Nov. 30, 1948. J. F. STEPHENS 2,455,320

AUTOMATIC CONDENSATION CONTROL APPARATUS

Filed May 22, 1944 3 Sheets-Sheet 1

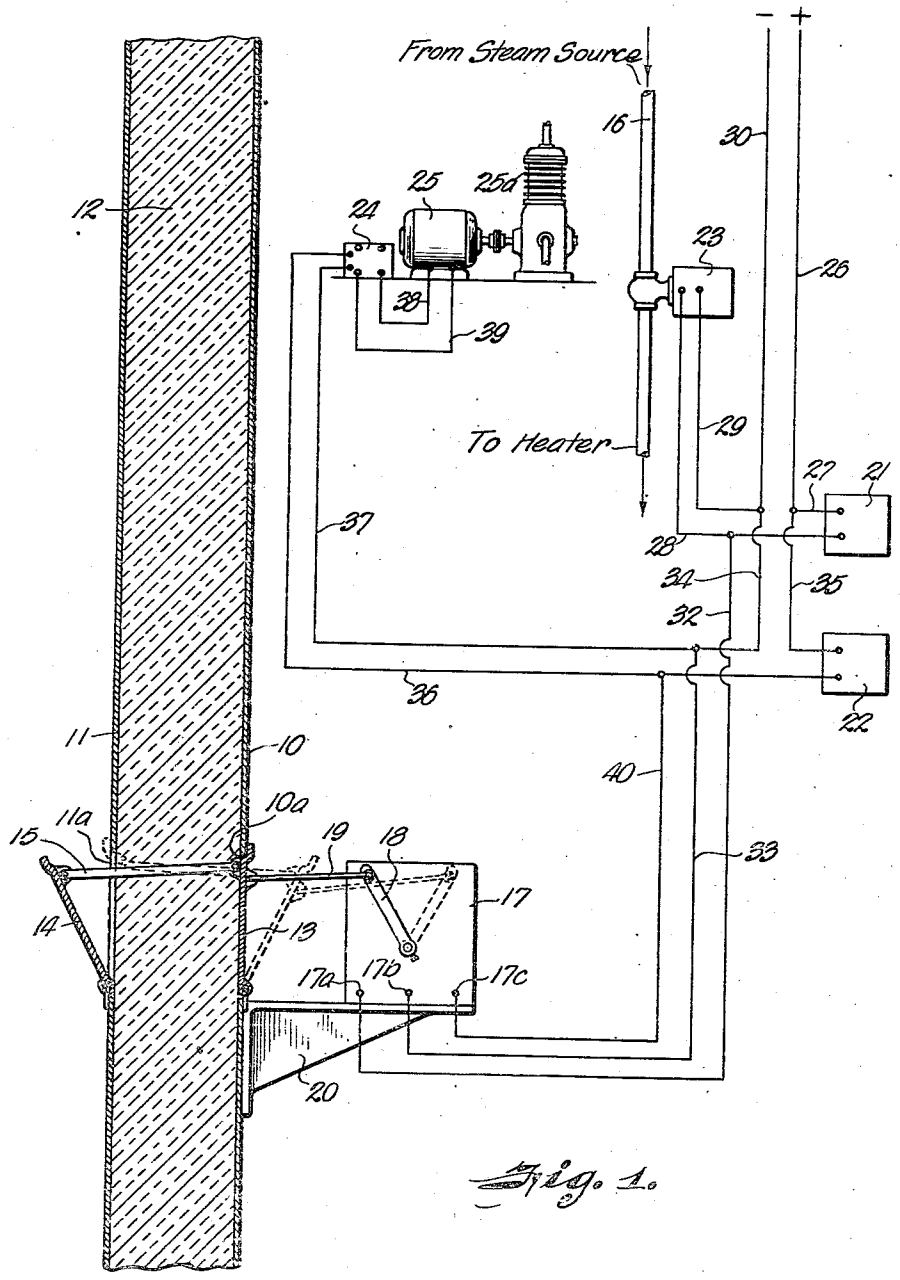


Fig. 1.

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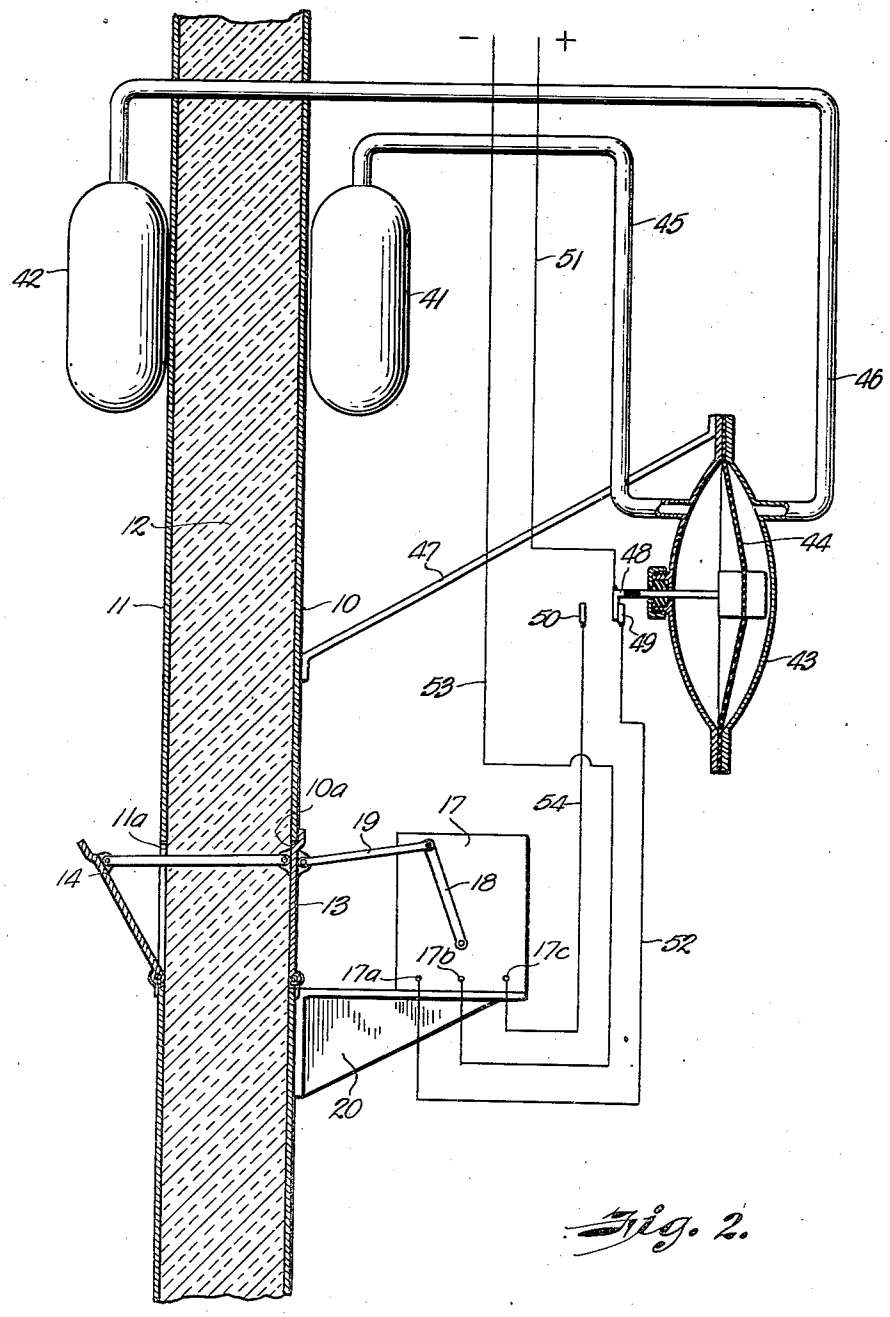


Fig. 2.

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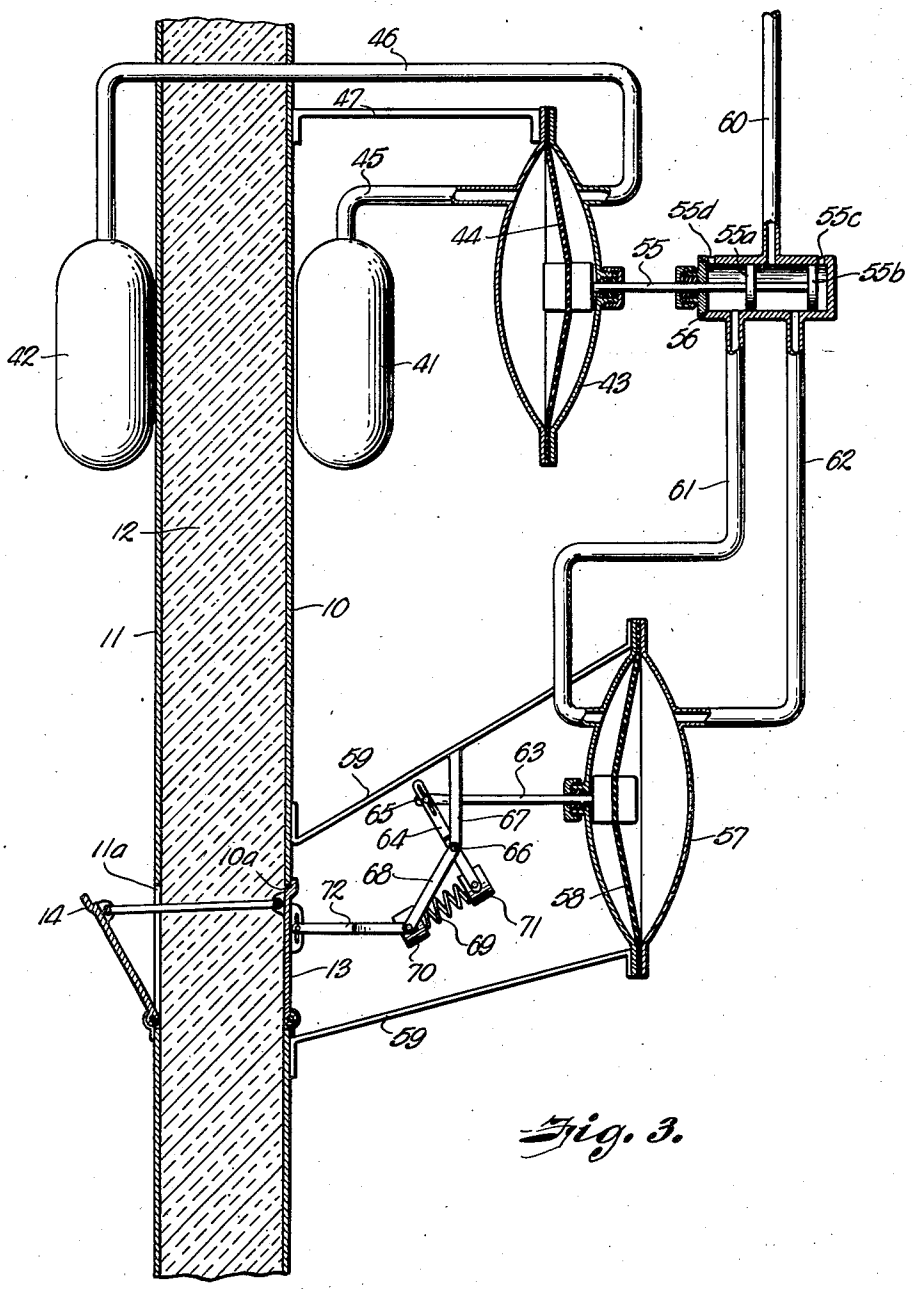


Fig. 3.

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UNITED STATES PATENT OFFICE

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AUTOMATIC CONDENSATION CONTROL APPARATUS

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Application May 22, 1944, Serial No. 536,742

8 Claims. (Cl. 257—3)

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My invention relates to new and useful improvements in apparatus for inhibiting vapor condensation within insulated walls.

It has become common practice to insulate the walls of buildings and equipment such as refrigerated trucks, railroad refrigerator and passenger cars and aircraft. Many buildings and much of the equipment are air-conditioned to maintain the inside temperature substantially constant regardless of outside temperature variations. Many localities have a wide temperature range throughout the year or even during a 24-hour period. As a result the outside temperature may fluctuate substantially above and below the regulated inside temperature causing considerable amounts of moisture to condense in the insulated walls. The condensed moisture saturates the insulation increasing its thermal-conductivity or K factor. Furthermore, the condensed moisture represents an increase of weight within the insulated wall. In the case of aircraft this may be an important factor. If the inside space is heated, as in the case of a building or railroad passenger car exceedingly low outside temperatures frequently freeze the condensed moisture. Alternate freezing and thawing of the condensate weakens the wall and breaks down the insulation sufficiently to permanently impair its insulating properties.

If the side of the insulated wall exposed to the lower temperature is vented moisture condensation will be substantially inhibited without materially affecting the efficiency of the insulation. Small amounts of moisture which may condense within the wall quickly vaporize and pass from the insulated space.

An important object of my invention is to provide an apparatus that is responsive to temperature variations to automatically vent the side of an insulated wall exposed to the lower temperature.

Another object of my invention is to provide an automatic condensation control apparatus that is simple in construction, efficient in operation and inexpensive to manufacture.

Other objects and advantages of my invention will be apparent during the course of the following description.

In the drawing forming a part of this specification and wherein like numerals are employed to designate like parts throughout the same,

Fig. 1 is a diagrammatic view showing an automatic condensation control apparatus embodying my invention,

Fig. 2 is a diagrammatic view showing a modification of the automatic condensation control apparatus, and

Fig. 3 is a diagrammatic view illustrating still another modification of the apparatus.

In the drawing, wherein for the purpose of illustration are shown preferred embodiments

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of my invention, the numerals 10 and 11 designate spaced parallel inner and outer panels. The space between panels 10 and 11 is filled with an insulating material 12. For the purpose of my invention it is desirable that the insulating material be non-hygroscopic, although this is not a critical consideration. Mineral fibers such as "Fiberglas," "mineral wool" and the like are suitable insulation materials. This structure represents an insulated wall which may conveniently be the wall of a building or of an insulated piece of equipment. Ventilation of the insulated space through the inner and outer panels is provided through openings 10a and 11a. These openings are horizontally aligned and are closed by hinged louvers or closure plates 13 and 14. A connecting link 15 pivoted to closure plates 13 and 14 holds one of the plates in an open position when the other plate is closed, as shown in the drawings.

The theory of moisture condensation within the insulated wall and the manner in which condensation is prevented by venting the relatively colder side of the wall is easily explained. Atmospheric air always contains some water vapor. The amount of water vapor that can be suspended in the air is a function of the air temperature. The proportion of water vapor to air is usually expressed in terms of pounds of water vapor to pounds of dry air. When the air contains a maximum amount of water vapor at a given temperature it is said to be saturated or to have a relative humidity of 100 per cent. If the air contains less than the maximum amount of water vapor, the percentage of vapor it contains is called its relative humidity. For example, at 100° F. air may contain a maximum of .04293 pound of water vapor per pound of dry air. If air at this temperature holds only half the maximum amount of vapor or .02146 pound of water vapor per pound of dry air it is said to have a relative humidity of 50 per cent. If warm air containing water vapor is cooled sufficiently it will reach a temperature at which it is saturated. If the air is cooled below this temperature it becomes supersaturated and water vapor will condense. The temperature at which condensation begins is called the dew point. Water vapor condensed out of the air is deposited as a film of moisture or dew on any object with which it is in contact. Air at 100° F. having a relative humidity of 50 per cent will reach its dew point when cooled to approximately 79° F., since air at this temperature can contain only .02147 pound of water vapor per pound of dry air.

If the inside temperature and the temperature of the insulation 12 is below the dew point of the outside temperature, moisture will condense on the outer panel 11. If this panel is impervious to moisture the condensed vapor will not enter the insulated space. In actual commercial prac-

tice it is difficult to seal the outer wall making it absolutely vapor tight. As a consequence, warm moisture-laden air enters the insulated space. When this air comes in contact with any surface cooled below its dew point, whether it be the insulation or the inner panel, it deposits its moisture. If, however, the inner panel 10 is vented so that the relatively cold inside air has access to the insulated space any condensate formed within the wall will be taken up by the unsaturated cooler air. Under ordinary conditions air has a relative humidity considerably under 100 per cent so that evaporation of the moisture is relatively rapid.

Conversely, if the temperature of the outside air is below the dew point of the inside air condensation will take place on surfaces having a temperature below the dew point of the inside air which may be the insulation itself on the surface of panel 10 or on the inside surface of panel 11. By venting panel 11 the outside or atmospheric air has access to the insulated space. This atmospheric air circulating through the insulation 12 evaporates any condensate formed.

According to my invention the panels 10 and 11 are vented by opening and closing closure plates 13 and 14. Since the inside temperature may be below the dew point of the outside temperature at one time and the outside temperature below the dew point of the inside temperature at another time, it is necessary to provide an apparatus to automatically vent insulated space through the panel exposed to the lower temperature and seal the panel exposed to the higher temperature.

In Fig. 1, I have shown an electrically energized apparatus that is particularly adapted to automatically vent the colder side of the insulated wall while simultaneously controlling a refrigeration unit and heater unit for maintaining the interior temperature substantially uniform. The apparatus can be adapted to any type of cooling unit or heater unit; but, for the purpose of illustration, I have here shown it associated with a refrigeration unit (not shown) operated by a compressor 25*a* and a steam heating system (not shown) in which steam is supplied through a pipe 16.

Closure plates 13 and 14 are moved to the open and closed position by a motor 17 through the torque arm 18 and rod 19. The motor is supported by a bracket 20 attached to panel 10. Motor 17 is preferably a conventional two-position or positive-action type in which the torque arm is always in either the full line or dotted line position depending upon the manner in which current is supplied to terminals 17*a*, 17*b* and 17*c*. If current is supplied to the motor through terminals 17*a* and 17*b* torque arm 18 moves in a counterclockwise direction to the full line position; and if current is supplied to the motor through terminals 17*b* and 17*c* the torque arm 18 is moved in a clockwise direction to the dotted line position. The operation of motor 17 is controlled by a heating thermostat 21 which closes its circuit when the inside temperature drops below a predetermined minimum and a cooling thermostat 22 which closes its circuit when the interior temperature rises above a predetermined maximum.

In the three embodiments shown in Figs. 1, 2 and 3 the controls, while of a different character in every case, vent the cold side. The control apparatus shown in Fig. 1 is for use where air conditioning is employed. The control equipment shown in Figs. 2 and 3 is adapted for use where venting of the walls is dependent solely upon temperatures existing on opposite sides of the walls and is in no wise connected with heating and cooling systems.

Explaining now the details of Fig. 1, if the outside temperature is cooler than the inside temperature, the latter temperature will fall until it reaches the selected minimum interior temperature, whereupon heating thermostat 21 operates motor 17 to close closure plate 13 and open closure plate 14. Simultaneously, the electrically operated valve 23 in the steam supply line is opened and the temperature within the space being heated rises to the maximum at which the thermostat 21 is set, when valve 23 in the steam supply line is closed. During this period when heat is being supplied the temperature within the space being heated and vent control is functioned by the heating thermostat. Likewise, however, if the outside temperature is higher than the inside temperature, the latter temperature will rise until it reaches the selected maximum interior temperature whereupon the cooling thermostat 22 functions to operate motor 17 which opens plate 13 and closes plate 14, simultaneously energizing starter 24 which starts motor 25 and compressor 25*a* the refrigeration unit. Thus, the cooling thermostat 22 automatically operates the refrigerating system when the interior temperature rises above the maximum for which the thermostat is set and automatically turns off the system when the temperature falls below the minimum. During this period functioning of the vent plates is under the control of the cooling thermostat 22.

When the heating thermostat 21 actuates to close the circuit, current is supplied from a suitable source through conductors 26 and 27. This current passes through conductor 28 to valve actuating mechanism 23, the circuit being completed through conductors 29 and 30. Actuation of the heating thermostat 21 also permits current to flow through conductor 32 to terminal 17*a* of motor 17 and from terminal 17*b* of the motor back to the negative side of the current supply line through conductors 33, 34 and 30.

When the cooling thermostat 22 is actuated current is supplied through conductors 26 and 35, thence to the automatic starter through conductor 36 and thence back to the negative side of the current source through conductors 37, 34 and 30. Current is supplied to motor 25 through conductors 38 and 39. Operation of thermostat 22 also permits current to flow through conductor 40 to terminal 17*c* of motor 17 and back to the negative side of the current source through conductors 33, 34 and 30.

It may thus be seen that the control apparatus here described will automatically operate the heater or refrigerator system to maintain the interior temperature within a predetermined range and that it simultaneously operates to open or close plates 13 and 14 depending upon whether the outside temperature is warmer or cooler than the interior temperature. The wall closure plate in the panel exposed to the coolest temperature will automatically be opened.

In Fig. 2, I have shown a simpler form of apparatus for operating motor 17. This form of the invention is not concerned with operation of a refrigerating and heating system but merely with automatically venting the cold side of the insulated wall. The temperature control bulbs 41 and 42 on the inner and outer panels 10 and

41 contain a suitable fluid having relatively high coefficient of expansion. Fluid pressure from bulbs 41 and 42 is transmitted to a diaphragm actuated switch comprising a housing 43 partitioned by a flexible diaphragm 44. Outlet tube 45 from bulb 41 communicates with a compartment on one side of the diaphragm while outlet tube 46 from bulb 42 communicates with the opposite side of the diaphragm. Housing 43 is carried by a suitable support 47. A switch arm 48 attached to diaphragm 44 is shifted with movement of the diaphragm between the fixed contacts 49 and 50.

If, for example, the temperature differential on opposite sides of the wall is such that condensation is likely to occur within the insulated space the fluid pressure in the bulb on the warm side will be greater than the pressure in the bulb on the cooler side. This pressure differential actuates the diaphragm and switch to complete the current through the fixed contacts 49 and 50. In Fig. 2 the higher temperature is on the inside. Consequently, excessive pressure exists in bulb 41. Under these conditions current flows from the positive side of the current source through conductor 51, switch arm 48, contact 49 and conductor 52 to terminal 17*a* of motor 17. From terminal 17*b* of the motor the circuit is completed through conductor 53. Energizing motor 17 through terminal 17*a* and 17*b* causes torque arm 18 to move in a counterclockwise direction closing the inner vent plate 13 and opening the outer vent plate 14 thus venting the colder side of the insulated wall.

Conversely, if the outside temperature is warmer than the inside temperature and the temperature differential sufficiently great to produce conditions advantageous to condensation and moisture accumulation within the insulated wall pressure conditions will be reversed, the greater pressure existing in outside bulb 42. This pressure differential between bulbs 42 and 41 moves diaphragm 44 to the left shifting switch arm 48 into engagement with stationary contact 50. When this occurs, current flows through conductor 51, switch arm 48, contact 50 and conductor 54 to the terminal 17*c* of motor 17. From the terminal 17*b* of the motor the circuit is completed through conductor 53. Energizing motor 17 through terminals 17*b* and 17*c* causes torque arm 18 to rotate in a clockwise direction closing outer vent plate 14 and venting the inner wall 10 to the colder interior atmosphere.

In Fig. 3 of the drawing a further modification is shown. Movement of diaphragm 44 is translated through a mechanical relay to operate the wall closure plates 13 and 14. Instead of a switch arm the diaphragm carries a piston rod 55 having spaced pistons 55*a* and 55*b* mounted to reciprocate within a cylinder 56. The pressures developed in bulbs 41 and 42 under normal temperature variations are insufficient to mechanically operate the closure plates 13 and 14. Accordingly, I provide a second housing 57 partitioned by diaphragm 58 and attached to panel 10 by supports 59. Fluid under relatively high pressure is supplied to cylinder 56 through pipe 60. From cylinder 56 the fluid is directed to housing 57 at opposite sides of diaphragm 58 through pipes 61 and 62. When the inside temperature is higher than the outside temperature so that moisture condensation is likely to occur within the insulated space, a sufficient pressure differential is developed in bulbs 41 and 42 to push diaphragm 44 to the right and position

pistons 55*a* and 55*b* as shown in the drawing. During movement of the pistons air in the cylinder is vented through ports 55*c* and 55*d*. As the pistons move to the right, air ahead of the piston 55*b* is vented through port 55*c* and excess fluid in housing 57 is vented through pipe 61 and port 55*d*. In this position of the pistons, fluid under relatively high pressure passes through pipe 62 into housing 57 at the right of diaphragm 58. This high pressure fluid develops sufficient pressure against diaphragm 58 to actuate a mechanical linkage for opening and closing vent plates 13 and 14.

The mechanical linkage here shown comprises a rod 63 carried by and movable with diaphragm 58. At its outer end rod 63 is pivoted to the shank or stem of a yoke 64 through a pin and slot connection 65. The yoke, in turn, is pivoted at 66 to a U-shaped supporting bracket 67. A pair of links 68 are also pivoted at 66 and at opposite sides of the yoke. A compression spring 69 is confined by the spring retainers 70 and 71. Spring retainer 70 is pivoted between the free ends of links 68 and spring retainer 71 is pivoted between the bifurcations of yoke 64. The spring retainer 70 is also coupled to plate 13 by a yoke 72.

When diaphragm 58 is moved to the left, rod 63 rotates yoke 64 about pivot 66 in which position compression spring 69 holds rod 63 under tension and yoke 72 under compression. Yoke 72 presses against the closure plate 13 forcing it to a closed position and opening closure plate 14 venting the insulated space to the colder outside temperature.

On the other hand, if the outside temperature is warmer than the inside temperature a pressure differential is developed in bulbs 41 and 42 which moves diaphragm 44 to the left. This moves pistons 55*a* and 55*b* to the left so that pipes 60 and 61 communicate permitting the high pressure fluid to enter housing 57 at the left of the diaphragm. Fluid is supplied to housing 57 under sufficient pressure to overcome compression spring 69. Consequently, diaphragm 58 moves to the right rotating yoke 64 in a clockwise direction about pivot 66. As the yoke rotates spring 69 is compressed. As the shank of yoke 64 moves to the right spring retainer 71 rotates about its pivot. When the yoke moves beyond a vertical position, compressed spring 69 forces link 68 to the right about pivot 66 opening plate 13 and closing plate 14. This action vents the inner panel 10 exposed to the colder temperature.

Spring 69 holds closure plates 13 and 14 in position even though pressure is released in housing 57. The closure plates will not be moved though diaphragm 58 returns to a center or near center position. The linkage does not jackknife to move the closure plates until sufficient pressure has been applied to diaphragm 58 to move it beyond the center position.

It is to be understood that the forms of the invention herewith shown and described are to be taken as preferred embodiments of my invention and that various changes in the size, shape and arrangement of parts may be resorted to without departing from the spirit of my invention or the scope of the appended claims.

Having thus described my invention, I claim:

1. In combination, a wall comprising spaced panels each having an opening therein, movable closure plates for said openings, co-ordinating means for simultaneously actuating said closure

plates to open one and close the other, and a mechanical actuating means responsive to temperature variations at opposite sides of the wall adapted to function said co-ordinating means and vent the panel exposed to the lower temperature.

2. In combination, a wall comprising spaced panels each having a ventilating opening therein, movable closure plates for said openings, mechanical linkage between the closure plates co-ordinating their movement to simultaneously open one panel when the other panel is closed, and a temperature responsive mechanical actuating means coactive with the closure plates to automatically open the plate in the panel exposed to the lower temperature.

3. In combination, a wall comprising spaced inner and outer panels each having a ventilating opening therein, movable closure plates for said openings, and co-ordinating means for simultaneously actuating said closure plates to open one and close the other, refrigerating means and heating means within the space enclosed by wall; and temperature responsive means coactive with the refrigerating and heating means and said closure plate actuating mechanism to automatically operate the refrigerating means and closure plate actuating mechanism when the temperature at the inside panel exceeds a predetermined maximum, to close the inner panel plate and open the plate in the outer panel, and to automatically operate the heating means and closure plate actuator mechanism when the inside temperature falls below a predetermined minimum, to close the outer panel plate and open the inner panel plate.

4. In combination, a wall comprising spaced panels each having a ventilating opening therein, movable closure plates for said openings, and co-ordinating means for simultaneously actuating said closure plates to open one and close the other, a mechanism for operating the co-ordinating means, said mechanism including a housing, a flexible diaphragm partitioning said housing, temperature responsive means on opposite sides of the wall, one of said means connected to the housing on one side of the diaphragm the other connected to the housing on the other side of the diaphragm, and operative connections between the diaphragm and co-ordinating means adapted to automatically open the plate in the panel exposed to the lower temperature.

5. In combination, a wall comprising spaced inner and outer panels each having a ventilating opening therein, movable closure plates for said openings, and co-ordinating means for simultaneously actuating said closure plates to open the one exposed to the lower temperature and close the other, said co-ordinating means including an electric circuit, a switch and plate actuator in the circuit; a mechanism for operating the co-ordinating means including a housing, a flexible diaphragm partitioning said housing, temperature responsive means on opposite sides of the wall,

one of said means connected to the housing on one side of the diaphragm the other connected to the housing on the other side of the diaphragm, and operative connections between the diaphragm and switch.

6. In combination, a wall comprising spaced panels each having a ventilating opening therein, movable closure plates for said openings, co-ordinating means for simultaneously actuating said closure plates to open the one exposed to the lower temperature and close the other, said co-ordinating means including a housing, a flexible diaphragm partitioning the housing a pressure fluid supply pipe having connections with the housing on both sides of the diaphragm, a valve in the fluid supply pipe, connections between the diaphragm and closure plates; a mechanism for operating the co-ordinating means including a second housing, a flexible diaphragm partitioning said second housing, temperature responsive means on opposite sides of the wall, one of said means connected to the second housing on one side of the diaphragm the other connected to the second housing on the other side of the diaphragm, and operative connections between the diaphragm and the second housing and said valve in the fluid supply pipe.

7. In combination with a wall separating two zones each of which zones at times is colder than the other, said wall comprising a pair of spaced panels, a vent in each panel, operating mechanism linked to said vents for opening and closing same, and temperature responsive means adapted so to control said operating mechanism that the space between said panels always is vented to the colder zone only.

8. In combination, a wall comprising a pair of spaced panels, temperature-controlled apparatus situated outside of the space between said wall panels, a vent in one panel opened by said apparatus responsive to a predetermined temperature condition and closed by said apparatus responsive to a predetermined different temperature condition, and a vent in the other panel closed by said apparatus responsive to said first temperature condition and opened by said apparatus responsive to said last temperature condition.

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