Aug. 22, 1961 F. J. HOSKEN ET AL 2,996,898

VACUUM COOLING APPARATUS

Filed Dec. 10, 1956

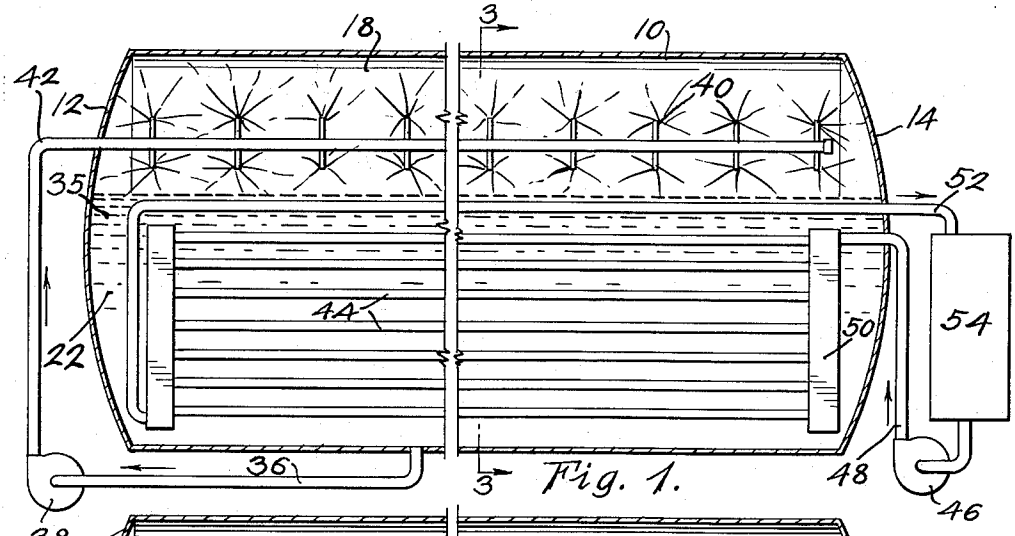


Fig. 1.

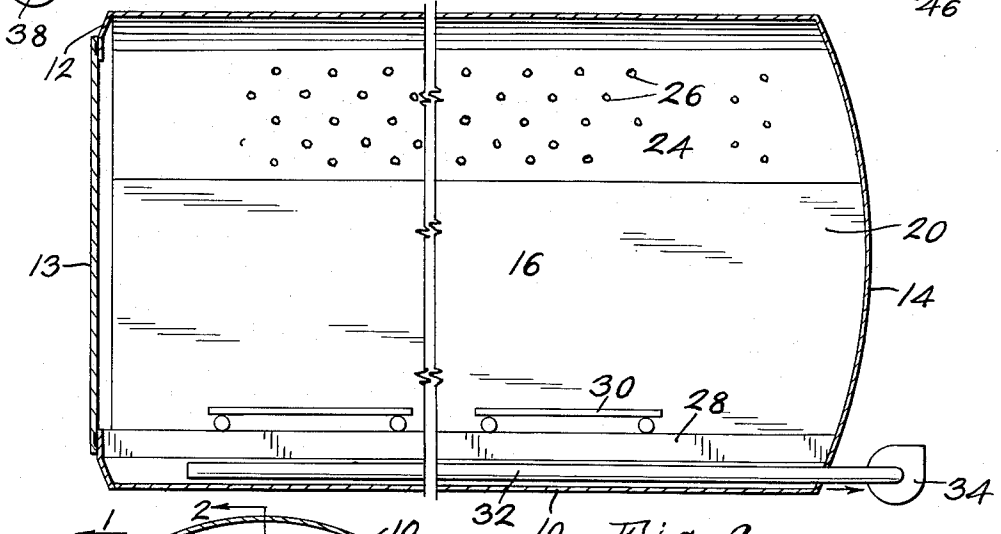


Fig. 2.

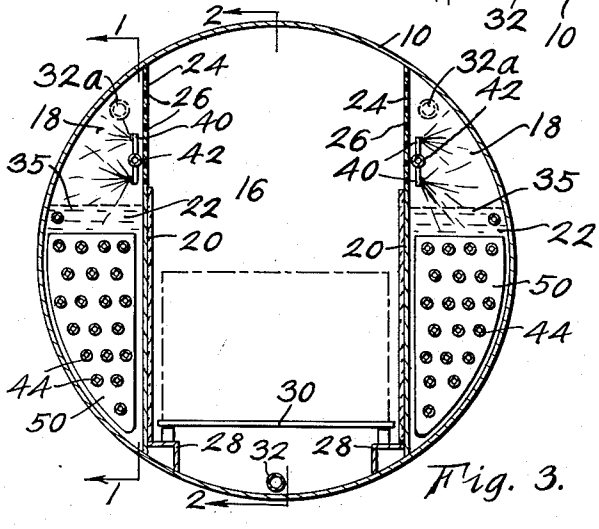


Fig. 3.

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United States Patent Office 2,996,898
Patented Aug. 22, 1961

2,996,898

VACUUM COOLING APPARATUS

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Filed Dec. 10, 1956, Ser. No. 627,208
6 Claims. (Cl. 62—268)

This invention relates to coolers for produce and the like and more particularly to vacuum cooling apparatus for maintaining comestibles in good condition during storage and shipment.

Vacuum cooling of produce to remove some of the moisture therefrom and prevent spoilage is a well known expedient which is practiced extensively by growers, shippers and warehousemen. In the prior art vacuum cooling systems, however, the low pressure steam produced as the water is boiled off the produce is condensed by passing it over refrigerated cooling coils that cause heavy layers of ice to form thereon with extremely poor heat transfer characteristics.

In addition, many of the conventional vacuum cooling installations use a gas to coil heat transfer system that is decidedly inferior in efficiency to the liquid to coil system employed in the novel vacuum apparatus that forms the subject matter of the present invention.

A further problem encountered with the prior art vacuum systems is that of maintaining the temperature of the cooling chamber below that of the freezing temperature of water at the reduced pressure which exists in the chamber. This is sometimes necessary in cooling vegetables such as string beans. In several of the prior art systems a spray is used to build up a layer of ice on the coils and these ice coated coils form the cold body that condenses the low pressure steam. When it is desirable to lower the temperature of the cooling chamber below the freezing point of water, however, the spray solution must be a relatively concentrated salt solution or the like which will build ice at a lower temperature. This solution cannot be recirculated and reused for all practical purposes because the condensate will effect a considerable dilution and attendant reduction in salt concentration, thus permitting the freezing point to rise.

Another problem is that of ice building on the coils to the extent that flow is restricted. This necessitates a defrosting operation usually accomplished by spraying a concentrated freezing point depressant solution over the coils to melt the ice therefrom and improve the heat transfer characteristics of the system as well as opening the flow path.

It is, therefore, the principal object of the present invention to provide an improved vacuum cooling apparatus that utilizes a refrigerated spray to condense the low pressure steam emanating from the produce.

A second object of the invention is to provide a vacuum cooling system which employs a liquid reservoir in which the refrigerating coils are immersed to produce more efficient heat transfer and prevent the buildup of a block of ice on the coils.

Another object of the invention is to provide a vacuum cooling apparatus wherein the spray that is used to condense the low pressure steam is continuously circulated.

A further object of the invention is the provision of a vacuum cooling system in which the volume of the condensate is so small compared with the volume of the spray solution that said spray solution can be used over and over again without having any appreciable effect on the concentration of any freezing point depressant dissolved therein, thus maintaining a relatively constant freezing temperature below that of water.

Additional objects of the invention are to provide a vacuum cooling apparatus that is simple, relatively inexpensive to build and operate, and one that does not require defrosting in order to improve the heat transfer and clear the flow path, although ice may be allowed to build on the coils during standby operation so that the latent heat of fusion thereof can be utilized to bring about a rapid cooling of the spray and condensate at the beginning of the actual produce cooling operation.

Other objects will be in part apparent and in part pointed out specifically hereinafter in connection with the description of the drawing that follows, in which:

FIGURE 1 is a vertical section taken along line 1—1 of FIGURE 3 showing one of the condensing chambers within the vacuum cooling apparatus of the present invention;

FIGURE 2 is a vertical diametrical section taken along line 2—2 of FIGURE 3 showing the cooling chamber therein; and

FIGURE 3 is a section taken along line 3—3 of FIGURE 1 illustrating the construction and relative positions of the cooling chamber and condensing chambers on opposite sides thereof.

Referring now to the drawing, the vacuum cooling apparatus of the present invention will be seen to comprise a large vacuum tank having a cylindrical body 10 closed at each end by heads 12 and 14. Head 12 includes a sealable access door 13 to admit the material being treated. The interior of the tank is divided into a central cooling chamber 16 and two identical condensing chambers 18 on opposite sides thereof by spaced partitions 20. Each partition is fluid tight from the bottom of the tank part way up to form cooling liquid reservoirs 22 within the condensing chambers. The upper portion 24 of the partitions, however, is provided with a plurality of openings 26 to admit low pressure steam from the cooling chamber 16 into the condensing chambers 22 above the liquid reservoirs therein, as shown most clearly in FIGURE 3.

The cooling chamber 16 is provided with longitudinally extending tracks 28 on opposite sides thereof upon which flats or dollies 30 can be placed to move the produce, indicated by dotted lines in FIGURE 3, into the tank. Along the bottom of the cooling chamber a suction or vacuum line 32 is positioned and connected through head 14 to a vacuum pump 34. Additional vacuum lines 32*a*, indicated by dotted lines in FIGURE 3, can be provided in the top of the compartments, if desired, and connected into the vacuum circuit including line 32 and pump 34. These vacuum lines, of course, are used to evacuate the tank until the pressure therein drops to the point at which the water carried on and within the produce vaporizes to produce low pressure steam. The latent heat of vaporization required to change the water to steam at the temperature and reduced pressure inside the tank comes from the produce resulting in its being cooled substantially. Also, removal of moisture from the produce also tends to destroy bacteria that would otherwise cause rapid spoilage. The low pressure steam being lighter than air will rise to the top of the tank and through the grids or openings 26 in the partitions into the condensing chambers.

The principal feature of the present invention lies in the use of a spray of refrigerated liquid to condense the low pressure steam rather than depending upon the poor heat transfer that would be attained by passing the vapor over the refrigerating coils. An examination of FIGURES 1 and 3 will show that each of the reservoirs 22 in the condensing chambers is filled with a liquid coolant indicated by numeral 35. This coolant liquid may be plain water if the temperatures to be maintained in the tank are not below the freezing point of water or a solution with a lower freezing point than water such as, for example, a brine solution, calcium chloride solution or

an ethylene glycol solution. A 5 percent ethylene glycol solution has been found quite satisfactory and has the added advantage of being a good carrier for a rust inhibitor. It is important to note that the volume of coolant in the reservoirs is quite large compared with the volume of condensed low pressure steam that will be taken from the produce. Therefore, the degree of dilution of the coolant liquid is relatively insignificant and the concentration of any freezing point depressant dissolved therein remains substantially unchanged. As a result, the coolant liquid can be circulated through the cooling system continuously and reused over and over again. Continuous circulation of the coolant and low pressure steam condensed thereby is accomplished by means of coolant line **36** that is connected through the bottom of the tank into each of the reservoirs **22**. A pump **38** raises the coolant liquid and condensed steam up to the top of the tank, whereupon it is fed back into the condensing chambers of the tank above the liquid level therein and sprayed out through nozzles **40** attached into spray line **42**. The spray of pre-cooled coolant liquid and condensed steam emanating from the nozzles contacts the incoming low pressure steam passing into the condensing chambers through the perforated portions of the partitions and causes it to condense and drop down into the reservoir. Of course, as the low pressure steam condenses it liberates its latent heat of vaporization to the coolant liquid and previously condensed steam. There fore, a refrigerating system must be provided to remove this added latent heat of vaporization from the coolant liquid in order to maintain a constant temperature therein.

In the specific construction illustrated in FIGURES 1 and 3, refrigerating coils **44** are completely immersed in each of the reservoirs. Pump **46** feeds the refrigerant through line **48** into head **50** connected to one end of the refrigerating coils and line **52** returns the refrigerant to the compressor and condenser, both of which have been indicated by box **54** as they are well known to the art. The coils **44** may be plain or finned and arranged in either parallel or series flow relation. The sole function of the refrigeration unit is to remove the heat from the coolant liquid that has been added by the condensation of the low pressure steam, thereby maintaining a relatively constant temperature throughout the coolant liquid. The refrigeration system does not directly, however, function to condense the steam as it is completely immersed in the coolant liquid. At this point it should be brought out that excellent heat transfer takes place between the liquid coolant and the refrigeration coils because of the highly efficient liquid-to-cold-body-heat-exchange relationship that is present. Such a relationship is many times more efficient than the gas-to-cold body system employed in the prior art processes. Also, the gas blanket and ice cake that builds up on the prior art refrigeration coils which insulates them and cuts down the efficiency of the heat exchange system are entirely eliminated in the present apparatus. Further the "delta *t*" or rise in temperature of the coolant liquid as the steam condenses is quite small, due to the volume of liquid in the reservoir, and the large heat transfer area of the refrigerating coils provides a system that will function to compensate for the "delta *t*" quite rapidly, easily and efficiently. At periodic intervals a portion of the coolant liquid should be drained from the reservoir and the concentration of any freezing point depressant dissolved therein brought up to normal. The spray nozzles are, of course, designed to substantially fill the condensing chambers above the liquid level with a spray of coolant so that the low pressure steam will immediately condense upon entering the spray. The spray creates an extremely large heat transfer surface that will condense the steam very rapidly.

The coil temperature is preferably maintained approximately 15 degrees colder than the freezing temperature of the spray solution and condensate that make up the liquid in the compartments. However, this liquid is not allowed to freeze to any appreciable extent during normal cooling operation by merely controlling the refrigerant by suitable thermostatic or electronic controls, not shown. When, however, the vacuum cooling apparatus of the present invention is not being used to cool produce but is in a standby condition, it is desirable to maintain a cool refrigerated atmosphere inside the tank in readiness for the receipt of produce. During this standby operation it has been found advantageous to permit a thin film of ice to build upon the coils as the latent heat of fusion required to convert the ice to water when produce is introduced into the tank provides means for rapidly bringing the temperature of the tank down to that required for cooling and it eliminates the need for a long cool down period or an oversized refrigerating unit to cool the tank in a short time. Of course, when in standby condition, no low pressure steam is being evolved to liberate its heat or vaporization upon condensation and the liquid in the reservoirs will gradually cool down until it freezes on the coils. With only a 15 degree differential between the coil temperature and the freezing point of the liquid, however, a relatively thin film of ice is all that can build up on the coils before the insulating characteristics of the ice film are sufficient to prevent a greater ice build up. Thus, the liquid in the tank cannot freeze to any appreciable extent. Upon the introduction of produce and the resultant vaporization and condensation of the water carried thereby, the liquid in the tank will rapidly heat up to a temperature at which the ice film will melt and remove its latent heat of fusion from the liquid, thereby accomplishing a rapid cool down of the tank and contents thereof. Actually, this brief defrosting operation is highly advantageous and eliminates the need for large capacity refrigerating units to handle the heavy cooling load at the beginning of a produce cooling cycle.

From the foregoing description of the several new and useful features of the vacuum cooling apparatus of the present invention it will be seen that the many useful objects for which it was designed have been achieved.

Although the invention has been described in connection with the one specific form thereof illustrated in the accompanying drawing, we realize that certain changes and modifications may be made therein by those skilled in the art without departing from the true scope of the invention. Therefore, it is our intention that the measure of protection afforded herein shall be limited only insofar as said limitations are expressly set forth in the appended claims.

What is claimed is:

1. In a vacuum cooling system, a hermetic enclosure including a sealable access door adapted to admit material to said enclosure for treatment, said enclosure having a fluid reservoir therein, a supply of liquid coolant within the reservoir, spray means extending within the enclosure along opposite sides thereof above the reservoir, pump and conduit means connected between the reservoir and spray means for circulating the fluid therebetween, refrigerating means immersed in the liquid coolant for cooling said liquid, and means communicating with the enclosure for evacuating the enclosure to vaporize any water carried by the material within said enclosure thereby cooling said material, said spray of coolant liquid forming means for condensing the vaporized water, and the refrigerating means acting to remove the heat from the coolant liquid and condensed vapor by said condensation.

2. In a vacuum cooling system, a hermetic enclosure including a sealable access door adapted to admit material to said enclosure for treatment, a fluid reservoir within the enclosure, a supply of coolant liquid within the reservoir, a refrigeration coil immersed in the coolant liquid, refrigerating apparatus for circulating a refrigerant through the refrigerating coil to maintain a sub-

stantially constant temperature throughout said coolant liquid, the refrigerant being at a temperature approximately 15 degrees cooler than the coolant liquid, suction means connected into the enclosure for reducing the pressure therein to the point at which any water carried by the material within said enclosure will boil off as low pressure steam, conduit means having spray nozzles connected therein located within the enclosure above the reservoir, and pump means operatively connected between the reservoir and the conduit means for withdrawing the coolant liquid from said reservoir and spraying it through the nozzles, the spray issuing from the nozzles being directed to interrupt the low pressure steam and acting to condense the low pressure steam and deliver it into the reservoir, the heat of vaporization given up upon condensation of the steam being carried away from the enclosure by the refrigerant within the refrigeration coil, the heat of vaporization required to vaporize the water on the material causing said material to be cooled.

3. In a vacuum cooling system, a hermetic enclosure including a sealable access door adapted to admit material to said enclosure for treatment, spaced partitions within the enclosure dividing the interior thereof into a cooling chamber and two condensing chambers on opposite sides thereof, the lower portions of said partitions being imperforate to form a coolant liquid reservoir in the bottom of the condensing chambers whereas the upper portion is perforated to admit vapors from the cooling chamber, a liquid coolant within the reservoirs of the condensing chambers, a refrigeration coil submerged in the coolant liquid in each of the reservoirs, refrigeration means for supplying a refrigerant to the refrigeration coils, said refrigeration means being operative to maintain a substantially constant temperature throughout the coolant liquid, spray means located above each reservoir within the condensing chambers and adjacent the perforated portion of the partitions, pump and conduit means connected between the reservoir and spray means for continuously delivering coolant liquid from said reservoir to said spray means, and suction means communicating with the lower end of said enclosure for evacuating the enclosure and vaporizing any water carried by the material being treated therein to cool said material, the spray of coolant liquid providing means for continuously condensing said water vapor as it passes through the partitions into the condensing chambers.

4. A device in accordance with claim 3 in which the coolant liquid contains a freezing point depressant dissolved therein so that the temperature of the cooling liquid can be maintained below the freezing point of water.

5. A device in accordance with claim 4 in which the coolant liquid contains approximately 5 percent glycol by volume and a rust inhibitor.

6. In a vacuum cooling system, a hermetic enclosure having a cooling chamber adapted to receive material for treatment and at least one condensing chamber including liquid spray means and a reservoir containing a source of coolant liquid, evacuation apparatus communicating with the lower end of said cooling chamber to establish a predetermined vacuum condition therein sufficient to convert any water carried by the material into vapor so as to cool the material whereupon the resultant vapor will flow upwardly from the material once the predetermined vacuum condition has been attained, means interconnecting said coolant liquid reservoir and said spray means for circulating a spray of coolant liquid through said spray means, the spray of coolant liquid being directed to intercept the vapor flowing upwardly from the material at a location removed from the produce so as to condense the vapor and deposit it into the reservoir, and refrigerating means immersed in the coolant liquid on said reservoir for selectively reducing the temperature of the coolant liquid including the condensed vapor to maintain a substantially constant temperature of the coolant liquid during the vacuum cooling operation.

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