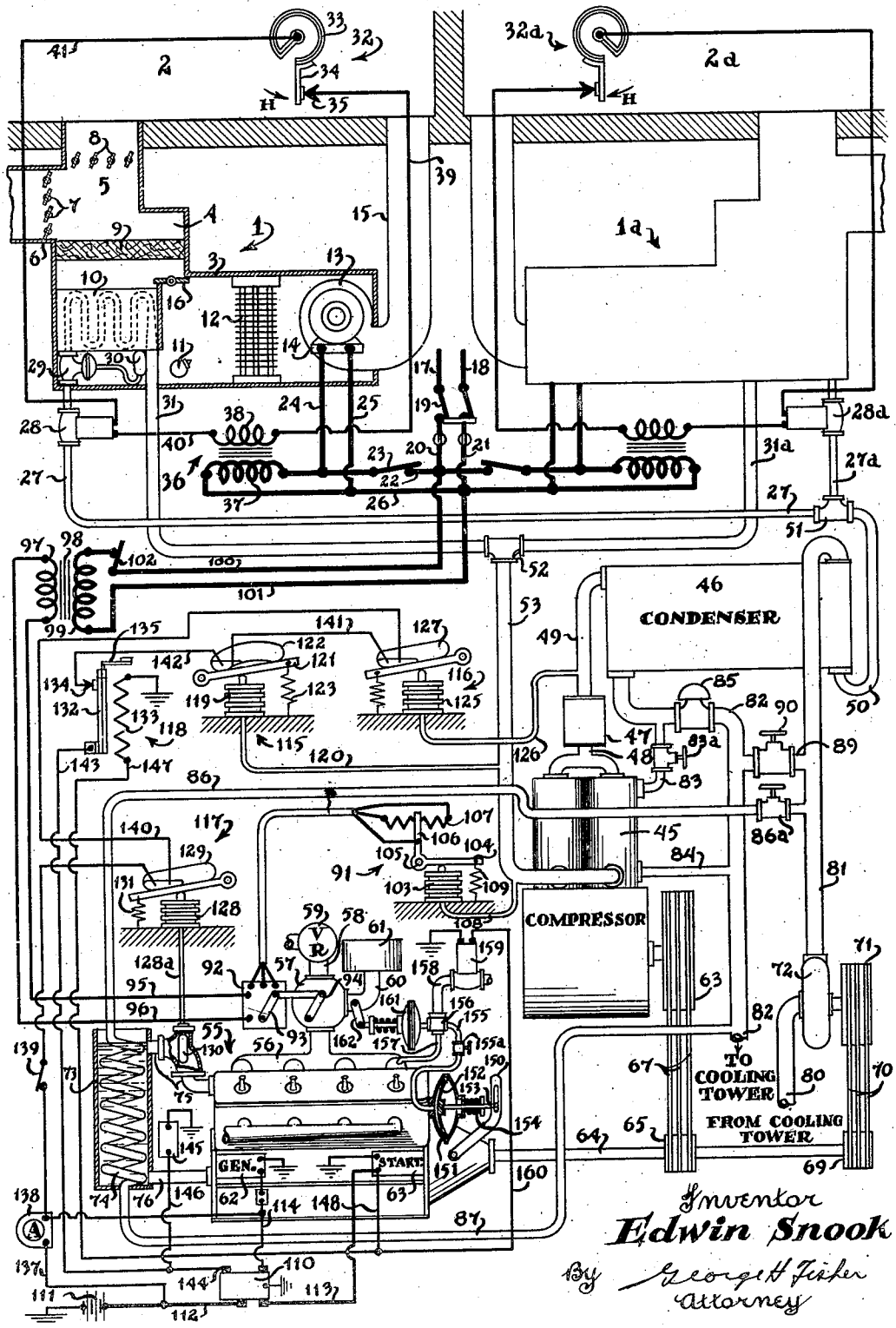
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AIR CONDITIONING

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AIR CONDITIONING

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This invention relates in general to air conditioning systems.

The primary object of my invention is to provide a novel air conditioning system which is low in first cost and which is dependable and highly economical in operation.

More specifically, it is an object of my invention to provide an automatically controlled air conditioning system of the type utilizing a compression refrigeration system in which the output of the compressor is graduatingly varied in accordance with the cooling or conditioning load on the system in such manner that refrigerating effect produced just balances the prevailing requirements for refrigeration.

In accordance with my invention, these results are achieved by utilizing an internal combustion engine for driving the compressor. This type of prime mover in its present state of development is not only very dependable and economical in operation, but also is highly flexible in output as its speed may easily be varied over a wide range without serious reduction in efficiency. My invention contemplates utilizing this variable speed characteristic of an internal combustion engine for providing a highly flexible air conditioning system which continuously provides just the required amount of air conditioning to maintain space conditions within proper values, and which readily adapts itself to any change in the conditioning load.

In accordance with my invention, I utilize a direct expansion type of cooling coil for cooling the air being conditioned, and control the throttle valve or other speed controlling device for the internal combustion engine in accordance with changes in pressure of refrigerant within the cooling coil. By this arrangement, the speed of the engine is continuously modulated in a manner to just carry the cooling load upon the cooling coil. While I prefer to modulate the engine speed in accordance with changes in the condition of the refrigerant in the cooling coil or evaporator, my invention is not limited to this specific arrangement, but may also be applied by modulating the engine speed in accordance with one or more conditions of the air being conditioned.

One of the objects of my invention, therefore, is to provide an air conditioning system in which the speed of the engine or the output of the compressor is modulated in accordance with changes in condition of the air being conditioned in a manner to provide just the necessary refrigeration effect for maintaining the condition of the air within the conditioned space at desired values.

By modulating the compressor output in accordance with the pressure or temperature of the evaporated refrigerant, a very flexible control arrangement is provided which will maintain the compressor output at the proper value to carry whatever cooling load is imposed upon the compressor. Hence, as many cooling coils as desirable may be connected to a single compressor, and the compressor operation will automatically vary to actuate whatever cooling coils are in operation.

A further object of my invention, therefore, is to provide a novel control system for a refrigeration system having a plurality of cooling coils, the control system graduatingly controlling the compressor output in a manner to just carry the combined cooling loads upon all of the cooling coils.

In utilizing an internal combustion engine for driving the compressor, provision must be made for starting and stopping the engine. Another object of the present invention consists of the provision of the engine with automatic means for causing starting of the engine when there is a demand for air conditioning and for stopping the engine whenever the demand for air conditioning disappears.

As an internal combustion engine is not adapted for starting under load, it is necessary that such engine be unloaded during the starting operation. Another object of my invention is to provide a novel unloading arrangement which unloads the engine while being started and which automatically throws the load upon the engine after it has started.

A further object of my invention is the provision of an automatic device for discontinuing attempts of the control apparatus to start the engine if for some reason the engine fails to start after a predetermined period of time.

Another object is the provision of automatic control means for stopping the engine in the event of failure of the system to operate properly.

While my invention is concerned particularly with air conditioning systems employing internal combustion engines, certain novel features are of broader application. Other objects and advantages of my invention will appear from the following description and the appended claims.

For a full description of my invention, reference is made to the following detailed description and to the accompanying drawing in which

the single figure illustrates diagrammatically one form of my invention.

Referring to the drawing, reference character 1 indicates generally an air conditioning chamber for conditioning a space 2. The conditioning chamber 1 may take any desired form and is shown herein for illustrative purposes as comprising an L-shaped casing 3 having an inlet 4 which is connected to a re-circulated air duct 5 and to a fresh air inlet duct 6. Suitable dampers 7 and 8 are provided for controlling the proportions of fresh and re-circulated air passed through the conditioning chamber. Within the inlet 4 of the conditioning chamber is an air filter 9 which may be of any suitable form. The air after passing through filter 9 flows downwardly through a direct expansion cooling coil 10 and flows from beneath said coil over a spray pipe 11 and through a heating element 12 to a fan 13 which is driven by a motor 14. The air discharged from the fan 13 is conveyed by a suitable duct 15 back to the conditioned space 2. Reference character 16 indicates a by-pass damper for by-passing a portion of the air around the cooling coil 10. This damper is normally kept closed where the dehumidifying load is relatively light. In locations where the dehumidifying load is heavy, however, this damper may be operated for increasing the dehumidifying effect of the coil 10. Suitable automatic controls for damper 16 may be provided if desired. The humidifying spray 11 and the heating element 12 are intended for winter operation. It will be understood, however, that if desired, the heating element 12 may be used for reheating during summer operation.

Reference characters 17 and 18 indicate suitable line wires which may be, for instance, 110 volts A. C. These wires are connected to a double pole switch 19 which, in turn, is connected to line wires 20 and 21. The line wire 20 is connected to a wire 22 having interposed therein a manual switch 23. This wire is connected to a wire 24 leading to the fan motor. Also connected to the fan motor is a wire 25, this wire being connected to a wire 26 which, in turn, connects to the line wire 21. When the switches 19 and 23 are closed, the fan motor 14 is energized for causing a flow of air through the conditioning chamber and to the space being conditioned. During normal operation of the system, the switches 19 and 23 are kept closed and hence the fan motor 14 operates continuously.

Reference character 27 indicates a liquid refrigerant line leading to the cooling coil or evaporator 10. Interposed in this conduit is a solenoid valve 28 for controlling the flow of refrigerant to said cooling coil. Reference character 29 indicates a suitable expansion valve of known form which acts to reduce the pressure of the refrigerant entering the cooling coil 10. This expansion valve if desired may be of the thermostatic type having a control bulb 30 which is attached to the discharge or suction line 31 which conveys evaporated refrigerant from the cooling coil.

The solenoid valve 28 is caused to open and close by means of a thermostat 32 which is located within the conditioned space 2. This thermostat may be of any suitable form and is shown herein as comprising a circular bimetallic element 33 which carries a switch blade 34 cooperating with a contact 35. When the space temperature is below a predetermined value, the bimetallic element will cause the switch blade 34 to be separated from contact 35. Upon an increase in temperature to a predetermined value, however, the switch arm 34 will be caused to engage contact 35. Reference character 36 indicates a step-down transformer, the primary 37 of which is connected to the wires 22 and 26 thereby causing the transformer to be energized whenever the fan motor 14 is running. The secondary 38 of the transformer 36 has one terminal connected to the contact 35 by a wire 39, the other terminal of said secondary being connected to the solenoid valve 28 by a wire 40. The other terminal of the solenoid valve 28 is connected to the bimetallic element of the room thermostat by a wire 41. By this arrangement, when the space temperature is low, the switch blade 34 of the thermostat is disengaged from contact 35, this causing the solenoid valve 28 to be deenergized thereby causing said valve to remain closed for preventing flow of liquid refrigerant into the cooling coil 10. When, however, the space temperature becomes too high, the thermostat 32 will cause energization of the valve 28 thereby causing said valve to open for permitting flow of refrigerant into the cooling coil.

Reference character 1*a* indicates a second conditioning chamber for conditioning a space 2*a*. The conditioning chamber 1*a* may be of the same type as the chamber 1 and may be provided with a solenoid valve 28*a* corresponding to the valve 28 of chamber 1. The valve 28*a*, in turn, is controlled by means of a thermostat 32*a* which is responsive to the temperature within the space 2*a*. This thermostat may, likewise, control the solenoid valve 28*a* in a manner to prevent flow of refrigerant into the cooling coil when the space temperature is low and to permit a flow of refrigerant into the cooling coil when the space temperature rises to a predetermined value.

The cooling coils of the conditioning chambers 1 and 1*a* are actuated by a common condensing unit, this unit consisting of a compressor 45 and a condenser 46. The discharge of the compressor 45 is connected to an oil separator 47 by means of a conduit 48, the outlet of said oil separator being connected by a conduit 49 to the refrigerant inlet of the condenser 46. The refrigerant outlet of the condenser 46 is connected to a pipe 50 which leads to a T fitting 51 to which is attached the liquid refrigerant line 27 leading to the cooling coil 10, and the liquid refrigerant line 27*a* which leads to the cooling coil located within the chamber 1*a*. The outlet or suction line 31 of the cooling coil 10 is connected to a T fitting 52 and the suction line 31*a* which leads from the cooling coil within chamber 1*a* is also connected to said fitting. The T fitting 52, in turn, is connected to a main suction line 53 which is connected to the suction side of the compressor 45. From the description thus far, it will be apparent that the compressor 45 causes chilling of the cooling coils in both chambers 1 and 1*a* and that the refrigerant flowing into each of said cooling coils is controlling by means of a thermostat responsive to the temperature of the space cooled by the respective cooling coil.

The compressor 45 is driven by means of an internal combustion engine generally indicated as 55. This internal combustion engine may be of any suitable type and is shown herein as arranged to utilize natural gas as a fuel. The engine 55 is provided with a usual intake manifold 56 to which is attached a carburetor 57, this carburetor being connected to a fuel supply pipe 58 in which is interposed a suitable

pressure reducing valve 59. The carburetor 57 is also provided with an air intake pipe 60 upon which may be mounted an air filter 61. The motor 55 is also provided with the usual electric generator 62 and with a starting motor 63.

Reference character 64 indicates a power shaft which is driven by the engine 55. Mounted upon the shaft 64 is a pulley 65 which drives through the medium of belts 67 a pulley 68 which is mounted upon the crank shaft of the compressor 45. By this arrangement, it will be apparent that the internal combustion engine 55 drives the compressor 45. Also mounted upon the shaft 64 is a pulley 69, this pulley cooperating with belts 70 to drive a pulley 71 which, in turn, drives a water circulating pump 72. The purpose of pump 72 will become apparent as this description proceeds.

Referring again to the engine 55, this is cooled by means of a tank 73 which may be open at its upper end, this tank containing coil 74 through which cooling water may be circulated. The water jacket outlet of the engine is connected to the upper end of the tank 73 by means of a conduit 75, while the water jacket inlet of the engine is connected to the bottom of the tank by a conduit 76. By this arrangement, the usual water circulating pump of the engine causes circulation of water from the engine into the top of the tank and from the bottom of the tank back to the engine. It will be understood that cooling water is circulated through coil 74 thereby causing the jacket water to be cooled while flowing through tank 73.

The purpose of the pump 72 which is driven by the engine, as previously described, is for causing circulation of cooling water through the condenser for condensing the refrigerant within said condenser. For this purpose the intake of the pump 72 is connected to a conduit 80 which may lead from any suitable source of cooling water, such for instance as a cooling tower which may be located upon the roof of the building being air conditioned. The discharge of the pump 72 is connected to a conduit 81 which leads to the cooling water inlet of the condenser 46. The cooling water outlet of the condenser 46 is connected to a pipe 82 which leads back to the cooling tower. By driving the circulating pump for the cooling water by the same prime mover which drives the compressor, the supply of cooling water to the condenser is automatically varied in accordance with the requirements for cooling water. Thus, when the compressor is operating at low speed, a relatively small amount of cooling water is needed for condensing the compressed refrigerant. At this time, the circulating pump will be operating also at low speed and hence only such relatively small quantity of cooling water will be supplied. As the compressor speed increases, more cooling water is required. At this time, however, the pump speed will also have increased and hence the supply of cooling water to the condenser will be increased. This arrangement, therefore, automatically varies the supply of cooling water in accordance with variations in operation of the system.

In accordance with my invention, I utilize the cooling water from the cooling tower for also cooling the compressor 45 and the internal combustion engine 55. In order to cool the compressor, a pipe 83 is connected into conduit 82, this pipe conveying water to the inlet of the compressor water jacket. The outlet of the compressor water jacket is connected by a pipe 84 to the conduit 82. Interposed in the conduit 82 between the connections with pipes 83 and 84 is a spring loaded reducing valve 85. The purpose of this valve is to interpose sufficient resistance to the flow of water through the conduit 82 such as will cause a flow of a portion of the water through the compressor jacket. Located in the pipe 83 is a control valve 83a. By adjusting this valve, the flow of cooling water through the compressor jacket may be regulated.

In order to cool the internal combustion engine 55, a pipe 86 is connected into the water conduit 81, this pipe 86 conveying cold water from the cooling tower to the inlet of the cooling coil 74 which is located within the cooling tank 73 for the engine 55. The outlet of this cooling coil 74 is connected by a pipe 87 to the conduit 82. Due to the resistance offered by the reducing valve 85, it will be apparent that water will be forced from the pipe 81 through the cooling coil 74 to the pipe 82. Interposed in the conduit 86 is a control valve 86a by which the flow of cooling water through the cooling coil 74 may be controlled.

Interposed between the conduits 81 and 82 is a by-pass 89 having located therein a valve 90. The purpose of this by-pass is to permit a portion of the cooling water from the cooling tower to by-pass the condenser and the cooling coil 74, thereby flowing directly back to the cooling tower. By this arrangement, a greater amount of cooling water can be made to flow through the cooling tower than flows through the condenser and cooling coil 74, this permitting further cooling of the cooling water by the cooling tower. The valve 90 therefore provides a regulating means for controlling the temperature of the water leaving the cooling tower.

While I have shown the cooling tank 73 and coil 74 for indirectly cooling the engine by the condenser cooling water, it will be apparent that if desired, the condenser cooling water may be passed directly through the engine water jacket. In localities where the water is impure, however, the arrangement which I have disclosed is preferable.

My invention contemplates controlling the speed of the engine graduatingly in accordance with the refrigeration load upon the system. For this purpose, I prefer to control the throttle valve of the engine in accordance with the suction or low side pressure within the refrigeration system. In this case, this result is achieved by the use of a suction pressure controller generally indicated as 91 which controls a proportioning motor 92, this proportioning motor having an operating arm 93 which is connected by suitable linkage to the throttle valve lever 94 of the carburetor 57. The proportioning motor 92 may be of any desired type and is preferably of the type shown and described in Patent No. 2,028,110 issued to Daniel G. Taylor on January 14, 1936. This type of proportioning motor is adapted to be controlled by means of a potentiometer and causes its operating shaft to assume an angular position corresponding to the position of the potentiometer slider upon its resistance. Motor 92 receives its source of power through wires 95 and 96 which are connected to the secondary 97 of a step-down transformer 98. The primary 99 of transformer 98 is connected by wires 100 and 101 to the line wires 20 and 21. If desired, a switch 102 may be interposed in

wire 100 for deenergizing transformer 98 during winter operation of the system.

The suction pressure controller 91 comprises a bellows 103, this bellows being fixedly secured at its lower end and being arranged to cooperate with the actuating arm 104 of a bell-crank lever which is pivoted at 105, this bell-crank lever including a control arm 106 which cooperates with a resistance 107 to form a control potentiometer. This potentiometer is connected to the proportioning motor as indicated. The interior of the bellows 103 is connected to the suction line 53 by a conduit 108. Upon a rise in suction pressure, the bellows 103 will expand, this causing movement of the control arm 106 to the left across control resistance 107, this, in turn, resulting in a follow-up movement by the proportioning motor 92 in a direction for opening the engine throttle valve. Conversely, upon a fall in suction pressure, the bellows 103 will contract under the action of spring 109, this causing movement of the control arm 106 in the opposite direction which results in a follow-up movement by the proportioning motor 92 in a direction to close the engine throttle valve. The control arrangement just described, therefore, acts to increase the flow of fuel to the engine and hence to increase the engine speed when the suction pressure increases, and to decrease the engine speed when the suction pressure decreases. The controller 91 may be so designed and adjusted as to maintain the suction pressure at such a value that the cooling coil temperature is lowered sufficiently to both cool and dehumidify the air. For instance, assuming the "Freon" is used as the refrigerant, the controller 91 may be arranged so that the control arm 106 engages the right-hand end of resistance 107 when the suction pressure falls to 34 pounds per square inch, and engages the opposite end of said resistance when the suction pressure rises to 36 pounds per square inch.

My invention contemplates also the provision of automatic means for starting the engine when cooling is required, and for stopping the engine when the demand for cooling disappears. My invention also contemplates the provision of safety controls for automatically placing the engine out of operation whenever the system fails to function correctly. This automatic arrangement for starting and stopping the engine will now be described in detail.

Reference character 110 indicates a starting relay for controlling the starting motor 63. This relay may be of any suitable type but is preferably of the type shown and described in Patent No. 1,773,913 issued to L. K. Loehr et al. on August 26, 1930. This starting relay is so arranged that upon the closing of a control circuit, a magnetic device is energized which causes pulling in of a switch in the starter circuit. For this purpose, the relay 110 is connected to a storaeg battery 111 by means of a wire 112. Another terminal of the relay is connected to the starting motor 63 by means of a wire 113. One terminal of the starting motor and the battery are each grounded and hence upon the closing of the relay switch, a circuit through the starting motor is completed. The relay 110 is also arranged to open the starting motor circuit when the engine starts and is further arranged to maintain such circuit open so long as the engine is in operation as determined by operation of the generator 62. For this purpose, the generator 62 is connected to a terminal of relay 110 by a wire 114.

For controlling the control circuit of the starting relay 110 are provided a suction pressure controller 115, a high pressure cut-out 116, a motor temperature thermostat 117 and a thermal cut-out 118.

Referring to the suction pressure controller 115, this controller may be of any suitable form and is shown herein as comprising a bellows 119 which is mounted upon a suitable fixed support and which has the interior thereof connected by a tube 120 to the suction line 53. The bellows 119 is arranged to actuate the pivoted mercury switch carrier 121 which carries a mercury switch 122. The free end of the switch carrier 121 is connected to a spring 123 which urges said carrier downwardly against the bellows 119. When the suction pressure rises above a predetermined value, the bellows 119 will expand against the action of spring 123, this causing tilting of the mercury switch 122 to closed position. When the suction pressure falls, however, the bellows 119 will contract under the action of spring 123, this causing tilting of the mercury switch 122 towards open position. The controller 115 is preferably of the type having a wide differential and for this purpose the mercury switch 122 is illustrated as being of the bent type. Assuming that "Freon" is used as the refrigerant, this controller may be so designed and adjusted that the mercury switch 122 is tilted to open position when the suction pressure falls to, for instance, 25 pounds per square inch and to tilt to closed position when the suction pressure rises to around 40 pounds per square inch.

Referring to the high pressure cut-out 116, this controller may be similar to the controller 115 and comprises a bellows 125 which is connected to the compressor outlet pipe 49 by a tube 126. The bellows 125 actuates through a suitable switch carrier a mercury switch 127. This controller is provided for stopping the system in the event of failure of flow of cooling water to the condenser and is arranged to cause opening of the mercury switch 127 whenever the pressure of the refrigerant at the compressor discharge rises above a maximum desired value, for instance, 175 pounds per square inch (assuming that "Freon" is used as the refrigerant).

The engine temperature responsive thermostat 117 comprises a bellows 128 which is arranged for actuating the mercury switch 129. Bellows 128 is connected by a capillary tube 128a to a control bulb 130 which is located in the jacket discharge 75 of engine 55. The bulb, tube and bellows contain a suitable volatile fluid whereby the pressure within bellows 128 varies in accordance with changes in temperature of the engine cooling water. So long as the cooling water temperature is below a maximum, the bellows 128 will remain contracted by a spring 131 sufficiently to hold mercury switch 129 in closed position. When, however, the engine temperature exceeds a proper operating value, for instance 175° F., the bellows 128 will expand sufficiently to tilt mercury switch 129 to open position.

The thermal cut-out 118 comprises a bimetallic element 132 which is subjected to the influence of a heating element 133. Bimetallic element 132 carries a contact which cooperates with a contact 134 for forming a switch. When the heating element 133 is unheated, the bimetallic element 132 will assume a position in which the contacts are closed. When, however, the element 133 rises to a predetermined temperature, the bimetallic element 132 will warp towards the

left, thereby disengaging its contact from the contact 134. A spring clip 135 is provided which locks the bimetallic element 132 away from the contact 134 whenever said element warps sufficiently to cause disengagement of its contact from contact 134. Thus, whenever heating element 133 is raised to a predetermined temperature, the bimetallic element 132 will cause opening of the contacts and the contacts will be held open until the clip 135 is manually reset.

Each of the mercury switches 122, 127 and 129 and the thermal cut-out 118 are connected in series for controlling the control circuit of the starting relay 110. For this purpose, a wire 137 is connected to the storage battery, this wire leading through an ammeter 138 and a manual switch 139 to the mercury switch 129. The mercury switch 129 is, in turn, connected to mercury switch 127 by a wire 140 and said latter mercury switch is connected by a wire 141 to the mercury switch 122, this mercury switch, in turn, being connected by a wire 142 to contact 134 of the thermal cut-out 118. The bimetallic element 132 of the thermal cut-out 118 is connected by a wire 143 to the control terminal 144 of the starting relay 110. The wire 143 is also connected to an ignition coil 145 by means of wire 146.

In normal operation of the system, the mercury switches 129 and 127, and the thermal relay 118 will remain in circuit closing position. Therefore, when the suction pressure in conduit 53 rises sufficiently to cause making of mercury switch 122, the circuit from the battery through each of the mercury switches and the thermal cut-out will be completed, this causing energization of the ignition coil 145 for the engine, and also causing energization of the control circuit for starting relay 110. This, in turn, will cause operation of the starting motor for starting the engine, and when the engine is started, the relay 110 will automatically deenergize the starting motor. The motor will then operate under the control of the suction pressure controller 91 until such time as the suction pressure in line 53 may fall sufficiently for causing controller 115 to open mercury switch 122. This will result in deenergizing the ignition coil 145, thereby stopping the engine.

The purpose of the starting relay 118 is to deenergize the control circuit for the relay 110 if for some reason the engine should fail to start within a predetermined period of time. For this purpose, the heating element 133 of cut-out 118 is connected by wires 147 and 148 to the starting motor terminal. The heating element 133 is, therefore, energized whenever the starting motor 63 is operating. If the engine starts normally, the starting motor and heating element will be energized for only a short time, and hence the heating element will not become sufficiently heated to cause opening of the contacts. If, however, the starting motor 63 should operate for a predetermined period of time, for instance, 30 seconds without starting the engine, the heating element 133 will reach such a temperature as to cause bimetallic element 132 to open the contacts. This will break the control circuit for relay 110, thereby causing deenergization of the starting motor and of the ignition coil. The clip 135 will then hold the contacts of the controller 118 in open position thereby preventing closing of these contacts upon cooling of heating element 133. The control arrangement just described, therefore, acts to place the system out of operation if the engine should fail to start.

In order to start the engine 55, it is necessary that the compressor load be removed as internal combustion engines are not adapted for starting under load. In order to unload the compressor while the engine is being started, I provide an automatic clutching device which will now be described. Reference character 150 indicates a clutch operating lever. This lever is arranged to be actuated by a diaphragm motor 151, this motor including a diaphragm 152 attached to a stem 153 which, in turn, is attached to the operating lever 150. A compression spring 154 urges the stem 153 and the diaphragm 152 towards the right, this causing biasing of the clutch operating lever 150 in a manner to disengage the clutch. The diaphragm 152 is located within a suitable housing and such housing is connected by a small tube 155 to a fitting 156 which, in turn, is connected to the intake manifold 56 by means of a tube 157. Also attached to the fitting 156 is a tube 158 to which is connected a solenoid valve 159. This solenoid valve is of the type which opens when energized and which closes when deenergized. One terminal of solenoid valve 159 is grounded and the other terminal thereof is connected to the starting motor terminal by means of wires 148 and 160.

Assuming that the engine is at rest and the starting motor deenergized, the solenoid valve 159 will be deenergized thereby causing it to remain closed. At this time, also the pressure in the intake manifold of the engine will be equal to atmospheric pressure, and this will permit the diaphragm 152 to be moved by spring 154 in a direction for disengaging the clutch. When the starting motor is energized for starting the engine, the solenoid valve 159 will be caused to open. This will permit a flow of air through tubes 158 and 157, which prevents any reduced pressure within the intake manifold from affecting the diaphragm 152. Therefore, while the engine is being started, the clutch will be held in disengaged position by spring 154, and the vacuum developed within the intake manifold will have no effect. After the engine starts, however, the starting motor is automatically deenergized and simultaneously, the solenoid valve 159 is deenergized thereby causing said valve to close. This will prevent flow of air into tubes 158 and 157 thereby causing the pressure within said tubes and in the housing surrounding the left side of the diaphragm to be reduced to that prevailing within the intake manifold. This will cause the diaphragm 152 to be urged to the left thereby causing rotation of lever 150 for engaging the clutch. The automatic clutching mechanism just described, therefore, causes disengagement of the clutch when the engine is stopped and causes engagement of said clutch when the engine has started.

My invention also includes an automatic choking arrangement for choking the engine during the starting of operation. For this purpose, a diaphragm motor 161 is provided. This motor is similar to but smaller than the clutch operating diaphragm motor previously described. This diaphragm motor is arranged to actuate the choke arm 162 of the carburetor. When the engine is at rest, the spring of the diaphragm motor urges said motor in a direction for rotating the choke arm 162 to choking position. After the engine is started, the vacuum developed within the intake manifold causes movement of the motor for rotating the choking arm 162 to running position. Preferably, the diaphragm

motor 160 is arranged so as to cause movement of the choke to running position before the clutch operating mechanism causes engagement of the clutch. This result may be obtained by making the spring of the choke diaphragm motor lighter in relation to diaphragm size than the spring of the clutch operating diaphragm motor. Also, by the use of the restrictor 155a the exhausting of the diaphragm chamber for the clutch operating diaphragm motor may be restricted, thereby causing a lapse of time to occur before engagement of the clutch, this allowing the choke to be moved to running position before the clutch engages. This restrictor also acts to cause gradual engagement of the clutch.

Operation

If neither of the thermostats 2 or 2a are calling for cooling, the refrigerant valves 28 and 28a will be closed, this preventing flow of refrigerant into either evaporating coil. Continued operation of the compressor after this occurs will result in pumping down the low side or suction pressure to such a valve that the suction pressure controller 115 opens the control circuit for the starting relay, this placing the engine out of operation.

If now should the temperature in either space 2 or 2a become excessive, the thermostat in such space will cause opening of its respective refrigerant valve. This will permit flow of refrigerant into the cooling coil in which such refrigerant evaporates for causing a cooling action. Due to this evaporation of refrigerant within the cooling coil, the suction pressure will eventually increase to such a value that the suction pressure controller 115 causes closing of the starting circuit, thus energizing the ignition coil for the engine and causing operation of the starting motor. At this time, the choke will be in choking position and the clutch will be disengaged. During the operation of the starting motor, the solenoid valve 159 will be held open, thereby preventing the slight vacuum in the engine occurring during the starting operation from releasing the choke or causing engagement of the clutch. When, however, the engine starts, the starting motor is automatically deenergized and the solenoid valve 159 allowed to close. This closing of the valve 159 permits the vacuum within the intake manifold of the engine to affect the choke diaphragm motor for releasing the choke and then for affecting the clutch diaphragm motor for gradually engaging the clutch. Engagement of the clutch will cause operation of the compressor and will also cause operation of the water circulating pump for circulating water to cool the condenser, the compressor, and the engine.

Operation of the compressor will cause the evaporated refrigerant to be withdrawn from the cooling coil and compressed, this compressed refrigerant being condensed for return to the cooling coil.

From this point, the speed of the engine will be modulated in accordance with the cooling load upon the compressor by means of the suction pressure controller 91. Thus, as the temperature of the air flowing across the cooling coil increases, an increased amount of refrigerant will be evaporated thereby causing the suction pressure of the refrigeration system to increase. In response to this increase in suction pressure, the controller 91 will cause operation of the proportioning motor 92 for increasing the opening of the throttle valve. This will cause the engine speed to be increased thereby increasing the action of the compressor for counteracting the increase in suction pressure. Conversely, when the temperature of the air flowing across the cooling coil 10 decreases, less refrigerant will be evaporated, this causing the suction pressure to decrease which, in turn, results in reducing the speed of the engine. The suction pressure controller 91, therefore, acts in a manner to maintain a constant suction pressure and to vary the compressor speed in accordance with the cooling load.

If now should the temperature in the other space become excessive, the other solenoid valve will be opened, thus permitting a flow of refrigerant into the other cooling coil. The evaporation of refrigerant in this second coil will cause an increased amount of evaporated refrigerant to flow to the compressor, this resulting in the suction pressure rising. In response to this rise in suction pressure of the system, the engine speed will increase just sufficiently to maintain the suction pressure substantially constant. The control system which I have disclosed, therefore, provides for varying the engine speed in accordance with the number of cooling coils in operation, and also in accordance with the total cooling load upon the cooling coils in operation.

It will be apparent that when the temperatures of both spaces fall below the settings of the respective thermostats, both refrigerant valves will be closed thereby preventing entrance of refrigerant into the cooling coils. This will prevent further operation of the cooling coils thereby preventing the system from overcooling when operating. Whenever both solenoid valves are closed, the system will automatically shut down due to the suction pressure being pumped down sufficiently low for causing controller 115 to break the control circuit for the internal combustion engine.

It should be noted that during operation of the system, the speed of the water circulating pump is varied simultaneously with change in speed of the compressor, this causing the supply of cooling water for the system to be automatically varied in accordance with the operation of the system, thereby providing just the proper quantity of cooling water for satisfying the requirements for cooling.

From the foregoing, it will be seen that my invention provides for automatically controlling an air conditioning system utilizing an internal combustion engine as a source of power. While my invention is more concerned with air conditioning systems utilizing internal combustion engines, certain phases of the invention are of broader application. Also many changes which are within the scope of my invention will be apparent to those skilled in the art. I, therefore, desire to be limited only by the scope of the appended claims and the prior art.

I claim as my invention:

1. In an air conditioning system, in combination, an evaporator, means for causing air to be conditioned to flow in heat exchange relationship with said evaporator, a compressor connected to said evaporator, an internal combustion engine for driving said compressor, control means for graduatingly varying the output of said engine, means responsive to a load condition on the system for graduatingly actuating said control means in a manner to vary gradu-

atingly the output of said engine in accordance with changes in said load condition, a control circuit for automatically starting and stopping said engine, automatic switching means in said circuit for causing starting of said engine when air conditioning is required, automatic clutching mechanism interposed between said internal combustion engine and said compressor, said automatic clutching mechanism comprising a device responsive to vacuum developed upon operation of said engine for causing engagement of said clutching mechanism, and means actuated by said control circuit for preventing operation of said vacuum responsive device until after said engine is started.

2. In an air conditioning system, in combination, an evaporator, means for causing air to be conditioned to flow in heat exchange relationship with said evaporator, a compressor connected to said evaporator, an internal combustion engine for driving said compressor, control means for graduatingly varying the output of said engine, means responsive to a load condition on the system for graduatingly actuating said control means in a manner to vary graduatingly the output of said engine in accordance which changes in said load condition, a control circuit for automatically starting and stopping said engine, automatic switching means in said circuit for causing starting of said engine when air conditioning is required, and automatic clutching mechanism interposed between said internal combustion engine and said compressor, said automatic clutching mechanism comprising a device responsive to vacuum developed upon operation of said engine for causing engagement of said clutching mechanism.

3. In a system of the class described, in combination, an internal combustion engine, means driven by said internal combustion engine, a control circuit for starting and stopping said engine, automatic switching means in said circuit arranged for causing starting of said engine when said driven means requires engine operation, and automatic means controlled by the operation or non-operation of said engine for unloading the engine during the starting operation and for automatically loading it after the engine starts, said last named means including a device actuated by said control circuit for preventing loading of said engine until after it is started.

4. In an air conditioning system, in combination, an evaporator, means for causing air to be conditioned to flow in heat exchange relationship with said evaporator, a compressor connected to said evaporator, an internal combustion engine for driving said compressor, control means for graduatingly varying the output of said engine, means responsive to a load condition on the system for graduatingly actuating said control means in a manner to vary graduatingly the output of said engine in accordance with changes in said load condition, control circuit means for automatically starting and stopping said engine, switching means associated with said circuit means for starting said engine, means for unloading said engine, and control means for causing operation of said unloading means while said engine is being started and for automatically causing said unloading means to be placed out of operation after said engine has started.

5. In an air conditioning system, in combination, an evaporator, means for causing air to be conditioned to flow in heat exchange relationship with said evaporator, a compressor connected to said evaporator, an internal combustion engine for driving said compressor, control means for graduatingly varying the output of said engine, means responsive to a load condition on the system for graduatingly actuating said control means in a manner to vary graduatingly the output of said engine in accordance with changes in said load condition, control circuit means for automatically starting and stopping said engine, switching means associated with said circuit means for starting said engine, means for unloading said engine, and control means for causing operation of said unloading means while said engine is being started and for automatically causing said unloading means to be placed out of operation after said engine has started, said control means including a device controlled by said control circuit and a device responsive to a condition of the engine which varies when said engine stops and starts.

6. In an air conditioning system for a space, in combination, cooling means for said space including an evaporator in heat transfer relationship with said space, a compressor connected to said evaporator, an internal combustion engine connected to said compressor for driving the same, said engine having an intake manifold, means including a thermostat responsive to the temperature of the space for starting said engine when space temperature rises to a predetermined value, unloading means for said engine to permit the same to start while in an unloaded condition, and means actuated by a predetermined low intake manifold pressure produced by operation of the engine for rendering said unloading means inoperative to thereby cause said engine to assume its load after starting.

7. In an air conditioning system for a space, in combination, cooling means for a space including an evaporator in heat transfer relationship with said space, a compressor connected to said evaporator, an internal combustion engine connected to said compressor for driving the same, said engine having a speed controller, a starting circuit means, and an intake manifold, means including a thermostat responsive to space temperature for closing said starting circuit means to start said engine when space temperature rises to a predetermined value, unloading means for permitting said engine to start in an unloaded condition, means actuated by a predetermined low intake manifold pressure produced by operation of the engine for rendering said unloading means inoperative to thereby cause said engine to assume its load after starting, and means influenced by the pressure in said evaporator for actuating said speed controller in a manner to increase the engine speed upon increase in said pressure while decreasing the speed upon decrease in said pressure.

8. In an air conditioning assembly, a compressor having a discharge pipe for compressed refrigerant fluid and a suction pipe for expanded refrigerant fluid, an internal combustion engine drivingly connected to said compressor, an ignition circuit for said internal combustion engine, said ignition circuit including a switch, means responsive to a function of the operation of said compressor for controlling said switch, a valve in said discharge pipe, an electromagnet holding said valve in open position, said electromagnet having an operating circuit including a thermostat, the construction being such that said valve will be held in open position by said electromag-

net, when the circuit is completed through the thermostat, whereby when said thermostat moves to open the circuit through said electromagnet said valve will close, altering the operation of said compressor to operate said switch to open said ignition circuit.

9. In an air conditioning system for a space, in combination, cooling means for said space including an evaporator in heat transfer relationship with said space, a compressor connected to said evaporator, an internal combustion engine for driving said compressor, an ignition circuit for said engine, a speed controller for said engine, pressure responsive means influenced by the pressure in said evaporator for positioning said controller in a manner to increase the speed of the engine upon increase in said pressure and to decrease the speed of the engine upon decrease in said pressure, valve means for controlling the flow of refrigerant into said evaporator, means responsive to the temperature of said space for closing said valve means when the temperature falls to a predetermined value, and means influenced by the pressure in said evaporator for opening said ignition circuit in response to decrease in pressure in said evaporator caused by closing of said valve means.

10. In an air conditioning system, in combination, a cooling coil in heat exchange relationship with the air to be conditioned, a compressor connected to said cooling coil for withdrawing evaporated refrigerant therefrom and for compressing such evaporated refrigerant, a condenser for condensing the compressed refrigerant, pumping means for supplying a cooling medium to said condenser, a variable speed prime mover connected to both said compressor and said pumping means to thereby cause said compressor and pumping means to operate at speeds determined by the speed of the prime mover, and control means responsive to a load condition on the system for varying the speed of the prime mover in accordance with changes in load.

11. In an air conditioning system for conditioning a space, in combination, an evaporator in heat exchange relationship with said space, a compressor connected to said evaporator for withdrawing evaporated refrigerant therefrom, an internal combustion engine for driving said compressor, a speed controller for graduatingly varying the speed of said internal combustion engine, means influenced by a condition of the refrigerant which changes upon change in load on the evaporator for controlling said speed controller in a manner for operating the engine at the proper speed for carrying the load, an ignition circuit for said engine, a starting motor for said engine, means including a thermostat responsive to the temperature of the space for energizing said ignition circuit upon rise in space temperature to a value requiring cooling, and means energized with said ignition circuit for energizing said starting motor for starting said engine and responding to operation of said engine for deenergizing said starting motor.

12. In an air conditioning system for conditioning a space, in combination, an evaporator in heat exchange relationship with said space, a compressor connected to said evaporator for withdrawing evaporated refrigerant therefrom, an internal combustion engine for driving said compressor, a speed controller for graduatingly varying the speed of said internal combustion engine, means responsive to a first condition which is indicative of the load on the system for controlling said speed controller in a manner to graduatingly vary the engine speed in accordance with said load condition, an ignition circuit for the engine, a starting motor for the engine, means including a device responsive to a condition of the air in said space which is affected by said evaporator for energizing said ignition circuit when said condition varies to a value indicating that conditioning of the air is desirable, and means energized with said ignition circuit for energizing said starting motor for starting said engine and responding to operation of said engine for deenergizing said starting motor.

13. In an air conditioning system for conditioning a space, in combination, an evaporator in heat exchange relationship with said space, a compressor connected to said evaporator for withdrawing evaporated refrigerant therefrom, an internal combustion engine for driving said compressor, a speed controller for graduatingly varying the speed of said internal combustion engine, means responsive to a first condition which is indicative of the load on the system for controlling said speed controller in a manner to graduatingly vary the engine speed in accordance with said load condition, an ignition circuit for the engine, a starting motor for said engine, unloading means for said engine, means including a device responsive to a condition of the air in said space which is affected by said evaporator for energizing said ignition circuit when said condition varies to a value indicating that conditioning of the air is desirable, and means energized with said ignition circuit for controlling said unloading means and said starting motor, said last mentioned means responding to operation of said engine for placing said starting motor and unloading means out of operation.

14. In an air conditioning system for conditioning a space, in combination, an evaporator in heat exchange relationship with said space, a compressor connected to said evaporator for withdrawing evaporated refrigerant therefrom, an internal combustion engine for driving said compressor, an ignition circuit for the engine, a starting motor for said engine, electrical means for unloading said engine when energized, means including a device responsive to a condition of the air in said space which is affected by said evaporator for energizing said ignition circuit when said condition varies to a value indicating that conditioning of the air is desirable, and means energized concurrently with said ignition circuit for energizing said unloading means and said starting motor, said last mentioned means responding to operation of said engine for deenergizing said starting motor and unloading means to place them out of operation.

15. In an air conditioning system for conditioning a space, in combination, an evaporator in heat exchange relationship with said space, a compressor connected to said evaporator for withdrawing evaporated refrigerant therefrom, an internal combustion engine for driving said compressor, a starting motor for said engine, loading and unloading means for said engine, said loading and unloading means including electromagnetic means and being incapable of loading the engine until a lapse of time following actuation of said electromagnetic means, switching means for controlling said starting motor and said electromagnetic means, and means responsive to engine operation for positioning said switching means in a manner to place said start-

ing motor out of operation when the engine is running and to cause loading of said engine.

16. In an air conditioning system for conditioning a space, in combination, an evaporator in heat exchange relationship with said space, a compressor connected to said evaporator for withdrawing evaporated refrigerant therefrom, an internal combustion engine for driving said compressor, a starting motor for said engine, loading and unloading means for said engine, said loading and unloading means including an electromagnetically actuated valve said valve when open causing unloading of the engine, and being incapable of causing loading of the engine until a lapse of time following closure of said valve, means including a device responsive to the condition of the air in said space which is affected by the evaporator for starting and stopping said engine, and switching means actuated in response to engine operation for controlling said starting motor and said electromagnetically actuated valve.

17. In an air conditioning system for conditioning a space, in combination, an evaporator in heat exchange relationship with said space, a compressor connected to said evaporator for withdrawing evaporated refrigerant therefrom, an internal combustion engine for driving said compressor, loading and unloading means for said engine, said last recited means including an electro magnetically actuated valve arranged when open to cause unloading of the engine, said valve being incapable of causing loading of the engine until a lapse of time following closure of said valve, means including a device responsive to the condition of the air in said space which is affected by the evaporator for starting and stopping said engine, and switching means actuated in response to engine operation for controlling said electromagnetically actuated valve.

18. In an air conditioning system for conditioning a space, in combination, an evaporator in heat exchange relationship with said space, a compressor connected to said evaporator for withdrawing evaporated refrigerant therefrom, an internal combustion engine for driving said compressor, a control circuit for automatically starting and stopping said engine, automatic switching means in said circuit for causing starting of the engine when air conditioning is required, and automatic clutching mechanism interposed between said internal combustion engine and said compressor, said automatic clutching mechanism comprising a device responsive to vacuum developed upon operation of the engine for causing engagement of the clutching mechanism.

19. An air conditioning system for conditioning a space, comprising, in combination, a conditioning chamber, fan means for causing air to flow through said chamber to said space, means including a direct expansion cooling coil for cooling the air flowing through said chamber, a compressor connected to said direct expansion cooling coil for withdrawing evaporated refrigerant therefrom, an internal combustion engine including ignition means, starting means and speed governing means for driving said compressor, electrical means energizable to start said internal combustion engine and to position the speed governing means thereof in at least two different positions and including a circuit for the ignition means and a circuit for the starting means, means responsive to a load condition on the system in control of said electrical means to start the engine and to position said speed governing means in its different positions, and means to deenergize said starter after said engine is in operation.

20. An air conditioning system for conditioning a space, comprising, in combination, a conditioning chamber, fan means for causing air to flow through said chamber to said space, means including a direct expansion cooling coil for cooling the air flowing through said chamber, a compressor connected to said direct expansion cooling coil for withdrawing evaporated refrigerant therefrom, an internal combustion engine for driving said compressor and including a fuel valve, ignition means and starting means, electrical circuits in control of the ignition means and starting means of the engine, a switch in control of said circuits, means to render said starting means inoperative after the engine had been placed in operation and while said switch is closed, electrical means in control of the fuel valve of the engine energizable in a manner to position the fuel valve in at least two different positions whereby the speed of the engine may be varied when the engine is in operation, and an electrical controller in control of the energization of said electrical means, said switch and said electrical controller both being responsive to a single condition which is indicative of the load on the system.

21. In a refrigeration system, in combination, an evaporator, a compressor for supplying refrigerant to said evaporator, an internal combustion engine for driving said compressor, a starting motor for the engine, unloading means for unloading the engine during starting thereof and including an electromagnetic valve, and means to energize said starting motor and valve simultaneously and to maintain said valve open until the starting motor is deenergized, the arrangement being such that the load is not placed on said engine until said valve is deenergized.

22. In a refrigeration system, in combination, an evaporator, a compressor for supplying refrigerant to said evaporator, an internal combustion engine for driving said compressor, a starting motor for the engine, unloading means for unloading the engine during starting thereof and including an electromagnetic valve, means to energize said starting motor and valve simultaneously and to maintain said valve open until the starting motor is deenergized, the arrangement being such that the load is not placed on said engine until said valve is deenergized, and means for automatically varying the speed of said engine in accordance with the load on the system while the engine is in operation.

23. In an air conditioning system for conditioning a space, in combination, an evaporator in heat exchange relationship with said space, a compressor connected to said evaporator for withdrawing evaporated refrigerant therefrom, an internal combustion engine for driving said compressor, a starting motor for said engine, loading means for said engine, time delay means in control of said loading means, and control means responsive to engine operation for automatically rendering said starting motor inoperative and for simultaneously placing said time delay means in operation when the engine is in operation whereby the load is applied to said engine only after a delayed interval following deenergization of said starting motor.

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