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METHOD AND APPARATUS FOR REFRIGERATION

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2 Sheets-Sheet 1

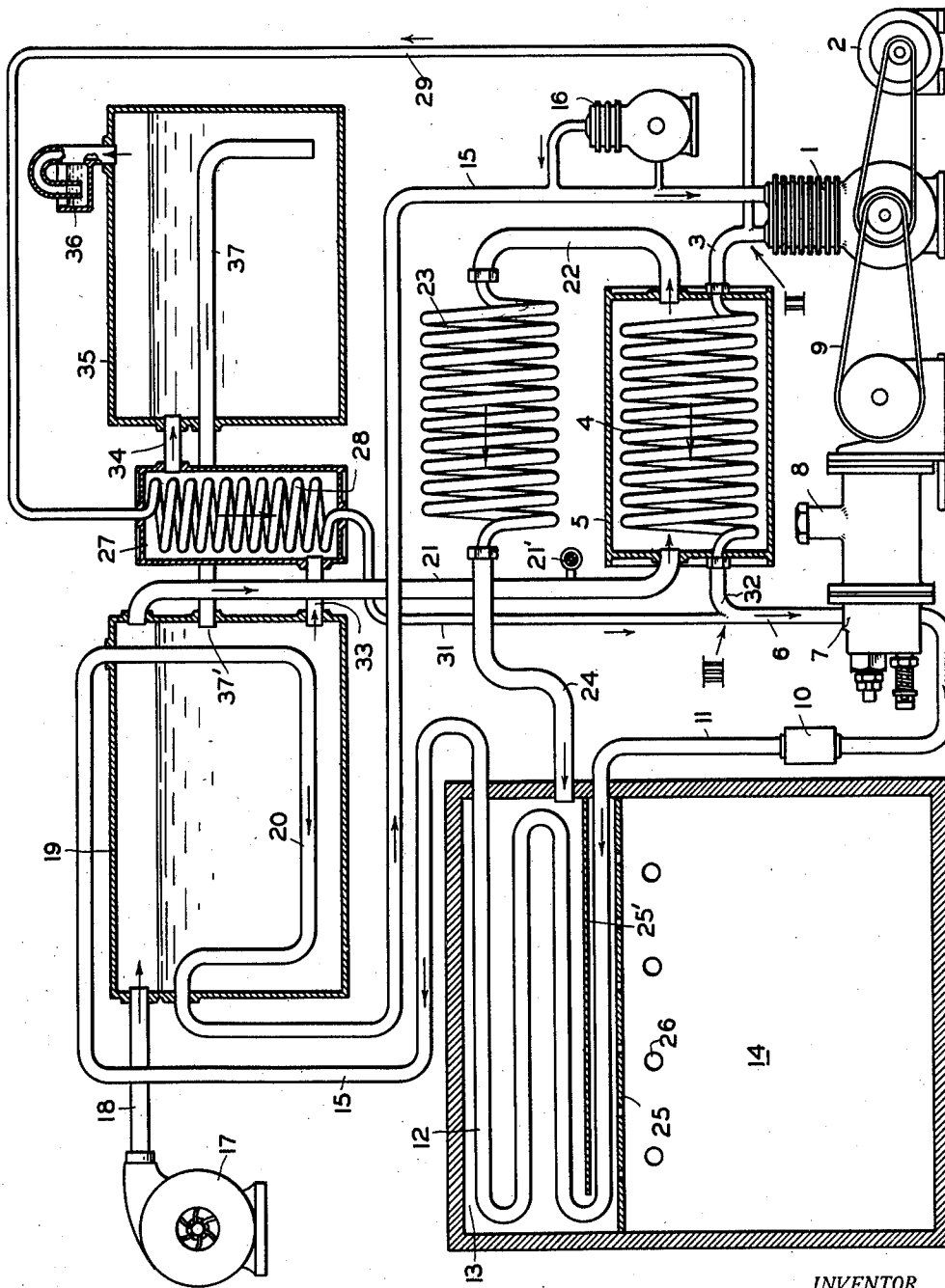


FIG. 1.

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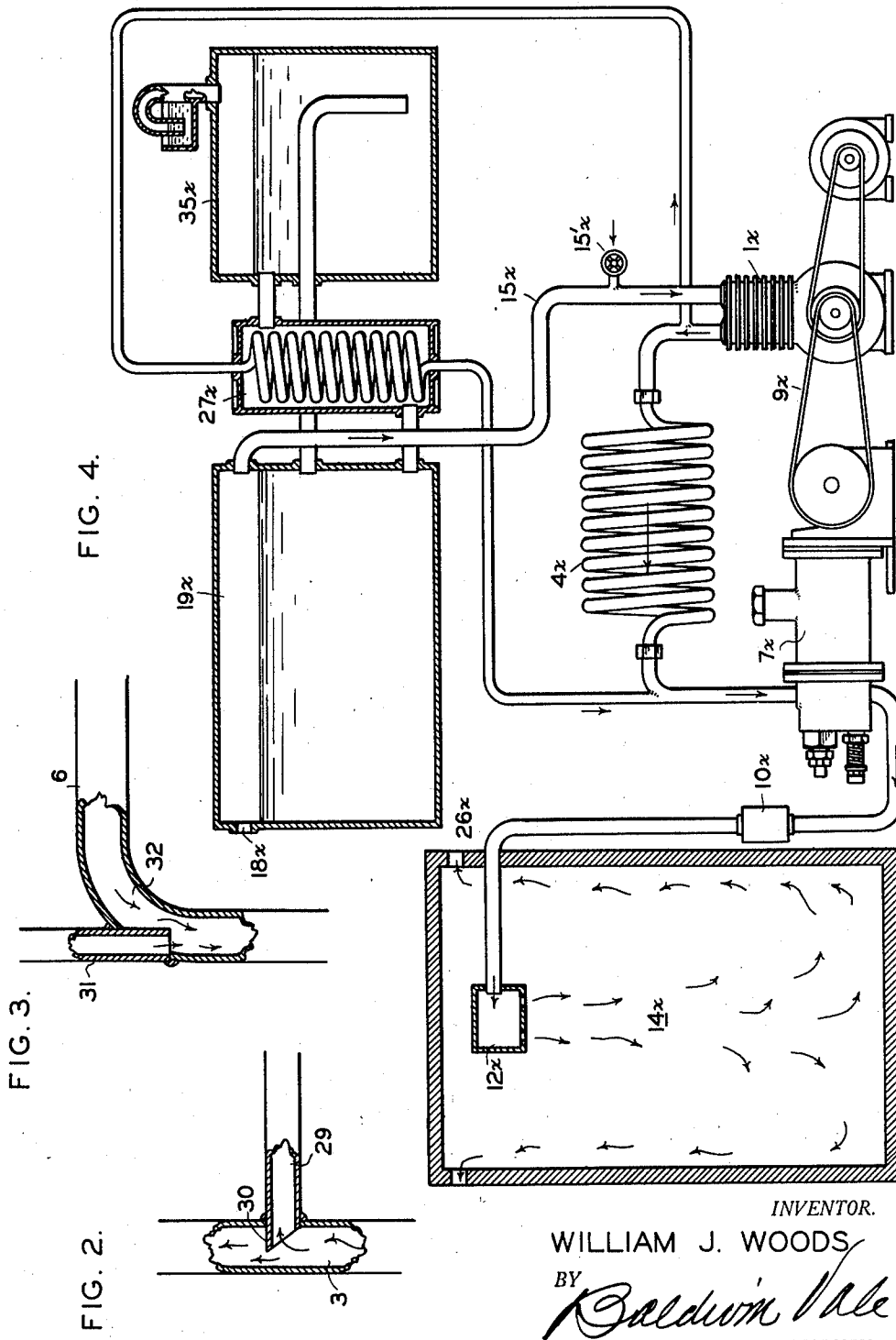
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METHOD AND APPARATUS FOR REFRIGERATION

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4 Claims. (Cl. 62-136)

This invention relates to improvements in methods and apparatus for refrigeration and more particularly to refrigerating systems utilizing air as the cooling medium.

Among the objects of the invention is to render practical refrigeration by the compression cooling and subsequent controlled expansion of atmospheric air.

Another object is to provide an apparatus having a large refrigerating capacity with the minimum horsepower expenditure.

Another object is to safeguard the foodstuffs against tainting by omitting the poisonous gases in general use as cooling media.

Another object is to efficiently create low temperatures for the prolonged refrigeration of foodstuffs in transit.

Another object is to sterilize the air used to prevent contamination of the foodstuffs by the refrigerating medium.

Another object is to reduce the humidity of the circulating air. This causes a dry surface gloss to form on the foodstuffs, preventing further evaporation of moisture and oxidization of the commodities.

Another object is to dehydrate the drying agent to compensate for the moisture absorbed from the air.

Another object is to design the apparatus to require the minimum of attention during its operation.

Other objects and advantages appear as the description progresses.

In this specification and the accompanying drawings, the invention is disclosed in its preferred form. It is, however, to be understood that it is not limited to this form because it may be embodied in other forms without departing from the spirit of the invention as defined in the claims following the description.

In the accompanying two sheets of drawings:

Fig. 1 is a schematic diagram partly in vertical section of an apparatus suitable for the practice of the present method of refrigeration.

Figs. 2 and 3 are detail views in vertical section of portions of the circulatory system indicated at II and III, respectively, in Fig. 1.

Fig. 4 is a schematic diagram of a modified form of the apparatus.

In detail, the construction shown in the drawings, referring more particularly to the form shown in Fig. 1, comprises the air compressor 1, driven at the required speed by any suitable prime mover such as the motor 2. The air compressed at 1 is delivered at a pressure depend-

ing upon the refrigerating temperature desired, the size of the refrigerating unit and other conditions. In the present instance, the compressed air is maintained at a pressure of 105 pounds per square inch with a consequent temperature of over 200 degrees Fahrenheit.

The compressed air passes from the compressor 1 through the pipe 3 and the cooling coils 4, which are enclosed within the air-cooled casing 5. As the air passes through these cooling coils its temperature is progressively reduced until it reaches atmospheric temperature as the air approaches the opposite end of the coil.

The end of the coil 4 leads through the pipe 6 into the intake of the reciprocating engine 7 of the type made the subject matter of further applications. This engine is dry lubricated from the reservoir 8 for successful operation at low temperatures, thus obviating the use of liquid lubricants which would congeal at the operating temperatures of the engine. The expansion engine closes the end of the pipe 6, thus creating a substantially sealed reservoir in the pipes 3, 6 and the coil 4 to maintain the pressure of the compressed air therein.

A predetermined volume of air is intermittently admitted into the engine from the cooling coils and is permitted to expand within the engine cylinder and is discharged therefrom at the end of the engine cycle at substantially atmospheric pressure. The expansion of the air proportionately lowers its temperature to the point desirable for refrigerating. This temperature can be regulated to accord with the conditions of the specific application of the apparatus, by varying the pressure maintained by the compressor 1 by regulating the cutoff of the expansion engine 7 and the length of the cooling coils to control the number of thermal units dissipated at 4.

The speed of the expansion engine is retarded and regulated by belting or otherwise linking the engine to the compressor 1 at 9. The energy derived from the expansion of the air within the engine cylinder transforms the engine into a power unit, thus assisting in the driving of the compressor. An approximate equilibrium between the power output at 7 and the power consumption at 1 is established by the belt 9, permitting the use of a motor of moderate horsepower at 2.

The screen filter 10 is provided at the outlet of the expansion engine to cleanse the air passing therethrough of particles of dry lubricant dispersed by the engine 7 and other foreign substances. The expanded air is delivered through

the pipe 11 into the refrigerating coils 12 located in the compartment 13 at the top of the cooling chamber 14. As the refrigerated air passes through the coils 12 it absorbs the heat from the air circulating in the compartment 13, chilling it to the required temperature.

The air from the coils 12, still at a low temperature, is returned to the intake of the compressor through the return pipe 15—15. The already chilled air is then subjected to another cycle of refrigeration through the circulating system with the further dissipation of thermal units at 4 and a consequently lowered temperature at 12. The refrigerating air is thus further chilled each time it passes through the circulating system until it reaches a constant temperature determined by the efficiency of the apparatus and the law of diminishing returns.

The air lost by inevitable leaks in the system is replaced by the conventional automatic air injector 16 which injects air from the atmosphere into the return pipe 15 whenever the pressure therein falls below a predetermined minimum.

The portion of the apparatus thus far described is sufficient to serve as a complete refrigerating unit for small installations at a minimum cost. It is essential that foodstuffs be safeguarded against spoiling when stored for extended periods. This is accomplished by dehumidizing and sterilizing the free air circulating over the commodities before being admitted into the cooling chamber.

The air to be circulated through the cooling chamber 14 is drawn from the atmosphere by the blower 17 and forced through the pipe 18 and released above the top of the drying agent contained in the closed tank 19. The drying agent can be any suitable chemical moisture absorbent, preferably liquid, such as sulphur dioxide. The drying agent abstracts the moisture from the air as it passes thereover and dehumidizes it to the relatively low point of humidity desirable for refrigeration.

Since it is a fact that chemical drying agents of practically any nature become heated in proportion to the amount of moisture absorbed, it is advisable to arrange the pipe 15 to pass through the tank 19 at 20. Lowering the temperature of the drying agent also increases its efficiency.

The constant draft maintained by the blower 17 forces the dry air from the tank 19 through the outlet pipe 21 and discharges it into the casing 5 containing the cooling coils 4. The cold draft from 21 circulates among the coils 4 and absorbs thermal units therefrom and cools the coils to the temperature previously described. Suitable baffles, obvious to those skilled in the art, may be arranged within the casing 5 to insure the proper circulation of the air among the coils 4.

In thus cooling the coils 4, the air circulating in the casing 5, as it approaches the opposite end thereof, becomes heated to a temperature of above 300 degrees F. This high temperature completely sterilizes the air, exterminating rot and mold spores and all other bacterial growths deleterious to the foodstuffs to be refrigerated. By thus hygienically sterilizing the air to be circulated in the cooling chamber, foodstuffs can be stored for prolonged periods without danger of spoiling.

The heated air passes from the casing 5, through the pipe 22, into the secondary cooling coils 23, wherein it is again cooled to atmospheric

temperature. The cooled air is conducted through the pipe 24 and is released in the compartment 13 of the cooling chamber 14.

It will be obvious to those skilled in the art that the blower 17 could be installed at the point 24 to place the air circulating through the coils 23, the casing 5, and the tank 19 under a minus pressure. This would tend to reduce the air resistance within the coils 4 and expedite the circulation of air throughout the system. With the blower 17 located at 24 a valve controlled bypass such as 21' can be provided to admit atmospheric air into the line 21 when desired. The valve 21' can be regulated to mingle a predetermined ratio of air of atmospheric humidity with the dry air in the pipe 21 to render the circulating air of the precise humidity desired.

The air entering this compartment 13 rises by thermal displacement due to its relative warmth and circulates among the refrigerating coils 12, gradually becoming chilled, then descends through the perforated partition 25 into the cooling chamber 14. The baffle plate 25' is provided to cause the air circulating in the compartment 13 to travel laterally to impinge upon the full length of the coils 12 before descending through the partition 25. The air chilled in the compartment 13 circulates among the commodities stored in the cooling chamber 14, finally escaping through the ports 26 provided in the upper sides of the chamber as the air becomes relatively warmed.

If the drying agent in the tank 19 is a liquid such as sulphur dioxide, it may be continuously circulated through an auxiliary dehydrating system to drive off the moisture absorbed from the atmosphere to prevent the drying agent from becoming saturated. The heater 27 has the coil 28 supplied through the pipe 29 with the hot air compressed at 1. The deflector 30 (see also Fig. 2) is provided at the junction of the pipe 29 with the pipe 3 and serves to direct a portion of the current of air from the compressor 1 into the pipe 29.

The opposite end of the coil 28 has the return pipe 31 leading therefrom and rejoining the compressed air line at an elbow such as 32 in the pipe 6, as also detailed in Fig. 3. This arrangement of the end of the pipe 31 causes the compressed air flowing in the pipe 6 to aspirate the air from the pipe 31, thus expediting circulation in the heating coil 28.

The liquid drying agent enters the heater at the lower end thereof through the pipe 33 and rises within the heater by thermal displacement as it becomes heated by contact with the coil 28. The heated liquid passes out of the upper end of the heater through the pipe 34 into the closed vaporizing tank 35. The heating of the liquid drying agent evaporates the moisture dissolved therein, which is allowed to pass off in the tank 35. The accumulations of vapor within the tank escape from the tank into the atmosphere through the water trap 36.

The pipe 37 has its inlet extending into the lower stratum of liquid at the bottom of the tank 35 and discharges at a higher level 37' into the tank 19. The dehydrated liquid from the bottom of the tank 35 rises within the pipe 37, thermally displacing the cooler liquid at the terminus of the pipe, and flows back into the tank 19. The thermosyphonic action of the liquid within the heater 27 also tends to raise the liquid in the tank 35 to a higher level than that in the tank

19, thereby inducing a gravity flow of the liquid back through the pipe 37.

The form of the apparatus just described is known as the "closed cycle" since the refrigerating air is not liberated at the end of the cycle but returned to the intake of the compressor to be subjected to further refrigeration. The apparatus may also be modified to perform an "open cycle" of operation wherein the refrigerated air is released within the cooling chamber 14.

This form of the apparatus is shown in Fig. 4 and comprises, in detail, the motor driven compressor 1x which is supplied with dehumidized air drawn through the intake pipe 15x from above the liquid drying agent contained in the tank 19x. The air in this tank is replenished from the atmosphere through the port 18x as it is withdrawn by the intake 15x. The drying agent is continuously dehydrated in the heater 27x and the vaporizing tank 35x to prevent its becoming saturated with the moisture absorbed. Suitable means can be provided for cooling the drying agent in the tank 19x to counteract the heat incidental to the absorption of moisture. The valve controlled bypass 15'x is provided to mingle atmospheric air with the dried air in the intake 15x to obtain a mixture of the desired humidity.

The dehumidized air is compressed at 1 to a pressure depending upon the conditions of refrigeration required. In this instance the air is raised to a pressure of about 90 pounds with a consequent temperature of around 375 degrees F. This temperature is sufficient to completely sterilize the air, exterminating all bacterial growths therein that are deleterious to the foodstuffs to be refrigerated.

The sterilized air passes from the compressor 1 and is cooled to atmospheric temperature within the cooling coils 4x. The end of the coil 4x leads into the intake of the dry lubricated expansion engine 7x, wherein the compressed air is expanded to atmospheric pressure. The power produced by the expansion of the air within the engine 7x is utilized to assist in the driving of the compressor 1x by the belt connection 9x therebetween.

The expansion of the air at 7x chills it to a temperature suitable for refrigerating. A screen filter such as 10x is provided at the outlet of the expansion engine to cleanse the air of any dry lubricant dispersed by the engine 7x, and other impurities. The refrigerated air is conducted through the pipe 11x into the perforated manifold 12x at the top of the cooling chamber 14x. The air liberated through the manifold 12x descends in the central portion of the cooling chamber as indicated by the arrows in Fig. 4 and circulates among the foodstuffs stored therein. As the circulating air becomes relatively warmed, it rises along the sides of the chamber and passes

into the atmosphere through the ports 26x provided at the upper end thereof.

Having thus described this invention what is claimed and desired to secure by Letters Patent is:

1. The method of refrigeration consisting of compressing air to a relatively high pressure and temperature; cooling the compressed air; expanding the cooled air to lower its temperature to a point suitable for refrigeration; then delivering the expanded air back to the compressor to be subjected to another cycle of refrigeration; creating a draft of atmospheric air; heating said draft to a temperature sufficient to effect sterilization by circulating the draft in proximity with said heated compressed air; cooling said draft to atmospheric temperature then circulating said draft in proximity with said chilled expanded air.

2. The method of refrigeration consisting of compressing air to a relatively high pressure and temperature; cooling the compressed air; expanding the cooled air to lower its temperature to a point suitable for refrigeration; then delivering the expanded air back to the compressor to be subjected to another cycle of refrigeration; creating a draft of atmospheric air; drying said draft to a relatively low absolute humidity; heating said draft to a temperature sufficient to effect sterilization by circulating said draft in proximity with said heated compressed air; cooling said draft to atmospheric temperature; then circulating said draft in proximity with said chilled expanded air.

3. The method of refrigeration consisting of compressing air to a relatively high pressure and temperature; cooling the compressed air; expanding the cooled air to lower its temperature to a point suitable for refrigeration; then delivering the expanded air back to the compressor to be subjected to another cycle of refrigeration; creating a draft of atmospheric air; drying said draft to a relatively low absolute humidity by means of a liquid chemical drying agent; heating said draft to effect sterilization; cooling said draft back to atmospheric temperature; then circulating said draft in proximity with said chilled expanded air; cooling said drying agent by passing the chilled expanded air in proximity therewith; and dehydrating said drying agent by continuously heating relatively small quantities thereof; and delivering said heated drying agent into a vaporizing chamber; then returning the dehydrated drying agent back to its source.

4. The method of refrigeration consisting of creating a draft of atmospheric air; drying said draft to a relatively low absolute humidity; heating said draft at atmospheric pressure to a temperature sufficient to effect sterilization; cooling said draft to atmospheric temperature; then circulating said draft in proximity with suitable chilled coils.

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