5 Sheets—Sheet 1.

G. G. FRYER.

Refrigerating and Ventilating Apparatus.

No. 219,085. Patented Sept. 2, 1879.

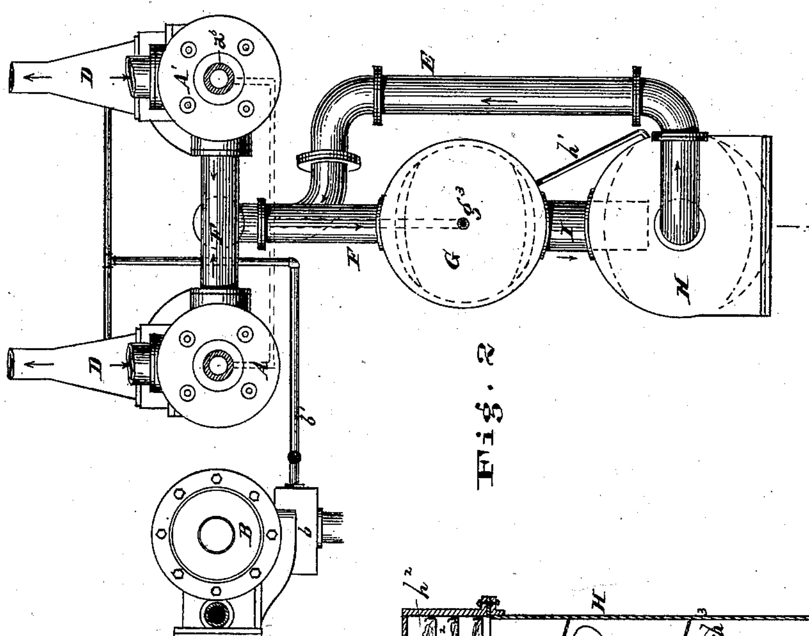

Fig. 2

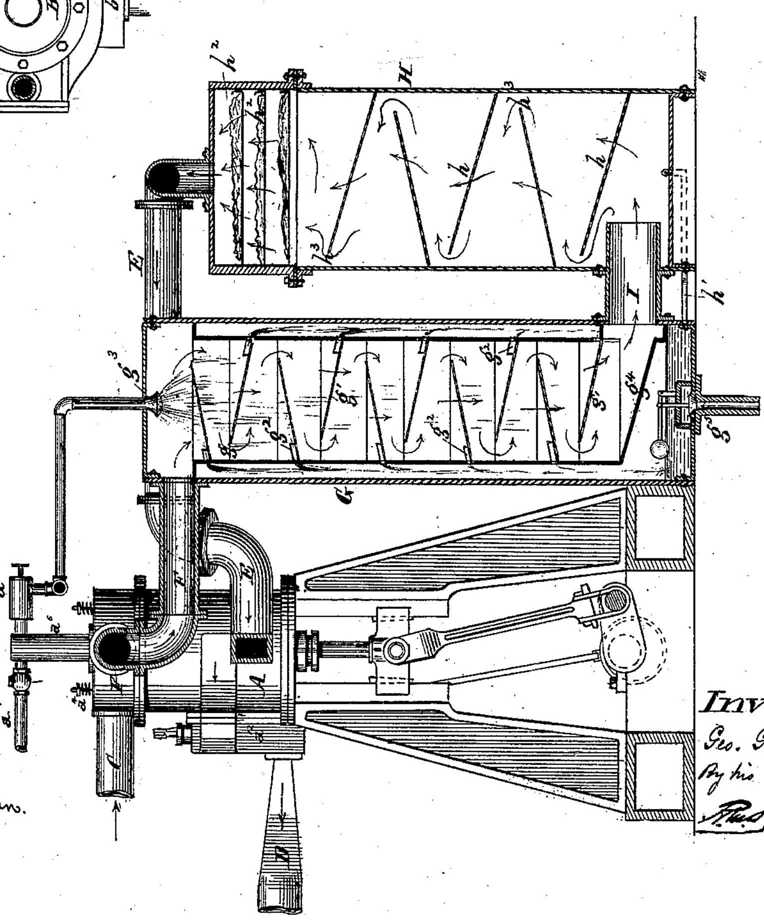

Fig. 1

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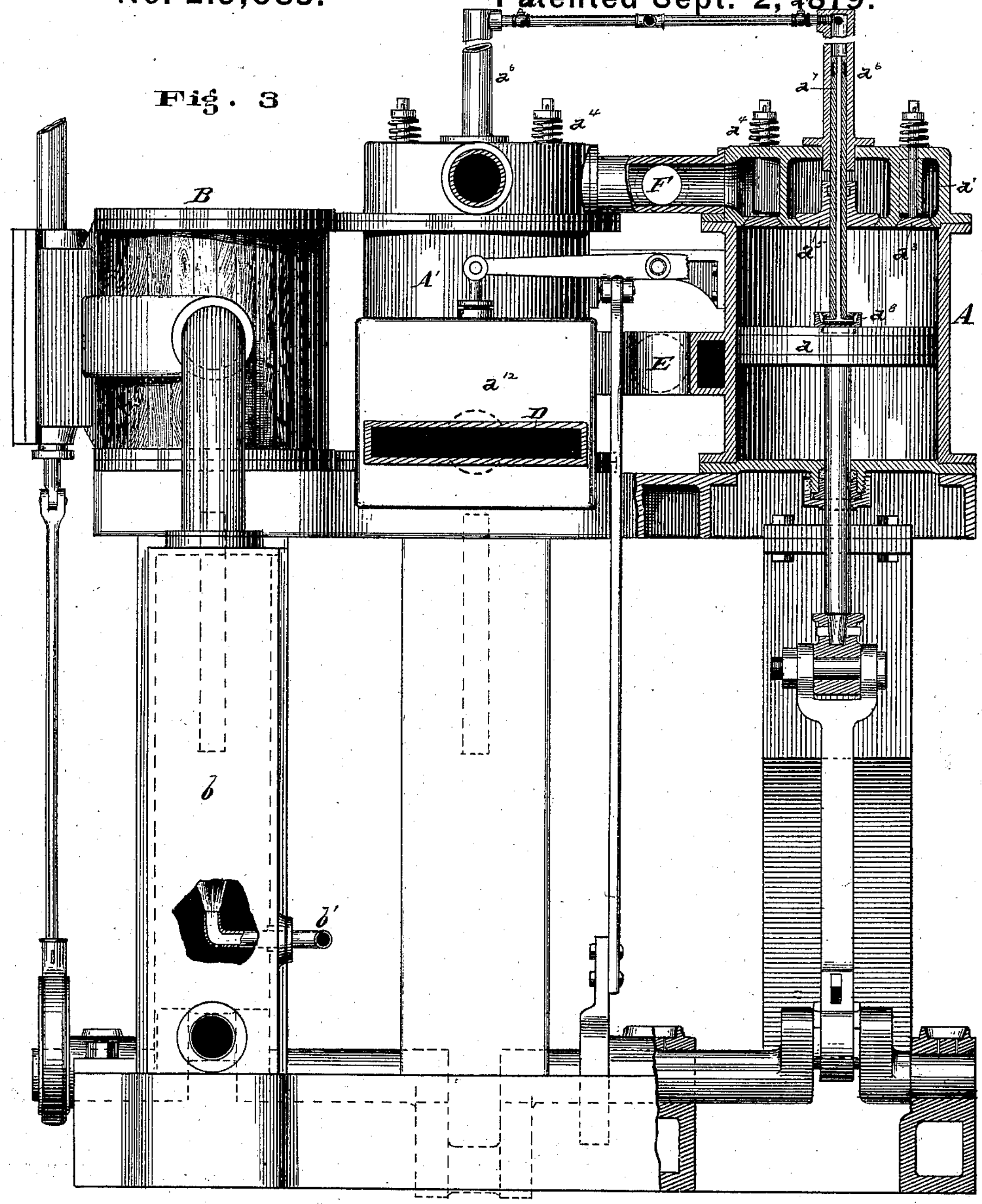
Fig. 3



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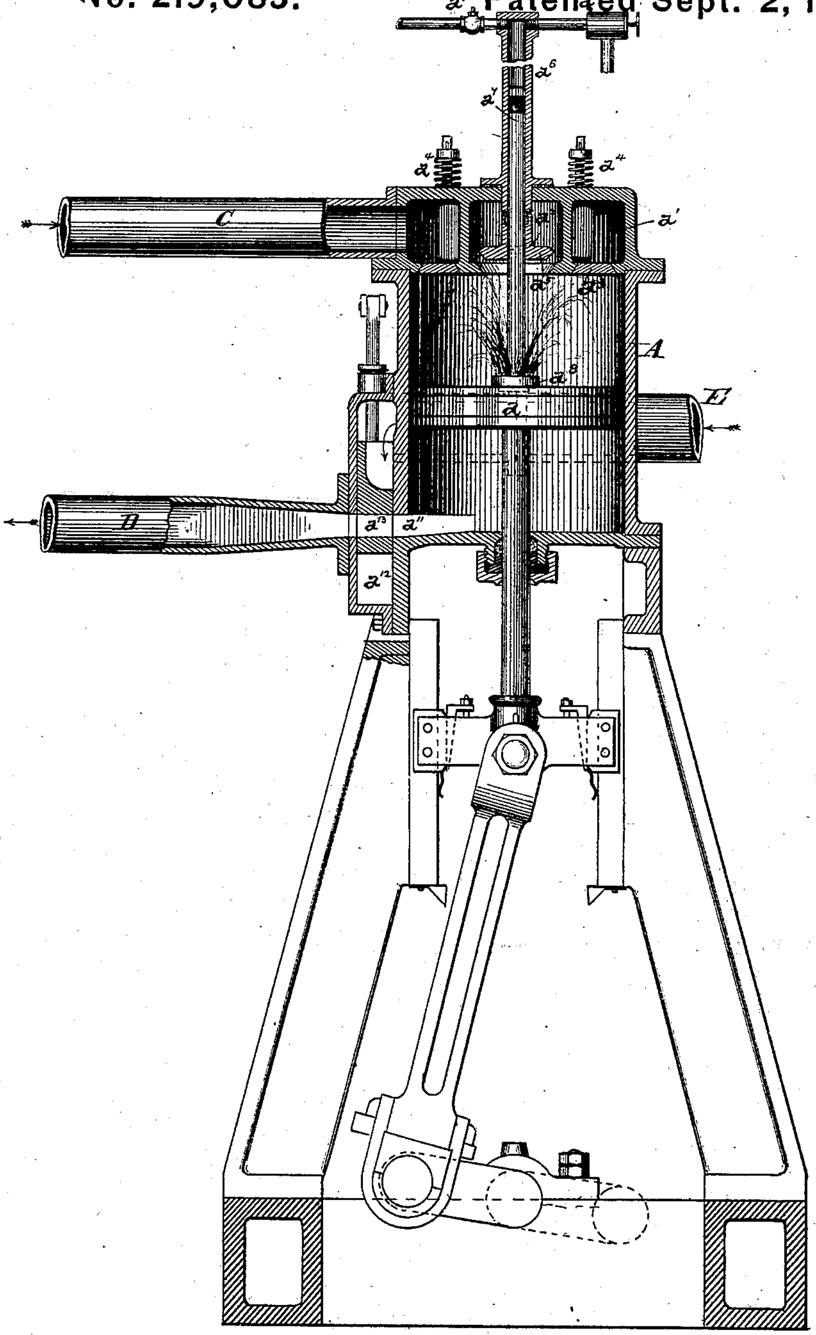

Fig. 4

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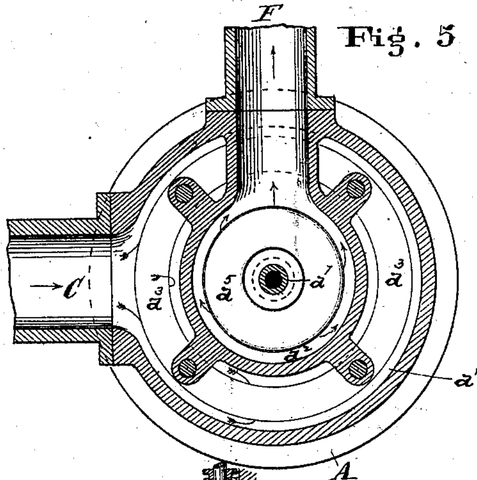

Fig. 5

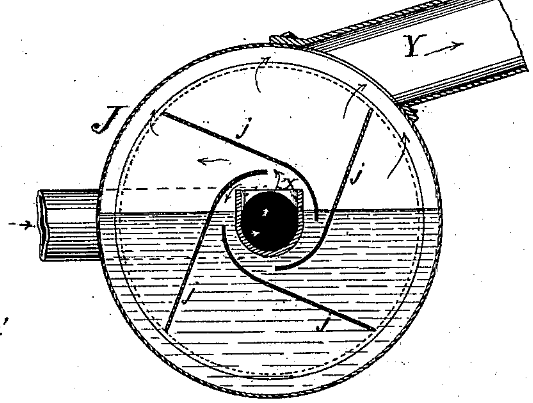

Fig. 6

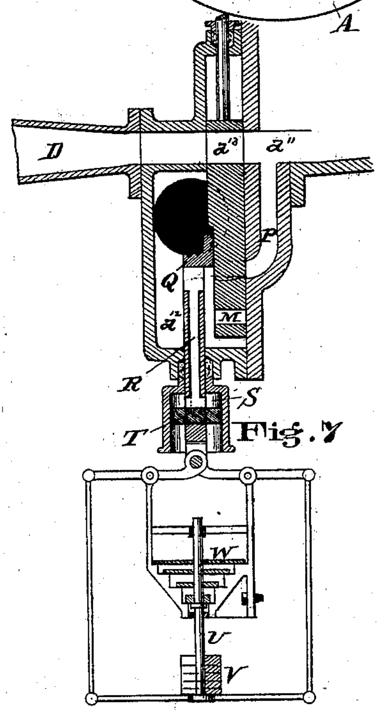

Fig. 7

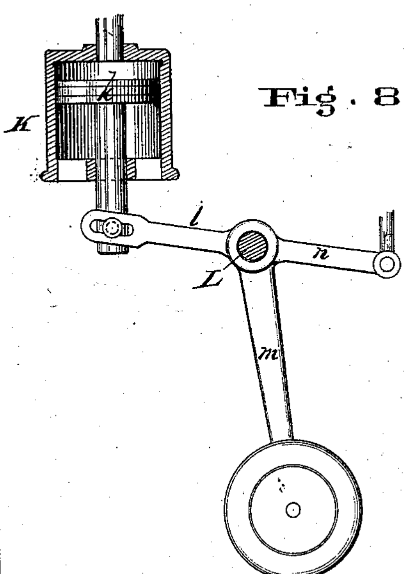

Fig. 8

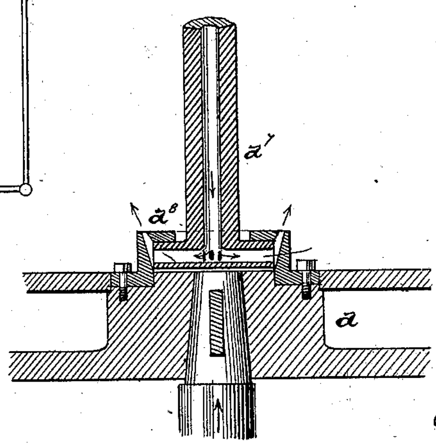

Fig. 9

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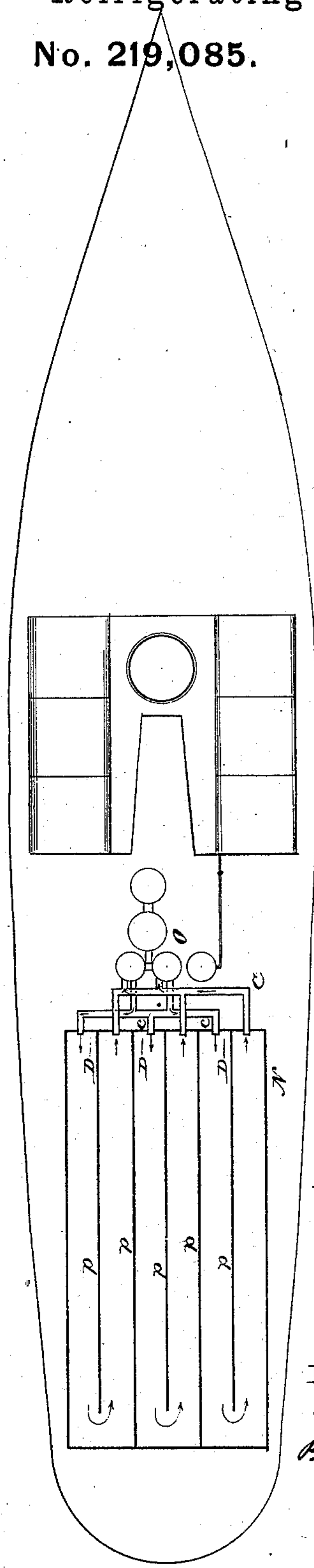

Fig. 10

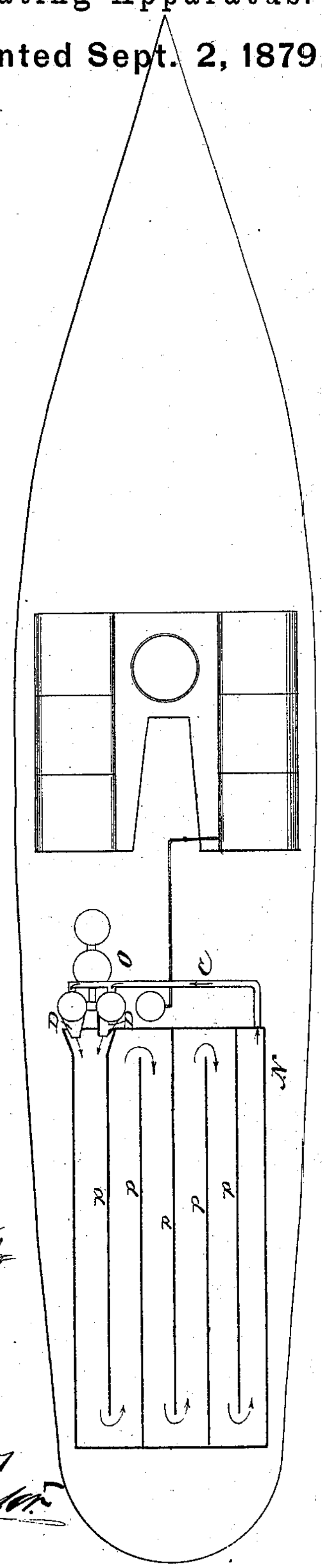

Fig. 11

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UNITED STATES PATENT OFFICE.

GEORGE G. FRYER, OF PHILADELPHIA, PENNSYLVANIA.

IMPROVEMENT IN REFRIGERATING AND VENTILATING APPARATUS.

Specification forming part of Letters Patent No. **219,085**, dated September 2, 1879; application filed May 27, 1879.

To all whom it may concern:

Be it known that I, GEORGE G. FRYER, of Philadelphia, county of Philadelphia, and State of Pennsylvania, have invented an Improvement in Refrigerating and Ventilating Apparatus, of which the following is a specification.

My invention relates to apparatus which is designed to produce artificial refrigeration and ventilation by first compressing air, and then allowing said compressed air to expand within a cylinder, at the same time performing work, which causes a great part of the calorific intensity of the air to be given up, corresponding to a certain amount of work done, and the expanded air allowed to pass into an air-tight compartment, thereby producing intense refrigerative power within said compartment, and, finally, the subsequent withdrawal of the expanded air when its power of refrigeration is spent and its return to the compression cylinders, and so on continuously; and consists in the construction and arrangement of the machinery and apparatus so that, first, the air is compressed and expanded simultaneously in the same cylinder, only on opposite sides of the piston; second, the injection-water is thrown into the compressing end of the cylinder during compression in the form of spray, and has a maximum supply when the air-compression is nearest its maximum; third, the valves of the compressing end of the cylinder do not necessitate any clearance whatever, and thereby prevent loss in the pressure of the compressed air; fourth, the expansion-valve is so constructed that a clear flow can be had from the expansion end of the cylinder into the compartment or main without the changing of direction; fifth, the process whereby the expanding air is expanded to atmospheric pressure, if necessary, to obtain the greatest refrigerative effect from air compressed to any pressure, and mechanism therefor; sixth, the automatic cut-off or throttling of the steam in the chest of the steam-cylinder of the compressors through the agency of the compressed air, so that the expanding air may be made to do a maximum amount of work; seventh, the mechanism of extracting the water from the compressed air; eighth, the condensation of the exhaust-steam from the steam-cylinder of the compressors by the cooled air from the expanded-air main or cylinder; ninth, the injection of water into the top of the compressed-air chamber by the same pump by which the injection-water is forced into the cylinder; tenth, the method of disinfecting the air withdrawn from the compartment.

The apparatus will be fully described hereinafter, showing the means by which it accomplishes the above ten effects.

The object of my invention is to produce a low degree of temperature for the purpose of refrigeration and ventilation, such as is necessary to carry meats, fruits, and other perishable substances in a vessel to a great distance. I also propose to ventilate and disinfect vessels from infected ports. I can also convert water into ice by the same means; but that is not my present object.

My object is, further, to so construct and arrange machinery, and operate the same, that the maximum effect is obtained with the minimum expenditure of power, and hence at a small expense.

I do not claim the process of compressing air and then allowing it to expand, at the same time performing work, for that is old, and was originally suggested by Dr. Gorrie about 1855; nor do I lay claim, broadly, to any process for placing compressed air in a suitable condition to exercise refrigerating effect by causing it to operate the piston of the compression-cylinder, or to perform work, because such is not my invention. My process consists in utilizing all of the energy of the compressed air, and producing the maximum degree of cold due to the conversion of the heat into work, by regulating the supply of compressed air admitted to the cylinder according to the degree of compression of the said air.

In the accompanying drawings, Figure 1 is a vertical section of my complete apparatus. Fig. 2 is a plan of same. Fig. 3 is a longitudinal section and elevation combined of the compressors. Fig. 4 is a transverse vertical section through one of the compressors. Fig. 5 is a cross-section through the head of the compressors, and shows the plan of the valves. Fig. 6 is a section of the disinfectant-saturator. Fig. 7 is a section of the expansion-valve and automatic cut off. Fig. 8 is a section and elevation combined of the automatic cut-off or throttling mechanism which regulates the supply to the steam-cylinder. Fig. 9 is a section of the pump-plunger, piston, and cap by which the plunger is made to follow the piston. Fig. 10 is a plan of a ship, showing the arrangement of machinery and the course of the air in the compartment to be cooled. Fig. 11 is a modified view of Fig. 10.

A is a compressing and expanding cylinder, the piston *a* of which is operated by means of the steam-engine B through the agency of a shaft, cranks, and pitmen. The compressing-cranks are directly opposite to each other, and the engine-crank is at right angles to them.

The top or head of the cylinder A has two chambers, a^1 and a^2. Opening into the annular chamber a^1 is the suction-pipe C. This annular chamber a^1 is supplied with a circular or ring-shaped valve, a^3, which is held against its seat by springs a^4.

The chamber a^2 is supplied with a valve, a^5. The valve a^3 opens into the cylinder and is used for the purpose of admitting air into said cylinder prior to compression, and the valve a^5 is used for the purpose of allowing the escape of air after compression.

Situated over the chamber a^2 is a pump-cylinder, a^6. Working in this pump is a plunger, a^7, which is made to follow the piston *a*. Upon the bottom of said plunger a^7 is a small perforated flange, and over this flange is a perforated cap, a^8, which is secured to the piston *a*.

The plunger a^7 is hollow, delivering the water forced through it by means of perforations in flange and cap into the compressing end of the cylinder. This plunger a^7 also acts as a guide-rod for the valve a^5, and tends to raise or lower it at proper intervals.

The pump-cylinder a^6 is furnished with a suction-pipe and check-valve, a^9, and a discharge-pipe and relief-valve, a^{10}.

The bottom portion of the cylinder A is supplied with a port, a^{11}, opening into a valve-chest, a^{12}, which is furnished with a valve, a^{13}, operated by an eccentric or cam. Opening from this chest a^{12} is the discharge-pipe D. This port-opening a^{11} and discharge D are so arranged that when the port in valve a^{13} is opposite port a^{11} a clear discharge, as well as a straight one, for the expanded air is obtained, as shown in Fig. 4, and which straight discharge prevents all possibility of the deposition of ice caused by the congelation of any moisture that remains in the expanded air.

Opening into the chest a^{12} is the compressed air-pipe E. The valve a^{13} is made to cut off either automatically or regularly, and will be spoken of hereinafter.

The description thus far applies to the other cylinder, A′, and its appurtenances also.

The steam-engine B is preferably of a condensing system. The steam is condensed in the condenser *b*, (which may be constructed on either the principle of the surface or jet condenser,) in which the water may be replaced by cold air taken from pipe D or bottom of the cylinder A and conveyed to the condenser by pipe *b′*.

The compressed air from the compressors is driven through pipe F into the top of cylinder or chamber G. The interior of this chamber G is occupied by a number of wire-cloth sieves, g^1, held in suitable frames *g*, of sheet-iron. These sieves are secured in an inclined position, so that any water will run to the slots g^2 in the frames *g* and pass down between the chamber G and the frames *g* to the bottom, where it is allowed to pass off by means of a valve and float, g^5, in the usual manner.

The lower frame *g* has an inclined bottom, g^4, which prevents the air from coming in contact with the water at the bottom of the chamber G.

The openings between the sieves g^1 and the frames *g* are preferably meniscus in shape.

Water is discharged into the top of chamber G by means of a rose-nozzle, g^3, which has direct communication with the pump a^6 and relief-valve a^{10}.

The relief-valve a^{10} is used to regulate the supply of water injected into the cylinder A and chamber G. It also acts as a check-valve.

The air is led from the bottom of chamber G to chamber H by means of pipe I. In this chamber H are secured a series of screens, *h*, on an incline, and leaving openings h^3 between the sides of chamber H and said screens for the passage of air. The screens in H may be substantially the same as in chamber G.

Situated upon the top of the chamber H is a box, h^2, containing suitable drying materials (such as chloride of calcium) arranged on trays. Opening into this box h^2 is the pipe E, which conveys the compressed air to the air-chest a^{12} prior to being expanded.

Any water extracted by the screens *h* runs down the walls of chamber H and is conveyed by a pipe, h^1, to the bottom of the chamber G. Both the chambers G and H may have non-conducting coverings to prevent absorption of heat.

The drying-box may be replaced or used in connection with a disinfecting-fluid saturator, such as shown in Fig. 6. The saturator may be composed of a cylindrical basin, J, which contains the disinfecting-fluid, and in which fluid a fan covered with wire-gauze is caused to revolve by the current of compressed air passing in at the opening X and out by the pipe Y, and which air is disinfected by passing through the saturated gauze.

Fig. 8 represents a mechanism by which the compressed air is made to regulate the supply of steam to the chest of the engine B or to the cylinder itself; and consists of a cylinder, K, in which a piston, *k*, works, and which moves a three-armed lever, *l m n*, in which lever *n* operates any of the ordinary automatic cut-off or throttling mechanisms used to regulate the supply of steam, and, in reality, takes the place of the governor. The fulcrum of the lever *l m n* is at L.

The effect of cutting off the supply of compressed air to the expanding end of the cylinder A is very important, and this is one of my improvements.

The cut-off may be automatic, and is regulated by the pressure of the compressed air from the compressors. Mechanism for operating an automatic cut-off by this means is shown in Fig. 7, in which a^{13} is the ordinary slide-valve, and which has a second port, M, which allows compressed air to pass into the cylinner by means of port P.

Upon valve a^{13} the cut-off valve Q slides, and which is secured to a hollow rod, R, upon the lower end of which is secured a piston, T, which works in a cylinder, S.

The compressed air passes through the hollow rod R, and gives the same pressure in the cylinder S that it has in the chest a^{12}.

The piston T imparts vertical movement by any suitable means to a rod, U, which is weighted at V to balance the normal pressure on piston T.

The rod U in its upward movement becomes weighted with weights W at certain distances, which hold the valve Q in certain positions, so that it will cut off at required portions of the stroke of the piston *a* for given pressures.

From this it is readily seen that when the pressure of the air is greatest the cut-off takes place sooner, thus making the air expand and do more work, which insures greater refrigerative effect.

Fig. 10 represents a plan of a steamship, in which N is an air-tight compartment properly protected with non-conducting covering, and divided by partitions *p*, which insures regular currents, and O the refrigerating apparatus, from which the discharge-pipes D D enter the chamber N, and the air is withdrawn from said chamber through the pipe C. A modified form of this arrangement is shown in Fig. 11, in which like letters of reference correspond to like parts. Here the discharge and suction pipes enter two large mains, which supply cooled air and withdraw air at two or more places at once. By this arrangement a more uniform temperature is obtained and maintained.

Operation: The operation of the apparatus to produce refrigeration by air is as follows: Air is compressed in the compressing-cylinder during the upward stroke of the piston *a*, and at the same time water is injected into said cylinder in the form of spray by means of pump-plunger a^7. This upward travel of the pump-plunger a^7 also tends to keep open valve a^5, allowing the compressed air to pass into the pipe F, by which it is conveyed to the chambers G and H, which may be one chamber divided into two compartments, if desired. As the air is compressed in the cylinder and the volume becomes smaller the same quantity of water is injected as at the beginning of the compression; hence the relative volume of water to the volume of compressed air is greatest when it is most needed. All of the water does not usually go through the plunger a^7, but some is forced through the relief-valve d^{10}, and discharged as spray into the top of the chamber G by a rose-nozzle, g^3. The relief-valve may be closed, so that all of the water will be discharged into the cylinder A. The water is discharged upon wire-gauze screens g^1 in the chamber G, and during its descent it drips from one screen to the next, but tends to run out by the slots g^2 and descend to the bottom of chamber G out of contact with the current of compressed air, and little or none of the water ever gets to the lower screen of the chamber G. The compressed air is made to take a circuitous route by the screens g^1. Some of the air passes through the screens. By this means the partly-cooled air from the compressor is thoroughly cooled, and when it passes through the pipe I it has very little water in suspension. During the ascent of this cooled air in the chamber H the screens *h* extract most of the moisture, which runs to the bottom of the chamber H, and finally to the bottom of the chamber G by pipe h^1. When there is any excess of water it runs off automatically by the ball float-valve g^5. The air now passes through the drying-box h^2, containing the drying materials, where it is thoroughly dried. From box h^2 it passes by the pipe E to the chest a^{12}, when it is allowed to pass into the lower end of the cylinder A; but the supply being cut off at a certain portion of the stroke, it is allowed to expand itself performing work. This expansion is performed at the same time that the air is being compressed on the other side of the piston *a*, and consequently the air is made to do work. As soon as the air is fully expanded the valve a^{13} opens its discharge-port, and a clear and straight discharge is obtained into the compartment or main, which prevents the formation of ice, which forms when ordinary valves and crooked discharge are used, and prevents undue friction.

During the downward stroke of the piston the air is drawn in at the top of the cylinder by the valve a^3, and the expanded air is discharged at the bottom. As the piston *a* descends it draws the plunger a^7 with it, which sucks water into the cylinder a^6, and at the same time instantly closes the valve a^5.

The same air may be used over and over again; but when this is the case it should be invariably disinfected at each handling, which may be done by the means shown in Fig. 6.

Should the pressure of the compressed air be greater than required the mechanism shown in Fig. 8 comes into play, and reduces the power of the engine B, and makes the expanding air do a greater proportion of the work of compression. The automatic cut-off for the air is shown in Fig. 7, and has been previously explained. I do not confine myself to the particular mechanism described to do this; but the employment of a cylinder, S, and piston T, in combination with valve Q, is the best means.

The valve shown in Fig. 4 may be actuated by a suitable eccentric or cam, so as to make it a regular cut-off; but I prefer two valves and an automatic cut-off, as it is economy and gives a greater refrigerative effect.

This operation of compressing and expanding goes on simultaneously at each upward or compressing stroke of the piston.

I claim—

1. In a refrigerating and ventilating apparatus, the cylinder A, provided with a piston, a, in combination with the annular induction-valve a^3, discharge-valve a^5, and expansion-valve a^{13}, substantially as and for the purpose specified.

2. In a refrigerating and ventilating apparatus, the pump-cylinder a^6, provided with a supply-pipe and check-valve, a^9, in combination with a hollow perforated pump-plunger, a^7, attached to and actuated by the compression-piston, substantially as shown and described.

3. In a refrigerating and ventilating apparatus, the cylinder A, provided with a head having separate compartments a^1 and a^2, for the induction and eduction of air, in combination with valves a^3 and a^5, substantially as and for the purpose specified.

4. The cylinder for expanding the compressed air, provided with the port a^{11}, in combination with the valve-port a^{13} and pipe D, leading in a nearly straight line to the apartment to be cooled, whereby a direct course for the expanded air to said apartment is provided, as and for the purposes set forth.

5. In a refrigerating and ventilating apparatus, the combination, with the cylinder-port P and the valve-port M, of the cut-off valve Q, having a hollow rod, R, a piston, T, and a cylinder, S, together with the rod U and the weights V and W, for the purpose of cutting off automatically the compressed air admitted to the expansion-cylinder, substantially as shown and described.

6. In a refrigerating and ventilating apparatus, the chamber G, in combination with the cylinder or frames g, provided with slots g^2, the sieves g^1, and a rose-nozzle, g^3, substantially as and for the purpose specified.

7. In a refrigerating and ventilating apparatus, the combination of the chamber G, sieves g^1, rose-nozzle g^3, relief-valve a^{10}, and automatic discharge-valve g^5, substantially as and for the purpose specified.

8. The chamber H, provided with the sieves h, in combination with the compressing-cylinder A and cooling-chamber G, as described.

9. The process herein described of utilizing all of the energy of the compressed air admitted to the cylinder, and producing the maximum degree of cold due to the conversion of the heat into work, which consists in regulating the supply of compressed air admitted to the cylinder according to the degree of compression of said air, as described.

10. In a refrigerating and ventilating apparatus, the combination of the plunger a^7, cylinder a^6, relief-valve a^{10}, rose-nozzle g^3, and chamber G, substantially as and for the purpose specified.

11. In a refrigerating and ventilating apparatus, the disinfectant apparatus composed of a cylinder, J, supply-pipe X, discharge-pipe Y, and revolving plates $j\,j$, having their peripheries covered with wire-gauze or perforated plates, substantially as shown, and for the purpose specified.

12. In a refrigerating and ventilating apparatus, the cylinder or cylinders for the simultaneous compression and expansion of air on opposite sides of the piston, substantially as described, in combination with the receiving-chambers G and H, the suction-pipe C from the refrigerator, discharge-pipe F, supply-pipe E, and exhaust-pipe D, all constructed and operating substantially as described, and for the purposes specified.

In testimony of which invention I hereunto set my hand.

GEO. G. FRYER.

Witnesses:
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CHAS. F. VAN HORN.