

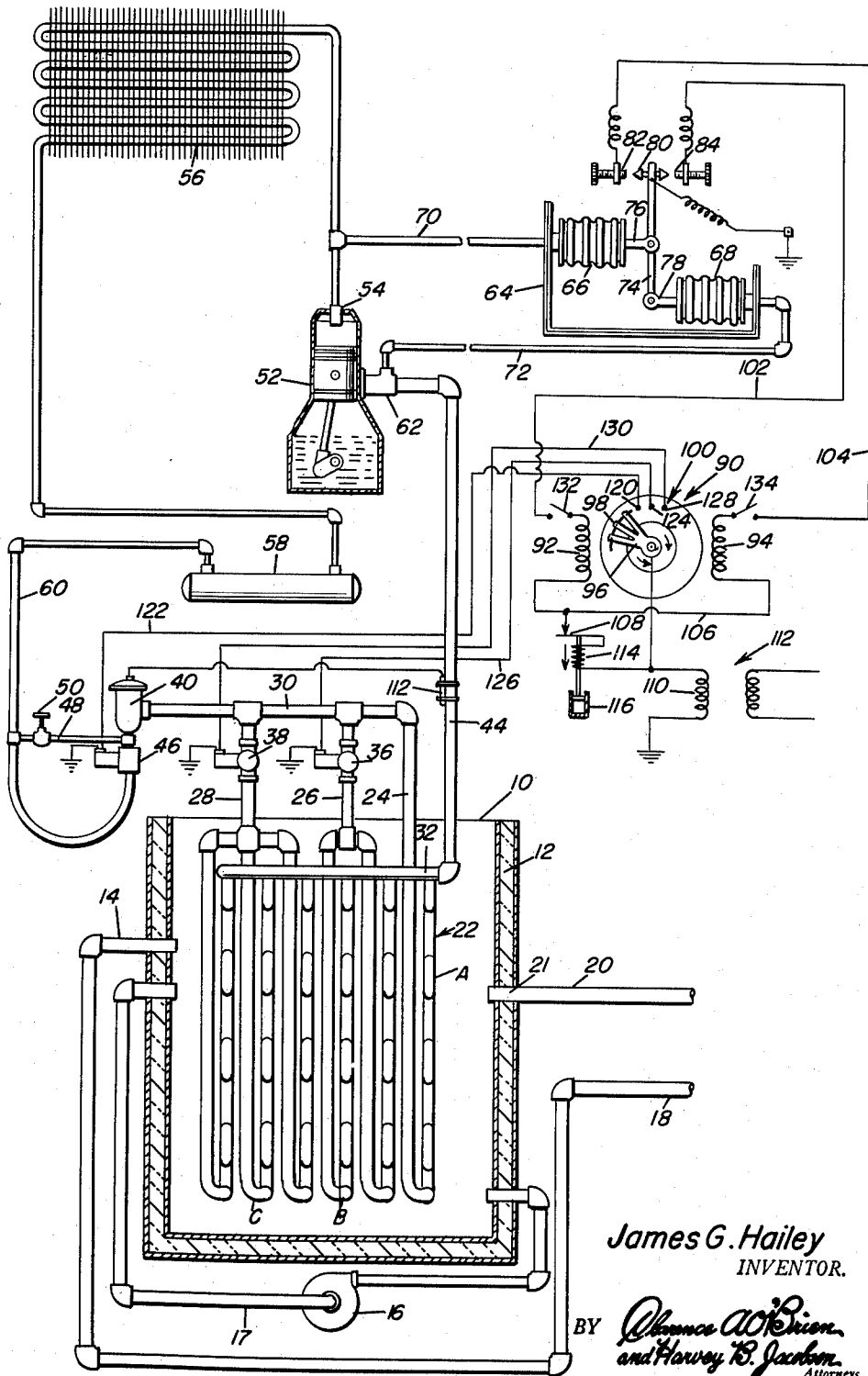
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ENERGY STORAGE FOR AIR CONDITIONING SYSTEMS

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## ENERGY STORAGE FOR AIR CONDITIONING SYSTEMS

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This invention relates to an energy storing system and particularly to an energy storing system for utilizing the maximum output of a compressor to store the energy of the compressor at low load demand so that it may be utilized to meet a peak load demand in excess of the capacity of the compressor.

In the operation of air conditioning systems it is found that the load is highly variable with peak demands in considerable excess over the average load rating of the system. Heretofore, it has been necessary to provide a compressor system having sufficient capacity to meet the peak demand of the cooling system in order to have a satisfactory cooling system. This has resulted in a compressor having a very low load utilization factor and that during the majority of the time it is operated at far below its full load capacity. However, as is well known in the utilization of electrically driven equipment the efficiency rapidly falls away with decrease of load so that the actual current consumed at low load is not materially different than the current consumed at full load. Consequently, it is highly desirable to utilize a compressor and its equivalent at a high load factor so that the device will operate substantially constant over its normal load range so that the minimum of electrical demand will be produced. Further, it is customary to have the charge of electric power dependent upon the maximum load demand whereby the utilization of the compressor at low load factors over a long period of time and then a utilization of the compressor at a peak demand will increase the cost of energy consumed.

The present system provides an energy storing system in which the energy output of the compressor during the low load intervals on the cooling system may be stored up and withdrawn during high peak loads on the system so that the compressor and its driving motor operate at substantially continuous load rating over long periods of time.

This is accomplished by providing an evaporator having a plurality of sections and connecting the sections in parallel relation between a header fed by the compressor and a return line to the compressor so that the energy absorbed by the evaporator will be substantially constant.

As ice forms on the lines of the evaporator and reduces the heat absorption therethrough, additional sections of the evaporator will be connected into service so as to maintain substantially constant the heat transfer to the evaporator until all of the evaporator has been coated with a sufficient coating of ice so that during the heat demand the ice may be melted to provide the necessary cooling in excess of the full load rating of the compressor.

It is, accordingly, an object of the invention to provide an improved cooling system.

It is a further object of the invention to provide an improved energy storing system between a compressor and a cooling system.

It is a further object of the invention to provide a heat transfer device having a sectionalized evaporator.

It is a further object of the invention to provide an

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evaporator having a variable effective area and means responsive to the load on the compressor for changing the effective area of the compressor.

It is a further object of the invention to provide an improved control system responsive to the pressure across a compressor for connecting sections of a sectionalized evaporator into operative relation with the compressor.

Other objects and many of the attendant advantages of the present invention will be apparent from the following detailed description taken in conjunction with the accompanying drawing in which the figure is a schematic illustration of an air cooling system utilizing the invention.

In the exemplary embodiment a container 10 is provided with suitable thermal insulation 12 to provide an insulated space therein. The insulated space within the container 10 will be filled by a suitable thermal absorbing liquid such as water. An outlet connection 14 at one side of the container 10 will be connected through a conduit 18 to any suitable load such as an air conditioning system (not shown), and the warm water will return through a conduit 20 to the inlet 21 at the other side of the container 10.

In order to maintain fluid circulation in the container 10 independent of the load demand, a circulating pump 16 is connected across the container 10 by a conduit 17.

The heat transferring fluid system will normally be of a completely closed type but for simplicity of illustration the container 10 is shown with the top removed so that the connections to the evaporators and other portions in the container may be readily seen.

An evaporator indicated generally at 22 is contained within the container 10 and has a plurality of sections 24, 26 and 28 indicated herein although it is obvious that any desired number of sections of evaporator may be used. The sections 24 to 28 are connected to a header 30 and to a return connection 32. One of the sections, such as 24, is constantly connected to the header 30 and the remaining sections, such as 26 and 28, are connected to the header by means of suitable electric control valves herein indicated as valves 36 and 38.

A thermostatically controlled valve 40 is connected in series with the header 30 and is controlled by means of the usual thermostat 42 responsive to the temperature in return line 44 from the return header 32. An auxiliary control valve 46 of the electrically controlled type is connected in series with the header 30 and has connected in shunt therewith a by-pass 48 having a manual control valve 50 therein.

A compressor 52 having a capacity substantially equal to or slightly greater than the average load demand of the cooling system has an output connection 54 connected through a condenser 56 to a receiver tank 58 which communicates by means of a conduit 60 through the valves 50, 46 and 40 to the header 30. The return connection 44 from the header 32 returns to the suction or low pressure side of the compressor 52 by means of return connection 62. The load responsive switch comprises a container or housing 64 having a first pressure extensible device such as a bellows 66 rigidly mounted on one side of the housing and a second pressure extensible device such as a bellows 68 rigidly mounted on the other side of the housing 64. The bellows 66 and 68 extend in substantially parallel offset relation with respect to each other with the inner ends being in substantial alignment with each other but capable of movement therebetween while the outer ends of the bellows 66 and 68 are rigidly fixed in the housing 64.

The bellows 66 is communicated with the output terminal 54 of the compressor by means of a suitable conduit 70 so that the bellows 66 is responsive to the output pressure of the compressor. Likewise, the bellows 68 is

communicated to the intake terminal 62 of the compressor by means of a conduit 72 so that the bellows 68 is responsive to the suction or intake pressure of the compressor 52. A switch arm 74 is provided with a floating connection by having a central portion journaled on the terminal 76 of the bellows 66 and on the terminal 78 of the bellows 68 so that the arm 74 will move in proportion to the motion of the bellows 66 and 68. The movable contact 80 is mounted on the arm 74 and makes contact with fixed contacts 82 and 84.

A stepping relay indicated generally at 90 may be of any desired type but is preferably of a commercial type manufactured under Patent No. 2,323,840. As is well known this stepping relay has a plurality of stepping coils 92 and 94 which when energized will step the contactor member 96 in either direction depending upon the coil being energized.

The contactor 96 is provided with any suitable number of contact fingers 98 which preferably correspond in number to a plurality of contacts 100.

The actuating magnet herein indicated as a subtracting relay coil 92 is indicated as being connected to the fixed contact 84 of the pressure switch device by means of a conductor 102. Likewise, the adding relay 94 of the stepper device is shown as being connected to the fixed contact 82 by means of an electrical conductor 104. Subtracting coil 92 and adding coil 94 are provided with a common connection 106 which is connected through a time-delay switch 108 to a secondary coil 110 of a supply transformer 112.

Switch 108 is operated by means of an actuating coil 114 connected in series therewith and herewith shown as being controlled in time-relation by means of a dashpot 116, although it is apparent that any desired timing mechanism such as a motor or other timing device could be utilized.

First contact 120 of the contacts 100 is connected to the series electrically controlled valve 46 by means of an electrical conductor 122. Likewise the electrically controlled valve 36 is connected to the contact 124 of the contacts 100 by means of the conductor 126 while the contact 128 of the contacts 100 is connected to the electrically controlled valve 38 by means of the electrical conductor 130.

A limit switch 132 is provided in series with the subtracting coil 92 of the stepping relay so that when the contact element 96 is moved to completely open relation with respect to the contacts 100 the stepping relay will be ineffective to move the contact any further. Likewise, the adding relay 94 is provided with a limit switch 134 so that when the contact 96 provided with the fingers 98 is in contact with each of the contacts 100 the relay will be ineffective to further advance the contact 96.

In the operation of the system according to the invention the compressor 52 will operate to compress any normal refrigerant liquid which will be cooled in the condenser 56 delivered to the receiver 58 from which it will be delivered through the thermostatically control valve 40 into the header 30 into the evaporator where it will be evaporated and returned to the compressor. This will cool the water in the container 10 and the cold water will be pumped through the outlet 14 by means of a pump (not shown) to the air conditioning system where the coolness will be transferred to the air and the warm water will be returned to the container 10 by means of the conduit 20.

In putting the system in operation the container 10 will be filled with warm or tap water and as this is a condition for which the device is not intended for operation the warm water will cause excessive evaporation of the refrigerant material in the evaporator so that a high pressure would be produced at the intake terminal 62 of the compressor. Likewise a high pressure would be produced at the output terminal 54 of the compressor which would swing the arm 74 of the switch device so

that movable contact 80 would contact switch contact 84 to energize the subtracting coil 92 of the stepper relay. Coil 92 would then move the contact 96 backwards one step and as the pressure in bellows 66 and 68 would still be maintained, the contacts 80 and 84 would maintain the energization of coil 114 until the timing device 116 would operate to open the switch 108 which would thereby deenergize the coil 114 and allow the timing device 116 to close the switch 108 again actuating the subtracting coil 92, and such action would be repeated until the fingers 98 had been removed from all of the contacts 100 and all of the electrically controlled valves would be closed. However, the thermostatic device 42 would open the thermostatically controlled valve 40 so that the header 30 would be connected to the by-pass 48 so that refrigerant would be controlled by means of the by-pass valve 50. By-pass valve 50 therefore would be set to allow the maximum passage of refrigerant without overloading the compressor 52. As soon as the water in the container 10 has been sufficiently cooled to reduce the excessive pressure at the intake 62 of the compressor the contact 80 would move out of engagement with the contact 84 so that the device would be in condition for normal operation. Assuming that the heat transfer required by the air conditioner is less than that produced by the evaporator coil 22 permanently connected to the header 30 the chilling of the water would decrease the evaporation in that particular section of the evaporator so that the bellows 68 would be contracted moving the fixed contact 82 and the movable contact 80 together so that the additive relay 94 would be operated which would close the limit switch 132 and move the finger 98 into contact with the contact 120 of the contacts 100 and open the electrically controlled valve 46 and place the header 30 in normal control in the refrigerating system.

If there is still a low demand for the energy transfer to the water in the container 10 section 22a will be cooled to the point where ice will begin to form on the exterior thereof and as the latent heat of fusion of the water being frozen will be absorbed by the evaporator it will be transferred to the evaporator to produce the desired difference in pressure between the intake and output pressures of the compressor. However, after a predetermined interval the ice will reach a sufficient thickness so that the heat transferred to the section A of the evaporator 22 will not be sufficient to produce a desired back pressure at the compressor so that the bellows 68 will again contract and the relay coil 94 will operate to step the stepping relay to contact 124 and energize electrical valve 36 while section B of the evaporator 22 will be placed in condition so that there will be sufficient area to again produce the desired reduction of pressure at the intake terminal 62 of the compressor. Obviously, if the demand for heat from the cooling system is continued in abatement the section B will likewise become coated with ice after which the stepper relay will again be operated to connect section C of the evaporator 22 into the circuit so that the maximum area of the evaporator will be in use until it becomes sufficiently coated with ice.

In the event the air conditioner then calls for more cooling than the capacity of the compressor 52 the warm water will gradually melt the ice from the evaporator and the latent heat of fusion of the water being converted from the ice will produce the necessary cooling in the excess of the amount produced by the compressor 52 so that the peak demand of the air conditioning system may be met by the energy stored in the ice in the container 10. If the excessive demand persists for a sufficient interval of time enough of the ice will be removed from the evaporator 22 to cause a high pressure in the inlet 62 of the compressor 52 so that the differential pressure device connected across the compressor will actuate the stepper relay so that the subtracting coil 92 will cause the opening first of the con-

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factor 128 and the closing of the valve 38 and eventually the valve 36 so that the compressor will be directly connected across the constantly connected section of the evaporator to carry the normal load therein.

It will be apparent that the present refrigerating system comprises a heat or energy storing container in which excess energy not required by the air conditioning system may be stored until such time as it may be needed after which it may be released to meet a peak in excess of the capacity of the compressor. It will thus be seen that the compressor will operate at substantially full load over relatively long periods of time so that energy may be added to or subtracted from the storage container as may be needed to meet the fluctuations of the requirement of the air conditioning system.

For purpose of exemplification a particular embodiment of the invention has been shown and described according to the best present understanding thereof. However, it will be apparent to those skilled in the art that many changes and modifications in the construction and arrangement of parts thereof may be made without departing from the true spirit and scope of the invention.

What is claimed as new is as follows:

1. An energy storage device comprising a compressor, a refrigerant, an evaporator including a plurality of evaporator coils, a liquid heat storage medium having latent heat of fusion surrounding said coils and means automatically responsive to the pressure of the refrigerant when entering and leaving the compressor for selectively connecting said coils in operative relation with said compressor in response to the heat absorbed by said coils.

2. An energy storage system comprising an evaporator, consisting of a plurality of sections, each being separately controlled by electrical sectional control means, means including a compressor for supplying liquid refrigerant means responsive to the pressure differential across said compressor for determining the effective sections of said evaporator, said means including a pressure operated switch controlling the said sectional control means.

3. An energy storage system comprising a container, an evaporator mounted in said container, a quantity of liquid in said container, said liquid having latent heat of fusion, a plurality of valves controlling the effective area of said evaporator, means including a compressor for supplying liquid refrigerant to said evaporator and switch means responsive to the pressure across said compressor for controlling said valves.

4. For use with a variable consumption cooling system, a system for storing energy during low load conditions and releasing the stored energy during high load conditions comprising an insulated container, an evaporator mounted in said container, a filling of water in said container, means for transferring heat from the cooling system to said water, a refrigerant compressor having a capacity of the order of the average load on said cooling system, electrically actuated valves controlling the connection of said evaporator to said compressor, a switch responsive to the load on said compressor and a selector responsive to operation of said switch for energizing said valves.

5. For use with a variable consumption cooling system, a system for storing energy during low load conditions and releasing the stored energy during high load conditions comprising an insulated container, an evaporator mounted in said container, a filling of water in said container, means for transferring heat from the cooling system to said water, a refrigerant compressor having a capacity of the order of the average load on said cooling system, electrically actuated valves controlling the connection of said evaporator to said compressor, a switch responsive to the load on said compressor and a selector responsive to operation of said

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switch for energizing said valves, a pressure responsive bellows connected to the output pressure of said compressor, a second pressure responsive bellows connected to the input pressure of said compressor, a switch including a contact arm jointly controlled by said bellows, a stepping relay for energizing said valves in accordance with the operation of said contact arm.

6. For use with a variable consumption cooling system, a system for storing energy during low load conditions and releasing the stored energy during high load conditions comprising an insulated container, an evaporator mounted in said container, a filling of water in said container, means for transferring heat from the cooling system to said water, a refrigerant compressor having a capacity of the order of the average load on said cooling system, electrically actuated valves controlling the connection of said evaporator to said compressor, a switch responsive to the load on said compressor and a selector responsive to operation of said switch for energizing said valves, a pressure responsive bellows connected to the output pressure of said compressor, a second pressure responsive bellows connected to the input pressure of said compressor, a switch including a contact arm jointly controlled by said bellows, a stepping relay for energizing said valves in accordance with the operation of said contact arm, a timing relay connected for actuating said stepping relay in response to a predetermined actuation of said switch.

7. For use with a variable consumption cooling system, a system for storing energy during low load conditions and releasing an insulated container, an evaporator mounted in said container, a filling of water in said container, means for transferring heat from the cooling system to said water, a refrigerant compressor having a capacity of the order of the average load on said cooling system, electrically actuated valves controlling the connection of said evaporator to said compressor, a switch responsive to the load on said compressor and a selector responsive to operation of said switch for energizing said valves, a pressure responsive bellows connected to the output pressure of said compressor, a second pressure responsive bellows connected to the input pressure of said compressor, a switch including a contact arm jointly controlled by said bellows, a stepping relay for energizing said valves in accordance with the operation of said contact arm, a timing relay connected for actuating said stepping relay in response to a predetermined actuation of said switch, a limit switch operative to limit the actuation of said stepping relay.

8. An energy storage device as claimed in claim 1 wherein the pressure responsive means include a switch comprising a first bellows connected to the input of the compressor, a second bellows connected to the output of the compressor, a contact arm journaled for floating motion in response to actuation of said bellows, and fixed contacts in the path of movement of said contact arm.

9. For use with a variable demand cooling system, a constant load heat exchanger comprising an insulated container, a heat adsorbing fluid in said container, a multi-section evaporator of said fluid, a header, one section of said evaporator being constantly connected to said header, electrically controlled valves operable to selectively communicate the remaining sections of said evaporator with said header, a compressor having a capacity of the order of the average demand of said cooling system, an electrically controlled valve in series between said compressor and said header, a manually controlled by-pass around said last-mentioned valve, a return conduit from said evaporator to said compressor, a pair of pressure extensible elements mounted in offset substantially parallel opposed arrangement, the inner ends of said extensible elements being substantially in transverse alignment, the outer ends of said extensible elements being fixed, means communicating one of said extensible elements with the output side of said compressor, means communicating the other of said extensible elements with the in-

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take side of said compressor, a contact arm mounted on the inner ends of said extensible elements, a movable contact carried by said arm, spaced apart fixed contacts arranged in the path of travel of said movable contact, a stepping relay actuated by contact of said movable contact with one of said fixed contacts, said stepping relay controlling the energization of said electrically controlled valves.

10. For use with a variable demand cooling system, a constant load heat exchanger comprising an insulated container, a heat adsorbing fluid in said container, a multi-section evaporator in said fluid, a header, one section of said evaporator being constantly connected to said header, electrically controlled valves operable to selectively communicate the remaining sections of said evaporator with said header, a compressor having a capacity of the order of the average demand of said cooling system, an electrically controlled valve in series between said compressor and said header, a manually controlled by-pass around said last-mentioned valve, a return conduit from said evaporator to said compressor, a pair of pressure extensible elements mounted in offset substantially parallel opposed arrangement, the inner ends of said extensible elements being substantially in transverse alignment, the outer ends of said extensible elements being fixed, means communicating one of said extensible elements with the output side of said compressor, means communicating the other of said extensible elements with the intake side of said compressor, a contact arm mounted on the inner ends of said extensible elements, a movable contact carried by said arm, spaced apart fixed contacts arranged in the path of travel of said movable contact, a stepping relay actuated by contact of said movable contact with one of said fixed contacts, said stepping relay controlling the energization of said electrically controlled valves, a timing relay responsive to continued contact between said movable contact and one of said fixed contacts to cause repeated operation of said stepping relay.

11. For use with a variable demand cooling system, a constant load heat exchanger comprising an insulated container, a heat adsorbing fluid in said container, a multi-section evaporator in said fluid, a header, one sec-

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tion of said evaporator being constantly connected to said header, electrically controlled valves operable to selectively communicate the remaining sections of said evaporator with said header, a compressor having a capacity of the order of the average demand of said cooling system, an electrically controlled valve in series between said compressor and said header, a manually controlled by-pass around said last-mentioned valve, a return conduit from said evaporator to said compressor, a pair of pressure extensible elements mounted in offset substantially parallel opposed arrangement, the inner ends of said extensible elements being substantially in transverse alignment, the other ends of said extensible elements being fixed, means communicating one of said extensible elements with the output side of said compressor, means communicating the other of said extensible elements with the intake side of said compressor, a contact arm mounted on the inner ends of said extensible elements, a movable contact carried by said arm, spaced apart fixed contacts arranged in the path of travel of said movable contact, a stepping relay actuated by contact of said movable contact with one of said fixed contacts, said stepping relay controlling the energization of said electrically controlled valves, a timing relay responsive to continued contact between said movable contact and one of said fixed contacts to cause repeated operation of said stepping relay, limit switches operative to determine the maximum operation of said stepping relay.

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