

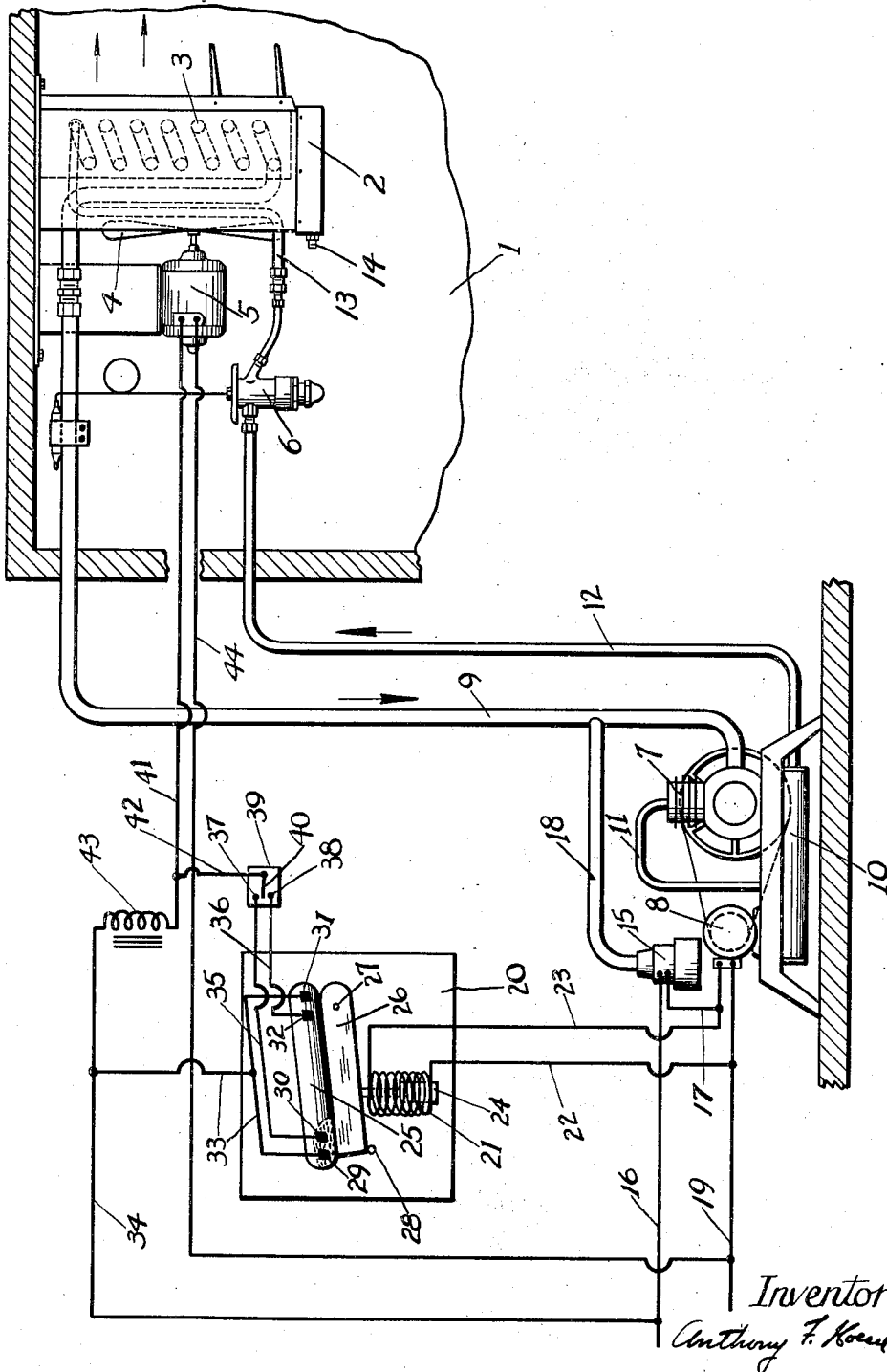
**April 2, 1940.**

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**2,195,924**

## REFRIGERATING SYSTEM

Filed Nov. 2, 1938



## UNITED STATES PATENT OFFICE

2,195,924

## REFRIGERATING SYSTEM

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Application November 2, 1938, Serial No. 238,345

5 Claims. (Cl. 62-6)

The present invention relates to refrigerating systems and especially to refrigerating systems pertaining to the storage rooms for meats and other hydrous products.

5 This application, in part, relates to United States Patent Number 2,060,316 issued to myself November 10, 1936, for Refrigerating system, in which the fan speed of an air cooler for a cold storage room is varied in accordance with  
10 different conditions resulting from the operation or non-operation of the air cooler,

The cold storage rooms are generally inside of a building proper, and in many cases the building is unheated or only partially heated during  
15 the winter months.

Since the refrigeration system, in order to have adequate capacity, is designed to have a heat absorption capacity usually in excess of the maximum heat load, which occurs during the summer  
20 time when the greatest temperature difference exists between the inside and outside of the refrigerated storage space, and consequently a greater heat leakage occurs, such systems are automatically controlled so that the periodic on-  
25 and-off-time cycles produce the requisite amount of refrigeration necessary to maintain the refrigerated storage space within the desired temperature limits.

Because most of these systems employ cooling  
30 units which are operated on a defrosting cycle, it is usually necessary to have the refrigerating system of such capacity that, under the maximum load, there will be a sufficient off-time period during which the refrigerant circulation,  
35 through the cooling unit, is stopped.

It is usual practice to install a refrigerating system with sufficient capacity so that, under maximum heat load conditions, the refrigerant is circulated 16 to 18 hours out of the daily 24  
40 hours. In order to maintain a fairly steady temperature and also to allow the cooling unit to defrost periodically, during maximum heat load conditions, it is usual to so adjust the automatic controls that the system periodically cycles  
45 for about 30 minutes on the on-time cycle and about 15 minutes on the off-time cycle. During the off-time cycle, the cooling unit becomes defrosted; thereby preventing the progressive accumulation of frost, upon the cooling unit surfaces, which would gradually decrease the heat  
50 absorption capacity of the cooling unit.

Assuming a given storage space maintained at 38° F. and having an ambient temperature of 90° F., during the summer time, which drops  
55 to say 60° F. during the winter time, and having

a service load equal to one-quarter of the heat leakage load, due to the temperature difference between the inside and outside of the cooled compartment, we then have, for summer operation, a heat leakage load expressed as

$$(90^{\circ} \text{ F.} - 38^{\circ} \text{ F.}) 1.25 = 65$$

and for winter operation the expression becomes  
(60° F.—38° F.) 1.25=27.5.

The ratio of refrigeration demand (the summer demand being taken as unity) then becomes  
27.5÷65=42.3 per cent for the winter time.

Since effective refrigeration is produced only during the on-time cycle, which for the summer demand was 30 minutes, we then find that  
15 30×.423=12.7 minutes on-time cycle during the winter demand.

The winter off-time cycle then becomes  
(30-12.7)+15=32.3 minutes.

In many cases, such as outlined for winter operation above, where the off-time cycle greatly exceeds the on-time cycle, it is found that meats and certain other products tend to slime upon their surfaces. This seems to be entirely due to the fact that the decreased on-time cycle does  
25 not produce sufficient refrigeration to remove sufficient moisture from the atmosphere, in the cooled chamber—which atmosphere is surcharged with moisture during the off-time cycle, when the cooling unit surfaces become defrosted.  
30

Forced convection circulation type coolers, prior to my invention, operating on alternate on-time and off-time cycles in respect to the refrigerant circulation through the cooler, had their fans operating either continuously at a given speed or else the fan was stopped whenever the cooled compartment reached its desired minimum temperature. The fan, whenever the compartment reached the desired maximum temperature, was again started. Whenever the fan was cyclically operated, it was controlled either by a room thermostat or else in conjunction with the cyclical operation of the compressor circulating the refrigerant fluid. Both of these methods, of cyclically operating the fan, are so well known in the art that it is presumed unnecessary to elaborate upon the details thereof.

In the following, I will frequently use the term 'velocity volume' when referring to air circulation. This is to be understood as connotative of a certain air volume within a given time. An increased 'velocity volume' is to be considered as a greater volume of air circulation within a given time period, than the volume of air circulation

within the given time period under a decreased 'velocity volume'.

With a constant predetermined velocity volume of air circulation, during both the on-time cycle and off-time cycle, we usually find that, during the summer time operation, it is rather difficult to maintain conditions of sufficient humidity; and, therefore, the meats tend to dehydrate.

With a similar constant predetermined velocity volume of air circulation, during winter time operation, we also find it difficult to maintain conditions of sufficiently reduced humidity; and, therefore, the meats tend to slime upon their surfaces.

Whenever an artificial air circulation is maintained within a cold storage room, it tends to remove the so-called stationary air film, which is adjacent the boundary wall surfaces and which air film is of a greater temperature than the average air temperature within the cooled room. This air film wiping effect is proportional to the velocity volume of air circulated, and results in a greater heat leakage load, through the walls, with an increased velocity volume.

Whenever an artificial air circulation is maintained past the surfaces of a cooling unit, we find that the cooling capacity, of such cooling unit, is increased with increase of velocity volume; and conversely decreased with decrease of velocity volume.

As we increase the velocity volume of an air circulation over the cooling unit surfaces, during the refrigerant circulation on-time cycle, we find that the outlet air has a much higher absolute humidity, than its absolute humidity at a decreased velocity volume of air circulation.

During the refrigerant circulation off-time cycle, the cooling unit tends to reach the same temperature as the temperature of the circulated air; and the time rate, of such tendency, is inversely proportional to the velocity volume of the air circulation. With a high velocity volume of air circulation, the frost, accumulated upon the cooling unit surfaces, tends to quickly melt and exit to the sewer. With a low velocity volume of air circulation, the frost melts more slowly and the exit air has a much higher absolute humidity.

In the cold storage preservation of meats, we find that a very low velocity volume, of air circulation, coupled with a comparatively low absolute humidity, within limits, will successfully preserve meats without excessive dehydration. With higher velocity volumes, we find that much higher absolute humidities are necessary for equivalent limitations of dehydration.

An object of the present invention is to provide a cooling unit, having a forced air circulation of differential velocity volumes between that during the refrigerant circulation on-time cycle and that during the refrigerant circulation off-time cycle; the differential velocity volumes being reversed, relative to the cycles aforementioned, whenever the heat load varies from maximum to minimum and vice versa.

Another object is to, within a refrigerated storage room, during maximum heat loads, maintain a high velocity volume of air circulation during the refrigerant circulation on-time cycle; and to reduce the velocity volume during the refrigerant circulation off-time cycle.

Another object is to, within a refrigerated storage room, during minimum heat loads, maintain a reduced velocity volume of air circulation dur-

ing the refrigerant circulation on-time cycle; and to increase the velocity volume during the refrigerant circulation off-time cycle.

A further object is to more completely dry the circulated and refrigerated air, of a refrigerated storage room, passing through a cooling unit during conditions of low outside temperatures and, consequently, low heat inleakage through the walls of said storage room.

A further object is to provide a refrigerating system that will neither excessively dehydrate meats and such during warm weather nor allow meats and such to slime upon their surfaces during cold weather.

In the drawing:

The figure of the drawing is an elevational, diagrammatic representation of a refrigerating system embodying the invention.

A storage room 1, contains a cooling unit 2, in which is disposed a cooling coil 3 through which an air circulation, indicated by arrows, is forced by means of the fan 4, driven by the electric motor 5.

A thermostatically controlled expansion valve 6 regulates the flow of refrigerant, to the cooling unit, in accordance with the superheat of the refrigerant vapor leaving the cooling unit. Since this type of expansion valve is so universally used, throughout the refrigerating industry, it is presumed unnecessary to explain its exact mode of operation.

A compressor 7, driven by the electric motor 8, evacuates refrigerant vapor from the suction conduit 9, leaving the cooling coil 3, and compresses the vapor into the condenser-receiver 10, to which the compressor 7 is connected by means of the discharge conduit 11. A refrigerant liquid line 12 conveys the condensed refrigerant, from the condenser-receiver 10, to the thermostatically controlled expansion valve 6, the outlet of which connects to the inlet conduit 13 of the cooling coil 3.

The cooling unit 2 contains a drain connection 14, which is piped to a sewer and serves to lead away any frost melted, from the surfaces of the cooling coil 3, during the refrigerant circulation off-time cycle.

A pressure responsive switch 15, fully explained in United States Patent Number 1,520,936, issued December 30, 1924, to J. H. Kennedy, serves to make and break an electric circuit between conductors 16 and 17, with an increase and decrease, respectively, of the refrigerant vapor pressure in the suction conduit 9, to which it connects by means of conduit 18.

The conductors 16 and 19, when connected to a suitable source of electrical energy, serve to energize the system.

A solenoid operated single pole, double throw, switch 20 comprises a solenoid coil 21 connected to the conductor 17 by means of conductor 22, and to conductor 19 by means of conductor 23, which connects to one leg of the motor circuit, as shown.

The solenoid coil 21, when energized, pulls up the plunger 24, which tilts the mercury tube switch 25 mounted upon the rocker arm 26, pivoted at 27. A stop 28 limits the downward movement of the rocker arm 26.

The mercury tube switch 25 contains two sets of contact points: 29-30 and 31-32, of which contact points 29 and 31 connect to the common conductor 33 connected to the conductor 34 which, in turn, is connected to the conductor 16. The contact points 30 and 32 connect, respec-

tively, by means of conductors 35 and 36 to the contacts 37 and 38 of the single pole, double throw, switch 39; having a switch arm 40, which can be manually shifted to engage with either contact 37 or 38. The switch arm 40 connects, electrically, with the conductor 41 through the conductor 42.

In the circuit between conductors 34 and 41, the latter of which connects to the fan motor 5, is placed a choke coil 43 when using A. C. current, but replaced by a resistor coil when using D. C. current.

The capacity of the choke coil 43 is such as to give the required reduced speed of the fan 4, whenever its function comes into action.

The second leg of the electrical circuit, of the fan motor 5, connects to conductor 19 by means of conductor 44.

The system, as indicated by the position of the mercury tube switch 25, is on the refrigerant circulation off-time cycle, during which the compressor 7 and its driving motor 8 are at rest since the pressure responsive switch 15 has broken the circuit between conductors 16 and 17.

Assume that the switch arm 40 is moved into engagement with the contact 38, which position we shall call the summer time position. If we now trace the circuit of the fan motor 5, we note that conductor 44, connected to conductor 19, is in complete circuit at all times. Therefore, we can dismiss this leg of the fan motor circuit in all future explanations, and confine ourselves to the changes occurring in the other leg of the motor circuit, comprising the conductors 34 and 41.

In the aforementioned position of the switch arm 40, there will be no current passing there-through since, because the mercury is at the opposite end, no circuit is established between the contact points 31 and 32.

The current passing through the conductors 34 and 41 is now restricted to the capacity of the choke coil 43, and the fan motor 5 is now operating at a reduced speed. In consequence, the velocity volume of air circulated through the cooling coil 3 is at its minimum.

During this time, the low velocity volume of air circulation gradually melts the accumulated frost, some of which may exit from the drain 14. In consequence of the low velocity volume, the exit air is highly humidified, tending to restore some of the moisture which was previously taken therefrom.

In time, the cooling unit 3 becomes sufficiently elevated in temperature that the refrigerant liquid, contained therein, increases in pressure to the point for which the pressure responsive switch 15 is adjusted to establish the circuit between the conductors 16 and 17. Since the conductor 19 is in constant circuit with the compressor motor 8, the compressor motor 8 now starts the compressor 7 and the refrigerant circulation is now on the on-time cycle; and will remain so until sufficient refrigeration has occurred to allow the refrigerant vapor pressure to be reduced to the low point, for which the pressure responsive switch 15 has been adjusted, at which the circuit, between the conductors 16 and 17, is broken.

Assuming the compressor motor 8 starting operation, we now find that the solenoid coil 21 is energized, and the plunger 24 is pulled upwards; thereby tilting the mercury tube switch 25, which rolls the mercury to the opposite end of that shown in the drawing, and establishes the electrical circuit between the contacts 31 and

32. Since the switch arm 40 engages the contact 38, we find that, in this position of the mercury tube switch, the choke coil 43 is now shunted and the fan motor 5 operates at its full speed; giving the maximum velocity volume of air circulation through the cooling coil 3, resulting in maximum refrigeration.

The compressor 7 continues in operation until such time as the temperature of the compartment 1, is sufficiently reduced to allow the cooling coil 3 to reach its low temperature, which results in the reduction of refrigerant pressure therein to the point for which the pressure responsive switch 15 is adjusted to break the electrical circuit and stop the motor 8.

The above method of operation could be termed the summer time operation, during which the heat load would be at its maximum, and results in maximum refrigerating effect for a given time period of the on-time cycle. During the off-time cycle, the reduced velocity volume of air, over the cooling unit surfaces, results in the exit air being highly humidified and restoring, partially at least, some of the moisture extracted therefrom and from the stored meats, etc. contained within the compartment.

For winter time operation, we move the switch arm 40 into engagement with the contact 37; and the entire system works progressively similar to that of the detailed explanation of the summer time operation, with the exception that contact points 29 and 30, of the mercury tube switch 25, now become the path for the electrical circuit, shunting the choke coil 43, whenever the pressure responsive switch 15 breaks the circuit of the motor 8 and stops the operation of the compressor 7.

It will be noted that, whenever the choke coil 43 is shunted, the fan motor 5 operates at its maximum speed. When the shunting circuit is broken, the choke coil 43 reduces the amount of electrical energy passing into the fan motor 5; thereby, its speed and the velocity volume of air, passing over the surfaces of the cooling coil 3, is consequently also reduced.

With the switch arm 40 in engagement with the contact 37 (winter time operation position), the fan motor 5 operates at a reduced speed whenever the compressor 7 is in operation. Because the cooling unit 3 now has its surfaces swept by an air circulation of low velocity volume, the exit air is materially decreased in temperature and absolute humidity, as compared with the increased temperature and absolute humidity of the greater air circulation when the switch arm 40 is biased to summer time operating position.

Assuming that, for a given high temperature of air entering the cooling unit 2—such as at the start of the on-time cycle of refrigerant circulation—which high temperature is practically a constant irrespective of seasonal outside temperature variations, it will take a given time to reduce the temperature of the cooling coil 3 with a high velocity volume of air circulation. It follows that a decreased velocity volume of air circulation, with its reduced rate of heat input to the cooling coil 3, will allow the cooling coil 3 to more quickly reduce its temperature.

As the refrigerant circulation, cyclically controlled by the pressure responsive switch 15, is responsive to the temperature of the cooling coil 3, it is readily evident that whenever the cooling coil 3 lowers in temperature more readily, and in this instance due to the decreased velocity volume

of air circulation over the surfaces thereof, the length of on-time cycle becomes much less.

While it was earlier stated that a refrigerating system, under a given condition of summer time operation, might have an on-time cycle of 30 minutes and an off-time cycle of 15 minutes—which, for a given condition of winter time operation, might change to an on-time cycle of 12.7 minutes and an off-time cycle of 32.3 minutes—this condition of cycling would obtain if the velocity volumes of air circulation were equal during the different on-time cycles of refrigerant circulation and also equal during the different off-time cycles.

Since my invention contemplates a high velocity volume of air circulation during the refrigerant circulation on-time cycle for summer time operation, and a low velocity volume of air circulation during the refrigerant circulation on-time cycle for winter time operation, we find that if the system is adjusted to operate about 30 minutes on-time cycle and 15 minutes off-time cycle during summer time, the system will then, for the given winter time condition, operate with an approximate on-time cycle of 6 minutes and an off-time cycle of approximately 16 minutes. This is a very desirable condition since, as previously mentioned, an increasingly long period of refrigerant circulation off-time cycle tends to increase the surface sliming of meats and such.

With the system as now adjusted, for winter time operation, we find that the velocity volume of air circulation increases to its maximum when the compressor 7 ceases to circulate the refrigerant fluid. Therefore, the moisture frozen upon the surfaces of the cooling coil 3, during the refrigerant circulation on-time cycle, is now readily defrosted and rejected to the sewer. With the high velocity volume, the air cannot so readily absorb the defrosted moisture; also, the wall surfaces of the compartment, being swept with a high velocity air, have the stagnant high temperature air films, adjacent thereto, swept away; providing for a higher rate of wall heat leakage to further tend to reduce the off-time cycle.

While the above is a specific concept of my invention, it is readily understood that many variations can be employed without departing from the spirit and scope of the invention, which is to be limited only by the following claims.

I claim:

1. In a refrigerating system the combination of, a cooled compartment, a cooling unit in said compartment, means to force an air circulation over the surfaces of said cooling unit, means to circulate a refrigerant through said cooling unit, means cyclically controlling said refrigerant cir-

culating means in periods of on-time cycle and off-time cycle, and means for decreasing and increasing said air circulation during the on-time cycle and off-time cycle, respectively.

2. In a refrigerating system the combination of, a cooled compartment, a cooling unit in said compartment, means to force an air circulation over the surfaces of said cooling unit, means to circulate a refrigerant through said cooling unit, means cyclically controlling said refrigerant circulating means in periods of on-time cycle and off-time cycle, and means for decreasing and increasing said air circulation during the on-time cycle and off-time cycle, respectively, and means to reverse the decreased and increased air circulation relative to said cycles.

3. The method of refrigerating a storage compartment having a wide variation of heat inleakage, through the walls thereof, due to seasonal variation of outside temperature, and which compartment is cooled by a cooling unit having a forced air circulation over the surfaces thereof and a cyclical circulation of refrigerant there-through, which comprises, during low heat inleakage, increasing the air circulation during the off-time cycle of refrigerant circulation and decreasing the air circulation during the on-time cycle of refrigerant circulation.

4. The method of refrigerating a storage compartment having a wide variation of heat inleakage, through the walls thereof, due to seasonal variation of outside temperature, and which compartment is cooled by a cooling unit having a forced air circulation over the surfaces thereof and a cyclical circulation of refrigerant there-through, which comprises, during low heat inleakage, increasing the air circulation during the off-time cycle of refrigerant circulation and decreasing the air circulation during the on-time cycle of refrigerant circulation; and reversing the increased and decreased air circulation, relative to said cycles, during high heat inleakage.

5. The method of refrigerating a storage compartment having a wide variation of heat inleakage, through the walls thereof, due to seasonal variation of outside temperature, and which compartment is cooled by a cooling unit having a forced air circulation over the surfaces thereof and a cyclical circulation of refrigerant there-through, which comprises, during low heat inleakage and during the refrigerant circulation off-time cycle, increasing the air circulation as compared to the air circulation during high heat inleakage and during the refrigerant circulation off-time cycle.

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