E. F. NAUER.

REFRIGERATING APPARATUS.

APPLICATION FILED JUNE 5, 1913.

1,199,486.

Patented Sept. 26, 1916.

2 SHEETS—SHEET 1.

Fig. 1.

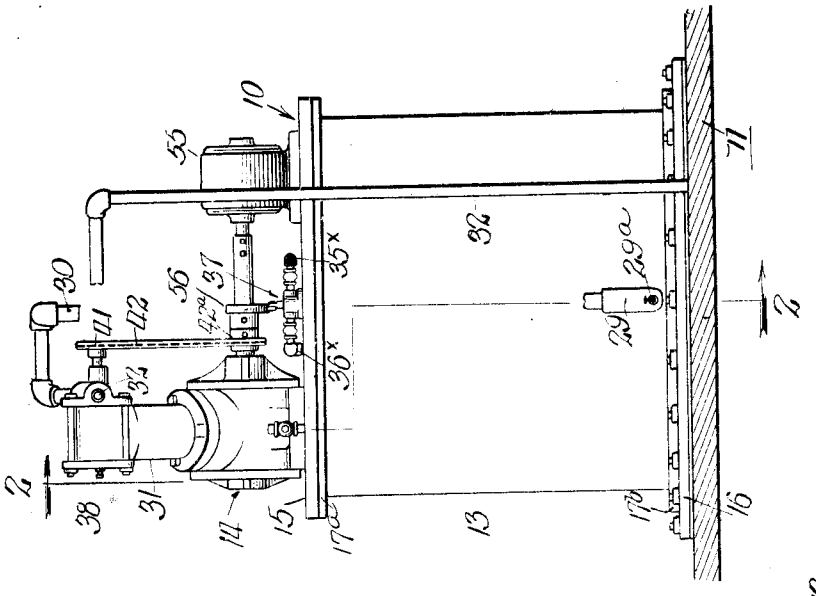
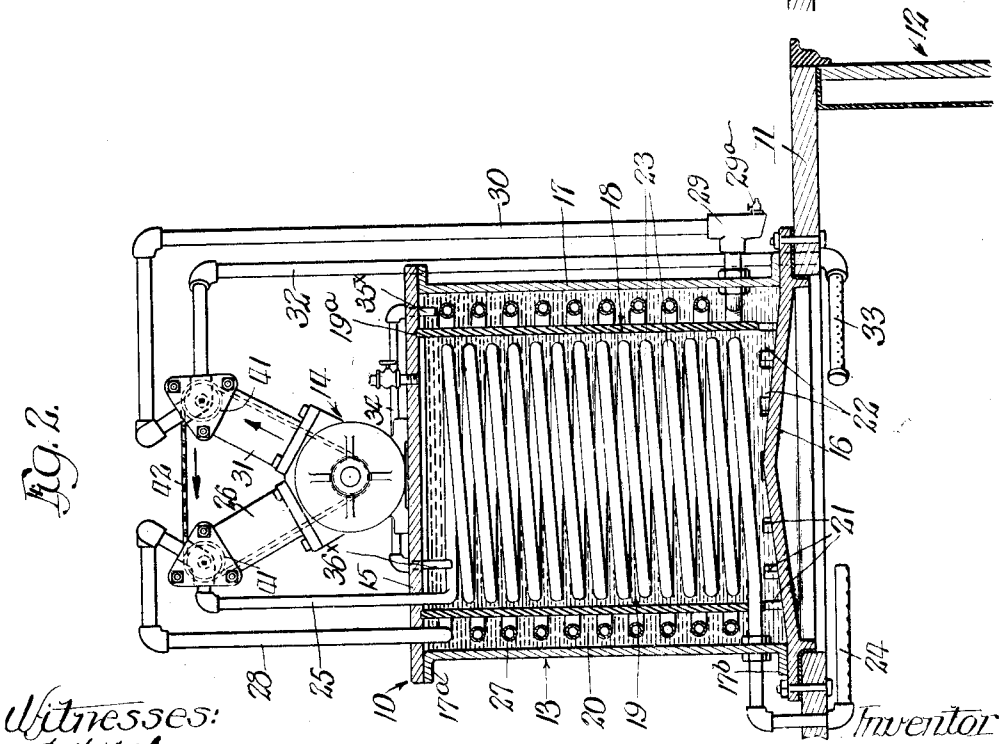


Fig. 2.



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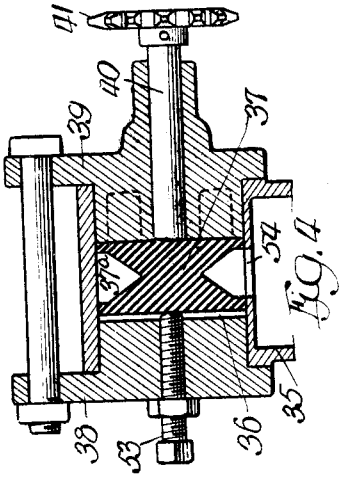


FIG. 4

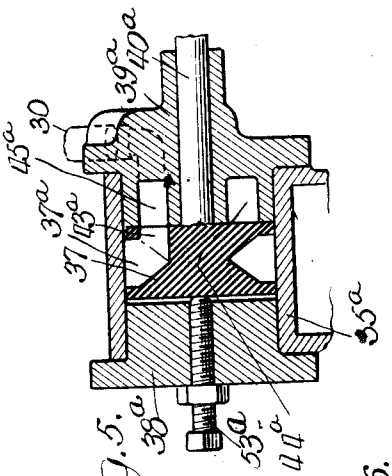


FIG. 5.

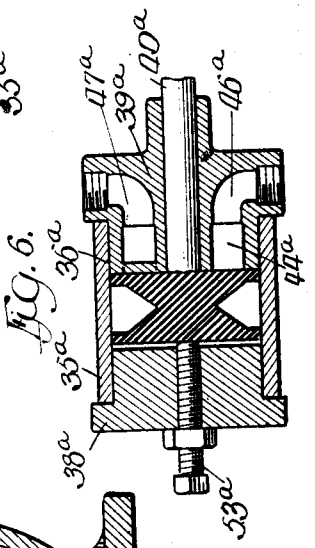


FIG. 6.

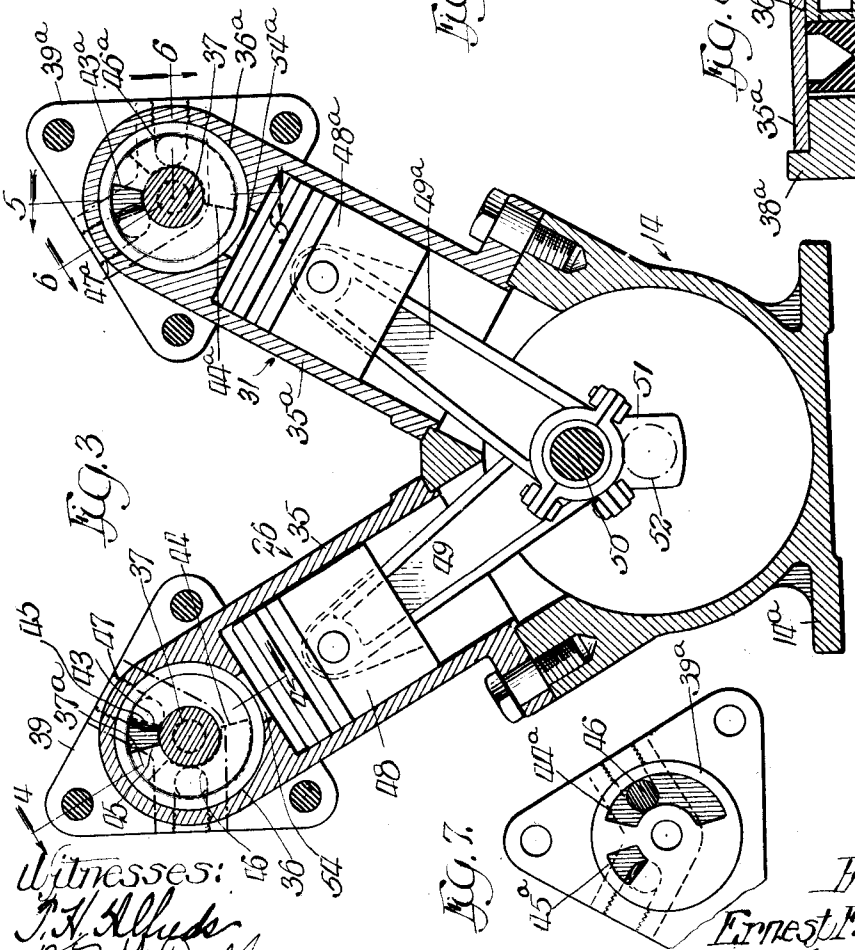


FIG. 3

FIG. 7.

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UNITED STATES PATENT OFFICE.

ERNEST F. NAUER, OF CHICAGO, ILLINOIS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO ISKO, INCORPORATED, OF DETROIT, MICHIGAN, A CORPORATION OF MICHIGAN.

REFRIGERATING APPARATUS.

1,199,486. Specification of Letters Patent. Patented Sept. 26, 1916.

Application filed June 5, 1913. Serial No. 771,812.

To all whom it may concern:

Be it known that I, ERNEST F. NAUER, a citizen of the United States, and a resident of Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Refrigerating Apparatus; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, and to the letters of reference marked thereon, which form a part of this specification.

This invention relates to an improvement in refrigerating apparatus, and consists of the matters hereinafter described and more particularly pointed out in the appended claims.

The invention is of that type in which air is used as the refrigerating medium, and in which the desired low temperature is imparted to the air by passing it through successive stages of compression, cooling, expansion and exhaustion, by means of suitable devices, designed to promote a circulation of air from the box or compartment that is to be refrigerated into and through the refrigerating apparatus and back to the box again.

In the drawings: Figure 1 is a view representing a side elevation of my improved refrigerating apparatus, the same being shown as attached to the top wall of the box or compartment that is to be refrigerated—in this case, to the top wall of an ordinary refrigerator. Fig. 2 is a view representing a vertical section through the apparatus in a plane indicated by the line 2—2 thereof. Fig. 3 is a view representing, on an enlarged scale, a section through the compressor and the expansion engine used in my improved apparatus. Figs. 4, 5 and 6 are detail, sectional views on a still larger scale of the valves used in the compressor showing said valves in different positions. Fig. 7 is a detail view in elevation, showing the port openings in the cylinder heads.

Referring now to that embodiment of my invention shown in the drawings, 10 indicates the refrigerating apparatus as a whole, which is attached to the top wall 11 of a refrigerator 12 that is of any familiar or usual construction.

13 indicates a closed tank which comprises the base of the refrigeration apparatus, and which acts to support a compressor and an air expansion engine, which have a common crank casing and base indicated at 14. The tank 13 has a top wall 15, a bottom wall 16 and an upright cylindrical side wall 17, the latter being provided with suitable flanges at the top and bottom (17^a and 17^b, respectively) for attachment to the top and bottom walls. Within the tank 13 is fixed a cylindric partition wall 18, which divides the tank into two compartments, that is to say, an inner central compartment 19 and an outer annular compartment 20, surrounding said central compartment. A plurality of openings 21 are located at or near the bottom of the partition wall 18 to provide for communication between the inner and outer compartments of the tank. The partition wall 18 is fixed at the top in an annular groove 19^a formed in the bottom face of the top wall 15 of the tank and has at its bottom annularly arranged spaced lugs 22, which depend below its main body and rest upon the bottom wall 16 of the tank. Thus, while there is a free passage at the bottom between the inner and outer compartments 19 and 20 of the tank, there is no connection within the tank between said compartments at the top.

Within the inner compartment 19 of the tank is located a coil of pipe 23. The lower or intake end of said coil extends through the side wall of the tank and through the top wall 11 of the refrigerator 12 and is therein connected to a perforated inlet pipe or nozzle 24, located near the top of the refrigerator. The upper delivery end of the coil 23 is connected by a pipe 25, which extends through the top wall of the tank, to the inlet side of a compressor 26.

In the outer annular compartment 20 of the tank 13, there is located a coil 27, which is connected at its upper intake end by means of a pipe 28 that extends through the top wall of the tank to the discharge side of the compressor 26. The bottom discharge end of the coil 27, extends through the side wall 17 of the tank, and is connected by a fitting 29 to an upright pipe 30, leading to the inlet side of an air expansion engine. The fitting 29 acts as a trap for the water of condensation and is provided with a petcock 29^a for drainage purposes. 32 indicates a pipe leading from the exhaust side of said engine. Said pipe extends downwardly alongside of, but without the tank

13, through the top wall 11 of the refrigerator, and is connected to a perforated pipe or nozzle 33 by means of which the air in said pipe 32 is discharged into the refrigerator.

Referring now to the circulation through the system thus described, it will be seen that the air in the refrigerator is drawn through the perforated inlet pipe 24 into the coil 23, whence it passes through the pipe 25 into the inlet side of the compressor 26. From the compressor 26, it is discharged through the pipe 28 into the coil 27 and from thence it passes by means of the pipe 30 into the inlet side of the air expansion engine 31. From the exhaust side of the expansion engine, it is conducted by means of the pipe 32 to the perforated pipe 33, whence it is discharged into the refrigerator. Thus, there is maintained through the system a continuous circulation of the air from the refrigerator, through the refrigerating apparatus and back to the refrigerator.

The tank 13, including both the inner and outer chambers, is filled with ordinary city water. The tanks are connected at the top by means of a pipe 34, which has an inlet 35^{x}, depending through the top wall of the tank into the outer annular compartment 20 and a discharge pipe 36^{x}, depending into the inner central compartment 19 of the tank. The pipes 35^{x} and 36^{x} are preferably placed at opposite sides of the respective compartments into which they depend.

37 indicates a pump which is adapted to pump the water from the outer compartment 20 and discharge it into the inner compartment 19. Thus with the connecting passage 21 between the compartments 19 and 20 at the bottom, the pump produces a continual interchange between the water in the two compartments.

The compressor 26 and air expansion engine 31 have, as before stated, a common crank casing 14 and a common base plate 14^{a}, which is securely attached to the top wall of the tank 10. Both of these devices are of the rotary valve type, and as shown herein, are identical in construction, the only difference being in the timing of their valves with relation to the movement of their respective pistons.

35 indicates the cylinder of the compressor, and 35^{a}, the cylinder of the air expansion engine. Said cylinders are arranged with their longitudinal central axes at an angle to each other, and are bolted to the crank casing 14. The cylinder 35 is provided in the head with a circular valve chamber 36, in which is mounted a circular rotative valve plug 37. The circular wall of the valve chamber 36, in which the rotative valve has bearing, is made integral with the cylinder. The lateral walls of said valve chamber are provided, by means of flanged plates 38, 39. One of these plates, namely the plate 39, provides bearing for a shaft 40, fixed to the valve plug and having attached to its end a sprocket wheel 41, which is connected by a sprocket chain 42 to the crank shaft of the compressor. The valve plug 37 has an annular groove 37^{a} in its periphery, and, communicating with said groove, a single port 43 in its face adjacent the plate 39. The plate 39 has in its face adjacent the valve plug a comparatively long arcuate groove 44, adapted to communicate with the port 43 in the valve plug in the course of the rotation of said valve plug, which constitutes the inlet of the compressor, and an additional comparatively short arcuate groove 45, which constitutes the discharge port of the compressor. The plate 39 has a passage 46, connecting the arcuate groove 44 with the pipe 25 that leads from the inlet coil 23 and a passage 47 which connects the short groove 45 with the outlet pipe 28.

48 indicates the piston of the compressor, 49, the pitman of same, 50, the crank pin and 51, the crank arm, the latter being fixed on a crank shaft 52, common to the compressor and to the air expansion engine alike. In the plate 38 is secured a set screw 53, which is adapted to maintain the rotative valve plug in proper bearing engagement against the opposite plate 39. A port 54 connects the valve chamber with the cylinder.

In the operation of the compressor, air is drawn into the cylinder while the valve plug is rotating with its single port 43 in register with the arcuate groove 44, this being the condition throughout practically the entire intake stroke of the piston. On the return stroke, the air which has been drawn into the cylinder, being incapable of escape, is compressed until the port 43 in the valve plug comes to register with the short groove 45 in the plate 39 when said air under high pressure is expelled through the port 47 into the pipe 28.

The different parts in the air expansion engine are similarly constructed to those just described, the like parts being indicated by the same numerals with the letter "a" as a superscript. The timing of the valve, however, in the case of the air expansion engine, is reversed, the short groove 45^{a} in this case constituting the inlet, while the longer arcuate groove 44^{a} constitutes the outlet. Thus, when the port 43^{a} in the rotative valve plug of the air expansion engine registers with the groove 45^{a}, the charge of air under high pressure is taken in from the pipe 30, at the time the piston is at the end of its outward stroke. This high pressure air taken into the cylinder drives the piston on its inward stroke and then when the supply is cut off, which occurs when the piston has traveled

about one-third of its course, expands, and is finally, when the piston is on its return stroke toward the head of the cylinder, exhausted through the groove 44ª in the plug 39ª into the pipe 32.

The crank shaft 52 is driven by a motor 55, mounted on the top of the tank 13. Said motor is preferably an electric motor. The pump 37 is driven by said crank shaft by an eccentric ring 56, mounted on said shaft. The sprocket chain 42, which drives the rotative valves of the compressor and air expansion engine, is connected to a sprocket wheel 42ª on the crank shaft.

The operation of my improved apparatus is as follows: The pipe 24 being located near the top of the refrigerator, the warmer air therein is drawn into the refrigerating apparatus through the action of the compressor. The air will usually be about 38 degrees F. and will be comparatively dry. As this comparatively cold air passes through the coil 23 in the inner compartment of the tank 13, it will absorb heat from the comparatively warmer water in said tank, thus lowering the temperature of said water. At the same time the air passing through the coil 23 will absorb heat and thus its temperature will be raised. When this air is acted upon by the compressor 26, its pressure will be changed from that of the atmospheric pressure, that is to say, the pressure in the refrigerator, to a much higher pressure, say for example, 60 pounds pressure. Its temperature will be raised. At this pressure and temperature produced in the compressor, the air will pass through the pipe 28 into the coil 27 in the outer compartment 20 of the tank 13. It has been found in practice that the air, when it reaches the coil 27, is much below the temperature which it should theoretically have at the pressure to which it has been raised by the compressor, that is, 60 pounds as supposed herein. Instead of having a temperature of 400°, the theoretical temperature corresponding to a pressure of 60 pounds, the air when entering the coil 27 has only a temperature of from 125° to 140°, the fall in temperature being due apparently to radiation and also probably to the condensation of the moisture in the air, which collects in the trap 29 and which must be drawn off at periodic intervals through the cock 29ª. In passing through the coil 27, the air loses a further part of its heat to the water in the said compartment 20, thus lowering its own temperature and increasing the temperature of the water in said compartment.

It will be apparent that the action of the air from the refrigerator in passing through the coil 23 will be to cool the water in the inner compartment 19 of the tank, while the action of the air in passing through the coil 27 will be to heat the water in the outer compartment 20. Thus, while the water in the inner compartment is comparatively cool, that in the outer compartment is comparatively warm. The pump 37, however, acts to conduct the warm water from the outer tank and mix it with the water in the inner tank, so that the continuous circulation between the two tanks tends to maintain the same temperature in the two tanks, with the result that heat will be acquired by the air which is at atmospheric pressure as it passes toward the compressor and heat will be lost by the air which is at the much higher pressure as it passes from the compressor. When the air, which passes from the coil 27, is conducted by the pipe 30 to the air expansion engine 31, it is at substantially the same pressure but at a lower temperature as compared with its condition when it left the compressor. This comparatively cold high pressure air enters the air expansion engine and in operating said engine, as heretofore described, is expanded down to atmospheric pressure, thereby greatly reducing its temperature, so that it is exhausted from the air expansion engine at a very low temperature, substantially in the neighborhood of 0 degrees F., or below. This cold air is led by the pipe 32 to the discharge nozzle 33, and escaping therefrom, drops to the bottom of the refrigerator. Thus, the refrigerating apparatus withdraws the warm air from the refrigerator, and, after passing it through the refrigerating apparatus, returns it to the refrigerator as cold air, maintaining a continuous circulation of cold air in the refrigerator and keeping it down to the desired temperature.

In designing the compressor, air expansion engine and motor for driving the compressor and pump, the parts are calculated so that the air expansion engine will act to, at least, take care of the friction of the parts, the motor taking care of the rest of the power necessary to drive the apparatus.

While in describing my invention, I have referred to certain details of mechanical constructions and arrangement, it is to be understood that my invention is in no way limited thereby, except as pointed out in the appended claims.

I claim as my invention:—

1. In a refrigerating apparatus, in combination with a box to be refrigerated, a cooling tank, having a partition wall dividing said tank into two compartments, one a cooling compartment and one a heating compartment, an inlet coil in said cooling compartment, adapted to receive the air from said box, an outlet coil in said heating compartment, a compressor interposed between said inlet and outlet coils, an air expansion engine connected with said outlet coil, a conduit for discharging the exhaust from said air expansion engine to said box to be re-

frigerated, a motor for driving said compressor and means providing for the interchanging of the water in the said two compartments.

2. In a refrigerating apparatus, in combination with a box to be refrigerated, a cooling tank, having a partition wall dividing said tank into two compartments, one a cooling compartment and one a heating compartment, an inlet coil in said cooling compartment, adapted to receive the air from said box, an outlet coil in said heating compartment, a compressor interposed between said inlet and outlet coils, an air expansion engine connected with said outlet coil, a conduit for discharging the exhaust from said air expansion engine to said box to be refrigerated, a motor for driving said compressor and means for forcing the water from said heating compartment of the cooling tank into said cooling compartment.

3. In a refrigerating apparatus, in combination with a box to be refrigerated, a cooling tank, having a partition wall dividing said tank into two compartments, one a cooling compartment and one a heating compartment, an inlet coil in said cooling compartment adapted to receive the air from said box, an outlet coil in said heating compartment, a compressor interposed between said inlet and outlet coils, an air expansion engine connected with said outlet coil, said air expansion engine being adapted to assist in driving said compressor, a conduit for discharging the exhaust from said air expansion engine to said box to be refrigerated, a motor for driving said compressor and means for forcing the water from said heating compartment of the cooling tank into said cooling compartment.

In testimony, that I, claim the foregoing as my invention I affix my signature in the presence of two witnesses, this 29th day of May A. D. 1913.

ERNEST F. NAUER.

Witnesses:

T. H. ALFREDS,

R. WILKINS.