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AIR DAMPER CONTROL FOR HEATING AND COOLING SYSTEMS

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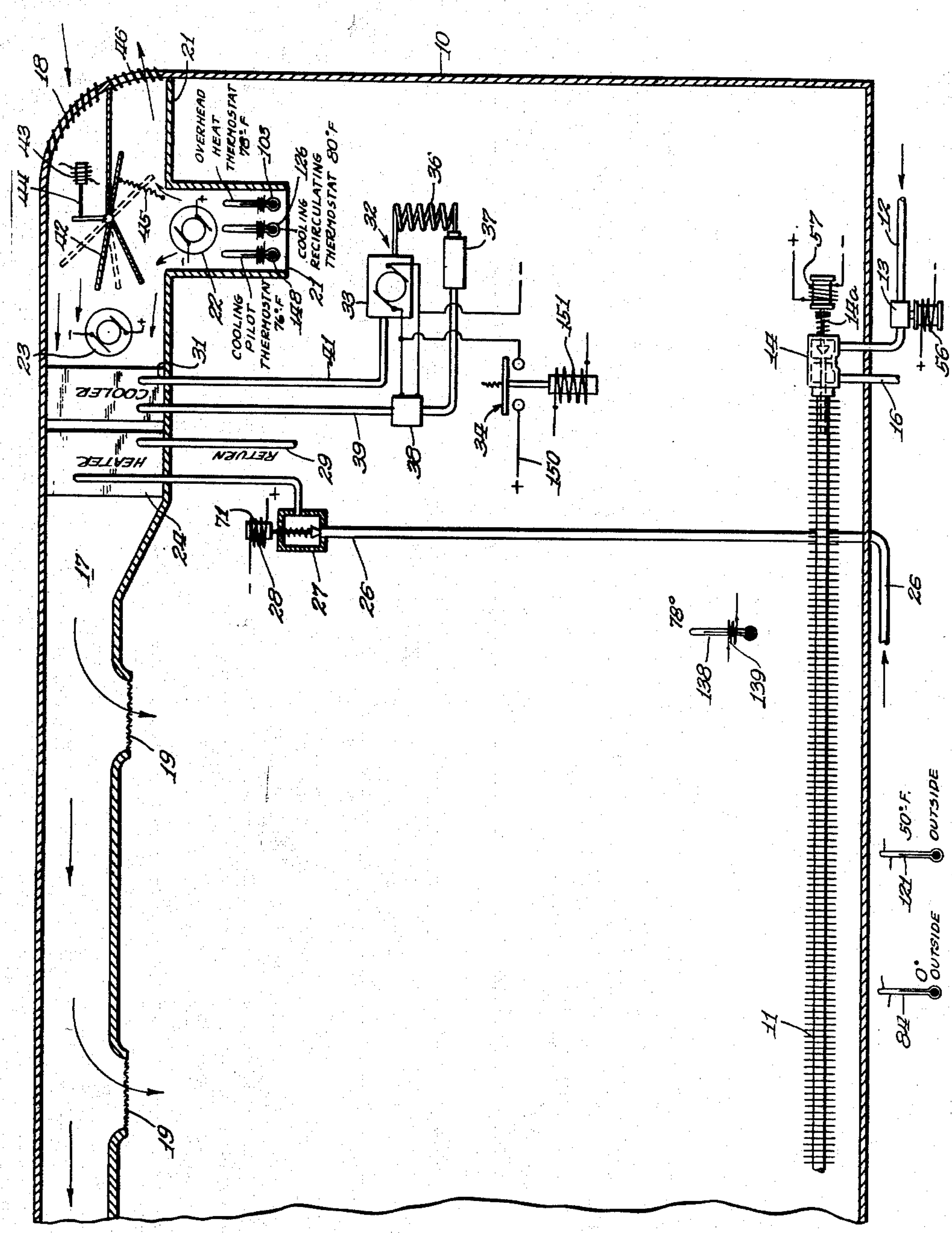

Fig. 1.

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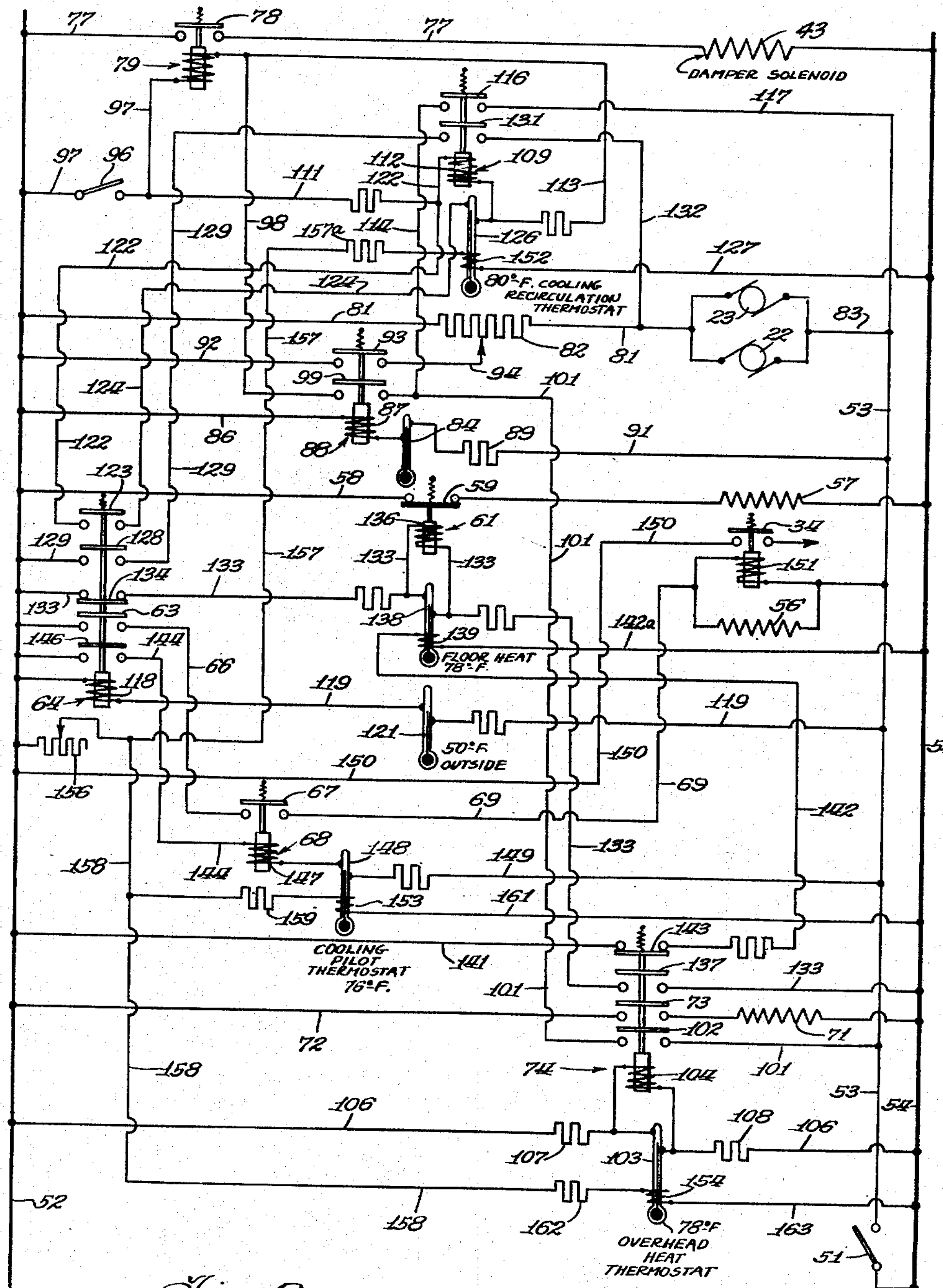

Fig. 2.

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AIR DAMPER CONTROL FOR HEATING AND COOLING SYSTEMS

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2 Claims. (Cl. 257—3)

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This invention relates generally to improvements in air conditioning systems and relates particularly to a control system in which air dampers are controlled to provide maximum fresh air for all conditions of ambient temperature.

In systems for controlling the temperature of enclosures it is desirable at all times to introduce as much fresh air into the enclosed space as is consistent with maintaining the loads on the heating and cooling apparatus at a minimum. Thus at times when the outside temperature is very low, for example, below 0° F., it is desirable to introduce 25 percent of fresh air into the space while recirculating 75 percent of the air therein so that the demand on the heating system is not too great. Likewise, when the outside temperature is greater than 80° F. it is also desirable to maintain like proportions of fresh and recirculated air, in order that the demand on the cooling system is not too great.

A principal object of the invention is to introduce a maximum amount of fresh air into the enclosed space between two extremes of ambient temperature and to recirculate a maximum amount of air within the enclosed space when such recirculation of air is required to relieve the heating load or the cooling load imposed on the system.

A second object comprehends the provision of floor and overhead heating when the temperature of the enclosure is below a certain intermediate value and the provision of overhead heating only when the temperature of the enclosure is above a certain intermediate value and below a certain maximum value.

Still another object is to provide for suitably tempering (heating and/or cooling) the air within the space when the temperature of the space reached certain predetermined values.

Another object is to provide blower and exhaust fans which are operable at different speeds according to the inside temperature requirements in relation to the outside temperature, and/or inside maximum temperature.

The invention is illustrated in certain preferred embodiments, in the accompanying drawings wherein:

Fig. 1 is a schematic longitudinal cross section taken through a railway car having the present invention embodied therein; and

Fig. 2 is a circuit diagram showing the electrical circuits controlling the apparatus of Fig. 1.

Referring to Fig. 1 of the drawings, a railway vehicle 10 is indicated schematically in longitudinal cross section, to which the heating and air conditioning system according to the present invention is applied. It should be understood, however, that the invention is not confined to a railway car, but is equally applicable to any enclosed space.

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The car 10 is supplied with heat by means of a floor radiator 11 which is supplied with heating medium, such as steam, from a main supply line 12, the supply of steam to the floor radiator 11 being under the control of a solenoid operated flow valve 13 and an additional solenoid operated admission valve 14, the condensate leaving the floor radiator 11 by means of outlet pipe 16.

The car 10 is provided with an overhead duct 17 which has an entrance opening 18 thereto for a supply of fresh air. The duct 17 is also provided with a plurality of outlets 19 whereby heated and/or cooled air is supplied to the interior of the car. The duct 17 is also formed with a return duct 21. In order to insure circulation of air through the car 10, an exhaust fan 22 is provided in the return duct 21, the duct 17 being additionally provided with a blower 23 for circulating both fresh and recirculated air.

The duct 17 also has situated therein an overhead air heater 24 which is supplied with steam from a supply line 26, the supply of steam to this heater being under the control of a solenoid operated flow valve 27 and a solenoid operated valve 28, the condensate discharging through pipe 29.

Under certain condition of operation, and also when the temperature outside the car rises above a certain value, the air supplied to the car 10 by the duct 17 is cooled. This is accomplished by means of a cooler 31 which is supplied with coolant or refrigerant by a mechanically operated refrigerator system 32 including a motor-compressor unit 33, under the control of a solenoid operated switch 34, a condenser 36 and coolant reservoir 37. The supply of coolant to the cooler 31 is also under the control of an electrically operated valve 38. This valve is positioned in a supply line 39, the spent coolant being returned to the compressor unit 33 by a suction pipe 41.

Under certain conditions of operation, as will be described in more detail, the car 10 is provided with 90 percent of fresh air, supplied to the car at the opening 18, and 10 percent of recirculated air from the interior of the car, the amount of fresh air and the amount of the recirculated air being under the control of a damper valve 42 which is actuated by an electrically energized device, for example a solenoid 43 and linkage 44. As shown in Fig. 1, the damper 42 is positioned whereby 90 percent of fresh air is supplied to the car and 10 percent of the air within the car is re-circulated, 90 percent of the air from within the car being vented to the outside atmosphere through an exit port 46. Under other conditions of operation, 75 percent of the air within the car 10 will be recirculated, and 25 percent of fresh air will be brought in from the outside of the car, the damper valve 42 under such conditions of operation taking the position as shown in the dotted line in Fig. 1.

Referring now to Fig. 2 of the drawings, means are provided for maintaining the damper 42 in the dotted line position as shown in Fig. 1, whereby to introduce 25 percent of fresh air into the car and to re-circulate 75 percent of the air, and to provide both overhead heat by means of the overhead heater 24, and floor heat by means of the floor radiators 11 when the temperature outside of the car 10 is below 0° F.

The circuits shown in Fig. 2 are under the control of a switch 51 which closes circuits including a positive line 52, a negative 53, and a main negative line 54, the latter of which is provided for circuits which are closed irrespective to the condition of the switch 51.

Assuming that the outside temperature is below 0° F. and the temperature in the return duct is below 78° F., heat at the floor of the car will be supplied by the floor radiators 11, the damper 42 will be in the dotted line position shown in Fig. 1 to give 75 percent of re-circulated air and 25 percent of fresh air, and the blower 23 and the exhaust fan 22 will operate at slow speed. The overhead heater will also supply heat to be circulated through the duct 17 and past the overhead openings 19. Under this condition of operation a winding 56 of the floor heat flow valve 13 is deenergized, the winding 56 being in parallel with the solenoid of relay 34 of the compressor 33 and remaining deenergized with the valve 13 open until the outside temperature rises to 50° at thermostat 121 and the temperature in the return duct rises to 76° F. At this time the valve 13 will close, thus shutting off the flow of steam to the admission valve 14 of the floor radiator.

The floor radiator admission valve 14 is normally held open by a spring 14*a*. Consequently the valve is held open to supply steam to the floor radiators 11 as long as the outside temperature remains below 50° F. and the temperature within the car is less than 78° F. However, when the temperature within the car reaches 78° F., the energizing circuit for relay 61 is by-passed around solenoid 136 and thereby permits relay contact 59 to close an energizing circuit through floor heat solenoid 57 to close valve 14.

The steam is supplied under pressure through the supply pipe 26 to the normally closed overhead heat valve 28. The condensate leaving the overhead heater 24 is discharged through pipe 29. The overhead heat valve 28 has a winding 71 which is normally deenergized. The winding 71 interposed is in a closed circuit which includes the bus 52, a conductor 72 and a closed contactor 73 of a relay 74 which is adapted to be energized when the temperature in the return duct 21 is below a certain value, which in the embodiment shown is 78° F.

When the outside temperature is below 0° F. the damper valve 42 is in the dotted line position shown in Fig. 1 to provide for 75 percent of re-circulated air and the admission into the car 10 of 25 percent of fresh air. Under this condition of operation, the solenoid 43 is de-energized, the winding thereof being in an open circuit which includes the positive line 52, a conductor 77, an open contactor 78 of a relay 79 interposed in circuit with the conductor 77, and the main negative line 54.

Under conditions when the outside temperature is below 0° F., the blower 23 and the exhaust fan 22 are operated at low speed. Under this condition the blower 23 and the exhaust fan 22 are in a closed circuit leading from positive line 52 through conductor 81, an adjustable resistor 82 connected therein and a conductor 83 to the negative bus 53.

The circuits thus far described are effective when the outside temperature is below 0° F. The system, according to the present invention, includes both floor heat and overhead heat, both of which are effective during the normal heating cycle. The floor radiators are made ineffective when the outside temperature rises above 50° F. At this time and throughout any additional rise in temperature, cooling is made available within the car 10 by the energization of master relay 64, provided that the interior temperature is such as to require cooling. If no cooling is required within the car 10 the overhead heating system will continue to operate to maintain the proper temperature without the need for heat to be supplied by the floor radiators 11.

The circuits for controlling the heating and air conditioning system according to the present invention include a holding or "stick" circuit which responds to certain conditions in order to be made effective. The first of these conditions is that the outside temperature is above 0° F. and the second condition is that the return duct temperature must be below 78° F. When the outside temperature stands between 0° F. and less than 50° F., and that the temperature in the return duct 21 is below 78° F., the following conditions will prevail. The first of these conditions is that the damper valve 42 will move to the full line position as shown in Fig. 1 to provide 90 percent of fresh air and 10 percent of re-circulated air. The second of these conditions is that the exhaust fan 22 and the blower 23 operate at intermediate speed.

Under the conditions just mentioned, a circuit is closed by a thermostat 84 which functions when the outside temperature rises above 0° F. This circuit includes positive line 52, a conductor 86, the winding 87 of a relay 88, and thence through a resistor 89 and a conductor 91 to the negative bus line 53. The energizing of the relay 88 closes a circuit which includes the positive line 52, a conductor 92, a contactor 93 of the relay 88 and a conductor 94 which taps the mid-point of the variable resistor 82 thereby increasing the operation of the blowers 23 and the exhaust fan 22 to an intermediate speed, and thence through the blower 23 and the exhaust fan 22 through a conductor 83 to the negative bus 53. It will be observed that the blower 23 and the exhaust fan 22 are connected in parallel so that both will operate at the same speed.

An additional circuit is closed upon energization of the relay 88, said circuit including the positive line 52, a normally closed switch 96 in a conductor 97, the winding of the relay 79, a conductor 98, contactor 99 of the relay 88, a conductor 101 and thence through a contactor 102 of the relay 74 which is maintained energized so long as the thermostat 103 in the return duct 21.

see also Fig. 1, is below 78° F. As long as the temperature in the return duct 21 is below 78° F., a circuit is made through a winding 104 of the relay 74, a conductor 106, and resistors 107 and 108 with which the winding 104 is in circuit. The closing of the relay 79 energizes the winding 76 of the solenoid actuator 43, thus moving the damper valve 42 to the full line position shown in Fig. 1, the damper valve 42 then being in position to admit 90 percent of fresh air and to recirculate 10 percent of the air within the car 10.

Energization of the relays 88 and 74 controls a "stick" circuit for energizing a relay 109. When the relays 88 and 74 are thus energized, under the conditions as described above, the "stick" circuit thus made includes a conductor 111 branching from the conductor 97, a winding 112 of the relay 109, thence through a conductor 113 which is connected to the lead 98, the circuit then being completed through the contactor 99 of the relay 88, the line 101 and the contactor 102 of the relay 74. The energization of the relay 109 closes another "stick" circuit which includes conductor 114 branching from the lead 101, thence through the closed contactor 116 of the relay 109 to the negative bus 53 through a conductor 117.

From the foregoing description it will be apparent that when the temperature outside the car is between 0° F. and 50° F. the system will operate to give 90 percent of fresh air, the air so supplied by the blower 23 and the exhaust fan 22 operating at intermediate speed, at the same time both floor heat and overhead duct heating being supplied with steam through the flow valves 13 and 27 and the floor radiator admission valve 14 and the overhead heat valve 28 as before; the circuits for maintaining conditions of the valves 13, 14, 27, and 28 remaining the same as though the outside temperature were at 0° F. or less.

Under the condition when the ambient outside the car 10 is greater than 50° F. the system is so arranged that the heating vapor supplied to the floor radiator 11 is cut off by the floor valve 14, heat being supplied to the interior of the car 10 through the overhead heater 24 under the control of the overhead heater valve 28, provided that the return duct temperature remains less than 80° F. Under this condition of operation, when the outside temperature is greater than 50° F., the blower 23 and the exhaust fan 22 will operate at full speed, the resistor 82 being shunted out of circuit with the blower 23 and the fan 22.

When the outside temperature reaches 50° F., a winding 118 of the master relay 64 will be energized, the circuit leading from the positive line 52 through the coil 118, and a conductor 119 including an outside thermostat 121 which closes when the outside temperature rises to 50° F. When the relay 64 is thus energized, an additional circuit is made for subsequent deenergization of the relay 109 when the return duct 21 attains a temperature of 80° F. This additional circuit includes a lead 122 branching from the lead 111, thence through a closed contactor 123 of the relay 64, a conductor 124 which leads to a re-circulating cooling thermostat 126 positioned in the return duct 21, and a conductor 127 to the main negative line 54.

The energization of the relay 64, which takes place when the outside temperature rises to 50° F., also causes the blower 23 and the exhaust fan 22 to operate as full speed, at full supply potential across the supply line 52, 53. When the relay

64 is energized, a circuit is made leading from positive line 52 through a closed contactor 128 of the relay 64, a conductor 129, a closed contactor 131 of the relay 109, a conductor 132 joining the conductor 81 and thence through the blowers 23 and the exhaust fan 22 and the conductor 83 to the negative bus line 53.

As long as the temperature of the return duct 21 is below 78° F. the relay 74 remains energized, the coil 104 of the relay being in circuit with the conductor 106 across the supply line 52, 54. The relay 64 controls the operation of the floor heat relay 61 and through it controls the floor heat valve 14. When the outside temperature reaches 50° F. the relay 64 is energized which condition opens contact 134 thereof and deenergizes the relay 61, the circuit for the relay 61 including positive line 52, conductor 133, contactor 134 (now open because the relay 64 is energized), winding 136 of the relay 61 and closed contactor 137 of the relay 74, the latter of which remains energized while the return duct is below 78° F. When the relay 61 is thus de-energized, the winding 57 of the floor heat valve 14 will be energized and the valve 14 will close thus cutting off the supply of steam to the radiators 11.

When the outside temperature moves below 50° F. and the temperature of the return duct 21 is less than 78° F., the circuit for energizing relay 61 is closed through de-energized closed contact 134 of relay 64 and energized closed contact 137 of relay 74. Under such conditions the temperature at the floor thermostat 138 will be below 78° F. Consequently the relay 61 will be energized open and the floor heat valve will remain open under the influence of spring 14*a*, but when the temperature within the car again reaches 78° F .while the outside temperature remains below 50° F., the supply of electric current to coil 136 of relay 61 will be cut off by the opening of contact 137 of relay 74 and thereby result in closing relay 61 to energize floor heat valve 14 closed. The floor heat thermostat 138 is provided with an auxiliary heater 139 which is energized and in a circuit including conductors 141, 142, 142*a* and contactor 143 of the relay 74. Thus, when the return duct thermostat 103 controlling the overhead heat is calling for heat, the relay 74 will be energized and the contactor 143 will be opened. Auxiliary heat will be removed from the floor heat thermostat 138, but as soon as said return duct thermostat 103 is satisfied the contactor 143 will close and the thermostat 138 will receive sufficient auxiliary heat to cause it to close and thereby short out the coil 136 of the relay thus re-energizing the winding 57 to close the floor heat valve 14. The amount of electrical heat applied to the floor heat thermostat is such as to cause it to function when the overhead heat thermostat 103 is satisfied. Consequently the floor heat radiators are effective only when the floor heat thermostat calls for heat when steam is being supplied to overhead heater 24. If, for any reason, the floor thermostat 138 is closed while the overhead heat thermostat is calling for heat, the relay 61 will be de-energized closed by the functioning of thermostat 138 and the radiator valve 14 will be energized closed to shut off the floor heat.

However, floor heat will not be supplied to the radiators 11 since the flow of steam to the floor radiators 11 is also under the control of the flow valve 13 which is closed when its coil 56 is energized. The temperature in the return duct 21 is adapted to control the flow valve 13 and to energize the coil 56 to close said valve. When the temperature in the return duct 21 reaches 76° F. and the ambient is above 50° F. a circuit is made which includes a conductor 144, contactors 146, a coil 147 of the relay 68, a cooling pilot thermostat 148 and a lead 149 to the negative bus 53. The energization of the relay 68 closes the circuit through the contactor 63 of the relay 64, the contactor 67 of the relay 68, the lead 69 and the coil 56 of the flow valve 13, thus closing the valve 13. A parallel circuit is made at this time through a coil 151 of the solenoid operated switch 34 thus supplying current to the motor-compressor unit 33 through a conductor 150, see Fig. 1. The motor-compressor unit 33 is provided with an electrically operated valve 32 which controls the supply of refrigerant to the evaporator 31.

The overhead heat thermostat 103, the cooling re-circulation control thermostat 126 and the cooling pilot thermostat 148 are respectively provided with auxiliary heaters 152, 153 and 154 which have a maxium variation of 6° F. and are adjustable by a variable resistor 156. Auxiliary heater 152 is in a circuit which comprise adjustable resistor 156, a conductor 157, a resistor 157*a* and the conductor 127. Auxiliary heater 153 is in a circuit which includes the adjustable resistor 156, a conductor 158, a resistor 159, and a lead 161. The auxiliary heater 154 is in a circuit including the adjustable resistor 156, lead 158, a resistor 162, and a lead 163.

It will be seen from the foregoing that there is a range of temperatures within the car 10 during which range both overhead heat and cooling will be had. This range of temperatures in the return duct 21 is from 76° F. to 78° F. As explained, the relay 68 will be energized when the temperature in the return duct 21 reaches 76° F. to start the compressor 33, the cooling pilot thermostat 148 controlling the relay 68. The relay 74 is deenergized when the temperature in the return duct 21 reaches 78° F., the thermostat 103 shorting out the coil 104. When the temperature in the return duct 21 reaches 78° F. the circuit for energizing the relay 79 is opened and the solenoid 76 is deenergized, thus moving the damper 42 to the dotted line position seen in Fig. 1 to provide for 75 percent of re-circulated air and 25 percent of fresh air. When the temperature in the return duct reaches 78° F. overhead heat from the overhead heater 24 is cut off, since the deenergization of the relay 74 will open the contactor 73 and deenergize the winding 71 of the valve 28. At this time the air moving past the evaporator 31 will cool the car 10.

When the temperature in the return duct 21 and the car 10 reaches 80° F. both relays 109 and 79 will be deenergized, the cooling re-circulating control thermostat 126 shorting out the winding 112 of the relay 109 to reduce the operating speed of the fan 22 and blower 23 and also shorting out the winding of relay 79 so as to deenergize the damper solenoid 43 and thereby permit the damper 42 to assume the dotted line position in Fig. 1. The short circuit so made leads from positive line 52 through conductor 97, closed switch 96, conductor 111, conductor 122, closed contactor 123, conductor 124, the cooling re-circulation thermostat 126, conductors 113 and 98 through closed contact 99 of relay 88, and thence through conductor 101 and closed contact 102 of relay 74 to the negative bus 53. The deenergization of the relay 109 opens the contactor 131, which when closed shorts out the resistor 82 controlling the speed of the blowers 23 and the exhaust fan 22. When the contactor 131 is open the fan 22 and the blower 23 will operate at intermediate speed, only a portion of the resistor 82 being in circuit with the fan and blowers, the circuit thereto then including the conductor 92, closed contactor 93, lead 94, part of the resistor 82 and conductors 81 and 83. The deenergization of relay 79 opens contact 78 and therefore deenergizes the solenoid 43, whereby the damper is moved by spring 45 to the dotted line position of Fig. 1 for delivery of 75 percent of re-circulated air and 25 percent of fresh air through the cooler 31.

It will be thus seen that a novel and useful form of a combined heating and air cooling system has been provided which is sensitive in its operation to wide changes in outside temperature, and which will control the temperature within the space within narrow limits. The system according to the present invention is characterized by the provision of a maximum amount of fresh air when the outside temperature, within the space within narrow limits. without placing too severe a load on the heating and cooling portions of the system. The system according to the present invention is also characterized by the provision of a damper controlling the amount of fresh air to be introduced into the space when the heating and/or cooling loads are such as to require the recirculation of the previously treated air.

While the invention has been described in accordance with a preferred embodiment, its scope is not intended to be limited in terms of the embodiment shown nor otherwise than by the terms of the appended claims.

We claim:

1. A system for supplying tempered air to an enclosed space to maintain a desired temperature therein, comprising, in combination, an electrically operated blower communicating with the enclosed space and with the outside atmosphere for delivering a stream of air into said enclosed space, an electrically operated exhaust fan connected in parallel with said blower and operable to withdraw air from the enclosed space and discharging the same into the outside atmosphere, means for altering the temperature of the air stream delivered by said blower, a damper operable to vary the proportions of external air and recirculated air delivered into the enclosed space and electrical means for actuating said damper, means including a thermostat responsive to the temperature of the enclosed space and a relay control thereby for increasing and decreasing the effectiveness of said temperature altering means, means including a second thermostat responsive to a predetermined outside temperature and a relay control thereby for varying the operating speeds for said blower and said exhaust fan, a relay controllable by the last mentioned relay and adapted to control the energization of said damper actuating means, whereby the said damper may be altered to reduce the temperature altering load on the system by varying the proportion of recirculated air and fresh air in relation to the temperature requirements of the enclosed space, a master relay, a third thermostat responsive to a predetermined higher outside temperature for controlling the master relay, and a relay cooperating with a closed contact of said master relay for closing an energizing circuit to further alter the operating speeds of said blower and said fan.

2. A system for supplying tempered air to an enclosed space according to claim 1 characterized in that a fourth thermostat is provided for controlling the last mentioned relay effective to alter the operating speeds of said blower and fan, the said fourth thermostat being set to function at a predetermined inside temperature to open the last mentioned energizing circuit through said blower and said fan.

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