March 19, 1940. F. L. MURPHY ET AL 2,193,835

AIR CONDITIONING SYSTEM

Filed April 18, 1936 9 Sheets-Sheet 1

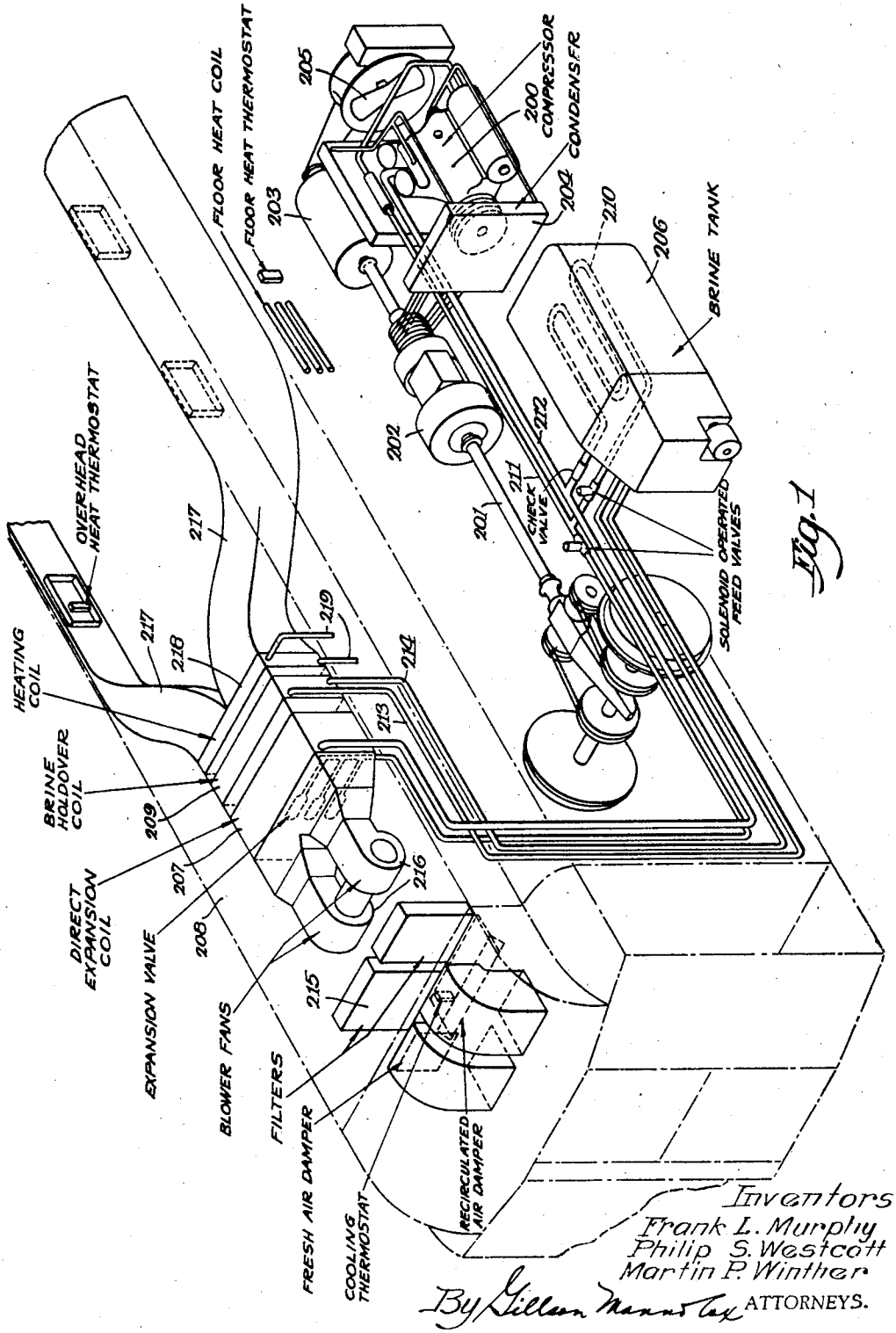


Fig. 1

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AIR CONDITIONING SYSTEM

Filed April 18, 1936 9 Sheets-Sheet 2

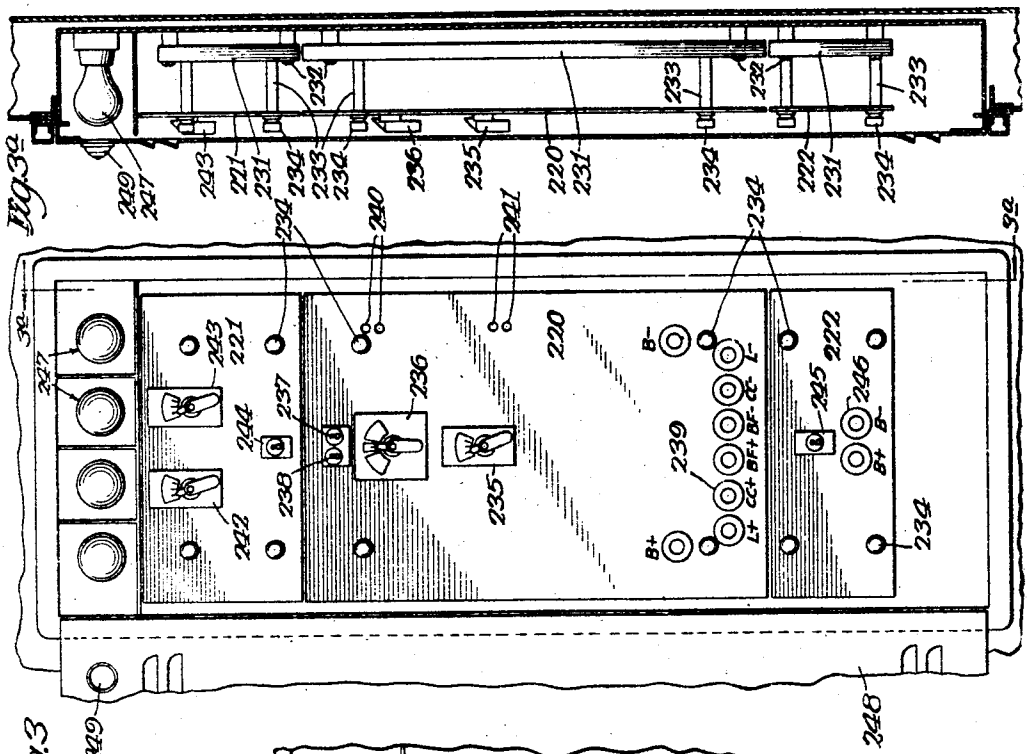


Fig. 3

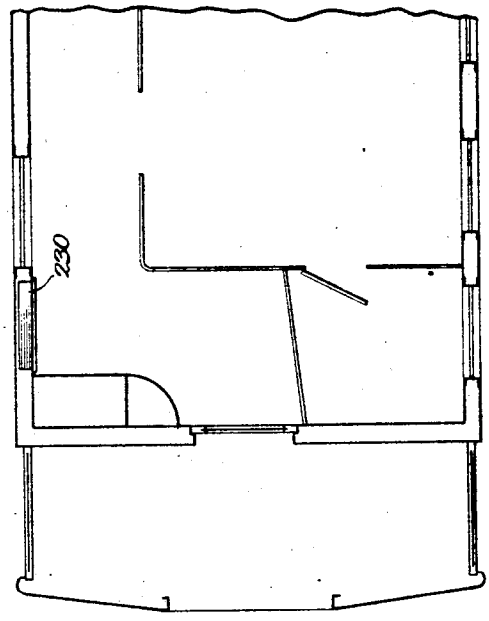


Fig. 2

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March 19, 1940. F. L. MURPHY ET AL 2,193,835

AIR CONDITIONING SYSTEM

Filed April 18, 1936 9 Sheets-Sheet 3

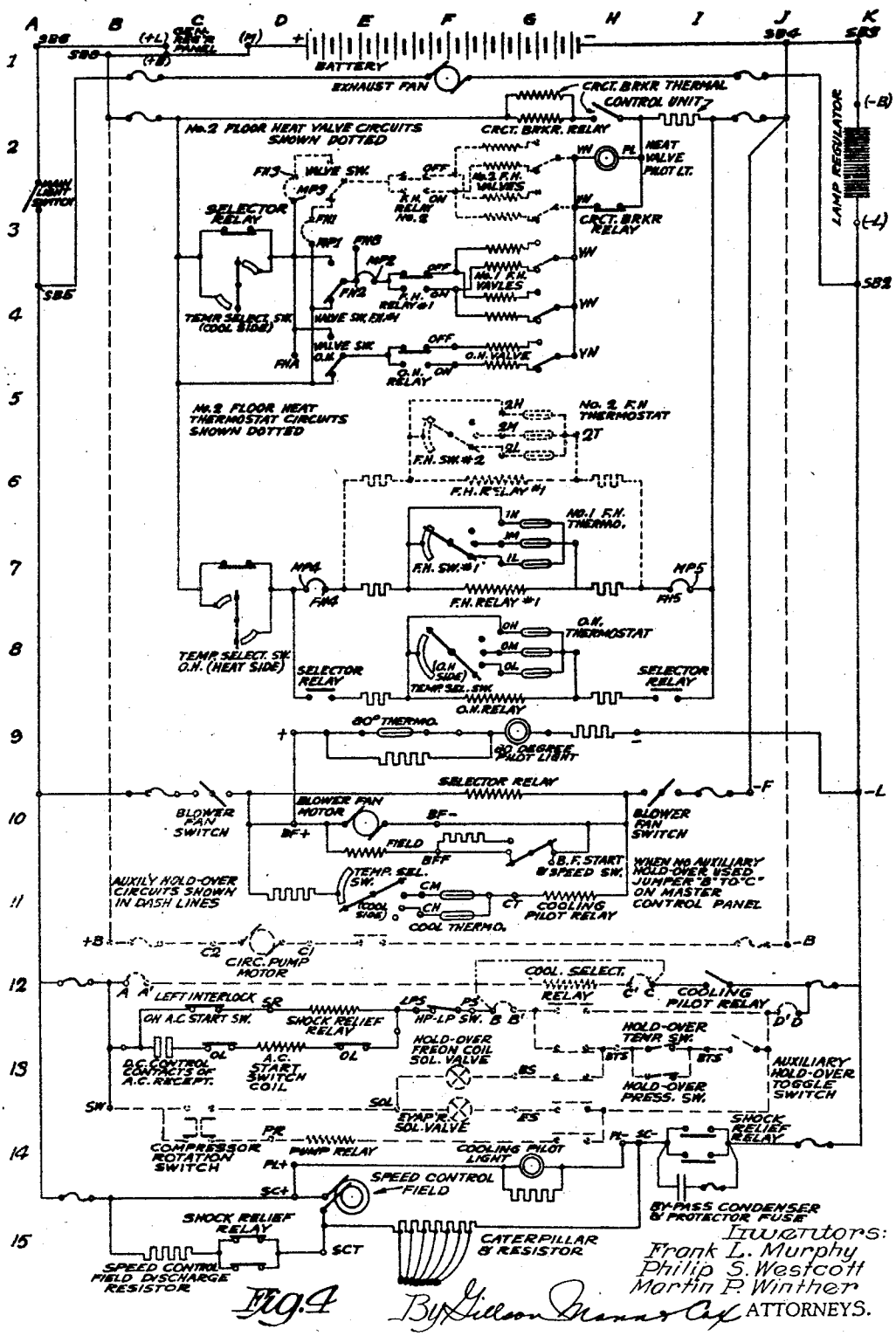


Fig. 4

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March 19, 1940. F. L. MURPHY ET AL 2,193,835

AIR CONDITIONING SYSTEM

Filed April 18, 1936 9 Sheets-Sheet 4

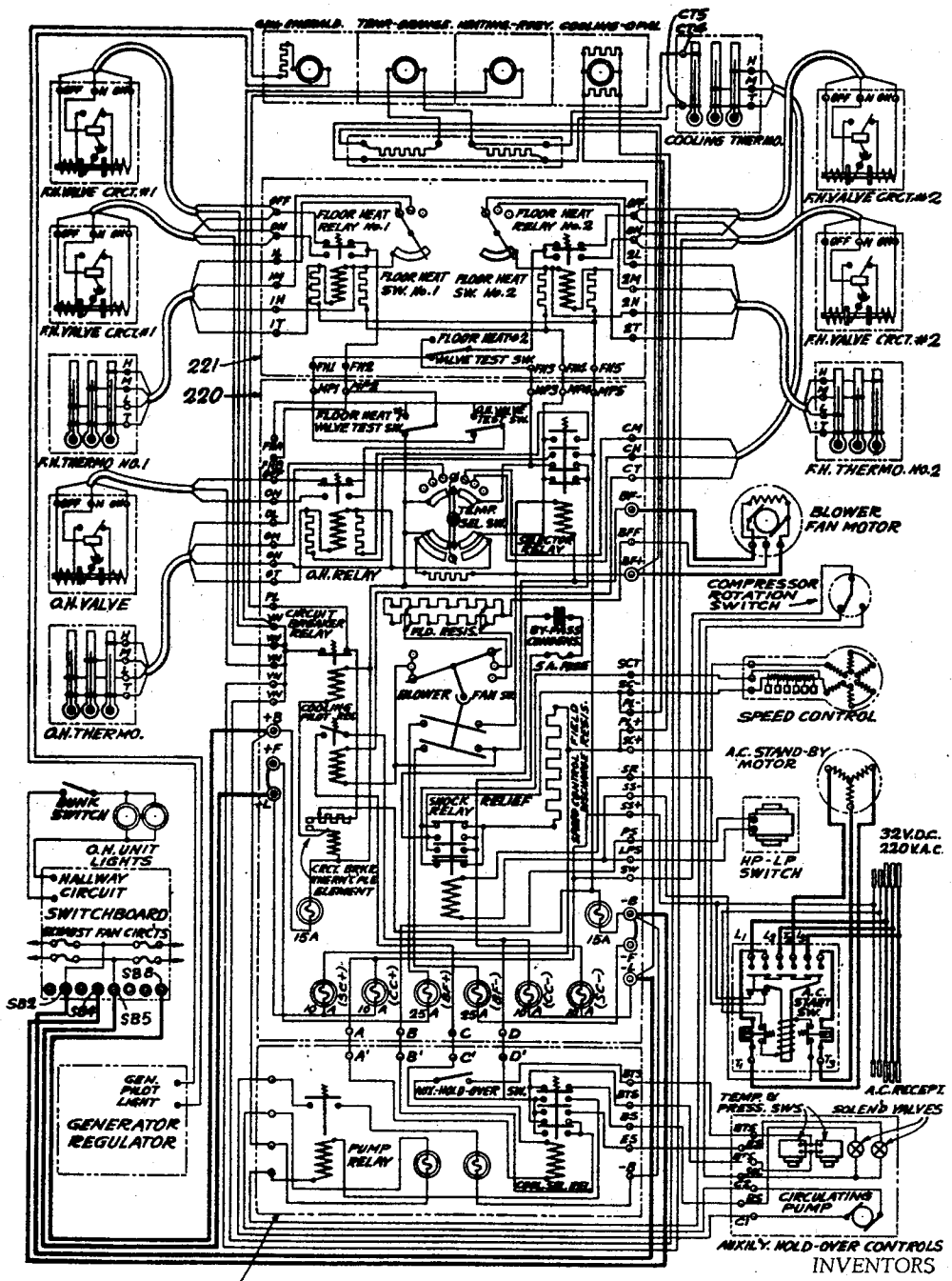


Fig. 5

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March 19, 1940. F. L. MURPHY ET AL 2,193,835

AIR CONDITIONING SYSTEM

Filed April 18, 1936 9 Sheets-Sheet 5

CONTROL PANEL CIRCUITS - CAR COOLING FROM OVERHEAD EVAPORATOR

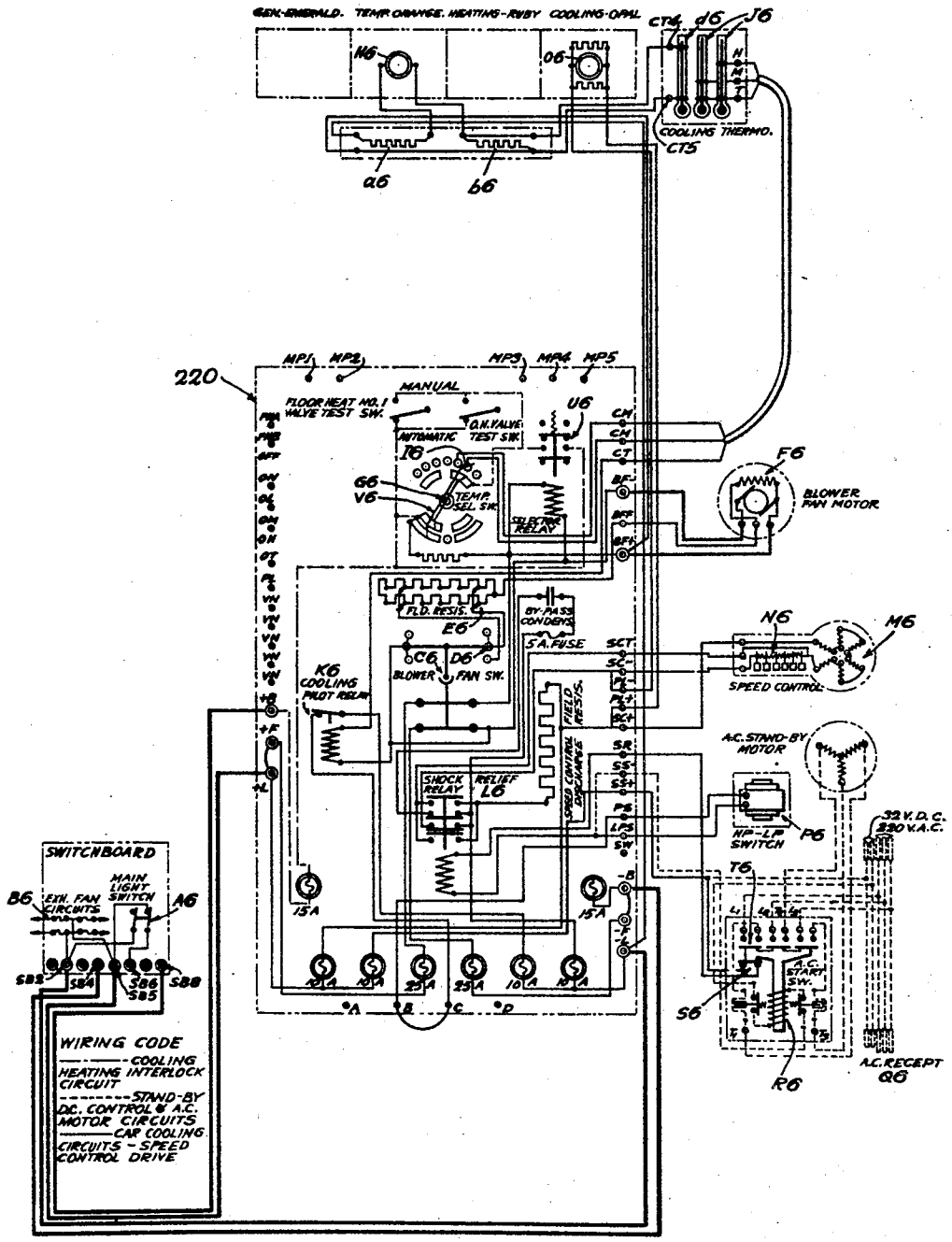


Fig. 6

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March 19, 1940. F. L. MURPHY ET AL 2,193,835

AIR CONDITIONING SYSTEM

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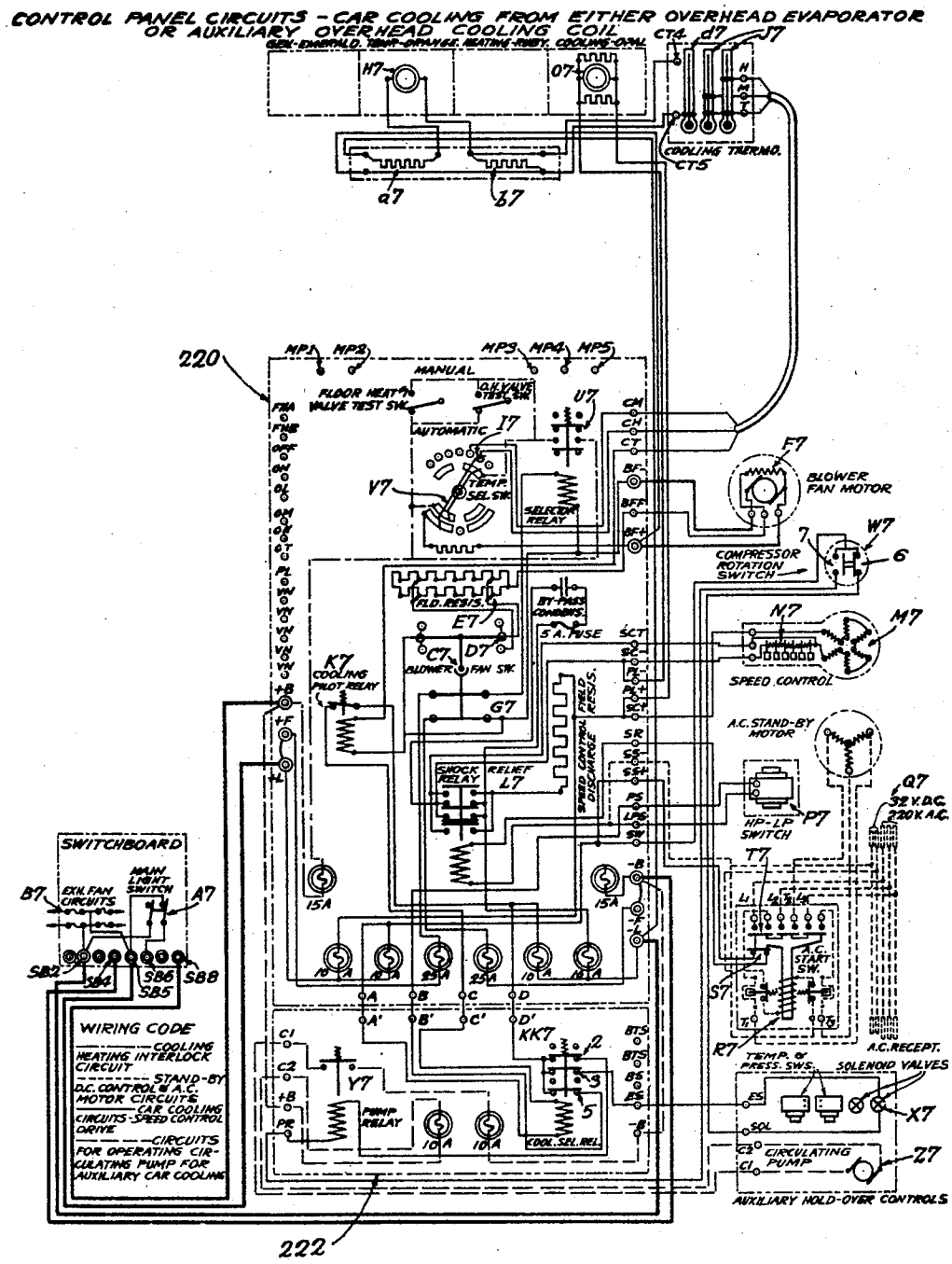


Fig. 7

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AIR CONDITIONING SYSTEM

Filed April 18, 1936 9 Sheets-Sheet 7

CONTROL PANEL CIRCUITS - HOLD-OVER TANK COOLING

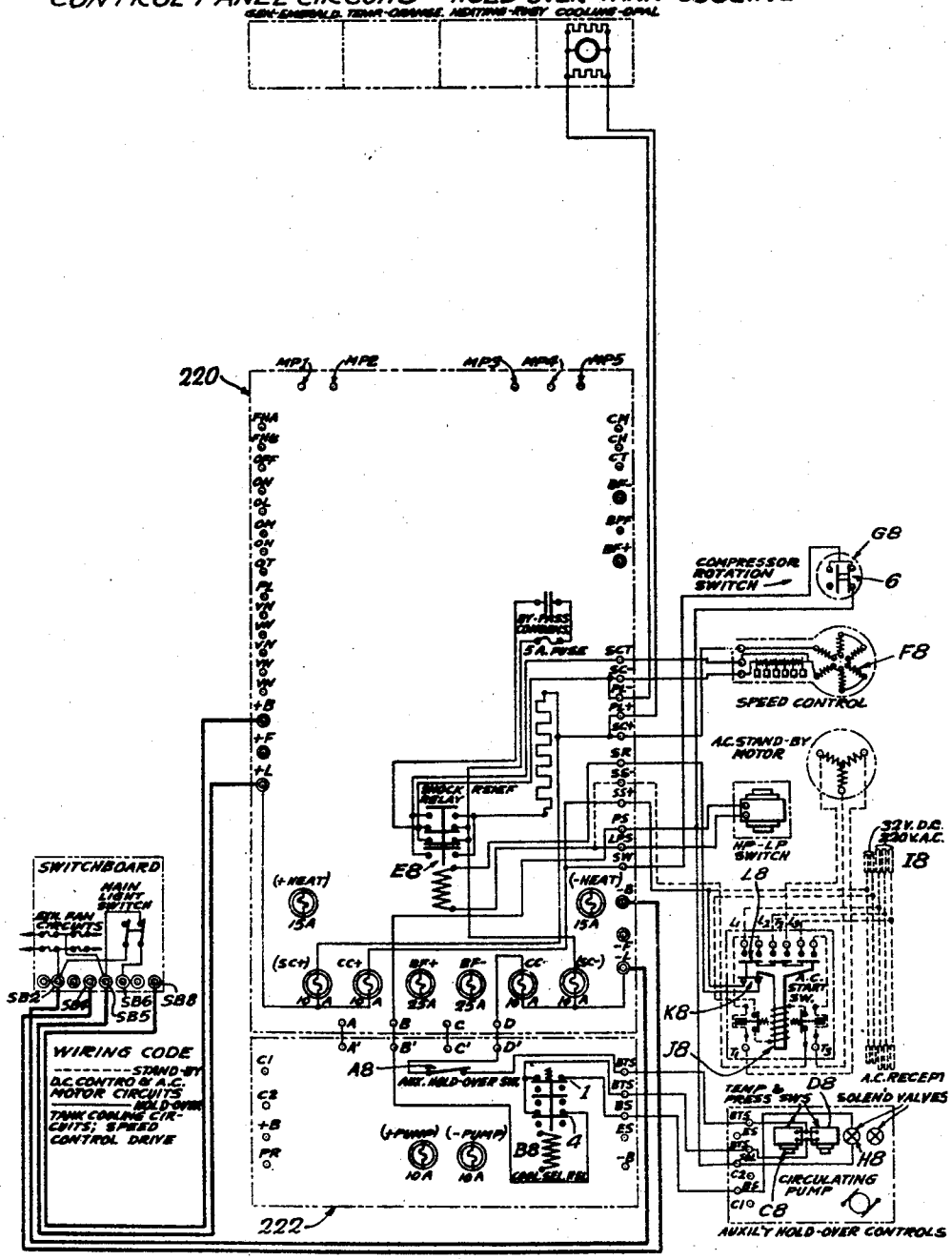


Fig. 8

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AIR CONDITIONING SYSTEM

Filed April 18, 1936 9 Sheets-Sheet 8

CONTROL PANEL CIRCUITS - CAR HEAT FROM OVERHEAD HEAT COIL

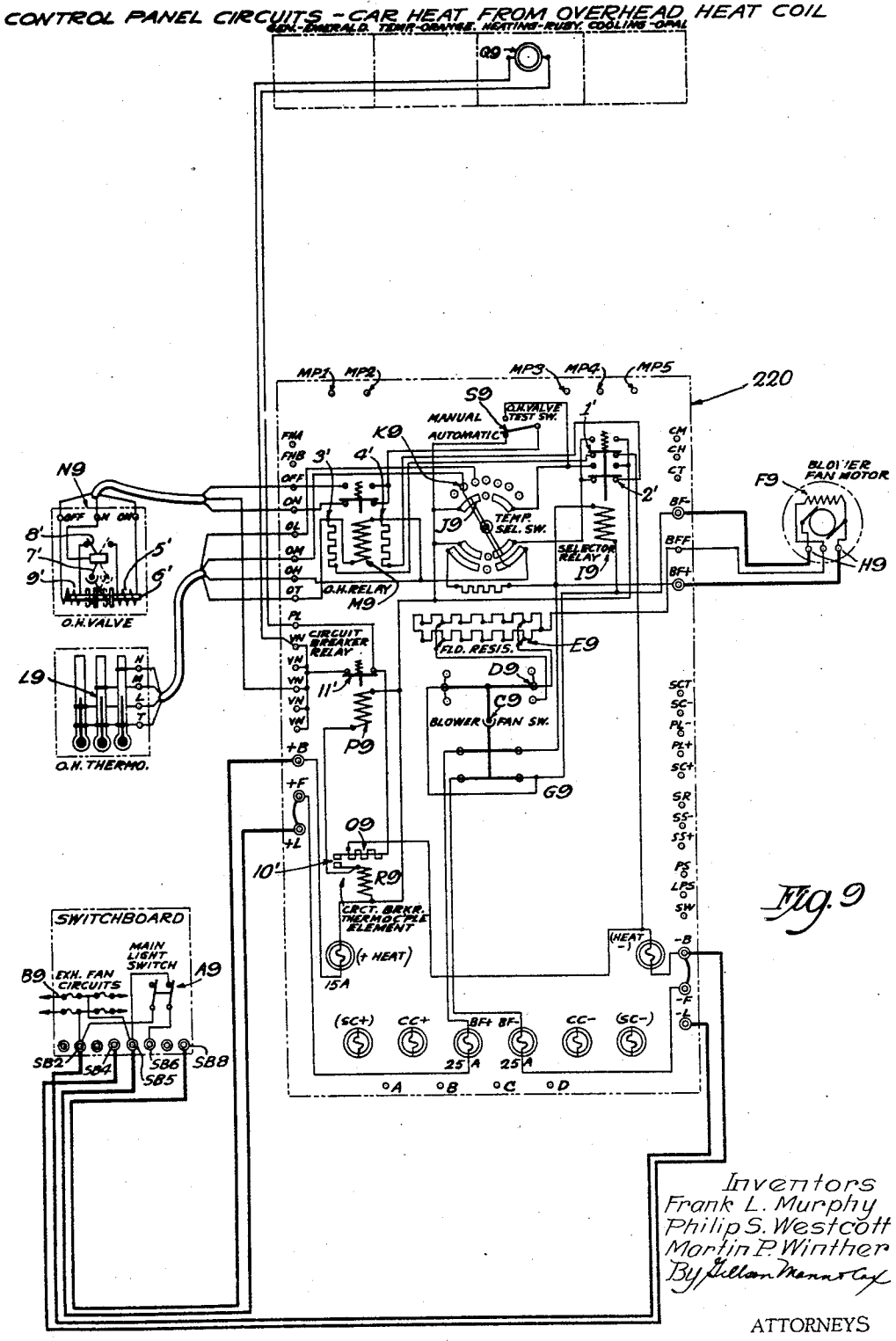


Fig. 9

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AIR CONDITIONING SYSTEM

Filed April 18, 1936 9 Sheets-Sheet 9

CONTROL PANEL CIRCUITS - CAR HEATING FROM FLOOR HEAT COILS

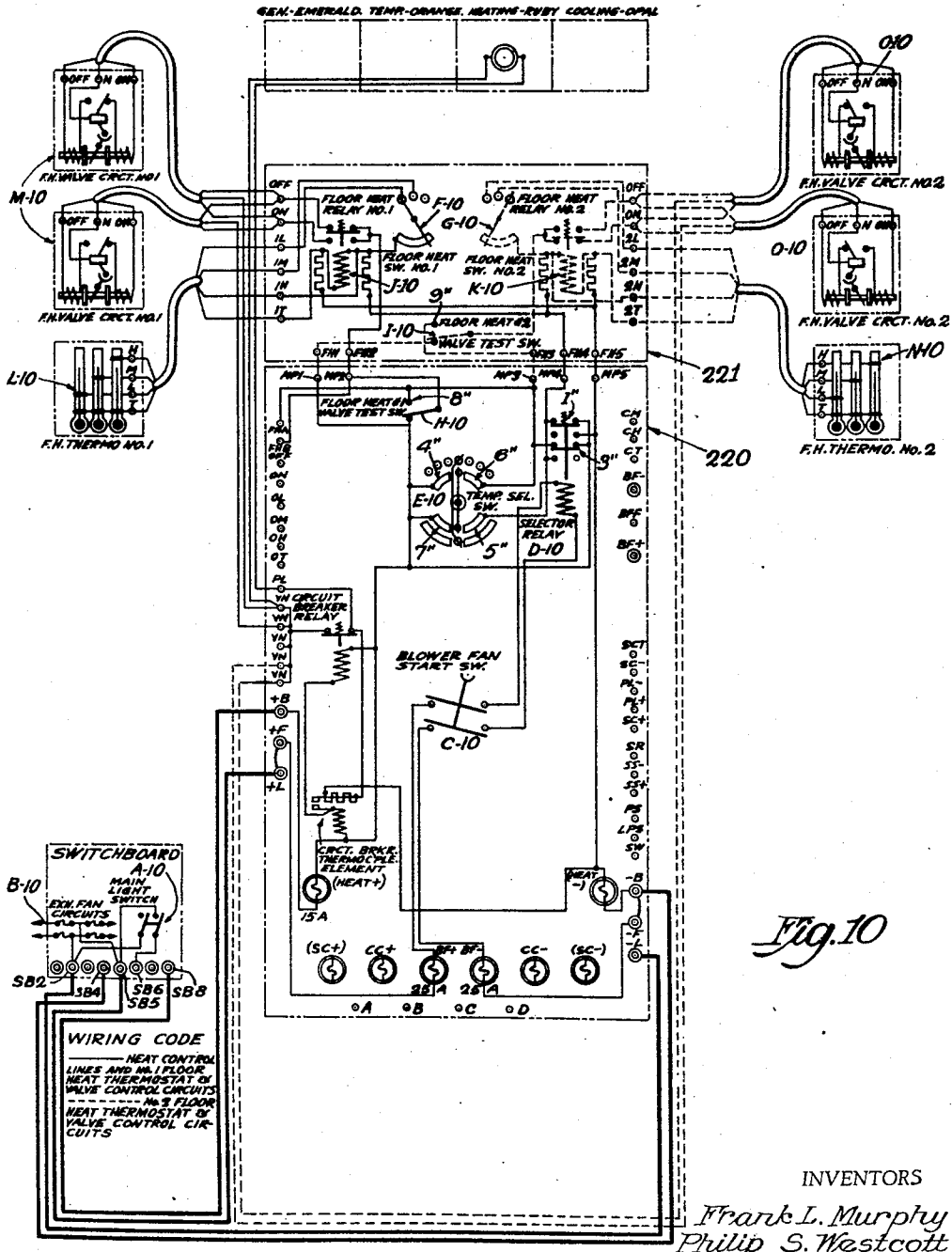


Fig. 10

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Patented Mar. 19, 1940 2,193,835

UNITED STATES PATENT OFFICE

2,193,835

AIR CONDITIONING SYSTEM

Frank L. Murphy, Chicago, Philip S. Westcott, Oak Park, and Martin P. Winther, Waukegan, Ill., assignors to Pullman-Standard Car Manufacturing Company, Chicago, Ill., a corporation of Delaware

Application April 18, 1936, Serial No. 75,242

10 Claims. (Cl. 257—3)

This invention relates broadly to air conditioning systems for enclosures, but for the purpose of disclosure, it will be explained with particular reference to its application to passenger car air conditioning.

While there is some similarity between the electrical systems on most railway cars in service today, there are nevertheless many variances, due to the fact that not all cars were built by the same car builder, or at the same time and due further to the fact that the circuits employed are necessarily dependent upon the type of car to which the system is applied, (i. e. sleeping car, observation car, dining car, business car, coach, etc.). Consequently, whenever an air conditioning system is to be applied to any particular car, the electrical control system for the air conditioning equipment must be individually adapted to the electrical system already on the car, and this is obviously a costly and time-consuming task.

Among the primary objects of this invention, therefore, are the following: To separate the electrical control for the floor heating system already on most cars from the electrical control of the forced air heating and cooling system to be applied to the car; to make a similar separation between the control of the latter system and the control of auxiliary holdover refrigeration equipment so that the application of the holdover refrigeration equipment may conveniently be made; to so correlate the parts of the circuit that balanced fusing is feasible and maintenance, inspection and repair facilitated; to provide circuit means for positively preventing interference between heating and cooling; to provide convenient means for making the main light switch the master control switch regardless of the particular electrical control arrangement on the car; to provide suitable electrical control for the auxiliary holdover system; and to provide electrical means for indicating when the cooling system is not properly performing its function.

As the disclosure proceeds, further objects and advantages of the invention will become apparent.

In the drawings:

Fig. 1 is a diagrammatic, isometric view of a railway car equipped with an air conditioning system;

Fig. 2 shows a fragment of the floor plan for a conventional Pullman car, the preferred location of the control panels for the air conditioning system being indicated on this view;

Fig. 3 is a front view of the master control panel, floor heat control panel, auxiliary holdover control panel, and indicator lamp compartment;

Fig. 3a is a longitudinal sectional view through the control locker;

Fig. 4 is a schematic wiring diagram of the entire electrical system for controlling the air conditioning equipment, the components of the system being shown in their electrical relation rather than their physical relation;

Fig. 5 is a wiring diagram showing particularly the elements which are grouped on the control panels and their connections with the other components of the air conditioning system.

Fig. 6 is the same as Fig. 5 except that only the circuits dealing with car cooling from the overhead evaporator are shown;

Fig. 7 is the same as Fig. 5 except that only the circuits dealing with car cooling from either the overhead evaporator or the auxiliary overhead cooling coil are shown.

Fig. 8 is the same as Fig. 5 except that only the circuits dealing with holdover tank cooling are shown;

Fig. 9 is the same as Fig. 5 except that only the circuits dealing with car heating from the overhead heating coils are shown;

Fig. 10 is the same as Fig. 5 except that only the circuits dealing with car heating from the floor heat coils are shown.

The specific disclosure which follows of a preferred embodiment of this invention is made for the purpose of complying with Sec. 4888 of the Revised Statutes, and is not to be construed as imposing limitations upon the appended claims except as may be required by the prior art.

General organization

The air conditioning system is adapted to be used on various classes of vehicles, and the choice of a railway passenger car for illustrating an embodiment of the invention is for the most part arbitrary. There are however, some problems in air conditioning railway passenger cars which make the system of this invention particularly suitable for application to this class of vehicles.

The system disclosed includes means for filtering, cooling, and dehumidifying the air in the summer time, and means for filtering, heating and humidifying the air in the winter time.

The cooling of the air is accomplished by a refrigerating system which is operated through a variable speed device from one of the car

axles when the car is in motion, or by a standby motor when the car is at stations. The refrigerating system includes parallel evaporator circuits, one of which is adapted to cool the air that is being delivered to the car interior by direct expansion coils, and the other being adapted to store up refrigeration in the form of ice whenever car cooling is not required and there is power available for operating the refrigerating system.

Car heating is accomplished by a steam coil in the path of the air that is being delivered into the car interior. The steam coil may have a humidifier associated with it for delivering moisture to the air after it has passed through the coil.

A complete disclosure of the physical components of the system as well as a general disclosure of the electrical system controlling the operation of the equipment may be found in the application of Frank L. Murphy, Philip S. Westcott, and Martin P. Winther, Ser. No. 38,502, filed August 30, 1935, and the subject matter of that application is specifically made a part of the present disclosure.

Briefly, the system includes a refrigerant compressor **200** (Fig. 1) driven while the car is in motion from an axle driven shaft **201** through a magnetic coupling **202** which may be of the type disclosed in the patent to Anthony Winther No. 1,982,461, issued Nov. 27, 1934, and when the car is at stations, by an alternating current standby motor **203**. The compressor feeds to a condenser **204** cooled by a fan **205** which is driven from the armature shaft of the motor **203** (the shaft being rotated whenever the compressor is operating). An evaporator coil **210** in a brine tank **206** is connected in parallel with a direct expansion coil **207** mounted in an air conditioning chamber **208** just below the roof of the car, and suitable valves, indicated generally in Fig. 1 control the flow of refrigerant to the two parallel-connected coils.

A brine coil **209** is mounted in the air conditioning chamber **208** alongside the direct expansion coil **207** and when under certain conditions refrigerant is not available for the coil **207**, brine is drawn from the tank **206** (where it has been cooled and partly frozen by the evaporator coil in the tank) for abstracting heat from the air being delivered into the passenger space.

The liquid line to the evaporator coil **210** in the brine tank and to the direct expansion coil **207** is indicated at **211** and the suction line from these coils at **212**. The feed line to the brine coil **209** is shown at **213** and the return line at **214**.

Air is drawn from the interior of the car and mixed with selected quantities of outside air (the latter being passed through filters **215** before being mixed with the recirculated air) and then forced by blowers **216** through the coils **207** and **209** into air ducts **217** located along the side decks of the car from which the air is distributed into the car interior.

A steam coil **218** in the air conditioning chamber **208** is provided for heating the air in the winter time and it may have a humidifier (not shown) associated with it. Steam lines for the overhead heating coil **218** are indicated at **219**.

Other physical components of the air conditioning system will be identified and located as the disclosure of the electrical system controlling the apparatus proceeds.

Electrical system—in general

For convenience of disclosure, the system will be described generally from the standpoint of operation, considering first the separable parts of the system, as shown in Figs. 6–10 inclusive, and then the system as a whole, as shown in Figs. 4 and 5.

The more important components of the air conditioning system are designated on the drawings by appropriate titles in order to facilitate the disclosure and to avoid confusion, and reference characters will not ordinarily be applied to these parts. Also, it will be convenient to locate certain elements of the electrical system by the use of coordinates, particularly in Fig. 4 where the components of the system are shown in their electrical relation rather than their physical relation.

The electrical controls common to all types of cars are as far as possible placed on a master control panel, generally designated **220**, and other auxiliary controls are grouped on a floor heat control panel **221** and an auxiliary holdover control panel **222**. A master control panel is always used but the two auxiliary panels may or may not be used, according to particular requirements.

The following control equipment is mounted on the master control panel **220**:

Temperature selector switch ("Air conditioning control").
Overhead heat relay.
Valve cut-out and test switches (for overhead heat and #1 floor heat valve circuits).
Selector relay.
Blower fan start and speed switch.
Fan motor field resistance units for fan motor speed control.
Cooling pilot relay.
Circuit breaker relay.
Circuit breaker thermal unit.
Shock relief relay contact by-pass condenser and protective fuse.
Speed control field discharge resistor.
Line fuses.

The following control equipment is mounted on the floor heat control panel **221**:

#1 floor heat relay.
#1 floor heat temperature switch.
#2 floor heat relay.
#2 floor heat temperature switch.
#2 floor heat valve test switch.

The following control equipment is mounted on the auxiliary holdover control panel **222**:

Cooling selector relay.
Holdover switch.
Pump relay.
Pump line fuses.

Referring to Fig. 4, the four basic control circuit groups are (from top to bottom):

1. Heat controls:
   - *a.* Thermostats and heat relays with interlock control (No. 2 floor heat thermostat circuit is shown in dotted line diagram).
   - *b.* Heat relay valve circuit contacts with valve test switches, heat valve solenoids and solenoid selection switches, valve line circuit breaker and interlock control (No. 2 floor heat valve circuit shown in dotted line diagram).

2. Blower fan controls. (All those directly related to circulation of conditioned air thru car—an indication of "in-service" operation):
   a. Blower fan motor start and speed switch.
   b. Cooling thermostat with temperature selection switch and cooling pilot relay.
   c. Heat selector relay to place cooling and heating selective controls under the control of the car attendant for road service (blower fan running).
3. Miscellaneous cooling controls:
   Circuits used only for holdover system shown in dash line diagram.
   Without holdover system (without panel 222) terminals "B" and "C" (panel 220) are "jumpered" as shown in dash double-dot diagram.
   a. Cooling selector relay (subject to car temperature controls 2—*b* above).
   b. Compressor drive control.
   Train in motion—shock relief relay (for speed control).
   Train standing—A. C. standby motor starter switch.
   c. Miscellaneous holdover system controls.
   Holdover "cut-out" switch, solution temperature controls, Freon overhead evaporator valve and holdover coil valve solenoids, compressor rotation switch, and pump relay.
4. Speed control field excitation and discharge circuit:

Each of the above basic circuit groups is separately fused, the physical locations indicated on Fig. 5. The following diagram shows panel 220 cover plate designations, and also the number of the basic circuit as outlined above.

+B (1)						−B (1)
+L (4)	+CC (3)	+BF (2)	−BF (2)	−CC (3)	−L (4)	

Preferably, the control panel assemblies are located in a locker 230 (Figs. 2, 3 and 3*a*) at the end of the car passageway. Each panel assembly comprises a base 231 upon which the panel equipment (not shown) is mounted. The panel bases are secured in the locker by screws 232 and each base supports its panel at a given distance from the base by studs 233 and thumb nuts 234.

Projecting through the control panel 220 are the following:

Blower fan start switch 235.
Air conditioning temperature selector switch 236
Overhead heat valve test switch 237
Floor heat No. 1 valve test switch 238
Fuses 239
Cooling test binding posts 240; and
Speed control test binding posts 241

Projecting through the panel 221 are the following:

Body No. 1 floor heat temperature selector switch 242
Lounge No. 2 floor heat temperature selector switch 243; and
No. 2 floor heat test switch 244

Projecting through the panel 222 are the following:

Holdover switch 245; and fuses 246.

The indicator lights, generally designated 247 are mounted in box-like compartments at the top of the locker and the locker door 248 is equipped with bulls-eye lenses 249 of appropriate color to give the desired visual indication when the locker door is closed.

Car cooling from overhead evaporator 207 alone

The portion of the circuit relating to this function of the system is shown in Fig. 6.

Upon closing the main light switch A6, the circuit to the exhaust fans is energized, as indicated at B6. The blower fan switch C6 is then turned on, starting the blower fan motor, the field F6 of which is in series with motor speed resistor taps E6. The blower fan switch also completes circuit to the temperature pilot light H6 (orange) which has in series with it a resistor *a*6, the purpose of which is to limit the current to the lamp through the mercury tube *d*6, which has a resistor *b*6 across its terminals to prevent arcing in the mercury tube.

The temperature selector switch G6 is then turned to the right to energize the circuit controlling the cooling apparatus including the cooling pilot relay K6. The contacts I6 of the temperature selector switch G6 determine which one of the two mercury tubes J6 controls the operation of the cooling pilot relay K6 which in turn governs the entire cooling system.

Assuming the temperature selector switch is in the "high" position, as shown in Fig. 6 and that the "high" cooling thermostat J6 calls for cooling, the cooling pilot relay K6 is energized which closes the contacts of the shock relief relay L6, thereby energizing the speed control field M6 to drive the compressor from the car axle. The speed control windings M6 are in series with a caterpillar resistor N6 which changes the resistance in the field circuit in a manner fully described in the Winther patent heretofore identified, thus limiting the speed of the compressor to some predetermined maximum.

When the cooling pilot relay K6 has been energized, and the shock relief relay has closed the circuit through the speed control circuit M6, an opal light O6 is illuminated to indicate that the speed control circuits have been properly closed.

A high pressure, low pressure switch P6 is located in the refrigerant line to cut out the compressor in case of pressures which exceed or fall below predetermined maximum or minimum values. The switch P6 is connected in series with the operating coil of the shock relief relay L6 so that whenever head pressures or suction pressures become dangerous, the refrigerant system is shut down.

At stations where the refrigerating apparatus is to be operated by standby power, as for example 220 volt, 3 phase current, a plug Q6 is fitted into a power receptacle to operate an A. C. motor for driving the compressor, but the circuit through the alternating current standby motor is not closed until the plug has been pushed into the receptacle a sufficient distance not only to connect the three A. C. lines with the corresponding power lines but also to close the circuit through two D. C. terminals which energize the coils R6 of an A. C. starting switch and close the contacts T6 to energize the A. C. standby motor. At the same time, the upward movement of the armature opens contacts S6 (before the contacts T6 are closed) which prevents the speed control field M6 from being energized at the same time that the A. C. standby motor is running.

The heat selector relay U6 operates during

car cooling selection to prevent heating from interfering with cooling. This is accomplished by means of the rotary interlocking switch V6 which moves under common control with the cooling temperature switch I6.

The terminals CH and CT project through the cover plate of the panel 220 (see Figs. 3 and 6) so that they may be easily shorted for testing the operation of the system even though the cooling thermostat J6 does not call for car cooling.

Terminals SCT and SC likewise project through the cover plate in order that the caterpillar resistance N6 of the speed control may be readily tested.

Car cooling from either overhead evaporator 207 or auxiliary overhead cooling coil 209

This portion of the electrical controls is shown in Fig. 7.

The functioning of the circuit up to and including the energization of the cooling pilot relay K7 is the same as described under "Car cooling from overhead evaporator 207." (A7 of Fig. 7 corresponding to A6 of Fig. 6; B7 of Fig. 7 corresponding to B6 of Fig. 6, etc.)

The closing of the cooling pilot relay K7 energizes the cooling selector relay KK7 which in turn

(a) Closes contacts 2 for holdover cooling, subject to availability of the compressor through action of the rotation switch W7.

(b) Closes contacts 3 for energizing the evaporator solenoid X7, subject to availability of the compressor through action of the rotation switch W7.

(c) Closes contacts 5 for energizing the shock relief relay L7.

The energization of the shock relief relay L7 closes the contacts which control the energization of the speed control field M7, thereby driving the compressor and moving the compressor rotation switch W7 to position 6 (assuming the car speed is sufficient) which closes the other side of the circuit through the solenoid X7 and thus permits refrigerant to flow to the evaporator 207. The caterpillar resistor N7 functions as before to limit the speed of the compressor.

The functioning of parts N7 to V7 inclusive is the same as parts N6–V6 (Fig. 6) described under the heading of "Car cooling from overhead evaporator 207" (Fig. 6).

When the speed of the car falls below a predetermined minimum, the contacts 6 of the compressor rotation switch W7 are opened and the contacts 7 are closed, the latter contacts being in series with the brine pump relay Y7 and also in series with the contacts 2 of the cooling selector relay KK7. Therefore, when the car is travelling below a predetermined minimum speed, or is at stations where alternating current power is not available and the cooling pilot relay K7 is energized, the pump relay K7 closes contacts which energize the circulating pump Z7 and causes brine to be circulated through the auxiliary overhead cooling coil 209.

Holdover tank cooling

The circuits dealing with holdover tank cooling are best shown in Fig. 8 (some reference, however, being made to Fig. 7 for related circuits).

Before refrigerant is permitted to flow through the evaporator coil in the brine tank 206, all demand for car cooling must be satisfied. When this condition exists and the car speed is sufficient to operate the compressor, refrigerant is permitted to flow through the evaporator coil in the brine tank. After a predetermined amount of ice has been formed in the tank as determined by suitable controls, the compressor is shut down and does not start again until car cooling is called for, or until there is need for more ice in the holdover tank.

Since the cooling pilot relay K7 of Fig. 7 is in series with a cooling thermostat J7 and the temperature selector switch, the closing of the circuits for freezing the brine is made dependent upon the cooling pilot relay K7 (Fig. 7). In other words, when the contacts of the cooling pilot relay are open, either because the cooling thermostat J7 does not call for cooling or because the temperature selector switch is set to "off" position, the circuits for refrigeration control of the holdover tank are unlocked and the flow of refrigerant through the evaporator coil in the brine tank is permitted subject to suitable control.

Assuming, then, that the circuit through the cooling pilot relay K7 (Fig. 7) is open, which in turn causes the cooling selector B8 (Fig. 8) to become de-energized, and assuming also that the auxiliary holdover switch A8 is closed, as well as the main switch light, the armature of the cooling selector relay B8

(a) Closes contacts 1 to the solenoid valve H8 which controls the flow of liquid refrigerant to the holdover cooling coil 210;

(b) Closes the contacts 4 to the compressor power circuits through the master control panel 220.

The flow of refrigerant through the holdover cooling coil in the brine tank 206 is controlled by a low pressure switch C8 and a temperature switch D8, the two being connected in parallel. The former is connected in the suction line from the holdover cooling coil 210 and measures in effect the average internal temperature of the ice block during formation, opening a pair of contacts when the pressure drops below a predetermined value. The latter consists of a thermostatic bulb positioned a given distance from the evaporator coil and as soon as the bulb is encased with ice from the growth on the evaporator coil, it acts to open a pair of contacts and thereby perform its part in controlling the flow of refrigerant to the evaporator coil.

The reason for using a combination of pressure and temperature control in the brine tank is fully disclosed in the Murphy, Westcott and Winther application hereinbefore identified, and further discussion here is deemed unnecessary.

It should be noted that either the pressure switch C8 or the temperature switch D8 is capable of closing the circuit for operating the compressor, but that both switches must be opened to break the compressor control circuit. This is due to the fact that the temperature and pressure switches C8 and D8 are connected in parallel.

In road service, when the holdover tank calls for ice formation through either the pressure switch C8 or the temperature switch D8 (and assuming that car cooling is not called for), the shock relief relay E8 is energized, which in turn energizes the field coils F8 of the speed control, causing the compressor to be placed in driving connection with the car axle. Then, if the compressor rotation switch G8 is in the position shown in Fig. 8 (due to sufficient car speed) the

circuit through the solenoid valve H8 for the holdover evaporator is closed, which opens the valve and permits refrigerant to flow through the coil 218.

At stations where standby A. C. 220 volt power is available, the plug I—8 is pushed into the power receptacle and the compressor is operated from the A. C. standby motor in the same manner as has been previously described. It will be understood that when the armature of the A. C. starting switch J8 is lifted, the circuit through the speed control field F8 is opened at K8 through the shock relief relay E8, before the armature reaches the end of its stroke to close the circuit through the A. C. standby motor at the contacts L8.

It will be noted that the check valve in the suction line of the holdover evaporator not only serves to prevent refrigerant from condensing in that coil, but also makes possible the combination pressure and temperature control for the holdover coil. If a check valve were not used, the pressure within the holdover coil would quickly rise to a point sufficient to operate the pressure switch, and as a result holdover cooling would be effected even though not desired.

Car heating from overhead heat coils

The description which follows has particular reference to Fig. 9.

On closing the main light switch A9, the exhaust fan circuits indicated generally at B9 are energized. The blower fan switch C9 is then turned on which energizes the blower fan motor field F9 through one or more resistor taps E9 depending upon the position to which the switch is thrown. The switching on of the blower fan also energizes the selector relay I9 thereby

(*a*) Closing contacts 1' which connect negative battery to one side of the overhead heat relay M9 and

(*b*) Closing contacts 2' which connect positive battery to the inside contacts J9 of the temperature selector switch.

The temperature selector switch is then turned to the left which

(*a*) Selects one of the temperature control tubes L9 as the means for governing the action of the overhead heat relay (the contact K9 of the temperature selector switch in this instance being the one for medium heating).

When the mercury in the medium thermostat tube L9 closes its contact, the overhead heat relay M9 which is normally energized is shorted across 3' and 4'.

Assuming that the car calls for heating and that the overhead heat relay contacts are, therefore, in the position shown in Fig. 9, the solenoid 5' is energized and draws the plunger 6' to the right, thereby rotating the valve handle 7' and the valve stem to open the steam port to admit steam to the heat coil 218.

Before the plunger reaches the end of its travel, the valve handle 7' trips a toggle switch 8' which opens the circuit to the solenoid 5' and prepares the solenoid 9' (adapted to move the plunger 6' in the opposite direction) for turning off the steam when no further heating is required.

When the temperature in the car rises sufficiently to close the contact at L9, the operating coil of the overhead heat relay M9 is shorted across 3' and 4' to move the armature against contacts which close the circuit through the "off" solenoid 9' of the overhead heat valve N9 thereby shutting off the steam to the heating coil.

In a similar manner, when the plunger 6' approaches the end of its travel to the left, the toggle switch 8' is tripped to open the circuit through the "off" solenoid 9' and prepare the "on" solenoid 5' for action when heating is again needed.

An auxiliary circuit is provided for protecting against a condition where the heat valve is sluggish or sticks during on or off rotation. Since it requires current to move the overhead heat valve N9 to either on or off positions, it is possible to protect the circuits against overload due to sticky valve operation by introducing a thermal element O9 in the circuit. Whenever either one of the coils 5' or 9' is energized for more than a predetermined period of time, the thermal element O9 closes the contacts 10' to energize the circuit breaker relay P9 and thus open the valve operating circuit through the contacts 11'.

When the temperature selector switch is rotated to the right (cooling side) the inside contacts J9 are separated, thereby disconnecting the positive battery line from the overhead heat relay M9 to disconnect thermostat control and insure that the valve circuit contactor of overhead heat relay M9 is in the "off" position.

At the same time, the two other inside contacts are connected (when the temperature selector switch is rotated to the right) to provide a positive battery supply to the overhead heat valve line even though the test switch 5' may have been left in manual position. As a result, energy is only supplied to the "off" solenoid 9' of the heat valve N9 in order to prevent heating from interfering with cooling.

Car heating from floor heat coils

The description which follows has particular reference to Fig. 10.

It is desirable to provide some means for insuring that sufficient heat will be supplied to the car under any and all circumstances to keep the pipes from freezing. For example, when the car is left in the yard and the car attendant has opened the main light switch A10, as is customary, an auxiliary thermostatically controlled heating system furnishes sufficient heat to the floor heat coils to keep the car from freezing.

It is also desirable to be able to use the floor heat coils as auxiliary heating means during cold weather when the overhead heat coil is operating to take the main heat load.

When the car is left in the yards and the attendant has opened the main light switch A10, the exhaust fan circuits indicated diagrammatically at B10 are also open as well as most of the air conditioning control circuits (see Fig. 4). As a result, the blower fan start switch C10 may be either open or closed since the light switch A10 is the primary control, and the heat selector relay D10 is necessarily de-energized. The temperature selector switch E10 may be left in any position as the inside switch contacts (the heating and cooling interlock) 4'' and 5'' of the heating and cooling interlock switch are shorted at 1'' on the selector relay D10 to supply positive battery current to the floor heat relays J10 and K10, and the contacts 6'' and 7'' of the heating and cooling interlock switch are shorted at 3'' on the selector relay D10 to supply positive battery current to the "manual" setting contacts

8" and 9" of the valve test switches H10 and I—10 respectively. Thus, even if the valve test switches are left in "manual" position instead of "automatic" car heating is assured during the yard "out-of-service" operation.

Assuming that the floor heat No. 1 (body) temperature selector switch F10 is set for "low" heat selection (as shown in Fig. 10), the mercury tube L10 of the floor heat thermostat No. 1 shorts the winding of the floor heat No. 1 relay J10 to place the valve circuit contact in "off" position and throw both floor heat No. 1 valves M10 (in parallel) in "off" position. Obviously if the temperature within the car is such that the mercury in the tube L10 does not reach the top contact, the floor heat No. 1 valves M10 are open.

Assuming that the floor heat No. 2 (lounge) temperature selector switch G10 is set for "high" heat selection, the floor heat No. 2 relay K10 is energized because the floor heat No. 2 relay is not shorted by the mercury tube N10 of the floor heat thermostat No. 2. Thus the valve circuit contact associated with the floor heat No. 2 relay K10 is pulled to "on" position throwing both floor heat No. 2 valves O10 to their operative position.

In road service, when the main light switch A10 is closed, the exhaust fans are running, the blower fan start switch C10 is at "on" position, and the heat selector relay D10 is energized, the contacts 1" and 3" are open, placing the interlock circuits on temperature selector switch D10 control.

The overhead heat selection (high, medium or low) is then made and the contacts 4 and 5 energize the floor heat relays J10 and K10.

The floor heat temperature selector switches F10 and G10 may be operated as under yard service.

The switch arms of the manual test switches H10 and I—10 may be moved from automatic position to manual position to determine whether or not the floor heat solenoid valves are operating properly. If they are sluggish, or sticking, the switch arms are left in manual position and the valves may be operated manually.

The temperature selector switch E10 and particularly the inside contacts, interlock the cooling system with the heating system and prevent the two from overlapping at any time. If cooling is selected, the contacts 4 and 5 are disconnected to make sure that all heat thermostats and heat relays are inoperative. Contacts 6" and 7" when bridged by the switch arm supply current to the "off" solenoids of the heat valves if the valve test switches H10 and I—10 happen to be left in manual position.

Thus far, the description has dealt primarily with certain segregated portions of the electrical system, and it will now be helpful to describe the operation of the system as a whole, with particular reference to the schematic diagram of Fig. 4 (coordinates being used where possible to assist in locating the parts).

Road operation (in-service condition)

Car cooling
- Close main light switch (A—2)
  - Exhaust fans run (F—1)
- Close blower fan start (and speed selection) switch (C—9, E—9, G—10)
  - Selector relay energized. (F—9)
    - a. Opens yard (out-of-service) interlock contacts (C—3, C—7) to heat valve test switches (D—2, D—3 and D—4) and heat relays (F—6, F—7, F—8) to transfer control to the inside interlock switch (C—3, C—7) of the cooling and heating temperature selector switch (F—3 and E—10).
    - b. Completes circuit (D—3 and H—9) to overhead heat thermostat (G—5) and relay (F—8).

Temperature selector switch ("Air conditioning control") rotated to the right to select desired cooling temperature. (E—10.)
- Inside or heat interlock switch (C—3) (rotated under common control with the switch for thermostat tube temperature selection (E—10) operates to prevent heating interfering with cooling).
  - a. Disconnects all heat relay (+B) supply (C—7). (Guarantees heat relay valve line contacts (E—2, E—3 and E—4) will be in "off" position during cooling.) (See "Car heating" description.)
  - b. Completes circuit (C—3) from (+B) to "manual" side of valve test switches (D—2, D—3, D—4) to insure valve current flow to heat valve "off" solenoids (F—2, F—3, F—4), even though valve test switches may have been left in "manual" position. (See "Car heating" description.)

Cooling thermostat tube mercury column (F—11) rises, completing circuit to cooling pilot relay (G—10). (Car cooling called for.)
- a. Cooling pilot relay energized (G—10). Cooling pilot contact closes (I—11).
- b. Cooling selector relay energized (G—12). Cooling selector contacts transferred to "car cooling" position. (G—12 and G—13.)

A. Primary evaporator cooling of car.

Compressor driving power available from car axle (train motion).
- a. Shock relief relay energized (D—12) subject to the Freon high-low pressure protective switch (F—12).
- b. Shock relief relay makes top contact (H—13 and H—14), and at the same time, bottom contacts (C—15) open disconnecting speed control field discharge resistor (E—15).
- c. Cooling pilot lamp lighted (F—14).
- d. Speed control field (D—14) energized to provide magnetic coupling to drive compressor from car axle.
- e. Compressor rotation switch transfers above approx. 5 M. P. H.) (E—13).
- f. Solenoid winding of evaporator Freon valve energized (F—13) and valve opened.

Compressor driven from A. C. standby motor.
- a. Standby power plug (external to car equipment), inserted into receptacle.
- b. Receptacle D. C. control contacts (B—12) "bridged" by plug element completing circuit to standby motor automatic starter switch winding (D—12).
- c. Shock relief control line interlock contacts (C—12) (left side of standby starter switch arm assembly) opens circuit to shock relief relay winding (D—12). This in turn opens speed control field contacts (H—13 and E—14) to de-energize speed control

while A. C. standby power is available.

d. Speed control field (D—14) being de-energized leaves the driven unit (field rotor) free of magnetic coupling to the car axle drive.

e. Standby motor starter switch closes, completing A. C. circuit to drive motor, which is shaft-connected to speed control driven unit, and to compressor which is belted to it.

f. Compressor rotation switch (B—13) transfers, completing circuit to evaporator solenoid valve (F—13) which opens and admits Freon to evaporator circuit.

B. Holdover or secondary car cooling.

No compressor driving power available.

a. As compressor does not rotate, compressor rotation switch contacts (B—13) remain on holdover pump relay circuit.

b. Holdover pump relay energized (D—13).

c. Holdover pump relay contacts close (E—11).

d. Holdover pump motor (C—11) runs to drive cold holdover solution from the storage tank to the auxiliary overhead cooling coil and return to the spray header of the storage tank.

Temperature (80°) pilot light (F—9).

The temperature pilot lamp lights when car is too warm (80° is reached), when special damper for fresh and recirculated air control, should be shifted to increase recirculated air and decrease fresh air until lamp goes out again.

The pilot light is controlled directly from a heavy duty thermostat tube (E—9) mounted on the same plate as the cooling thermostat tubes.

Electrical operation is as follows:

Below 80°, the thermostat tube by-pass resistor (E—9) is in series with a permanent line resistor (G—9), the two together limiting voltage across the lamp to about 6 volts on a 32-volt supply line (filament burns at a dull red color).

At 80°, mercury column (E—9) closes shunt circuit around the by-pass resistor (E—9), raising lamp voltage to about 25 volts.

The line resistor (G—9) (always in circuit) limits the maximum current the thermostat tube (E—9) must carry.

The by-pass resistor (E—9) prevents a complete open circuit condition when mercury column drops and opens shunting circuit, and so reduces arcing at surface of mercury column (E—9) to an amount not harmful.

Holdover tank cooling (in service).

(Cooling of car must be satisfied before compressor capacity is made available for holdover tank ice forming).

Cooling thermostat tube mercury column (F—10 or F—11) lowers until circuit is broken to the cooling pilot relay (G—10).

a. Cooling pilot relay (G—10) is de-energized.

Cooling pilot contact (I—11) opens.

b. Cooling selector relay (G—12) de-energized.

Cooling selector contacts (G—12 and G—13) disconnect "car cooling," control circuits and return to back contact position to allow holdover tank cooling as may be required.

Holdover toggle switch closed (I—12).

Holdover pressure and temperature switches closed. (H—12, H—13.)

Compressor driven from either speed control (D—14) (train operation), or standby motor (external A. C. power available) through the operation of the same control circuits described previously under "car cooling—Primary evaporator."

Operation of holdover tank low pressure and temperature switches is briefly as follows:

a. Low pressure switch (H—13) operation controlled by holdover tank Freon coil suction line pressure (a measure of average internal temperature of ice block during formation). Closes at 23 lbs. and opens circuit at 10 lbs.

b. Temperature switch (H—12) controlled by bulb in temperature well so placed that the warmed holdover solution from the spray header during secondary or holdover cooling of car will expose same to the warmer solution as soon as the surface begins to melt. This allows refreezing of surface ice without having to melt down the bulk of the cake, which would be necessary to cause the low pressure switch to close again after an initial freezing.

Closes circuit at 38 degrees and opens circuit at 34 degrees.

NOTE—Either switch completes circuit, but both must be open to break circuit.

Pre-cooling of holdover tank in Yard, without being subject to the condition of car cooling operation first, may be accomplished by:

a. Closing main light switch (A—2)

b. Leaving blower fan switch off (C—9, H—9)

c. Closing holdover toggle switch (I—12)

d. Plugging in A. C. standby power for running standby motor. (D. C. interlock contacts at B—12.)

Car heating

Close main light switch (A—2).

Exhaust fans run. (F—4)

Close blower fan switch (C—9, H—9 G—10).

Selector relay energized. (F—9).

a. Opens yard (Out-of-service) interlock contacts (C—3) to heat valve test switches (D—2, D—3, D—4) and heat relays (F—6, F—7 and F—8) in order to transfer control to the inside interlock switch (C—3 and C—7) of the temperature selector switch assembly (F—8 and E—10).

b. Completes circuit (D—8 and H—8) to overhead heat thermostat (G—7 and G—8) and relay (F—8).

Temperature selector switch (F—8) ("Air conditioning control") rotated to the left to select desired overhead heating temperature.

Inside or heat interlock switch (C—7) (rotated under common control with the switch for thermostat tube temperature selection) operates to:

a. Open circuit (C—8) heat valve test switches (D—2, D—3, D—4) when thrown to "manual" position (see outline on "Circuit breaker operation").

b. Completes (B) circuit (C—7) to all heat relays (F—6, F—7 and F—8).

Overhead heat:

Overhead heat thermostat tube mercury column (G—7 and G—8) too low to "bridge" overhead heat relay winding (F—8), thus energizing it (car heating called for).

Overhead heat relay contacts (E—4) transferred to "on" position.

Overhead heat valve "on" solenoid (F—4) energized.

Valve solenoid plunger shifts, rotating valve arm to open steam port and admit steam to heat system.

At end of valve arm swing, solenoid toggle switch (G—4) disconnects "on" solenoid and connects "off" solenoid (F—4), in preparation for "off" valve operating current from heat relay contact (E—4) when car is sufficiently warmed (mercury column) (G—7, G—8) in thermostat tube rises to "bridge" across heat relay winding (F—8).

Floor heat

Temperature selector switch rotated to one of the overhead heat temperature selection positions (F—8).

Floor heat control switch (F—5 or F—6) (two on panel 221) turned, to select floor heat temperature desired.

Floor heat relay (F—6 or F—7) (two on panel 221) energized when floor heat thermostat mercury column (G—5 or G—6) is too low to "bridge" relay winding (F—6 or F—7) (heating called for).

Valve control is similar to that described for "Overhead heat" operation.

Circuit breaker operation

A sluggish or sticking valve overheats circuit breaker thermal element (H—1) (in series with all heat valve (F—2, F—3, F—4) solenoid "N" lines).

Thermal element warps control contact (G—1) closed.

a. Magnetic hold-in winding of thermal unit assembly, energized (G—1)

b. Circuit breaker relay winding energized (G—1)

c. Relay contacts (G—2) open, leaving heat valve pilot light (G—2) in series with valve solenoid line, reducing valve operating current to only enough to light the pilot lamp.

Thermal element (H—1) cools down.

Magnetic hold-in winding (G—1) retards return of warping member (H—1) to normal, (open contact position) until thermal unit (H—1) is thoroughly cooled down and hold-in winding (G—1) can no longer oppose return to normal.

Thermal element contact (H—1) opens.

a. Relay (G—1) deenergized.

b. Relay contacts (G—2) close, by-passing pilot light (G—2) and reconnecting valve solenoid circuit (F—2, F—3, F—4) directly to battery circuit for another current impulse to "free" the valve.

When valve continues to stock, the above cycle of circuit breaker operations repeats accordingly.

When attendant notices heat valve pilot lamp (G—2) is lighted, the following pertains:

a. Valve test switches (D—2, D—3 or D—4), normally set at "automatic" position, are each in turn transferred to "manual" position.

b. The test switch which causes heat pilot light to go out, indicates on corresponding name plate, which circuit is involved.

c. Valve test switch of the circuit indicating valve trouble, is left in "manual" position, disconnecting valve from automatic thermostat control.

d. Attendant manually shifts valve arm back and forth, to "free" same if possible.

If able to secure "free" action once more, the test switch is returned to "automatic" position.

If not able to clear the trouble, valve is left "free" of electrical control.

(Test switch left in "manual" position) and valve operated by hand until terminal is reached for repairs.

Yard storage (out-of-service condition)

Main light switch (A—2) open.

Exhaust fans (F—1) not running.

Blower fan switch open (C—9, H—9).

Selector relay de-energized (F—9).

a. Disconnects both (+) (—) power (D—9 and H—9) to overhead heat relay (F—8).

b. Floor heat relay (F—6 or F—7) (two on panel 221) but under the control of floor heat temperature switch (F—5 or F—6) which assures full thermostatic control to prevent car freezing up in winter, when car is out of service. (B+) power to floor heat thermostat circuits supplied through heat selector relay (F—9), yard operation interlock (C—7), which is closed in this case.

c. Completes (+) supply (C—3) to valve test switch "manual" position (D—2, D—3, D—4) terminals.

Heat valves must have operating current supplied to either "on" or "off" solenoid operating windings as valve does not re-return to "off" position automatically.

Selector relay contact (C—3) assures current supply to heat relay transfer contacts (E—2, E—3, E—4) for proper valve control, even though valve test switches (D—2, D—3, D—4) may be in "manual" position.

General operation notes

Test terminals are provided on the panel 220 for "Cooling test" and (speed control) "S. C. Test." Cooling test consists of shorting around the cooling thermostat (F—10 and F—11) to create artificial car cooling control, for checking cooling operation.

Speed control test is arranged to check the condition of the caterpillar resistance contacts

(E—15) of the speed control, by measuring voltage drop across same (across "SCT" D—15 to "SC—" H—13).

Some of the more outstanding features of the system above described are:

Heating-cooling interlock

The outstanding feature of the heating-cooling interlock is that the circuits prevent heating from interfering with cooling, and vice versa, and yet insure that the floor heat system is in operation during yard service.

Specifically—during cooling:

1. All heat thermostat relays assured to be in the "off" position.
2. All heat relay contacts for operating heat valve solenoid circuits assured to be in the "off" position.
3. Flow of current to the heat valve solenoid windings is asssured (the heat relay contacts being in "off" position means that the current goes to the "off" solenoid of the valve).

During yard service:

1. Floor heat relay circuits energized to guarantee floor heat control to prevent freezing or allow preheating of car before service (with a positive flow of current to floor heat valve solenoids).
2. Overhead heat relay control is off (with a positive supply of current to "off" solenoid).

Car heating in road service

The system provides full protection and control of floor and overhead heating but at the same time allows operation of valve test switches in determining faulty valve operation.

In yard service and during cooling, it is desirable to have the manual side of the test switches connected directly to the power supply so that even if a yard man accidentally leaves the test switch in manual position, the heating valves will be turned off (the heat relays being de-energized by reason of the heating interlock for the relays) which puts the valve contacts to off position, and, therefore, guarantees a source of current for operating the heat valve solenoids.

During car heating in normal road service, it is desirable to have the manual side of the test switches disconnected from the battery so that when the heat pilot lights, the faulty valve may be located by opening successively the various valve control circuits by means of the test switches until the circuit which caused the light to stay on is broken, whereupon the light is extinguished.

Interlock between blower fan and the cooling and heating selection

The main purpose of this interlock is to prevent the heating and cooling circuits from being operative unless the blower fan is operating to enable them to do some useful work. In one sense, the blower fan circuit is an indicator that the system is in condition for road service. Another purpose is to ensure that the blower fan is operating when the evaporator is in service to prevent the latter from freezing up.

Specifically, the blower fan start switch energizes the heat selector relay and the cooling side of the temperature selector switch, the heating side of which is under control of the heat selector relay.

The function of cooling pilot relay

Control of cooling thermostat operation is directed into a cooling pilot relay located on the master panel so as to provide a flexible arrangement whereby the cooling pilot relay contacts may be used to secondarily control any combination of cooling circuits required.

For example:

1. Cooling pilot relay may directly excite shock relief relay to operate the speed control in an axle drive mechanical air conditioning system.
2. Cooling pilot relay may excite cooling selector relay located on separate hold-over control panel which in turn sets up individual control circuits including car cooling through the primary compressor-evaporator system, car cooling through the brine auxiliary cooling system, and brine tank liquid cooling from the compressor.
3. Pilot relay contact may be used to complete circuit to excite a standby motor A. C. starter switch coil.
4. Cooling pilot relay contact may be utilized to excite the starting relays of a direct current motor to drive the compressor as in the case of the electro-mechanical air conditioning system.
5. Cooling pilot relay may be used to operate the ice water pump or by-pass valve relay of the ice system of air conditioning.

Speed control field excitation circuit

The shock relief relay is an intermediate relay under the control of the cooling pilot relay for completing the circuit to excite the speed control field as required. When disconnecting the speed control field after a cycle of operation, the inductive discharge across the contacts of the shock relief relay tends to seriously damage them from arc burn and a by-pass condensor across the shock relief relay contacts is provided to act as a shunt circuit to absorb the rush of induced alternating current when the shock relief contacts are opened. An additional protective fuse is put in series with the condenser because when a condenser fails, it is generally a case of insulation breakdown and unless a fuse is provided to open the circuit, a short circuit condition would result which would short the entire speed control field circuit.

The induced voltage set up with the disconnecting of the speed control field by the shock relief relay contacts at the end of a cooling operation tends to burn out the cooling pilot light intended to operate at normal battery voltage. To allow use of a standard car lighting type lamp and still not suffer from high induced voltage, a by-pass resistor is inserted across the cooling pilot light to provide a discharge path from the A. C. current set up through the cooling pilot light circuit.

Shock relief relay interlock with A. C. standby service

The A. C. standby motor starter switch assembly provides a normally closed interlock which provides means of completing the circuit to the shock relief relay unless the A. C. standby motor starter switch is closed due to plugging in of station or yard receptacle when the interlock contact on the A. C. switch disconnects the shock relief relay during A. C. motor operation.

Compressor rotation switch

The compressor rotation switch is intended as a means of electrical circuit selection depending upon availability of the compressor. When the

compressor is running, whether from standby power or through the speed control in road service, the compressor rotation switch completes one side of the circuit to the overhead evaporator and the holdover Freon solenoid valves.

Whenever the compressor is not available, the compressor rotation switch returns to normal to complete one side of the circuit to the brine pump relay.

Cooling selector relay

The cooling selector relay is mounted on the auxiliary holdover panel and is subject to car cooling control through the cooling pilot relay.

The operation for car cooling involves:—

1. Completion of circuit to the holdover brine pump relay (subject to compressor rotation switch, i. e. compressor availability).

2. Completion of circuit to evaporator solenoid valve (subject to compressor rotation switch, i. e. compressor availability).

3. Completion of circuit through high pressure and low pressure Freon switch to the compressor power control circuits which may result in

(*a*) Normal excitation of the shock relief relay for speed control operation, or

(*b*) Standby A. C. motor operation.

The operation for forming ice in the brine tank involves:

1. Completion of compressor power circuit through high-low pressure Freon switch to operate compressor by either

(*a*) Normal shock relief relay excitation for speed control operation.

(*b*) Standby A. C. motor operation.

2. Completion of circuit to holdover Freon coil solenoid valve (subject to compressor rotation switch, i. e. compressor availability).

Both auxiliary holdover functions of the cooling selector relay are subject to holdover tank temperature switch and Freon suction side low pressure switch operation.

The cooling selector relay is made to complete all the interlaced circuits with one mechanism so that

1. Car cooling has prior control over auxiliary tank cooling, the latter being available only when car cooling is satisfied, and

2. When car cooling is called for, compressor availability will determine whether the compressor power circuits are energized, or the holdover pump relay.

Temperature (80°) pilot light

This light is used to visually indicate that a critical temperature has been reached for cooling service (chosen at 80°). To maintain a common standard of thermostat tube mounted in a common mounting with cooling thermostat tubes which are placed so as to be controlled by the temperature of the recirculated air, special circuit conditions are required to allow operation of a pilot light by the thermostat tube directly. This is because of the fact that the amount of current required to illuminate the pilot light under normal conditions would seriously damage or make inoperative the usual design of thermostat tube used. Where a thermal element of greater capacity is to be used, the additional control resistors described below are not essential.

To limit the maximum amount of current the thermostat tube must carry in lighting the lamp, a line resistor (Fig. 4, G9) is placed in series with the pilot light, reducing the voltage to the pilot light and thus restricting the current through the thermostat to an amount where sufficient illumination is given by the light to be readily seen by the operator.

Whenever the temperature in the recirculated air duct is 80° or above, the mercury column completes the circuit to the pilot light (causing it to be fully illuminated) indicating to the operator that the car is too warm and that steps must be taken to correct the condition and cool the car down to the normal operating range. This may be a case of readjustment of the fresh and recirculated air damper to reduce the fresh air and increase the re-circulated air, as in normal service, or it may be an indication that there is faulty operation of the cooling system otherwise unnoticed but brought to attention by the fact that the critical temperature of 80° has been reached.

When the air has cooled down below 80° and the mercury column is separated in the thermostat tube, instead of open circuiting the line to the pilot light which tends to create destructive arcing at the surface of the mercury in the tube, a thermostat by-pass resistor (Fig. 4 E9), is provided which means then that when the thermostat mercury column is below the 80° critical point, the current through the lamp is merely reduced down to a point where, while the lamp still glows at a dull red, it is insufficient to give a false indication. Thus, the thermostat tube merely acts to change the voltage across the pilot light between controlled minimum and maximum limits rather than between a condition of zero current and the maximum required for full illumination at normal line voltage.

General panel arrangement

Certain circuits such as the main control circuits dominated by fuses marked CC+ and CC— are best operated from the car lighting circuits to take advantage of the controlled line voltage effected by the lamp regulator, the latter being almost universally used on railway cars to stabilize the voltage to the car lighting circuits when the axle driven generator is operating at high speed.

Certain other circuits, such as the heat control circuits, may be satisfactorily operated from off the battery circuit direct regardless of voltage fluctuations.

The main light switch in the switchboard locker of the car becomes the master switch for all electrical equipment in the car with the exception of the heat control circuits for floor heating which must remain independent subject to the cooling operation interlock, in order to prevent freeze-up of the car in the winter when out of service. Thus, the main light switch becomes the key also to the operation of the air conditioning controls so that when the main light switch is opened, the air conditioning is completely shut off too. The electrical load put on the system by the blower fan is sufficient to add an excessive overload to the lamp regulator. Therefore, it becomes essential that the circuit to the blower fan be excited by the main line switch only on the line opposite in polarity to that which involves the lamp regulator controlled resistance group, whereas the opposite side of the blower fan circuit is returned direct to the battery. In this manner, the main light switch remains the key switch to the system and at the same time, the lamp regulator is not overloaded.

As many railroad cars have circuit applications where the lamp regulator is in the positive

lamp line necessitating the main line switch control to be in the negative lamp line, which is opposite in arrangement to that usually used on Pullman equipment, a means of easy modification of the master panel to provde for these external conditions for universal application of the panel to any car is covered in the arrangement of the power line terminals to the board.

The blower fan circuit terminals indicated as +F and −F are kept independent from other circuits on the board. The +L and −L lamp line power terminals feed the control circuits CC+ and CC− as well as the speed control circuits SC+ and SC−. The B+ and B− terminals feed all heat circuits and the auxiliary holdover brine circulating pump motor. By convenient method of inter-terminal strapping +F can be connected to adjacent terminal +L on one side of the power with −F connected to −B on the other side of the panel by an equivalent interconnecting strap. This would be for Pullman service application.

If the same panel is to be used for application to railroad owned cars, +F would be connected to the opposite adjacent terminal +B and on the other side of the panel, the strap would be changed to connect −F to −L.

All circuit fusing is so arranged as to systematically segregate each major grouping of panel circuit controls without overlapping so that in case of fuse trouble, there is no doubt left as to the circuit in which the trouble is to be found, thus providing quick and accurate segregation of circuits. This also allows balanced fusing on both sides of the line for a given circuit, the fusing being of minimum capacity to take care of the particular needs of that circuit, thereby providing a greater factor of safety in fuse protection than would be possible where the circuits interlace as has been done in prior installations of this character.

Fuses are also located on the board in a systematic manner so that the various circuits may easily be checked.

Terminals at the top and bottom of the master panel are so located as to match up with equivalent terminals for floor heat and holdover panels providing quick and accurate means of expanding the function of the master panel to suit car conditions whenever any sort of sub-panel is added.

Summary

The particular advantage of the control panels which have been described is that they may be used on all types of railway cars without modification. Furthermore, they are adaptable not only to air conditioning systems in which the compressor is driven through a magnetic clutch from the car axle, but also to electro-mechanical systems where the compressor is driven by an electric motor energized by the axle generator, and to ice systems which are interlocked with heating systems.

It will be understood that various parts of the control equipment mounted on the master control panel **220** may be eliminated under certain circumstances, and other equipment may be substituted in its place without departing from the spirit of this invention. Such modifications would necessarily be made if the control panel were to be used with an electro-mechanical system for example, but the important thing is that even this use of the panel does not necessitate making up a new panel or completely revising the control equipment. Formerly, every time the system was changed in any minor detail, an entire new panel was necessary, even though the change in the old panel was in some slight detail.

Although no means for humidifying the air in the winter time is shown in the drawings, it will be understood that a water spray may be placed in the air conditioning chamber and controlled by a hygrostat for supplying the proper amount of moisture to the air.

This application is closely related to a co-pending application filed by the same applicants and bearing Ser. No. 62,004, filed February 1, 1936. Reference is made to that application for subject matter disclosed but not claimed in the present application.

What we claim, therefore, is:

1. In an air conditioning system, a cooling circuit, a heating circuit including a floor heat valve having "on" and "off" solenoids, thermostatic means for selectively energizing said solenoids, and means for positively supplying current to the "off" solenoid whenever the cooling circuit is in operation.

2. For use in an air conditioning system, a floor heat valve having "on" and "off" solenoids, thermostatic means for selectively energizing said solenoids, a manual test switch for the floor heat valve, and means for positively supplying current to the "off" solenoid even though the manual test switch is left in test position.

3. For use in an air conditioning system, a cooling circuit, a heating circuit including a floor heat valve having "on" and "off" solenoids, thermostatic means for selectively energizing said solenoids, a temperature selector switch for determining which circuit shall be in operation, means associated with the temperature selector switch for preventing heating from interfering with cooling, said last named means being adapted to positively supply current to the "off" solenoid whenever the cooling circuit is in operation.

4. In an air conditioning system, a main heating circuit including a heat thermostat, a cooling circuit including a cooling thermostat, a temperature selector switch for selecting the circuit to be in operation, means associated with said switch for preventing both circuits from being in operation at the same time, an auxiliary heating circuit including a floor heat valve thermostat, and means for associating the auxiliary heating circuit with the main heating circuit so that the former is also subject to the heating and cooling interlock associated with the temperature selector switch.

5. In an air conditioning system, a heating circuit including a heat thermostat, a main cooling circuit including a cooling thermostat, a temperature selector switch for selecting the circuit to be in operation, means associated with said switch for preventing both circuits from being in operation at the same time, an auxiliary cooling circuit including controls for an auxiliary holdover refrigerating system, and means for associating the auxiliary cooling circuit with the main cooling circuit so that the former is also subject to the heating and cooling interlock associated with the temperature selector switch.

6. In an air conditioning system for railway cars including a refrigerant compressor driven through an electromagnetic speed control device from one of the car axles, a speed control circuit for controlling the operation of said device, a heating circuit including a heat valve solenoid and a thermostat, an air flow circuit including a blower switch, and means for alter-

natively energizing the heating circuit or the speed control circuit, a control circuit associated with said other circuits, and means for separately fusing said circuits.

7. In an air conditioning system for use on railway cars having an electrical system including a variable source of electromotive force with a regulated line and an unregulated line extending therefrom, and a master switch for the system in the unregulated line, an air flow circuit including a blower fan, heating and cooling circuits associated with and normally master-controlled by the air flow circuit, and means for making the air flow circuit subject to the master switch regardless of the polarity of the regulated and unregulated lines, respectively.

8. In an air conditioning system for railway cars and the like, a primary cooling system, an electrical circuit for controlling the primary system including a cooling pilot relay and a thermostat, an auxiliary cooling system, an electrical circuit for controlling the auxiliary system including a cooling selector relay adapted to establish appropriate electrical circuits for operating the auxiliary system, and means including said cooling pilot relay for rendering ineffective the control circuit for the auxiliary system whenever the primary system is in operation due to the requirements of the thermostat.

9. In an air conditioning system for railway cars, a selector relay, a plurality of heating circuits each of which includes a heat valve solenoid, a heat thermostat and contacts associated with the selector relay, an air flow circuit including a blower switch, the selector relay operating coil and a temperature selector switch, an independent circuit controlling the heating and air flow circuits, means for fusing the heating circuits, and separate means for fusing the air flow circuit.

10. In an air conditioning system for railway cars, a plurality of relays including a selector relay, a master selector switch, a plurality of heating circuits each of which includes a heat valve solenoid, a thermostat, a temperature selector switch and contacts associated with one of said relays, a separate air-flow circuit including a blower switch associated with the selector relay, an independent circuit controlling the heating and air-flow circuits, means for fusing the heating circuits, and separate means for fusing the air-flow circuits.

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CERTIFICATE OF CORRECTION.

Patent No. 2,193,835. March 19, 1940.

FRANK L. MURPHY, ET AL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 8, first column, line 6, for "(B)" read --(+B)--; page 8, second column, line 3, for the word "stock " read --stick--; line 44, for "but" read --put--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 27th day of August, A. D. 1940.

Henry Van Arsdale,
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