

June 27, 1939.

C. A. RODMAN

2,164,223

METHOD OF AIR CONDITIONING

Filed Oct. 16, 1935

5 Sheets-Sheet 1

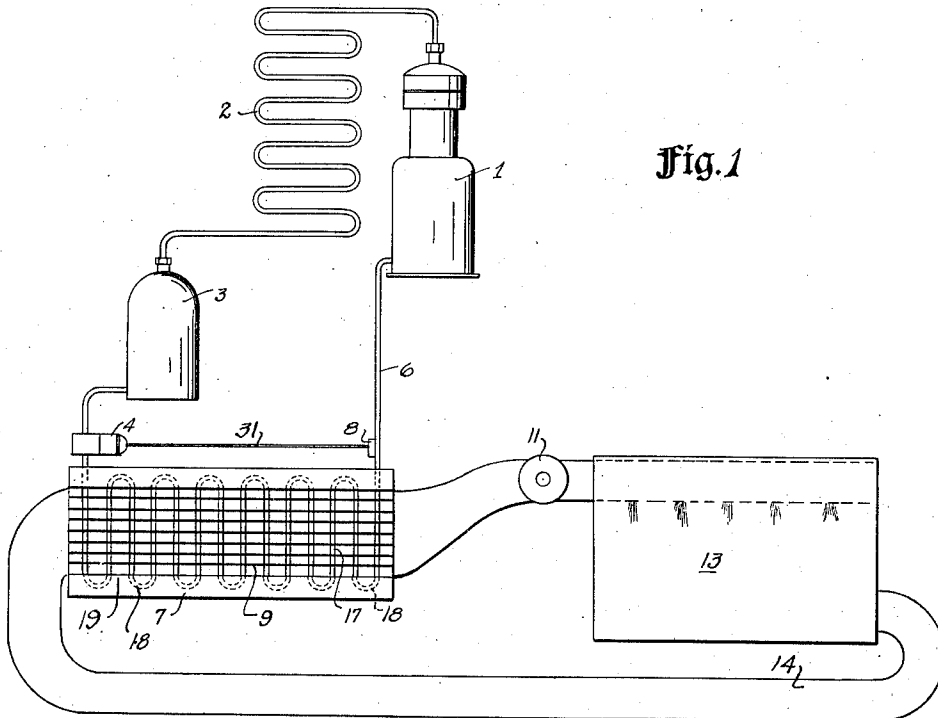


Fig. 1

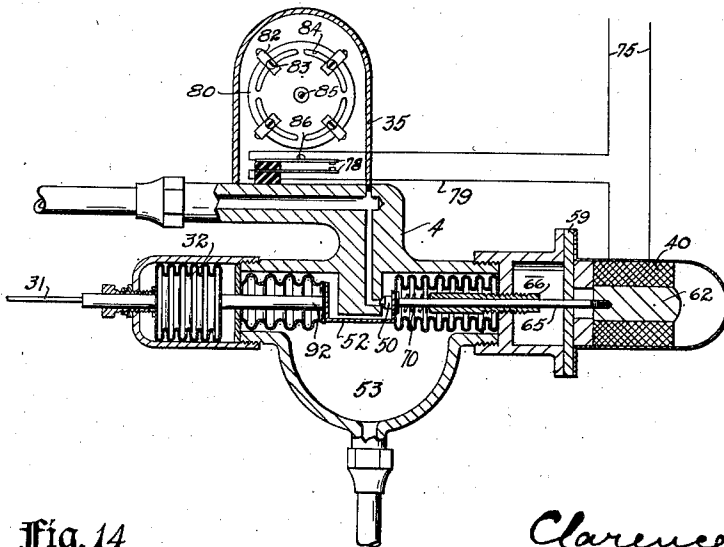


Fig. 14

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5 Sheets-Sheet 2

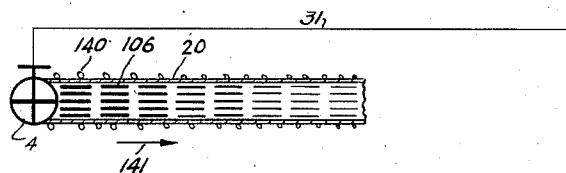
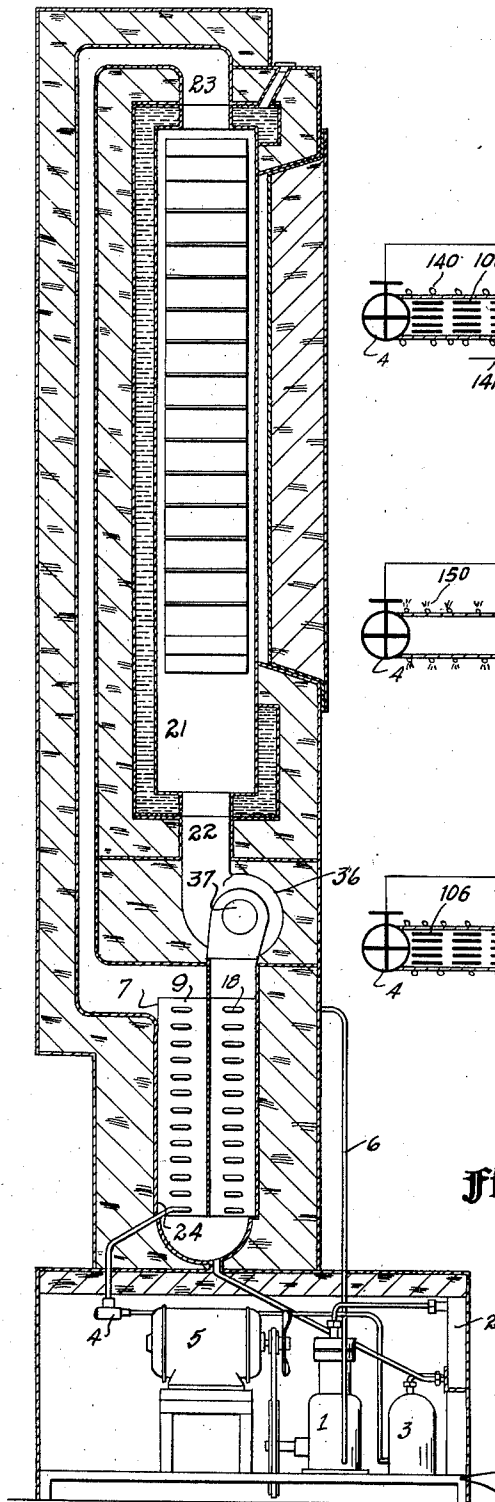


Fig. 2

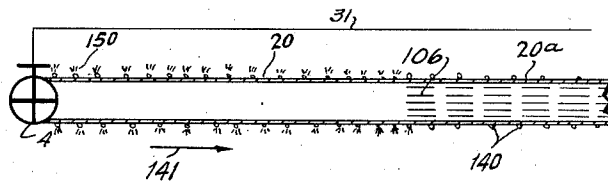


Fig. 3

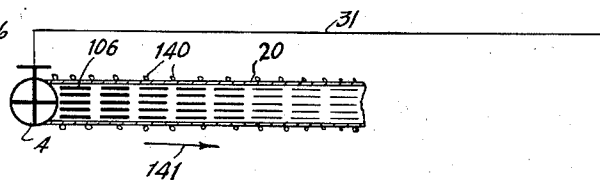


Fig. 4

Fig. 11

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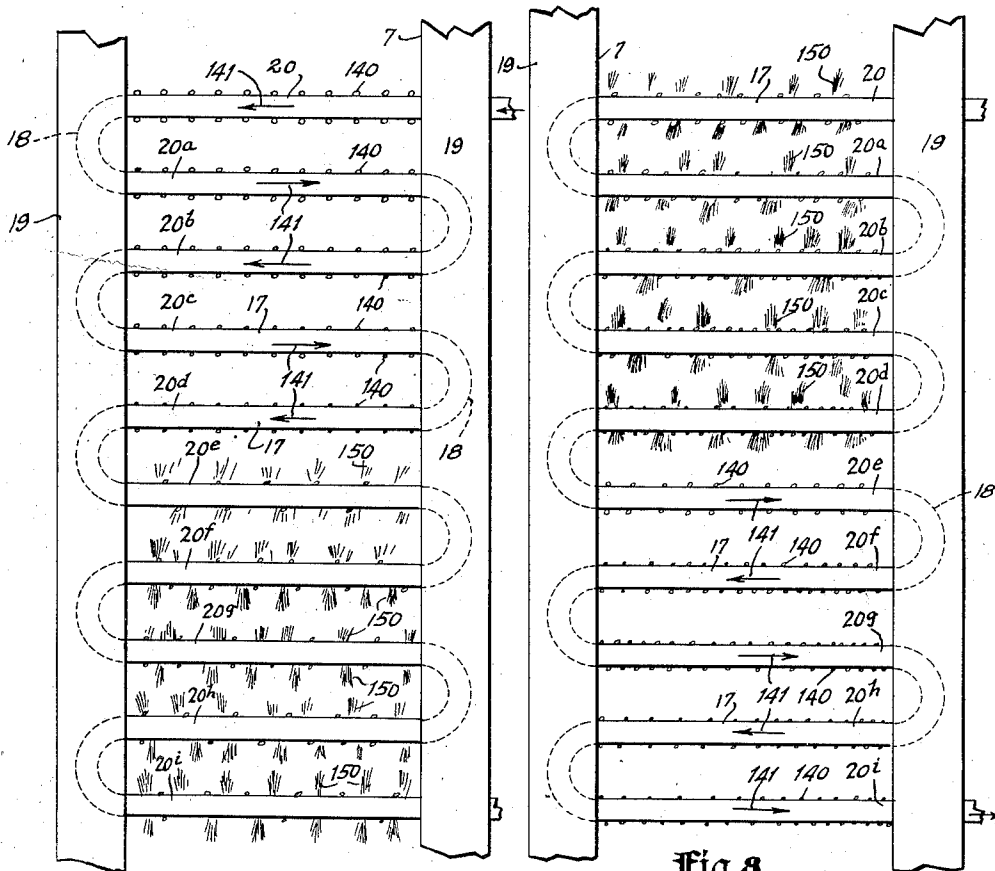
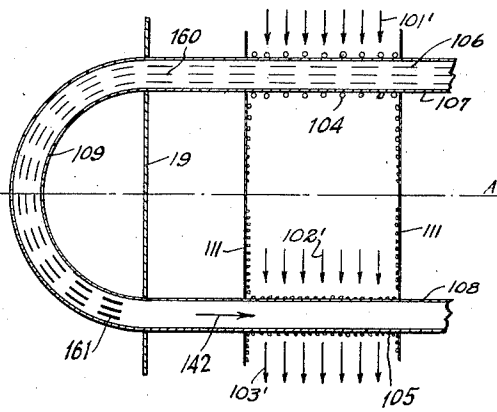
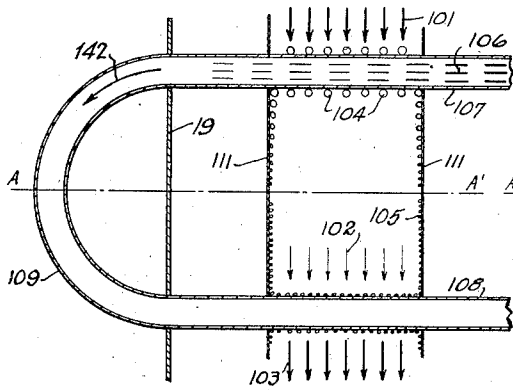


Fig. 7

Fig.8

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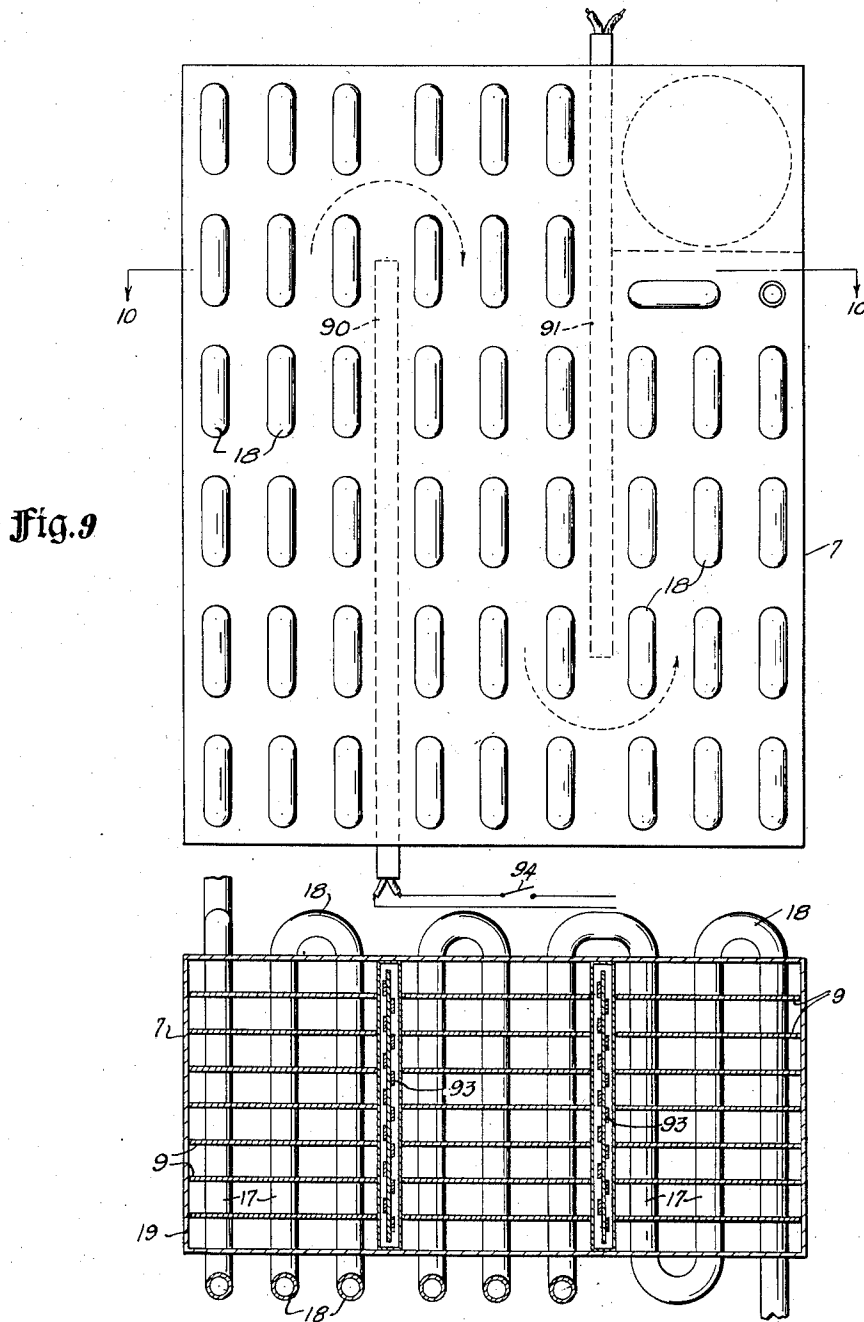
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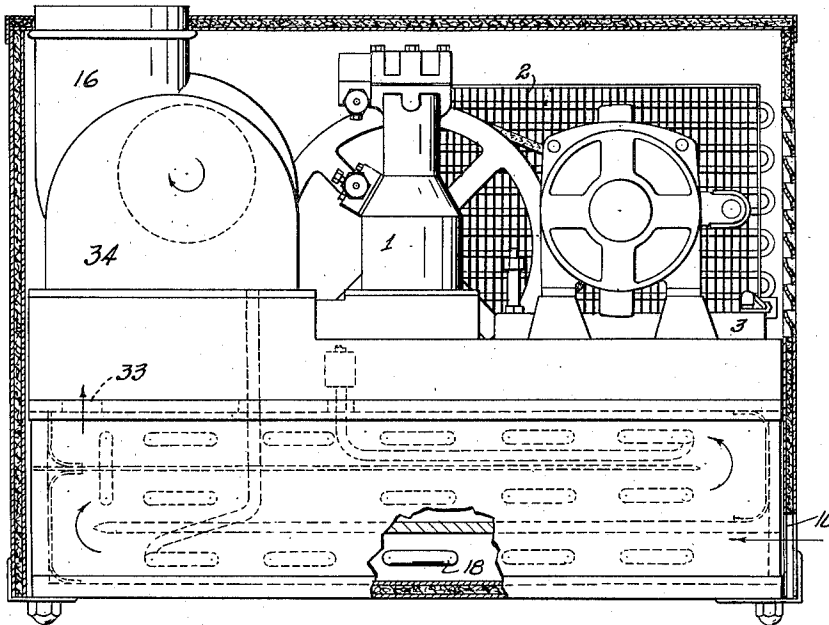


Fig. 12

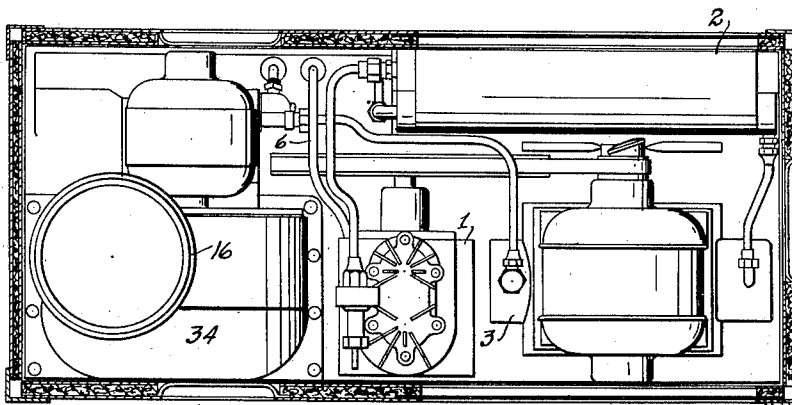


Fig. 13

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UNITED STATES PATENT OFFICE

2,164,223

METHOD OF AIR CONDITIONING

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Application October 16, 1935, Serial No. 45,295

4 Claims. (Cl. 62—170)

This invention relates to air conditioning systems and applies to systems for conditioning air for human comfort, for preserving foods at temperatures above freezing, and for refrigerating and preserving ice creams and like comestibles at temperatures well below the freezing point.

In all of these systems it is essential to maintain the humidity at predetermined values. In food preservation it is known to be a difficult problem to maintain humidity at sufficiently high values or relatively high points to prevent dehydration of food stuffs. The problem is made difficult by reason of the fact that attempts to maintain high humidity for this purpose frequently result in moisture deposit on the goods being preserved.

In my prior application Serial No. 687,070, now United States Patent No. 2,047,799, I have shown, described and claimed an air conditioning apparatus capable of being operated in a manner to perform the present method and which includes an expansion valve acting between the condenser and expansion sides of a refrigerating or cooling circuit, the valve being actuated to open at predetermined time intervals and being responsive to open varying amounts corresponding to temperature conditions of the expansion coil or to the load impressed thereon. The description in that application pertains particularly to this valve and a specific form of expansion or cooling coil and fin construction.

Therefore it is an object of the present invention to provide a method of conditioning air by producing and controlling the humidity values desired so as to prevent dehydration and avoid moisture deposit either upon the goods being preserved or upon the walls or surfaces of the preservation chamber or upon any mechanism therein while maintaining the goods at the proper temperature.

The drawings illustrate somewhat conventionally and diagrammatically the operation of my system and illustrative embodiments of apparatus with which it is used are also shown.

Further objects and advantages of my invention will become apparent from the following description which relates to the drawings and in which:

Fig. 1 is a diagrammatic view of the refrigerating system including condensing and expansion sides of the apparatus and means for forcibly circulating air through the expansion and cooling devices.

Fig. 2 shows a diagrammatic view of a single cooling pipe in the expansion line illustrating the moisture deposit as occurs in my system.

Fig. 3 is a similar view illustrating a condition at a succeeding interval.

Fig. 4 illustrates a condition occurring during continued operation.

Fig. 5 is an illustration of a portion of a cooling coil with its wall support and heat interconnecting fins, showing the action of air passing through two of these fins and a diagrammatic illustration of the moisture deposit and evaporation.

Fig. 6 is a similar view at a succeeding interval.

Figs. 7 and 8 are still more diagrammatic showings of a plurality of the reaches of the coils with the relative conditions of moisture deposit and evaporation.

Fig. 9 is a side elevation of the preferred form of coil assembly.

Fig. 10 is a sectional plane substantially on the line 10—10 of Fig. 9.

Fig. 11 corresponds to Fig. 3 of my U. S. Patent No. 2,009,817.

Fig. 12 is like Fig. 2 of my U. S. Patent No. 2,047,799.

Fig. 13 is a plan of Fig. 1 of my U. S. Patent No. 2,047,799.

Fig. 14 corresponds to Fig. 2 of my co-pending application, Ser. No. 24,381, filed May 31, 1935, now matured into Patent No. 2,095,834, issued October 12, 1937, pertaining to my thermo and timed controlled expansion valve.

In the drawings Fig. 1 illustrates a refrigerating system containing the usual elements of a compressor 1, condenser 2, receiver 3, an evaporator 4, a suction pump or fan 11, and a cooling chamber 13.

The evaporator utilized in this system is of a construction comprising a plurality of looped portions or tubes, having parallel reaches 17 connected by return bends 18, which return bends are insulated from the parallel transverse reaches. Fins 9 made of very thin material about .007" extend the full length of the evaporator except when intercepted by baffles, thereby partitioning the cross sectional area surrounding the transverse reaches into small areas. These transverse reaches and radiating fins are installed within a suitable box-like case 19, this serving as a support for the evaporator tubes and as an insulating partition for the end zones 18. The insulation, as surrounds the end zones 18 of the evaporator, can be of any suitable insulating material, a dead air space will provide sufficient insulation and serve the purpose for which the insulation is provided.

The suction pump or fan 11 located on the out-

let of the evaporator may be of the Sirroco fan type of blower, its purpose being to draw the air through the evaporator and discharge it into the cooling chamber 13. This chamber may be any space closed from the outside atmosphere, such as a living room, office, or compartments for food preservation, where means are provided for an exhaust of the air as it becomes warm, thus providing means of air circulation. In the drawings I have represented exhaust holes in the chamber itself, designated at 12, however, a duct 14 may also be provided leading from the cooling chamber back to the inlet side of the evaporator.

The refrigerant upon being condensed through the action of compressor 1 and condenser 2 is delivered into receiver 3. The passage of the refrigerant from the receiver 3 to the evaporator 7 is controlled by my thermo and time controlled expansion valve 4 as claimed in my U. S. Patent No. 2,095,834. The action of the valve is illustrated as depending upon the thermal condition of the refrigerant in the return tube 6 and the action of the timing device installed in the valve itself, but the return tube 6 can be placed in any location where control is desired, such as in a preservation chamber or other enclosure to which conditioned air is to be supplied. The compressor 1, condenser 2, and receiver 3 are of ordinary construction.

In our present day refrigerating systems objectionable conditions of dehydration occur in cooling with air because the refrigerated air, coming into contact with that which is to be cooled, immediately rises in temperature and absorbs large amounts of moisture from that with which it comes into contact. By the present invention I am enabled to refrigerate air without harmful dehydration and I am able to deliver the air from the evaporator at a humidity approaching the dew point of the conditioned air so that the air coming into contact with warm substances to be cooled, contains sufficient moisture within itself to eliminate or substantially reduce any harmful dehydration of the cooled substances.

It must be recognized that some atmospheric conditions exist wherein there is not sufficient moisture in the atmosphere to result in refrigerated or conditioned air of the desired humidity. Even though my system conserves a large percentage of the original moisture which is contained in the air, it is necessary at times to supply additional moisture through the use of sprays or like means.

As an aid to accomplishing the humidity control of the refrigerated air my thermally and time controlled expansion valve 4 is preferably installed in the refrigerant line between the receiver 3 and the evaporator 7.

As shown in Fig. 14 this time and thermo controlled expansion valve consists of only one valve element which is mounted on a movable rigid carrier 52. The carrier is directly connected to a stem or pin 52 attached to a thermal "syphon" bellows 32. This "syphon" bellows has a direct connection with the liquid in the thermal bulb through tube 31 so that a heating of the said liquid in the thermal bulb 8, Fig. 1 results in an expansion of the liquid and a consequent expansion of the bellows, moving the carrier which supports the valve element 50 and controlling the opening of the valve element from its seat. If the cooling system requires no refrigerant, the contracted condition of the bellows will keep the

valve seated, allowing no refrigerant to pass into the evaporator 7.

In the form shown a spring 70 mounted on a stem or pin 65, the stem or pin being supported by the valve casing 59 and sleeve 66, presses against the valve element 50, and holds it closed against the action of the Syphon bellows 32 and the liquid contained therein. At the opposite end of the stem or pin supporting the spring is a solenoid 40, and upon energization it will compress the spring 70 and allow the opening of the valve element 50 to be governed by the action of the thermal Syphon bellows 32.

At 75 are shown wires leading from a suitable source of supply of electrical energy such as city current. One line is shown leading directly to the solenoid 40 and the other to a pair of contact elements 78 mounted in the housing 35. The lower contact is shown connected with the solenoid 40 by a connecting wire 79 whereupon closing of the contacts 78 actuates the solenoid. At 80 is shown a revolving disk carrying adjustably mounted cam-like members 82, indicated as secured by a screw 83 and a slot 84, which slot is one of several arcuate slots in this revolving device, and by which the position of the cam or a plurality of cams may be arranged to obtain the desired timing of the closing of the switch. The closing of the switch 78 is effected by this cam engaging a raised button 86 or the like on the upper contact member of the switch so that as the cam moves past, the switch 78 is closed for a momentary interval, thus closing the circuit to the solenoid, energizing the same, and moving the armature 62 outwardly to release the pressure of the spring against the valve member 50, and allowing free action of the thermo bellows 32 to control the amount of opening of the valve member 50. The disk 80 is shown as mounted on a shaft 85 which may be rotated by any suitable time device such as an electric clock mechanism.

In the diagrammatic illustrations, Figs. 2 to 6, inclusive, the density of the refrigerant, which is represented by the corresponding thickness of the refrigerant lines 106, is considered to be in direct relation to the amount of moisture condensation on the outer surface of the reaches 17 of the evaporator 7, as illustrated by the representation of droplets of moisture 140; but it is observed that the velocity of the air passing over the evaporator reaches may affect this relation.

For the purpose of illustration of the operation of my method, assume a load is placed on my air conditioning system. A charge or impulse of refrigerant leaves the valve chamber 53 and enters the initial reach 20 of the evaporator reaches 17, wherein it immediately begins to expand, as illustrated by Fig. 2. During such expansion of the refrigerant, heat absorbed from the unrefrigerated air entering the evaporator, causes a consequent condensation on the reaches 17 and radiating fins 9. The amount of condensation depends upon the density of the refrigerant in the charge, the velocity of the air passing over the outer surface of the reaches 17, and the effective evaporator surface, as is illustrated by the represented droplets of moisture 140 appearing on the outer surface of the individual reaches. The introduction of refrigerant in successive charges causes an intermittent flow of refrigerant and this intermittent flow reduces the amount of condensation occurring when the unrefrigerated air first strikes the cold evaporator tubes, since the temperatures maintained on the

surfaces of the tubes and attached fins will not be as low as if a continuous flow of refrigerant were released by the expansion valve, hereinafter explained.

The charge or impulse continues to expand through the initial transverse reach 20, but in a lesser degree causing a smaller amount of condensation until it enters the end zone 18, Fig. 1 which is preferably insulated in order to effect an increased efficiency of the evaporator operation. The increase in efficiency, I believe results from the cooling and some condensing of the refrigerant as it passes through the end zone 18, due to the absence in such zones of a warm medium as is present around the transverse reaches of the evaporator. It is to be understood that the presence of insulated end zones is not necessary for satisfactory operation of my method, and it is not intended that the description of operation or effect of the end zones is to be considered as a limitation of my invention. By this cooling and condensing an increased expansionability to the charge of the refrigerant results, as illustrated by the refrigerant lines 161, Fig. 6, indicating a revivification of the refrigerant having passed through the end zone 109.

As this impulse or charge illustrated in Fig. 2 travels through the reaches 17 of the evaporator during expansion, there is a relative warming zone which is migratory and follows the refrigerant impulse caused by intermittent action of the valve 4, within and around the reach surfaces of the evaporator, as illustrated in Fig. 3. This relative warming zone is due to unrefrigerated, or warmer, air passing over the reaches and the absence of any appreciable amount of refrigerant in the tube at the instantaneous position of the zone.

In Fig. 3 there is illustrated diagrammatically the transfer or passage of the charge of refrigerant 106 from the initial reach 20 to the second reach 20a, this being also shown in Figs. 7 and 8. The charge of refrigerant 106 having passed through an end zone, not shown in Fig. 3, but similar to the end zone 18, Figs. 7 and 8, has been revived so that the refrigerant lines 106 have received expansive powers sufficient to cause condensation of moisture, as represented by the droplets 140. At the same time, the droplets of moisture 140 which have been deposited on the outside surface of the reach 20 are being vaporized, due to the passage of warm air over the outer surface of the reach during the interval of time existing between the admission of the successive impulses or charges of refrigerant. Flared lines 150 emanating from the represented droplets of moisture illustrate this vaporization. After an interval of time controlled by my timing device within the expansion valve, another charge of refrigerant will enter the same evaporator reach 20, the amount of the charge depending on the temperature condition of the refrigerant in the return duct 6. The expansion of this second charge within the transverse reaches again causes a deposit of moisture represented by the droplets 140 on the reach 20 and fins 9 from the air passing through the evaporator, as represented by Fig. 4. This deposit of moisture is vaporized in whole or in part by unrefrigerated air as the charge or impulse passes on through the evaporator tubes. Each impulse introduced into the reaches 17 produces some condensation, Figs. 2 and 4, and the relatively warm air flowing over the surface of the reaches 17 during the interval between each admission of

an impulse of refrigerant to the evaporator produces a vaporization of the moisture condensed by the previously admitted impulse of refrigerant, as illustrated in Fig. 3.

To further illustrate the effect of this intermittent flow of refrigerant upon the moisture within the air as it enters the evaporator, Figs. 7 and 8 are indicative of the moisture deposit conditions existing on the transverse reaches 17. The moisture deposit conditions are represented by the relative size of the droplets 140 on the surface of these reaches, if we assume that an interval of time elapses for a charge of refrigerant (represented by arrows 141 showing the presence of refrigerant and the direction of movement) to pass through one-half of the transverse reaches before another charge enters the initial transverse reach 20 of the evaporator 7. This control of the timing of refrigerant charges or impulses for a unit interval of time is made by adjusting the actuates or cams on the disk 80 of the timing device, a part of my thermo and timed controlled expansion valve 4, as illustrated in Fig. 14.

Fig. 7 is illustrative of the moisture deposit condition the relative size of the droplets 140 which may exist on the evaporator tubes as a charge, represented by arrows 141, entering the initial reach 20 expands through one-half of the transverse reaches 17 of the evaporator 7, namely, reaches 20, and 20a to 20d, inclusive. Comparatively, the moisture condensation is not as large in utilizing this intermittent flow of refrigerant because this method permits a more gradual reduction in the temperature of the air, than if a continuous flow of refrigerant be used. The vaporization occurring on the surface of the latter reaches 20e to 20f, inclusive, represented by the flared lines 150, is of moisture condensed during the passage of the charge or impulse of refrigerant having previously expanded therethrough, as illustrated in Fig. 8, and which will be hereinafter described.

As this charge or impulse of refrigerant, represented by arrows 141, within the lower or initial transverse reaches illustrated by Fig. 7, expands to the latter reaches of the evaporator, as illustrated by arrows 141, Fig. 8, part of the moisture on the initial reaches 20a to 20d, inclusive, of the evaporator will be vaporized by the unrefrigerated, or relatively warmer, air entering the evaporator chamber, as illustrated by the flared lines 150. Variations in the velocity of the air passing through the evaporator and the absence of refrigerant within the initial reaches are factors contributing to the vaporization of moisture on the reaches. This same air which absorbs some of the moisture from the tube surfaces will deposit a part of the moisture on the latter cold reaches of the evaporator, but the air during the conditioning operation retains an amount of moisture so that the conditioned air emitted from the evaporator is at or near its dew point. These exaggerative illustrations of operation exemplify the vaporization of moisture deposited on the initial reaches, the transfer of part of the vaporized moisture to the latter reach surfaces of the evaporator by subsequent condensation, and the passage of the balance of the vaporized moisture into the cooling chamber 13, Fig. 1, as refrigerated or conditioned moisture vapor as a means of eliminating harmful dehydration.

The fins 9, Fig. 1, which may be used in the evaporator are installed at right angles to the transverse reaches. The fin surface and thick-

ness are made in a predetermined relation to the air velocity, tube size, and distance between the reaches of the evaporator. The thickness of the fins 9 is preferably not to exceed .007 inch so that the tendency toward a thermal equilibrium as between the transverse reaches of the evaporator is avoided. Because of their thinness the fins 9 are very responsive to the evaporator surface, that is, of the condition of the tubes, and create ring like temperature zones around each tube. As a result, a thermal sensitivity of the tube surfaces is produced, which causes a thermal isolation along the fins at about one-half the distance between the transverse reaches of the evaporator. These thermal sensitive fins reflect the temperature condition of the tube surfaces and increase the effective area of contact for the air.

By the diagrammatic illustration of Figs. 5 and 6, I have shown what I understand to be the effect of the revivification of the refrigerant charge passing through the insulated end zone 109 and of the alternate cooling and relative warming of the reach surfaces and fins on the moisture content of the air during refrigeration. The thickness of the lines 101, 102 and 103 denotes the relative moisture content of the air at the locations indicated, the diameter of the circles 104 and 105 on the surface of the tubes denotes the relative amount of moisture deposit, and the thickness of the lines 106 within the tubes the density of the refrigerant. AA' indicates an imaginary plane passing through the looped portion of a section of the evaporator and at right angles to a vertical plane passing through the center lines of the reaches 108 and 107, and represents the approximate location of the thermal isolation points produced by the thin fins along their surfaces and between the transverse reaches. Fig. 6 illustrates in an exaggerated manner the relative surcharge which is produced in the charge or impulse of the refrigerant due to its passage through the end zones. The refrigerant represented by lines 160 has its heat absorptive capacity substantially spent, but after passing through the insulated end zone 109, it is revived, as indicated by the heavier refrigerant lines 161, Fig. 6. The arrows 142 indicate the direction of movement of the refrigerant.

In Fig. 5, air at 101 passing over reach 107, the reach having received a charge or impulse of the refrigerant which is beginning to expand within the tube, causes condensation of some of the moisture in the air on the reach 107 and fins 111, as illustrated by droplets 104. As the air passes through the thermal isolation plane AA', the moisture in any given volume of the air (i. e. per cubic foot) will have decreased as indicated by the lighter lines at 102, and with a corresponding temperature decrease. As the air passes over reach 108 it will vaporize some of the condensate, droplets 105, previously deposited on the tubes by other air. This vaporization results from slight warming of the air caused by the absence of any appreciable amount of refrigerant in the reach 108. Due to this vaporization and to the air circulation and the heat transfer by convection of the air which does not strike the evaporator tubes, the air at 103 will have an increase in humidity over air at 102.

Fig. 6 represents a condition existing after the bulk of the charge of refrigerant 106, Fig. 5, has expanded to the end zone 109. The quantity of air at 101' passing over reach 107 will deposit less moisture than the air at 101, Fig. 5, indicated by

the decrease in represented size of droplets of moisture 104, Fig. 6, as compared to the represented size of droplets of moisture 104, Fig. 5, and the air passing through the thermal isolation plane AA' to 102' will not be refrigerated or cooled to the extent which it is cooled at 102, Fig. 5. Therefore, the air at 102' will contain a higher moisture content for any given volume of dry air because of its higher temperature and the vaporization of a part of the moisture deposit on the reaches 107 and fins 111. Since the air at 102' in passing over reach 108 becomes relatively warmed due to transfer of heat by convection from air not coming into contact with the reaches, and by air circulation, a vaporization of some of the moisture present on reach 108 takes place and quantity of air, when it reaches the position 103', will be of a higher moisture content for any given volume than at 103, Fig. 5.

The air coming into the evaporator before the entrance of another charge of refrigerant into the initial reach, will be subjected to the moderated temperature conditions created at the surface of the reaches 107 and 108 and fins 111 and 112, by the preceding air. Consequently, less condensation, and a more gradual refrigeration or conditioning of the air subsequently passing through the evaporator results. Stratification of air caused by the variance in temperatures is eliminated by the diffusion of the strata when they come into contact with the baffles installed in the evaporator and the resultant air will be of a uniform humidity and temperature.

In Figs. 5 and 6, is illustrated the gradual refrigeration of the air and the resultant effects thereof on the moisture in the air as the air passes through the evaporator 7. As the impulses or charges of refrigerant are increased to achieve lower refrigeration temperatures the amount of vaporization of previously condensed moisture may be reduced. However, the result of gradual refrigeration results in less moisture deposits than if a continuous flow of refrigerant were used. Thus, the surcharge imparted to the refrigerant during its passage through the end zones of the evaporator and the variations in air velocity are factors contributing to the desired gradual refrigerating effects produced in part by the method of flow of the refrigerant itself.

Utilizing a pump or fan 11 in the air outlet of the evaporator creates a low pressure condition within the evaporator and a directed flow towards the location of the fan or pump, prevents the loss of moisture from the air which would take place due to impact if the air were forced through the evaporator by discharging the unrefrigerated air under pressure into the inlet of the evaporator. Due to this low pressure condition within the evaporator chamber, moisture on the tubes and fins is drawn to the latter reaches of the evaporator, providing an abundance of moisture on the latter reaches and fins of the evaporator so as to saturate the refrigerated air upon its being drawn from the evaporator. As the air passes through the evaporator at a velocity due to this low pressure condition it entrains some moisture by molecular attraction between the condensate and the vapor in the air.

The gradual refrigeration as produced by my system of intermittent flow of refrigerant follows the laws of thermodynamics. By admitting a charge of refrigerant at intervals and achieving the desired refrigerated air temperature condition, the density of the charge of refrigerant in the tube is much higher than if a like quan-

tity of refrigerant were admitted continuously for an appreciably longer interval of time. This increase in density makes possible a more effective refrigerating expansion through the entire evaporator reaches, so that the air is conditioned or refrigerated materially upon coming into contact with the latter reaches of the evaporator.

The surcharges as given to the refrigerant impulse or charge in passing through the insulated end zone 18, Fig. 1, and caused by the cooling or condensing of the refrigerant passing through this area, provides a stimulant to the refrigerant charge or impulse and increases its ability to expand and effect refrigeration within the latter reaches.

Unrefrigerated air passing over the reaches of the evaporator during the period, between successive charges of refrigerant, increases the average temperature of the surfaces of the initial reaches and reduces the condensation of moisture from the unrefrigerated air in contract with the continuous flow system of refrigerant now being used in our present day refrigerating and air conditioning systems.

The alternate cool and warm migratory zones moving along the transverse reaches of the evaporator, result in higher humidity air and effective refrigeration and conditioning of the air by moisture absorption during and after refrigerating or conditioning.

If a continuous flow of refrigerant were used to accomplish the same resultant temperature condition of the refrigerated air, the continued initial expansion of the refrigerant would cause low temperatures of the surfaces of the initial reaches and attached fins. Because the throttling effect necessitated by a continuous flow of refrigerant would reduce the pressure of the refrigerant in the tubes, as compared with the pressure existing in the tubes when the refrigerant is admitted intermittently, a consequent reduction in expansion and reduction in effective refrigeration would result in the latter reaches. This concentration of refrigeration around the initial reaches due to continuous flow would cause the air coming into contact with the refrigerated surfaces of the initial reaches and fins to be reduced to a much lower temperature than the resultant desired temperature of the refrigerated air, and produce increased condensation as compared with the results achieved by an intermittent flow of refrigerant.

One of the means of control of the humidity of the refrigerated or conditioned air is the actuates or cams on the timing device which is a part of my expansion valve. Consequently, automatic control may be effected by the installation in the cooling chamber of a humidostat. The humidostat controls an electrical circuit which indirectly controls the impulse period of contact of the cam with the switch and also the number of impulse periods for a unit interval of time. The control of air velocity can be made a function of the operation of this humidostat. The present day systems of air conditioning have given little thought to this automatic control of humidity. However, if an automatic control is used, outside moisture must be added to the refrigerated or conditioned air, and the present day systems have proven to be undesirable under these conditions. Since my system ordinarily requires no addition of outside moisture and very little even in extreme conditions, and because of the several variables as present in the

operation of my intermittent flow system, the humidity of the refrigerated or conditioned air is controlled with satisfactory results.

Fig. 11 represents a dispensing machine for comestibles in the nature of candy bars and coated ice creams such as shown and described in my co-pending application Serial No. 731,657, filed June 21, 1934, wherein the cooling means used is my air conditioning system comprising a motor 5, driving a compressor 1, having the usual connection with the compressor. The expansion coil 7 or evaporator has been described above and it has its initial reach connected to a storage tank 3 while the other end of the expansion coil 7 is connected, as usual, to the inlet of the compressor 1.

The merchandise chamber is shown as formed in an upright rectangular housing 21, and it may contain suitable chutes, shelves or other merchandise storing means. In the form of device shown, I have indicated a jacket of brine with a tubular passage 22 connected with a chamber 36 surrounding a fan 37 which preferably is of the radial blade or "sirroco" type. The air passes through the passage 22 from the cold side of the evaporator. The upper end of the cooling chamber opens into a passage 23 which is connected with the casing 24 surrounding the cooling coil 7, so that I have a continuous cycle of refrigeration of the same air. However, provisions may be made to exhaust the air to the atmosphere after passing through the cooling chamber and to admit air from the outside atmosphere into the evaporator chamber 24.

Figs. 12 and 13 illustrate an air conditioning system, where air is refrigerated by entering the evaporator at 10 and leaving at 33 where it enters the chamber of a suction fan or pump 34 and is discharged to the cooling chamber through the duct 16. Figs. 12 and 13 illustrate a compact structure capable of performing my air conditioning method and of being adapted to limited spaces where a demand for air conditioning is present.

If excess moisture deposits on the reaches of the evaporator, it may be necessary to defrost the reaches in order to obtain an efficient result in the operation of the evaporator. Fig. 9 illustrates a defrosting device as covered in my co-pending application Ser. No. 24,382, filed May 31, 1935, and it may be used in my air conditioning system. It is installed within the hollow partitions of the baffles 90 and 91, these partitions serving as baffles and directing the circuitous flow of the air during its refrigeration. Any kind of a heating element may be used, as for example, the resistance unit in an electric iron.

Fig. 10 is a cross section taken of the evaporator unit along the line 3—3 of Fig. 9 illustrating an installation of a heating unit within the hollow partitions of the baffles 90 and 91.

Current is supplied to the heating elements 93 by closing suitable switches, one of which is indicated at 94, Fig. 9. The fan or pump at the outlet of the evaporator is continued in operation and the heat of the surfaces of the partitions 90 and 91, coming in contact with the air passing along both sides of each partition and also in contact with the reaches 17 of the coils transfers the heat thus delivered to the surfaces of the coils and very rapidly effects melting and evaporation. The defrosting is thus accomplished in a few minutes' time, whereupon the circuit to the heating elements is opened and

the refrigeration process may be immediately resumed.

Any means of defrosting the evaporator coils may be used in my air conditioning system but it is preferable to have a means which will defrost the coils in a minimum of time while preventing any appreciable rise in temperature in the cooling compartment 14, Fig. 1. The mere shutting down of the refrigerating system with a continued operation of the fan will defrost the system if a minimum of time is not required.

Through data which I have collected through the many experiments performed on apparatus as above described, these being performed under average humidity and temperature conditions which exist in this temperate zone, I have found that the best results for humidity and temperature control were obtained in using an air velocity through the evaporator of about $2\frac{1}{4}$ cubic feet per minute for each square foot of area of evaporator cooling surface. This cooling surface includes both the effective tube area and the effective fin surface area. Other air velocities in relation to the effective cooling area have given satisfactory results.

More arid or higher humidity atmospheric regions will require a change in the air velocity as well as a variation in refrigerant delivery to the evaporator, but these two variables provide a means of coping with most atmospheric conditions in order to obtain the desired resultant conditioned air.

It is to be understood that the specific construction and particular details of my air conditioning system may be varied without departing from the spirit of my invention. The particular arrangement of the apparatus within my system has produced an operative system eliminating this harmful dehydration of air so that air can be refrigerated or conditioned without the necessity of adding moisture from outside sources and no harmful dehydration results in the cooling of substances such as chocolate coated ice creams, candy bars, and comestibles which are of the nature requiring cooling by a medium approaching the moisture saturation point.

I claim:

1. The method of conditioning relatively warm air having moisture content for preserving comestibles and the like which comprises the steps of causing the air to flow along a predetermined path, admitting refrigerant in heat exchanging relation to the air along a portion of the path of travel of the air while constraining the refrigerant and air from admixture with each other, whereby part of the moisture content of the air condenses, intermittently interrupting the said admission of refrigerant, controlling the interval of admission of the refrigerant to cause re-evaporation by the air of part of the condenser moisture during the intervals between each admission of refrigerant, and controlling the amount of refrigerant during each interval of flow of refrigerant.

2. The method of conditioning relatively warm air having moisture content for preserving comestibles and the like which comprises the steps of causing the air to flow along a predetermined path, admitting refrigerant in successive timed impulses in heat exchanging relation to the air along a portion of the path of travel of the air

while constraining the refrigerant and air from admixture with each other, whereby a part of the moisture content of the air condenses, controlling the interval of time between the admission of each successive impulse of refrigerant to cause reevaporation by the air of part of the moisture condensed during said predetermined time intervals, and controlling the amount of refrigerant admitted during each interval of flow of refrigerant.

3. The method of conditioning air for preserving comestibles and the like by reducing the temperature of relatively warm air having moisture content in a manner so that the amount of moisture content in a unit volume of the conditioned air is substantially at its moisture saturation point, comprising the steps of cooling the effective area of an evaporator surface by admission of refrigerant into the evaporator, providing intervals of time between each admission of an impulse of refrigerant to the evaporator, controlling the amount of refrigerant in each impulse admitted to the evaporator by the resulting temperature of the conditioned air, passing the relatively warm air over the effective area of evaporator surface in the same general direction of flow as the refrigerant and at a predetermined velocity in relation to the evaporator surface for inhibiting moisture condensation from the air as the air passes over the intermittently cooled reaches of the evaporator and for further causing the moisture condensed on the reaches of the evaporator to be vaporized by the warm air passing over the reaches during intervals of time between the admission of successive impulses of refrigerant, whereby the air during the process of cooling is reduced in temperature in such a manner that upon leaving the evaporator, the conditioned air is at or near its moisture saturation point.

4. The method of conditioning air for preserving comestibles and the like by reducing the temperature of relatively warm air having moisture content in a manner so that the amount of moisture content in a unit volume of the conditioned air is substantially at its moisture saturation point, comprising in the steps of cooling the effective area of an evaporator surface by admission of refrigerant into the evaporator, providing intervals of time between each admission of an impulse of refrigerant to the evaporator, controlling the amount of refrigerant in each impulse admitted to the evaporator by the resulting temperature of the conditioned air, passing the relatively warm air over the effective area of evaporator surface in the same general direction of flow as the refrigerant and at a velocity of about two and one-quarter cubic feet per minute for each square foot of effective evaporator surface for inhibiting moisture condensation from the air as the air passes over the intermittently cooled reaches of the evaporator and for further causing the moisture condensed on the reaches of the evaporator to be vaporized by the warm air passing over the reaches during intervals of time between the admission of successive impulses of refrigerant, whereby the air during the process of cooling is reduced in temperature in such a manner that upon leaving the evaporator, the conditioned air is at or near its moisture saturation point.

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