This invention relates to methods and apparatus useful in the conditioning of air, and particularly to unit air conditioners and refrigerators having applications in process and product refrigeration, such as the cold storage warehousing or packing of meats, eggs, fruits, vegetables and the like, and in wholesale and retail food markets.

The present invention is primarily concerned with the problem of effectively controlling the temperature and humidity of air circulating in a refrigerated zone, and has particular application wherever it is desired to maintain relative humidity within such a zone at a high, substantially uniform value. In the cold storage of meat and eggs, for example, relative humidity must be maintained at a high value to prevent drying or deterioration of the product. It will be understood that a principal difficulty where refrigerator coils are employed is condensation of moisture on contact of the air with the coils, with consequent lowering of humidity. For example, if coil temperatures are depressed more than about 10° below air temperatures to be maintained in the refrigerated zone, dehumidification of air circulating about the coils will occur at a rapid constant rate. On the other hand, efficient refrigeration of the zone is not easily obtained unless temperature differentials of at least 10°, and preferably 20° to 30°, are employed. As a result, practical units of this type are generally concerned primarily with the function of cooling air, with humidity control only a secondary function within the limits of the design. Where humidity control is a prime factor, high first costs and installation expenses are often encountered. Moreover, as the operation of humidity control mechanisms is generally based primarily on temperature control, over humidity has little relation to actual conditions of humidity existing within the refrigerated zone.

In addition to problems of control, most unit air coolers and humidifiers make poor use of available refrigeration space. For example, conventional ceiling or floor mounted units are housed in part if not entirely within the walls of the refrigerated enclosure. As a result, such units are very uneconomical of head room or floor space, and in walk-in type refrigerator units often constitute a safety hazard as well.

The present invention is directed to what appears now to be a simple solution to the above and to many additional problems, as will appear. Accordingly a principal object of the invention is to maintain humidity at a relatively high value in refrigerated zones, such as walk-in refrigerators and the like.

Another object of the invention is to positively and independently control both the temperature and humidity of air circulating in such a refrigerated zone.

Another object of the invention is to provide an apparatus for positively controlling temperature and humidity in a walled, enclosed refrigerated zone that is unusually economical of useful space within the zone, and which is safe and efficient in operation.

Other objects and advantages of the invention will be apparent from the following description and from the drawings in which:

Fig. 1 is a view in perspective of a refrigeration system embodying the invention.

Fig. 2 is a view in longitudinal section along the line II—II of Fig. 1, showing details of an unit air conditioner useful in the refrigeration system.

Fig. 3 is a view in transverse section along the line III—III of Fig. 2.

Fig. 4 is a view in bottom plan of the air conditioning unit of Figs. 2 and 3; and

Fig. 5 is a view in of a modification of the unit according to the invention.

Generally stated, the present invention involves controlling the temperature and humidity of air circulating in a refrigerating zone by first withdrawing the air from the zone and dividing the withdrawn air into separate portions. One portion of the withdrawn air is deflected over a source of low temperature, causing the air to be cooled, while the other portion is simultaneously deflected over a source of water vapor; the two separated portions then being combined into a single return stream at substantially the humidity and low temperature desired in the refrigerated zone. By this general process moisture lost by condensation during the cooling of one portion of the air is restored by vaporization of moisture into the other portion of the air, with desired conditions of temperature and humidity being achieved on reuniting the separated portions. The ultimate effect is to permit maximum temperature differentials between the low temperature source and the circulating air, and consequently maximum refrigeration potentials, without preventing positive maintenance of relative humidity at a desired high value.

The general construction of an exemplary system capable of accomplishing the functions of the invention is illustrated in Fig. 1. As there shown, a unit air conditioner A is mounted in the ceiling of a zone of refrigeration, such as a walk-in type refrigerator B, and projects upwardly through the roof of the refrigerator. In the sectional view of Fig. 2, the unit A may include two banks C of refrigerator coils spaced on either side of a vertically mounted blower D. The blower acts to suck air from the refrigerator upwardly through a duct or outlet 20 positioned in the ceiling of the refrigerator. The duct, in turn, is in communication with air passages E returning air blown through the unit to the refrigerator. The Drip pans F are positioned below the banks of coils C to catch moisture condensing on the chilled coil surfaces.

According to the invention, baffles G adjacent the blower serve to deflect portions of the air downwardly and across the surface of water dripping from the refrigerator coils and collecting in the drip pans F. As a result, air circulating into the refrigerator room 24 through inlet openings 22 is humidified to the extent that the deflected portions of air passing over the drip pans have picked up water vapor from the condensate in the pans.

It is a further feature of the invention that warm water may additionally be supplied to the drip pans F by means of control mechanism responsive to conditions of humidity within the refrigerator, such as, for example, a solenoid valve S controlled by humidistat H. Accordingly, when the relative humidity falls below a certain value within the refrigerator, valve S is caused to open permitting warm water to enter the drip pans. Some of this warm water may be discharged through drains 23 provided in the pans, but enough is available for a sufficient time to permit the deflected air to pick up a large amount of water vapor, thus immediately raising the humidity in the room. Preferably means are also provided to spread the warm inlet water over as large a surface area as possible to facilitate its rapid vaporization into the deflected air.
stream. The ultimate effect is a positive control intermittently supplying relatively warm water to the drip pans when called for by lowered humidity in the refrigerator room; whereby humidity within the room may be maintained at a high, substantially uniform value.

In the drawings, the conditioner unit A is shown as a substantially rectangular box including top and bottom walls 12 and 14, side walls 16 and tapered end walls 18. Suspended within the unit is a motor 23 for the blower, which may be connected to a suitable source of electrical power, as by wall plug 29. The lower wall 24 is provided with a central duct 20 to house the impeller blade 26 of the blower, the latter taking any conventional form. When supplied with power the impeller blade acts to suck air rapidly upwardly through the duct 20 and into air passages E formed by the walls of the unit.

Positioned in the air passages E and in the path of a major portion of air flowing through the passages are banks of refrigerator coils C. Preferably the separate coils 30 in the bank are interconnected by fins 32 to enlarge the cooling area presented to the air stream. The coils 30 may be chilled in any suitable manner, as by the conventional refrigeration system 34. In this system liquid refrigerant is expanded into the coils through an injector 36 causing the refrigerant to evaporate and chill the individual coil elements 30. The expanded refrigerant is returned from the coils through conduit 38 to a conventional mechanical compressor 40. The refrigerant is then compressed to a pressure and temperature at which it can again be liquefied in a shell and tube water cooled condenser 42; or in a smaller unit an air condenser might be utilized. The liquefied refrigerant is then conducted back through the conduit 44 and expanded through the injector 36 into the coils for reevaporation and removal of heat. It should be understood, however, that the coil refrigeration system just described is intended merely as illustrative of suitable means for cooling the air, and that any other source of low temperature might also satisfactorily perform the desired function.

As best seen in Fig. 2, the drip pans F form a part of the lower wall of the unit and extend transversely under the cooling coils C from a position immediately adjacent the duct 29 to a position adjacent the air passage return openings 22. Preferably the drip pans merge into a single pan extending all about the blower duct, as shown in Fig. 4. This construction permits the entire cooling and humidifying unit A to be recessed in the ceiling 46 of the refrigerator in a position substantially flush with the lower surface of the ceiling. As a result, little usable storage space within the refrigerator B is lost to the unit. This is of particular importance, for example, in walk-in type refrigerator units where ample head room is a primary factor. Moreover, by positioning the blower unit externally and above the refrigerator room, improved operation is provided as well as increased safety to personnel moving about within the refrigerator.

Positioned adjacent upper edge portions of the duct 20 are the baffles G. As indicated generally by the flow arrows (Fig. 2), each baffle serves to divert a substantial portion of the air stream downwardly into a path across the surface of water collecting in the drip pans. This diverted air picks up some water vapor and, after rejoining the principal air stream blown through the banks C of refrigerator coils, contributes to maintaining the humidity of the total outgoing air at a relatively high percentage. This effect would be achieved even if no additional water were added to the drip pans; the vaporization of the condensate from the refrigerating coils serving to increase the humidity of the air circulating through the unit A and into the refrigerator room 24. However, as noted above, it is preferable to supplement the condensate with warm water which will more readily vaporize into the diverted air stream.

According to the invention, water supplied from a city main, as through conduit 50, is heated and supplied to the drip pans F in response to conditions of humidity within the refrigerator as determined by the device H. Preferably the temperature of the warm water source is maintained between about 60° and 100° F. Any suitable means may be employed to preheat the water supplied but preferably heat generated by the refrigerator B of the refrigerant system is utilized for this purpose. As shown in Fig. 1, the inlet water supplied through conduit 59 is circulated through a jacket 52 surrounding the compressor, and from the compressor flows through conduit 54 to the solenoid valve S. During conditions of relatively high air humidity within the refrigerator B, the valve S will be closed preventing flow of water into the drip pans.

As humidity within the room falls below a certain predetermined value, the humidistat H acts positively to open the solenoid valve S allowing warm water to enter the drip pans through branch conduits 56. In the apparatus the inlet water flows into the drip pans through elongated perforated pipes 58 about which may be coiled elongated rolls of perforated material, such as screening 60. The effect of the screening 60 is to spread and distribute the water to provide a greater surface which increases the rate of heat transfer and also diverts beneath the baffles G. As a result, although the warm water flows for only a short time when the humidity is low, the large area of surface evaporation permits the relative humidity of the circulating air to be raised very rapidly, providing rapid efficiency in dehydration over conditions of humidity within the refrigerator.

Moreover, by proper control of coil temperatures in relation to the amount of air circulated through the blower, air temperatures within the refrigerator may be accurately and effectively controlled. The refrigeration system is an unusually efficient, simultaneous regulation of both temperature and humidity in a unit air conditioning system.

In order to understand the method of the invention and the principles involved, assume first that no baffles are provided in the unit A. Under such conditions, the moisture in the air circulating upwardly through the blower and across the banks of refrigerating coils would soon condense and drip into the pans F. Continued circulation of the air through the blower would remove further amounts of moisture, causing a progressive decrease in the relative humidity of the air circulating within the refrigerator room 24 by a continuing process of condensation and removal of the condensate through the drains 23. Such dehumidification occurs even though the coils are as little as 10° below that of the circulating air. In accordance with the invention, however, a substantial portion of the circulating air is diverted to the baffles G over the condensate collecting in the drip pans before it picks up as water vapor an appreciable amount of the condensate. As a result, undesirable dehumidification within the refrigerating zone is virtually eliminated permitting much greater temperature differential between the refrigeration coils and the circulating air substantially dehumidified. It has been found, for example, that when baffles are used in accordance with the invention, temperatures of the cooling coils may be as much as 15° or even 20° cooler than circulating air, with little or no resultant dehumidification of the air.

By the further advantage of supplying warm water to the drip pans and responsive to conditions of humidity in the refrigerator room, it is possible to greatly magnify the effectiveness of the deflecting baffles G. In particular, positive control over relative humidities of the circulating air may be achieved regardless of substantial differences in temperature between the air and the refrigerator coils 30. As a result, high relative humidities in the refrigerating zone may be consonant with rapid efficient cooling of the circulating air. This combination of effects is of unusual value in many industrial refrigeration applications, such as the storage of eggs, meat and other such products, where
removal of moisture from the product is to be particularly avoided. In a preferred application of the invention, a decrease in relative humidity below a desired point will cause the humidistat H to open the solenoid valve S allowing warm water to flow from the reservoir 52 about the condenser to the drip pans F. This water, being considerably warmer than the circulating air, is immediately vaporized into that portion of the air deflected over the pans F, causing the humidity of the circulating air to be instantaneously increased. However, the flow of water will continue only so long as necessary to return the humidity in the refrigerator room 24 to above the predetermined set value regulating the humidistat H. In this way, relative humidities within the refrigerator may be maintained at a relatively high, substantially uniform value throughout the continuous periods of use. Moreover, coil temperatures considerably below that of the circulating air may be used without fear of excessive dehumidification. For example, coil temperatures as much as 40° to 60° below that of the circulating air have been effectively employed.

Fig. 5 illustrates a modification of the condition unit A employing a single air passage E arranged annularly about the ducted blower unit D. The modified unit employs a single annular drip pan 63 positioned below an annular bank 65 of coils 67. In corresponding fashion an annular baffle G would be positioned inwardly adjacent the coils.

In operation, air would be drawn upwardly through the ducts as before, but would be distributed radially outwardly through the passage E in all directions.

From the above description it will be apparent that the present invention makes possible efficient positive control over both temperature and humidity in a refrigerated zone. In particular, the invention permits relatively high, substantially uniform, relative humidities in a refrigerated zone even though operating temperatures of the refrigerant source range from 10° to 60° or more below the desired temperatures of the air circulating within the zone. Moreover, the invention provides such a unit that may be recessed in an out of the way position in the ceiling of the refrigerator, providing substantial economies of space, increased head room and greater safety of operation.

Those skilled in the art to which this invention relates, many changes in construction and widely differing embodiments and applications of the invention will suggest themselves without departing from the spirit and scope of the invention. For example, when a supply of warm water is employed as an additional source of water vapor, the water might be warmed by heat generated in the blower motor D instead of the condenser 42, or an independent heating source might be employed. Moreover, more than one deflecting baffle G might be employed before each bank of refrigerant coils and still obtain the desired effects. Accordingly it should be understood that the disclosures and the description herein are purely illustrative and are not intended to be in any sense limiting.

I claim:

1. In an air conditioner of a type particularly adapted to conditioning air for use in a refrigerated zone, means for controlling the temperature and humidity of air entering the zone, comprising: a ducted fan recessed in a ceiling of said refrigerated zone; an air passage in communication with said fan and with said refrigerated zone; refrigerant coils positioned in said air passage; means cooling said coils to a desired low temperature; a drip pan below said coils, said drip pan being provided with a drain; and a baffle adjacent said fan to divert a portion of air blown through the passage into a path across the surface of said drip pan; a conduit in fluid communication with a source of warm water and with said drip pan; a valve in said fluid conduit; and means for controlling said valve in response to variations in humidity in said refrigerated zone whereby a decrease in humidity in said refrigerated zone below a certain predetermined value will cause warm water to be introduced into the drip pan where its water vapor may be picked up by the air diverted across the drip pan, thereby restoring the desired conditions of humidity in said zone. 2. The device of claim 1, in which said humidity responsive means is a humidistat positioned in said refrigerated zone. 3. The device of claim 1, in which lower portions of said fan and drip pan are substantially in the plane of said ceiling. 4. The device of claim 1, in which the temperature of said source of warm water is thermostatically controlled to between about 60° F. and 100° F. 5. The device of claim 1, in which said refrigerant coils are provided with fins extending laterally into said air passage above said baffle. 6. In an air conditioned refrigerator, walls including a ceiling forming a zone of refrigeration; an access door mounted in one of said walls; a refrigerant and humidifier unit recessed in said ceiling so as to be substantially flush with a lower portion thereof, said unit comprising: a blower fan impelling air through the unit, an air passage leading from an outlet adjacent said fan to a return inlet in said ceiling, a drip pan arranged closely adjacent said fan, a bank of refrigerant coils mounted above said drip pan in said air passage so as to provide chilling surfaces in upper portions of said air passage and an air space above said pan, and a baffle adjacent a lower portion of said bank of coils to divert a portion of air impelled through the passage into the air space above said drip pan, remaining portions of the air impinging on the chilling surfaces provided by said coils, said drip pan, air passage, baffle and bank of coils being annular in general configuration, whereby control over the temperature and humidity of air circulating in said refrigerated zone may be achieved by control over the temperature of said coils and the positioning and inclination of said baffle. 7. A device for conditioning and refrigerating air comprising: walls forming an enclosure; openings in an upper wall of said enclosure; blower means recessed in one of said openings so as to provide lower surfaces substantially in the plane of said upper wall; an enclosed air passage above said upper wall leading to said blower and to another of said openings; a source of low temperature refrigeration in said air passage, said source including chilled air contacting surfaces; a drip pan positioned below said low temperature source so that water collecting in said pan may provide a source of water vapor; baffle means deflecting and dividing an air stream sucked into said blower into portions passing about said low temperature source and above the water in said drip pan, said divided portions reuniting prior to return to said zone into an air stream conditioned as to humidity and temperature; and means responsive to humidity to regulate flow of water from a source of warm water to said drip pan, said drip pan also being provided with a drain.

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