

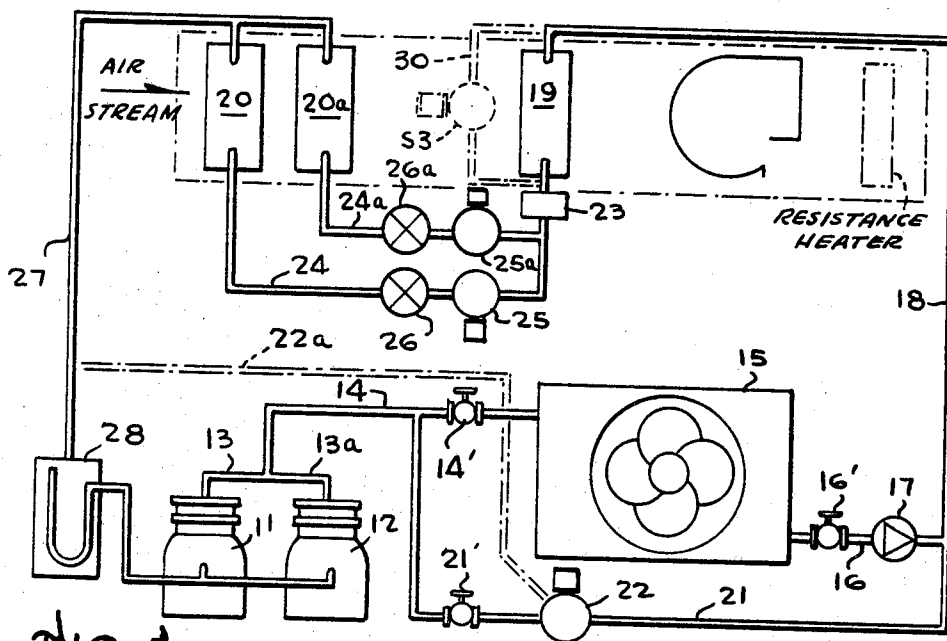
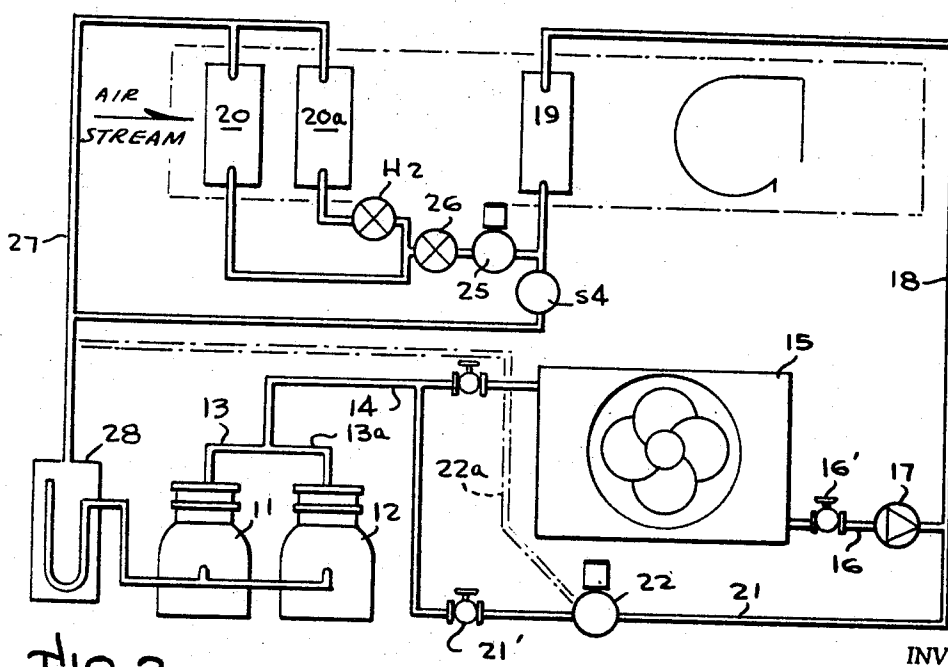
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AIR CONDITIONING SYSTEM HAVING REHEATING
WITH COMPRESSOR DISCHARGE GAS

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2 Sheets-Sheet 1



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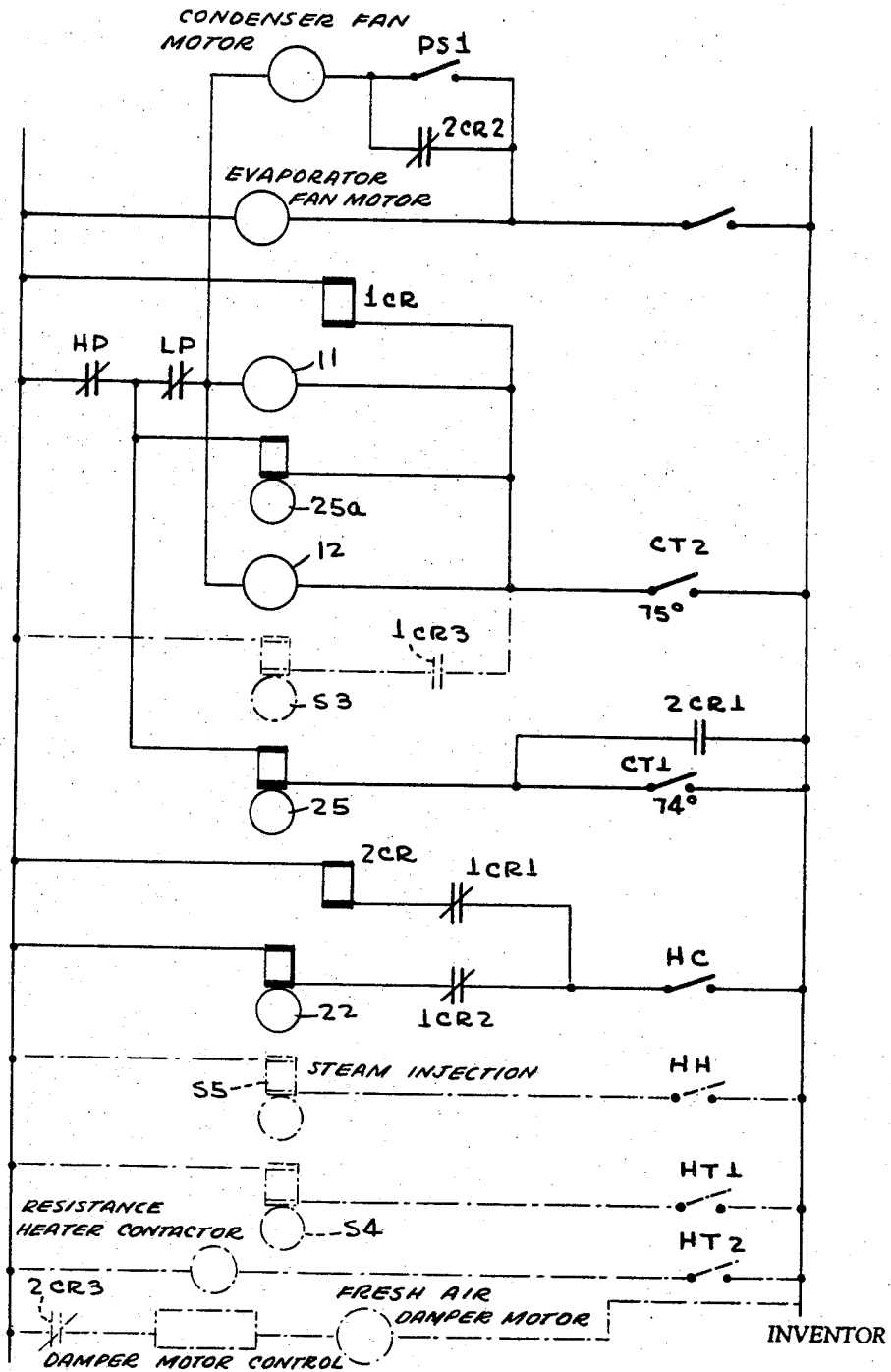


Fig-3

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AIR CONDITIONING SYSTEM HAVING REHEATING WITH COMPRESSOR DISCHARGE GAS

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ABSTRACT OF THE DISCLOSURE

An air conditioning system involving reheating by controlled quantities of refrigerant condensing in thermal exchange relation with the conditioned air, including a compressor, a condenser, an evaporator in the air flow path of air to be conditioned, a reheat coil in the air flow path, and controlled refrigerant conduits for delivering refrigerant from the compressor through the condenser, to the reheat coil and thence through an expansion device to the evaporator and for selectively diverting gaseous refrigerant from the compressor in bypassing relation around the condenser to the reheat coil in intermixed relation to refrigerant conveyed from the condenser to the evaporator. A suction line having an accumulator therein returns refrigerant from the evaporator to the compressor. Additional capacity control can be provided by using two interconnected compressors and two interconnected evaporators controlled by thermostat means operative to selectively terminate operation of one of the compressors and one of the evaporators under selected reduced load conditions.

The present invention relates in general to air-conditioning apparatus adapted for employment in installations where relative humidity is an important factor, and more particularly to air-conditioning systems involving the use of reheating by refrigerant by controlled delivery of refrigerant to a reheat coil disposed in the path of the air conditioned by the cooling coil of the system to neutralize unwanted sensible cooling and effect capacity control of the system.

An object of the present invention is the provision of an air-conditioning system having a reheat coil to which hot gaseous refrigerant may be fed from the compressor to effect controlled reheating of the air stream passing through the evaporator or cooling coil, wherein the need for a separate hot gas line to feed discharge gas from the compressor to the reheat coil is eliminated.

Another object of the present invention is the provision of an air-conditioning system having a reheat coil adjacent the cooling coil to be fed with hot gaseous refrigerant from the compressor for effecting desired neutralization of unwanted sensible cooling by the cooling coil, wherein no separate thermostatic expansion valve is needed to drain the reheat coil.

Another object of the present invention is the provision of an air-conditioning system having a reheat coil in addition to cooling coils to be selectively fed with hot gaseous refrigerant from the compressor to neutralize unwanted sensible cooling by the cooling coils wherein head pressure control is provided without the necessity of using a liquid receiver.

Another object of the present invention is the provision of an air-conditioning system having a reheat coil in addition to cooling coils to be selectively supplied with hot gaseous refrigerant from the compressor wherein two-stage cooling plus dehumidification is utilized.

Still another object of the present invention is the provision of an air-conditioning system having a reheat coil in addition to cooling coils to be selectively supplied

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with hot gaseous refrigerant from the compressor wherein head pressure control is provided for use only during reheat operation and which is disabled during non-reheat operation thus reducing the head pressure and power consumption at which the compressor operates during non-reheat operation.

Other objects, advantages and capabilities of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings illustrating preferred embodiments of the invention.

In the drawings:

FIGURE 1 is a schematic diagram of an air-conditioning system embodying the present invention;

FIGURE 2 is a schematic diagram of a modified version of an air-conditioning system embodying the present invention; and

FIGURE 3 is an electrical wiring diagram showing an electrical control system which may be used with the present invention.

Referring to the drawings, wherein like reference characters designate corresponding parts throughout the several figures, and referring particularly to FIGURE 1, the air-conditioning system of the present invention includes a pair of compressors 11, 12 of conventional construction each having a high pressure or discharge side and a low pressure or suction side, the discharge sides of the two compressors 11, 12 being connected together through branch conduits 13, 13a and common condenser inlet conduit 14 controlled by a manual service valve 14', to the inlet of condenser 15. The outlet end of condenser 15 is connected by conduit 16 having a manual service valve 16' and a check valve 17 therein and through conduit 18 joining and forming an extension of conduit 16, to the inlet of the reheat coil 19 disposed in the air stream of the cooled air which has passed over and emerges from the region of the pair of evaporators 20 and 20a.

A bypass conduit 21 having a manual service valve 21' therein and a combination solenoid valve and pressure regulator 22 is connected at its inlet end to the conduit 14 and at its outlet end to the conduit 18 to bypass refrigerant gas around the condenser and is contained in the condensing unit. This combination valve 22 is opened by a humidistat and thus allows discharge gaseous refrigerant from the compressor to enter the liquid line 18 where it mixes with liquid coming from the condenser 15 through the condenser outlet line 16 and check valve 17. The outlet of the reheat coil 19 is connected through a refrigerant dryer 23 and to evaporator inlet conduits 24, 24a individually controlled by inlet solenoid valves 25, 25a and expansion valves 26, 26a to conduct the refrigerant to the evaporators 20, 20a. The outlets of the evaporators 20, 20a are connected through a common suction line 27 and accumulator 28 of conventional construction to the suction side of each of the compressors 11, 12.

The rate of discharge gaseous refrigerant flow through the control valve 22 in the bypass line 21 is governed by the pressure existing at the compressor suction intake by way of an equalizer line 22a which extends to the suction line 27 and thus senses the pressure existing at the compressor suction intake. Therefore, the flow rate increases at reduced suction pressure, which will be the case when the return air temperature from the conditioned space drops due to reduced load. This feature also prevents frosting of the evaporator coil surface, which is often the case at low rates of loading.

When the humidistat controlling the bypass combination valve 22 signals that the humidity within the chamber or space being conditioned is satisfactory, the bypass line 21 is closed and all of the gaseous refrigerant discharged from the compressors 11, 12 is fed to the con-

denser 15. The liquid refrigerant condensed in the condenser 15 flows through the outlet conduit 16 and liquid line 18 to the reheat coil 19 which now functions as a subcooler, reducing the temperature of the liquid refrigerant, for example, from 90° to 80°. It is well-known that under such circumstances, the cooling capacity per pound of refrigerant circulated is greatly increased so that the slight amount of heating of the air stream is compensated by the increased system capacity due to subcooling. The introduction of subcooled liquid also results in more stable expansion valve operation, which, in turn, results in better utilization of the evaporators 20, 20a. This arrangement also permits locating the refrigerant drier 23 in the subcooled liquid line at the outlet of the reheat coil 19 where it removes contaminants from the refrigerant more efficiently. When it is required to pump the system down, as for instance, when both solenoid valves 25, 25a are closed and no reheat is called for, the reheat coil 19 being located in the relatively cool ambient becomes an excellent refrigerant reservoir obviating the need for any receiver. When the humidistat controlling the combination valve 22 indicates that reheat is required, it energizes the solenoid of the combination valve 22 in the bypass line 21, opening this valve to permit hot gaseous refrigerant discharged from the high side of the compressors 11, 12 to bypass the condenser 15 and mix with the liquid refrigerant coming from the condenser 15 through line 16 and proceeds to the reheat coil 19 where the discharge gas condenses in the reheat coil, giving up heat to the air stream, and flows to the evaporators 20, 20a. The check valve 17 in the condenser outlet line 16 prevents the bypassed gas from entering the condenser 15 through its outlet in cold weather.

The reheat coil 19 is sized so that it can function as the sole condenser of the system in the unlikely event that all discharge gas from the compressors 11, 12 bypasses the condenser 15. Provision is made to stop operation of the fan motor for condenser 15 whenever the head pressure of the system drops below a predetermined limit which would be the case when the reheat coil 19 becomes the condenser of the system. This is performed by a simple pressure switch hereinafter described in connection with the wiring diagram of FIGURE 3. It is well-known that in the event the condenser fan is stopped, the capacity of the condenser is drastically reduced and in such instances, it will merely function as a de-superheating coil, with most or all of the condensing taking place in the reheat coil 19.

It will be apparent that the system just described will operate effectively with only one compressor and one evaporator, in which event it will not be necessary to have more than one solenoid valve 25 and expansion device 26 between the reheat coil 19 and the evaporator. However, the preferred embodiment illustrated in FIGURE 1 provides capacity control by using the two interconnected compressors 11 and 12 in conjunction with the two parallel evaporators 20 and 20a, which are preferably controlled by a two-step thermostat shown in the wiring diagram of FIGURE 3, having contact CT1 which makes and breaks at two selected temperatures, for example, 74° and 72°, respectively, and contact CT2 which makes and breaks at other selected temperatures, for example, at 75° and 73°, respectively. At full load, both compressors 11 and 12 and both evaporators 20 and 20a are functioning because liquid solenoid valves 25 and 25a are both open. On a drop in load, thermostat contact CT2 opens, closing solenoid valve 25a and stopping the compressor 12. On a further drop in load, thermostat contact CT1 opens, closing solenoid valve 25, whereupon the low side of the system is evacuated, the suction pressure falls and compressor 11 stops after low pressure switch LP breaks.

However, should the humidity rise under any circumstances, the dehumidifying humidistat HC shown in FIGURE 3 will open reheat control valve 22 and energize the relay 2CR connected in series with the humidistat HC through the normally closed contacts 1CR1 of the cooling

relay 1CR, which thus opens liquid solenoid valve 25 to the evaporator 20. This will provide reheat without excessive cooling since only one-half of the system capacity is in operation. Reheat relay 2CR also breaks a contact 2CR2 to the condenser fan motor CD, thus activating the head pressure control switch PS1, which is otherwise bypassed when no reheat is required.

In the event the system operates at full capacity, closing of the second stage thermostat CT2 may also energize the cooling relay 1CR, opening the normally closed contact 1CR2 to the reheat valve 22, thus preventing reheat when both evaporators are in operation. Experience indicates that there is no need for reheat under such conditions, because at full system operation, humidity in the conditioned space is always satisfactory.

Referring more specifically to the operation of the control system of FIGURE 3 when reheat is required, the solenoid of the reheat valve 22 is energized through the normally closed cooling relay contact 1CR2 in series with the valve 22 and the humidistat HC. This opens the bypass line 21, as previously described, to admit hot gaseous refrigerant to the liquid line 18 and reheat coil 19, and at the same time the closing of the humidistat HC energizes the coil of relay 2CR which has a normally open contact 2CR1. This contact supersedes the first stage thermostat CT1 and opens liquid solenoid valve 25. A second normally closed contact 2CR2 is broken to activate head pressure control switch PS1. When the second stage thermostat CT2 calls for cooling, it opens solenoid valve 25a to the evaporator section 20a. At the same time, the cooling relay 1CR is energized. This relay 1CR has the normally closed contacts 1CR2 and 1CR1 which break, closing the reheat valve 22 and de-energizing relay 2CR so that the head pressure control is deactivated. If desired, a bypass line 30, shown in broken lines in FIGURE 1, controlled by a solenoid valve S3 may be provided around the reheat coil 19 and may be controlled by a third normally open contact 1CR3 of the cooling relay 1CR, which makes when the relay 1CR is energized by the second stage thermostat CT2 calling for cooling, opening the solenoid valve S3 to bypass the reheat coil 19.

If desired, the pressure switch PS1 of FIGURE 3, instead of being a simple pressure switch, may be a more sophisticated control of the commercially available type which responds to condenser temperature to control fan speed of the condenser fan in selected relation to condenser temperature.

The wiring diagram of FIGURE 3 also illustrates a humidifying humidistat HH connected across the line conductors in series with a steam injection solenoid valve S5 to actuate the same when humidification is required.

Also indicated in FIGURE 3 is a fresh air damper motor FM, actuated by a conventional commercially available control S90 for admitting fresh air to the air stream under selected conditions. The power supply to this control S90 can be interrupted by a normally closed relay contact 2CR3 of the reheat relay 2CR which breaks when this relay is energized indicating a call for dehumidification.

An alternate arrangement is illustrated in FIGURE 2, in which the reheat coil 19 is utilized for heating. During this time, the condenser fan for condenser 15 is inactive because the pressure switch PS1 is opened. The rate of flow to the reheat coil 19 is governed by the regulating valve 22, the outlet pressure of which is set, for example, for 60 p.s.i., so as to preclude condensation and consequently, the return of liquid to the compressor or compressors through the solenoid valve S4 when this valve is open under actuation by the first stage heating thermostat HT1 shown in broken lines in FIGURE 3. For example, at a pressure setting of 60 p.s.i. for valve 22, the condensing temperature for the refrigerant 22 would be approximately +34°; allowing for a line pressure drop between reheat coil 19 and the compressors 11, 12, perhaps +40°. Since the air moving over the reheat coil 19 is at a considerably higher temperature, for example, +60° to

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+70°, it cannot cool the refrigerant to its condensing temperature, and absorbs only its superheat. This type of operation supplies a limited amount of heat, and if further heat is required, a second stage heat thermostat, such as HT2 shown in broken lines in FIGURE 3, may be provided which will energize an auxiliary resistance heater in the supply air stream.

The cooling cycle in the system of FIGURE 2 is controlled as in the system of FIGURE 1, except that the solenoid valve 25a is omitted, and a single expansion valve 26 controls both evaporator sections 20 and 20a. When the thermostat contact CT2 breaks, it stops compressor 12. Now the evaporator pressure will tend to rise. This is sensed by a pressure regulating valve such as the valve H2 shown in FIGURE 2, a holdback valve, at the inlet to the evaporator section 20a. Valve H2 will throttle until the evaporator pressure is reduced to its normal level of about 68 p.s.i. for refrigerant 22.

While two separate compressors 11, 12 are shown in each of the above-described embodiments, the system of the present invention does not necessarily require two compressors, but will work satisfactorily with a single compressor, except that the system performance will be less efficient because the need for reheat occurs primarily when the cooling load is reduced so that operation at full compressor capacity would be wasteful.

It will be apparent that the above-described systems, wherein the hot discharge gas for the reheat coil 19 is coupled in bypassing relation to the condenser 15 through the bypass conduit 21 contained in the condensing unit, the important advantage is realized of eliminating a separate hot gas line for the reheat coil. Such a separate hot gas line becomes quite objectionable when the air unit is a long distance away from the compressor. Further, the reheat coil 19 is so arranged in the systems of this application as to utilize the reheat coil for subcooling during the refrigeration cycle or as a liquid receiver during system pump down when solenoid valves 25, 25a are closed.

By reason of the fact that the head pressure control pressure switch PS1 is normally bypassed by relay contact 2CR2 during the cooling cycle and is activated only when reheat is required, head pressure is maintained sufficiently high to ensure that the reheat coil is sufficiently warm to perform its function. However, since head pressure control is unnecessary except when reheat is called for, this avoids operation of the compressor or compressors at elevated head pressure and high power consumption when no reheat is needed as would occur with a head pressure control which operates at all times.

Whereas it has been customary in systems heretofore available to so control the system that reheating is available only when the cooling thermostat is satisfied, my systems provide reheat whenever needed during first stage cooling. Also, no separate thermostatic expansion valve to drain the reheat coil 19, which has been customarily required in systems heretofore available, is needed in my system.

While but two preferred embodiments of the present invention have been specifically shown and described, it will be apparent that various modifications may be made therein within the spirit and scope of the invention, and it is desired therefore that only such modifications be placed thereon as are imposed by the prior art and set forth in the appended claims.

What is claimed is:

1. An air conditioning system of the reheating type for automatic regulation of both temperature and humidity within a space to be conditioned comprising a refrigerant circuit including compressor means having discharge and suction sides, a condenser, evaporator means in thermal exchange relation to an air flow path along which conditioned air is supplied to said space, reheat coil means spaced downstream along said air flow path from said evaporator means for passage through said reheat coil means of substantially all air conditioned by said evapo-

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rator means, high-side conduit means connecting said condenser and reheat coil means and said evaporator means in series relation between said discharge and suction sides for coursing refrigerant from said compressor means through said condenser and reheat coil means to said evaporator means including a liquid conduit extending from the outlet of said condenser to the inlet of said reheat coil means and a first conduit section having an expansion device connected between the outlet of said reheat coil means and the inlet of said evaporator means, suction conduit means for returning refrigerant from said evaporator means to said compressor means, and valved bypass conduit means for conveying gaseous refrigerant discharged from said compressor means to said liquid conduit at a point adjacent the outlet of said condenser for delivery to said reheat coil means in bypassing relation to said condenser responsive to selected humidity conditions in said space to effect refrigerant condensation in said reheat coil means and rejection of heat to said air flow path.

2. An air conditioning system as defined in claim 1, wherein said liquid conduit includes check valve means between said condenser outlet and the junction thereof with said bypass conduit to prevent fluid flow from said junction toward said condenser outlet.

3. An air conditioning system as defined in claim 1, wherein said bypass conduit includes valve means having humidistat control means closing and opening said valve means to flow through said bypass conduit respectively below and above selected humidity conditions and means communicating said valve means with pressure conditions in said suction conduit for governing the flow rate there-through in preselected relation to variation in said pressure conditions.

4. An air conditioning system of the reheating type for automatic regulation of both temperature and humidity within a space to be conditioned comprising a refrigerant circuit including compressor means having discharge and suction sides, a condenser, evaporator means in thermal exchange relation to an air flow path along which conditioned air is supplied to said space, reheat coil means in said air flow path, high-side conduit means for coursing refrigerant from said compressor means through said condenser and reheat coil means to said evaporator means including an expansion device between said reheat coil means and said evaporator means, suction conduit means for returning refrigerant from said evaporator means to said compressor means, and valved bypass conduit means for conveying gaseous refrigerant discharged from said compressor means to said reheat coil means in bypassing relation to said condenser responsive to selected humidity conditions in said space to effect refrigerant condensation in said reheat coil means and rejection of heat to said air flow path, wherein said evaporator means comprises two evaporators, said high-side conduit means including a pair of inlet conduits for said respective evaporators for delivering refrigerant from said reheat coil means to their associated evaporator and each having a control valve and an expansion device therein, and two-stage thermostat means regulating said control valves to admit refrigerant to only one of said evaporators upon occurrence of selected lower temperature conditions and to both of said evaporators upon occurrence of selected higher temperature conditions.

5. An air conditioning system as defined in claim 4, including control means activated when both said control valves are in open condition admitting refrigerant to both said evaporators to maintain said valve means in said bypass conduit in closed condition preventing flow of gaseous refrigerant therethrough to said reheat coil means.

6. An air conditioning system as defined in claim 4, wherein said compressor means comprises two compressors connected in parallel to said high-side conduit means and said suction conduit means, said compressors being

controlled by said two-stage thermostat means to operate only one compressor during said selected lower temperature conditions and to operate both said compressors during said selected higher temperature conditions.

7. An air conditioning system as defined in claim 6, and including control means activated when both said control valves are in open condition admitting refrigerant to both said evaporators to maintain said valve means in said bypass conduit in closed condition preventing flow of gaseous refrigerant therethrough to said reheat coil means.

8. An air conditioning system as defined in claim 7, wherein said high-side conduit means includes a liquid conduit connecting the outlet of said condenser directly with the inlet of said reheat coil means, said bypass conduit means including valve means activated responsive to selected humidity conditions in said space and being connected at opposite ends thereof to said compressor means discharge side and to said liquid conduit to supply gaseous refrigerant to said reheat coil means from said discharge side in intermixed relation to liquid refrigerant in said liquid conduit in variable proportions.

9. An air conditioning system as defined in claim 8, wherein said valve means in said bypass conduit includes humidistat control means closing and opening said valve means to flow through said bypass conduit respectively below and above selected humidity conditions and means communicating said valve means with pressure conditions in said suction conduit for governing the flow rate therethrough in preselected relation to variation in said pressure conditions.

10. An air conditioning system as defined in claim 9, wherein said liquid conduit includes a section immediately adjacent the condenser outlet between the latter and the junction with said bypass conduit having a check valve therein passing outflow from said condenser toward said junction and preventing reverse flow therethrough.

11. An air conditioning system as defined in claim 4, including a second bypass conduit connected to said high-side conduit means adjacent the inlet and outlet of said reheat coil means having a normally closed valve therein operated upon occurrence of said selected higher temperature conditions to bypass refrigerant around said reheat coil means when both said evaporators are receiving refrigerant.

12. An air conditioning system of the reheating type for automatic regulation of both temperature and humidity within a space to be conditioned comprising a refrigerant circuit including compressor means having discharge and suction sides, a condenser, evaporator means in thermal exchange relation to an air flow path along which conditioned air is supplied to said space, reheat coil means in said air flow path, high-side conduit means for coursing refrigerant from said compressor means through said condenser and reheat coil means to said evaporator means including an expansion device between said reheat coil means and said evaporator means, suction conduit means for returning refrigerant from said evaporator means to said compressor means, and valved bypass conduit means for conveying gaseous refrigerant discharged from said compressor means to said reheat coil means in bypassing relation to said condenser responsive to selected humidity

conditions in said space to effect refrigerant condensation in said reheat coil means and rejection of heat to said air flow path, wherein said compressor means comprises two compressors connected in parallel to said high-side conduit means and said suction conduit means, control means for said compressors comprising two-stage thermostat means for operating only one compressor upon occurrence of selected lower temperature conditions and operating both of said compressors during selected higher temperature conditions.

13. An air conditioning system as defined in claim 1, wherein said condenser includes a motor driven fan, and means sensing head pressure in the system for stopping the fan motor when the head pressure drops below a selected limit.

14. An air conditioning system as defined in claim 13, including means for maintaining the head pressure sensing means deactivated when said valve means is in closed condition preventing flow through said bypass conduit means.

15. An air conditioning system of the reheating type for automatic regulation of both temperature and humidity within a space to be conditioned comprising a refrigerant circuit including compressor means having discharge and suction sides, a condenser, evaporator means in thermal exchange relation to an air flow path along which conditioned air is supplied to said space, reheat coil means in said air flow path, high-side conduit means for coursing refrigerant from said compressor means through said condenser and reheat coil means to said evaporator means including an expansion device between said reheat coil means and said evaporator means, suction conduit means for returning refrigerant from said evaporator means to said compressor means, and valved bypass conduit means for conveying gaseous refrigerant discharged from said compressor means to said reheat coil means in bypassing relation to said condenser responsive to selected humidity conditions in said space to effect refrigerant condensation in said reheat coil means and rejection of heat to said air flow path, wherein said evaporator means comprises two evaporators, said high-side conduit means including two inlet conduits for the respective evaporators joined to a common conduit section connected to said reheat coil means, having a single control valve and an expansion device controlling refrigerant feed to both said evaporators, and a second bypass conduit connecting the outlet of the reheat coil means with said suction conduit means in bypassing relation to said evaporators having a regulating valve for returning selected proportions of refrigerant from said reheat coil means to said suction conduit means during occurrence of predetermined temperature conditions requiring less cooling than the maximum capacity of said evaporators.

References Cited

UNITED STATES PATENTS

1,986,863	1/1935	Terry	62—173
2,392,405	1/1946	Phipps	62—90
2,926,503	3/1960	Neubauer	62—90

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