

**May 5, 1942.**

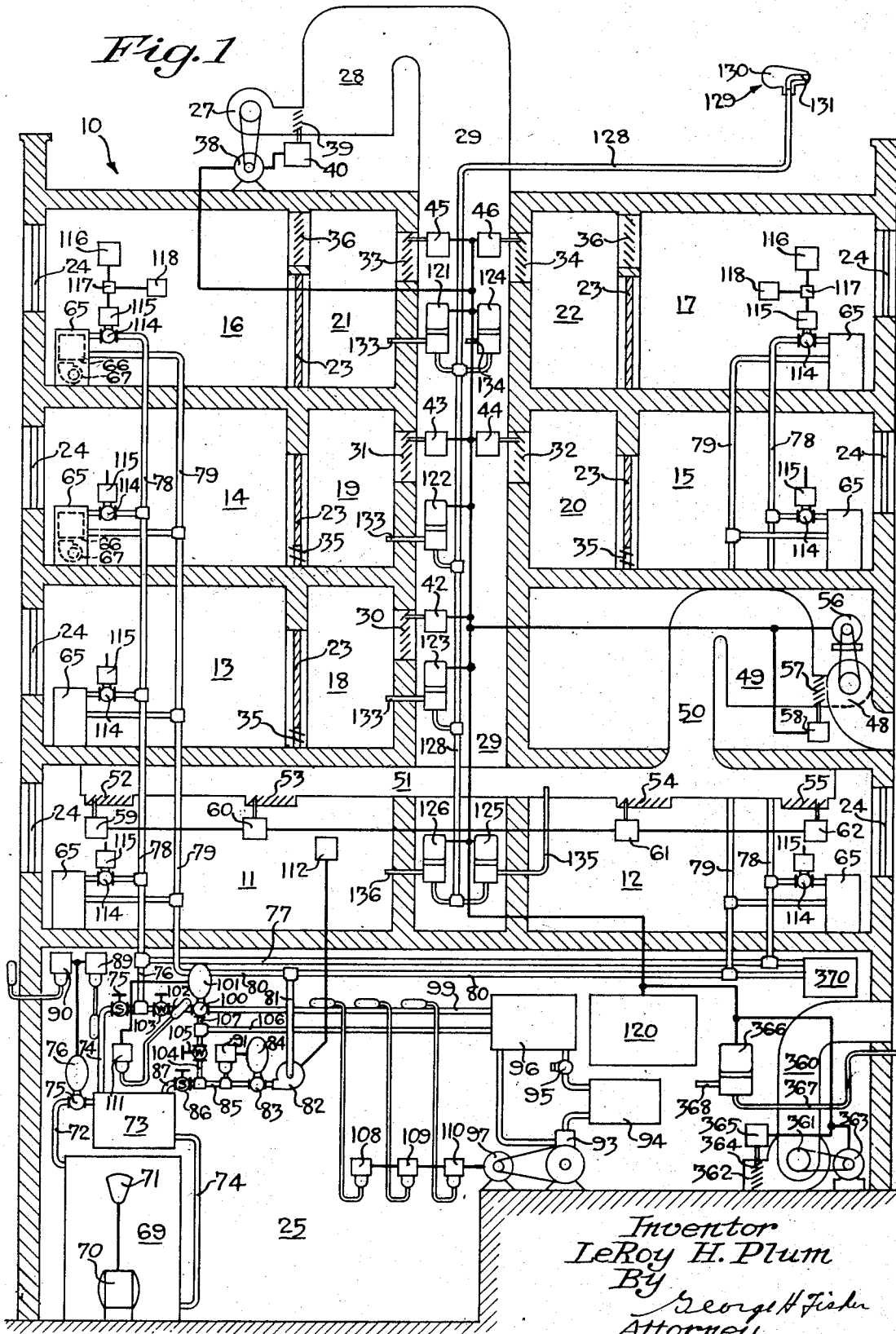
LE ROY H. PLUM

**2,282,210**

## AIR CONDITIONING SYSTEM

Filed Jan. 22, 1937

3 Sheets-Sheet 1



May 5, 1942.

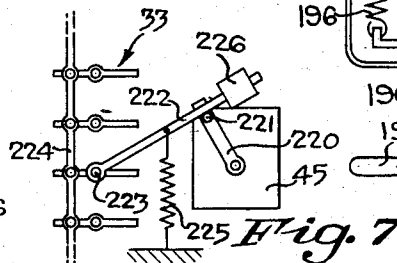
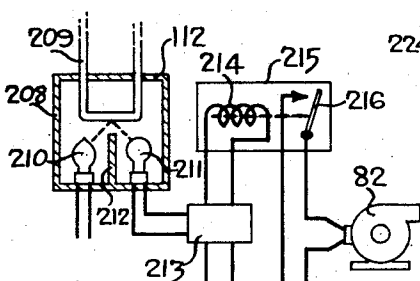
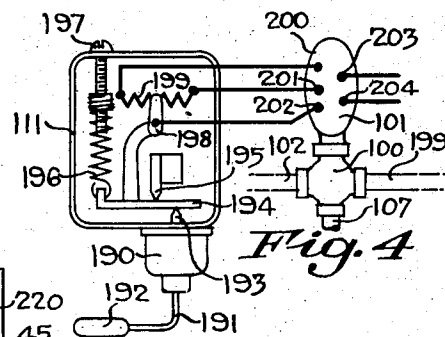
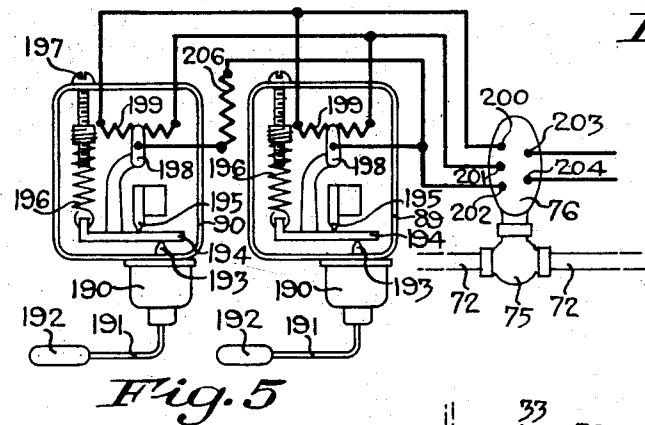
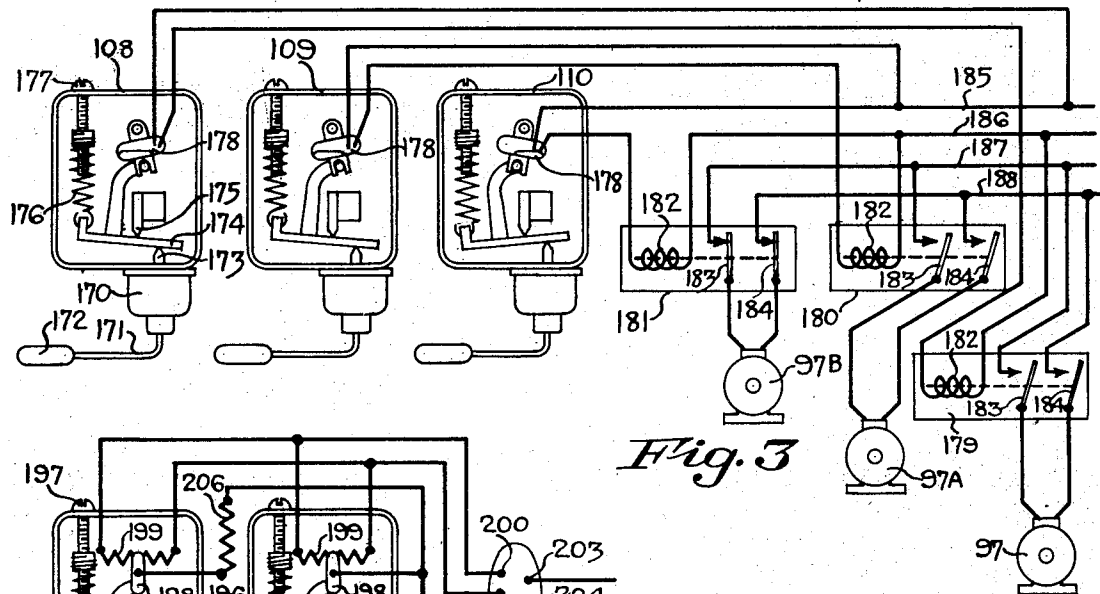
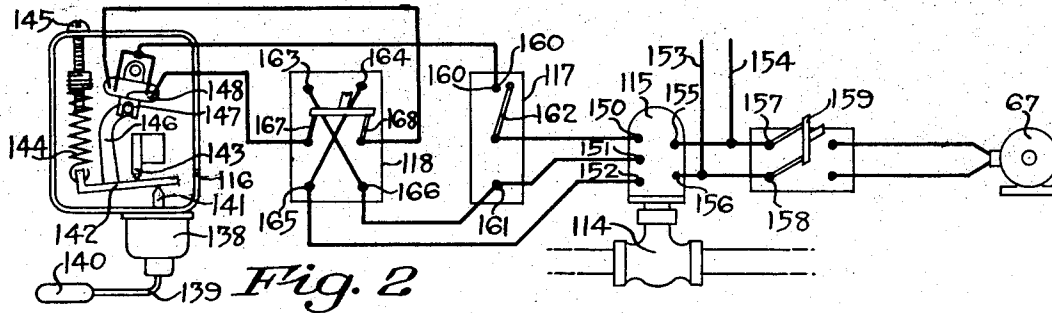
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2,282,210

AIR CONDITIONING SYSTEM

Filed Jan. 22, 1937

3 Sheets-Sheet 2



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May 5, 1942.

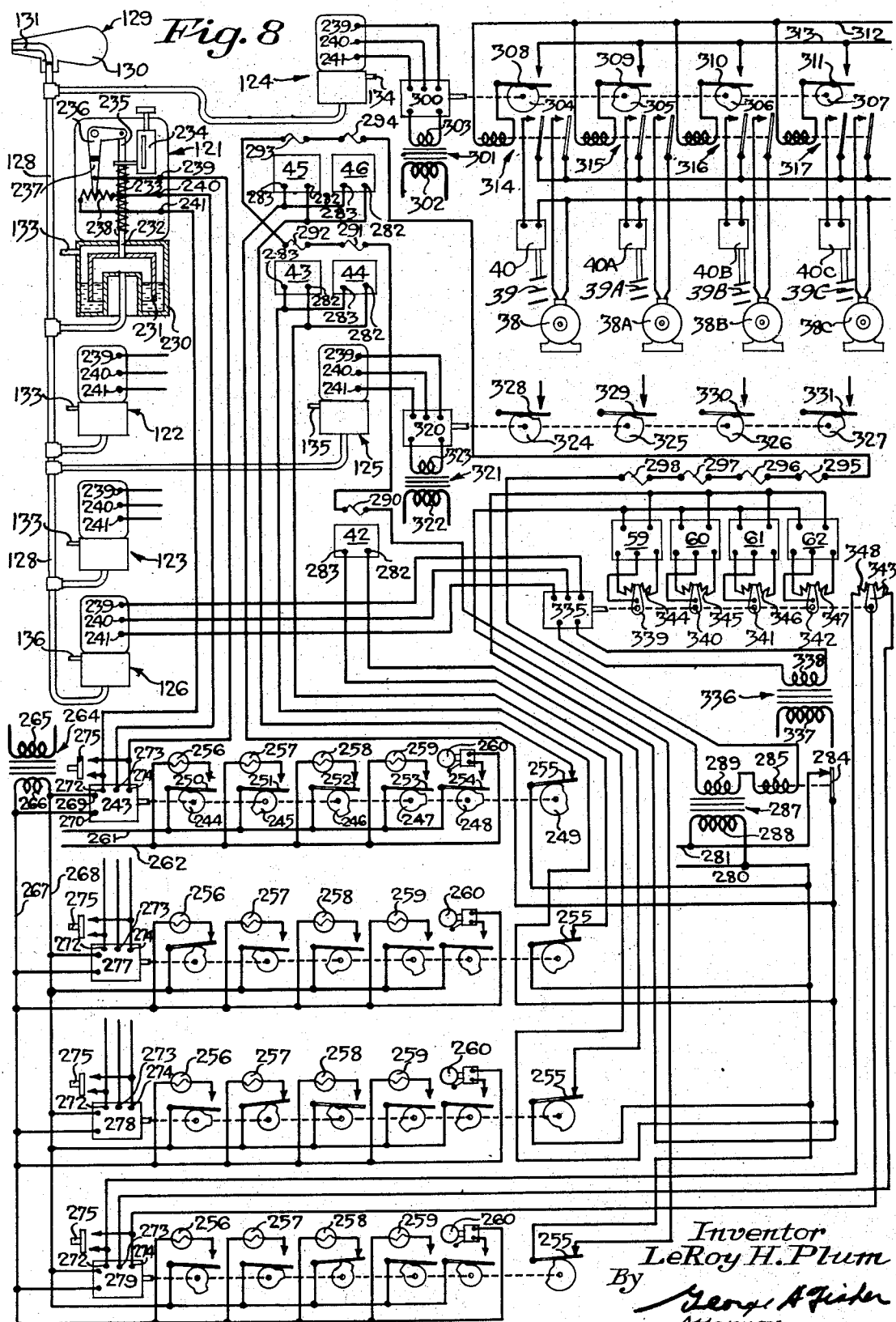
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2,282,210

AIR CONDITIONING SYSTEM

Filed Jan. 22, 1937

3 Sheets-Sheet 3



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## UNITED STATES PATENT OFFICE

2,282,210

## AIR CONDITIONING SYSTEM

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Application January 22, 1937, Serial No. 121,772

7 Claims. (Cl. 98—33)

This invention relates to air conditioning systems in general and more particularly to air conditioning systems as applied to a building having a plurality of zones.

An object of this invention is to provide an air conditioning system for a building having a plurality of zones wherein heat exchangers in each of the zones provide means for heating and cooling their respective zones, wherein conditioned air is supplied to all of the zones mainly for ventilating purposes and wherein the conditioned air supplying means is controlled to maintain a predetermined pressure differential between the air pressure in the building and the outside air pressure to prevent infiltration of outside air.

Another object of this invention is to provide a control system for the circulation of heating and cooling fluid through a plurality of heat exchangers whereby a substantially uniform rate of circulation of the heating or cooling fluid is obtained along with a means for adjusting the rate of circulation of the heating and cooling fluid whereby the rate of heat exchange may be increased or decreased. This gives extremely beneficial results, especially during morning pick-up periods following a night shut-down.

Another object of this invention is to provide a novel control system for controlling the supply of heating fluid and cooling fluid to a plurality of heat exchangers.

Still another object of this invention is to provide an air conditioning system for a building having a plurality of zones wherein a predetermined pressure differential is maintained between the air pressure within the building and the air pressure outside of the building to prevent infiltration of outside air along with indicating means for indicating the differential in pressure effective at any zone.

A further object of this invention is to provide a means for preventing the supply of air to a zone if the differential in pressure between the air pressure of that zone and the outside air pressure decreases to a predetermined value.

Still another object of this invention is to provide an air conditioning system for a building having a plurality of zones wherein the supply of conditioned air to all of the zones is prevented in case a fire occurs in the ductwork adjacent any of the zones.

The combination of the various features of this invention into a complete air conditioning system for obtaining new and beneficial results also forms object of this invention.

Other objects and advantages will become apparent to those skilled in the art upon reference to the accompanying specification, claims and drawings.

For a more thorough understanding of this invention reference is made to the accompanying drawings in which

Figure 1 diagrammatically discloses a building with the control system of this invention applied thereto.

Figure 2 illustrates the manner in which the supply of cooling fluid or heating fluid to the unit conditioners is controlled.

Figure 3 illustrates the manner in which the compressors of the refrigerating apparatus are controlled.

Figure 4 is a view showing the manner in which the three-way valve which controls the temperature of cooling fluid supplied to the unit conditioners is controlled.

Figure 5 illustrates the manner in which the temperature of the heating fluid delivered to the unit conditioners is accomplished.

Figure 6 illustrates a dew-point control for the cooling fluid circulating pump.

Figure 7 illustrates the manner in which the motors utilized in this invention may operate the dampers.

Figure 8 is a wiring diagram showing the operation of the various dampers and motors utilized in this invention.

Referring now to Figure 1 the building to be air conditioned is generally designated at 10 and is shown for purposes of illustration to have a plurality of zones, comprising a first floor having rooms 11 and 12, a second floor having a room 13, a third floor having rooms 14 and 15 and a fourth floor having rooms 16 and 17, although the building may have any number of rooms or any number of floors. The second floor is shown to have a corridor 18, the third floor corridors 19 and 20 and the fourth floor corridors 21 and 22. Doors 23 provide communication between the corridors and the rooms. The rooms are shown to be provided with windows 24. The building may also have a basement designated 25.

Four fans, one of which is shown at 27 in Figure 1 deliver outside air to an air conditioning apparatus 28 located on the roof of the building. The air conditioning apparatus 28 is of the usual type for delivering air at a desired temperature value and moisture content value to a duct 29 which extends downwardly into the building 10. Since this air conditioning apparatus may be of any well known type, a further

description thereof is not considered necessary. An opening having a damper 30 communicates between the passage 29 and the corridor 18 so that conditioned air from the passage 29 is delivered into the corridor 18. Similarly, dampers 31 and 32 control the supply of conditioned air to the corridors 19 and 20, and also dampers 33 and 34 control the supply of conditioned air to the corridors 21 and 22. The doors 23 on the second and third floors are shown to have grills 35 for admitting conditioned air from the corridors into the rooms. On the fourth floor the grills are shown to be grills 36 located above the doors 23 for admitting conditioned air into the rooms 16 and 17. In accordance with this invention, conditioned air is delivered to the corridors at a relatively high static pressure and this conditioned air is therefore forced through the grills into the rooms and then out through the crevices around the windows 24. In this manner a static pressure is built up in the building to prevent infiltration through the windows of hot air in the summer time and cold air in the winter time. The specific manner in which this positive static pressure is maintained will be pointed out more fully hereafter.

The four fans 27 are controlled by four motors, one of which is shown at 38 in Figure 1 and each fan outlet is provided with a damper 39 which is controlled by a motor 40 of usual design. The motor 40 may be of the type that opens the damper 39 when electrical energy is supplied thereto and closes the damper 39 by means of springs, gravity or other means when the supply of electrical energy is cut off. A further description therefore of the motor 40 is not considered necessary.

The damper 30 is controlled by a motor 42, the dampers 31 and 32 by motors 43 and 44 and the dampers 33 and 34 by motors 45 and 46. The motors 42, 43, 44, 45 and 46 may be similar in construction to motor 40, that is, these motors may open their respective dampers when electrical energy is supplied thereto and close their dampers when the supply of energy is cut off.

Four fans, one of which is shown at 48, are located on the second floor and deliver outdoor air into an air conditioning apparatus 49. This air conditioning apparatus 49 may be in all respects similar to air conditioning apparatus 28 located on the roof and therefore this air conditioning apparatus 49 supplies conditioned air at a desired temperature value and a desired moisture content value to a duct 50. The duct 50 connects into a horizontal duct 51 and this duct 51 delivers conditioned air to the spaces 11 and 12 on the first floor. The supply of air from the duct 51 to the space 11 is controlled by dampers 52 and 53 and the supply of air to the space 12 is controlled by dampers 54 and 55.

The fans 48 are each operated by a motor 56 and associated with the outlet of each fan 48 is a damper 57 controlled by a motor 58 in all respects the same as motor 40. In other words, when electrical energy is supplied to the motor 58 the damper 57 is opened and when the supply of electrical energy is cut off, the damper 57 is closed.

The dampers 52, 53, 54 and 55 controlling the supply of conditioned air to the spaces 11 and 12 are operated by motors 59, 60, 61 and 62 respectively. These motors are preferably of the proportioning type and also the spring return type as illustrated in Patent No. 2,032,658

granted to W. H. Gille on March 3, 1936. When electrical energy is supplied to these motors they move the dampers 52, 53, 54 and 55 to a desired open position and when the supply of electrical energy is cut off the dampers are moved to a closed position by means of springs, gravity, or other means.

Although the air conditioning apparatus 28 and 49 deliver air to the building at a given condition, heating of the building in winter time and cooling of the building in the summer time is accomplished mainly by unit conditioners 65, located in each room. These unit conditioners 65 may comprise a heat exchanger 66 to which is supplied either heating fluid or cooling fluid and a fan 67 for circulating the room air over the heat exchangers 66. In this manner the majority of the heating and cooling of the building is accomplished by unit conditioners while the humidity of the air is primarily controlled by the air conditioning apparatus 28 and 49.

A boiler 69 is located in the basement 25. The boiler 69 may be fired by a stoker or oil burner, or any other firing means, under the control of a pressure controller 71 responsive to steam pressures in the boiler 69. By reason of the pressure controller 71 the stoker or oil burner 70 is operated to maintain a constant steam pressure within the boiler 69. Steam is taken from the boiler 69 by a pipe 72 and delivered to a heat exchanger 73. The condensed steam flows from the heat exchanger 73 through a return pipe 74 back to the boiler 69. The amount of steam delivered to the heat exchanger 73 from the boiler 69 is controlled by a valve 75 which in turn is operated by a proportioning motor 76 which may be of the type shown and described in Patent No. 1,989,972 granted to Lewis L. Cunningham on February 5, 1935, or shown in Patent No. 2,028,110, granted to D. G. Taylor on January 14, 1936.

Water is heated in the heat exchanger 73 and flows through a pipe 74, a valve 75 and a pipe 76 to supply header 77. The valve 75 is closed in the summer time and opened in the winter time. Risers 78 lead from the supply header 77 and are connected to the heat exchangers 66 of the unit conditioners 65. Return risers 79 connected also to the heat exchangers 66 of the unit conditioners 65 terminate in a return header 80. The return header 80 is connected by a pipe 81 to an electrically operated circulating pump 82. The circulating pump 82 discharges through a valve 83 into a pipe 85 which in turn is connected by a valve 86 and a pipe 87 to the heat exchanger 73. The valve 83 is operated by a proportioning motor 84 in all respects the same as the proportioning motor 76. Valve 86 is normally closed in the summer time and opened in the winter time. From the above it is seen that water is heated in the heat exchanger 73 and is circulated by the circulating pump 82 through the heat exchangers 66 of the unit conditioners 65 and returned to the heat exchanger 73 for reheating. In other words, a closed system is provided for supplying hot water to the unit conditioners 65 for heating purposes in the winter time.

The proportioning motor 76 which controls the supply of steam to the heat exchanger 73 is controlled by a temperature controller 89 responsive to the temperature of the water leaving the heat exchanger 73 and by a compensator 90 responsive to outdoor temperatures. The arrangement is such that as the hot water temperature de-

creases the valve 75 is moved toward an open position to supply more steam and as the hot water temperature increases, the valve 75 is moved toward a closed position to decrease the supply of steam. The compensator 90 adjusts the effective setting of the temperature controller 89 to raise the setting thereof as the outdoor temperature decreases and to lower the setting thereof as the outdoor temperature increases. In this manner hot water is supplied to the unit conditioners 65 at a temperature which varies in accordance with outdoor temperatures. In other words, as the outdoor temperature increases the heating effect of the unit conditioners 65 is decreased and as the outdoor temperature decreases the heating effect is increased. The specific manner in which the temperature controller 89 and the outside compensator 90 control the proportioning motor 76 is shown in Figure 5 and is described later.

The valve 83 located on the outlet side of the circulating pump 82 is controlled by the proportioning motor 84 which in turn is controlled by a pressure controller 91 responsive to the head pressure in the heating system. When the head pressure in the heating system increases the valve 83 is moved toward a closed position and when the head pressure decreases the valve 83 is moved toward an open position. In this manner a constant head pressure in the hot water heating system is at all times maintained. By raising the setting of the pressure controller 91 the head pressure and therefore the rate of flow of the hot water is increased whereby more heat is given off by the unit conditioners 65 and this becomes quite advantageous during morning pick-up cycles. In this manner the building temperature may be rapidly restored to the normal value in the morning following a night shutdown.

Cooling fluid for summer cooling is supplied to the unit conditioners 65 from a mechanical refrigerating apparatus. This refrigerating apparatus may comprise three compressors, one of which is shown at 93. The compressors 93 discharge into a condenser 94 and the condensed refrigerant passes through an expansion valve 95 into an evaporator forming a part of a heat exchanger 96. The evaporated refrigerant is drawn from the heat exchanger 96 by the compressor 93 and recompressed. Each compressor 93 is operated by an electric motor 97.

Cold water is taken from the heat exchanger 96 through a pipe 99 and passed through a three-way mixing valve 100 to a pipe 102. The valve 100 is controlled by a proportioning motor 101 similar to the proportioning motors 76 and 84. The cold water then passes through a valve 103 to the pipe 76 and thence to the supply header 77 for distribution to the heat exchangers 66 of the unit conditioners 65. Water is returned from the unit conditioners 65 to the return header 80 and from there through pipe 81, pump 82, pipe 85, pipe 104 and a valve 105 to pipe 106 which returns the cooling fluid to the heat exchanger 96 for recooling. The valves 103 and 105 are normally closed in the winter time and opened in the summer time. A pipe 107 connects the junction of pipes 104 and 106 to the three-way mixing valve 100. Pipe 102 which leads to the supply header 77 therefore receives cold cooling fluid from the pipe 99 and relatively warm return cooling fluid from the pipe 107, the relative amounts of which are controlled by the three-way mixing valve 100.

The compressor motors 97 are controlled by temperature controllers 108, 109 and 110 responsive to the temperature of the cooling fluid leaving the heat exchanger 96. The arrangement being such that cooling fluid leaving the heat exchanger 96 is maintained at a substantially constant temperature. The manner in which the compressors are controlled is shown specifically in Figure 3.

The proportioning motor 101 which controls the three-way mixing valve 100 is in turn controlled by a temperature controller 111 responsive to the temperature of the cooling fluid leaving the three-way mixing valve 100. The arrangement is such that if the temperature of the cooling fluid in pipe 102 increases, the three-way mixing valve 100 is operated to increase the amount of cold cooling fluid taken from the pipe 99 and decrease the amount of return cooling fluid taken from the pipe 107. Vice versa as the temperature in the pipe 102 decreases the amount of cooling fluid taken from the pipe 99 is decreased and the amount of return cooling fluid taken from the pipe 107 is increased. In this manner cooling fluid at a constant temperature is delivered to the heat exchangers 66 of the unit conditioners 65 in the summer time.

It is evident that if the relative humidity in the various spaces is relatively high, the moisture in the air will condense on the heat exchangers 66 of the unit conditioners 65 during the summer time. This water of condensation is liable to trickle out on the floors and stain or ruin the finish thereof. In order to prevent this condensation of moisture on these heat exchangers in the summer time a dew-point controller 112 is utilized for preventing the operation of the circulating pump 82 when the dew-point temperature of the air in the spaces or rooms decreases to the temperature of the heat exchangers. Although any type of dew-point controller for accomplishing this result may be utilized, a particular type which adapts itself readily for this operation is specifically shown in Figure 6.

The supply of heating fluid and cooling fluid to the heat exchangers 66 of the various unit conditioners 65 is controlled by a valve 114 which in turn is operated by a motor 115. The motor 115 is controlled by a thermostat 116 responsive to the temperature of the air in the associated room. A summer-winter change over switch 118 reverses the controlling action of the room thermostat so that in the summer time when the space temperature increases above a desired value, the valve 115 is opened and in the winter time when the space temperature decreases below a predetermined value the valve 114 is also opened. A switch 117 is provided for placing the motor under the control of the thermostat 116 or for closing the valve 114 regardless of the demand for cooling or heating by the space thermostat. The particular manner in which the space thermostat 116 controls the motor 115 to operate the valve 114 is specifically shown in Figure 2.

Located in the basement 25 of the building is a master control panel 120. This control panel 120 has control means and indicating means located therein for controlling the operation of the various dampers and for indicating the static pressures existing throughout the building. The details of construction of this control panel 120 are shown in the lower portion of Figure 8. This invention contemplates the use of static pressure regulators 121 to 126 which may be of the type shown and described in application Serial No.

31,463, filed by Lewis L. Cunningham on July 15, 1935. The structure of these static pressure regulators is shown in the upper left-hand portion of Figure 8. These static pressure regulators include an inverted bell the underside of which is connected to a pipe 128 which extends upwardly to the roof of the building and on the upper extremity of the pipe 128 is mounted a weather vane generally designated at 129. This weather vane 129 includes a vane 130 and at all times points an opening 131 into the wind. The opening 131 connects into the pipe 128 and therefore the wind pressure of the outdoor static pressure as affected by the wind is transmitted through the pipe 128 to the space underneath the bells into the pressure regulators 121 to 126 inclusive. The space above the bells of each pressure regulator 121, 122 and 123 is connected by a pipe 133 into the corridors 21, 19 and 18 respectively. Thus the pressure regulators 121, 122 and 123 respond to the differential in pressure existing between the outdoor static pressure as affected by wind and the static pressure on each of the second, third and fourth floors. The static pressure regulator 124 has a pipe 134 for causing communication between the portion above the bell and the passage 29 whereupon the pressure regulator 124 responds to the differential in pressure between the outdoor static pressure as affected by wind and the pressure within the passage 29. A pipe 135 connects the space above the bell of the static pressure regulator 125 to the duct 51 which delivers conditioned air to the first floor and therefore this static pressure regulator 125 responds to the difference in pressure between the outdoor static pressure as affected by wind and the static pressure within the duct 51. The portion above the bell in the static pressure regulator 126 is connected by a pipe 136 to the space 11 and therefore this pressure regulator responds to the difference in pressures between the outdoor static pressure as affected by wind and the static pressure within the space 11. All of the various pressure regulators and damper motors are connected by suitable conduits to the panel board 120 located in the basement 25.

Referring now to Figure 2, a more complete description of the control of the valve 114 which controls the supply of heating fluid and cooling fluid to the unit conditioners 65 in each room is shown. The thermostat 116 may comprise a chamber 138 containing a bellows connected by a capillary tube 139 to a bulb 140. The chamber 138, tube 139, and the bulb 140 contain a volatile fluid so that upon an increase in temperature affecting the bulb 140 the bellows in the chamber 138 is operated to move a plunger 141 upwardly. The bulb 140 may respond to room temperature directly or may respond to room temperature indirectly by being located on the inlet side of the fan 67 in the conditioning unit 65. Plunger 141 operates a lever 142 about a pivot 143. The lever 142 is urged in one direction by a tension spring 144 which may be adjusted by a suitable screw 145. The lever 142 carries an arm 146 which operates a switch carrier 147. The switch carrier 147 carries a mercury switch 148 having a common center electrode, a left electrode and a right electrode. Upon an increase in temperature the mercury in the mercury switch 148 bridges the common electrode and the right electrode as shown in Figure 2 and upon a decrease in temperature the mercury bridges the common electrode and the left electrode.

The motor 115 which operates the valve 114

may be the usual two position motor having terminals 150, 151 and 152. The arrangement is such that when a circuit is completed across the terminals 150 and 151 the valve 114 is closed and when a circuit is completed across the terminals 150 and 152 the valve 114 is opened. Power may be supplied to power terminals 155 and 156 on the motor 115 from lines wires 153 and 154. The line wires 153 and 154 also connect to terminals 157 and 158 of a fan switch. When the switch 159 of the fan switch is closed a circuit to the fan motor 67 is completed as is obvious from Figure 2. The switch 117 comprises a terminal 160 and a terminal 161 which are adapted to be engaged by a switch arm 162. When the switch arm 162 engages the terminal 160 the valve 114 is placed under automatic operation and when the switch arm 162 engages the terminal 161 a circuit is completed across the terminals 151 and 152 of the motor 115 to close the valve 114. The summer-winter changeover switch 118 comprises winter terminals 163 and 164 and summer terminals 165 and 166 which are adapted to be engaged by switch arms 167 and 168.

Assume that the switch arm 162 is engaging the automatic terminal 160 and that the switch arms 167 and 168 are engaging the winter terminals 163 and 164. When the temperature affecting the bulb 140 is above the predetermined value, mercury engages the common electrode and the right electrode of the mercury switch 148 to complete a circuit across the terminals 150 and 151 of the motor 115 whereupon the valve 114 is closed. Upon a decrease in temperature the mercury bridges the common electrode and the left electrode of the mercury switch 148 to complete a circuit across the terminals 150 and 152 of the motor 115 whereupon the valve 114 is moved to an open position. In this manner the valve 114 is moved to an open position upon a decrease in temperature during the winter time and is moved to a closed position upon an increase in temperature. Assume now that the switch arms 167 and 168 are moved into engagement with the summer terminals 165 and 166. The operation of the motor 115 by the thermostat 116 is therefore reversed and the valve 114 will be moved to a closed position when the temperature affecting the bulb 140 decreases below a predetermined value and will be moved to an open position when the temperature affecting the bulb 148 increases above a predetermined value. In this manner the supply of heating fluid or cooling fluid to the unit conditioners is thermostatically controlled in the summer time as well as in the winter time by the same thermostat to maintain predetermined temperatures within the various spaces.

The manner in which the compressors of the mechanical refrigerating apparatus are operated is shown in Figure 3. The three compressors are shown at 97, 97A and 97B. The thermostat 108 controls the operation of the compressor 97, thermostat 109 controls the operation of the compressors 97A and the thermostat 110 controls the operation of the compressors 97B. Each thermostat may comprise a chamber 170 containing a bellows connected by a capillary tube 171 to a bulb 172. The bulb 172 as pointed out before, is responsive to the temperature of the cooling fluid leaving the cooler or heat exchanger 96. The bulb 172 contains a volatile fluid and upon an increase in temperature the bellows in the chamber expands to move a plunger 173 upwardly which operates a lever 174

about a pivot 175 against the action of a tension spring 176. The tension of the spring 176 and consequently the temperature setting of the thermostat may be adjusted by a suitable screw 177. The lever 174 operates a mercury switch 178, the arrangement being such that when the temperature increases to a predetermined value the switch is moved to a circuit making position. The thermostat 108 controls a relay or starter 179, thermostat 109 controls a relay or starter 180 and the thermostat 110 controls a relay or starter 181. Each relay or starter is shown to comprise a relay coil 182 and switches 183 and 184. Power is supplied to the relay coils 182 by line wires 185 and 186 and power is supplied to the switches 183 and 184 of the relays by line wires 187 and 188.

Assume now that the thermostat 110 is so adjusted to close its mercury switch when the temperature increases to 40°, that the thermostat 109 closes its switch when the temperature increases to 42° and that the thermostat 108 closes its switch when the temperature increases to 44°. Assume also that the temperature increases to 40° whereupon a circuit is completed from line wire 185 through mercury switch 178 of thermostat 110 and relay coil 182 back to the other line wire 186. The switches 183 and 184 are therefore closed and the compressor 97B is placed in operation. When the temperature increases to 42° the compressor motor 97A is placed into operation in exactly the same manner by the thermostat 109 and when the temperature increases to 44° the thermostat 108 brings the thermostat 107 into operation. As shown in Figure 3 the temperature of the cooling fluid is between 40 and 42° whereupon the compressor motor 97B is operating, while the compressor motors 97A and 97 are not operating.

Figure 4 shows the manner in which the three-way mixing valve 100 is controlled. As pointed out above the three-way mixing valve controls the amount of cold cooling fluid and the amount of return cooling fluid delivered to the heat exchangers 66 of the unit conditioners 65. The thermostat 111 which responds to the temperature of the cooling fluid leaving the mixing valve 100 may comprise a chamber 190 containing a bellows connected by a capillary tube 191 to a bulb 192. The bulb 192 contains a volatile fluid and responds to the temperature of the cooling fluid in the pipe 102 leaving the three-way mixing valve 100. Upon an increase in temperature the volatile fluid expands to move a plunger 193 upwardly to move a lever 194 about a pivot 195 against the action of a tension spring 196. The amount of tension in the spring 196 and consequently the temperature setting of the thermostat 111 may be adjusted by means of a suitable screw 197. The lever 194 operates a slider 198 with respect to a potentiometer resistance element 199. The slider 198 and the resistance element 199 form a control potentiometer for the motor 101. The left and right ends of the resistance element 199 are connected to terminals 200 and 201 of the motor 101 and the slider 198 is connected to a terminal 202 of the motor 101. Power is supplied to the motor 101 by means of line wires connected to power terminals 203 and 204 of the motor 101. Upon an increase in temperature the slider 198 moves to the left which proportionately operates the motor 101 to increase the amount of cold cooling fluid received from the pipe 99 and decrease the amount of return cooling fluid received from the

pipe 107. Upon a decrease in temperature the slider 198 moves to the right to decrease the amount of cold cooling fluid coming from the pipe 99 and increasing the amount of return cooling fluid coming from the pipe 107. In this manner the three-way mixing valve 100 is modulated in accordance with changes in temperature to maintain a substantially constant temperature in the pipe 102. For a more complete description of the operation of the motor 101 reference is made to the above referred to Taylor and Cunningham patents.

For the control of the steam supply to the heat exchanger 73 reference is made to Figure 5. Since the temperature controller 89 and the compensator 90 may be exactly the same in construction as the thermostat 111 of Figure 4 like reference characters have been utilized. The motor 76 of Figure 5 is exactly the same as motor 101 of Figure 4 and therefore the temperature controller 89 is electrically connected to the motor 76 in exactly the same manner as the temperature controller 111 is connected to the motor 101 of Figure 4. The temperature controller 89 operates the motor 76 in exactly the same manner as does the temperature controller 111 operate the motor 101 of Figure 4. Upon an increase of hot water temperature affecting the bulb 192 the valve 175 is modulated toward a closed position in direct proportion of the amount of increase in temperature. Upon a decrease in temperature the valve 75 is positively modulated toward an open position. In this manner the temperature of the water leaving the heat exchanger 73 is maintained at a substantially constant value. The compensator 90 is connected in parallel with the controller 89 and controls the valve 76 in substantially the same manner. Upon an increase in outdoor temperature affecting the bulb 192 the valve 175 is modulated toward a closed position and upon a decrease in temperature the valve 75 is modulated toward an open position. The resistance 206 in series with the slider 198 of the compensator 90 is provided to desensitize the controlling action of the compensator 90 whereby the temperature controller 89 performs the main control of the motor 76 and the compensator 70 performs an auxiliary control which acts to adjust the effective temperature setting of the temperature controller 89. In this manner the temperature of the hot water delivered to the unit conditioners 65 during the winter time is adjusted in accordance with outdoor temperatures and the temperature of the water is maintained substantially constant for any given outdoor temperature.

One type of dew-point controller 112 which may control the operation of the circulating pump 82 to prevent condensation from forming on the heat exchangers 66 of the unit conditioners 65 is illustrated in Figure 6. This dew-point controller 112 may comprise a casing 208 into which extends a pipe 209 having a polished surface. Cold water at the same temperature as the cooling water delivered to the heat exchanger 66 of the unit conditioners 65 is circulated through the pipe 209 so that this pipe 209 is maintained at the same temperature as the heat exchangers 66. The casing 208 is provided with vent openings so that the room air may contact the pipe 209. The casing 208 is provided with a light source 210 and a photo-electric cell 211. A partition separates the light source 210 and the photoelectric cell 211 so that light is trans-

mitted to the photoelectric cell 211 only by reflection off of the polished surface of the pipe 209. When the dew-point temperature of the air within the space 211 is above the temperature of the pipe 209 the light source 210 affects the photo-electric cell 211 which operates through a suitable amplifier 213 to energize a relay coil 214 of a relay 215. Energization of the relay coil 214 in this manner closes a switch 216 which causes operation of the circulating pump 82. If, however, the dew-point temperature of the air should decrease to the temperature of the pipe 209, water vapor will condense on the polished surface of the pipe 209 and cloud the surface whereupon reflection of light to the photo-electric cell 211 is prevented. Relay coil 214 thereby becomes deenergized and the switch 216 is opened to stop operation of the circulating pump 82 which stops the supply of cold cooling fluid to the heat exchangers 66. In this manner condensation of moisture on the heat exchangers 66 of the unit conditioners 65 is prevented.

Figure 7 illustrates the manner in which the motors utilized in this invention may operate the dampers. For purposes of illustration the motor 45 which operates the damper 33 which controls the supply of conditioned air to the corridor 21 on the fourth floor is utilized. The motor 45 operates a crank arm 220 provided with a pin 221. The pin 221 abuts against a lever 222 carried by the pivot of one of the vanes forming the damper 33. The vanes forming the damper 33 are connected together by a suitable link 224. The arm 222 is urged downwardly by a spring 225 and by a weight 226 to maintain normally the damper 33 in a closed position. Upon energization of the motor 45 the crank arm 220 is moved upwardly to overcome the biasing action of the spring 225 and the weight 226 to move the damper 33 toward an open position. When the supply of electrical energy to the motor 45 is cut off the spring 225 moves the crank arm downwardly and also moves the damper 33 to a closed position. If the spring 225 should break the weight 226 will perform this function. In this manner when the motor 45 is energized the damper 33 is opened and when the motor 45 is deenergized the damper 33 is closed.

Referring now to the upper left-hand portion of Figure 8 the static pressure regulator 121 is shown to comprise a chamber 230 having an inverted bell 231 therein. The inverted bell 231 is carried by a rod 232 which is connected to one end of a tension spring 233. The other end of the tension spring 233 is connected to a suitable adjustable mechanism 234 whereby the pressure setting of the instrument may be adjusted. The rod 232 operates a link 235 which is connected to a bell crank lever 236. The bell crank lever 236 carries a slider 237 adapted to slide across a resistance element 238. The slider 237 and the resistance element 238 form a control potentiometer. The slider 237 is connected to a terminal 239, the right end of the resistance element 238 is connected to a terminal 240 and the left end of the resistance element 238 is connected to a terminal 241. Upon an increase in the pressure differential formed by the static pressure on both sides of the bell 231, the bell 231 moves downwardly to move the slider 237 towards the left. Upon a decrease in pressure differential affecting the bell 231, the bell 231

moves upwardly to move the slider 237 toward the right.

The static pressure regulator 121 operates motor 243 of a step controller. The motor 243 may be of the type shown and described in the above referred to Cunningham and Taylor patents. Motor 243 operates cams 244 to 249 inclusive and these cams in turn operate switches 250 to 255 inclusive. Switch 250 operates an indicating light 256, the switch 251 operates a light 257, the switch 252 operates a light 258 and the switch 253 operates a light 259. The switch 254 operates an alarm 260. Power is supplied to the lights 256, 257, 258 and 259 and the alarm 260 by means of line wires 261 and 262. Assume that the step controller is in one extreme position as shown, switches 250 to 254 are open and switch 255 is closed. Assume now that the proportioning motor 243 operates to move the cams 245 to 249 in a clockwise direction. The switch 250 is first closed to light its associated light 256. Upon further operation the switch 251 is closed to light the light 257 at which time the switch 250 opens to extinguish light 256. Upon further rotation the switch 252 closes and lights the light 258 at the same time the light 257 is extinguished. Upon further rotation to the other extreme position switches 250 and 254 close and switch 255 opens. Closure of switch 253 lights the light 259 and closure of switch 254 sounds the alarm 260. In this manner the lights 256, 257, 258 and 259 indicate the position of the proportioning motor 243 and when the proportioning motor is moved to one extreme position the light 259 and the alarm 260 indicate this position.

Power is supplied to the proportioning motor 243 of the step controller by means of a step-down transformer 264 having a primary 265 and a secondary 266 connected to busses 267 and 268. Power terminals 269 and 270 of the motor 243 are connected to the busses 267 and 268. The proportioning motor 243 is provided with three control terminals 272, 273 and 274 which are connected respectively to the terminals 241, 240 and 239 of the static pressure regulator 121. Assume that the pressure differential between the outdoor pressure as affected by wind and the pressure in the corridor 21 is a maximum, then the step controller operated by the motor 243 will be in the position shown in Figure 8. As the pressure differential decreases the lights 256, 257, 258 and 259 are progressively lighted in accordance with the amount of decrease in this pressure differential. When the light 259 is lighted and the alarm 260 is sounded, the switch 255 is opened. In this manner the differential of pressure between the outdoor static pressure as affected by wind and the static pressure on the fourth floor is indicated by the step controller operated by the motor 243 and when this pressure differential decreases to a given value an alarm is sounded and the switch 255 is opened. If the proportioning motor 243 should be operated by the static pressure regulator 121 to an extreme position where the switch 255 is opened, the step controller may be operated to the other extreme position by closure of the manual switch 275.

The static pressure regulator 122 which responds to the differential pressure of the outdoor static pressure as affected by wind and the static pressure on third floor controls a step controller operated by a proportioning motor 277 and this step controller is in all respects the same as the step controller operated by the proportioning motor 243 and therefore like reference charac-

ters are utilized. This latter step controller indicates the differential in pressures existing on the third floor. The static pressure regulator 123 which responds to the differential in pressures between the outdoor static pressure as affected by wind and the static pressure on the second floor controls the step controller operated by the proportioning motor 278 and therefore an indication of the pressures involved on the second floor is afforded.

Power is supplied to all of the damper motors by means of line wires 280 and 281. When the switch 255 of the step controller operated by the proportioning motor 243 is closed a circuit is completed from the line wire 280 through switch 255, terminals 282 on the damper motors 45 and 46 for the fourth floor, terminals 283 of these damper motors 45 and 46 and switch 284 operated by a relay coil 285 back to the other line wire 281. When the switch 255 of the step controller operated by the pressures on the fourth floor is closed, power is supplied to the damper motors 45 and 46 and therefore dampers 33 and 34 will be operated to supply conditioned air to the fourth floor. In a like manner power is supplied to the damper motors 43 and 44 to open the dampers 31 and 32 on the third when the switch 255 of the step controller operated by the proportioning motor 277 is closed in response to pressures on the third floor. In this manner the dampers 31 and 32 supplying conditioned air to the third floor are maintained open as long as the pressure differential on the third is above a desired minimum value. Similarly power is supplied to the damper motor 42 when the switch 255 operated by the proportioning motor 278 is closed in response to pressures on the second floor. Conditioned air is thereupon delivered to the second floor. From the above it is seen that when a desired pressure differential between the outdoor static pressure and the static pressure on any of the floors is maintained the dampers controlling the delivery of conditioned air to these floors are maintained open but if the pressure differential should decrease to a given amount on any of these floors as by opening windows on these floors the dampers controlling the supply of conditioned air to these floors will be closed since the switches 255 are opened when the pressure differential decreases to a predetermined low value.

It is also seen that as the switch 284 controlled by the relay 285 is opened the power supply to the damper motors 42, 43, 44, 45 and 46 will be cut off and all of these dampers will be moved to a closed position. Power is supplied to the relay coil 285 by means of a step-down transformer 287 having a primary 288 connected across the line wires 280 and 281 and a secondary 289. The left end of the secondary 289 is connected through a fusible link 290 associated with the motor 42 on the second floor, fusible links 291 and 292 associated with the motors 44 and 43 respectively on the third floor, fusible links 293 and 294 associated with damper motors 45 and 46 on the fourth floor, fusible links, 295, 296, 297 and 298 associated with damper motors 62, 61, 60 and 59 respectively on the first floor and relay coil 285 back to the right side of the secondary 289. Since all of the above enumerated fusible links are connected in series with relay coil 285 the relay coil 285 will be maintained energized only as long as all of these fusible links are intact. If anyone of these series connected fusible links should break, the relay coil 285 would be deenergized and the switch 284 would open

whereupon all the damper motors would move to a closed position. The fusible links 290 to 298 are utilized for fire prevention purposes. The fusible links 290 to 294 are located in the passage 29 adjacent to the dampers 30 to 34 and the fusible links 294 to 298 are located in the duct 51 adjacent the dampers 52 to 55. If a fire should occur in the passage 29 or the duct 51 the fusible links near the fire would break and cause deenergization of relay coil 285 and consequent closing of all of the dampers. This would prevent the fire from being blown through the dampers into the corridors and rooms and also prevent the circulation of air through the building to prevent spreading of the fire throughout the building.

Referring now to the upper right-hand portion of Figure 8 the static pressure regulator 124 which responds to the differential between the outside static pressure as affected by wind and the static pressure in the passage 29 controls the operation of a proportioning motor 300 of a step controller. Power is supplied to the proportioning motor 300 by a step-down transformer 301 having a primary 302 and a secondary 303 connected to the power terminals of the proportioning motor. The proportioning motor is connected by three wires to the static pressure regulator 124 so that it is positioned in accordance with changes in the pressure differential. The proportioning motor 300 which may be of the type illustrated in the Cunningham and Taylor patents operates cams 304, 305, 306 and 307. The cams 304 to 307 operate switches 308, 309, 310 and 311 respectively. The switches 308 to 311 control the supply of power from line wires 312 and 313 to relays 314, 315, 316 and 317, respectively. The relay 314 controls the supply of power to the fan motor 38 and to the damper motor 40. The relay 315 controls the supply of power to the fan motor 38A and to the damper motor 40A. Similarly the relays 316 and 317 control the supply of power to fan motors 38B and 38C and damper motors 40B and 40C. With the parts in the position shown the pressure differential is at a maximum and the proportioning motor 300 is in one extreme position. Upon a decrease in the pressure differential the proportioning motor 300 is operated to first close the switch 308 which operates the fan 38 and energizes the damper motor 40 which opens the damper 39 whereupon a given amount of conditioned air is delivered to the passage 29 for distribution through the second, third and fourth floors of the building. Since the damper motors 40A, 40B and 40C are deenergized at this time their respective dampers are closed to prevent the pressure in the air conditioning apparatus 28 and the passage 29 from venting to the atmosphere outside of the building. This is necessary to maintain the desired pressure differential. Upon a further decrease in pressure differential the fan motor 38A is operated and the damper motor 40A is energized to open its damper 39. Upon further decreases in pressure differential the fans 38B and 38C are sequentially brought in operation and the damper motors 40B and 40C are energized to open their respective dampers. By reason of this construction a substantially constant pressure differential between the outdoor static pressure as affected by wind and the pressure within the passage 29 is maintained.

The static pressure regulator 125 operates a proportioning motor 320 which receives its power from a step-down transformer 321 having a pri-

mary 322 and a secondary 323 connected to the power terminals of the proportioning motor 320. The proportioning motor 320 operates cams 324, 325, 326 and 327 for sequentially closing switches 328, 329, 330 and 331. These switches control relays which in turn control the placing in operation of the four fans 56 and the four dampers 58 of the air conditioning apparatus which delivers conditioned air to the first floor. Since this method of control of the supply of conditioned air to the first floor is accomplished in the same manner as that for the second, third and fourth floors, a further description and illustration is not considered necessary. It is sufficient to state that a substantially constant pressure differential is maintained between the outdoor static pressure as affected by wind and the static pressure in the duct 51.

The static pressure regulator 126 which responds to the differential in pressure of the outside static pressure as affected by wind and the static pressure on the first floor controls a proportioning motor 335 which receives its supply of power from a step-down transformer 336 having a primary 337 and a secondary 338 which is connected to the power terminals of the proportioning motor 335. This proportioning motor 335 operates sliders 339, 340, 341, 342 and 343 with respect to resistance elements 344, 345, 346, 347 and 348. The sliders and the resistance elements form control potentiometers. The slider 339 and resistance element 344 control the operation of the spring return type proportioning motor 59 which positions the volume damper 52 on the first floor. Similarly the slider 340 and the resistance element 345 control the proportioning motor 60, the slider 341 and resistance element 346 controls the proportioning motor 61 and the slider 342 and the resistance element 347 control the proportioning motor 62. Proportioning motors 59, 60, 61 and 62 operate the dampers 52, 53, 54 and 55 which control the supply of conditioned air to the first floor of the building. These proportioning motors as pointed out above are of the spring return type as disclosed in the above referred to Gille patent. As the pressure differential increases the motor 335 is modulated to move the sliders which in turn modulate the motors 59, 60, 61 and 62 so that the dampers 52, 53, 54 and 55 are modulated in accordance with the differential in pressure to maintain a substantially constant pressure differential between outdoor static pressures as affected by wind and the static pressure on the first floor.

The slider 343 and the resistance element 348 form a control potentiometer for the proportioning motor 279 of the step controller located in the panel 120. This step controller performs an indicating function in exactly the same manner as the other step controllers contained in the control panel 120 so that the static pressures existing on the first floor are indicated. Power is supplied to the motors 59, 60, 61 and 62 from the line wire 280 through switch 255 of the step controller operated by the proportioning motor 279, the power terminals of these motors 59 to 62 and the switch 284 controlled by the relay coil 285 back to the other line wire 281. Therefore, if the pressure differential of the first floor should decrease to a predetermined low value the switch 255 would open and the power supplied to the damper motors 59, 60, 61 and 62 would be broken whereupon the dampers 52, 53, 54 and 55 would move to a closed position. This might occur if the windows on the first floor were opened

causing this decrease in pressure differential. Also if any of the fusible links should break the relay coil 285 would become deenergized to open the switch 284 to break the supply of power to the damper motors 59, 60, 61 and 62. Thus if a fire should occur in the building the dampers for the first floor would close as well as the dampers for the remaining floors. From the above it is seen that the dampers controlling the supply of conditioned air to the first floor are modulated in accordance with the differential in pressure between outside static pressures as affected by wind and the static pressure on the first floor, that the differential of pressures is indicated by a step controller in the basement and that the dampers 52, 53, 54 and 55 will close in case the pressure differential decreases to a predetermined low value or in case any of the fusible links should break.

Referring again to Figure 1, fresh air is supplied to the basement through an inlet duct 360 by a plurality of fans 361, the fans 361 discharging through an outlet duct 362 into the basement. The fans 361 may be operated by a plurality of motors 363 and the discharge ducts may be provided with a plurality of dampers 364 controlled by damper motors 365. The motors 363 and the damper motors 365 may be controlled in exactly the same manner as the fan motors and the damper motors on the roof and on the second floor are controlled. In order to accomplish this a static pressure regulator 366 may be utilized having the underside of the bell connected by a pipe 367 to the outside air and the overside of the bell connected by a pipe 368 to the basement. Since the pipe 367 is not connected to a weather vane, the static pressure regulator 366 will operate in response to the differential of outside static pressures and basement pressures. This mode of operation is all right for the basement since wind pressures would have substantially no effect in the basement. The basement may be heated or cooled by means of unit conditioners 370 suitably connected to the supply and return headers 77 and 80.

From the above it is seen that I have provided an air conditioning control system for a building wherein the building is heated or cooled by means of unit conditioners, wherein these unit conditioners are controlled by room thermostats provided with summer-winter changeover switches, wherein heating fluid, the temperature of which is varied in accordance with outdoor temperatures, is supplied to the unit conditioners in the winter time and wherein a cooling fluid at a constant temperature is supplied to the unit conditioners in the summer time. Provision is made for varying the head pressure on the cooling and heating system so that the rate at which the building temperature may be restored to the desired normal value following a night shut-down may be speeded up. Conditioned air at a desired temperature value and moisture content value is delivered to the building mainly for the purpose of ventilating the building and controlling the relative humidity in the building. The supply of this air to the building is so controlled that a substantially constant predetermined pressure differential is maintained between the outside static pressure as affected by wind and the inside static pressure so that a positive pressure is at all times maintained within the building to prevent infiltration of warm air during the summer and infiltration of cold air during the winter

through crevices around the windows. Provision is further made for controlling the static pressures on the main or first floor of the building along with means for indicating the static pressures.

In case the pressure differential of the portion of the building should decrease to a predetermined low value the dampers controlling the supply of air to that portion of the building will close. The decrease in pressure differential would most likely be caused by the opening of windows and therefore the closing of these dampers will prevent the loss of air through the open windows. Also if a fire should occur in the ductwork adjacent any portion of the building all of the dampers would be closed to prevent the circulation of air throughout the building and thereby decrease the probability of the fire spreading throughout the building.

Although for purposes of illustration I have disclosed one form of my invention, other forms thereof may become obvious to those skilled in the art upon reference to this specification and therefore this invention is to be limited only by the scope of the appended claims and prior art.

I claim as my invention:

1. In an air conditioning system for an enclosure, the combination of, means for supplying conditioned air under pressure to the enclosure, a pitot tube located outside of the enclosure and adapted to be pointed into the wind regardless of the direction of the wind, a vane for pointing the pitot tube into the wind, a differential pressure responsive controller having a pressure connection to the pitot tube and a pressure connection to the inside of the enclosure so as to respond to the difference in air pressure in the enclosure and the air pressure outside of the enclosure as affected by wind, and means controlled by the differential pressure responsive controller for controlling the conditioned air supplying means to maintain an enclosure air pressure which is greater by a substantially constant amount than the outside air pressure as affected by wind whereby infiltration of outside air is prevented regardless of wind velocity.

2. In an air conditioning system for an enclosure, the combination of, means for supplying conditioned air under pressure to the enclosure, a pitot tube located outside of the enclosure and adapted to be pointed into the wind regardless of the direction of the wind, a vane for pointing the pitot tube into the wind, a differential pressure responsive controller having a pressure connection to the pitot tube and a pressure connection to the inside of the enclosure so as to respond to the difference in air pressure in the enclosure and the air pressure outside of the enclosure as affected by wind, means controlled by the differential pressure responsive controller for controlling the conditioned air supplying means to maintain an enclosure air pressure which is greater by a substantially constant amount than the outside air pressure as affected by wind whereby infiltration of outside air is prevented regardless of wind velocity, and means controlled by the differential pressure responsive controller for also controlling the conditioned air supplying means to prevent the supply of conditioned air to the enclosure if the differential in pressure between the enclosure air pressure and the outside air pressure decreases to a predetermined value.

3. In an air conditioning system for an enclosure, the combination of, means for supplying conditioned air under pressure to the enclosure, a differential pressure responsive controller having a pressure connection outside of the enclosure and a pressure connection inside of the enclosure so as to respond to the difference in air pressure inside of the enclosure and the air pressure outside of the enclosure, a power failure type variably positionable mechanism for regulating the supply of conditioned air to the enclosure to interrupt the supply of conditioned air to the enclosure when the supply of power to the mechanism is interrupted, to supply conditioned air to the enclosure when power is supplied to the mechanism and to regulate variably the supply of conditioned air to the enclosure while power is supplied to the mechanism, means controlled by the differential pressure responsive controller for variably controlling the mechanism to regulate variably the supply of conditioned air to the enclosure to maintain an enclosure air pressure which is greater by a substantially constant amount than the outside air pressure whereby infiltration of outside air is prevented, and means controlled by the differential pressure responsive controller for interrupting the supply of power to the mechanism to interrupt the supply of conditioned air to the enclosure if the differential in pressure between the enclosure air pressure and the outside air pressure decreases to a predetermined value.

4. In an air conditioning system, the combination of a conduit for supplying outside air to a building for air conditioning purposes, a plurality of fans for forcing outside air into the conduit to build up a static pressure in the conduit, means responsive to the static pressure in the conduit for placing the fans in operation in sequence as the static pressure in the conduit decreases to maintain a substantially constant static pressure in the conduit, a damper associated with each fan and operative when closed to prevent communication between the outside atmosphere and the conduit whereby the pressure in the conduit is prevented from venting to atmosphere, and means for opening each damper when its associated fan is placed in operation.

5. In an air conditioning system for an enclosure, the combination of, means for supplying conditioned air under pressure to the enclosure, a power failure type variably positionable mechanism for regulating the supply of conditioned air to the enclosure to interrupt the supply of conditioned air to the enclosure when the supply of power to the mechanism is interrupted, to supply conditioned air to the enclosure when power is supplied to the mechanism, and to regulate variably the supply of conditioned air to the enclosure while power is supplied to the mechanism, a differential pressure responsive controller having a pressure connection outside of the enclosure and a pressure connection inside of the enclosure so as to respond to the difference in air pressure inside of the enclosure and the air pressure outside of the enclosure, means controlled by the differential pressure responsive controller for variably controlling the mechanism to regulate variably the supply of conditioned air to the enclosure to maintain an enclosure pressure which is greater by a substantially constant amount than the outside air pressure whereby infiltration of outside air is prevented, and means operative upon the occurrence of fire in the enclosure for interrupting the supply of power to

the mechanism to interrupt the supply of conditioned air to the enclosure.

6. In an air conditioning system for an enclosure, the combination of, means for supplying conditioned air under pressure to the enclosure, a power failure type variably positionable mechanism for regulating the supply of conditioned air to the enclosure to interrupt the supply of conditioned air to the enclosure when the supply of power to the mechanism is interrupted, to supply conditioned air to the enclosure when power is supplied to the mechanism and to regulate variably the supply of conditioned air to the enclosure while power is supplied to the mechanism, a differential pressure responsive controller having a pressure connection outside of the enclosure and a pressure connection inside of the enclosure so as to respond to the difference in air pressure inside of the enclosure and the air pressure outside of the enclosure, means controlled by the differential pressure responsive controller for variably controlling the mechanism to regulate variably the supply of conditioned air to the enclosure to maintain an enclosure air pressure which is greater by a substantially constant amount than the outside air pressure whereby infiltration of outside air is prevented, means

operative upon the occurrence of fire in the enclosure for interrupting the supply of power to the mechanism to interrupt the supply of conditioned air to the enclosure, and means controlled by the differential pressure responsive controller for also interrupting the supply of power to the mechanism to interrupt the supply of conditioned air to the enclosure if the differential in pressure between the enclosure air pressure and the outside air pressure decreases to a predetermined value.

7. In an air conditioning system for an enclosure, the combination of, means for supplying conditioned air under pressure to the enclosure, mechanism for regulating the supply of conditioned air to the enclosure, a differential pressure responsive controller responsive to the difference in air pressure inside of the enclosure and the air pressure outside of the enclosure for controlling said mechanism to maintain an enclosure pressure which is greater by a substantially constant amount than the outside pressure to prevent infiltration of outside air, and means operative upon the occurrence of fire in the enclosure for also controlling said mechanism to interrupt the supply of conditioned air to the enclosure.

LE ROY H. PLUM.