This invention relates to an apparatus for cooling materials and more particularly to an apparatus for freezing foods and also storing foodstuffs at low temperature and high relative humidity so as to prevent spoilage and in which the apparatus can be easily adjusted as conditions demand, to provide any combination of (1) freezing foodstuffs, (2) storing foods at low temperature and (3) cooling and humidifying, and in which the apparatus can be used in any one of these capacities alone.

It is one of the principal objects of this invention to provide an apparatus for freezing foodstuffs in which the necessity for an extensive area of freezing surface in the freezing room is avoided and in which the air is refrigerated by recirculating it through coils in which ammonia, sulfur dioxide, Freon or other gaseous refrigerant is directly expanded so as to obtain the extreme low temperatures necessary and in which the coils are prevented from icing up by constantly washing them with brine which is sprayed over the coils at high velocity so as to prevent the formation of any ice or frost thereon. This washing of the coils also greatly increases the rate of heat transfer between the coil and the air because of the superior rate of heat transfer from the coils to the brine and from the brine to the air as compared with a direct transfer of heat from the air to the coils. The spraying of the coils with brine also creates a whirling film and high turbulence on the coils with resulting improved heat transfer qualities.

It is another object of this invention to provide such an apparatus which can be adjusted to provide any condition desired in the handling of foodstuffs, which flexibility greatly facilitates the use of the apparatus in different seasons or under different conditions. Thus, the apparatus can be used for any combination of freezing foodstuffs. It can be used in the plain low temperature storage of foodstuffs and it can be used solely in the cooling and humidifying of foodstuffs, the humidification preventing loss of weight or discoloration due to the drying out of the foodstuffs.

This rotation in the use of the machine from freezing, cooling and humidifying or plain low temperature storage is accomplished by very simple regulating means controlling the amount of refrigerant admitted to the cooler.

Another object of the present invention is to increase the flexibility of the apparatus as above set forth by providing additional means located in another room so that any combination of desired conditions can be obtained. Thus, in the preferred form of my invention the main cooler is located in a freezing room and in use this cooler can be rotated from freezing to cooling and humidifying or plain low temperature storage. In addition the apparatus shown includes a second cooler operatively connected with this cooler and located in a cooling room. By the use of this secondary cooler any desired condition can be maintained in the cooling room and hence while the primary cooler is used for freezing, the secondary cooler can be used for cold storage or for cooling and humidifying so that any desired combination of freezing, cooling and humidifying or plain low temperature storage can be obtained in either room.

The accompanying drawing is a vertical section through a freezing and cooling room showing coolers embodying my invention installed therein.

The numeral 1 represents a freezing room and the numeral 2 a cooling room, the freezing room being as a rule much smaller than the cooling room and being used to freeze foodstuffs and the cooling room being much larger and being used to either hold the foodstuffs in a frozen condition at low temperature or hold the foodstuffs at low temperature with relative humidity so as to prevent deterioration of the same. In freezing foodstuffs in the freezing room 1 the foodstuffs are piled in tiers in any suitable manner and the air is maintained at such low temperature as to quickly freeze the foods. The foodstuffs stored in the storage room are likewise held at a freezing or low temperature with high relative humidity in the cooling room. The high relative humidity in the cooling room is desirable to prevent loss of weight or discoloration of the articles being stored therein.

The air in the cooling room 1 is maintained at a low temperature by drawing the same through the casing 3 of a brine spray cooler A. For this purpose suitable air inlet louvers 4 are provided in the bottom of the casing 3 and fans 5 are located in the top of this casing and driven by an electric motor 6 so as to draw air through the inlet louvers 4 and casing 3, the air being discharged through outlet ducts 7. Within the casing 3 is mounted a series of coil tubes 8, the opposite ends of which connect with an outlet header 9 and an inlet header 10. In these hairpin coils or tubes a refrigerating liquid is directly expanded, such liquid being ammonia, Freon, sulfur dioxide or the like. The liquid refrigerant is supplied to these coils by means of any standard compressor-condenser system, such being di-
agrammatically illustrated as comprising a compressor 11 withdrawing the gaseous expanded refrigerant from the outlet header 9 through a line 15 and compressing and passing it through a condenser 13 in which it is cooled and condensed and passes into a receiver 14 from which it passes through a line 12 to the inlet header 10 under control of a thermostat 16. To effect such control an expansion valve 17 is provided in the liquid or supply line 12 to the coils and is actuated by a thermal member 18 attached to the suction line 15 and the thermostat 16 controls a magnetic valve 19 on the liquid line which is disposed in advance of the expansion valve 17. The thermostat 16 is located in the freezing room 1 and controls the expansion valve 17 so as to maintain the temperature of the freezing room at the setting of the thermostat 16. In freezing foodstuffs this setting is, of course, well below the freezing temperature of the foods in the freezing room so as to quickly freeze the foodstuffs. However, the setting of the thermostat 16 is adjustable so as to provide any desired condition in the freezing room 1. Thus, if a low freezing temperature is desired in the room the thermostat 16 is set accordingly and at this setting the thermostat 16 functions with an expansion valve 19 so as to admit sufficient liquid refrigerant to the expansion coils 8 to maintain the desired low temperature. If it is desired to use the room for plain cold storage the thermostat 16 is set to the temperature desired and the thermostat will then function with the expansion valve 19 to maintain this temperature. If it is desired to maintain a higher cooling temperature but with high relative humidity the thermostat 16 is set higher and the desired temperature maintained in the freezing room 1. At the same time the desired high relative humidity will be maintained by means which are preferably constructed as follows:

In order to increase the heat transfer between the hairpin tubes 8 and the air stream drawn through the casing 3 by the fans 5, and also to maintain a high relative humidity of the air in the freezing room 1, brine is sprayed against the upper and lower sides of the hairpin tubes 8 from a plurality of upper and lower brine spray nozzles 20 and 21. A more detailed description of the location of the brine sprays is set forth in the co-pending application of Claude A. Bulkeley, Ser. No. 697,032, filed August 28, 1933, which has matured into Patent No. 2,038,536, dated April 28, 1936, to which reference is made for a more detailed description of the construction and operation of the cooler. The brine spray nozzles 20 and 21 are carried by upper and lower brine pipes 22 and 23 and brine is supplied to these pipes from a brine inlet pipe. The brine collects in the bottom of the casing 3 and is withdrawn through the pump suction 24 of a pump 25 which is driven by an electric motor 26. The outlet from the pump 25 connects with a three-way diaphragm valve 20 which controls the admission of brine to the pipe 30 which connects the upper and lower brine pipes 35 22 and 23. When the three-way diaphragm valve is held in the position connecting the pump 25 with the pipe 30 it will be apparent that brine is withdrawn from the bottom of the casing 3 and sprayed against the upper and lower sides of the hairpin tubes 8 so as to constantly wash the coils and prevent the formation of any ice thereon as well as to create a constantly replenished whirling film of brine thereon which greatly increases the rate of heat transfer from the hairpin tubes 8 to the air stream.

In the handling of foodstuffs it is desirable to increase the flexibility of the cooling unit in the freezing room 1 by having it function a somewhat similar cooling unit in a separate air control. By providing two such interconnected separate rooms any desired combination of conditions in the two rooms can be obtained. Thus, while the unit A is being used for freezing the unit in the cooling room 2 can be used for holding the foodstuffs in a frozen condition or for maintaining the conditions in the cooling room 2 at low temperature and high relative humidity so as to store these foods without deterioration, loss of weight or discoloration preparatory to being frozen.

To secure this additional flexibility a brine spray cooler B which is generally similar to the brine spray cooler A is located in the cooling room 2, this brine spray cooler B having a casing 31 with an inlet header 32 at its lower end and a brine being drawn through by means of fans 33 and redischarged into the room through air outlets 34, the fans being driven by a motor 35. In the casing a plurality of hairpin tubes 36 are mounted, the opposite ends of these tubes being connected with an inlet header 37 and an outlet header 33. The cooling medium which is supplied to these two hairpin tubes 36 is the brine from the brine spray cooler A in the freezing room. To effect this the other outlet of the three-way diaphragm valve 38 connects a pipe 41 discharging into the inlet header 37 of the brine spray cooler B. The outlet header 33 is connected by a pipe 42 with the pipe 30 which connects the upper and lower brine pipes 22 and 23 of the brine spray cooler A.

The three-way diaphragm valve 26 is controlled by a thermostat 45 in the cooling room 2. As the temperature in the cooling room rises above the setting of the thermostat 45, the thermostat 45 functions the diaphragm valve 26 to pass a greater proportion of cold brine from the bottom of the brine spray cooler A through the hairpin tubes 36 of the brine spray cooler B and the air passing through the brine spray cooler B will be decreased in temperature. This results, of course, in a greater load on the brine spray cooler A and as the temperature in the freezing room rises above the setting of the thermostat 16 the thermostat 16 functions to admit more refrigerant to the expansion coils 8 and maintain the freezing room at the desired low temperature. In order to secure a high relative humidity in the cooling room the hairpin tubes 36 are also sprayed with water or brine. For this purpose, as with the brine spray cooler A, water or brine is sprayed against the upper and lower sides of the hairpin tubes 36 from a plurality of upper and lower spray nozzles 50, 51. The spray nozzles 50 and 51 are carried by upper and lower brine pipes 52 and 53 and brine is supplied to these pipes from a brine inlet pipe 54 which connects with the outlet of a pump 55. This pump is driven by an electric motor 56 and discharges the water or brine from the bottom of the casing of the spray cooler B through a pump suction 51.

It has been found that the air in the freezing room 1 can be maintained at the desired low temperature for freezing foodstuffs with the use of a brine spray cooler A and that a brine spray cooler quickly responds to heavy loadings, bringing up, etc., as bringing in a large quantity of food to be frozen. In its action, the brine spray cooler A provides a means for quickly recirculating the air in the freezing room and passing this
air directly through tubes in which ammonia or the like is expanded and which are maintained at such low temperature as to cool the air well below the freezing point of the foods to be frozen.

Further, by subjecting these tubes to the constant washing, at high velocity of sprays, from both sides, the rate of transfer of the heat from the air stream to the hairpin tube is greatly increased, inasmuch as the transfer of the heat from the air to the whirling layer of water is rapid and also the transfer of heat from this whirling layer of water to the pipes is effected at a high rate of speed. Further, since the water is constantly being washed off the pipes the effective area of contact between the water and the air is greatly increased. The washing action of the water or brine on the tubes also prevents the formation of any ice even though the temperature of the tubes is below the freezing point of the brine solution being used.

Furthermore, it will be seen that by adjusting the thermostat to the temperature maintained in the room 1 the temperature of the cooling means and the temperature of all of the air leaving said coils well below the freezing point of said foods, means for passing an air stream through said casing and circulating the air stream over said foods, means for conducting cooled refrigerant to said coil and permitting it to expand therein and maintain the temperature of said cooling coil and the temperature of all of the air leaving said coils well below the freezing point of said foods, means for passing a liquid over the exterior of said cooling means, a second casing, a cooling coil in said second casing, means in said first casing for collecting the liquid from the coil in said second casing, means for conducting the liquid from the coil in said second casing to said means for spraying the liquid over the coil in said first casing to be recooled, means for by-passing variable amounts of liquid from said pump to said means for spraying the liquid over the coil in said first casing to be recooled, means for passing an air stream through said second casing, means for spraying liquid over the coils in said second casing, means for collecting the liquid so sprayed and means for returning this collected spray water to the means for spraying the liquid over the coils in the second casing.

1. A cooling system for freezing foods in a freezing room, comprising a casing, a refrigerant expansion coil in said casing, means for passing an air stream through said casing and circulating the air stream over said foods, means for passing the cooling medium admitted to the cooling means in said first casing in response to the temperature maintained by the air leaving said first casing and means for controlling the amount of liquid admitted to the coil in said second casing in response to the temperature maintained by the air leaving said second casing.

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