

Aug. 23, 1966

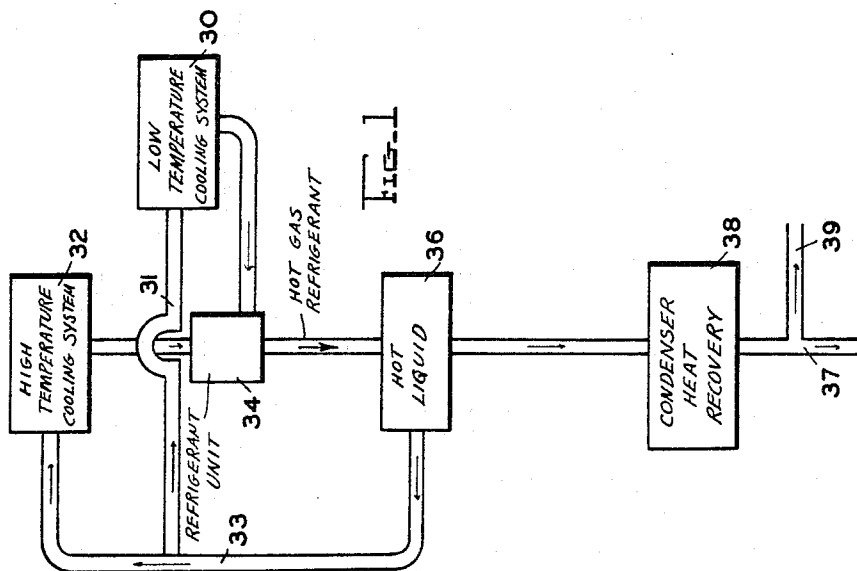
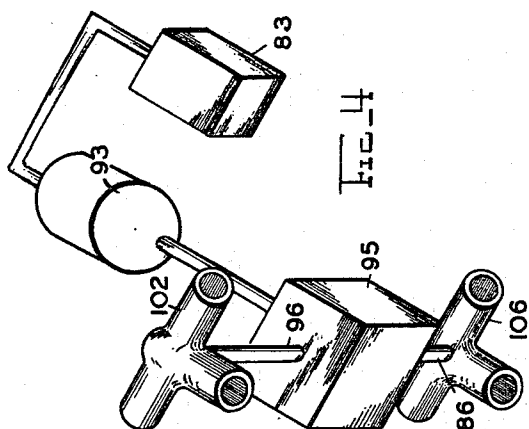
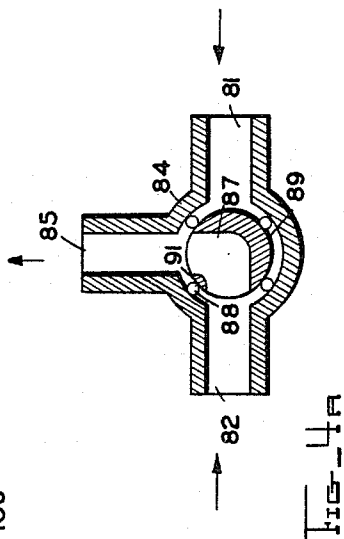
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HIGH AND LOW TEMPERATURE REFRIGERATION SYSTEMS
WITH COMMON DEFOSTING MEANS

Filed March 19, 1964

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

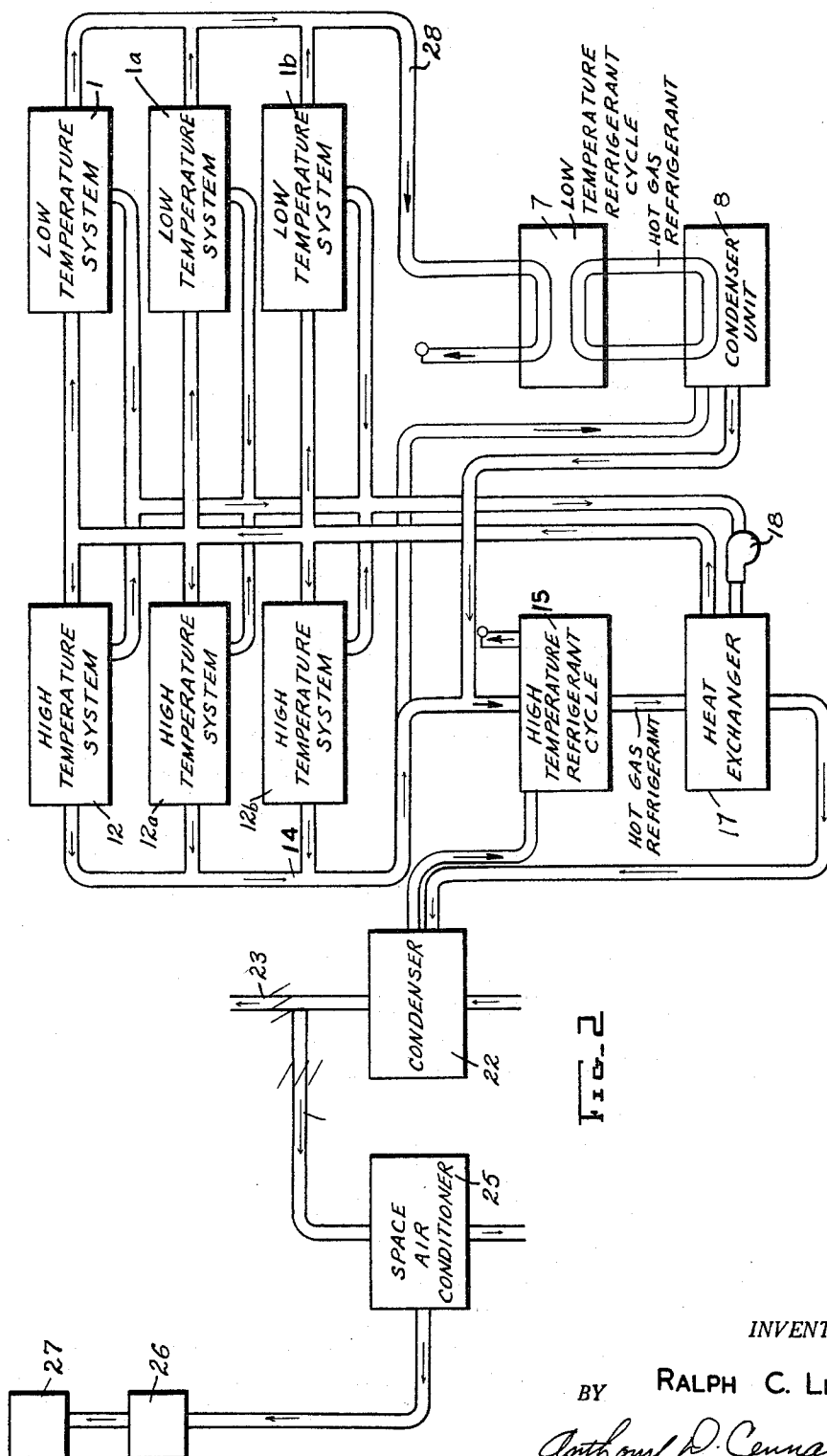


FIG. 2

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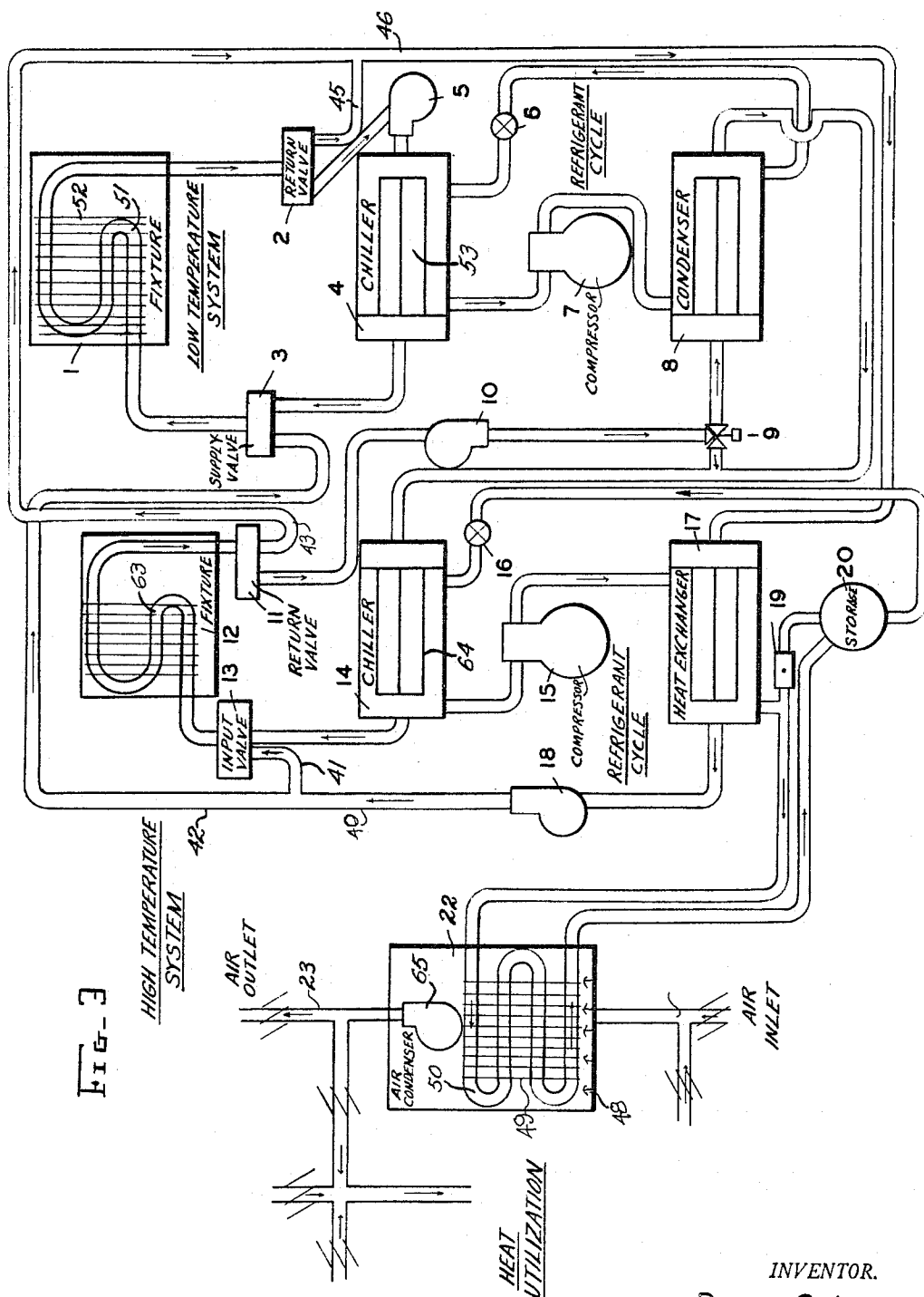


FIG. 3

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HIGH AND LOW TEMPERATURE REFRIGERATION SYSTEMS WITH COMMON DEFROSTING MEANS

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12 Claims. (Cl. 62—277)

This invention relates generally to refrigeration systems requiring mechanical refrigeration to store, freeze or preserve perishables, and specifically, the invention is a combination factory assembled compact refrigeration, defrost and heat recovery central system.

Refrigeration systems, such as may be found in a food supermarket, will comprise dual temperature operation. First, a medium temperature system is to provide air in the order of +25° F. to preserve the quick turnover perishables, such as meat and dairy products. The second system will provide the low temperature air to maintain frozen articles at approximately -40° F. Other commercial refrigeration systems for cold storage warehouses, walk in coolers, and refrigerated freight cars, will have one or the other temperature system dependent upon the product temperature maintained.

There are, in extensive commercial use today, many types and varieties of refrigeration systems. These systems, generally speaking, are efficient; but nonetheless, do have certain objectionable features. For instance, the systems have separate refrigeration units for each fixture. As many as twenty-five units may be included in a single system; consequently requiring extensive plumbing of large sized tubing. Further, these systems generate objectionable heat and noise, are expensive, and mostly utilize refrigerant gases for cooling directly in the evaporator coils. These gases, in turn, are expensive and operate under various pressures. In addition, there occurs frequent refrigerant losses that must be replaced; and the direct expansion systems are continually confronted with oil return problems that are related to the oil lubrication of the compressor machines.

The system of the present invention has, as one of its primary features, a unit construction comprising a single compact refrigeration system for the entire requirement—replacing the multiplicity of individual units; and will, in a typical embodiment, not be as large nor as expensive as its competitive counterparts in commercial use today. Yet, the system of the invention is readily adaptable to standard refrigerant storage and display cases.

Further, the present invention is a combination refrigeration system that utilizes the normally wasted heat to the condenser for creating a defrost medium and also includes means to utilize the waste heat for heating purposes. Specifically, condenser heat from cooling the hot gas refrigerant is captured by the present invention in the condenser coolant. A fractional part of the condenser coolant is liquid which is then periodically valved through the respective (cooling) coils to defrost the same. The major portion of the hot gas refrigerant generated is fed to an indoor air condenser where the dissipated heat is in turn used for space heating if required; or disposed outdoors.

Of primary significance is the elimination of the uses of gases for circulation through the coils of the circulating system. The present invention is directed to a liquid cool-

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ing system and confines the uses of refrigerants to the single unit that is displaced (such as in a basement) from the cooled area. In this way the refrigerant gases are confined to a single central area and safe liquids are circulated throughout the store for use as the coolants.

There is no water used in the system of the invention, and the heating and refrigeration is a complete air-cooled system. I have discovered unusually well suited liquid coolants, and I have circulated in the coils of the fixtures of the system of the invention a liquid coolant that is non-toxic, non-inflammable, and low in cost. The coolant may consist of one of the family of glycols, or may be what is commercially known as Freon 11. Further, the coolants are acceptable to USDA for use in conjunction with the cooling of food articles.

In a new installation of the system of the invention, because of the coolant used in the coils, considerably less plumbing will be required eliminating large copper refrigeration suction lines with the elimination of improper line sizing to the fixtures and coils. Small copper lines will flow the coolant to the fixtures and coils by means of a standard circulating pump. Reductions in operational and maintenance costs of the converted systems, in addition to the savings in construction costs of the new installation, will be appreciated.

It is accordingly a principal object of the present invention to provide a single compact central refrigeration system that will satisfy the entire requirements of an installation. A further object of the invention is to provide a new and improved refrigeration system having a heat capture means for defrosting and space heat utilization.

Another object of the invention is to provide a central refrigeration system that utilizes a liquid coolant and does not use conventional refrigerant gases as the space cooling medium.

Another object of the invention is to provide an efficient refrigeration system that is readily adaptable to standard fixtures and cooling apparatus, that eliminates costly supplies, and is more efficient in construction, operation and maintenance.

Other objects and features of the present invention will become apparent from the following detailed description when taken in conjunction with the drawings, in which:

FIGURE 1 is a heat flow chart of a preferred embodiment;

FIGURE 2 is a simplified schematic of a preferred embodiment;

FIGURE 3 is a more detailed schematic of a preferred embodiment of the present invention; and,

FIGURES 4 and 4a illustrate a three-way valve system utilized in the present invention.

Referring now specifically to FIGURES 1, 2, and 3, there is shown generally, in a typical installation, a low temperature refrigeration system, a medium temperature refrigeration system, a defrost system, interconnected with the two refrigeration systems, and a heat capture system for utilizing the waste condenser heat.

In order to understand the basic concepts underlying the present invention, a simple block schematic heat flow diagram is shown in FIGURE 1. The low temperature liquid cooling system 30 and the high temperature liquid

cooling system 32 provide a heat flow from the heat extraction of its given area. A refrigeration unit 34 has joined thereto the two cooling systems 30 and 32. The refrigerant in the unit provides a heat flow through the extraction of the heat from the liquid coolants. Connected to the refrigerant, in the hot gas portion of the cycle through a heat exchange relationship, is a hot liquid 36. This liquid obtains its heat from the refrigerant and is utilized via lines 31 and 33 to defrost the high temperature 32 and low temperature 30 cooling systems. Also connected to the refrigerant is a condenser heat recovery system 38 operative to extract the remaining heat from the refrigerant. The heat, so recovered, is utilized as a conventional space heat source via outlet 37 or is expelled to the atmosphere via outlet 39.

Referring to FIGURE 2, the heat flow system of FIGURE 1 is adapted to a simplified schematic in block of a preferred embodiment. In this illustration, the low temperature system 1 is representative of a plurality—in order of 16—refrigerated display cases or freezers 1a, 1b . . . 1n, such as may be found in a modern grocery super market. The cases include the liquid coolant line 4 for maintaining the temperature of the cases at -40°F . Connected in heat relationship to the line 23 is the low temperature refrigeration unit 7 to maintain the temperature of the liquid coolant at its appropriate temperature. To capture the heat from the refrigeration cycle is the condensation system 8.

The high temperature system 12 is also representative of a plurality of display refrigerated cases 12 and represented by cases 12a, 12b . . . 12n. These cases also have included in the illustration of FIGURE 2 the liquid cooling line 14 for maintaining the temperature of the cases at $+20^{\circ}\text{F}$. Joining with the coolant in cooling line 14 is the condenser coolant from the condensation system 8 and which together pass through the refrigeration cycle 15 to maintain the temperature of the liquid at its appropriate temperature. The refrigeration cycle 15 is accordingly operative to recover the heat from both the high and low temperature systems and which is then recovered for space heating on the condensing portion of the cycle. A part of the heat, so recovered, is utilized in heat exchanger 17 to heat a defrost liquid that is circulated via pump 18 periodically through the plurality of cases 1 and 12 for defrosting. The remaining portion of the heat recovered is utilized by condenser 32 as a heating source to heat an enclosed area or alternatively to be expelled into the atmosphere via outlet 23. The heat extraction system may be further utilized through an air conditioning unit 25 by way of refrigerator 26 and condenser 27.

It is a primary feature of the present invention that a single heat recovery system is utilized for the plurality of individually cooled areas. This single system eliminates the need for individual refrigeration systems that utilize refrigerants and cumulative, are excessive in costs; further, the single compact unit permits the use of liquid coolants. Also, by utilizing a single system, the total heat may be recovered and utilized. A preferred embodiment of a single compact refrigeration system that may be utilized to satisfy the needs of a typical supermarket is illustrated in FIGURE 3. With reference to FIGURE 3 in the low temperature system, the fixture 1 is representative of the "freezer" boxes or cases that may be found in a food supermarket. The fixtures 1 comprise, in addition to the case, coolant circulating coils 51 dispersed on the lowermost part thereof. The coils 51 have the coolant circulated therethrough and cool the surrounding air in a conventional manner through the temperature exchange fins 52 strategically placed. The coolant circulated through the coils 51 forms a closed circulation system with the chiller 4, the supply valve 3, the return valve 2, and the pump 5. The chiller 4 is of the direct expansion type and, as conventional, the refrigerant is in the tubes 53 and the primary coolant being cooled is

circulated within the chiller around the outside of the tubes 53. In the preferred embodiment, the primary coolant utilized to cool the low temperature fixtures, i.e., circulate through coils 51, is a liquid as described below.

The liquid coolant is pumped by pump 5 through the chiller, the three-way supply valve 3, the cooling coils 51, then through the three-way return valve 2, and again to the pump 5. A constant pressure is maintained by the pump 5 and in this way there is a continuous flow of liquid refrigerant through a closed loop system.

In order to maintain the liquid coolant in coils 51 of the fixtures 1 at a constant temperature, it will be required that the chiller 4 lower and maintain the temperature of the coolant to -50°F . In order to provide a -50°F . refrigerant for cooling the primary coolant, a refrigeration cycle forms a part of the system. Basically, the cycle comprises a circulating system having in sequence the tubes 53 of the chiller 4, compressor 7, the shell and tube condenser 8, and then back through the expansion valve 6. The compressor 7 and shell tube condenser 8 are preferably of the Freon 22 or 502 liquid-gas type. In operation of this cycle, the liquid Freon enters the expansion valve 6 under high pressure, and, in going from high pressure to low pressure, the liquid flashes into a gaseous state. The gas circulated through the chiller 4 absorbs heat from the liquid coolant, and then passes to the compressor 7 where the gas is compressed and heated before entering the condenser 8. In the condenser, the gas is again converted to a liquid and cyclically returned through expansion valve 6. The condenser 8 is a shell and tube condenser of commercially available design and is operable for full conversion of gas to liquid. A typical set of temperatures for the cycle may comprise a $+50^{\circ}\text{F}$. liquid entering the expansion valve 6, the gas leaving the valve 6 may be at -50°F . which, in turn, absorbs about 6°F . of superheat from the liquid refrigerant and hence enters the compressor 7 at -44°F ., the gas in the compressor will be heated at $+150^{\circ}\text{F}$. of which approximately 100°F . is extracted in the condenser 8.

Referring now to the high temperature system, there is provided another closed loop arrangement. This loop comprises coils 63 of the fixture 12, reversing input valve 13, discharge reversing valve 11, direct expansion chiller or evaporator 14, and pump 10. This part of the high temperature loop is substantially identical to the low temperature loop. However, to further economize the system, as explained hereinafter, and to reduce the size and number of components, the high temperature loop utilizes the waste heat given off by the shell and the tube condenser 8 of the low temperature system. Therefore, there is included in the high temperature closed coolant loop the shell and tube condenser 8.

In the high temperature refrigeration system, the coolant is again a liquid and consequently the loop is of the efficiency of the low temperature system. The liquid coolant in this system, instead of being returned directly to chiller 14, is instead circulated under constant pressure by pump 10 to be partially diverted through the shell and tube condenser 8. A flow control valve 9 divides the flow to maintain the head pressure in the low temperature refrigeration system. The portion of liquid coolant circulated in the shell of condenser 8 is then recombined with the remaining portion to be pumped through the chiller 14. The liquid coolant, at the proper temperature, is then forced back into the coils 63 of the fixture 12.

The high temperature liquid coolant has a temperature that is relative and is in the order of $+20^{\circ}\text{F}$. For a given system, the high temperature liquid circulated through the condenser 8 will absorb the condenser heat of the low temperature system. This may comprise raising the temperature of the liquid by 2° , for instance, from 27°F . to 29°F . Because of the heat and weight factor, the 2° increase in temperature will comprise the entire heat of the low temperature system. For other typical

weight factors, a different and proportional change will occur. The refrigerant is then passed through the chiller 14 where its heat is given up and, in turn, lowered from 29° F. to 20° F.

To maintain the liquid coolant of the high temperature system at 20° F., there is also provided a secondary refrigerant cycle. The secondary cycle is substantially similar to the previously described secondary refrigerant cycle for the low temperature system except for one primary departure as explained hereinafter. This secondary refrigerant cycle comprises the compressor 15, expansion valve 16, coils through the chiller 14, and coils through heat exchanger 17.

Basically, the secondary refrigerant cycle of the high temperature loop, in addition to providing a cooling system for the liquid coolant, is the heat capture system of the present invention. In operation, Freon 22 or 502 is circulated as described above in a liquid to gas—gas to liquid cycle. The secondary refrigerant cycle for the high temperature system, however, is further sophisticated over that of the low temperature cycle. Of primary difference in apparatus is that shell and coil heat exchanger 17 is utilized to provide a storage capacity for the hot defrost solution as explained hereinafter.

In operation of this refrigerant cycle, the compressed gas from the compressor 15 is converted into liquid by the combination effect of heat exchanger 17 and air condenser 22. In the preferred embodiment, there occurs approximately a 20% gas conversion to liquid in the heat exchanger 17. Also in operation, the liquid converted is directed to float control valve 19 wherein the float upon reaching a given level will release the liquid refrigerant to the storage receiver 20. The liquid from the storage receiver 20 is then recirculated through the secondary cycle.

A typical range of temperatures in the high temperature refrigerant cycle may comprise a temperature of +95° F. for the refrigerant entering the expansion valve and upon expansion a drop to +15° F. The gas in the coils 64 will absorb approximately 2° F., hence, from +15° F. to +17° F. It is to be noted here that this 2° represents the entire heat of the low temperature system and the cooling effect of the high temperature system. The gas is heated in the compressor to +175° F. with a drop 15 to +120° F. in the partial condensation in condenser 17. The liquid entering the storage receiver will when combined with the remaining condensed refrigerant be cooled therein to the +95° F., thereby completing the cycle.

The heat absorbing liquid in the condenser coils of heat exchanger 17 is the same liquid utilized as the liquid coolant circulated in both the high and low temperature fixture coils.

The heat taken from the chiller 14 by the refrigerant circulating through the coils 64—which heat comprises the heat from both the high and low temperature system—is uniquely utilized in the shell and coil heat exchanger 17. As generally accepted in refrigeration, the display fixtures or other cooling coils in the refrigerator cases will accumulate an excessive amount of frost—preventing further refrigeration. This frost, therefore, must be periodically eliminated. The heated liquid stored and adapted to pass through the shell of exchanger 17 is utilized in the present invention to defrost the coils 63 in fixture 12 and coils 51 in fixture 1. The liquid in the shell of heat exchanger 17 is heated by the refrigerant in the coil to approximately +140° F.

During the defrost cycle, the heated liquid solution is pumped by pump 18 to line 40 that feeds lines 41 and 42. The line 41 passes through the three-way valve 13 which automatically opens to the hot solution and closes the line to the cold solution from chiller 14. The hot solution is then forced out to line 43. The hot solution pumped into line 40 is also fed to the three-way valve 3 and again opening to the hot solution and closing to

the coolant from the chiller 4. The hot solution passes through the coil 51 of fixture 1, heats the coils, and melts the frost. The hot solution is then forced out to the line 45. The hot solution in lines 45 and 43 are joined and fed into return line 46 where the liquid solution is again permitted to pass through the shell and coil heat exchanger 17 until the storage capacity thereof is largely or completely consumed. The valves 13 and 3 are time regulated to open for empirically predetermined period to the hot solution and close to the coolant. Also, the valves are operative after a fixed period of time to reverse positions. In this way, the high and low temperature systems are automatically and periodically defrosted by passing the hot liquid solution through the cooling coils.

The amount of heat taken from the over-all system by the defrost liquid is extremely small on a percentage basis—in the order of 20%. Accordingly, there still remains to be removed an excessive amount of heat that is generated by the system. The present invention is further adapted to utilize this generated heat as a source of heat to warm an enclosed area. For instance, in a supermarket the heat from the refrigeration systems is not permitted to be wasted, but is utilized to heat the supermarket. As indicated above, only approximately 20% of the capacity of the gaseous Freon refrigerant is converted to liquid by the heat exchanger 17.

The remaining refrigerant gas passed through the coils in the shell and coil exchanger 17 is passed through an intermediary loop in the system. The refrigerant gas is passed through a high temperature inside air cooled condenser 22. Forming part of the condenser unit is a water spray mist 48 and fins 49 adapted to dissipate the heat from the coils 50. A blower 65 is operative to exchange air taken from the outside via inlet 25 for that heated. The intaken air is passed over the coils of condenser 22 to the indoor heat rejection to heat the enclosed area. It is understood in the summer, the heat is expelled into the atmosphere, such as via outlet 23. Basically, the condenser 22 is an air condenser operative to dissipate the balance of cumulated heat from the two refrigeration systems.

In operation, the Freon is condensed into liquid in the air condenser. The liquid is returned and captured in the refrigerant receiver 20 and recirculated in the refrigerant cycle. A typical temperature of the gaseous Freon in this heat dissipation cycle is +120° F. and when returned to a liquid, +110 F.

It was stated above that the coolant circulated in the low and high temperature primary systems is a liquid coolant rather than the conventional gases. In view of the temperatures, water and other liquids having a freezing point above -50° F. are ruled out. Similarly, liquids having a low boiling point are not usable.

One family of liquids found to be adaptable to the present system are the glycols. Glycols are aliphatic organic compounds having two hydroxyl groups per molecule. They are clear, colorless, and have practically no odor. They are heavier and more viscous than water, and their boiling points are much higher. Consequently, where the cooling coils are in direct contact with ingestible or body contacting perishables, glycols have been found to be the ideal cooling medium. Ethylene glycol has a pour point of -75° F., and in aqueous solution, displays excellent antifreeze properties. Ethylene glycol may be desired in certain instances, and again, for one reason or another, propylene glycol, diethylene glycol, dipropylene glycol, and tripropylene glycol may be utilized in the present invention as a coolant.

Under certain circumstances, without an unproportionate compensation in pressure, it may be desired to utilize a liquid coolant having a higher viscosity rate. One such liquid that has been utilized in the present invention is trichloromonofluoromethane —CCl₃F, and commonly known as Freon 11. This particular liquid

has a viscosity of .980 centipoise in the range of -40° F. to -60° F. and .323 centipoise at 140° F. Since this liquid does have a boiling point of 75° F., it has been found necessary to maintain it at a pressure of 30+ pounds to raise its boiling point to 140° F.

It was mentioned above that periodically it is desired to cut off the flow of cold coolant and to circulate through the cooling coils a high temperature defrost liquid.

The valves 2 and 3 of the low temperature system, and valves 11 and 13 of the high temperature system, were referred to as three-way valves and operable to switch from the liquid coolant to hot solution in the coils. With reference to FIGURE 4, there is illustrated a typical three-way valve arrangement that may be utilized in the preferred embodiment. A timer 83 is fixed to actuate the motor means 93 for a set period of time at a rate predetermined empirically. The shaft of motor 93, in turn, actuates the rotating elements 86 and 96 through the gear box 95. The rotating shaft opens the seal in the valves 102 and 103 to the hot solution and closes the seal to the coolant liquid. Upon deactivation of the motor, the reverse will occur.

Referring to FIGURE 4a, a typical valve is shown in a cutaway section. Housing 84 comprises a pair of inlets 81 and 82 and an outlet 85. The inlet 81 may be for the liquid coolant and inlet 82 for the hot solution. The seal 87 is positioned between the two inlets in a manner to provide an opening to one of the inlets and a seal to the other. The seal 87 is rotatable 90° to thereby reverse its seal-open position. The bearings 88 provide operation of the seal without binding. The seal 87 is connected to a motor driven shaft not shown in this section. The seal comprises a 90° section 89 and a smaller circular part 91. The 90° section makes fluid tight contact with the inner wall of housing 84. In the position shown, this contact thereby seals the inlet 81 and forms a direct opening between the inlet 82 and outlet 85.

It can be seen that the system of the invention is a complete unit that may be centrally located within an installation. The single unit eliminates the multiplicity of individual units and will provide all of the refrigeration requirements. The system, as described, eliminates the use of direct expansion refrigerant gases to the refrigeration coils throughout the building. This single feature reduces refrigerant leaks in order of 2000%, reduces the use of refrigerants from the order of 500-800 lbs. to 100-150 lbs., reduces the size of the pumps to one-half, reduces the number of compressors from 20-25 to 2-4, reduces the number of expansion valves from 56 to 2, and eliminates the damaging superheat thereby increasing the life of the machine by 500%. Also, the system, as described, typically provides for utilization of 600,000 B.t.u./hr. of what would otherwise be wasted heat. In most instances this would be sufficient to heat a typical supermarket.

Although certain and specific embodiments have been shown and described with respect to a specific use, it is to be understood that the system is basically a refrigeration system and the invention is equally applicable to any other requirement of maintaining constant low temperatures. A high and low temperature comprised the preferred embodiment; however, a single temperature system or a multiple temperature system may just as readily have the invention adapted thereto.

What is claimed is:

1. A refrigeration system for refrigerating separate areas to selectively different temperatures comprising a first closed system including cooling coils in a first area refrigerated, a liquid coolant, means for circulating said liquid coolant through said coils, and refrigeration means including chiller means in said first closed system in heat exchange relationship to said liquid for maintaining said liquid coolant at a predetermined temperature below the

temperature of said first area; a second closed system including cooling coils in a second area refrigerated, a second liquid coolant means for circulating said second liquid coolant through said second coils, and refrigeration means including chiller means in heat exchange relationship to said second liquid coolant circulating through said second coils to maintain the same at a second predetermined temperature below the temperature of said second area; a third closed system operative alternatively to said first and second systems and including said first and second coils of said first and second systems, a third liquid means containing said third liquid in condenser heat exchange relationship with at least one of said refrigeration means of said first and second systems for heating said third liquid, and means for alternately preventing the flow of said first and second liquid coolants in said coils and permitting the flow of said third heated liquid through said coils for defrosting said coils.

2. A refrigeration system as set forth in claim 1 wherein in said second liquid coolant is circulated in serial heat exchange relationship with said second heat exchange means and a condensing means of said first refrigeration means, and said third liquid is in condenser heat exchange relationship to said second refrigeration means.

3. A refrigeration system as set forth in claim 2 further comprising second heat dissipating means also in condenser heat exchange relationship to said second refrigeration means, and means for utilizing said dissipated heat.

4. A refrigeration system as set forth in claim 3 wherein in said third liquid absorbs in the order of 20% of the accumulated heat of said second heat exchanger and the remaining 80% is dissipated by said dissipating means.

5. A refrigeration system as set forth in claim 1 wherein in said liquid coolants have a freezing point of -50° F. or less and a boiling point at atmospheric pressure of less than 150° F.

6. A refrigeration system as set forth in claim 1 wherein in said liquid coolants have a freezing point of -50° F. or less and wherein said third liquid has a boiling point at atmospheric pressure of less than 150° F.

7. A refrigeration system as set forth in claim 1 wherein in said liquid coolant is a glycol.

8. A refrigeration system as set forth in claim 1 wherein in said liquid coolants and said third liquid are a glycol.

9. A refrigeration system as set forth in claim 1 wherein in said liquid coolant and said third liquid are trichloromonofluoromethane and wherein said third liquid is maintained under a pressure of at least 30 lbs.

10. A refrigeration system for refrigerating separate areas to selectively different temperatures comprising a first closed system including cooling coils in a first area refrigerated, a liquid coolant, means for circulating said liquid coolant through said coils, and first refrigeration means including chiller means for maintaining said liquid coolant at a predetermined temperature below the temperature of said first area, a second closed system including second cooling coils in a second area refrigerated, a second liquid coolant, means for circulating said second liquid coolant through said second coils, and second refrigeration means including second chiller means for maintaining said second liquid coolant at a second predetermined temperature below the temperature of said second area; and means combining said systems to effect a common heat recovery of heat separately absorbed by said respective system coolants.

11. A refrigeration system for refrigerating separate areas to selectively different temperatures comprising a plurality of closed systems each including cooling coils located in the different areas to be refrigerated, liquid coolant, and means to circulate said coolant through their respective coils, a refrigeration means for each of said systems each including chiller means for cooling the liq-

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uid coolant of its respective system to a selective temperature different than the other of said systems and capable of maintaining the respective area temperature, and means combining said plurality of closed systems to effect a common heat recovery of heat separately absorbed by said respective system coolants.

12. A refrigeration system according to claim 11 further including means to utilize at least a portion of the common heat recovery for heating a defrost liquid, and means to circulate said defrost liquid through said cooling coils alternately with the liquid coolants circulated there-through.

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