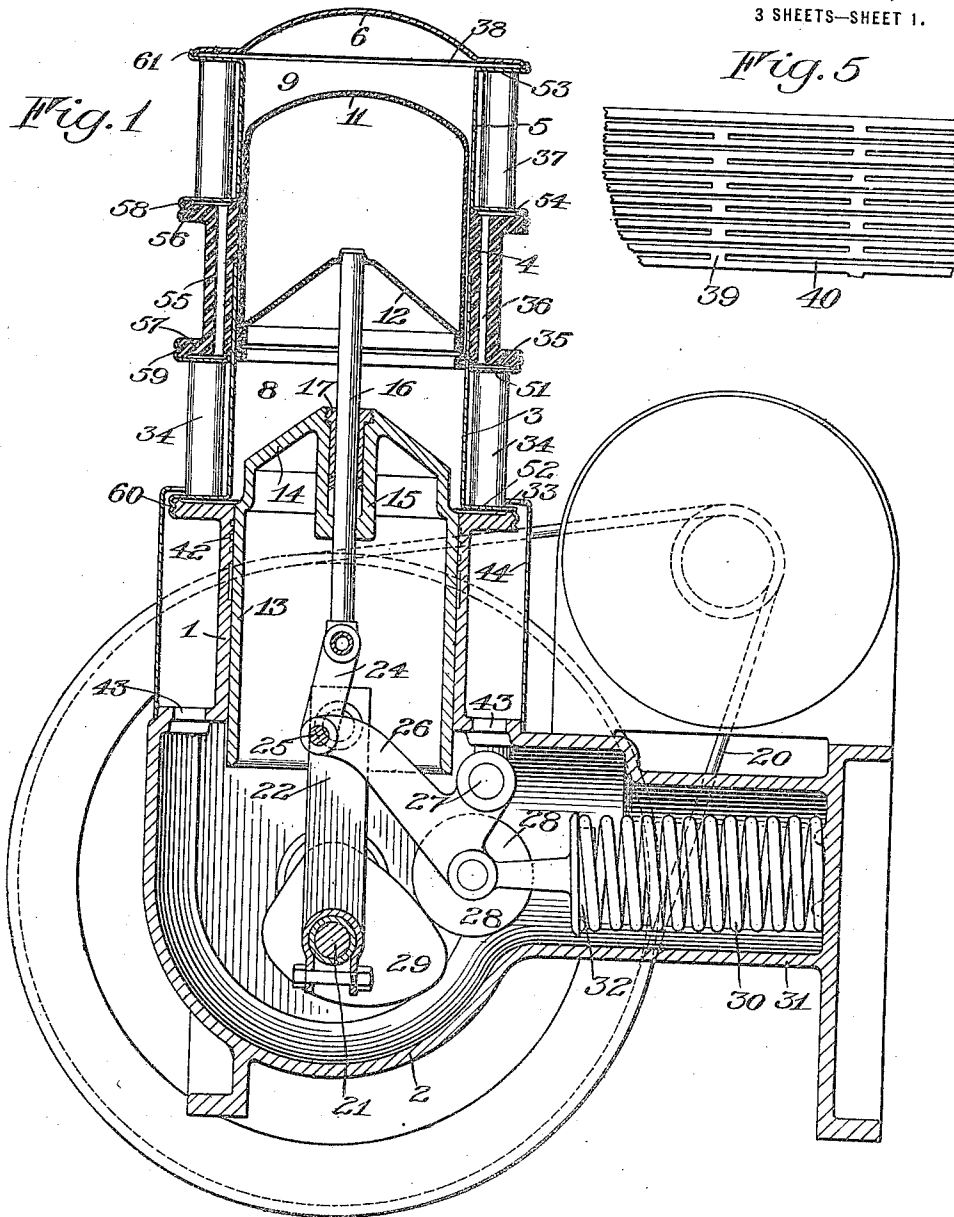


I. LUNDGAARD.
REFRIGERATING MACHINE.
APPLICATION FILED SEPT. 21, 1915.

1,240,862.

Patented Sept. 25, 1917.

3 SHEETS—SHEET 1.



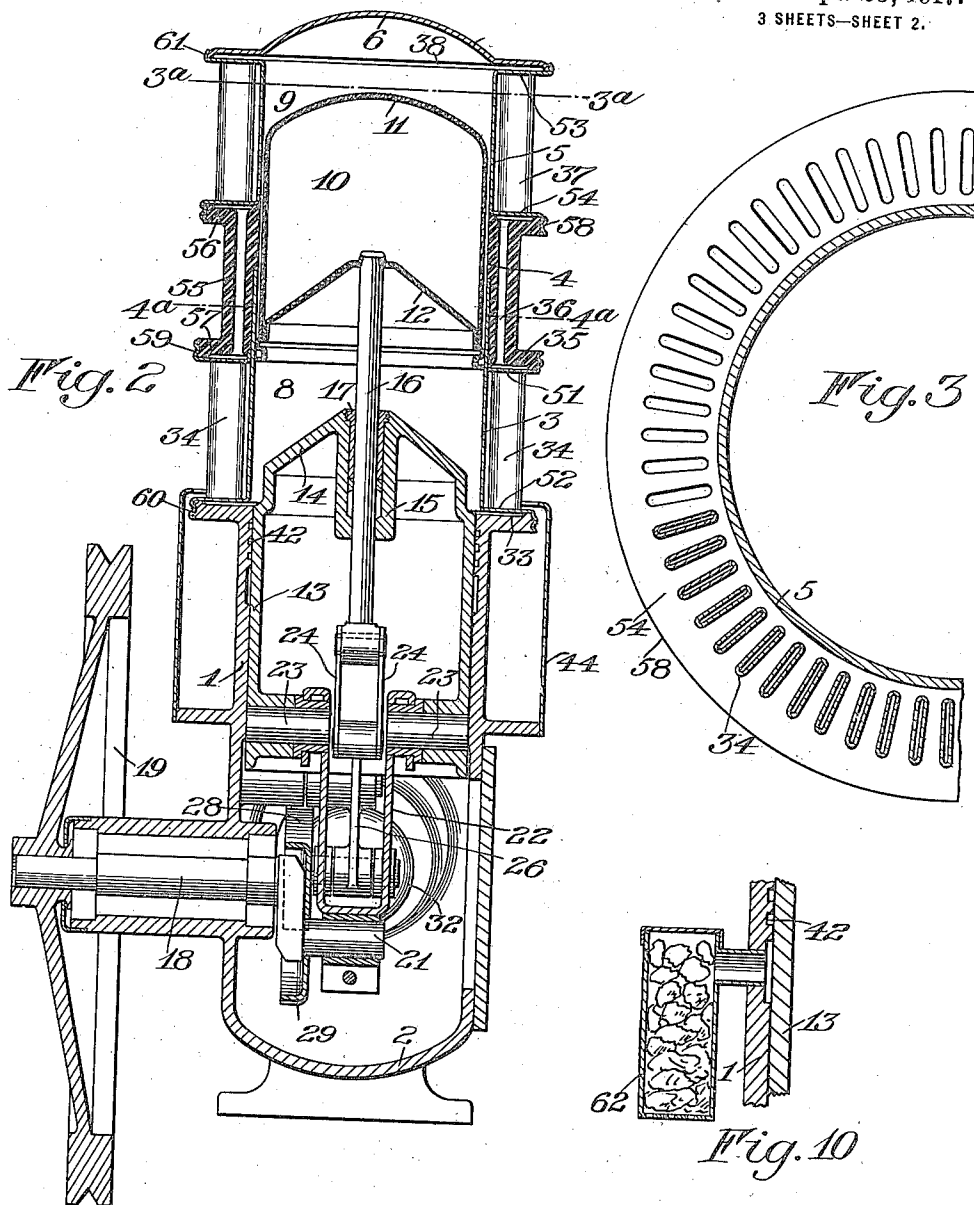
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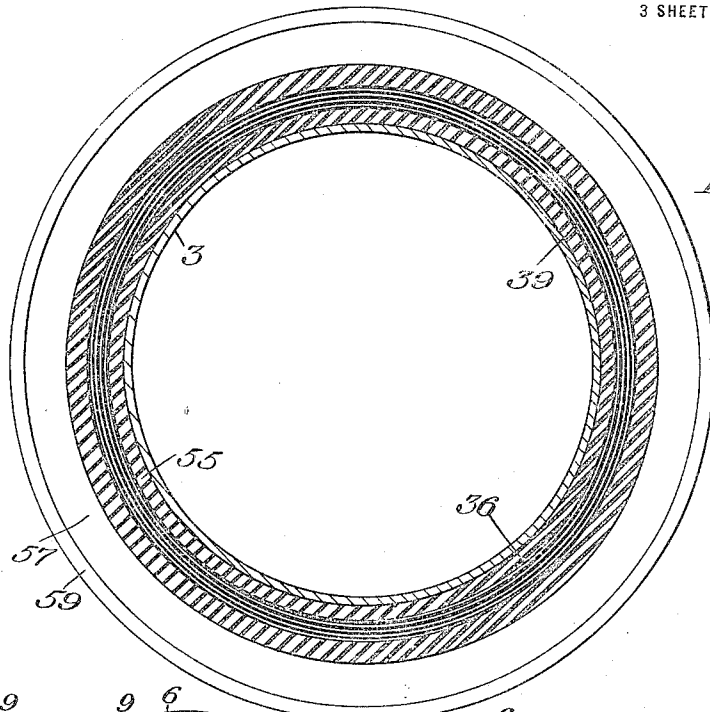
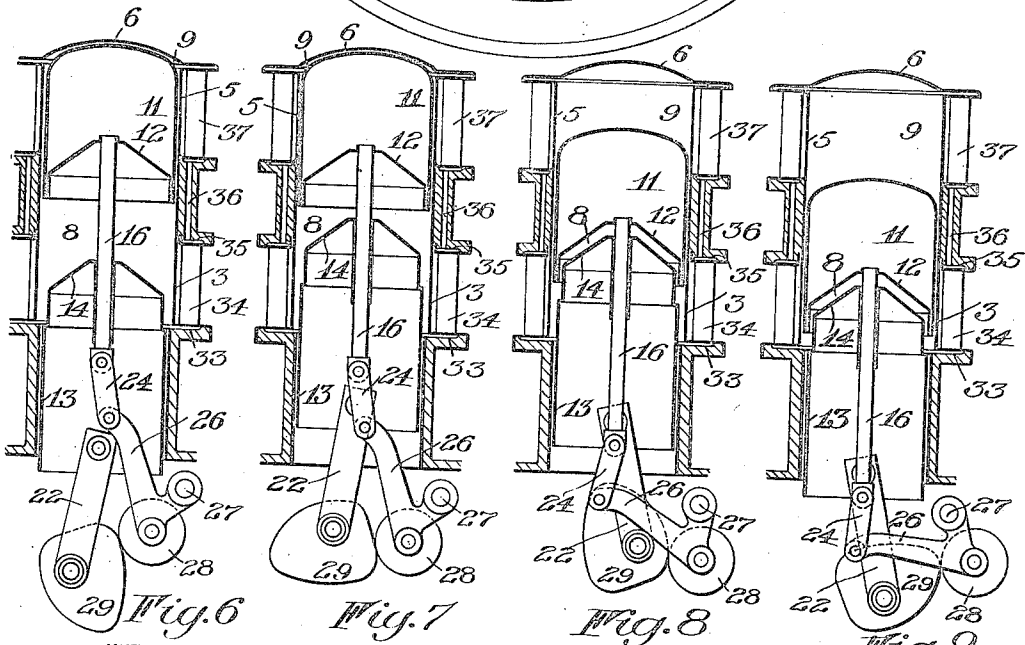


Fig. 4



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UNITED STATES PATENT OFFICE.

IVAR LUNDGAARD, OF ROCHESTER, NEW YORK.

REFRIGERATING-MACHINE.

1,240,862.

Specification of Letters Patent. Patented Sept. 25, 1917.

Application filed September 21, 1915. Serial No. 51,767.

To all whom it may concern:

Be it known that I, IVAR LUNDGAARD, of Rochester, in the county of Monroe and State of New York, have invented certain new and useful Improvements in Refrigerating-Machines; and I do hereby declare the following to be a full, clear, and exact description of the same, reference being had to the accompanying drawings, forming a part of this specification, and to the reference-numerals marked thereon.

My invention has for its object to provide a machine for refrigerating, which may be employed for cooling a fluid body or making ice, and it has for its chief purpose to afford a structure of simple construction which can be economically manufactured. A further object of my improvement is to provide a combination of parts that is dependent for its operation on a definite, contained body of fluid, such as air, which is alternately subjected to pressure and permitted to expand in order to absorb heat from the body to be cooled, and transmit such heat to and discharge the same into the atmosphere or other available cooling medium. Still another purpose of the invention is to reduce the operating cost of a refrigerating machine, and correspondingly increase its efficiency, without impairing the continued operation of the mechanism over an extended period. To these and other ends the invention consists in certain improvements and combinations of parts all as will be hereinafter more fully described, the novel features being pointed out in the claims at the end of the specification.

In the drawings:

Figure 1 is a longitudinal vertical sectional view of a machine constructed in accordance with a preferred embodiment of my invention;

Fig. 2 is a transverse vertical sectional view of the same;

Fig. 3 is a sectional view on the line 3^a—3^a of Fig. 2;

Fig. 4 is a sectional view on the line 4^a—4^a of Fig. 2;

Fig. 5 is a detail view in elevation of a portion of the plate, which I employ in the regenerating chamber;

Fig. 6 is a diagrammatic view showing the first position of the displacement and power pistons in the normal operation of the machine;

Fig. 7 is a similar view showing the pistons in second position, the power piston having moved on its upstroke;

Fig. 8 is a similar view showing the next position of the piston, when the displacement piston has traveled downwardly into compressing relation with the power piston;

Fig. 9 is a similar view with the pistons in last position immediately prior to resuming the relation shown in Fig. 6, both pistons having traveled downwardly, and

Fig. 10 is a detail view of a modification. Similar reference numerals in the several figures indicate the same parts.

The construction which is disclosed and described in this application is intended merely as illustrative of a possible means of carrying out the invention, and is not to be considered in any sense as limiting the invention to any specific form of mechanism, since I may accomplish the purposes contemplated in various ways, the common characteristic of which may be said to consist in utilizing a definite, contained mediating body consisting of some fluid, such as air, which is transferred alternately back and forth between a compression chamber and an expansion chamber, the expansion chamber being arranged within a body to be cooled and acting, together with fluid conducting means, to withdraw heat from such body, which body is of a temperature higher than the average temperature of the fluid in the expansion chamber; while the compression chamber is arranged within a body of lower temperature than the average temperature of the fluid within the compression chamber, so that heat is transferred from the mediating fluid to said body of lower temperature. Arranged between the compression and expansion chambers is a fluid conducting means which serves to carry the mediating fluid from one chamber to the other, and on account of a peculiar construction which combines a large surface with a small volume of the fluid conducting channels, is chiefly instrumental in the absorption of heat from the body to be cooled and in dissipation of the heat of the mediating fluid to the body into which said heat is to be discharged. The mediating fluid passes through a regenerating chamber which acts gradually to change its temperature as it passes from the compression chamber to the expansion chamber, or vice versa, so that by the time it

emerges from the regenerating chamber it will be near the average temperature of the respective surrounding body.

In the present embodiment I employ a single cylinder, the lower part of which consists of the portion 1 of the crank case 2. The cylinder is further constituted by wall 3, adjacent to the portion 1, intermediate wall 4 which is of insulating material, and upper wall 5, to which is secured the top 6. The several walls just referred to form a practically continuous and uninterrupted surface for the interior of the cylinder, which latter includes a compression chamber or portion designated generally at 8, and an expansion chamber or portion 9. The expansion chamber 9 embraces the space between the top 6 of the cylinder and a displacement piston when the latter is in lowered position, as shown in Fig. 9. The displacement piston 10 is preferably constructed so as to offer considerable resistance to conduction of heat, being made of rubber, celluloid, or fiber, and in the present instance is hollow, being provided with a curved top 11 to engage the top 6 of the cylinder and a conical bottom 12 for coöperation with the power piston which will presently be described. 13 designates the power piston provided with a conical top 14 for coöperation with the corresponding bottom of the displacement piston. The power piston 13 is open at its lower end, and provided at its upper end with a collar 15 having an opening to receive the piston rod 16, the latter being connected to the displacement piston and guided in the collar 15 by means of a bushing 17.

The piston 13 is driven by a crank shaft 18 which carries a pulley 19 to which power is transmitted by a belt 20 from a suitable motor. The crank shaft 18 is provided with a crank pin 21 which is connected by means of arms 22 with bearings 23 carried by the piston 13. The piston rod 16 carries links 24 which are connected to a pin 25 on the lever 26, the latter being pivoted on a fixed bearing 27. The lever 26 also carries a roller 28 which contacts with a cam 29 fixed on the crank pin 21 and operating to rock the lever 26 through the roller 28 and thereby lower the displacement piston in the cylinder. The cam 29 is so shaped and the parts timed in such a manner as to effect the proper relative movement of the power and displacement pistons in a manner which will be hereinafter more fully explained. The displacement piston is returned to its uppermost position through the instrumentality of a spring 30 arranged in a housing 31 of the casing and coöperating with a head 32 carried by the lever 26.

The compression chamber of the cylinder is connected with the expansion chamber by fluid conducting means preferably arranged

exteriorly of the cylinder. To this end, there is provided a passage 33 at the lower end of the compression chamber which leads to the flat restricted tubes 34, affording extended radiating surfaces in contact with which the fluid must come in passing from one portion of the cylinder to the other portion. The tubes 34 connect through a passage 35 with a regenerating chamber 36, and this in turn is connected with a series of tubes 37 similar to those already described. The tubes 37 lead to the upper portion or expansion chamber of the cylinder through a passage 38. The radiating tubes 34 are surrounded by the atmosphere, water, or other available cooling body, while the tubes 37 are surrounded by a chamber in which is the body to be cooled. The air under pressure in the compression chamber passes swiftly through the tubes 34, giving off heat to the surrounding body of lower temperature, and passing through the tubes 37 enters the expansion chamber 9 where it expands, substantially lowering its temperature, and draws heat from the surrounding body of higher temperature and thus serves to produce a cooling of the latter, the amount of which is dependent upon the degree of expansion of the mediating fluid. The regenerating chamber 36 is provided, in order to graduate the temperature of the mediating fluid as it passes in one direction or the other so that when it enters the tubes 34 and 37 it will have been brought to nearly the same temperature as that of the average temperature of the surrounding body. The regenerating chamber consists of two concentric annular walls of insulating material and arranged in the annular space between said walls is a series of spaced plates or other suitable surfaces, which, in the present embodiment, are formed by a continuous metallic coiled plate 39 which is shown in detail in Fig. 5. In order to make the regenerating plate as efficient as possible, and to reduce the transmission of heat from one part to another to a minimum, I preferably provide the plate 39 with a series of slots 40 which are arranged in spaced relation and overlap one another in the manner shown in Fig. 5. The regenerating chamber 36 is formed within any desirable insulating material, such as fiber, and acts to precool the compressed mediating fluid before it enters the expansion chamber. Thus, when the piston 11 moves from the position shown in Fig. 9 to that shown in Fig. 6, the cold or expanded fluid is forced out through the tubes 37 where it is partially warmed by cooling the medium to be refrigerated, but as it leaves the tubes 37 it is still colder than the water cooled tubes 34. As the cooled fluid passes over the metal plate 39 in the regenerating chamber, it cools the latter when the compressed gas again flows

to the expansion chamber, that is when the pistons move from the position of Fig. 7 to that of Fig. 9. The compressed fluid which has been cooled by water while passing through the tubes 34 is further cooled by passing over the metallic plate 39. Thus, the compression chamber is completely insulated from the expansion chamber, the upper and lower parts of the cylinder being insulated from each other, and as the displacement piston is formed of a non-conducting material, the opportunity for conduction of heat from one end of the cylinder to the other is reduced to a minimum. This is a highly important factor in my invention, as it enables the production of the necessary degree of expansion, and consequent efficiency of the expansion chamber, and I believe that it is entirely new to provide a refrigerating machine embodying a single cylinder having two parts forming compression and expansion chambers which are completely separated from each other by an insulating medium.

In order to effect successful results with a machine of this class, it is essential that atmospheric humidity be excluded from the compression and expansion chambers, after the initially contained mediating body is dried, which occurs quickly during the operation of the machine. This may be accomplished in different ways, and according to one method, I employ recesses 42 formed in the cylinder. The recesses prevent leakage of air from within, or access of moisture into the cylinder from without, since they afford a space into which any leaking air may find a temporary resting place, equalizing the pressure of the atmosphere, and acting as a retarding means or seal for any outgoing or incoming fluid between the piston and cylinder wall.

Another and supplemental means for accomplishing this purpose is illustrated by the modification of Fig. 10, in which 62 is a chamber through which any incoming air passes, and which contains lime, or calcium chlorid, or other suitable moisture absorbing material, which serves to prevent entrance to the cylinder of any moisture laden air. Openings 43 are provided in the crank case, connected with a chamber 44 which extends upwardly and partially around the tubes 34, so that the movement of the piston will create a certain amount of cooling influence, by the air currents forced through the chamber 44. In case of the formation of any ice inside the expansion chamber, sufficiently to prevent full movement of the displacement piston, the spring 30 will yield, and prevent undue strain or breakage of the machine, or any parts thereof.

The first position of the parts is shown diagrammatically in Fig. 6, the displacement piston being at the top of its up-

stroke, and the power piston at the bottom of its downstroke. Initially, the power piston moves upwardly, compressing the motive fluid between the pistons in the compression chamber of the cylinder. After the power piston reaches the limit of its upstroke, as shown in Fig. 7, the displacement piston descends swiftly upon the power piston, thereby forcing the motive fluid through the lower set of radiating tubes, the regenerating chamber, and upper set of radiating tubes, whence it enters into the expansion chamber, above the displacement piston. The expansion of the mediating fluid in the upper chamber by the simultaneous downward movement of the two pistons lowers its temperature and enables it to draw heat from the surrounding body and cool the latter. After the parts are in the position shown in Fig. 9, the displacement piston is returned quickly to the position of Fig. 6, forcing the mediating fluid back over the path already described. This completes the cycle, after which compression again takes place in the compression chamber.

In the preferred construction by which I find the greatest results can be accomplished, the wall 3 and tubes 34 are formed in a single unit, including top and bottom plates 51 and 52, while wall 5 and tubes 37 are also formed in a unit, including top and bottom plates 53 and 54. 55 designates a third or intermediate unit, forming the insulating, middle wall 4 of the cylinder, and the regenerating chamber 36, and provided with top and bottom flanges 56 and 57. The upper and lower units are preferably formed with flanges 58 and 59 which are secured to the top and bottom flanges of the section 55, while the lower unit is attached to the crank casing by the flange 60. The top 6 is attached to the upper plate 53 by a flange 61. The wall 3 preferably extends above the top plate 51, so as to partially overlap the intermediate unit, and form a smooth surface for the travel of the pistons.

I claim as my invention:

1. The combination with a cylinder forming a compression chamber at one portion and an expansion chamber at another portion for acting on a mediating fluid, said chambers being separated by heat non-conducting material, of a displacement piston movable in the expansion chamber, a power piston movable in the compression chamber, and means connected to the pistons for driving them the compression chamber being adapted to be surrounded by a body of lower temperature than the average temperature of the fluid within the compression chamber, and the expansion chamber being adapted to be surrounded by a body of higher temperature than the average temperature of the fluid within the expansion chamber.

2. The combination with a cylinder forming a compression chamber at one portion and an expansion chamber at another portion, said chambers being separated by heat non-conducting material, of a displacement piston movable in the expansion chamber, a power piston movable in the compression chamber, means connected to the pistons for driving them, and fluid conducting means located exteriorly of the cylinder and leading from the compression chamber to the expansion chamber.
3. The combination with a cylinder forming a compression chamber at one portion and an expansion chamber at another portion for acting on a mediating fluid, said chambers being separated by heat non-conducting material, of a displacement piston movable in the expansion chamber, a power piston movable in the compression chamber, means connected to the pistons for driving them, and fluid conducting means located exteriorly of the cylinder and leading from the compression chamber to the expansion chamber, the compression chamber being adapted to be surrounded by a body of lower temperature than the average temperature of the fluid within the compression chamber, and the expansion chamber being adapted to be surrounded by a body of higher temperature than the average temperature of the fluid in the expansion chamber.
4. The combination with a cylinder forming a compression chamber at one portion and an expansion chamber at another portion, said chambers being separated by heat non-conducting material, of a displacement piston movable in the expansion chamber, a power piston movable in the compression chamber, means connected to the pistons for driving them, and fluid conducting means located exteriorly of the cylinder and leading from the compression chamber to the expansion chamber, said fluid conducting means including a regenerating chamber formed within a body of heat non-conducting material.
5. The combination with a cylinder forming a compression chamber at one portion and an expansion chamber at another portion, said chambers being separated by heat non-conducting material, of a displacement piston movable in the expansion chamber, a power piston movable in the compression chamber, means connected to the pistons for driving them, and fluid conducting means located exteriorly of the cylinder and leading from the compression chamber to the expansion chamber, said fluid conducting means including a plurality of extended radiating surfaces with which the fluid contacts.
6. The combination with a cylinder forming a compression chamber at one portion and an expansion chamber at another portion, said chambers being separated by heat non-conducting material, of a displacement piston movable in the expansion chamber, a power piston movable in the compression chamber, means connected to the pistons for driving them, and fluid conducting means located exteriorly of the cylinder and leading from the compression chamber to the expansion chamber, said fluid conducting means including a regenerating chamber formed within a body of heat non-conducting material and a plurality of extended radiating surfaces with which the fluid contacts.
7. The combination with a cylinder forming a compression chamber at one portion and an expansion chamber at another portion, said chambers being separated by heat non-conducting material, of a displacement piston movable in the expansion chamber, a power piston movable in the compression chamber, means connected to the pistons for driving them, and fluid conducting means located exteriorly of the cylinder and leading from the compression chamber to the expansion chamber, said fluid conducting means including a regenerating chamber formed within a body of heat non-conducting material and a plurality of extended radiating surfaces arranged between the compression chamber and regenerating chamber and between the expansion chamber and regenerating chamber.
8. The combination with a cylinder forming a compression chamber at one portion and an expansion chamber at another portion, said chambers being separated by heat non-conducting material, of a displacement piston movable in the expansion chamber, a power piston movable in the compression chamber, means connected to the pistons for driving them, and fluid conducting means located exteriorly of the cylinder and leading from the compression chamber to the expansion chamber, said fluid conducting means including a regenerating chamber formed within a body of heat non-conducting material and a plurality of extended radiating surfaces arranged between the compression chamber and regenerating chamber and between the expansion chamber and regenerating chamber, the regenerating chamber embodying a series of spaced plates each of which is provided with a series of overlapping slots in spaced relation to each other.
9. The combination with a cylinder forming a compression chamber at one portion and an expansion chamber at another portion, for acting on a mediating fluid said chambers being separated by heat non-conducting material, of a displacement piston movable in the expansion chamber, a power piston movable in the compression chamber, means connected to the pistons for driving them, and fluid conducting means located exteriorly of the cylinder and leading from the compression chamber to the expansion chamber, said fluid conducting means including a regenerating chamber formed within a body of heat non-conducting material and a plurality of extended radiating surfaces with which the fluid contacts.

them, and fluid conducting means leading from the compression chamber to the expansion chamber, the expansion chamber being adapted to be surrounded by a body of higher temperature than the average temperature of the fluid within the expansion chamber and the compression chamber being adapted to be surrounded by a body of lower temperature than the average temperature of the fluid within the compression chamber.

10. The combination with a cylinder forming a compression chamber at one portion and an expansion chamber at another portion, for acting on a mediating fluid said chambers being separated by heat non-conducting material, of a displacement piston movable in the expansion chamber, a power piston movable in the compression chamber, means connected to the pistons for driving them, and fluid conducting means leading from the compression chamber to the expansion chamber, said fluid conducting means including a regenerating chamber formed within a body of heat non-conducting material, the expansion chamber being adapted to be surrounded by a body of higher temperature than the average temperature of the fluid within the expansion chamber and the compression chamber being adapted to be surrounded by a body of lower temperature than the average temperature of the fluid within the compression chamber.

11. The combination with a cylinder forming a compression chamber at one portion and an expansion chamber at another portion for acting on a mediating fluid, said chambers being separated by heat non-conducting material, of a displacement piston movable in the expansion chamber, a power piston movable in the compression chamber, means connected to the pistons for driving them, and fluid conducting means leading from the compression chamber to the expansion chamber, said fluid conducting means including a plurality of extended radiating surfaces with which the fluid contacts, the expansion chamber being adapted to be surrounded by a body of higher temperature than the average temperature of the fluid within the expansion chamber and the compression chamber being adapted to be surrounded by a body of lower temperature than the average temperature of the fluid within the compression chamber.

12. The combination with a cylinder forming a compression chamber at one portion and an expansion chamber at another portion for acting on a mediating fluid, said chambers being separated by heat non-conducting material, of a displacement piston movable in the expansion chamber, a power piston movable in the compression chamber, means connected to the pistons for driving them, and fluid conducting

means leading from the compression chamber to the expansion chamber, said fluid conducting means including a regenerating chamber formed within a heat non-conducting material, and a plurality of extended radiating surfaces with which the fluid contacts, the expansion chamber being adapted to be surrounded by a body of higher temperature than the average temperature of the fluid within the expansion chamber and the compression chamber being adapted to be surrounded by a body of lower temperature than the average temperature of the fluid within the compression chamber.

13. The combination with a cylinder forming a compression chamber at one portion and an expansion chamber at another portion for acting on a mediating fluid, said chambers being separated by heat non-conducting material, of a displacement piston movable in the expansion chamber, a power piston movable in the compression chamber, means connected to the pistons for driving them, and fluid conducting means leading from the compression chamber to the expansion chamber, said fluid conducting means including a regenerating chamber formed within a body of heat non-conducting material, and a plurality of extended radiating surfaces arranged between the compression chamber and regenerating chamber and between the expansion chamber and regenerating chamber, the expansion chamber being adapted to be surrounded by a body of higher temperature than the average temperature of the fluid within the expansion chamber and the compression chamber being adapted to be surrounded by a body of lower temperature than the average temperature of the fluid within the compression chamber.

14. The combination with a cylinder forming a compression chamber at one portion and an expansion chamber at another portion for acting on a mediating fluid, said chambers being separated by heat non-conducting material, of a displacement piston movable in the expansion chamber, a power piston movable in the compression chamber, means connected to the pistons for driving them, and fluid conducting means leading from the compression chamber to the expansion chamber, said fluid conducting means including a regenerating chamber formed within a body of heat non-conducting material and embodying a series of spaced plates each of which is provided with a series of slots in spaced relation to each other, the expansion chamber being adapted to be surrounded by a body of higher temperature than the average temperature of the fluid within the expansion chamber and the compression chamber being adapted to be surrounded by a body of lower temperature than the average tem-

perature of the fluid within the compression chamber.

15. The combination with a compression chamber and an expansion chamber for acting on a mediating fluid, said chambers being separated by heat non-conducting material, of a displacement member movable in the expansion chamber, a power member movable in the compression chamber, and fluid conducting means leading from the compression chamber to the expansion chamber and including a regenerating chamber, the expansion chamber being adapted to be surrounded by a body of higher temperature than the average temperature of the fluid within the expansion chamber and the compression chamber being adapted to be surrounded by a body of lower temperature than the average temperature of the fluid in the compression chamber.

16. The combination with a compression chamber and an expansion chamber for acting on a mediating fluid, said chambers being separated by heat non-conducting material, of a displacement member movable in the expansion chamber, a power member movable in the compression chamber, and fluid conducting means leading from the compression chamber to the expansion chamber and including a plurality of extended radiating surfaces with which the fluid contacts, the expansion chamber being adapted to be surrounded by a body of higher temperature than the average temperature of the fluid within the expansion chamber and the compression chamber being adapted to be surrounded by a body of lower temperature than the average temperature of the fluid in the compression chamber.

17. The combination with a compression chamber and an expansion chamber for acting on a mediating fluid, said chambers being separated by heat non-conducting material, of a displacement member movable in the expansion chamber, a power member movable in the compression chamber, and fluid conducting means leading from the compression chamber to the expansion chamber and including a regenerating chamber formed within a body of heat non-conducting material and a plurality of extended radiating surfaces with which the fluid contacts, the expansion chamber being adapted to be surrounded by a body of higher temperature than the average temperature of the fluid within the expansion chamber and the compression chamber being adapted to be surrounded by a body of lower temperature than the average temperature of the fluid in the compression chamber.

18. The combination with a compression chamber and an expansion chamber for acting on a mediating fluid, said chambers being separated by heat non-conducting material,

of a displacement member movable in the expansion chamber, a power member movable in the compression chamber, and fluid conducting means leading from the compression chamber to the expansion chamber and including a regenerating chamber formed within a body of heat non-conducting material, and a plurality of extended radiating surfaces arranged between the compression chamber and regenerating chamber and between the expansion chamber and regenerating chamber, the expansion chamber being adapted to be surrounded by a body of higher temperature than the average temperature of the fluid within the expansion chamber and the compression chamber being adapted to be surrounded by a body of lower temperature than the average temperature of the fluid in the compression chamber.

19. The combination with a compression chamber and an expansion chamber for acting on a mediating fluid, said chambers being separated by heat non-conducting material, of a displacement member movable in the expansion chamber, a power member movable in the compression chamber, and fluid conducting means leading from the compression chamber to the expansion chamber and including a regenerating chamber formed within a body of heat non-conducting material, and a plurality of extended radiating surfaces arranged between the compression chamber and regenerating chamber and between the expansion chamber and regenerating chamber, the regenerating chamber embodying a series of spaced plates each of which is provided with a series of overlapping slots in spaced relation to each other, the expansion chamber being adapted to be surrounded by a body of higher temperature than the average temperature of the fluid in the expansion chamber and the compression chamber being adapted to be surrounded by a body of lower temperature than the average temperature of the fluid in the compression chamber.

20. The combination with a cylinder having a compression chamber and an expansion chamber, of a power piston movable in the compression chamber, a displacement piston movable in the expansion chamber, radiating units surrounding the compression and expansion chambers and communicating with the cylinder, and a regenerating unit surrounding the cylinder intermediate the compression and expansion chambers and communicating therewith.

21. The combination with a cylinder having a compression chamber and an expansion chamber, of a power piston movable in the compression chamber, a displacement piston movable in the expansion chamber, said cylinder being formed by upper and lower units including radiating tubes surrounding

the cylinder, and an intermediate unit of heat non-conducting material arranged between the ends of the cylinder.

5 22. The combination with a cylinder having a compression chamber and an expansion chamber, of a power piston movable in the compression chamber, a displacement piston movable in the expansion chamber, a crank shaft connected to the power piston, a cam
10 on the crank shaft, a pivotally mounted lever connected to the displacement piston, a roller on said lever having engagement with the cam in the crank shaft, and a spring controlling said lever.

15 23. The combination with a compression chamber and an expansion chamber separated by heat non-conducting material for acting on a mediating fluid, of a displacement piston movable in the expansion

chamber, a power piston movable in the 20 compression chamber, fluid conducting means leading from the compression chamber to the expansion chamber, the expansion chamber being adapted to be surrounded by
25 a body of higher temperature than the average temperature of the fluid within the expansion chamber and the compression chamber being adapted to be surrounded by a
30 body of lower temperature than the average temperature of the fluid within the compression chamber, and means acting to prevent access of atmospheric humidity to the compression or expansion chambers.

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Witnesses:

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