

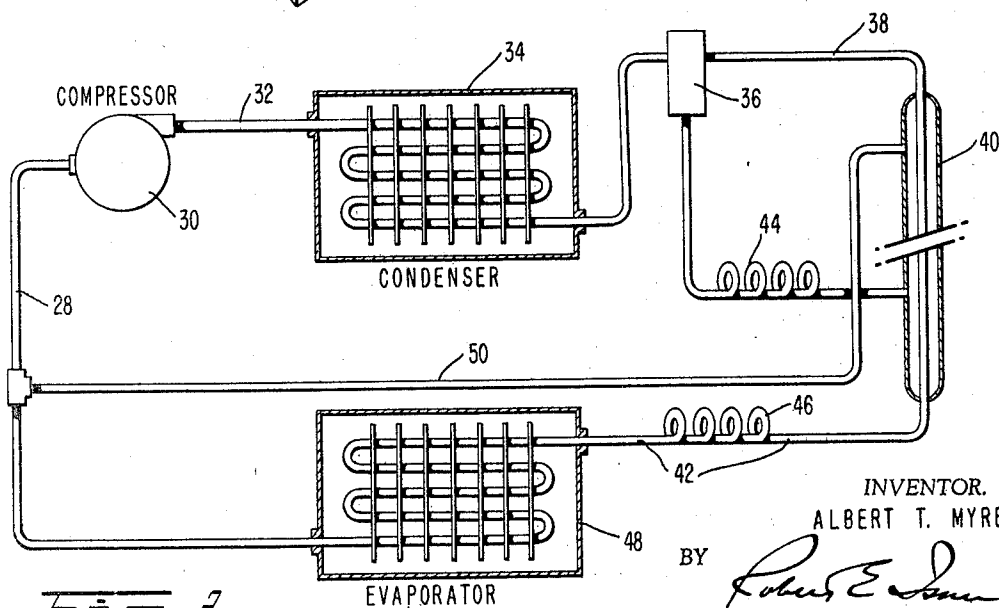
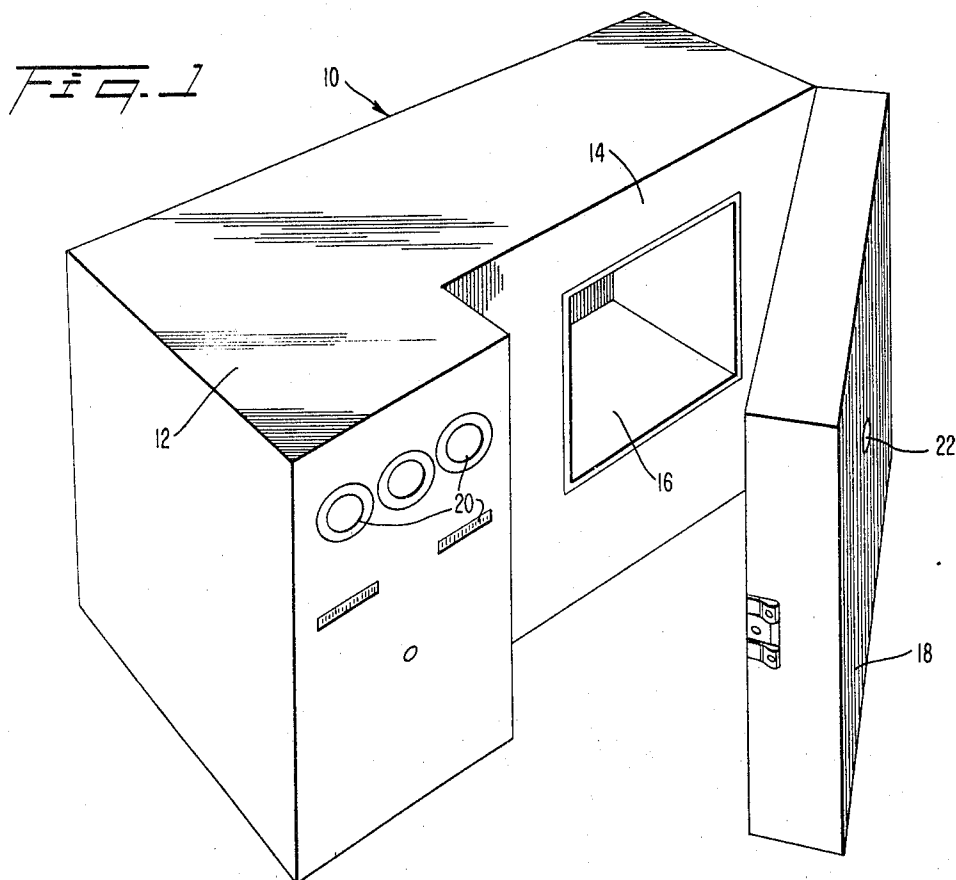
Jan. 6, 1970

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3,487,653

LOW TEMPERATURE ENVIRONMENTAL TEST SYSTEM

Filed Jan. 26, 1968



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3,487,653

LOW TEMPERATURE ENVIRONMENTAL
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Filed Jan. 26, 1968, Ser. No. 700,943

Int. Cl. F25b 1/00, 7/00

U.S. Cl. 62-76

8 Claims

ABSTRACT OF THE DISCLOSURE

Low temperature environmental test chamber incorporating improved refrigeration system employing a mixed refrigerant formed of a first component selected from the group consisting of dichlorodifluoromethane, monochlorodifluoromethane and an azeotrope constituted of monochlorodifluoromethane and monochloropentafluoroethane and a second component selected from the group consisting of monochlorotrifluoromethane and an azeotrope constituted of monochlorotrifluoromethane and trifluoromethane.

This invention relates to environmental test chambers and particularly to an improved low temperature environmental test chamber incorporating an improved refrigeration system employing mixed halocarbon refrigerants.

Environmental test chambers incorporating conventional refrigerating systems employing a single compressor and a single refrigerant fluid have heretofore generally operated with temperatures in the order of -40° F. as an effective lower limit. Lower temperatures than this, if desired, have generally been obtained by use of more complicated and expensive dual or cascade type refrigerating systems employing one or more separated refrigerants and a duality of components. Mixed refrigerants have also been proposed for such use, however, in such instance the suggested use thereof has been advanced in relatively complicated and expensive installations which have afforded no marked commercial or competitive advantage and which are economically unsuited for use in small and medium sized environmental test chambers.

This invention may be briefly described as an improved construction for environmental test chambers incorporating a refrigeration system employing a single compressor and evaporator in conjunction with a mixed halocarbon refrigerant.

Among the advantages attendant the subject construction is the permitted ready attainment of temperatures as low as -85° F. in a simple and inexpensive unit formed of conventional and readily available components and the consequent availability of an inexpensive environmental test chamber construction having a markedly expanded operating test range.

The object of this invention is the provision of improved environmental test chambers incorporating refrigeration systems employing a mixed halocarbon refrigerant.

Another object of this invention is the provision of an improved refrigeration system for low temperatures environmental test chambers and the like.

Other objects and advantages of the subject invention will become apparent from the following portions of this specification and from the appended drawings which illustrate, in accord with the dictates of the patent statutes, a presently preferred construction for an environmental test chamber incorporating the subject invention.

Referring to the drawings:

FIGURE 1 is an oblique view, partially cut away, illustrating an environmental test chamber incorporating the subject invention; and

FIGURE 2 is a schematic diagrammatic representation of the mixed refrigerant refrigeration system included in the unit of FIGURE 1.

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Referring to the drawings, and initially to FIGURE 1, there is provided a relatively small size environmental test chamber assembly 10 adapted to be supported on a table or the like and generally comprising a temperature control and component section 12 and an article receiving chamber section 14. The chamber section 14 includes a centrally located article receiving chamber 16 surrounded by insulated walls of appreciable thickness and accessible through an insulated door 18. Disposed within the control section 12 are suitable heat generating elements, air circulation means, control circuitry and the refrigeration system components as will be hereinafter described. Disposed on the front surface of the temperature control and component section 12 are readily accessible control and operation indicating elements 20 and an indicating thermometer 22 may be mounted on the door 18.

As pointed out earlier, environmental test chambers of the type described above have, because of size and cost factors, had an effective low temperature operating limit in the order of -40° F. through utilization of conventional refrigeration techniques and systems.

The subject environmental test chamber construction includes an improved refrigeration system that effectively lowers its operating temperature range to below -85° F. As previously indicated such system utilizes mixed halocarbon refrigerants of selective character as hereinafter disclosed and the essential components of such system are illustrated in FIGURE 2.

The mixed halocarbon refrigerants employable in the practice of the subject invention includes a first constituent thereof selected from the group consisting of dichlorodifluoromethane (R_{12}), monochlorodifluoromethane (R_{22}) and an azeotrope (R_{502}) constituted of monochlorodifluoromethane (R_{22}) and monochloropentafluoroethane (R_{115}), and a second constituent selected from the group consisting of monochlorotrifluoromethane (R_{13}) and an azeotrope constituted of trifluoromethane and monochlorotrifluoromethane (R_{503}). All of such refrigerants are commercially available, inter alia, from E. I. du Pont de Nemours & Company and from Allied Chemical Corporation. The preferred first constituent suitably comprises the dichlorodifluoromethane (R_{12}) refrigerant, at least in part because of its miscibility with oil. The azeotrope R_{502} assertedly comprises 48.8% by weight of monochlorodifluoromethane (R_{22}) and 51.2% by weight of monochloropentafluoroethane (R_{115}) and is available, inter alia, as FREON 502, from E. I. du Pont de Nemours & Company. As evidenced by such manufacturer's published data such azeotrope R_{502} and the refrigerants R_{12} and R_{22} are possessed of the following properties:

	(R_{502}) FREON-502	(R_{22}) FREON-22	(R_{12}) FREON-12
Chemical formula.....	(1)	CHClF ₂	CCl ₂ F ₂
Molecular weight.....	211.64	86.48	120.93
Boiling point, ° F.....	-50.1	-41.4	-21.6
Vapor pressure, p.s.i.a.: 120° F.....	295	277.3	172.4
0° F.....	45.9	38.8	23.8
Compression ratio, 120°/0°.....	6.43	7.15	7.24
Density, liquid, lbs./ cu. ft.: 120° F.....	70.01	68.10	75.91
0° F.....	87.86	83.90	90.66
Density, saturated vapor, lbs./cu. ft., 0° F.....	1.104	0.728	0.622
Specific heat ratio, C_p/C_v , 65° F. and 10 p.s.i.a.....	1.132	1.187	1.139
Latent heat of vaporization, B.t.u./lb. at 0° F.....	69.61	94.39	68.75
Solubility of water, p.p.m., 78° F.....	560	1,300	93

¹ CHClF₂/CClF₂CF₃ (48.8/51.2% by weight).

² Average molecular weight.

The preferred second constituent suitably comprises the azeotrope (R₅₀₃) assertedly constituted of 40.1% by weight of trifluoromethane (R₂₃) and 59.9% by weight of monochlorotrifluoromethane (R₁₃) and available as Genetron 23/23 from Allied Chemical Corporation. As evidenced by such manufacturer's published data such R₅₀₃ azeotrope and the R₁₃ refrigerant are possessed of the following properties:

	(R ₅₀₃) GENETRON 23/23 Azeotrope	(R ₁₃) GENETRON 13
Chemical formula.....	(¹)	CClF ₃
Molecular weight.....	87.5	104.5
Boiling point at 1 atmos., ° F.....	-127.6	-114.6
Critical temperature, ° F.....	67.1	83.9
Critical pressure (p.s.i.a.).....	607	561
Heat of vaporization at boiling point (b.t.u./lb.).....	74.2	63.9
Liquid density at -30° F. (b.t.u./ lb. ° F.).....	0.29	0.24

¹ 40.1% by weight GENETRON 23; 59.9% by weight GENETRON 13.

By way of illustrative example, in operation of a development proto type unit of the type hereinafter described, the system was initially charged at ambient temperatures to 45 p.s.i.g. with the first constituent of the mixed refrigerant specifically the R₁₂ refrigerant. Subsequent thereto the system was charged to 95 p.s.i.g. with the second constituent of the mixed refrigerant, specifically the azeotrope R₅₀₃. The system was then operated and adjusted to obtain optimum performance characteristics. While the amounts of refrigerants employed will be determined at least in part by the volume of the system, the desired temperature range and time for achieving a given temperature drop, by way of illustrative example the charging of the development prototype as above indicated utilized about 196 grams of R₁₂ refrigerant and 133 grams of the azeotrope R₅₀₃ refrigerant to provide a temperature of -90° F. attainable in about one hour. Based upon limited data now available it would appear that suitable quantities of the first and second refrigerants employable are, at least to some degree, expressable as a weight ratio, i.e.

$$\frac{\text{weight of first constituent}}{\text{weight of second constituent}}$$

In the described prototype unit the results above noted have been obtained with a ratio of about 1.47. Experience to date has indicated that as departures are made from the above stated amounts in the development prototype, the performance recedes from the stated. However, even with departure in the order of 5% from the stated amounts temperatures in the order of -85° F. are felt to be obtainable.

As illustrated in FIG. 2, there is provided a compressor unit 30 of conventional construction adapted to increase the pressure of the mixed refrigerant introduced therein via line 28 in the gaseous phase. The high pressure output of the compressor 30 is introduced via line 32 into a condenser unit 34, also of conventional construction, and wherein the first refrigerant constituent of the mixed refrigerant is selectively liquified. The mixed gas-liquid refrigerant fluid emanating from the condenser 34 is introduced into a liquid-gas separator 36, suitably in the nature of a small chamber or even a T joint. The uncondensed or gaseous second component of the mixed refrigerant is introduced via line 38 into the cascade condenser unit 40. The condensed refrigerant is expanded through a capillary tube 44 and passed through said cascade condenser 40 countercurrent to the second component of the mixed refrigerant. As will now be apparent to those skilled in this art, the selective expansion and evaporation of the first constituent and passage thereof counter current to the second refrigerant constituent effects a heat exchange therebetween and in a marked reduction in the temperature of the second constituent of the mixed refrigerant. For the herein stated

refrigerants, such heat exchange is sufficient to effect condensation of most if not all of the said second component and the resultant fluid thus exits from the cascade condenser 40 via the line 42. The liquified component of the second constituent of the mixed refrigerant is then expanded through the capillary tube 46 and introduced into the evaporator unit 48 wherein it absorbs heat from the surrounding environment in a conventional manner. The primary constituent of the mixed refrigerant now essentially in gaseous form, exits from the cascade condenser 40 via line 50 and is reintroduced to the compressor 30 together with the gaseous second constituent of the mixed refrigerant exiting from the evaporator 48 via line 52.

In operations effected to date the use of dichlorodifluoromethane (R₁₂) as the first refrigerant in association with the use of the R₅₀₃ azeotrope of trifluoromethane and monochlorotrifluoromethane is preferred although combinations of any of the hereinabove compounds for the first and second constituents of the mixed refrigerant may be used.

As will now be apparent to those skilled in this art the subject invention employs only standard equipment, includes no valves or other potentially troublesome components from a maintenance standpoint, and employs refrigerants of a wholly conventional and acceptable character. Units of the type herein described have successfully extended the low temperature range of small sized environmental test chambers from -40° to below -85° F. without any substantial increase in the complexity of the component elements thereof or increase in the cost thereof.

Having thus described my invention, I claim:

1. In combination, an environmental test chamber and a refrigerating system therefor comprising

a compressor for raising the pressure of a mixed gaseous refrigerant having a first constituent selected from the group consisting of dichlorodifluoromethane, monochlorodifluoromethane and an azeotrope constituted of monochlorodifluoromethane and monochloropentafluoroethane and a second constituent selected from the group consisting of monochlorotrifluoromethane and an azeotrope constituted of trifluoromethane and monochlorotrifluoromethane, condenser means for selectively effecting condensation of said first constituent of said compressed mixed refrigerant, means disposed on the output side of said condenser for separating said first and second constituents of said mixed refrigerant, means for selectively condensing said second constituent of said mixed refrigerant by counter current evaporation of said first constituent in heat exchange relation therewith, and means for selectively evaporating said second constituent of said mixed refrigerant.

2. The combination as set forth in claim 1 wherein said first constituent azeotrope comprises 48.8% by weight of monochlorodifluoromethane and 51.2% by weight of monochloropentafluoroethane.

3. The combination as set forth in claim 2 wherein said second constituent azeotrope comprises 40.1% by weight of trifluoromethane and 59.9% by weight of monochlorotrifluoromethane.

4. In combination, an environmental test chamber and a refrigerating system therefor comprising

a compressor for raising the pressure of a mixed gaseous refrigerant formed of dichlorodifluoromethane as a first constituent and an azeotrope constituted of trifluoromethane and monochlorotrifluoromethane as the second constituent thereof, condenser means for selectively effecting condensation of said first constituent of said mixed refrigerant, means disposed on the output side of said condenser for separating said condensed first constituent from the gaseous second constituent of said mixed refrigerant,

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means for selectively condensing said second constituent of said mixed refrigerant by counter current evaporation of said first constituent in heat exchange relation therewith, and

means for selectively evaporating said second constituent of said mixed refrigerant. 5

5. The combination as set forth in claim 4 wherein said second constituent azeotrope comprises 40.1% by weight of trifluoromethane and 59.9% by weight of monochlorotrifluoromethane. 10

6. The combination as set forth in claim 5 wherein the weight ratio of said first constituent to said second constituent comprises about 1.47

7. In a method of refrigeration, the steps of compressing a mixed gaseous refrigerant comprising 15
dichlorodifluoromethane as a first constituent and an azeotrope comprising about 40.1% by weight of trifluoromethane and about 59.9% by weight of monochlorotrifluoromethane as a second constituent thereof, 20

selectively condensing the first constituent of said compressed mixed refrigerant,
separating said condensed first constituent from said second constituent,

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selectively condensing said second constituent by counter current evaporation of said first constituents in heat exchange relation therewith, and
selectively evaporating said condensed second constituent of said mixed refrigerant.

8. The method as set forth in claim 7 wherein the weight ratio of said first constituent to the second constituent comprises about 1.47.

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U.S. Cl. X.R.

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