet and a first outlet, wherein the heat transfer fluid from the first cascade heat exchanger circulates from the first inlet to the first outlet and rejects the heat absorbed in the first cascade heat exchanger, and

(B) a second inlet and a second outlet, wherein a second refrigerant liquid circulates from the second inlet to the second outlet and absorbs the heat rejected by the heat transfer fluid and forms a second refrigerant vapor;

(e) a second compressor having an inlet and an outlet, wherein the second refrigerant vapor from the second cascade heat exchanger is drawn into the compressor and is compressed, thereby increasing the pressure and temperature of the second refrigerant vapor;

(f) a condenser having an inlet and an outlet for circulating the second refrigerant vapor therethrough and for condensing the second refrigerant vapor from the compressor to form a

second refrigerant liquid, wherein the second refrigerant liquid exits the condenser through the outlet; and

(g) a second expansion device for reducing the pressure and temperature of the second refrigerant liquid exiting the condenser and entering the second inlet of the second cascade heat exchanger;

wherein the first refrigerant is CO_2 and the second refrigerant comprises HFO-1234yf.

7. A method of exchanging heat between at least two refrigeration loops, comprising:

(a) absorbing heat from a body to be cooled in a first refrigeration loop and rejecting this heat to a second refrigeration loop; and

(b) absorbing the heat from the first refrigeration loop in the second refrigeration loop and rejecting this heat to ambient, wherein the refrigerant in the first refrigeration loop is CO_2 and the refrigerant in the second refrigerant loop comprises HFO-1234yf.

8. The method of claim 7, wherein the second refrigerant also comprises R134a.

9. The method of claim 7, wherein the second refrigerant also comprises HFC-32.

10. The system of claim 1 wherein the total equivalent warming impact of the system is a value lower than that for a system with CO_2 as the first refrigerant and CO_2 as the second refrigerant.