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J. D. STROBELL  
AIR CONDITIONING SYSTEM

2,663,155

Filed Oct. 4, 1949

2 Sheets-Sheet 1

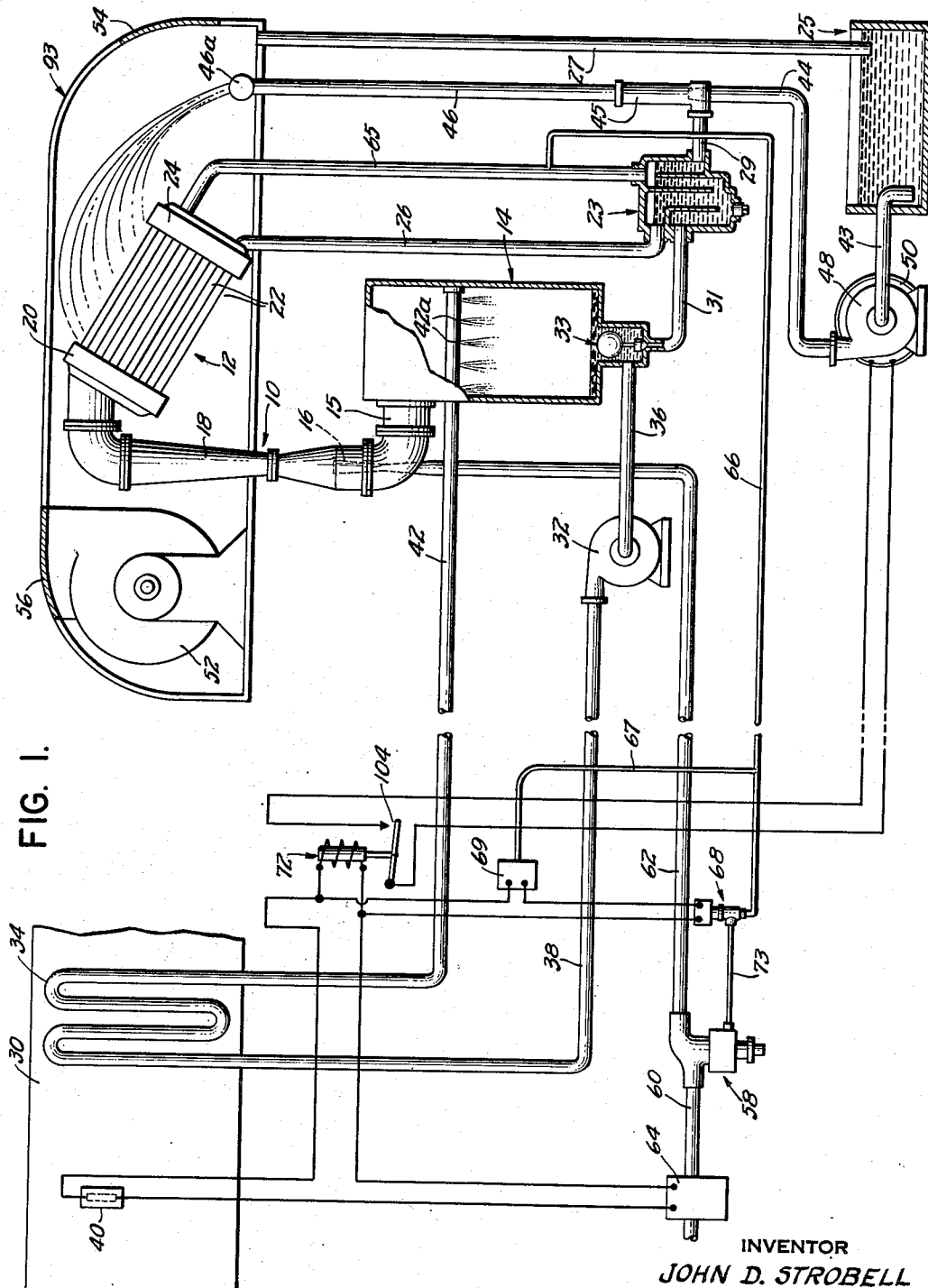


FIG. 1.

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FIG. 2.

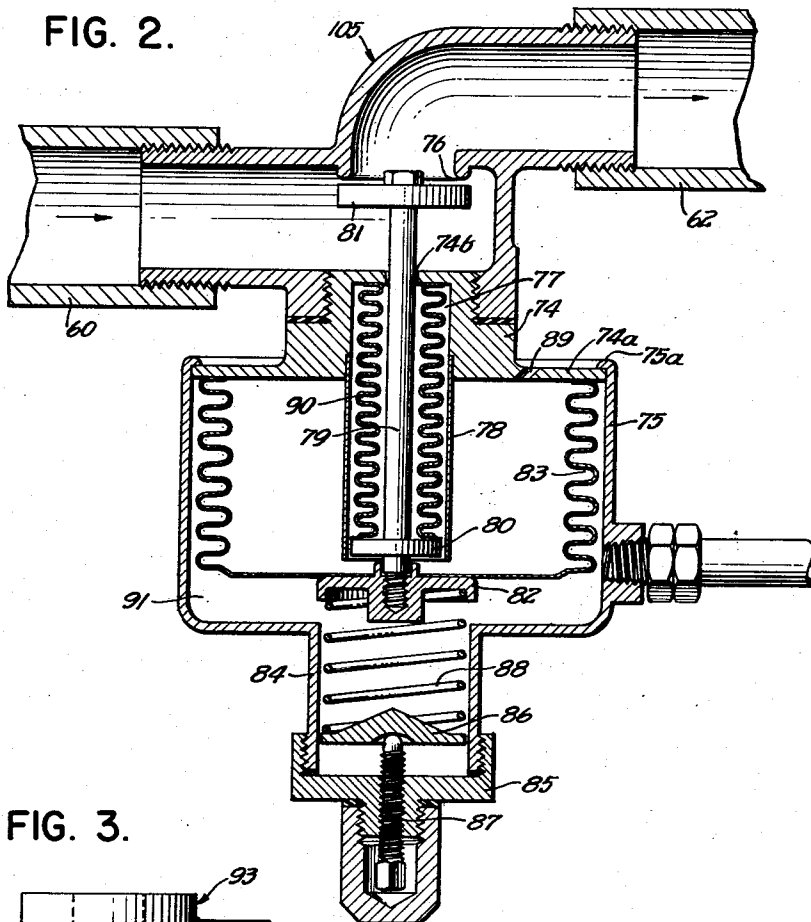
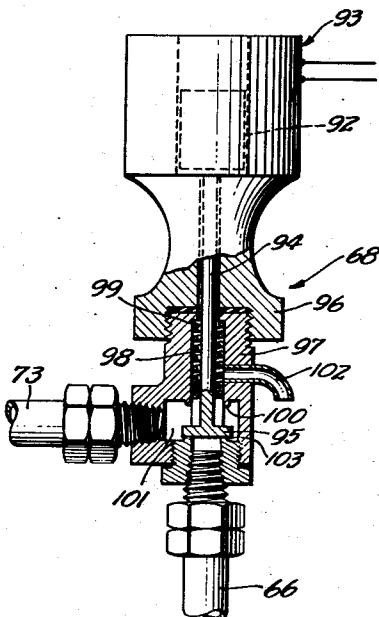


**FIG. 3.**



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## UNITED STATES PATENT OFFICE

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## AIR CONDITIONING SYSTEM

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This invention relates to an air-conditioning system of the steam ejector type and more particularly to a vacuum-operated valve employed in such a system to control its operation under pre-determined conditions. The system is especially adapted for use in railroad cars where a large amount of steam is readily available.

An object of this invention is to provide a system for air conditioning an enclosure which is simple and rugged in construction and efficient in operation. Another object is to provide a system of the above character which employs a minimum number of moving parts and consequently requires a minimum amount of servicing and repair. A further object is to provide a system of the above character including a control valve operatively responsive to certain desired conditions in the system. Still another object is to provide a system of the above character employing electrical controls which are free from complications. Other objects will be in part apparent and in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combination of elements and arrangement of parts as will be exemplified in the structure to be hereinafter described, and the scope of the application of which will be indicated in the following claims.

In the drawings:

Figure 1 is a diagrammatic representation of the system;

Figure 2 is an enlarged sectional view illustrating in detail one of the valves shown in Figure 1; and

Figure 3 is a sectional view illustrating in detail another valve shown in Figure 1.

Similar reference characters refer to similar parts throughout the several views of the drawings.

Air conditioning systems of the steam ejector type are employed in railroad cars because of the availability of steam under high pressure. In these systems, the steam is directed through a venturi device connected to an evaporating chamber, after which it passes to a condenser. This creates a partial vacuum in the evaporating chamber to increase evaporation of water sprayed therein, resulting in cooling of the water. The water is used to cool an enclosure such as a railroad car.

Since the above system is generally employed on railroad cars, it has to operate for long periods of time without servicing and therefore rugged equipment is desirable. Obviously, the system must be accurately controlled to prevent

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damaging the parts. For example, pressure conditions in the condenser must be such as to assure proper condensation of the steam during operation. Thus a suitable valving mechanism is provided to control steam flow according to condenser pressure conditions. Accordingly, steam flow is not permitted until the condenser is in operating condition whether or not the thermostat is calling for cooling.

The air conditioning system shown in Figure 1 has a venturi device, generally indicated at 10, a condenser, generally indicated at 12, and an evaporator, generally indicated at 14. The venturi device 10 includes a nozzle 16 which directs the steam into the constricted portion 18 of the venturi to draw a partial vacuum on evaporator 14 through connection 15 between the lower end of venturi 10 and the evaporator. The other end of venturi 10 is connected by a header 20 to condenser 12. The other end of the condenser is connected by a header 24 to a pipe 26 leading to a trap 23.

To condense the steam passing through the venturi device 10, the condenser is cooled by water sprayed upon pipes 22 by a nozzle 46a at the end of pipe 46. Such water is drawn from a sump 25 by a pump 48 driven by a motor 50, and pumped through pipe 44, purge ejector 45 and pipe 46 to nozzle 46a. The water sprayed upon condenser 22 falls downwardly to the bottom of enclosure 93, from which it drains to sump 25 through pipe 27. Air for cooling condenser 22 is circulated through enclosure 23 by a fan 52, the air entering the enclosure 23 through opening 54 and leaving through opening 56.

Condensation flows from the condenser through pipe 26 to trap 23, from which excess water is drawn by means of purge ejector 45 which is connected to trap 23 by pipe 29. Purge ejector 45 also draws a partial vacuum on condenser 12 through pipe 65 for purposes to be disclosed more fully hereinafter.

Water, cooled by evaporation in a manner to be described, is circulated between the evaporator and cooling coil 34 in the interior of the car 30 by pump 32. During cooling, air is forced over pipes 34 and through the car by a suitable fan (not shown). More particularly, the water flows from the evaporator 14 through pipes 36 and 38, and, after circulating through the coil 34, returns through pipe 42 to the evaporator 14, where it is sprayed downwardly through small holes 42a in the pipe.

A valve, generally indicated at 58, controls the flow of steam to the nozzle 16. When the valve

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is open, steam flows from a source (not shown) through pipes 60 and 62 to the nozzle 16. The action of the venturi device produces a suction on the evaporator, resulting in a partial vacuum therein. Water in the evaporator falling from the pipe 42 through this partially evacuated space evaporates rapidly, resulting in effective cooling thereof.

To maintain a constant level of water in evaporator 14, evaporator 14 is connected to trap 23 by a pipe 31. Flow of water through pipe 31 into evaporator 14 is controlled by a float valve, generally indicated at 33. When the water in the evaporator falls below a certain level, valve 33 opens and water flows from trap 23 into evaporator 14 until the evaporator again contains the required amount of water.

For effective operation to cool the coil 34 there must be an adequate source of steam to assure proper operation of the Venturi device and the consequent desired partial vacuum condition in the evaporator. To the same end, the condenser must operate properly and such operation is dependent on the maintenance of a proper pressure condition therein. The availability of adequate steam under pressure and proper condenser conditions are therefore made a prime requisite of a cooling operation of the system even though the car thermostat is calling for cooling.

Accordingly, the operation of the valve 58 is dependent upon several conditions in the system: (1) a thermostatic switch 40 in the car 30 must call for cooling by closing, (2) a pressure-responsive switch 64 in the steam line 60 must close, indicating a source of steam under sufficient pressure, and (3) valve 58 responsive to condenser pressure conditions must open, indicating a satisfactory condenser condition. The present system includes apparatus whereby the operation of the system is dependent upon all of these conditions.

Valve 58 is shown in detail in Figure 2, wherein the valve body, generally indicated at 105, is connected to pipes 60 and 62 and is provided with a valve seat 76. A fitting 74 forming a portion of the valve is threaded into valve body 105 and includes an outwardly extending annular flange 74a. The upper portion of a cylindrical casing 75 fits about and is supported upon flange portion 74a by an inwardly extending integral flanged portion 75a. Fitting 74 is provided with a vertically extending bore 77 within which fits a sleeve 78. Within the sleeve 78 is a valve stem 79 having a flange 80 formed on its lower end and a valve head 81 at its upper end coacting with the valve seat 76. Stem 79 is threaded into a spring seat 82 at its lower end secured to the central portion of a bellows 83. The upper periphery of bellows 83 forms an air-tight connection with the undersurface of annular flange 74a. Bellows 83 is expansible in vertical directions within the cylindrical casing 75 and a vent 89 to the atmosphere is provided in flange 74a leading into the interior of bellows 83 so that the interior of the bellows is open to atmospheric pressure at all times.

To prevent steam from passing through the opening 74b and thence into the interior of bellows 83, a flexible tubular sealing device 90 is secured to the fitting 74 and flange 80 and is positioned within sleeve 78. Sealing device 90 is expansible to permit the valve stem 79 to move freely upwardly and downwardly and at all times effectively seals the interior of bellows 83 from the pressures existing in pipe 60. Thus, the in-

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terior of bellows 83 is maintained at atmospheric pressure at all times. The area of valve head 81 is equal to the effective area of the interior of bellows sealing device 90 and thus steam under pressure passing through opening 74b and acting on the interior of bellows 90 is counterbalanced by the steam pressure acting on valve head 81.

A downwardly extending centrally located tubular extension 84 of casing 75 has a cap member 85 threaded on its lower end and a spring seat 86 slidably supported within tubular portion 84 upon an adjusting screw 87 threaded in cap 85. A spring 88 is supported between spring seats 82 and 86, the spring seat 82 having an annular depending flange 82a for supporting the spring in this position. Accordingly, it will be seen that by adjusting screw 87, any desired pressure may be exerted on the bottom of bellows 83 by way of compression of the spring 88. Spring 88 is preferably set so that atmospheric pressure within bellows 83 will move valve head 81 downwardly when the pressure within space 91 is of twenty inches vacuum or less. Valve head 81 moves into engagement with seat 76 when the pressure within space 91 is above ten inches vacuum.

The solenoid valve, generally indicated at 68 in Figure 1, is shown in detail in Figure 3. The armature 92 of the solenoid 93 is connected to a valve stem 94 having a valve head 95. The support 96 for the solenoid 93 has a fitting 97 threaded therein with a vertically extending bore 98. A spring 99 fits within bore 98 to urge the valve head 95 downwardly away from a valve seat 100 formed in a centrally located chamber 101 in fitting 97. A vent 102 to the atmosphere extends into the bore 98 so that when solenoid 93 is deenergized, the chamber 101 is connected to the atmosphere, spring 98 holding valve head 95 against a seat 103. When solenoid 93 is energized, valve head 95 is moved upwardly into engagement with seat 100, cutting off vent 102 from chamber 101.

Referring to Figures 1 and 3, pipe 66 is connected to chamber 101 of valve 68 as is pipe 73. Thus, when valve head 95 is seated on seat 100, pipes 66 and 73 connect the pressure existing in the condenser head 24 with the space 91 in casing 75 of valve 58, as seen in Figure 2, and when valve head 95 is seated on seat 103, space 91 is connected to the atmosphere.

To prevent solenoid valve 68 from connecting pipe 66 to pipe 73 until a partial vacuum has been drawn on condenser 12 by purge ejector 45, a condenser pressure switch 69 is positioned in the circuit of solenoid 93. This switch is connected by a pipe 67 to a pipe 66, which is connected to condenser 12 by a pipe 65. When the pressure in pipe 66 is twenty inches vacuum or less, switch 69 closes, completing the circuit to solenoid 93. This causes valve 68 to open, connecting space 91 in valve 58 to the condenser. Because of the differences in pressure at this time between the partial vacuum in space 91 and the atmospheric pressure in bellows 83, valve 81 snaps into an open position.

In operation, when thermostatic switch 40 is closed, calling for cooling, and pressure responsive switch 64 closes, indicating that the pressure of the supply steam is above a minimum value, the circuit to motor 50 is completed. Water flowing through pipe 44, purge ejector 45 and pipe 46 to nozzle 46a acts through purge ejector 45, pipe 29 and pipe 65 to draw a partial vacuum

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on condenser 12. When the pressure in condenser 12 is twenty inches vacuum or less, the reduced pressure in pipes 66 and 67 causes condenser pressure switch 69 to close. This completes the circuit to the solenoid in valve 68, which moves valve head 95 (Figure 3) upwardly, closing off the connection between vent 102 and chamber 101 (Figure 3), and connects pipe 66 to pipe 73. Thus, at this time, the pressure within the condenser is connected to space 91 (Figure 2) and the atmospheric pressure within the interior of bellows 83 (Figure 2) compresses spring 88 and snaps valve 81 open. Steam then flows past valve seat 76 to nozzle 16 (Figure 1), drawing a vacuum on evaporator 14. The water within evaporator 14 is circulated by pump 32 through coil 34 and then back into the evaporator through pipe 42.

When either switch 40 or switch 64 opens, the circuit to the solenoid of valve 68 (Figure 3) is broken. Spring 93 then moves valve head 95 downwardly against valve seat 103, cutting off the connection between condenser 12 (Figure 1) and space 91 (Figure 2) in valve 58 and connecting space 91 to atmospheric pressure through vent 102. Spring 93 then moves valve head 81 upwardly, preventing further flow of steam to nozzle 16 (Figure 1). At the same time, the circuit to motor 50 is broken, stopping the operation of spray pump 48. Thus, the valve 58 controls the operation of the machine, and it, in turn, is controlled by switches 40 and 64 and the pressure within condenser 12. If either switch 40 or 64 opens, or if the condenser pressure is above ten inches vacuum, then valve head 81 (Figure 2) shuts off the flow of steam to the nozzle 16 (Figure 1). On the other hand, the only time that the steam valve 58 opens is when both switches 40 and 64 are closed and the condenser pressure is less than twenty inches vacuum. Thus, a practical and efficient air-conditioning system has been disclosed which is controlled by a vacuum-operated valve in an efficient and practical manner. It will thus be seen that the several objects hereinabove mentioned, as well as many others, have been successfully accomplished.

As many possible embodiments may be made of the above invention, and as many changes might be made in the embodiment above set forth, it is to be understood that all matter hereinabove set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. In a control for a steam ejector air-conditioning system including a thermostat, an evaporator, means for circulating the coolant, a steam ejector for drawing a partial vacuum on said evaporator, a steam pressure pipe connected to said ejector, a condenser, and means for drawing a partial vacuum on said condenser at the start of a cycle of operation, in combination, a pressure responsive valve controlling the flow of steam through said pipe, means forming a pressure conducting connection between said condenser and said valve, for controlling the position of said valve by the pressure in said condenser, means for disconnecting said connection, and means operatively connecting said last-mentioned means to said thermostat, said thermostat controlling the operation of said disconnecting means and thus the operation of said valve.

2. In a control for a steam ejector air-conditioning system including a thermostat, an evapo-

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rator, means for circulating the coolant, a steam ejector for drawing a partial vacuum on said evaporator, a steam pressure line connected to said ejector a steam pressure responsive electrical switch in said steam pressure line, a condenser, and means for drawing a partial vacuum on said condenser at the start of a cycle of operation, in combination, a pressure responsive valve controlling the flow of steam through said pipe, means forming a pressure conducting connection between said condenser and said valve for controlling the position of said valve by the pressure in said condenser, means for disconnecting said last-mentioned connection, and means operatively connecting said last-mentioned means to said thermostat and said steam pressure switch, whereby said steam pressure switch and said thermostat control the operation of said disconnecting means and thus regulate the operation of said valve.

3. In a control for a steam ejector air-conditioning system including a coolant, a thermostat, an evaporator, means for circulating the coolant, a steam ejector for drawing a partial vacuum on said evaporator, a steam pressure pipe connected to said ejector, a condenser, and means for drawing a partial vacuum on said condenser at the start of a cycle of operation, in combination, a pressure operated valve positioned in said steam pressure pipe for controlling the flow of steam through said pipe, a pipe forming a connection between the interior of said condenser and said valve, a valve positioned in said last-mentioned pipe, and means operatively connecting said last-mentioned valve to said thermostat, whereby said thermostat controls the operation of said last-mentioned valve and thus regulates the operation of said first-mentioned valve.

4. In a control for a steam ejector air-conditioning system including a coolant, a thermostat, an evaporator, means for circulating the coolant, a steam ejector for drawing a partial vacuum on said evaporator, a steam pressure pipe connected to said ejector, a condenser, and means for drawing a partial vacuum on said condenser at the start of a cycle of operation, in combination, a control valve positioned in said steam pressure pipe for controlling the flow of steam therethrough, a pipe connecting the interior of said condenser to said control valve, an electrically-controlled valve positioned in said last-mentioned pipe, said last-mentioned valve closing when the circuit thereto is broken, and a circuit connecting said last-mentioned valve, said steam pressure switch and said thermostat in series.

5. In a control for a steam ejector air-conditioning system including a coolant, a thermostat, an evaporator, means for circulating the coolant, a steam ejector for drawing a partial vacuum on said evaporator, a steam pressure pipe connected to said ejector, a condenser, and means for drawing a partial vacuum on said condenser at the start of a cycle of operation, in combination, a pressure responsive control valve positioned in said steam pressure pipe for controlling the flow of steam therethrough, a second pipe connecting the interior of said condenser to said pressure responsive control valve, a steam pressure responsive electrical switch positioned in said steam pressure pipe, an electrically-controlled valve positioned in said second pipe, said last-mentioned valve closing when the circuit thereto is broken, a condenser pressure switch responsive

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to pressure in said second pipe, a circuit connecting said last-mentioned valve, said steam pressure switch, said condenser pressure switch and said thermostat in series, whereby if either said thermostat, said condenser pressure switch or said steam pressure switch opens said electrically-controlled valve will disconnect said condenser from said control valve to interrupt the flow of steam to said ejector.

6. In a steam ejector air-conditioning system, in combination, a thermostat, a steam pressure pipe, a steam ejector, said steam pressure pipe being connected to the nozzle of said steam ejector, a condenser, means for drawing a partial vacuum on said condenser at the start of a cycle of operation, an evaporator, said steam ejector drawing a partial vacuum on said evaporator, a cooling coil, means for circulating a liquid from said evaporator through said cooling coil and thence back into said evaporator, a steam pressure switch operatively connected to said steam pressure pipe, said steam pressure switch opening when the steam pressure in said steam pipe falls below a minimum value, a pressure-operated control valve positioned in said steam pipe, a second pipe connecting the interior of said condenser to said control valve, the pressure in said condenser controlling the operation of said valve, and valve means positioned in said second pipe, said valve means closing when said steam pressure switch or said thermostat opens, whereby said control valve is controlled by the pressure in said condenser, said steam pressure switch and said thermostat.

7. In a steam ejector air-conditioning system, in combination, a thermostat, a steam pressure pipe, a steam ejector, said steam pressure pipe being connected to the nozzle of said steam ejector, a condenser, means for drawing a partial vacuum on said condenser at the start of a cycle of operation, an evaporator, said steam ejector drawing a partial vacuum on said evaporator, a cooling coil, means for circulating a liquid from said evaporator through said cooling coil and thence back into said evaporator, a steam pressure switch operatively connected to said steam pressure pipe, said steam pressure switch opening when the steam pressure in said steam pipe falls below a minimum value, a pressure-operated main control valve positioned in said steam pipe, a second pipe connecting the interior of said condenser to said control valve, the pressure in said condenser controlling the operation of said valve, further valve means positioned in said second pipe, said further valve means closing when said steam pressure switch or said thermostat opens, and condenser pressure responsive control means operatively connected to said second pipe and to said further valve, said control means preventing said further valve from opening until a partial vacuum is drawn on operation of said main condenser, whereby said control valve is determined by vacuum in said condenser, pressure in said steam pipe and closure of said thermostat.

8. In a control for a steam ejector air-conditioning system including a coolant, a thermostat, an evaporator, means for circulating the coolant, a steam ejector for drawing a partial vacuum on said evaporator, a steam pressure pipe connected to said ejector, a condenser, and means for drawing a partial vacuum on said condenser at the start of a cycle of operation, in combination, a steam pressure responsive switch in said steam pressure pipe, a valve positioned in said steam pressure pipe, said valve including a valve head

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controlling the flow of steam through said steam pressure pipe, a bellows operatively connected to said valve head, means connecting one side of said bellows to atmospheric pressure, pipe means connecting the opposite side of said bellows to the interior of said condenser, said valve being operated by the difference between the pressure in said condenser and atmospheric pressure, a valve positioned in said pipe means, and means operatively connecting said last-mentioned valve to said thermostat and said steam pressure switch, said last-mentioned valve closing whenever said thermostat or said steam pressure switch opens.

9. In a control for a steam ejector air-conditioning system including a coolant, a thermostat, an evaporator, means for circulating the coolant, a steam ejector for drawing a partial vacuum on said evaporator, a steam pressure pipe connected to said ejector, a condenser, and means for drawing a partial vacuum on said condenser at the start of a cycle of operation, in combination, a steam pressure switch, a valve positioned in said steam pressure pipe, said valve including a valve head controlling the flow of steam through said steam pressure pipe, a bellows operatively connected to said valve head, means connecting one side of said bellows to atmospheric pressure, pipe means connecting the opposite side of said bellows to the interior of said condenser, said valve being operated by the difference between the pressure in said condenser and atmospheric pressure, a valve positioned in said pipe means, means operatively connecting said last-mentioned valve to said thermostat and said steam pressure switch, said last-mentioned valve closing whenever said thermostat or said steam pressure switch opens, and pressure controlled means operatively connected to said last-mentioned valve and to said condenser, said pressure-operated means preventing said last-mentioned valve from opening until a partial vacuum is drawn on said condenser.

10. In a control for a steam ejector air-conditioning system, including a thermostatic switch, a steam pressure switch, an evaporator, a steam ejector for drawing a partial vacuum on said evaporator, a steam pressure pipe for supplying steam under pressure to said steam ejector, a condenser, and means for drawing a partial vacuum on said condenser at the start of a cycle of operation, in combination, a valve positioned in said steam pressure pipe, said valve including a valve head controlling the flow of steam through said steam pressure pipe, a bellows operatively connected to said valve head, means connecting one side of said bellows to atmospheric pressure, pipe means connecting the opposite side of said bellows to the interior of said condenser, said valve being operated by the difference between the pressure in said condenser and atmospheric pressure, a valve positioned in said pipe means, said valve including a pair of ports and a vent to the atmosphere, one of said ports being connected to the portion of said pipe means leading to said condenser and the other of said ports being connected to the portion of said pipe means leading to said first-mentioned valve, a valve head positioned in said second-mentioned valve, and means operatively connecting said second-mentioned valve to said thermostatic switch and said steam pressure switch, said thermostatic switch and said steam pressure switch controlling the position of the valve head of said second-mentioned valve, said second-mentioned valve closing whenever said thermostatic switch or

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said steam pressure switch opens to disconnect the portion of said pipe means leading from said second-mentioned valve to said first-mentioned valve from said condenser and to connect it to atmospheric pressure through said vent.

11. In a control for a steam ejector air-conditioning system including a coolant, a thermostat, an evaporator, means for circulating the coolant, a steam ejector for drawing a partial vacuum on said evaporator, a steam pressure pipe connected to said ejector, a steam pressure switch in said steam pressure pipe, a condenser, and means for drawing a partial vacuum on said condenser at the start of a cycle of operation, in combination, a bellows-operated valve positioned in said steam pressure pipe, a vent in said valve connecting the interior of said bellows to atmospheric pressure, a casing surrounding said bellows, a pipe connecting the space between said casing and said bellows to said condenser, a second valve positioned in said last-mentioned pipe, said second valve being operatively connected to and controlled by said thermostatic switch and said steam pressure switch, said second valve disconnecting said condenser from said first-mentioned valve whenever said steam pressure switch or said thermostatic switch opens.

12. In a control for a steam ejector air-conditioning system including a coolant, a thermostat, an evaporator, means for circulating the coolant, a steam ejector for drawing a partial vacuum on said evaporator, a steam pressure pipe connected to said ejector, a steam pressure switch on said steam pressure pipe, a condenser, and means for drawing a partial vacuum on said condenser at the start of a cycle of operation, in

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combination, a bellows-operated valve positioned in said steam pressure pipe, a vent connecting the interior of said bellows to atmospheric pressure, a casing enclosing the exterior of said bellows-operated valve, a pipe connecting the space between said casing and said bellows to said condenser, adjustable spring means positioned within said bellows-operated valve acting upon said bellows to move said bellows toward a closed position, a second valve positioned in said last-mentioned pipe, a solenoid for operating said second valve, said solenoid being connected in series with said thermostatic switch and said steam pressure switch, and vent means to the atmosphere in said second valve, said second valve disconnecting said first-mentioned valve from said condenser when either said thermostatic switch or said steam pressure switch opens and connecting the space between said casing and said bellows to atmospheric pressure through said vent means.

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## References Cited in the file of this patent

## UNITED STATES PATENTS

| Number    | Name    | Date          |
|-----------|---------|---------------|
| 1,805,342 | Otto    | May 12, 1931  |
| 2,033,844 | Morgan  | Mar. 10, 1936 |
| 2,033,845 | McNulty | Mar. 10, 1936 |
| 2,042,523 | Graham  | June 2, 1936  |
| 2,044,644 | Stalcup | June 16, 1936 |
| 2,085,942 | Bancel  | July 6, 1937  |
| 2,122,210 | Miller  | June 28, 1938 |
| 2,208,947 | Markson | July 23, 1940 |
| 2,314,524 | Spence  | Mar. 23, 1943 |