

July 10, 1934.

C. W. CHAMBERLAIN

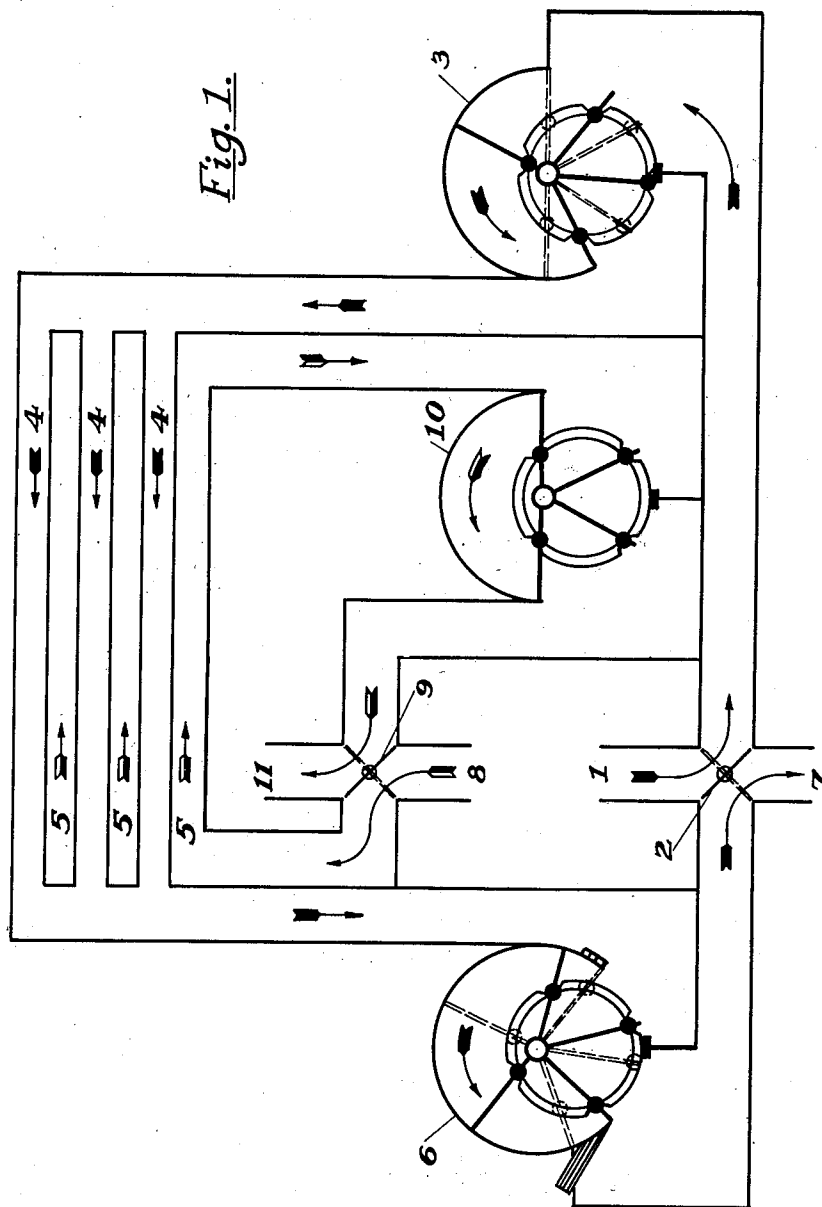
1,965,733

METHOD AND APPARATUS FOR HEATING, COOLING, AND VENTILATING

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3 Sheets-Sheet 1

Fig. 1.



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Fig. 2.

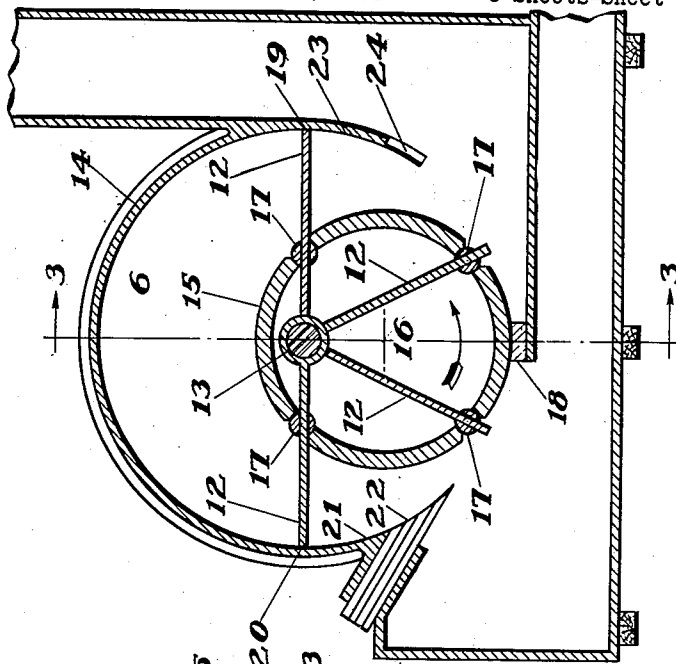
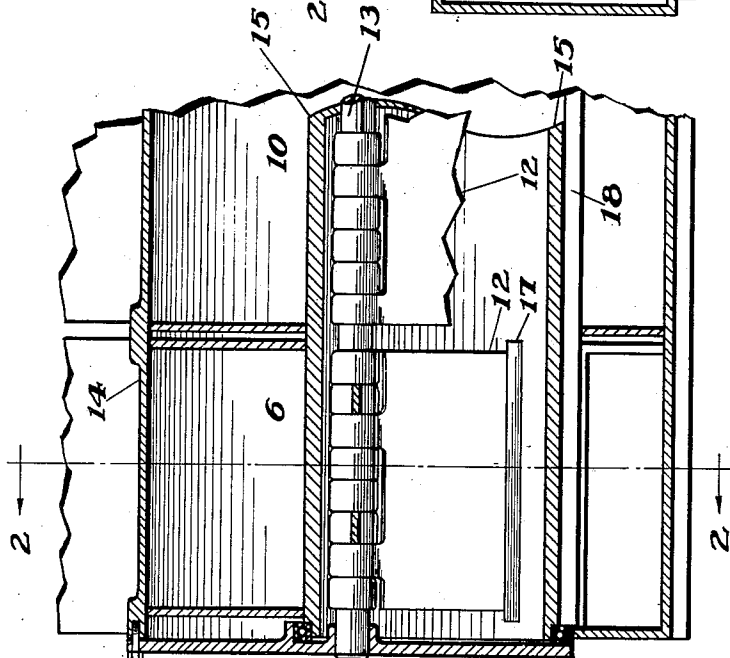


Fig. 3.



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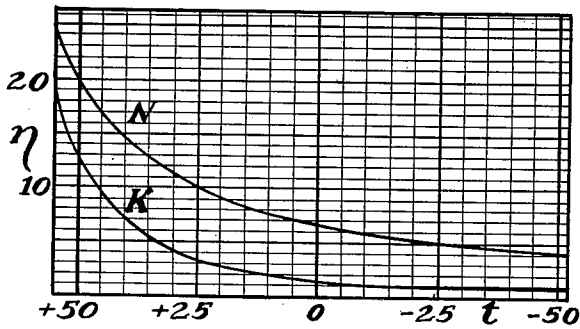


Fig. 4.

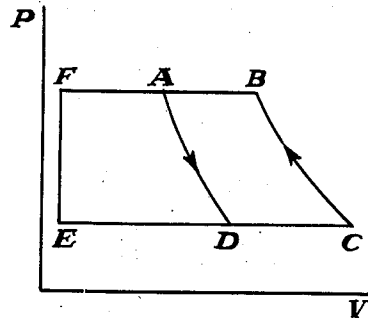


Fig. 5.

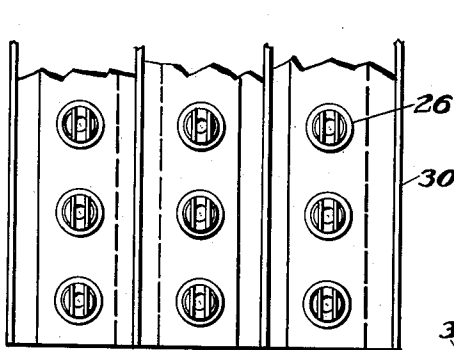


Fig. 8.

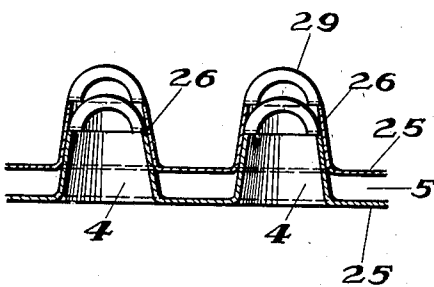


Fig. 6.

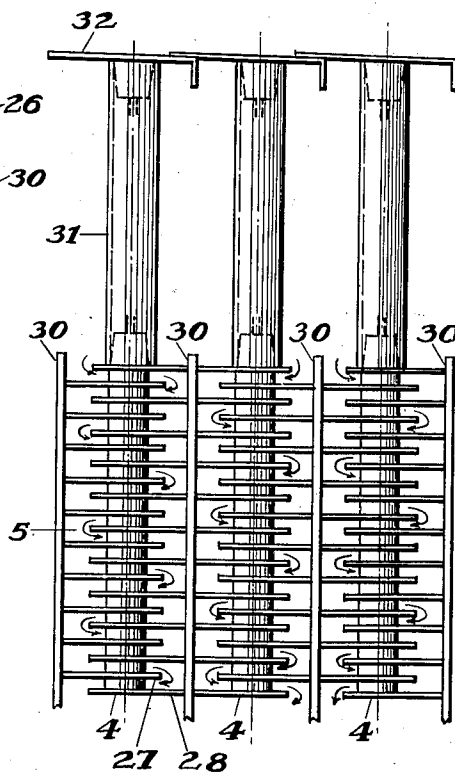


Fig. 7.

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UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS FOR HEATING,
COOLING AND VENTILATING

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Application January 2, 1931, Serial No. 506,175

6 Claims. (Cl. 257—9)

The present invention, relating, as indicated to methods of and apparatus for heating, cooling and ventilating, has more particular reference to processes of and machines for heating, cooling and ventilating the interiors of buildings and the like, and its principal object, broadly stated, is to provide methods and means whereby these functions can be mechanically effected.

My invention relates to the movement of heat from the exterior atmosphere to the interior air of a compartment to be heated, or the removal of heat from the interior air of a compartment to be cooled, to the outside atmosphere by the expenditure of an amount of energy less than the mechanical equivalent of the heat so transferred.

One object of my invention is to heat and ventilate confined spaces by removing by purely mechanical means heat from the foul or vitiated air of such space, and returning such air to the outside atmosphere at a temperature lower than the temperature of the outside atmosphere, introducing fresh air into the confined space, and raising the temperature of the fresh air so introduced, thus retaining in the interior the heat of the expelled air and pumping heat from the outside atmosphere into the interior to restore the heat lost by the interior through conduction, radiation and other means.

Another object of my invention is to cool and ventilate confined spaces by the introduction of fresh air the temperature of which has been lowered by mechanical means, returning the vitiated air to the outside atmosphere and raising the temperature of the air so removed, thus retaining in the interior the refrigerating effect of the expelled air and pumping heat from the confined space to the outside atmosphere to remove heat gained by the interior of such space through conduction, radiation and other means.

Another object of my invention is to reduce to a minimum the range of temperature in the compression and expansion members of heating and cooling machines, thereby increasing their efficiency.

Another object of my invention is the utilization of the excess of temperature of the vitiated air removed from an interior over the temperature of the outside atmosphere to increase the efficiency of mechanical heating.

Another object of my invention is the utilization of the refrigerating effect of the vitiated air removed from an interior to increase the efficiency of mechanical cooling.

Another object of my invention is to reduce to a minimum the temperature range through which

heat falls by conduction in a mechanical heating and cooling machine, thereby increasing its efficiency.

A seventh object of my invention is to provide a single machine which will heat, cool, and ventilate, without any change or addition of mechanism, or change of direction of flow of air currents through the machine.

To the accomplishment of the foregoing and related ends, said invention, then, consists of the means hereinafter fully described and particularly pointed out in the claims. The annexed drawings and the following description setting forth in detail certain mechanism embodying the invention, such disclosed means constituting, however, but one of various mechanical forms in which the principle of the invention may be used.

In said annexed drawings:

Fig. 1 is a schematic diagram indicating the cycle through which the vitiated and fresh air is moved when the machine operates as a heater; Fig. 2 is a fragmentary sectional view of a portion of the apparatus illustrated in Fig. 1; Fig. 3 is a fragmentary part sectional, part elevational view of the apparatus illustrated in Fig. 2 taken on a plane substantially indicated by the line 3—3; Fig. 4 is a graph showing by means of curves the thermodynamic efficiency of the Kelvin apparatus and the method and apparatus comprising my invention; Fig. 5 is an indicator diagram for the apparatus of my invention; and Figs. 6, 7 and 8 are respectively part sectional, elevational and a plan view of the heat exchanger unit employed in my invention.

Referring more specifically to the drawings, and more especially to Fig. 1 in the schematic arrangement here illustrated, the vitiated air from near the floor of the interior or room enters at 1, is deflected by the vane 2 to the compressor 3, passes through the counter-flow heat interchanger 4, 5, where its temperature is lowered, to the expander 6 where its pressure is lowered to that of the atmosphere and its temperature below that of the atmosphere, then deflected by the vane 2 to the outside atmosphere at 7.

Fresh air from outside the confined space to be heated is admitted to the machine at a higher level 8, is deflected by the vane 9 through the counter-flow heat interchanger 5, 4, where its temperature is raised, to the displacer 10, then deflected by the vane 9 to the interior at 11.

The compressor, expander, and displacer hereinafter more fully described are operated at the same speed. Their diameters are preferably equal but their lengths so proportioned that equal

masses of air enter and leave the interior at each stroke.

The same machine is used to cool the confined space by the setting of the vanes 2 and 9 to the position shown in dotted lines in Fig. 1, these positions being at right angles to those occupied when the machine is used to heat the interior. In this case fresh air from the outside enters at 7, is deflected by the vane 2 to the compressor 3, passes through the counter flow heat interchanger 4, 5 where its temperature is lowered, to the expander 6 where its pressure is lowered to that of the atmosphere and its temperature below that of the atmosphere, then deflected by the vane 2 to the interior at 1.

Vitiated air from the interior to be cooled is admitted to the machine at a higher level 11, is deflected by the vane 9 through the counter-flow heat interchanger 5, 4 where its temperature is raised, to the displacer 10, then deflected by the vane 9 to the exterior at 8.

It will be noted that the direction of motion of the machine and the air currents through the machine remain the same whether the machine operates as a cooler or as a heater.

An ideal indicator diagram for the whole cycle is shown in Fig. 5, where E C B A shows the action of the compression cylinder and F A D E shows that of the expansion cylinder. The area A B C D represents the net amount of work that is expended. The compression and expansion are treated as approximately adiabatic and the volume of the heat interchanger such that its pressure is sensibly constant.

In the case where it is desired to remove vitiated air at 15 degrees centigrade and introduce fresh air at 25 degrees, with the outside temperature at 13 degrees, the volume at C, B, A, and D, Fig. 5, that is the maximum volume of the compressor, the volume after adiabatic compression to 25 degrees, the volume after cooling at constant pressure to 13 degrees, and the volume after adiabatic expansion to atmospheric pressure, are 1, 0.96, 0.88, and 0.92 respectively. The corresponding pressures in atmospheres are 1, 1.13, 1.13, and 1, while the corresponding temperatures are 15, 25, 13, and 3.4. The coefficient of performance of the machine in this case is 24.8.

If the outside temperature is -50 degrees centigrade, the volumes at C, B, A, and D are 1, 0.92, 0.69, and 0.75. The corresponding pressures in atmospheres are 1, 1.13, 1.13, and 1, while the corresponding temperatures are 15, 25, -50, and -57.5, with a coefficient of performance of approximately 4.

The apparatus illustrated in the schematic diagram, Fig. 1 is most clearly illustrated in Figs. 2, 3 and 6 to 8. Referring more specifically to Figs. 2 and 3, it will be noted that I have in these figures illustrated the construction of the expander and compressor which have been more or less diagrammatically illustrated at 3 and 6 in Fig. 1. Referring then more specifically to Fig. 2 it will be noted that the compressor or expander consists of a drum 14 which has a portion of its lateral wall cut away so as to be in communication with the ingress and egress ducts. The cylinder 14 has mounted coaxially therein, a fixed shaft 13, upon which are rotatably mounted a plurality of separately movable fins or vanes 12, which extend into close proximity to the inner periphery of the cylinder 14. Mounted eccentrically of the cylinder 14 is a cylindrical member 15, which is rotatable about its axis 16. The cylinder member 15, which is a driving or driven member depend-

ing upon the use to which the apparatus is put has a plurality of slots therein corresponding to the number of vanes 12, and through which such vanes extend. Cylindrical stuffing boxes 17 are provided in the slots through which the vanes 12 extend, so that as the cylindrical member 15 rotates or is caused to rotate, the fluid trapped intermediately of the vanes 12 will not escape at this point.

A fixed abutment 18 in contact with the periphery of the cylindrical member 15 separates the high and low pressure sides of the apparatus and in effect separates the ingress and egress conduits. As the cylindrical member 15 rotates it will be noted that the eccentricity thereof relative to the cylindrical member 14 will produce a relative movement between the vanes 12. If the lateral wall of the cylinder 14 were to terminate at 19 and 20, or at such points as to provide the maximum capacity for each stroke depending upon the number of vanes 12 employed, then the rotation of the cylindrical member 15 effecting a rotation of the vanes 12 about the fixed axle 13 would cause the apparatus to operate as a displacer, simply moving volumes of air from one side to the other without effecting any change in the pressure or volume thereof. This form of construction is adopted for the displacer 10 illustrated in Fig. 1, where only a displacement of air is desired without any change in its pressure, temperature or volume.

If, however, the peripheral extent of the wall of the cylinder 14 is increased past this semicircle for a 4 vane device on either side, then the machine may be converted into either a compressor or an expander. As illustrated in Fig. 2, the machine is adapted to function as the expander 6 illustrated in Fig. 1. In forming the expander the ingress lip 23 is extended and in producing the compressor 3 the egress lip 21 is extended by means of a plurality of elements such as 22 which may be inserted to accurately vary the extent of such egress lip 21, and accordingly regulate or vary the pressure built up by the compressor formed in this manner.

From the above description it will be noted that an element such as is illustrated in Fig. 2 may be employed with very little change in each of the three steps, namely, the compressor, displacer and expander.

In the preferred form of construction of the apparatus comprising my invention, these three units, namely the compressor, displacer, and expander will be formed as is most clearly illustrated in Fig. 3, namely, by having these units disposed side by side in axial arrangement, so that the shell 14 of the hereinbefore described cylinder may be made continuous for all three units, and the axle or shaft 13 may likewise extend through such units. As illustrated in Fig. 3 the expander and the displacer are shown side by side with the figure broken away without showing the compressor, which would be placed adjacent the displacer 10 on the other side thereof from the expander 6. In this preferred form of construction, the cylindrical member 15 will extend through the several elements and may be journaled in bearings mounted in the ends of the cylinder 14. It will be noted that means may be employed in communication with the cylinder 15, so that the same may be driven by suitable prime mover means (not shown). In this combined form of construction the cylindrical member 15 in addition to its function of producing the proper relative movement be-

tween such several elements, also functions as a mechanical linkage between the several units.

The counter-flow heat exchanger is more clearly illustrated in Figs. 6, 7 and 8. The ducts 4 through which the air flows in one direction through such heat exchanger are produced by the struck up portion 26 of the web or plate member 25. These struck up portions are tapered so that telescopic engagement of adjacent portions will be had as such plates 25 are brought into assembled relation. The struck up portion 26 of the plates 25 have their ends formed with transversely extending baffles 29 which will serve as baffles extending across the stream of air or fluid passing through the conduits 4. Such baffles 29 are a continuous metallic extension of the side walls of the struck up portions 26, so that conduction of heat from the fluid flowing through the tubes 4 and the side walls and flat surface of the plates 25 is a maximum. The strips 25 from which the tube portions 26 are struck up have such struck up portions provided adjacent their edges as at 27 and 28 in the manner illustrated at 27, so that when a plurality of such plates are employed to form a heat exchange unit, the plates 25 will provide a circuitous passage for the air flowing from one end of such heat exchanger to the other, around the outside of the conduit 4. The particular construction of the heat exchange element as hereinbefore described is desirable due to the fact that a metallic path is had between the air on the inside of the tube 4 and the air on the outside thereof, while the longitudinal extent of the tube 4 is broken up into a plurality of sections, so that conduction of heat in this direction is reduced to a minimum. In the assembly of the heat exchanger the fins or plates adjacent one end of the radiator will be omitted from such tubes as at 31, so that this open space will serve as a header for the heat exchange element. Strips of insulating material such as 30 are positioned intermedially of the conduits 4 so that the air will take a truly counter flow through the heat exchanger as illustrated in Fig. 7.

By employing the hereinbefore described form of counter flow heat interchanger the outside air will flow in at one end of the interchanger and the inside air will flow in at the other end thereof, so that the resultant temperature of each of such streams will be substantially equal to the temperature of the other stream at the incoming end.

It is believed that a further description of the apparatus comprising my invention is unnecessary for those familiar with the art, it being noted that in the above description and in the drawings associated therewith, a number of elements have been shown diagrammatically in form, but inasmuch as such elements are well known to those familiar with the art, a more detailed description thereof is believed unnecessary.

Other modes of applying the principle of my invention may be employed instead of the one explained, change being made as regards the mechanism herein disclosed, provided the means stated by any of the following claims or the equivalent of such stated means be employed.

I therefore particularly point out and distinctly claim as my invention:—

1. The method of tempering the air of an enclosed space, which comprises the steps of drawing separate apportioned amounts of air from such space and from the space surrounding the same, compressing one of said amounts of air, cooling said compressed air, adiabatically expanding said compressed air and discharging the same to one of said spaces, and simultaneously discharging the other of said amounts of air to the other of said spaces, the cooling of said compressed air being accomplished solely by the last named amount of air.

2. The method of heating an enclosed space which comprises the steps of withdrawing the vitiated air from such space at approximate atmospheric pressure, compressing said vitiated air, cooling said compressed vitiated air and then adiabatically expanding said compressed air and discharging the same to the outside, and simultaneously introducing fresh air from the outside to said space, the heating of said fresh air being accomplished solely by cooling said vitiated compressed air.

3. The method of cooling an enclosed space which comprises the steps of withdrawing the vitiated air from such space at approximate atmospheric pressure, and simultaneously compressing fresh air drawn from the outside, cooling said compressed air and then adiabatically expanding said compressed air and introducing it into the said space to replace the withdrawn vitiated air, the cooling of said compressed air being accomplished solely by said withdrawn air.

4. In apparatus for tempering the air of an enclosed space, the combination of means for drawing separate apportioned amounts of air from such space and from the space surrounding the same, means for compressing one of said amounts of air, means for cooling said compressed air solely by the use of the other of said amounts of air, whereby the latter amount is heated, means for adiabatically expanding said compressed air, and means for separately discharging said separate amounts of air to said separate spaces.

5. In apparatus for heating an enclosed space, the combination of means for withdrawing the vitiated air from such space, means for compressing said vitiated air, means for introducing fresh air from the outside to said space, means for cooling said compressed vitiated air solely by means of said fresh air whereby said fresh air is heated, means for adiabatically expanding said compressed vitiated air and discharging the same to the outside of said space.

6. In apparatus for cooling an enclosed space, the combination of means for withdrawing vitiated air from such space, means for compressing a quantity of fresh air from the outside of said space, means for cooling said compressed air solely by means of said vitiated air, discharging said heated vitiated air to the outside of said space, and means for adiabatically expanding said compressed fresh air and introducing the same to said space.

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