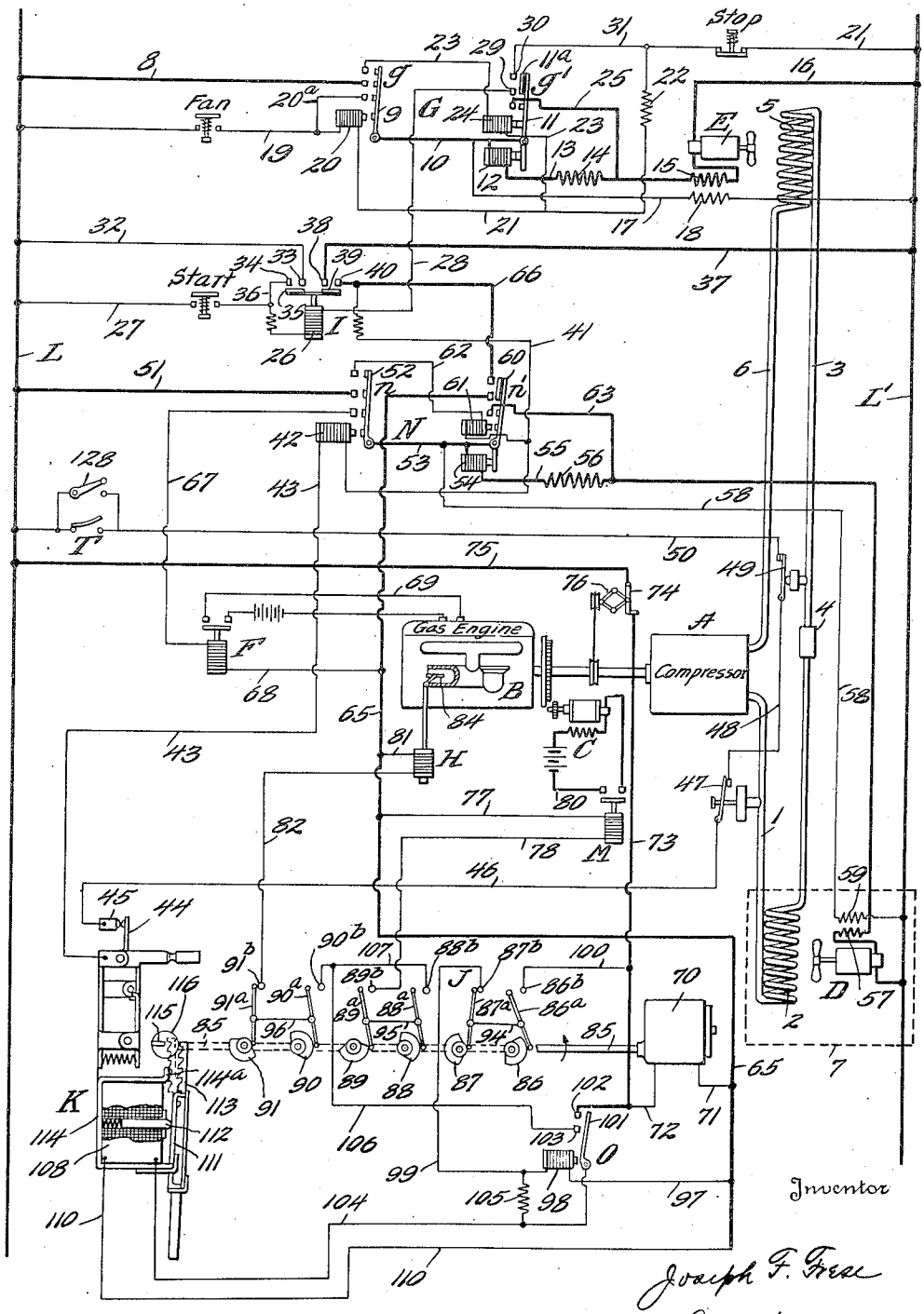
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AIR COOLING SYSTEM FOR VEHICLES

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AIR COOLING SYSTEM FOR VEHICLES

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This application is a division of my application Serial Number 624,594, filed July 25, 1932, patented November 27, 1934, No. 1,981,859.

The invention relates to an air conditioning system suitable for use on railway passenger cars for keeping the air in the car at a desired temperature. In such a system, power is required to operate the compressor of a refrigerating apparatus and I employ as a driving means for the compressor an internal combustion engine, with means controlled by a thermostat switch for starting the engine and compressor when the temperature of the air in the car rises to a predetermined degree, and for stopping the engine and compressor when the temperature of the air is lowered to a predetermined degree.

As an internal combustion engine must be cranked to start it, and also choked, if it happens to be cool, and as it may not start until it has been cranked and choked several times, I provide means for automatically cranking the engine intermittently for predetermined time periods and for closing the choke valve during a part of each period. When the engine starts, a switch controlled by the operation of the engine opens and circuits controlling the starting and choking devices are thereby opened and these devices become inoperative. If the engine does not start after a predetermined number of cranking and choking operations, a circuit breaker is automatically opened and this disables a circuit which controls the ignition circuit of the engine and the circuits of the starting and choking devices. It may be that, if the engine does not start after several cranking and choking operations, there is something wrong with the system requiring personal attention, such as exhaustion of the fuel supply and therefore the circuit breaking device is provided for disabling the starting devices after a predetermined number of these operations. The circuit breaker must be manually reset before the apparatus can be again placed under automatic control and this insures individual attention.

In this air conditioning system a fan motor is employed to circulate the air in the car or room past the refrigerating coils. It is essential to have this motor in operation at all times while the compressor is in operation, and it is desirable to have it operate to circulate the air in the room during intervals when the compressor is stopped. Therefore, I provide switches for stopping and starting this motor at will, and interlocking connections whereby the gas engine and compressor cannot be operated except while the air circulating fan motor is in operation, and whereby interruption of the circuit of this motor will cause stoppage of the gas engine and compressor if these happen to be working at the time.

I provide also an electric motor for circulating a cooling medium around the condensing coil at the compression side of the compressor, shown herein diagrammatically as a fan motor, although it may be a motor connected to a pump where liquid is used for causing condensation of the fluid used for refrigeration. This motor, used for cooling, must be in operation while the compressor is working.

To place the system in operative condition, the air circulating fan motor must first be started. The starter for this motor, when closed, makes up a circuit to the magnet of a normally open relay switch, which circuit is, however, normally open at a push button switch. Upon the closure of this push button switch, the relay is energized and connects a starter for the cooling motor to one side of the supply circuit. The main contactor magnet of this starter, connected to one side of the line by said relay, is connected to the other side of the line through a safety circuit which includes a thermostat switch. The starter last referred to cannot operate except when the thermostat switch is closed. When closed, the starter completes the circuit to the cooling motor and also makes up the circuits of the engine controlling devices previously referred to, and the engine then operates the refrigerating apparatus. When the temperature in the room rises sufficiently to cause the thermostat switch to open, the circuit through the magnet of the main contactor of the starter is opened and the starter opens the circuit of the cooling motor and the interlocking connections to the engine controlling devices.

In the accompanying drawing, the invention is illustrated diagrammatically.

Referring to the drawing, A represents the compressor of a refrigerating system; B indicates an internal combustion engine for operating the compressor, and C indicates an electric starting motor for the engine. The circulating system for the refrigerant is indicated by a pipe 1 leading from the compression side of the compressor to a condensing coil 2, wherein the fluid is cooled by air or other cooling fluid circulated around the coil by an electric motor D, a pipe 3 leading through an expansion valve 4 to a refrigerating coil 5, and a pipe 6 leading from the latter coil to the intake side of the compressor. The coil 2, which gives off heat generated by compression

of the refrigerating fluid, will be placed outside of the room which is to be cooled, or in a compartment by itself. In the diagram, the dotted line 7 indicates such a compartment. The refrigerating coil 5, which is cooled by the expanded refrigerant and absorbs heat from the air, is placed within, or in communication with, the room to be cooled, and a fan motor E is provided for circulating the air of the room around and between the convolutions of the coil.

A relay F controls the ignition circuit of the engine; a relay M controls the circuit of the starting motor, and a magnet H controls the actuation of the choke valve of the engine. A motor driven timing mechanism J, controls the circuits of the relay M and magnet H and also the circuit of a tripping device K which is adapted to open a safety circuit in case the gas engine does not start after a predetermined number of cranking and choking operations. The opening of this circuit disables the circuits of the various devices which control the starting and running of the gas engine and the automatic mechanism will not operate until the circuit is closed by hand. This safety circuit includes a thermostat switch T which, by changing temperature in the room, operates to close or open the circuit and thereby control the starting and stopping of the engine, when the tripping switch is closed.

In the diagram, L and L' indicate the supply wires leading from a suitable current source, such as the battery which furnishes current for lighting on railway passenger cars and which is usually charged by a dynamo driven from the axle of the car. It is essential that the fan motor E, for the coil 5, shall be in operation at all times while the compressor is operating, and to insure this, the circuits and interlocks are so arranged that this motor must be started before any of the other mechanisms can operate. The motor E may be started by momentarily depressing a normally open push button switch marked "Fan" and it can be stopped by momentarily depressing a normally closed push button switch marked "Stop". The circuits of the motor are controlled by a starter G comprising a main contactor *g* and an auxiliary contactor *g'*. The armature circuit of the motor, shown in heavy lines, extends from supply wire L through conductor 3 to the normally open main contactor *g*, thence through arm 9 of the contactor to conductor 10, which is connected to arm 11 of contactor *g'* and to the coil of magnet 12, thence through conductor 13, starting resistance 14 and series coil 15 to the armature of motor E and thence through conductor 16 to the supply wire L'. The shunt field circuit of the motor extends from conductor 10 through conductor 17 and the field winding 18 to the supply wire L'.

The normally open push button switch marked "Fan" is in a circuit which extends from the supply wire L by conductor 19 to the magnet 20 of the contactor *g*, thence through conductor 21, resistance 22 and normally closed "stop" push button to the supply wire L'. By momentarily depressing the "fan" push button, the magnet 20 is energized and the contactor arm 9 closes the armature and field circuits and the motor starts. When the arm 9 closes, it establishes a holding circuit 20^a for the magnet and completes a circuit from supply wire L and conductor 8 through conductor 23 and shunt magnet 24 of contactor *g'*, to conductor 21 and the supply wire L'. The contactor arm 11 is centrally pivoted and the magnet 24 tends to rock it to closed position, but the magnet 12, which is in series with the motor armature, holds the contactor in open position until the starting current of the motor falls to a predetermined value, when the shunt magnet overpowers the series magnet and the contactor arm is rocked to closed position. The contactor arm is connected to the part 10 of the armature circuit, as shown, and when the arm closes, it establishes a shunt circuit 25 around the starting resistance 14, thereby cutting out said resistance. The fan motor E now operates to blow air around the coil 5 and will continue to operate until the "stop" push button is depressed to break the circuit through the magnet 20. When this occurs, the contactor *g* will open and break the circuit through the field and armature of the motor as well as through the magnets of the contactor *g'* and the contact arm of the latter will move to open position.

When the contactor *g'* closes, in starting the motor E, it makes up a circuit for the magnet 26 of a relay I, which circuit is normally open at the push button marked "Start". This circuit extends from supply wire L through conductor 27 and the "start" push button to magnet 26, thence through conductor 28 to a contact 29. An insulated contact 11^a on the contactor arm 11 engages and electrically connects this stationary contact with a contact 30 which is connected by wire 31 to conductor 21 which leads through the "stop" push button switch to the supply wire L'.

The relay circuit thus made up may be completed by momentarily depressing the "start" push button. The relay I controls the operation of an automatic motor starter N comprising a main contactor *n* and an auxiliary contactor *n'*, and the starter in turn, controls the operation of the motor D which circulates air around the condensing coil 2.

Closure of the "start" push button will not effect any result, except when the contactors of the starter G are closed and the fan motor E is running, because the circuit of the relay I is always open at the contactor *g'* when the latter is in its open position. When this push button switch is closed after the motor E has been started, the relay I operates to complete a holding circuit for its magnet in shunt to the "start" push button, this shunt extending from supply wire L through conductor 32 to a contact 33 which is connected to a contact 34 by an insulated contact 35 on the movable member of the relay, and a conductor 36 connects the contact 34 with the circuit of the relay magnet between the coil of the latter and the "start" push button.

A conductor 37 leads from the supply wire L' to a stationary contact 38 of the relay I and when the relay is closed, an insulated contact 39 connects the contact 38 with a contact 40 and makes up a circuit through the thermostat T, as follows: from the supply wire L' through conductor 37 and relay contacts 38, 39, and 40 to conductor 41, thence through coil of starter magnet 42, thence by conductor 43 to tripping switch members 44—45, thence by conductor 46 to an over-pressure switch 47, thence by conductor 48 to under-pressure switch 49, thence by conductor 50 to thermostat switch T and thence to supply wire L.

If the thermostat switch happens to be open, because the air in the room is above the predetermined temperature, no result will follow the making up of the circuit just traced by the closure of the relay I; but if the thermostat switch is closed at this time, because of lower room temperature, the magnet 42 will be energized and the

contactors of the starter N will close in succession, completing the circuits of the motor D and making up circuits for the devices which control the starting of the gas engine.

The starter N is the same as the starter G, except that the magnet 20 of the latter has a holding circuit which keeps the main contactor closed until the "stop" push button switch is opened, while the corresponding magnet 42 of the starter N has no holding circuit and is only energized while its circuit is complete through the thermostat switch, the relay I and the switches 44—45, 47 and 49. The circuits of the motor D are the same as the circuits of the fan motor E. Thus the armature circuit of the motor D extends from supply wire L through conductor 51 to arm 52 of main contactor *n*, thence through conductor 53 to the series coil 54 of contactor *n'*, thence by conductor 55 through starting resistance 56 to the series coil 57 of the motor, thence to the armature of the motor and to supply wire L', as shown. The shunt field circuit extends from conductor 53 through conductor 58 to the shunt field winding 59 and thence to the supply wire L'. The conductor 53 connects the arm 52 of the main contactor to the arm 60 of the auxiliary contactor. When the main contactor closes, it completes circuits through the series magnet 54 and the shunt magnet 61 of the auxiliary contactor simultaneously, the circuit of the latter magnet extending from supply wire L and conductor 51 through conductor 62 to the magnet 61, thence to conductor 41 and contacts of relay I and conductor 37 to supply wire L'. When the auxiliary contactor *n'* closes, it forms a shunt around the starting resistance 56 through conductor 63 and the motor D then operates at full speed.

The contactors of the starter N, which close when the thermostat switch closes, serve as relays, cooperating with the relay I, to make up circuits for the various engine controlling devices. Thus, the auxiliary contactor *n'*, in closing, connects a trunk line conductor 65 through conductor 66 and relay I to conductor 37 which is connected to the supply wire L'. The main contactor *n*, in closing, connects one terminal of the coil of relay F to supply wire L through conductors 67 and 51, and the other terminal of the coil is permanently connected to the conductor 65 by conductor 68. Hence, when the starter N operates, the relay F is energized and operates to close the ignition circuit 69 of the gas engine.

The motor 70 of the timing mechanism J is also energized upon the closure of the contactors of the starter N. The circuit of this motor extends from the trunk line conductor 65 through conductor 71 to the motor and thence through conductors 72 and 73 to a normally closed centrifugally operated switch 74 and thence by conductor 75 to the side L of the supply circuit. The governor 76 is driven by the gas engine, and opens the switch 74 after the gas engine has started and is operating under its own power, and, when the engine stops, the governor closes the switch. When the switch is opened by the governor, the circuit of the timing motor 70 will be broken and this motor will stop.

The relay M has one end of its coil connected by conductor 77 to the trunk line conductor 65 and the other terminal of the coil is connected by conductor 78 to the stationary contact 89^b on the timing mechanism. As hereinafter explained more in detail, the timing mechanism connects this relay through conductor 73 and the governor switch to the side L of the supply circuit, and the relay then closes the circuit 80 of the starting motor C which cranks the engine during the period while the relay is closed.

The magnet H has one terminal connected by conductor 81 to the trunk line conductor 65 and the other terminal is connected by wire 82 to stationary terminal 91^b of the timing mechanism. During the cranking period, the timing mechanism closes the circuit of this magnet through the centrifugally operated switch, as hereinafter described. When the magnet is energized, it operates to close a choke valve 84 on the engine, to cause enrichment of the explosive mixture. When the engine starts, the circuits through the devices M and H, as well as through the motor 70, will be broken by the governor switch.

The timing device J, comprises the small motor 70 to which is geared by suitable reduction gearing a slow moving cam shaft 85 on which are mounted six segmental cams 86, 87, 88, 89, 90, and 91, of insulating material. The cams are adapted to bear against rollers on the rear ends of switch arms 86^a to 91^a, respectively, and these arms are spring-pressed toward stationary contacts 86^b to 91^b, respectively. As shown in the diagram, the switch arms are arranged in electrically connected pairs. The pair 86^a—87^a, connected by a conductor 94, controls a relay O; the pair 88^a—89^a, connected by a conductor 95, controls the circuit through the starter relay M, and the pair 90^a—91^a, connected by a conductor 96, controls the circuit through the magnet H which operates the choke valve.

The cams 86 and 87 are set so that after a short period during the revolution of the cam shaft both of the switch arms 86^a and 87^a will be closed on their respective contacts 86^b and 87^b. When these switches are both closed, a circuit will be established through the coil of relay O from conductor 65, which is then connected to the side L' of the supply circuit, through conductor 97 to the coil 98, thence by conductor 99 to contact 87^b, thence through arm 87^a, connector 94, arm 86^a, contact 86^b and conductor 100 to the conductor 73 which leads through the governor switch to the side L of the supply circuit. The relay arm 101, in closing, will bridge contacts 102 and 103 and it will establish a holding circuit from contact 102 through arm 101, conductor 104, resistance 105, coil 98 and conductor 97 to conductor 65. The magnet will hold the arm 101 in closed position after the circuit initially established through the magnet by the switch arms 86^a—87^a is broken. The closure of the relay will also make up a circuit from conductor 73 through contact 103 and conductors 106 and 107 to the stationary contacts 88^b and 90^b, and it will complete a circuit through the clutch magnet 108 of the tripping device K as follows: from the side L of the supply circuit through conductors 75 and 73 to contact 102, thence through relay arm 101 to conductor 104, thence through coil of magnet 108 and conductor 110 to the trunk line conductor 65 which is connected, at the time, through the interlocks described, to the side L' of the supply circuit. This magnet immediately attracts its armature 111, against the action of a spring-pressed pin 112, and the upper end of steel rack rod 113, which is slidingly mounted on the armature, is drawn against the flanged end 114^a of the magnet frame 114, as shown in dotted lines, in position to be engaged by a tooth 115 on a sleeve 116 which is secured to the end of the shaft 85. This rack rod operates to open the

switch 44—45 if the engine does not start after a predetermined number of revolutions of the shaft 85. The details of the tripping device are shown in my original application before mentioned.

When the motor 70 starts, by reason of closure of the thermostat switch, and after the cams 86 and 87 have caused the closure of the circuit through the magnet of relay O, the cams 88 and 89 cause the connected switch arms 88^a and 89^a to engage the contacts 88^b and 89^b, respectively, and complete a circuit through the magnet of relay M which operates to close the circuit 80 of the starting motor C, and the engine is cranked by the latter motor. Contact 89^b is, at this time, connected to the side L' of the supply circuit through the coil of the magnet of relay M and conductor 65, and the contact 88^b is connected to the supply wire L through relay O, conductor 73, centrifugal switch 74 and conductor 75.

The cranking period of the engine depends upon the setting of the cams 88 and 89. If the engine is warm, it may start as soon as the cranking operation is commenced, and as the ignition circuit is closed by the relay F, if the engine starts after a few moments, the centrifugal governor 76 will open the switch 74 and interrupt the circuit to the motor 70 and also the holding circuit of the relay O, and thus the current to the timing mechanism will be completely cut off.

If the engine does not start within a predetermined time after the cranking operation commences, the choke valve of the engine will be closed, to enrich the mixture, while the cranking continues. The magnet H which controls the choke valve is in a circuit which is controlled by the connected arms 90^a and 91^a. While these arms are both in engagement with their respective contacts, the magnet H will be energized and the choke valve will be closed. The circuit for the magnet extends from conductor 65 through conductors 81 and 82 and the magnet coil to contact 91^b, thence through arms 91^a and 90^a to contact 90^b, thence through conductors 107 and 106 and relay O to the conductor 73. If the engine starts while the choke valve is closed, the centrifugal governor switch will break the circuit through wire 73 and the circuits through motor 70, starter relay M and choke valve magnet H and clutch magnet 108 will be interrupted.

If the engine does not start after the choking operation, the circuit through wire 73 will not be broken and the operations of cranking, without choking, and then with choking will be repeated during each succeeding revolution of the shaft 85 until the engine starts, or until the tripping device K operates to break the circuit in which are included the several safety switches, the thermostat and the magnet 42. The interruption of this circuit renders all of the engine controlling devices inoperative until the continuity of the circuit is restored by the manual resetting of the tripping device.

The tripping device can be arranged to open the switch 44—45 after any desired number of revolutions of the cam shaft, by providing a suitable number of teeth on the rack rod. If the engine does not start after a limited number of choking and cranking operations, it is desirable to throw the engine controlling devices out of action as the failure to start may be due to lack of fuel or other causes requiring personal attention. Therefore, after four or five revolutions of the crank shaft, the tripping device will operate to separate the contacts 44 and 45 and as these are in circuit with the magnet 42 of the starter N, the contactors of the starter will open the circuits of the devices which control the starting and operation of the gas engine. Before the engine can be started again, the switch 44—45 must be reset by hand.

For testing the engine controlling system while the thermostat switch is open, a switch 128 is shown for shunting the thermostat switch and similar shunting switches may be arranged around the pressure controlled switches 47 and 49.

The operation of the system will be clear from the foregoing, without further extended description. When the cooling system is to be used, the fan motor E is started by depressing the "fan" push button. This motor operates to circulate the air of the room through the refrigerating coil 5. It is essential to have this motor in operation at all times while the compressor is in operation and it may be desirable to have it operate to circulate air in the room even when the cooling system is not in use. Therefore, the circuit arrangements are such that the compressor cannot be started until after the motor E has been started, and when this motor is stopped, the gas engine will also stop.

After the fan motor E has been started, the "start" push button, when depressed, will cause the relay I to make up circuits for the starter N. The starter N is controlled by a circuit which includes the thermostat switch, trip switch 44—45, pressure controlled switches 47 and 49 and also the magnet 42 which actuates the main contactor of the starter N. When the thermostat switch closes, this starter causes motor D to circulate air or other cooling fluid around the condensing coil 2 and the closure of the starter contactors make up the circuits for the various engine controlling devices. The ignition circuit is first closed and the timing mechanism causes the starter motor to crank the engine, and during a part of the cranking operation the choke valve is closed. Also the clutch magnet which moves the rack rod into operative engagement with the timing shaft is energized. If the engine starts after one or a predetermined number of cranking and choking operations, the engine controlled switch 74 opens the circuit to the timing mechanism and the circuits which control the starter motor and the magnet for operating the choke valve and the clutch magnet are opened, while the ignition circuit, controlled by a relay connected to a circuit independent of the engine controlled switch, remains closed. If the engine does not start after a predetermined number of cranking and choking operations, the tripping device operates the circuit breaker and the magnet controlling the starter N is de-energized and the opening of the starter contactors cuts off the motor D and the various engine controlling devices.

When it is desired to discontinue the use of the apparatus for a time, the "stop" push button is depressed and this de-energizes the starter G causing the fan motor E to stop. When the contactors of the starter G open, the interlocking connection to the magnet of the relay I is broken, and when this relay opens, the interlocking connections to the starter N are broken, and when the contactors of the latter starter open, the motor D stops and the circuits which control the engine starting device are also interrupted.

What I claim is:

1. In an air cooling system, a compressor and driving means for the same, a condensing coil

and a refrigerating coil connected to the compressor, an electric fan motor for circulating air around the refrigerating coil, a starter for said motor, a normally open manually operable switch controlling the operation of said starter, an electric motor for circulating cooling fluid around the condensing coil, a starter for the latter motor and means controlled thereby for operating the compressor, and interlocking connections between said starters whereby the first mentioned starter must be closed before the second mentioned starter can be closed.

2. In an air cooling system, a compressor and driving means for the same, a condensing coil and a refrigerating coil connected to the compressor, an electric fan motor for circulating air around the refrigerating coil, a starter for said motor, a normally open manually operable switch controlling the operation of said starter, an electric motor for circulating cooling fluid around the condensing coil, a starter for the latter motor and means controlled thereby for operating the compressor, interlocking connections between said starters whereby the first mentioned starter must be closed before the second mentioned starter can be closed, and a normally open manually operable switch for initiating the closure of the second mentioned starter.

3. In an air cooling system, a compressor and driving means for the same, a condensing coil and a refrigerating coil connected to the compressor, an electric fan motor for circulating air around the refrigerating coil, a starter for said fan motor, a circuit controlling the operation of said starter including a normally open manually operable switch, an electric motor for circulating cooling fluid around the condensing coil, a starter for the latter motor, a relay controlling the operation of the last mentioned starter, a circuit for said relay controlled by said first mentioned starter and including a normally open manually operable switch, and means, controlled by the starter for the motor which circulates fluid around the condensing coil, for operating the compressor.

4. In an air cooling system, a compressor and driving means for the same, a condensing coil and a refrigerating coil connected to the compressor, an electric motor for circulating cooling fluid around the condensing coil, a starter for said motor, means controlled by said starter for operating the compressor, a normally open switch controlling the operation of said starter, an electric fan motor for circulating air around the refrigerating coil, and a starter for the latter motor controlling the operation of said switch.

5. In an air cooling system, a compressor, a condensing coil and a refrigerating coil connected to the compressor, an electric motor for circulating cooling fluid around the condensing coil, a starter for said motor, a normally open switch controlling the operation of said starter, driving means controlled by said starter for operating the compressor, an electric fan motor for circulating air around the refrigerating coil, a circuit for the fan motor, switch mechanism for closing and opening said latter circuit to start and stop said fan motor at will, and connections whereby the aforesaid starter may be made operative only while the circuit of the fan motor is closed.

6. In an air cooling system a compressor and a driving motor for the same, a condensing coil and a refrigerating coil connected to the compressor, an electric fan motor for circulating air around the refrigerating coil, a circuit for the fan motor, switch mechanism for closing and opening said circuit to start and stop said fan motor at will, starting means for said driving motor and connections whereby said latter means may be made effective only while the circuit of the fan motor is closed.

7. In an air cooling system, a compressor, driving means for the same, a condensing coil and a refrigerating coil connected to the compressor, electrically operated means for starting said driving means, an electric fan motor for circulating air around the refrigerating coil, switch mechanism for closing the circuit of said fan motor, and means controlled by said switch mechanism for making said starting means operative only while the circuit of the fan motor is closed.

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