

Sept. 22, 1942.

E. R. WOLFERT

2,296,304

REFRIGERATING APPARATUS

Filed April 23, 1938

3 Sheets-Sheet 1

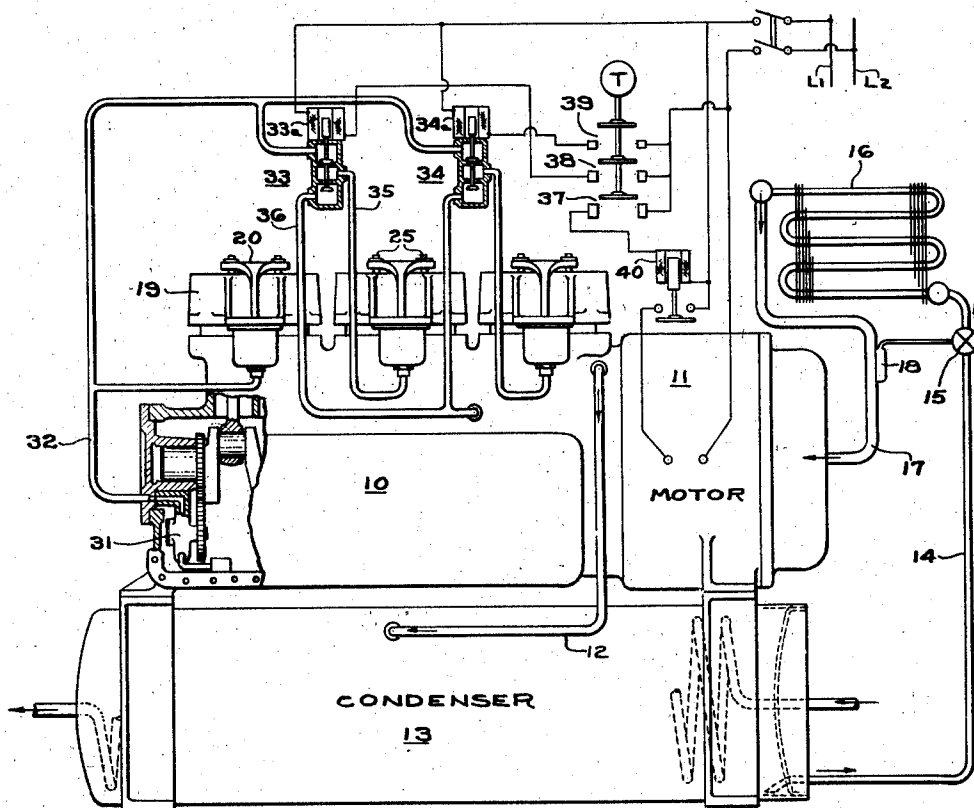


FIG. 1.

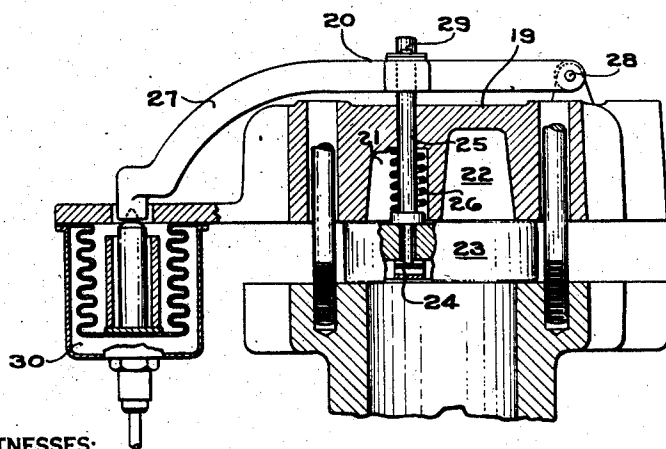


FIG. 2.

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3 Sheets-Sheet 2

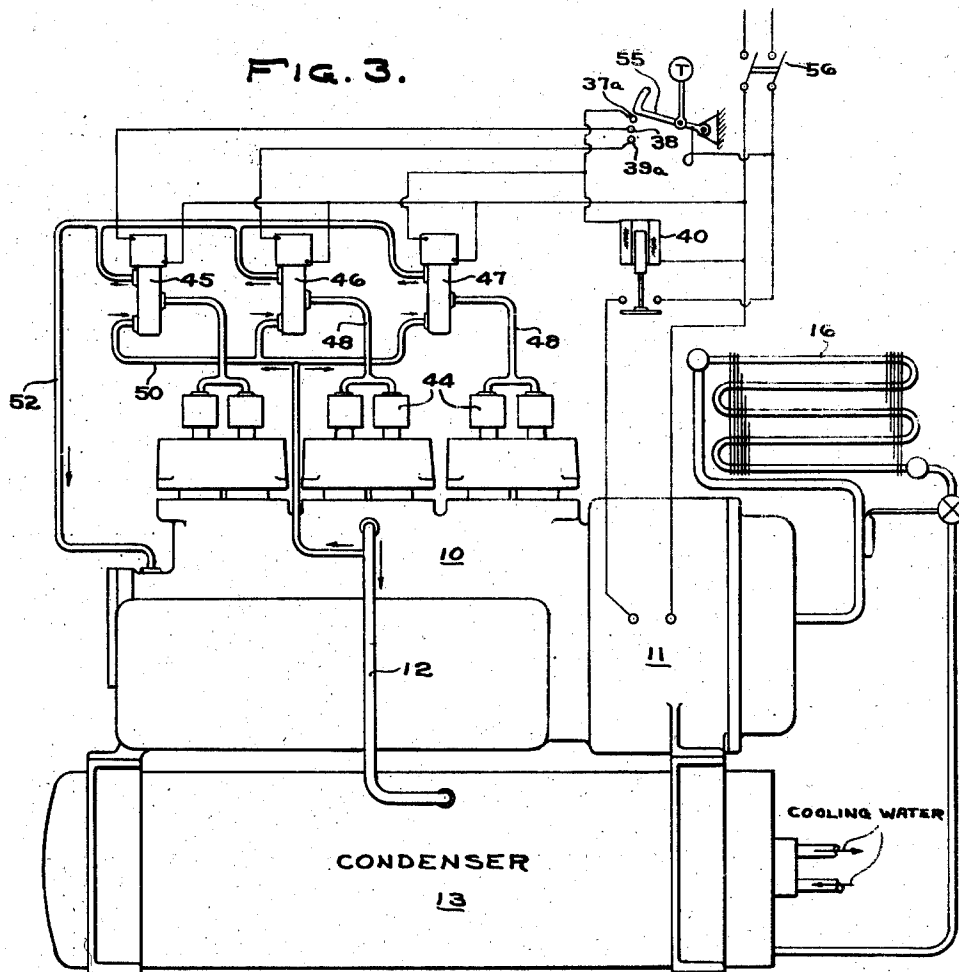
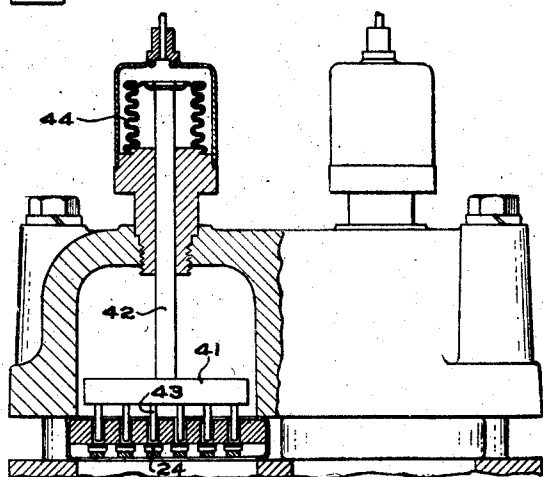


FIG. 6.

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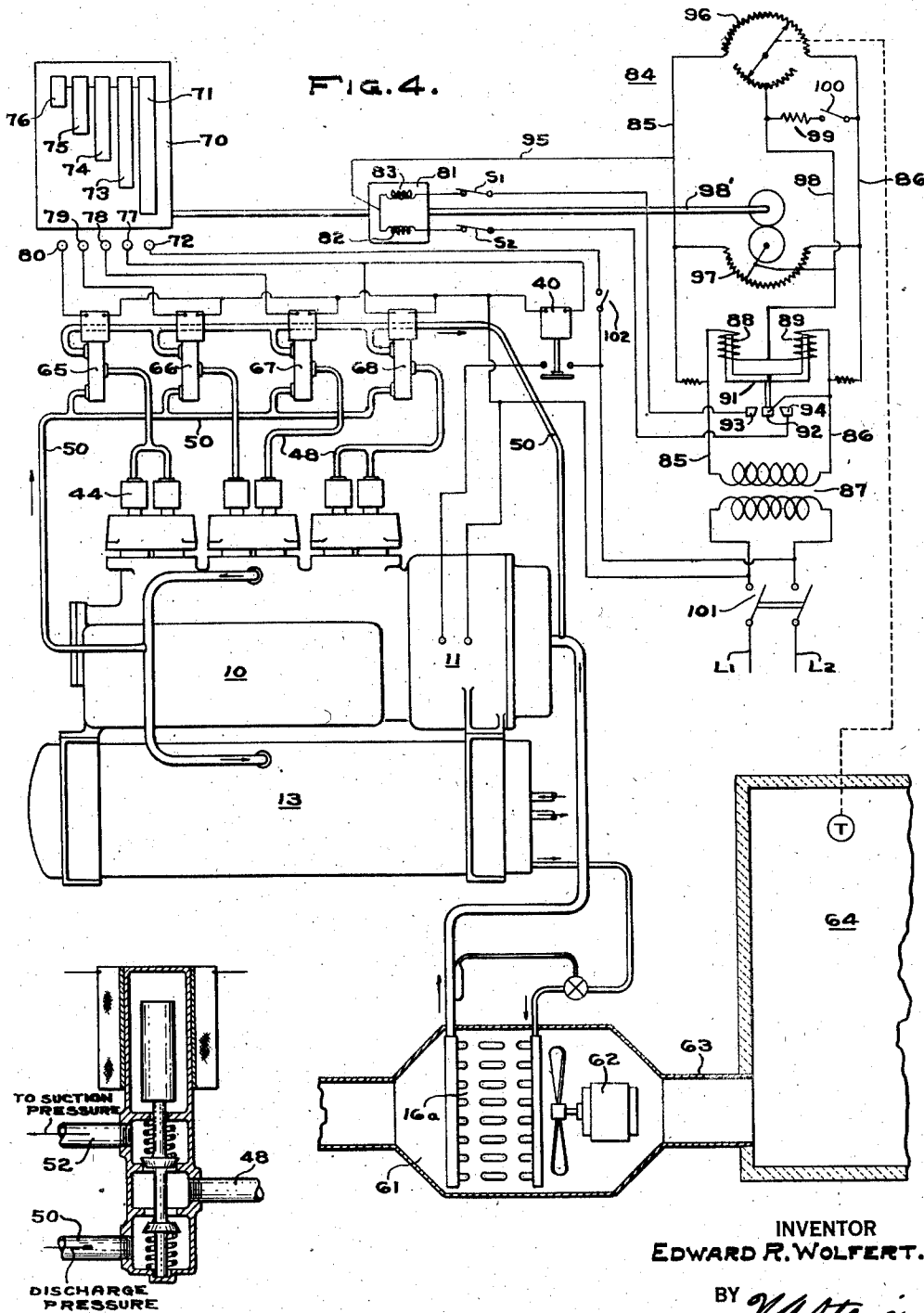
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3 Sheets-Sheet 3



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2,296,304

REFRIGERATING APPARATUS

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Application April 23, 1938, Serial No. 203,796

20 Claims. (Cl. 62-4)

My invention relates to refrigerating apparatus of the mechanical compression type, such as that used for air conditioning an enclosure, and it has for an object to provide improved apparatus.

Another object is to provide apparatus of improved operating characteristics, more particularly apparatus adapted to maintain a more nearly uniform condition of the air in the enclosure.

A particular object is to provide improved means for varying the capacity or output of the refrigerant compressor.

In accordance with my invention, I provide one or more cylinders with unloader mechanisms. Control mechanism, responsive to the temperature of the air conditioned enclosure, is adapted first to initiate operation of the compressor and then to operate the unloader mechanisms to load the associated cylinders successively upon successive increases in temperature. One or more of the cylinders are always loaded when the compressor is operating at full speed but are preferably unloaded for starting.

The above recited and other objects are effected by my invention as will be apparent from the following description and claims taken in connection with the accompanying drawings, forming a part of this application, in which:

Fig. 1 is a diagrammatic view of one embodiment of my invention in which the pressure developed by the lubricating oil pump is used for operating the unloaders;

Fig. 2 is a detail sectional view of one of the unloader mechanisms of Fig. 1;

Fig. 3 is a diagrammatic view of a second embodiment in which condenser pressure is used for operating the unloader mechanisms under control of solenoid-operated pilot valves;

Fig. 4 is a diagrammatic view of another embodiment in which a potentiometer control is employed;

Fig. 5 is a detail sectional view of the solenoid-operated pilot valve employed in Figs. 3 and 4; and,

Fig. 6 is a detail view, partly in section, showing the condenser-pressure-operated unloader mechanism employed in Figs. 3 and 4.

Referring first to Figs. 1 and 2, I show a six-cylinder compressor 10 driven by an electric motor 11 of any suitable type known in the art. The compressor and motor are enclosed in a common fluid-tight casing. The compressed refrigerant is conveyed through a conduit 12 to a condenser 13, from which the condensed refrigerant is conveyed through a conduit 14 and an expan-

sion valve 15 to an evaporator 16. The evaporator is arranged in any suitable manner to cool air for the enclosure to be air conditioned. The vaporized refrigerant is conveyed from the evaporator through a conduit 17 to the motor compressor unit. The expansion valve 15 may be of any suitable type, for example, it may be a thermostatic expansion valve having a thermostatic bulb 18 subjected to the temperature of the suction conduit 17, and regulating the flow of refrigerant to the evaporator to maintain a constant degree of superheat of the vaporized refrigerant leaving the evaporator.

The six cylinders are divided into three pairs of cylinders, each pair being provided with a common cylinder head 19 and a common unloader mechanism 20. Referring to Fig. 2, the cylinder head 19 is formed with an inlet chamber 21 and a discharge chamber 22. The inlet chambers 21 of the several cylinders communicate with the suction conduit 17 through the motor containing portion of the casing and suitable passages provided in the casing, and the discharge chambers 22 communicate with the discharge conduit 12 through suitable passages formed in the casing. A valve cage 23 is clamped between each cylinder and the cylinder head, and contains the suction and discharge valve for controlling flow between the cylinder and the suction and discharge chambers, respectively. The suction valves are pressure operated, the suction valve 24 shown in Fig. 2 being of the reed valve type. By holding the valve 24 down, the cylinder is unloaded, since the refrigerant gas may return to the suction chamber 21 upon upward movement of the piston in the cylinder.

The unloader mechanism 20 includes a rod 25 extending through the cylinder head and the suction chamber 21 and adapted to hold the suction valve 24 in lowered or opened position; a spring 26 being arranged as shown in Fig. 2 to bias the rod 25 downwardly to the unloaded position. Suitable provision may be made for preventing leakage of refrigerant gas through the opening in the cylinder head through which the rod 25 extends. A lever 27 is pivotally connected to the cylinder head at 28 and is adapted to raise the rod 25 by abutment with a pin 29 extending through the rod 25. The lever 27 is operated by a bellows 30, being raised when fluid pressure is applied to the bellows.

It will thus be apparent that, when fluid pressure is applied to the bellows 30, the rod 25 is raised to retracted position through the lever 27, whereupon the valve 24 is permitted to close upon

the upstroke of the piston and the cylinder is loaded. When fluid pressure is not applied to the bellows 30, the rod 25 is pressed downwardly by the spring 26 and holds the valve 24 open. Upon the upstroke of the piston, the gas in the cylinder is not compressed but returns through the suction valve to the suction chamber. Hence, the cylinder is unloaded.

The compressor 10 of Fig. 1 is provided with an oil pump 31 which supplies oil under pressure to the several bearings through passages not shown. The oil pressure developed by this pump, which is dependent upon operation of the compressor, is used to actuate the several unloader mechanisms and is delivered thereto through a conduit 32. The conduit 32 is connected directly to the bellows 30 of the first unloader mechanism, so that the latter is loaded at all times that the compressor is operating at substantially normal speed and the oil pump is developing substantially full oil pressure. The second and third unloaders, however, are controlled by pilot valves 33 and 34, which are actuated by solenoids 33a and 34a, respectively. The pilot valves may be similar to the one shown in greater detail in Fig. 5. Each pilot valve is connected to the bellows 30 of the associated unloader mechanism through a conduit 35, and is adapted, when the solenoid is energized, to place the conduit 35 and the bellows 30 in communication with the oil pressure conduit 32 for loading the cylinders. When the solenoid is deenergized, the pilot valve places the conduit 35 and the bellows 30 in communication with the crank case of the compressor through a conduit 36. The crank case is at suction pressure, so that the associated cylinders are unloaded.

If the compressor operates at a suction pressure which varies considerably, such suction pressure may be imposed on the bellows 30 in any suitable manner (not shown) in opposition to the oil pump pressure, so that the resultant pressure on the bellows will represent only the pressure actually developed by the oil pump.

The compressor is controlled by a thermostat T, which is responsive, for example, to the temperature of the enclosure cooled by the evaporator 16. The thermostat T is provided with contacts 37, which are closed upon increase above a predetermined maximum temperature, and contacts 38 and 39, which are closed upon further increase to successively higher temperatures, respectively. These temperatures differ but slightly and represent substantially the temperature desired to be maintained. The contacts 37 control the relay 40 for the compressor motor 11, and the contacts 38 and 39, control the solenoids 33a and 34a, respectively.

OPERATION

When the compressor is shut down, there is no pressure developed by the oil pump, so that all the cylinders of the compressor are unloaded by the action of the springs 26, as explained above.

As the temperature of the enclosure cooled by the evaporator 16 increases to the predetermined value mentioned above, the thermostat T closes its contacts 37 to energize the relay 40. The latter closes the circuit from the line conductors L₁ and L₂ supplying electric current to the motor 11. Inasmuch as the cylinders are unloaded, the required starting torque of the motor is greatly reduced, so that a motor of lower starting current may be used. As the speed of the

motor compressor unit approaches normal running speed, the pressure developed by the pump 31 actuates the first unloader mechanism to load the first pair of cylinders. The other cylinders remain unloaded, since the pilot valves 33a and 34a are positioned to cut off oil pressure from the associated bellows. The compressor continues in operation, therefore, with only the first two cylinders loaded.

As the temperature increases to the second mentioned predetermined value, the thermostat T closes the contacts 38 to energize the solenoid 33a, whereupon the pilot valve 33a admits oil pressure to the second unloader mechanism, for loading the second pair of cylinders. As the temperature increases further to the third mentioned predetermined value, the contacts 39 are closed to energize the solenoid 34a, whereupon the pilot valve 34 admits oil pressure to the third unloader mechanism to load the remaining cylinders. The compressor now operates at full capacity, the refrigerating system effects cooling at the maximum rate.

Upon decrease in temperature below said predetermined values, the second and third pairs of cylinders are unloaded in reverse order and the compressor is shut down.

With this arrangement all the cylinders are unloaded for starting, regardless of the action of the pilot valves, since the compressor must attain nearly normal running speed before the oil pump develops sufficient pressure to actuate any of the unloader mechanisms to load the associated cylinders.

Fig. 3

In Fig. 3, I show an embodiment comprising the same refrigerating system as in Fig. 1 but in which the pressure of the compressed refrigerant is used to operate the unloader mechanisms. In this case, the pressure may be used to operate the mechanisms in unloading direction, thereby providing a simpler form of mechanism, as shown in Fig. 6. A bar 41, attached to a rod 42, carries fingers 43 adapted to engage the several valve reeds 24 to hold them in open position. A bellows 44 is connected directly to the rod 42.

The bellows of the first, second and third pairs of cylinders are controlled by solenoid-operated pilot valves 45, 46 and 47, respectively, constructed as shown in Fig. 5. Each pilot valve is connected to a conduit 48 which communicates with the bellows 44 of the associated pair of cylinders, a conduit 50 which communicates with the compressor discharge through the conduit 12, and a conduit 52 communicating with the crankcase of the compressor, which is at suction pressure by reason of communication with the suction passages within the casing of the motor compressor unit. The pilot valve is adapted, when the solenoid is deenergized, to place the conduits 48 and 50 in communication, thereby admitting compressor discharge pressure to the bellows 44 for unloading the associated cylinders. When the solenoid is energized, the pilot valve places the conduits 48 and 52 in communication.

The control is similar in principle to that shown in Fig. 1, including a thermostat T actuating a switch arm 55 which engages contacts 37a, 38a, and 39a, respectively, as the thermostat responds to successively higher predetermined temperatures. The contact 37a controls the motor relay 40 and the solenoid of the pilot valve 47,

and the contacts 38a and 39a control the solenoids of the pilot valves 45 and 46, respectively.

Fig. 3 operation

Assuming the entrance switch 56 to be closed and that the switch arm 55 moves into engagement with the contact 37a, the relay 40 completes the electric circuit to the motor 11 for starting the motor compressor unit. The solenoid of the pilot valve 47 is simultaneously energized, so that the pilot valve 47 places the associated bellows 44 in communication with the conduit 52 at suction pressure, which action results in loading the associated pair of cylinders. However, an appreciable period of time, such as two seconds, is required for sufficient flow of gas through the conduits before the cylinders are actually loaded and this period of time is greater than the period of time required for starting, the latter being about $\frac{3}{4}$ second, or 40 cycles when using 60 cycle current. Such action results in unloading for starting. The first and second pairs of cylinders remain unloaded, since the pilot valves 45 and 46 admit discharge pressure to the associated bellows 44.

As the temperature increases further to the second predetermined temperature, the switch arm 55 engages the contact 38a to energize the solenoid of the pilot valve 45, the latter admitting suction pressure to the bellows of the first pair of cylinders for loading the latter. Upon further increase to the third predetermined temperature, the switch arm engages the contact 39a for energizing the solenoid of the pilot valve 46, whereupon the second pair of cylinders is loaded.

Upon decrease in temperature, the control operates in reverse order, as will be apparent.

Fig. 4

In Fig. 4, the compressor 10, the motor 11 and the condenser 13 are the same as in Figs. 1 and 3. The evaporator 16a is of different form, comprising a plurality of coils over which the air flows in parallel. Any suitable provision known in the art may be made for distributing liquid refrigerant to the several coils in equal proportions. The evaporator 16a is disposed in an air conditioning chamber 61. A fan 62 circulates air through the chamber, over the evaporator coils, and through a duct 63 into the enclosure 64 which is to be air conditioned. It will be apparent that this air cooling arrangement is independent of the particular control and may also be used in the other embodiments.

Each cylinder of the compressor is provided with an unloader mechanism of the type shown in Fig. 6, including a bellows 44 operated by compressor discharge pressure as in Fig. 3. Four solenoid-operated pilot valves, 65 to 68, control the loading of the cylinders. The valve 65 controls the first two cylinders, valve 66 the third, valve 67 the fourth, and valve 68 the fifth and sixth.

These pilot valves are of the construction shown in Fig. 5, and are connected in the same manner as in Fig. 3. The connecting conduits are of sufficiently restricted bore so that an appreciable period of time, such as 2 or 3 seconds, is required for sufficient flow therethrough to load or unload the cylinders.

The solenoids of the pilot valves are controlled by a drum controller, the drum 70 of which is shown projected in Fig. 4. The drum includes a contact segment 71 which is adapted upon forward movement to engage a stationary contact

72 connected to the line conductor L1, and contacts 73 to 76, which are adapted upon further successive forward movements of the drum, to engage the contacts 77 to 80, which control the pilot valves 68 to 65, respectively.

The drum 70 is operated by a reversible motor 81, having a forward winding 82 and a reversing winding 83 and controlled by a potentiometer control 84, which is of a type well-known in the control art. The latter includes conductors 85 and 86 which are supplied with current at low voltage through a transformer 87. The potentiometer control further includes balancing relay coils 88 and 89 connected in series between the conductors 85 and 86 and biasing an armature 91 in opposite directions. The armature actuates a contact 92 connected to the conductor 86. The contact 92 is adapted to engage contacts 93 and 94 connected to the forward winding 82 and the reversing winding 83, respectively. The opposite terminals of the windings 82 and 83 are connected to the conductor 85 through a conductor 95. Limit switches S1 and S2 are provided to terminate operation of the motor 81 when the drum 70 is moved to the end of its travel in either direction. These switches are operated in any suitable manner as is fully understood by those skilled in the art.

The potentiometer control further includes a controller potentiometer 96 which is actuated by a thermostat T disposed in the enclosure 64 and responsive to the temperature of the air therein. It further includes a balancing potentiometer 97, also connected between the conductors 85 and 86 and actuated by the reversing motor 81 through the shaft 98'. A conductor 98 is connected between the balancing relay coils 88 and 89 and to the movable contact arms of the potentiometers 96 and 97. A resistance 99 and a switch 100 may also be connected between the conductors 98 and 86. When the potentiometer control is in equilibrium, the voltage drop between the conductors 98 and 86 is equal to the voltage drop between the conductors 85 and 98, whereupon the coils 88 and 89 are balanced and the armature 91 remains in intermediate position. Upon operation of the potentiometer 96 to disturb this balance, however, the armature 91 is tilted to effect operation of the motor 81. The relay actuates the balancing potentiometer 97 to restore the balanced condition whereupon operation of the motor 81 ceases.

Fig. 4—Operation

In considering the operation of the embodiment shown in Fig. 4, assume that the entrance switch 101 is closed and that the apparatus is shut down due to the action of the thermostat T. Next assume that the temperature in the enclosure rises to a predetermined value indicating demand for some cooling. The thermostat T moves the contact arm of the potentiometer 96 in counterclockwise direction, thereby interposing less resistance between the conductors 85 and 98 and decreasing the voltage drop therebetween, and increasing the resistance between the conductors 98 and 86 and increasing the voltage drop therebetween. Accordingly, the coil 89 overcomes the force of the coil 88 and tilts the armature 91 in counterclockwise direction. The contact 92 is moved to engage the contact 94, thereby energizing the forward winding 82 of the motor 81. The motor 81 thereupon operates in forward direction to bring the several contacts successively into engagement. It will

be assumed that the first temperature increase is sufficient to bring the contact segment 73 into engagement with the contact 77. As the motor operates the drum, the contact arm of the balancing potentiometer 97 is actuated in counterclockwise direction, increasing the resistance between the conductors 85 and 98 and decreasing the resistance between the conductors 98 and 86, thereby counteracting the action of the potentiometer 96. When the drum has been actuated to an extent called for by the extent of movement of the potentiometer 96, the voltage drops are again balanced, whereupon the forces exerted by the coils 88 and 89 are balanced and the contact 92 disengages the contact 94 to terminate operation of the motor 81.

The engagement of the contact segment 73 with the contact 77 energizes the motor relay 40 and the pilot valve 68. The relay 40 energizes the motor 11 to initiate operation of the compressor 10. At the moment of starting, all of the cylinders are unloaded, due to the action of the several pilot valves in admitting compressor discharge pressure to the bellows of the associated unloader mechanisms while the compressor is shut down. The energization of the solenoid of the pilot valve 68 serves to place the bellows of the associated cylinders in communication with suction pressure for loading said cylinders. The time required for flow of gas from the bellows 44 through the connecting conduits to the crank case, however, maintains the cylinders unloaded for a brief period, about two seconds, which is greater than the period of $\frac{2}{3}$ second, or 40 cycles, required for starting. In this way, unloading for starting is obtained.

As the temperature in the enclosure 64 increases further, the potentiometer control operates in the same manner to effect further movement of the drum 70, thereby successively energizing the solenoids of pilot valves 67, 66 and 65. In the latter case, the compressor operates at full capacity.

Upon decrease in temperature in the enclosure 64, the thermostat T moves the contact arm of the controller potentiometer 96 in clockwise direction, thereby increasing the resistance between the conductors 85 and 98 and increasing the voltage drop therebetween, and decreasing the resistance between the conductors 98 and 86 and the voltage drop therebetween. The increased voltage imposed on the coil 88 causes the same to tilt the armature 91 in clockwise direction so that the contact 92 engages the contact 93. A circuit is thereby completed through the reversing winding 83, so that the motor 81 moves the drum 70 in reverse direction. The motor moves the contact arm of the potentiometer 97 in clockwise direction until the drum 70 has been moved to the extent called for by the action of the potentiometer 96, whereupon the action of the potentiometer 97 counterbalances the action of the potentiometer 96 and restores balance of the voltage drops. The coils 88 and 89 are again balanced and the contact 92 is moved to intermediate position, out of engagement with the contact 93.

The several contacts of the drum are successively disengaged as the temperature decreases, thereby successively de-energizing the solenoids and causing the pilot valves to impose compressor discharge pressure on the several bellows 44 for unloading the associated cylinders. As the temperature decreases beyond the minimum value of the control range, the pilot valve 68 operates to

unload the associated cylinders and the relay 40 opens the circuit to the motor 11 to terminate operation of the motor compressor unit.

The operation of the compressor may be terminated by opening the switch 102 connected between the stationary contact and the line conductor L1. The opening of this switch de-energizes the relay 40 to open the motor circuit and also de-energizes the solenoids of the several pilot valves. The operation of the compressor may also be terminated by closing the switch 100, which connects the resistance 99 between the conductors 98 and 86, thereby reducing the voltage drop therebetween. The coil 88 overcomes the coil 89 and tilts the armature 91 in clockwise direction to engage the contacts 92 and 93. The drum 70 is operated in reverse direction to unload the cylinders and to terminate operation of the compressor. The value of the resistance 99 is sufficiently low that the drum is moved to the end of its travel before the potentiometer 97 reduces the resistance between the conductors 86 and 98 to restore balance between the voltage drops and terminate further operation of the motor 81.

It is to be understood that suitable known instrumentalities, such as a controller resistance, protective resistances, overload protective devices, etc., may be used in connection with this control, and since such instrumentalities are well understood in the art of potentiometer control, and since the details thereof are not a part of the present invention, they are not specifically described herein.

While I have shown my invention in several forms, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various other changes and modifications without departing from the spirit thereof, and I desire, therefore, that only such limitations shall be placed thereupon as are imposed by the prior art or as are specifically set forth in the appended claims.

What I claim is:

1. In apparatus for air cooling an enclosure, the combination of an evaporator, a multi-cylinder compressor, and a condenser connected in a refrigerant circuit, means for conveying air over said evaporator and into the enclosure, and means for starting and stopping the compressor and loading and unloading one or more cylinders of the compressor automatically in response to the temperature of the air in the enclosure.

2. In apparatus for air cooling an enclosure, the combination of an evaporator, a multi-cylinder compressor, and a condenser connected in a refrigerant circuit, the cylinders of said compressor being provided with suction valves, means for conveying air over said evaporator and into the enclosure, and means responsive to the temperature of the air in the enclosure for automatically loading and unloading a portion of the total number of the cylinders of said compressor, by holding the suction valves thereof in open position, while the compressor remains in operation with one or more cylinders fully loaded.

3. In apparatus for air cooling an enclosure, the combination of an evaporator, a multi-cylinder compressor, and a condenser connected in a refrigerant circuit, means for conveying air over said evaporator and into the enclosure, and automatically operable means for starting the compressor and effecting operation thereof with one or more cylinders fully loaded in response to a predetermined maximum temperature of the air

in the enclosure and for loading another cylinder or cylinders in response to a higher predetermined maximum temperature of the air in the enclosure.

4. In apparatus for air cooling an enclosure, the combination of an evaporator, a multi-cylinder compressor, and a condenser connected in a refrigerant circuit, means for conveying air over said evaporator and into the enclosure, and automatically operable means for effecting operation of the compressor with at least one cylinder loaded in response to a predetermined maximum temperature of the air in the enclosure, for loading another cylinder or cylinders in response to a higher predetermined maximum temperature of the air in the enclosure, and for shutting down the compressor upon decrease substantially below said first-mentioned predetermined maximum temperature.

5. In a refrigerating system, the combination of an evaporator, a multi-cylinder compressor and a condenser connected in a refrigerant circuit, an electric motor for driving the compressor, fluid pressure operated means for loading and unloading one of the cylinders of the compressor, means for controlling the application of fluid pressure to said fluid pressure operated means in response to a load condition of the system and also to unload said one cylinder while the compressor is shut down, and a fluid passage connecting said first-mentioned and said second-mentioned means, said passage being sufficiently restricted so that the time required for flow of fluid to effect loading of the cylinder is as great as the time required for the compressor to attain substantially running speed, whereby the compressor is unloaded during at least a substantial portion of the starting period.

6. Apparatus for cooling an enclosure comprising a multi-cylinder compressor, a condenser and an evaporator connected in a refrigerant circuit, said evaporator being arranged to cool the enclosure, a motor for driving the compressor and means operable automatically to initiate operation of the compressor with one cylinder unloaded in response to increase in temperature of the air in the enclosure above a predetermined value, and to load said one cylinder in response to increase in said temperature above a second and higher predetermined value.

7. Apparatus for cooling an enclosure comprising a multi-cylinder compressor, a condenser and an evaporator connected in a refrigerant circuit, said evaporator being arranged to cool the enclosure, a motor for driving the compressor and means operable automatically to initiate operation of the compressor with all the cylinders unloaded in response to a predetermined maximum temperature in said enclosure, to load one of the compressor cylinders immediately after the compressor has attained substantially the normal operating speed, and to load another cylinder in response to a higher predetermined maximum temperature in said enclosure.

8. In apparatus for cooling an enclosure, the combination of an evaporator, a compressor having first and second cylinders and a condenser connected in a refrigerant circuit, said evaporator being arranged to cool the air in the enclosure, a motor for driving the compressor, and means operable automatically to affect operation of the compressor with the first cylinder loaded and the second cylinder unloaded in response to a temperature in the enclosure between a predetermined minimum value and a pre-

terminated maximum value, to effect operation of the compressor with both the first and the second cylinders loaded in response to a temperature above said predetermined maximum value, and to terminate operation of the compressor in response to a temperature substantially below said predetermined minimum value.

9. In apparatus for cooling and dehumidifying air for an enclosure, the combination of an evaporator, a compressor having first and second cylinders, and a condenser connected in a refrigerant circuit, said evaporator being arranged to cool the air in the enclosure, a motor for driving the compressor, and means operable automatically to effect operation of said compressor with the first cylinder loaded and the second cylinder unloaded in response to increase in cooling load above a predetermined value, to effect operation of the compressor with both the first and second cylinders loaded in response to a higher predetermined value of cooling load, and to terminate operation of said compressor in response to decrease in cooling load below said first-mentioned predetermined value.

10. In a refrigerating system, the combination of an evaporator, a compressor having first and second cylinders, and a condenser connected in a refrigerant circuit, a motor for driving the compressor, means for starting and stopping the compressor in response to a load condition of the system, means operable automatically to load and unload said second cylinder in response to variation in a load condition of the system, and means operable automatically to unload all of the compressor cylinders when the compressor stops, regardless of the action of the last-named means, and to load at least said first cylinder upon operation of the compressor.

11. In a refrigerating system, the combination of a compressor having a plurality of cylinders, a condenser and an evaporator connected in a refrigerant circuit, a motor for driving the compressor, a pump operable simultaneously with the compressor for supplying lubricant under pressure thereto, a plurality of fluid pressure operated unloader mechanisms each associated with one or more cylinders for loading the same when fluid pressure is applied and for unloading the same when fluid pressure is not applied, means providing communication at all times between the outlet of said pump and one of said unloader mechanisms, and means providing and controlling communication between the outlet of said pump and another of said unloader mechanisms automatically in response to a cooling load condition of the refrigerating system.

12. In a refrigerating system, the combination of a compressor having a plurality of cylinders, a condenser and an evaporator connected in a refrigerant circuit, a motor for driving the compressor, a plurality of fluid pressure operated unloader mechanisms, each mechanism being associated with one or more cylinders and arranged to unload the cylinder when compressor discharge pressure is applied to the mechanism, means for controlling the application of compressor discharge pressure to one of said unloader mechanisms automatically in response to a low cooling load condition of the refrigerating system, and means operable automatically to apply condenser discharge pressure to each unloader mechanism, to provide unloading of the cylinders during starting of the compressor.

13. In air cooling apparatus for an enclosure, the combination of an evaporator, a compressor

and a condenser connected in a refrigerant circuit, means for conveying air over said evaporator and into the enclosure, said compressor comprising a plurality of cylinders and unloader mechanisms for a plurality of said cylinders, a motor for driving the compressor, and means operable automatically to energize and de-energize said motor and to control the unloader mechanism of one cylinder to load and unload the same in response to increase above and decrease below, respectively, a predetermined value of a cooling load condition of the enclosure, the loading of said one cylinder being delayed until the starting current of the motor has passed its peak value, and to control the unloader mechanism of another cylinder to load and unload the same in response to increase above and decrease below, respectively, a second and higher predetermined value of said cooling load condition.

14. In air cooling apparatus for an enclosure, the combination of an evaporator, a condenser and a compressor connected in a refrigerant circuit, means for conveying air over said evaporator and into the enclosure, said compressor comprising a plurality of cylinders and unloader means for loading and unloading one of said cylinders, a motor for driving said compressor, and means operable automatically to start and stop said motor and compressor in response to increase above and decrease below, respectively, a predetermined value of a cooling load condition of the air in the enclosure and to control said unloader means to load and unload said one cylinder in response to increase above and decrease below, respectively, a second and higher predetermined value of said cooling load condition.

15. In apparatus for cooling an enclosure, the combination of an evaporator, a multi-cylinder compressor, and a condenser connected in a refrigerant circuit having a high-pressure side and a low-pressure side, an unloader mechanism adapted to unload one but not all of the cylinders and including fluid pressure-actuated means, and means operable automatically in response to a load condition for connecting said fluid pressure-operated means to either the high-pressure side or the low-pressure side and for shutting off communication with the other of said sides, the unloader mechanism being adapted to unload the associated cylinder when connected to the high-pressure side and to load the cylinder when connected to the low-pressure side.

16. In refrigerating apparatus, the combination of an evaporator, a multi-cylinder compressor and a condenser connected in a refrigerant circuit; one cylinder of said compressor having a valve cage disposed across the end of the cylinder and comprising a valve plate having a plurality of suction ports formed therein and pressure-operated suction valve members controlling flow of fluid through said ports; a cylinder head for said one cylinder; an unloader mechanism for said one cylinder comprising a rod extending through the cylinder head, a comb-like member at the inner end of the rod including a bar and a plurality of fingers carried by

the bar and extending through said ports and adapted to hold said valve members in open position, and a pressure-actuated member attached to the outer end of the rod; and means operable automatically in response to a load condition of the refrigerant circuit for controlling the application of fluid pressure to said pressure-actuated member.

17. The method of cooling an enclosure which comprises conveying air in heat transfer relation to an evaporator, vaporizing refrigerant in the evaporator, withdrawing refrigerant vapor from the evaporator by means of a multi-cylinder compressor, initiating and terminating operation of the compressor with at least one cylinder loaded and another unloaded in response to temperature of air in the enclosure, and loading and unloading a second cylinder in response to temperature of the air in the enclosure.

18. The method of cooling an enclosure which comprises conveying air in heat transfer relation to an evaporator, vaporizing refrigerant in the evaporator, withdrawing refrigerant vapor from the evaporator by means of a multi-cylinder compressor, initiating operation of the compressor with one cylinder loaded and a second cylinder unloaded in response to a predetermined temperature of air in the enclosure, and loading said second cylinder in response to a slightly higher predetermined temperature of air in the enclosure.

19. In apparatus for cooling an enclosure, the combination of an evaporator, a compressor, and a condenser connected in a refrigerant circuit, said evaporator being arranged to cool the enclosure, said compressor comprising first and second compressing elements provided with suction valves, and means for maintaining the suction valve of said first compressing element in opened position to unload said first compressing element, while said second compressing element remains loaded, in response to decrease in the temperature of the enclosure below a predetermined value.

20. In apparatus for air cooling an enclosure, the combination of an evaporator, a multiple cylinder compressor, and a condenser connected in a refrigerant circuit including a high-pressure side connected to the compressor discharge and a low-pressure side connected to the compressor suction, means for conveying air over said evaporator and into the enclosure, a fluid pressure-operated unloader mechanism adapted to unload one or more but not all of the cylinders of the compressor, means including a pilot valve for selectively placing said unloader mechanism in communication with said high-pressure side and shutting off its communication with the low-pressure side or placing said unloader mechanism in communication with said low-pressure side and shutting off its communication with said high-pressure side, and means for automatically controlling said pilot valve in response to an operating condition of the apparatus.

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