Aug. 31, 1965 H. MALKOFF 3,203,196

AIR CONDITIONING SYSTEM WITH FROST CONTROL

Filed May 10, 1963 3 Sheets-Sheet 1

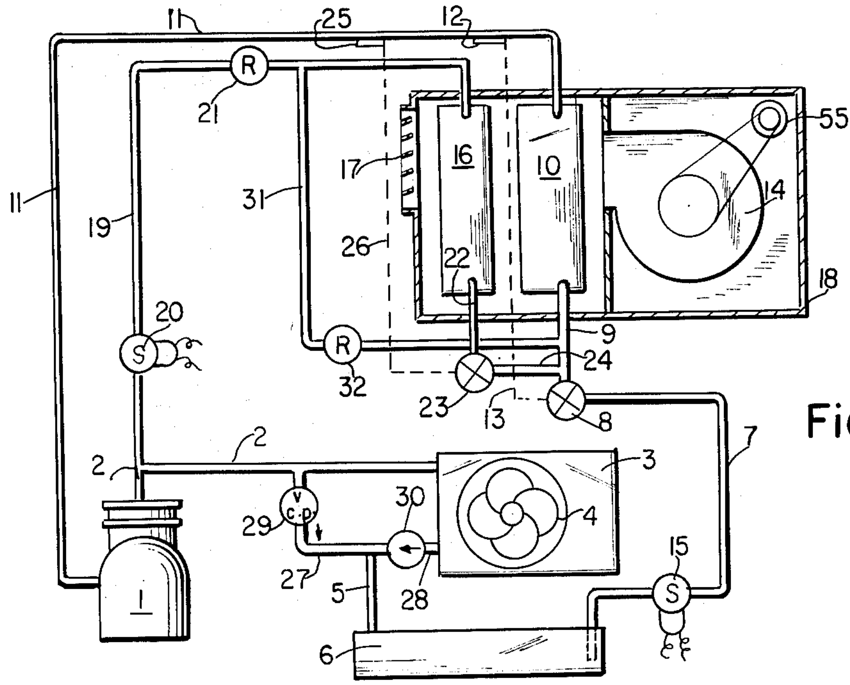

Fig. 1

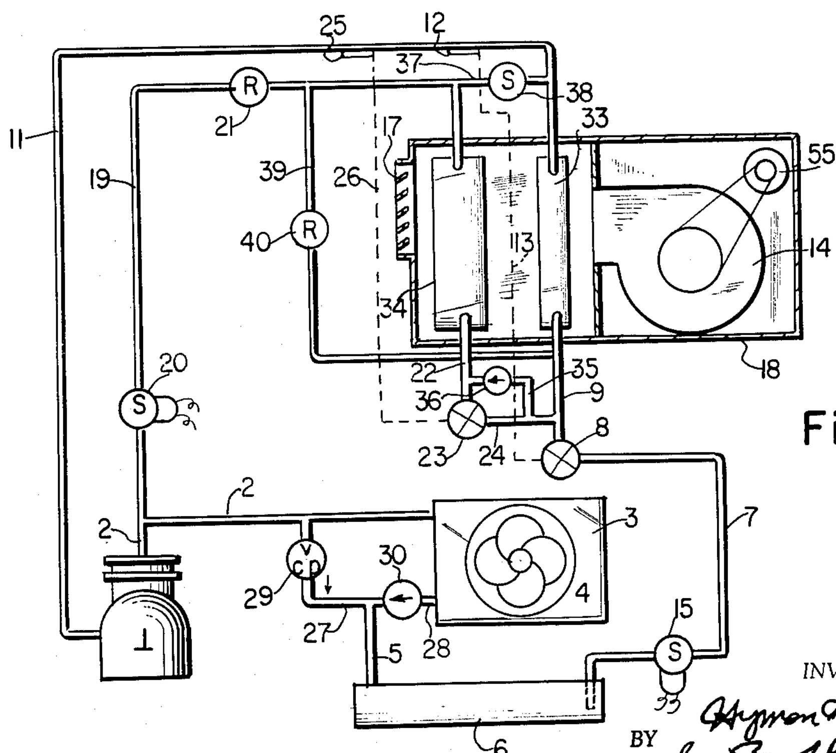

Fig. 2

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AIR CONDITIONING SYSTEM WITH FROST CONTROL

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Fig. 4

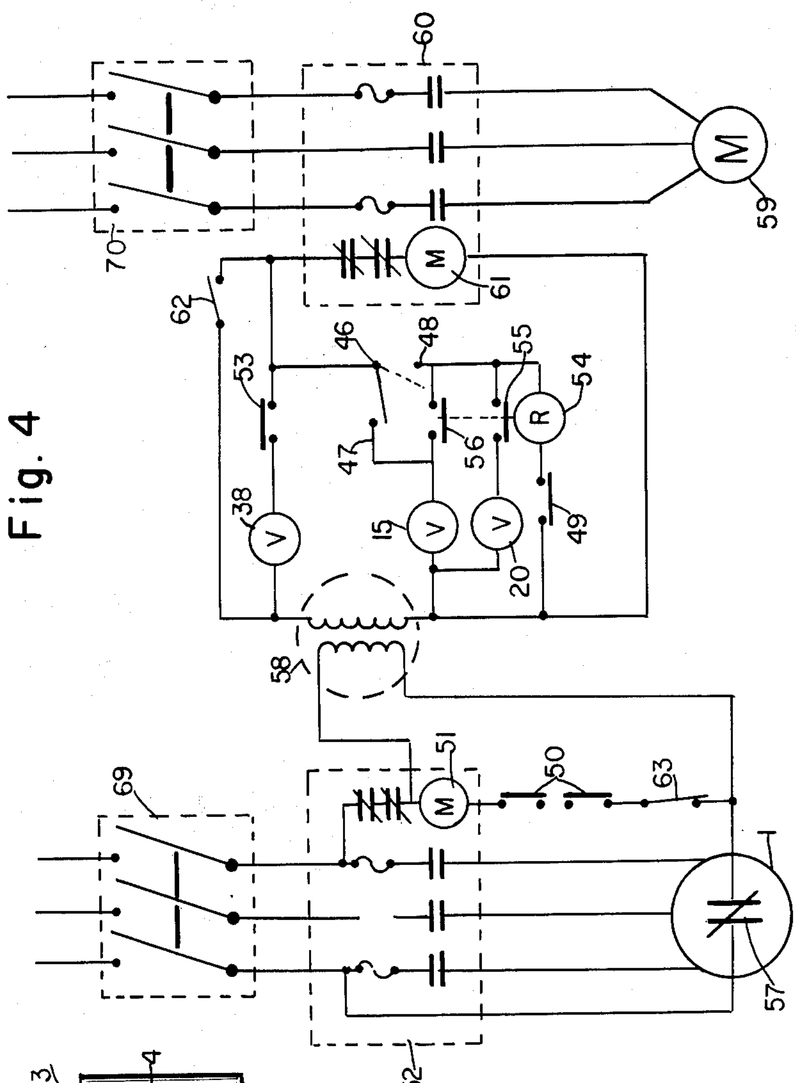

Fig. 3

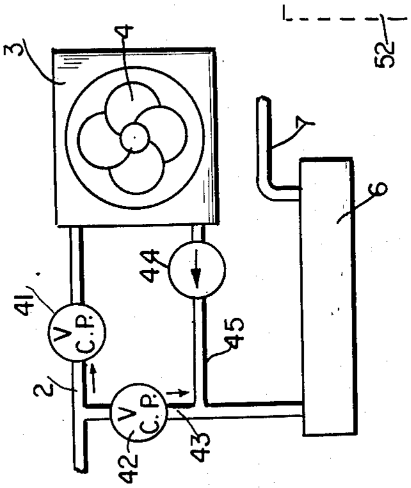

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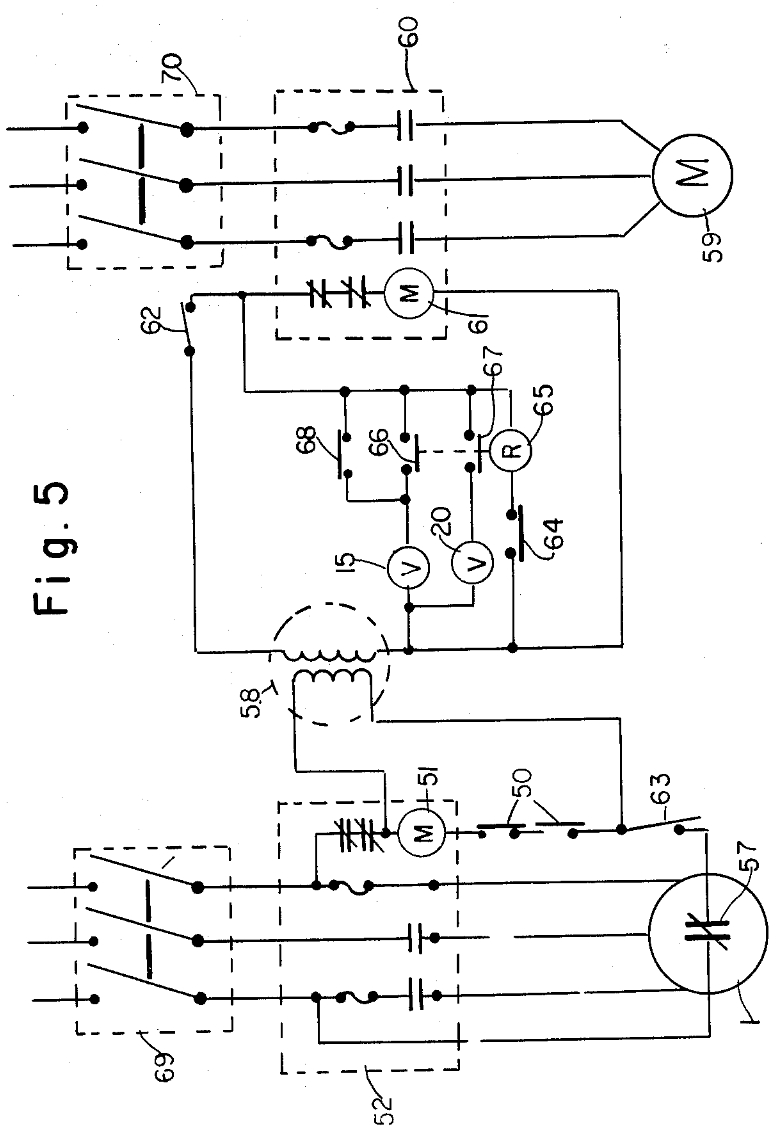
Fig. 5



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United States Patent Office

3,203,196
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3,203,196
AIR CONDITIONING SYSTEM WITH FROST CONTROL

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Filed May 10, 1963, Ser. No. 279,515
6 Claims. (Cl. 62—173)

This invention relates to a vapor compression air conditioning system or apparatus with frost control especially designed and adapted for employment in situations, either domestic or industrial, where relative humidity is a critical factor, and has for a chief object the provision of means embodied in the system itself for reheating or raising the dry bulb temperature of the chamber or space being conditioned immediately following the reduction in temperature and absolute humidity due to the chilling effect of the cooling coil upon the air stream passing through it, together with means which enables the system to operate at the maximum dehumidification level and the lowest refrigerant temperature level for a given evaporator without frost accumulation upon the evaporator surface.

Another object consists in providing such a system which incorporates a secondary or auxiliary condenser that is, when needed, supplied with heat from the discharge of the compressor in the system, and serves to warm the air stream that is forced through the air cooling evaporator in the system for conditioning the chamber or space.

Another object consists in providing such a system which includes means for regulating the amount of heat supplied from the compressor discharge to the secondary or auxiliary condenser in order to avoid undesired rise of temperature within the chamber or space that is being conditioned while insuring adequate supply of heat for the re-heating function.

Another object consists in providing such a system in which the secondary or auxiliary condenser is constructed as a portion of the evaporator, with the two portions serving as the evaporator during normal cooling cycles and the secondary or auxiliary portion acting separately as a condenser during reheating.

Another object consists in providing such a system in which the re-heating means is constructed and arranged for cooperative functioning with means for maintaining a predetermined high side pressure regardless of ambient temperature at the condenser, or oversizing of the latter, or heat load at the evaporator.

A further object consists in providing certain improvements in the form, construction and arrangement of the several parts, and in the method of operation, whereby the above named, and other objects inherent in the invention, are efficiently attained.

This invention is an improvement upon U.S. application Serial No. 187,691, filed April 16, 1962, now Patent No. 3,139,735, by Daniel E. Kramer, Otto J. Nussbaum, and myself, and is particularly directed to the inclusion of means that enables operation of the evaporating coil at the lowest possible refrigerant temperature short of frosting in order to obtain the maximum dehumidification. Since dehumidification of an air-water-vapor mixture is directly related to the surface temperature of a cooling coil, and since the surface temperature of a cooling coil is directly related to the refrigerant temperature in the same coil, this improvement opens a possibility for maximum dehumidification to the lowest possible dew point temperature of the exit air stream from the evaporator, by providing a safeguard included within the system to prevent the refrigerant temperature from dropping so low as to cause frosting on the air evaporator surface.

One of the greatest advantages of this invention is to

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enable the construction of air conditioning systems using very low air flows per ton of air conditioning and in that way minimizing the size of ducts and air moving equipment and the power required therefor with corresponding lessened first cost and duct space, and also minimizing discharge velocities from nozzles in the air conditioned space, affording the maximum quietness for a given system as well as maximum comfort.

Practical embodiments of the invention are represented in the accompanying drawings, in which

FIG. 1 represents diagrammatically an air conditioning system of the vapor compression type with the secondary or auxiliary condenser for reheating shown as separately connected in the system with respect to the evaporator and including the present improvement;

FIG. 2 represents a similar view in which the secondary or auxiliary condenser is shown as interconnected with the evaporator so as to serve as a part of the latter during cooling cycles of the system, while acting separately as a secondary condenser during reheating when necessary.

FIG. 3 represents a modification of the means shown in FIGS. 1 and 2, for maintaining a predetermined high side pressure in the system, and to insure re-starting after long off-cycles of the compressor without short cycling of its motor.

FIG. 4 represents diagrammatically an electric control system for the form of the invention shown in FIG. 2, and

FIG. 5 represents an electric control for the form of the invention shown in FIG. 1.

In air conditioning for either human comfort or industrial purposes, where relative humidity is an important factor, the dehumidification of the air, which is accomplished by a cooling coil, usually requires the employment of a reheat coil, or the like, thereafter, in order to maintain a minimum desired dry bulb temperature in the chamber or space being conditioned, especially on relatively cool but humid days. Steam or hot water coils are commonly used for the reheat step. According to the present invention, heat of condensation of the air conditioning system is automatically employed for reheating. However, as the heat in the gas stream leaving the compressor discharge is substantially greater, say twenty percent, than the amount of heat which has been absorbed by the evaporator from its load, it will be evident that the use of all this heat in the reheating cycles would result in a constantly rising dry bulb temperature in the chamber or space, which is not desired. Furthermore, it is necessary, especially in a system having an air cooled condenser, that the latter be adequate in capacity for dissipating the maximum heat developed at the evaporator during hot weather. Consequently, in properly attaining the functional purpose of using heat of condensation for reheating the air stream passing through the evaporator following the chilling and dehumidification step, it is requisite so to distribute or apportion the heat of compressor discharge as to accomplish the reheating of the air in the chamber or space while directing the remainder of the heat to be dissipated by the main air cooled condenser which feeds the evaporator during the cooling dehumidification step.

In brief summary, the invention comprehends the provision of a system with a secondary or auxiliary condenser that is operatively associated with the evaporator and functionally connected with the compressor in such manner as to receive from the latter sufficient heat for reheating steps and have its heat thus obtained dispersed throughout the chamber or space being conditioned by the air current or stream forced through the evaporator by the usual blower or fan, while leaving the remainder of the heat of compressor discharge for the main condenser; the system including means enabling the operation of the evaporator at the lowest refrigerant temperature possible without frosting of the evaporator coils, thereby obtaining maximum dehumidification with low air flow per ton of air conditioning and consequent economy in the size of air ducts, air moving equipment, and required power, the whole operation being automatic and thermostatically or humidistatically controlled.

Referring now to the drawings, and specifically to FIG. 1, the system includes the usual closed circuit for refrigerant flow comprising a compressor, which may be of the hermetic suction cooled type, denoted by 1, connected by a conduit 2 with the inlet of an air cooled condenser 3 equipped with the usual fan 4. The outlet of the condenser communicates through a conduit 5 with a receiver 6, which, in turn, is connected by a conduit 7 with a thermostatic expansion valve 8, from which latter a pipe or tube 9 leads to the inlet of an evaporator 10. A suction conduit 11 connects evaporator outlet with compressor intake, thus completing the circuit. The expansion valve 8 is controlled by the customary feeler bulb 12 clasped to the suction conduit with its capillary tube 13 leading to the valve, while a suitable device, here shown as a blower 14, serves to force air through the evaporator for circulation within the chamber or space being conditioned. All the elements just described may be of any well known or approved form, construction and arrangement which calls for no further description. A solenoid valve 15 controls refrigerant flow through conduit 7.

A feature of the present invention consists in the provision of a secondary or auxiliary condenser 16, which may be composed of coils as is usual in condensers, and is positioned in axial alignment with the evaporator 10 at the side of the latter opposite the blower 14, so that the air stream from the latter will pass through both evaporator and secondary condenser, and thence out into the chamber or space being conditioned through the opening 17, which may be louvered, in the usual housing 18 that embraces the blower and evaporator.

A conduit 19 branches off from compressor discharge conduit 2 and leads to the inlet of the secondary or auxiliary condenser 16, and in this conduit 19 is fitted a solenoid valve 20, together with a pressure regulating valve 21 that is positioned either between the valve 20 and the auxiliary condenser 16 or at the inlet side of the solenoid valve 20. The solenoid valve 20 is thermostatically or humidistatically controlled, as will be hereinafter described, and it will be clear that, when the secondary or auxiliary condenser is called upon to serve as a reheater, the opening of valve 20 will supply hot gas from the compressor thereto. This hot gas is condensed by the stream of cool air generated by the blower 14, and the condensate is fed through an outlet tube 22 to a second thermostatic expansion valve 23, and thence through a pipe 24 to pipe 9 at the inlet of the evaporator 10. Valve 23 is controlled by feeler bulb 25 and capillary tube 26, the bulb being clasped to the suction conduit 11 at a point further or down stream from the evaporator 10 than bulb 12. The air stream which cools the condenser 16 is, in turn, warmed by the latter which thus serves as a reheater for the chamber or space being conditioned. Valve 21 is of the outlet pressure regulating type, which is well known and requires no description, that may be set for a predetermined reheat temperature of the auxiliary condenser 16.

In operation, when the degree of humidity within the chamber or space being conditioned is satisfactory, the system serves as a well known air conditioner, with the hot gas from the discharge of compressor 1 flowing to the condenser 3 and the resultant condensate depositing in the receiver 6, from which latter the refrigerant, still under pressure, is forced through the conduit 7 to the expansion valve 8 which sharply reduces refrigerant temperature so that it enters the evaporator 10 cold and mainly in liquid phase. As the low temperature refrigerant passes through the coils of the evaporator the air stream from the blower is chilled, and travels through the secondary or auxiliary condenser 16 (which is functionless at this stage) and out from the opening 17 in the housing 18 for circulation in the chamber or space being conditioned. The warmth of the air stream from the blower largely vaporizes the refrigerant passing through the evaporator coils and it exits from the latter mainly in gaseous phase and of elevated temperature to return to the compressor through the suction conduit 11, for re-compression and repeated circulation through the system.

The chilling by the air stream is effective to de-humidify the air within the chamber or space, but this step results in lowering of the dry bulb temperature therewithin to an uncomfortable or undesired point which calls for activation of the reheater condenser 16. This is automatically accomplished by the humidistat or thermostat of the electric control circuit, to the hereinafter described, or a combination of both, which causes the solenoid valve 20 in the conduit 19 to open and permit some of the hot gas from the compressor discharge to flow to the inlet of the secondary or auxiliary condenser 16, the amount of the flow being regulated by the setting of valve 21. This hot gas moving through the coils of condenser 16 warms the air stream from the blower 14 and serves to re-elevate the temperature within the chamber or space being conditioned. Upon attainment of the desired temperature, the solenoid valve 20 is thermostatically closed and the reheater secondary condenser ceases to function.

As previously described, when the reheater condenser 16 is in operation its condensate is fed to the evaporator through the expansion valve 23 with the result that expansion valve 8 operates at minimum capacity, or may be entirely out of action. The locating of feeler bulb 25 down stream with respect to bulb 12, insures that the valve 23 operates at full capacity, so that valve 8 will be called upon only when the super-heat of the vapor at the outlet of the evaporator 10 rises above a predetermined degree.

The cycles of dehumidification and reheating above described are automatically and sequentially performed as conditions in the chamber or space being conditioned require to maintain the air at desired degrees of humidity and temperature.

When constructing such systems for installations in which the main air cooled condenser 3 is to be subject to low ambient temperatures in some or all seasons of the year, e.g. 60° F. and lower down to below zero, it is highly desirable to equip the system for automatically maintaining a predetermined high side pressure in the condenser 3, receiver 6, and conduit 7, regardless of the ambient temperature at the said condenser, the size of the condenser, or the heat load of the evaporator. Such arrangements are shown and described in U.S. Patents Nos. 2,564,310 and 2,963,877, issued respectively August 14, 1951 and December 13, 1960 which obviates the necessity of full description herein, it being deemed sufficient to note that from the compressor discharge conduit 2 a by-pass pipe or conduit 27 branches and leads to the outlet 28 of the condenser and to the conduit 5 which connects the condenser and the receiver which is adequately sized. In the by-pass 27 is fitted a valve 29 which is of a well known type that is designed and adapted to maintain an approximately constant pressure at its outlet side, i.e. its side that is toward the condenser outlet and the receiver. I prefer to use a constant outlet pressure modulating valve, but there may be substituted other devices such, for instance, as a constant pressure automatic expansion valve, or a solenoid valve combined with a pressure switch, or any other mechanism or combination thereof which will maintain its outlet or downstream pressure at the desired predetermined degree. Refrigerant flow restricting means 30 is positioned at the condenser outlet between the condenser itself and the junction of the by-pass 27 with the conduit 5. This is shown as a spring loaded check valve which permits flow from the condenser but restrains reverse flow, but there could be substituted other devices for the same purpose such as a serpentine restrictor tube or a valve (preferably modulating) with inlet pressure control.

When the ambient temperature at the condenser 3 is relatively warm, e.g. above 60° F., the valve 29 remains closed; but, if the ambient falls below 60° F., or such other point as may have been selected by the setting of the valve for the opening thereof, the pressure at the outlet side of the valve will be reduced causing the valve to open and permit refrigerant flow toward the condenser outlet which raises the pressure at that point and causes the condenser to be gradually flooded by the condensation of gas flowing to its inlet through the conduit 2, thus reducing the condenser area of effective heat transfer surface and raising the high side pressure. When, the desired pressure has been attained, the valve 29 will close, and it will thus be seen that the effect of the said valve in maintaining a nearly constant pressure at its outlet side results in the maintenance of a nearly or approximately constant pressure throughout the high side from compressor discharge to expansion valve. In locations where the condenser ambient is warm, the valve 29 will remain closed and its associated parts will be without function. Hence, in these situations, this arrangement for maintaining high side pressure need not be incorporated in the system, but it is otherwise of substantial value, even in areas where seasonal temperature changes may call for its effect at only certain times of the year. And in this system, which embodies the secondary or auxiliary condenser acting as a reheater, it will be understood that, during the reheat cycles, the total condensing capacity of the main and reheat condensers may be materially in excess of the available heat load that is necessary to maintain a predetermined high side pressure, with the result that the reduction of the condensing capacity of the main condenser 3 by the activity of the valve 29 insures the supplying to the reheater condenser 16 of a proper amount of heat-carrying vapor for its functioning.

A dominant feature of the present improvement consists in a hot gas conduit 31 which is connected at one end with conduit 19 and extends to pipe 9 at the inlet of the evaporator 10. In this conduit 31 is positioned a modulating valve 32 of the outlet pressure regulating type, and this valve is set to maintain an outlet pressure which corresponds to a refrigerant temperature, e.g. 25° F. to 28° F., that is close to the frosting point of the outer surface of the evaporator coils but sufficiently above the point to prevent frosting of the moisture collected on the coils during the dehumidification cycle in which the air stream from the evaporator is at the lowest dew point that is possible without the objectionable frosting.

Referring to the modified form of the invention represented in FIG. 2, certain parts are the same as in FIG. 1, and will be given the same reference numerals. Thus, the condenser is 1, its discharge conduit 2, the air cooled main condenser 3, its fan 4, its outlet conduit 5, the receiver 6, the liquid supply conduit 7, its thermostatic expansion valve 8, the evaporator inlet pipe or tube 9, the suction conduit 11, the feeler bulb and capillary 12 and 13, the blower 14, the supply conduit solenoid valve 15, opening 17 in the housing 18 which encloses the blower, evaporator and reheater, the conduit 19 leading from the compressor to the reheater, its solenoid valve 20 and regulating valve 21, the reheater outlet tube 22, the second thermostatic expansion valve 23, its pipe connection 24 to pipe 9, the second feeler bulb and capillary tube 25 and 26, the by-pass 27, main condenser outlet 28, the constant pressure valve 29, and spring loaded check valve 30.

The modification in this form of FIG. 2 relates to the construction of evaporator and secondary or auxiliary condenser that performs as a reheater. Here, the evaporator proper is smaller than in the form of FIG. 1, and is denoted by 33, while the secondary or auxiliary condenser for reheating bears the numeral 34. These two elements of the system are so interconnected that the condenser reheater acts as part of the evaporator during the cooling-dehumification cycles. This is accomplished by connecting tube 22 and pipe 24 with a by-pass 35 in which is fitted a check valve 36 that permits flow from 24 to 22, by-passing valve 23, but prevents reverse flow, and by connecting conduit 19 with the suction conduit 11 by a tube 37 and locating a solenoid valve 38 in the said tube.

In the operation of this construction, when there is a high heat load, solenoid valve 15 will be open and expansion valve 8 will be feeding refrigerant to both sections 33 and 34 of the evaporator, the supply to the latter moving through pipe 35 and check valve 36, for the cooling cycle, the outflow of vaporized refrigerant proceeding to the suction conduit 11, directly from section 33 of the evaporator and through tube 37 and solenoid valve 38 (which is open) from the section 34. When this cycle has continued to a low temperature condition of the chamber or space being conditioned such that reheat is demanded, solenoid valve 15 may close, solenoid valve 20 opens, and solenoid valve 38 closes. In this setting, hot gas from the compressor flows to section 34 of the evaporator which performs as a condenser and becomes the reheater for the air stream from blower 14, the condensate from the reheater passing to section 33 of the evaporator through expansion valve 23 as described in explaining the form of the invention illustrated in FIG. 1. As the section 33 of the evaporator in the form of FIG. 2 is smaller than the evaporator 10 of FIG. 1, the refrigerant temperature, and consequent suction pressure, fall during the reheat cycle while reduces the system capacity and thus lessens the amount of total heat available at the compressor discharge, but the provision of the regulating valve 21 in conduit 19 insures a minimum temperature of the condenser reheater 34, in cooperation with the minimum head pressure control means consisting of the components 27, 28, 29; or the corresponding means of FIG. 3, to be described.

In this FIG. 2 of the invention, my improvement includes an addition similar to that provided for the form of FIG. 1, in that a hot gas conduit, here marked 39, connects conduit 19 with pipe 9 at the inlet of evaporator section 33, while a valve 40, similar to and of like setting with valve 32, is installed in the conduit 39 and serves the same purpose.

Referring to both forms of the invention exhibited in FIGS. 1 and 2, and dealing particularly with the arrangement for maintaining a predetermined minimum high side pressure, there is shown in FIG. 3 a slight modification in which an inlet pressure regulating valve is positioned at the entrance to the condenser. Such a structure is illustrated and described in U.S. Patent No. 2,934,911, issued May 3, 1960, which obviates the necessity of a detailed explanation in this specification. Briefly touching the showing of FIG. 3, it is noted that the main condenser and its fan are denoted by the reference numerals 3 and 4, the receiver by 6, the compressor discharge conduit by 2 and the supply conduit for the evaporator by 7. In the discharge conduit is fitted a valve marked 41 which is of the constant inlet pressure type, while a constant outlet pressure valve 42, similar to the valve 29 of FIGS. 1 and 2, is located in a by-pass 43, similar to the by-pass 27 of said figures, which connects the discharge conduit 2 with the receiver. A check valve 44, serving the same purpose as the valve 30 of FIGS. 1 and 2, is in the condenser outlet conduit, here identified by 45. This arrangement is highly advantageous when the ambient temperature at the main condenser 3 is extremely low, and it provides means for preventing migration of refrigerant from evaporator and receiver to condenser during off-cycles of the compressor, as well as for imposing high compressor discharge pressure on the receiver immediately following the establishing of compressor on-cycles and slightly in advance of imposing said pressure on the condenser whenever the receiver pressure is lower than the predetermined minimum normal refrigerating pressure in order to insure immediate flow of refrigerant at satisfactory operating pressure from the receiver to the expansion valve, as fully explained in said Patent No. 2,934,911.

It should be emphasized that the additions I have made to the systems shown in FIGS, 1 and 2, while simple in structure, are important in function because they enable the systems to operate at the highest dehumidification degree with the lowest refrigerant temperature without the danger of frost accumulation upon the surface of the evaporator coils.

A similar effect could be obtained with the inlet to the hot gas conduits 31 and 39 connected at any point to conduit 19 between valve 20 and the auxiliary condensers 16 and 34; or the outlets of conduits 31 and 39 with the suction conduit at any point between the feeler bulb 25 and the compressor 1, but I prefer the connections shown and described.

In turning to the electric control circuits for the system, it should be noted that the circuits shown in the above named application Ser. No. 187,691 are adequate and require neither change nor addition because the frost prevention means which is the significant feature of the present invention does not begin to function unless solenoid valve 20 in conduit 19 is caused to open by the electric controls disclosed in said application Ser. No. 187,691. The regulating valve 21 in the same conduit may be positioned on either side of valve 20 as it will be understood that 21 does not function until 20 opens. As soon as the latter opens the former comes into action regardless of the relative positioning of the two valves and, as previously explained, serves to maintain a predetermined temperature within the secondary or auxiliary condensers 16 and 34, and this is not altered by the inclusion in the system of conduit 31 with its valve 32, or conduit 39 with its valve 40. Consequently, it is only necessary here to re-state the electric controls set forth in said application 187,691, which are diagrammatically represented in FIGS. 4 and 5.

In FIG. 4, which is adapted to the form of the invention shown in FIG. 2, the primary controlling element is a single pole, double throw thermostat 46 that is installed in the chamber or space being conditioned, although it might be installed in the air stream. On rise in temperature contact is made at 47 which breaks contact at 48 to deactivate the humidistat 49. The contact at 47 completes a circuit through solenoid valve 15 in the evaporator supply line 7, thus admitting refrigerant to the evaporator 33, 34. The resulting increase in evaporator pressure causes pressure switch 50 to close which energizes a starter coil 51 and thus activates a starter 52 and completes the circuit to the compressor 1. On further increase in the temperature of the chamber or space being conditioned, a second stage thermostat 53 makes contact to complete the circuit through solenoid valve 38 to open the same and establish flow communication between evaporator section 34 and the intake of compressor 1 through the suction conduit 11. At this point solenoid valve 20 in conduit 19 is closed due to the act of thermostat 46 in breaking contact at 48, so that evaporator section 34 is not in flow communication with the compressor discharge 2.

When the temperature of the chamber or space falls, thermostat 53 breaks contact and closes solenoid valve 38. On further drop in temperature, the thermostat 46 switches from contact 47 to contact 48 which completes the circuit to the humidistat 49. If the degree of humidity in the chamber or space is now above the setting of the humidistat, a circuit will be made through the relay coil 54 which closes contacts 55 and 56, thus energizing both solenoid valves 15 and 20. In this condition valve 15 admits liquid refrigerant to the evaporator section 33, while valve 20 connects the compressor discharge with the reheat section 34 of the evaporator, through conduits 2 and 19, the said section 34 being isolated from the cooling section 33 of the evaporator due to the fact that valve 38 is now closed.

When the humidistat 49 becomes satisfied, it opens and de-energizes relay coil 54, thus breaking contacts 55 and 56, which closes both valves 15 and 20. With these valves closed the operation of the compressor serves to evacuate the cooling section 33 of the evaporator and cause a drop in suction pressure that will bring about opening of the pressure switch 50 with the consequent de-energizing of the starter coil 51 and stopping of the compressor.

In the event of overloading or overheating of the compressor, a thermostat 57, which is built into the body of the compressor, opens contact, thus de-energizing the circuit to the starter coil 51 and to the control transformer 58, which de-energizes the entire control circuit with the result of de-activating the evaporator blower motor 59 and closing all solenoid valves which are operatively associated with the evaporator. The blower motor is controlled by a magnetic starter 60 that is equipped with a starter coil 61 provided with overload protectors under control of a manual switch 62 in the control circuit. Thus, when the compressor stops due to overload, or is manually stopped by breaking the switch 62, the transformer 58 is de-energized and starter coil 61 breaks the contacts in the magnetic starter 60 which halts the blower motor 59.

Turning now to the control circuit exhibited in FIG. 5, which is designed for operating the form of the invention shown in FIG. 1, it will be observed that, in many respects, there is correspondence with FIG. 4. Here, however, the primary controlling element is a humidistat 64 which, on rise of humidity within the chamber or space being conditioned, closes to complete the circuit through a relay 65 that, in turn, closes contacts 66 and 67 and opens solenoid valve 15 in evaporator supply line 7 as well as solenoid valve 20 in the conduit 19 leading to the reheater condenser 16. This initiates the reheating cycle as previously explained. This step naturally causes a rise in the dry bulb temperature of the chamber or space, and this may be sufficient to close the thermostat 68 and complete a second and parallel circuit through solenoid valve 15 in the evaporator supply conduit.

When the humidity within the chamber or space has been lowered to a degree that satisfies the humidistat 64, the latter opens with the effect of de-energizing relay 65 to break contacts 66 and 67 and close the solenoid valve 20. The solenoid valve 15 will remain open until the temperature satisfies the thermostat 68. The remaining functions of this form of control are as described in connection with FIG. 4, and the same reference numerals are applied to corresponding elements.

The elements shown at the upper left and right of both FIGS. 4 and 5, and denoted by 69 and 70 are fused disc switches, conventionally represented, which are deemed to require no explanation.

Although very similar in set-up and performance, it may be noted that the arrangement of FIG. 4 is designed particularly for employment in situations when maintenance of desired temperature is the predominant consideration and dehumidification takes place only when the thermostat is fully satisfied; such a condition being instanced by installations for cooling comfort when the outdoor dry bulb temperature is relatively low and there is a substantial latent heat load but a comparatively low sensible heat load. The control symbolized by FIG. 5, is, on the other hand, especially conceived for installations where control of humidity is the primary consideration and temperature is not required to be regulated within close limits.

As hereinabove indicated, the conduits **31** may be connected to the conduit **19** at any desired point, which, of course, also applies to conduit **39**; while it is also noted that valve **21** may be positioned at either side of valve **20**. And when it is said that **19** branches off from compressor discharge conduit **2** the meaning, of course, is that **19** may be connected to **2** at any proper point, it being noted that the reference numeral **2** is applied twice to the discharge. Further, in stating that the conduits **31** and **39** extend to and are connected at the inlet of he evaporator it is not intended to limit the arrangement specifically to that shown but to point out that the connection is to the evaporator supply, denoted generally by **7**. And finally, it should be noted that, in the modification shown in FIG. 3, valves **41** and **42** can perform substantially the same function of regulating pressure within the condensing element as valve **21**, thus dispensing with the need for the latter in certain installations.

As the operation of the system has been included with the foregoing description of the parts and their arrangement, a full understanding of the invention is not thought to require an additional detailed recitation of the operation; but it may be helpful briefly to observe that there is provided an air conditioning system designed and adapted for sequentially and automatically supplying a stream of air which has been cooled below its dew point while passing through an evaporator, and, when necessary, reheated and returned to a chamber or space with accurate control of both humidity and temperature; the warming or heating following the cooling effect of dehumidification being accomplished through utilization of the heat of compressor discharge supplied in regulated amount to an element of the system that performs as a condenser and, in one form of the invention, also performs as a part or section of the evaporator; the system also including means which enables it to operate at the maximum dehumidification level and the lowest refrigerant level without the accumulation of frost on the surface of the evaporator coils.

It will be understood that various changes may be resorted to in the form and arrangement of the several parts of the apparatus without departing from the spirit and scope of the invention, hence, I do not intend to be limited to details herein shown or described unless included in the claims or required by disclosures of the prior art.

What I claim is:

1. An air conditioning system designed and adapted for automatic regulation of both temperature and humidity within a chamber or space, said system comprising, a closed refrigerant circuit including compressor, air cooled condenser and evaporator, means for causing a flow of air through the evaporator, condensing means having pre-set pressure means for affecting the temperature of said air flow to control humidity and temperature within the chamber or space, and means to insure the maximum dehumidification level within the chamber or space and the lowest refrigerant temperature level within

the evaporator while avoiding accumulation of frost on the evaporator surface and eliminating the necessity of a defrost cycle.

2. An air conditioning system designed and adapted for automatic regulation of both temperature and humidity within a chamber or space, said system comprising a closed refrigerant circuit including compressor, condenser and evaporator, means for causing a flow of air through the evaporator, a refrigerant condensing element for raising the temperature of said air flow in certain cycles of system operation, said element having an inlet and an outlet, automatic means for refrigerant flow connection of the condensing element inlet with and disconnection of it from the hot gas compressor discharge, means for connecting the outlet of the element with the evaporator supply, and automatic means for operating the system at maximum dehumidification level and lowest refrigerant temperature level for a given system without causing accumulation of frost on the evaporator surface, the said automatic means for refrigerant flow connection of the condensing element with and disconnection of it from the hot gas compressor discharge comprising a conduit connecting the compressor discharge with the condensing element, an open and shut valve means in said conduit, means for regulating the pressure within the condensing element, said second mentioned automatic means comprising a conduit connecting the last named conduit with the evaporator inlet, and an automatic pressure regulating valve means in the last named conduit.

3. A system as defined in claim **2**, in which the automatic means for refrigerant flow connection of the condensing element with and disconnection of it from the hot gas compressor discharge comprises a conduit connecting the compressor discharge with the condensing element, an automatic open and shut valve in said conduit, an automatic pressure regulating valve also in said conduit, a conduit connecting the last named conduit with the evaporator inlet, and another automatic pressure regulating valve in said last named conduit.

4. A system as defined in claim **2**, in which the first of said regulating valve means maintains a predetermined reheat temperature of the condensing element, and the second of said valve means maintains an outlet pressure corresponding to a refrigerant temperature that is close to the frosting point of the outer surface of the evaporator but sufficiently above said point to prevent frosting thereof during dehumidification.

5. A system as defined in claim **4**, in which the first mentioned automatic means is thermostatically controlled.

6. A system as defined in claim **4**, in which the first mentioned automatic means is humidistatically controlled.

References Cited by the Examiner

UNITED STATES PATENTS

2,451,385	10/48	Groat	62—173
2,679,142	5/54	McGrath	62—173
3,105,366	10/63	Atchison	62—428

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