April 9, 1940. C. E. PLOEGER 2,196,473

AIR CONDITIONING

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Fig. 1.

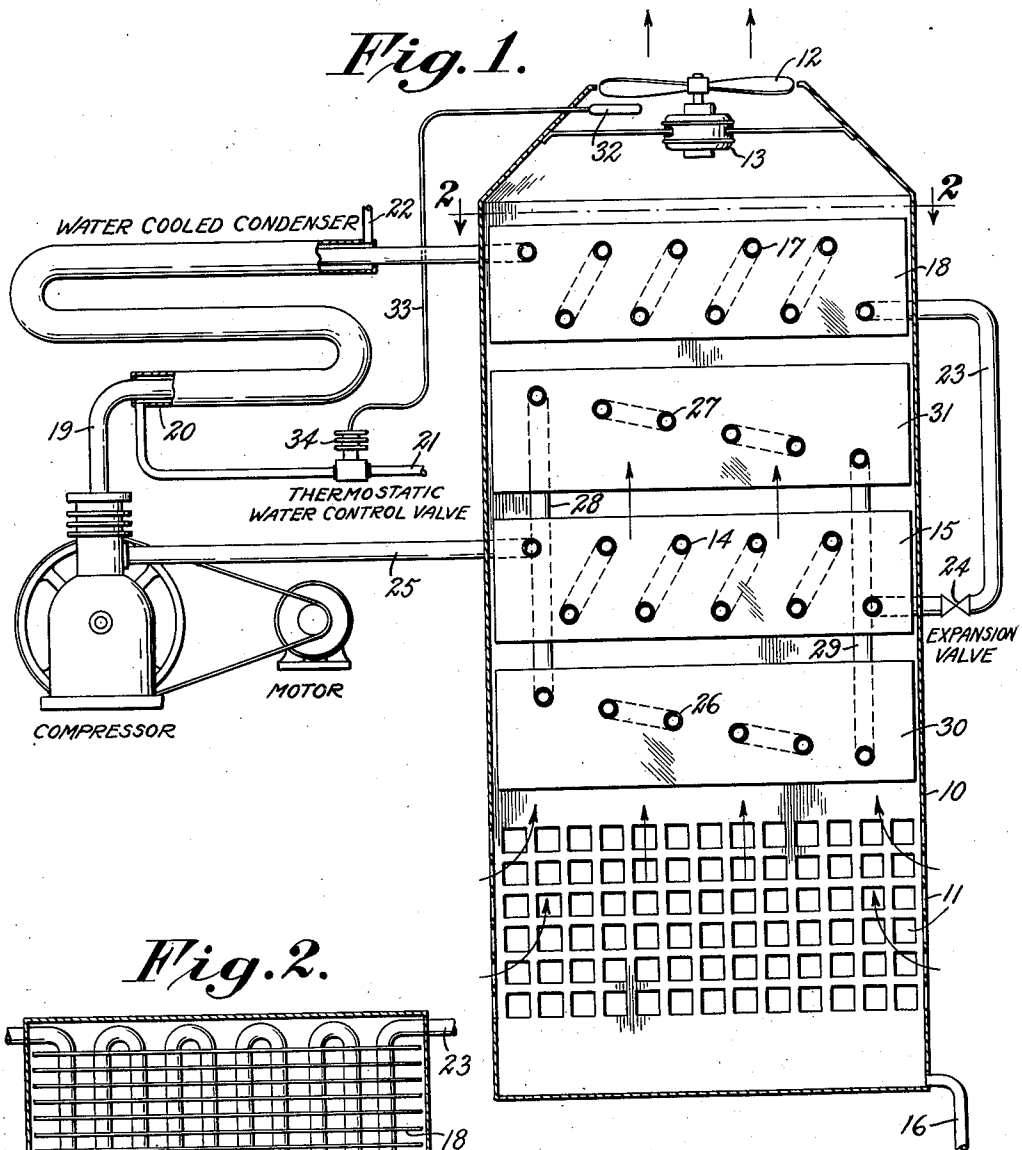
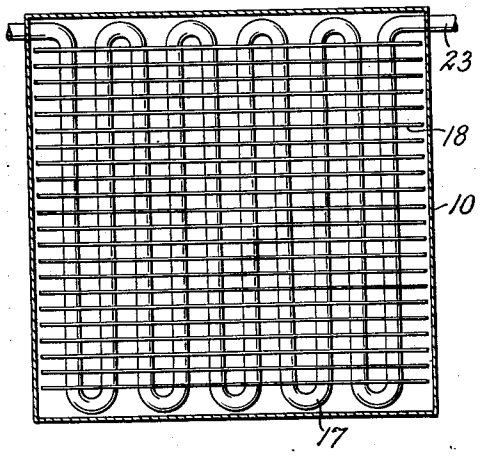


Fig. 2.



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AIR CONDITIONING

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3 Claims. (Cl. 62—6)

My invention relates to air conditioning and more particularly to a ventilation system in which air is dehumidified by cooling with refrigeration apparatus.

In a system of this type, air to be conditioned may be cooled to a temperature below its dew point to cause condensation of water vapor and thereby reduce the absolute humidity of the air. This cooling may be effected by flowing air in thermal transfer relation with the cooling element of a refrigeration apparatus. The resulting cold dry air is then at a temperature too low for comfort so that if the system is employed for comfort cooling it is preferable to increase the dry bulb temperature of the air before introduction into an enclosure to be conditioned. This heating may be accomplished by flowing the air in thermal transfer relation with the condenser or a portion of the condenser of the refrigeration apparatus.

In accordance with my invention I provide improved means for accomplishing cooling of air for dehumidification and subsequent re-heating, and also provide for simplified control of the air temperature. I provide a heat exchanger such as vaporization-condensation member containing a volatile fluid which is arranged so that the vaporization portion of the member is in thermal exchange relation with the air before the air is cooled by the cooling element of a refrigeration apparatus and so that the condensation portion is in heat exchange relation with the air after it has been cooled and dried. Heat absorbed by the vaporization portion in precooling of the air is returned to the air after it has been dried. The vaporization portion is arranged below the condensation portion so that the heat transfer fluid circulates automatically therein, that is, the vaporous fluid liquefies in the condensation portion and returns by gravity to the vaporization portion. I further arrange a portion of the condenser of a refrigeration apparatus in the air stream and provide for controlling the cooling of the other portion of the condenser responsive to temperature of the air which is to be maintained substantially constant at a predetermined temperature.

For a better understanding of my invention reference may be had to the following description taken in connection with the accompanying drawing in which Fig. 1 more or less diagrammatically represents air conditioning apparatus embodying my invention, and Fig. 2 is a sectional view taken on line 2—2 of Fig. 1.

Referring to the drawing, a vertical casing 10 serves as a duct through which air is circulated. The lower portions of the walls of the casing are grilled to provide an inlet, as indicated at 11, and the upper end is provided with a discharge opening adjacent which is disposed a fan 12 driven by a motor 13 supported within the casing. The fan 12 withdraws air from an enclosure through the grilles 11, draws the air upwardly through the casing past cooling and reheating elements whereby the air is conditioned, and delivers the conditioned air to the enclosure through the discharge opening, the path of flow of air just described being indicated by the arrows in Fig. 1.

As air is drawn upwardly through the casing 10, it flows over the surfaces of a cooling element comprising a zig-zag coil 14 having cross plates or fins 15 which are fixed to the coil in close spaced relation. The coil 14 is arranged substantially horizontally within the casing 10, and a relatively large surface is presented by the fins 15 to withdrawn air for cooling and dehumidifying the air. The moisture condensed from the air when it is cooled below its dew point drips from the surfaces of the coil 14 and plates 15, and is collected at the bottom of the casing from which it flows through a drain pipe 16 which may have a suitable connection for carrying away the water.

After being cooled and dehumidified, the air flows over the surfaces of a reheating element constructed in the same manner as the cooling element just described and comprising a zig-zag coil 17 having plates or fins 18 fixed thereto, whereby a relatively large heat dissipating surface is provided to add sensible heat to the cooled air before it is delivered to the enclosure.

The zig-zag coils 14 and 17 of the cooling and reheating elements form the evaporator and condenser, respectively, of a refrigerating system. This refrigerating system may comprise a motor and a compressor driven thereby which compresses the refrigerant gas. During operation, the compressed refrigerant gas is discharged from the compressor and flows through a water cooled condenser comprising a conduit 19 provided with a jacket 20 having inlet and outlet connections 21 and 22, respectively, through which cooling water can be circulated.

All or a part of the condensation of the compressed refrigerant gas may be effected in the water cooled condenser, as will be described hereinafter, and the condensed or partially condensed refrigerant flows therefrom through the condenser coil 17 which may, with the plates 18, serve

as a reheating element to reheat the cooled and dehumidified air which flows over its surfaces, as previously mentioned. In this manner, heat abstracted from withdrawn air by the evaporator coil 14 may, if desired, be restored to the cooled air.

The refrigerant, which is condensed either in the water cooled condenser or both in the water cooled condenser and condenser coil 17, flows through a pipe 23 and, under the control of an expansion valve 24, into the evaporator coil 14. The vaporized refrigerant is withdrawn through pipe 25 from the evaporator coil 14 by the compressor, in which it is again compressed and the refrigerating cycle repeated.

In accordance with my invention, in order to reduce the amount of work that must be done by the refrigerating system to cool and dehumidify withdrawn air, a vaporization - condensation member is provided which contains a volatile fluid that serves as a heat transfer agent. This member comprises a vaporization portion which is in the form of a zig-zag coil 26 supported within the casing 10 below the evaporator coil 14, and a condensation portion which is in the form of a zig-zag coil 27 supported within the casing between the evaporator coil 14 and condenser coil 17, the ends of the coils 26 and 27 being connected by vertical pipes 28 and 29 to provide a closed fluid system. To the coils 26 and 27 are fixed a plurality of plates 30 and 31, respectively, in a manner similar to that shown in Fig. 2, so that relatively large surfaces are presented to withdrawn air as it flows upwardly through the casing 10.

The volatile liquid vaporizes in the coil 26, abstracting sensible heat from withdrawn air to supply the heat of vaporization, and the vapor of the volatile fluid flows upwardly to the coil 27 from which abstracted heat is returned to dehumidified air. In transferring heat to dehumidified air, the vapor is condensed to liquid state, and, since the coil 27 is disposed above the coil 26, the condensed liquid flows by gravity back to the coil 26. It will therefore be seen that the volatile liquid serves as a heat transfer agent which circulates naturally through the closed fluid system. The coils 26 and 27 are preferably supported in an inclined position, as shown in Fig. 1, so that the vaporized heat transfer agent will flow upwardly through pipe 28, and the condensate will flow downwardly through pipe 29.

In order to dehumidify withdrawn air it is necessary to reduce the temperature of the air from the dry bulb temperature below the dew point. When sensible heat is abstracted from withdrawn air by flowing over the surfaces of the coil 26 and plates 30, the dry bulb temperature of the air is lowered considerably, so that the quantity of refrigeration that must be effected by the evaporator coil 14 to bring withdrawn air below the dew point is reduced a substantial amount. Since the pre-cooling of withdrawn air is accomplished automatically without any mechanical device, considerable saving is effected in that less work is required of the refrigerating system to cool and reduce the moisture content of withdrawn air. Further, the sensible heat abstracted when withdrawn air is pre-cooled is effectively utilized to reheat the cold dry air.

The temperature of conditioned air delivered to the enclosure can readily be controlled by regulating the amount of reheating that will be effected by the condenser coil 17 when air flows over the surfaces of this coil and the plates 18. This is accomplished by positioning a thermostat 32 within the casing 10 adjacent the discharge opening, and connecting such thermostat by a capillary tube 33 to a thermostatic water control valve 34 which is located in the inlet connection 21 of the water cooled condenser. The thermostat 32 and capillary tube 33 are filled with a suitable fluid, and constitute an expansible fluid thermostat for controlling the valve 34 to increase the amount of water circulated through the condenser when the air delivered to the enclosure is above a desired temperature; and, conversely, to decrease the amount of water circulated through the condenser when the air delivered to the enclosure is below the desired temperature.

When the amount of water circulated through the condenser is increased, more condensation of compressed refrigerant gas takes place in the water cooled condenser, so that less reheating can be effected through the condensation of refrigerant gas in the condenser coil 17 and the temperature of conditioned air is reduced to the desired temperature; and, when the amount of water circulated through the water cooled condenser is decreased, less condensation of refrigerant gas takes place in the water cooled condenser, so that a greater amount of reheating can be effected through the condensation of refrigerant gas in the condenser coil 17 and the temperature of conditioned air is increased to the desired temperature. It will therefore be seen that the desired temperature of conditioned air delivered to the enclosure can be readily controlled by adjusting the valve 34 in the inlet water connection 21. Although I have fully described reheating of the air by heat of the condenser portion 17 and the coil 27 of the vaporization-condensation member, any suitable heat exchanger may be provided in place of the vaporization-condensation member.

It will be understood that various changes and modifications may be made within the scope of the invention indicated by the following claims.

What is claimed is:

1. A ventilation system including an enclosure, a duct, means for flowing air through said duct to the enclosure, refrigeration apparatus including a cooling element and a condenser for respectively dehumidifying and partially reheating air flowing through said duct, said cooling element and a portion of said condenser being positioned in spaced relation in said duct, means including a heat conducting fluid circuit for precooling air prior to dehumidification and for partially reheating dehumidified air, said circuit having a heat absorbing part positioned in said duct ahead of said cooling element relative to the flow of air and a heat dissipating part positioned in said duct between said cooling element and said portion of the condenser, and means responsive to the temperature of the air delivered from said duct for controlling cooling of the other portion of said condenser.

2. Air conditioning apparatus comprising a casing through which air may flow upwardly and having an inlet and an outlet above the inlet, means for circulating air upwardly through said casing, means including an evaporator element and a condenser of a refrigerating system for dehumidifying and for subsequently partially reheating air flowing through said casing, said evaporator element and a portion of said condenser being positioned in spaced relation in said casing, said evaporator element being disposed be-

low said condenser, means including a closed circuit containing heat conducting fluid for precooling air prior to dehumidification and for partially reheating dehumidified air, said circuit having a heat-absorbing portion positioned in said casing below said evaporator element and a heat rejecting portion positioned in said casing between said evaporator element and said condenser, means associated with the portion of said condenser outside of said casing for condensing refrigerant flowing therethrough, and means responsive to the temperature of air discharged from the outlet for controlling said last-mentioned means.

3. An air conditioning system including means providing a passage for air to be conditioned, refrigeration apparatus including a cooling element and a condenser, said cooling element and a portion of said condenser being positioned in spaced relation in the passage for respectively dehumidifying and reheating air flowing therein, and means operative responsive to a temperature condition of the dehumidified and reheated air to control cooling of the other portion of said condenser.

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