

Dec. 22, 1942.

J. J. SHIVELY

2,305,740

REFRIGERATION

Filed July 27, 1939

2 Sheets-Sheet 1

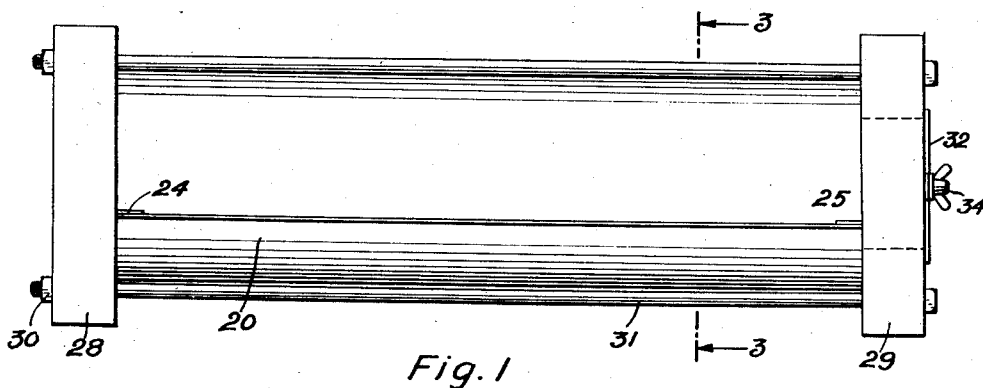


Fig. 1

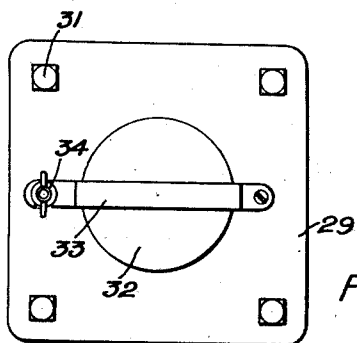


Fig. 2

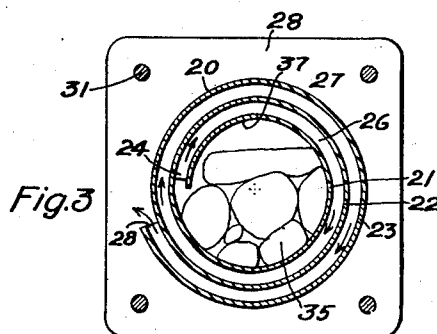


Fig. 3



Fig. 6

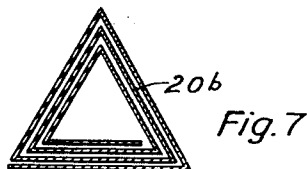


Fig. 7

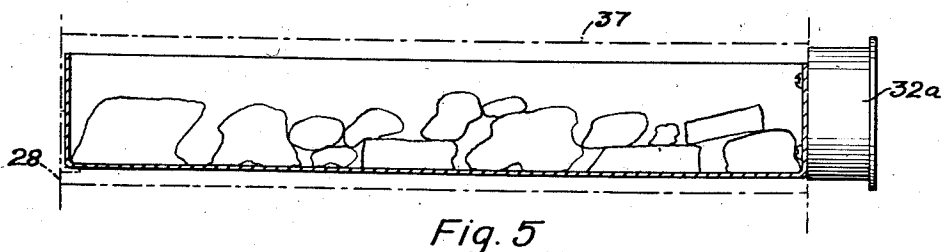


Fig. 5



Fig. 4

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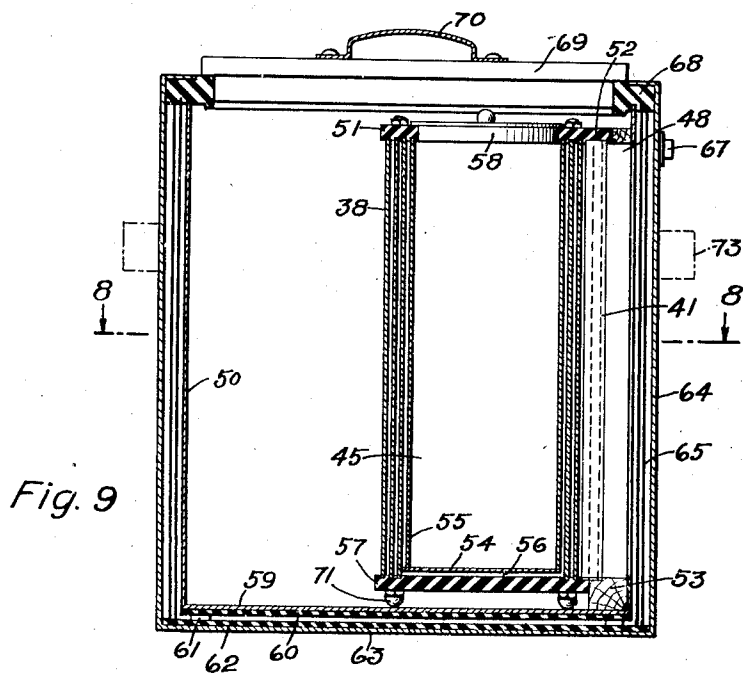
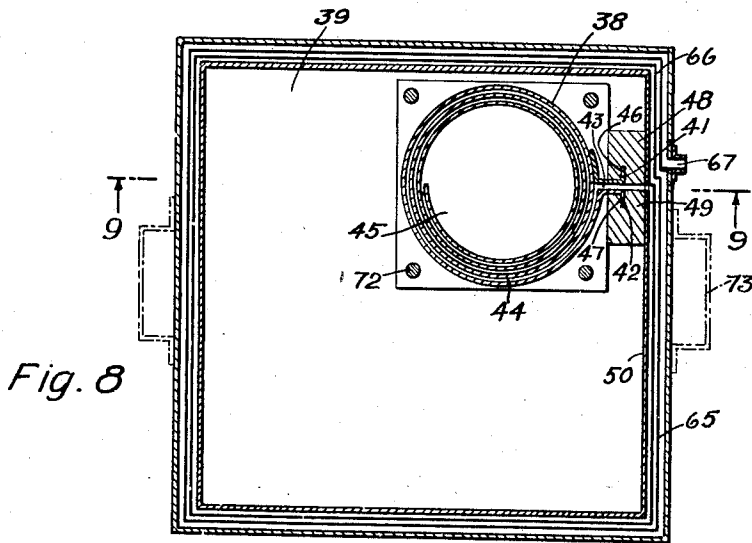
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REFRIGERATION

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2 Sheets-Sheet 2



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REFRIGERATION

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3 Claims. (Cl. 62—91.5)

This invention pertains to improvements in refrigeration and is directed more particularly to a method of and apparatus for restraining and otherwise controlling the evaporation of solidified carbon dioxide.

A purpose of the invention is to provide a method of controlling the evaporation of solidified carbon dioxide without the maintenance of super-atmospheric pressure.

A further object is to provide apparatus for the above purpose in which heavy masses of insulating materials may be avoided.

Another object is to provide a method of forming a heat insulating wall which consists in evaporating a portion of a body of refrigerant and leading the derived vapor in a path making one or more convolutions about the remaining refrigerant.

A further object is to provide a cooling unit having a wall formed in the above manner but in which heat may be transmitted to the refrigerant through the material defining the path of the escaping vapor in a direction counter to the flow of the vapor.

Another object is to provide means to employ the above method for insulating the walls of a refrigerator.

Another object is the provision of apparatus of the above types which shall be compact, simple and inexpensive.

Other objects and advantages will become evident to those skilled in the art during the course of the following description in connection with the attached drawings, in which:

Figure 1 is a side elevation of a cooling unit embodying the invention;

Figure 2 is an end view of the same;

Figure 3 is a cross sectional view of the same on the plane 3—3, Figure 1;

Figure 4 is a side view of the end plug;

Figure 5 is a longitudinal section of an alternative form of refrigerant receptacle;

Figure 6 is a diagrammatic cross section of an alternative shape of cooling unit body;

Figure 7 is a similar section of another form of the same;

Figure 8 shows a horizontal section of a refrigerator embodying the invention; and

Figure 9 is a vertical section of the same in the plane 9—9, Figure 8.

In the type of unit shown in Figures 1, 2 and 3, the body 20 of the cooling unit comprises a spirally wound sheet of heat conducting material, preferably metal such as aluminum. The convolutions 21, 22 and 23 of the spiral may be spaced

by narrow insulating strips 24 and 25 leaving a spiral passageway 26 leading from the central chamber 27 to the outlet opening 28. While the device is illustrated as having three complete convolutions, it should be understood that any number of convolutions may be used depending on the desired characteristics of the unit as hereinafter explained.

Plates 28 and 29 of insulating material, are clamped over the ends of the body 20 by means of nuts 30 on bolts 31. The plate 28 closes the left end of the central chamber 27, while the right end thereof is normally closed by a removable insulating plug 32 provided in the end plate 29. A clamp 33 and nut 34 may be used to hold the plug 32 firmly in position.

The operation of this form of the device is as follows:

The plug 32 is removed from plate 29, a supply of solidified carbon dioxide 35 placed in the chamber 27, and the plug 32 is replaced.

As the end plates 28 and 29 and plug 32 are insulators but little heat can pass through them. The effective cooling surface of the unit is therefore the outer surface of the body 20. Heat absorbed by this surface may find its way to the refrigerant 35 by two paths. First the heat may travel around the successive coils 23, 22 and 21 to the chamber 27 by direct conduction through the metal. Secondly, heat may pass radially inward from each coil to the next by radiation and conduction across the passageway 26. However, as the solidified refrigerant 35 evaporates, the evolved gas passes continuously outward through the passageway 26. Carbon dioxide gas being itself a good insulator, very little heat can be conducted through it between successive convolutions or coils. Furthermore, as the gas is flowing outward, any heat taken up by it is carried continuously outward. In other words, the flow of gas is counter to the inward flow of heat, thereby further retarding the latter. The surfaces of the coils 21, 22 and 23 may be polished, cutting radiation across the passageway 26 to a minimum by providing reflecting surfaces. The polished walls may also be crimped or slightly corrugated to prevent travel of heat along them by successive angular reflections.

From the above description it is evident that very little heat can penetrate radially to the refrigerant 35, and the major part of the heat absorbed by the outer surface of body 20 must be transmitted directly through the entire length of the inner coils. The rate of heat transmission through a conductor is dependent directly on the

cross sectional area of the conductor, and also on the length of the path of travel. In this case the above area is a single cross section of the sheet from which the coils 21, 22 and 23 are wound and the length of path is determined by the number and circumference of the coils. By using a thin sheet and a substantial total length of spiral the rate of transfer may be kept comparatively low, necessitating a correspondingly large temperature difference between the evaporating refrigerant in the chamber 27 and the outer surface of the body 20 in proportion to the heat absorbed. A thicker sheet, a shorter total length of spiral, or the combination of both gives a greater rate of heat transfer and consequently a smaller temperature difference between the refrigerant 27 and the outer surface.

As the flow of gas through the passage 26 is practically unrestricted, the pressure in the chamber 27 is approximately atmospheric and the temperature of the evaporating solidified carbon dioxide is held substantially constant at a point below -100° Fahrenheit. This low temperature if applied directly to a medium to be cooled, such as the interior atmosphere of an ordinary refrigerator would in most cases result in unduly violent cooling, causing freezing of objects near the cooling surface and wastefully rapid evaporation of the refrigerant. By proper selection of outer surface, sheet thickness and number of convolutions in the wall, the present invention may be made to operate with a surface temperature in any desired range above the evaporating temperature of the refrigerant through control of the rate of heat transfer as described. This control is accomplished without subjecting the refrigerant to superatmospheric pressures which would require tight and strong containers, relief valves, safety devices, etc. Furthermore, the only insulating material required by the cooling unit is the relatively small amount necessary for the end plates 28 and 29 and the plug 32.

While the body 20 has been described above as substantially cylindrical, it may have any convenient shape, such as the rectangular coils 20a, shown in Figure 6 or the triangular coils 20b, Figure 7, the only requirement in this respect being that the coil unit be continuous with a continuous passage for gas between convolutions.

In case it is desired to maintain a very low rate of evaporation a receptacle 36 for the solidified refrigerant 35 may be attached to the insulating plug 32a, Figure 5, so as to clear the wall 37 of the chamber 27. With this modification of the device, there is no direct transfer of heat from the wall 37 to the refrigerant, practically the entire cooling output being effected by slow conduction of heat from the evolved gas to the coils of the body as the gas moves outward between them. As a further modification, the device in this form may be used for storage of solidified refrigerant by making the coils of insulating material such as sheet fiber, the structure being much more compact than the usual heavily insulated storage receptacles.

In Figures 8 and 9 a cooling unit 38 of the general type described is placed vertically in the interior 39 of a refrigerator 40. A pair of angles 41 and 42, comprising between them the outlet 43 of the spiral passage 44 leading from the refrigerant chamber 45 are slidable vertically in grooves 46 and 47 in insulating ribs 48 and 49 fastened to the lining 50 of interior 39. The upper end plate 51 of the unit 38 has an exten-

sion 52 which overlies the angles 41 and 42 and engages the ribs 48 and 49 when the unit is in place, thus closing the top of outlet 43. The bottoms of angles 41 and 42 engage a cross block 53 to close the bottom of the outlet 43.

A bottom 54 is fastened to the inner convolution 55 of the unit 38 to support the refrigerant, a space 56 being provided between the bottom 54 and the lower end plate 57. The convolutions of 38 are spaced by being sunk into the plates 51 and 57, thus dispensing with spacers. An insulating lid 58 is provided in the upper plate 51.

Under the bottom 59 of the lining 50 is a layer 60 of insulating material supported by blocks 61 and spaced thereby from a second insulating layer 62 resting on the bottom 63 of the outer casing 64.

A vertical partition 65 comprising a number of continuous convolutions about the lining 50 is spaced between 50 and the outer casing 64 so as to form a continuous passage or labyrinth 66 leading from the outlet 43 of unit 38 to a vent 67 near the top of casing 64. The partition 65 may be of insulating sheet material or of very thin polished metal such as aluminum foil, and may be spaced by being supported in the second insulating layer 62 and an upper insulating frame 68. A large insulating cover 69 is removably fitted into the frame 68 and is provided with a handle 70.

Knobs 71, on the lower ends of bolts 72 holding the end plates 50 and 57, rest on the bottom 59 to assist in supporting the unit 38. The refrigerator 40 may be provided with carrying handles 73.

In operation of the refrigerator shown in Figures 8 and 9, solidified refrigerant is placed in the chamber 45. If desired, the entire unit 38 may be removed from the refrigerator for filling or to facilitate washing the bottom 59 and lining 50, the angles 41 and 42 sliding upward in the grooves 46 and 47. The unit 38 being charged and in place as shown, and the lids 58 and 69 having been replaced, the refrigerant in chamber 45 cools the unit 38 as previously described, while the interior 39 is cooled by the outer surface of 38. The gas evolved in chamber 45, having passed out through the spiral passageway 44 to the latter's outlet 43, enters the lining of the refrigerator between the blocks 48 and 49 and travels through the labyrinth 66 until it finally escapes at the outside vent 67. The gas thus makes several convolutions around the interior 39, acting as an insulator flowing counter to the direction of heat penetration in the same manner as described in connection with the cooling unit. The gas in its first circuit around the lining 50 may absorb a certain amount of heat from the latter, thus further aiding in refrigerating the chamber 39.

By use of the outward or counter-flowing successive layers of carbon dioxide both in the cooling unit and in the refrigerator shell as described, full use is made of both the refrigerating and insulating properties of the chemical, and the structure is light, simple and compact.

As carbon dioxide gas is heavier than air, the high location of the vent 67 keeps the passages 44 and 66 normally filled with the gas even when the flow is very slow or after the refrigerator may have been entirely used up.

While the invention is illustrated in preferred forms, it is not limited to the precise structures shown, as various modifications may be made

without departing from the scope of the appended claims.

What is claimed is:

1. In a cooling unit in combination, a chamber adapted to contain a volume of volatile refrigerant, means to conduct heat into said chamber comprising a single continuous metallic sheet disposed in a plurality of successive spirally overlapping convolutions about said chamber, said convolutions being outwardly spaced to form a continuous unrestricted passage for vaporized refrigerant directly from said volume of refrigerant in said chamber to the exterior of said unit, and insulating means to close the ends of said unit.

2. A cooling unit having a refrigerant chamber and a wall therefor comprising a continuous elongated sheet having high heat conductivity and disposed in a plurality of successive spirally overlapping convolutions about said chamber in outwardly spaced relation, the inner convolution

of said wall having unrestricted heat communication with refrigerant in said chamber.

3. In a refrigerator in combination, an outer shell, an inner shell comprising a refrigerating chamber and having a discharge opening therein, means between said shells forming a continuous passage making a plurality of convolutions about said chamber and having an outlet from said passage through said outer shell and an inlet to said passage through said inner shell, a cooling unit in said refrigerating chamber having therein a chamber adapted to contain a volatile refrigerant, the wall of said unit comprising a continuous heat conductor defining a second passage for escape of vaporized refrigerant in a plurality of convolutions around said refrigerant chamber and having a vapor discharge opening, and sealing means to connect said opening to said inlet.

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