(No Model.)

3 Sheets—Sheet 1.

A. G. WATERHOUSE & B. B. BREWER.

REFRIGERATING MACHINE.

No. 302,607. Patented July 29, 1884.

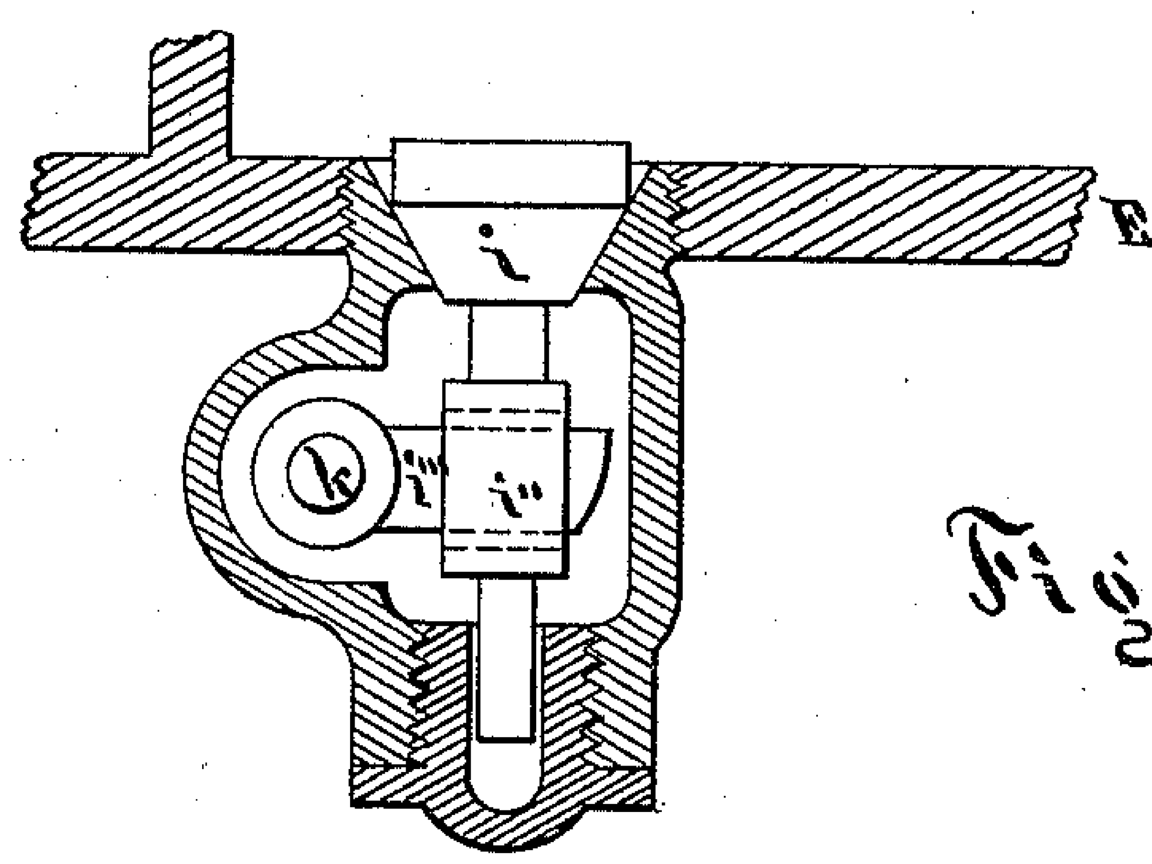
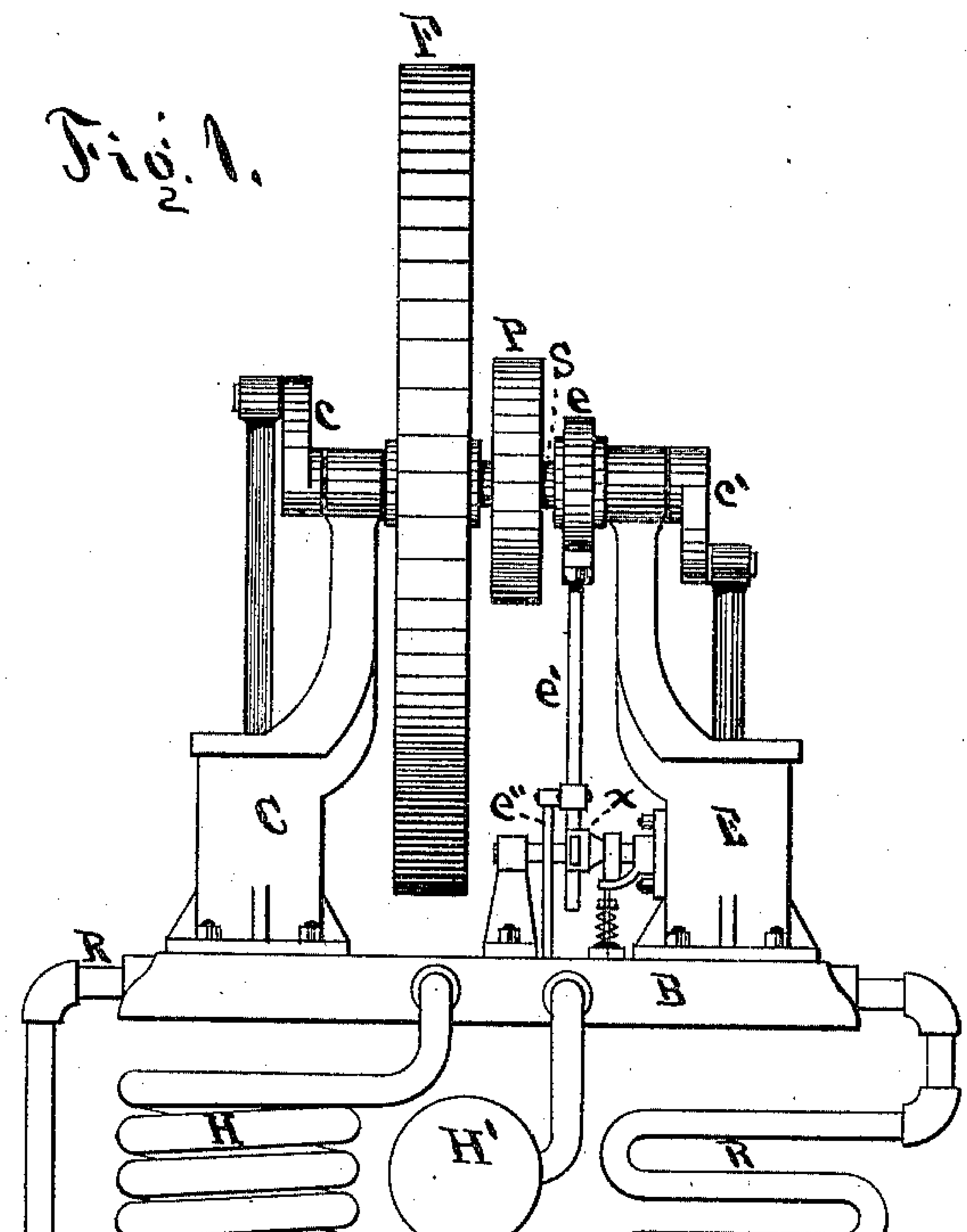


Fig. 5.

Fig. 1.



Witnesses.
John Tregoning
John H. Graham

Inventors.
Addison G. Waterhouse
Benjamin B. Brewer
per B. B. Ward their Atty.

N. PETERS. Photo-Lithographer. Washington, D. C.

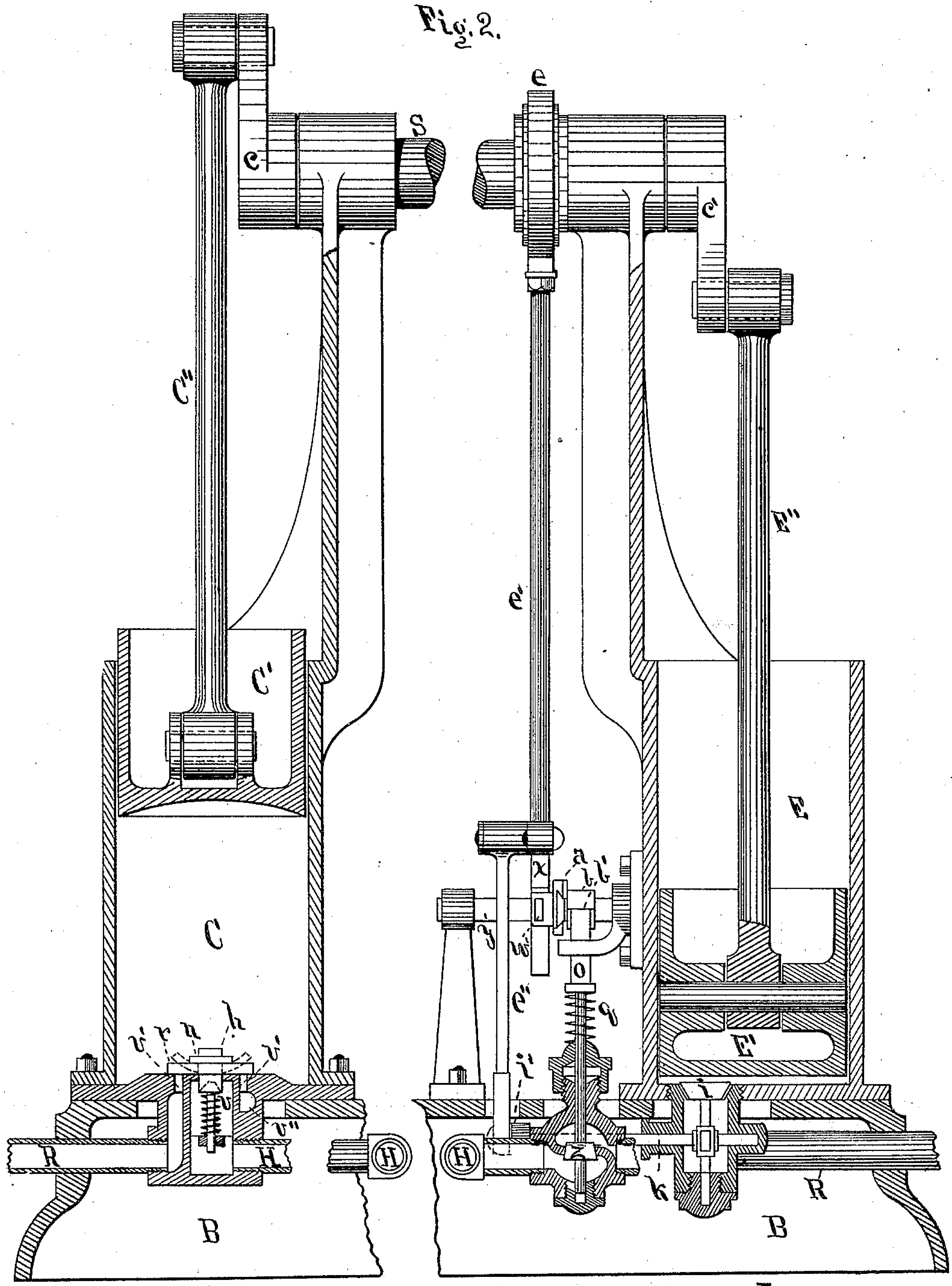
(No Model.) 3 Sheets—Sheet 2.

A. G. WATERHOUSE & B. B. BREWER.

REFRIGERATING MACHINE.

No. 302,607. Patented July 29, 1884.

Fig. 2.



Witnesses
John Tregoning
John H. Graham

Inventors.
Addison G. Waterhouse
Benjamin B. Brewer
per. B. B. Ward their Atty.

(No Model.) 3 Sheets—Sheet 3

A. G. WATERHOUSE & B. B. BREWER.

REFRIGERATING MACHINE.

No. 302,607. Patented July 29, 1884.

Fig. 4.

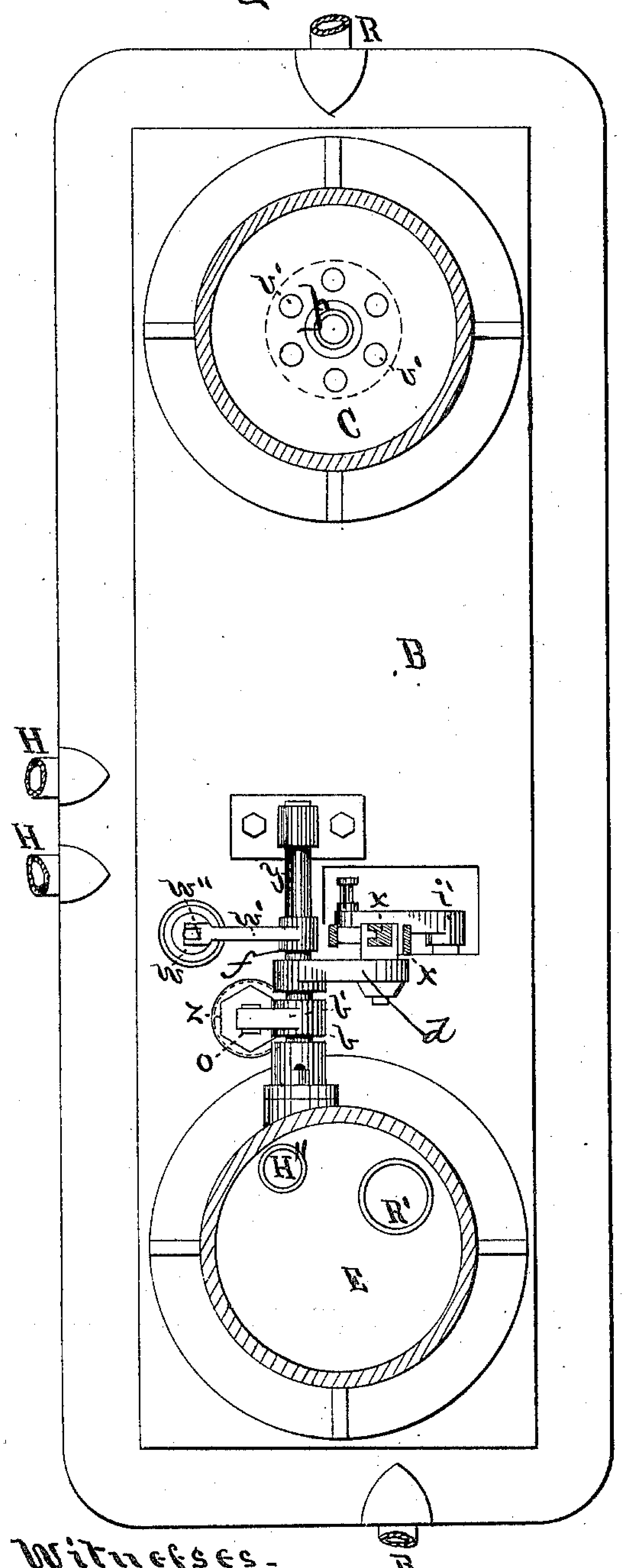
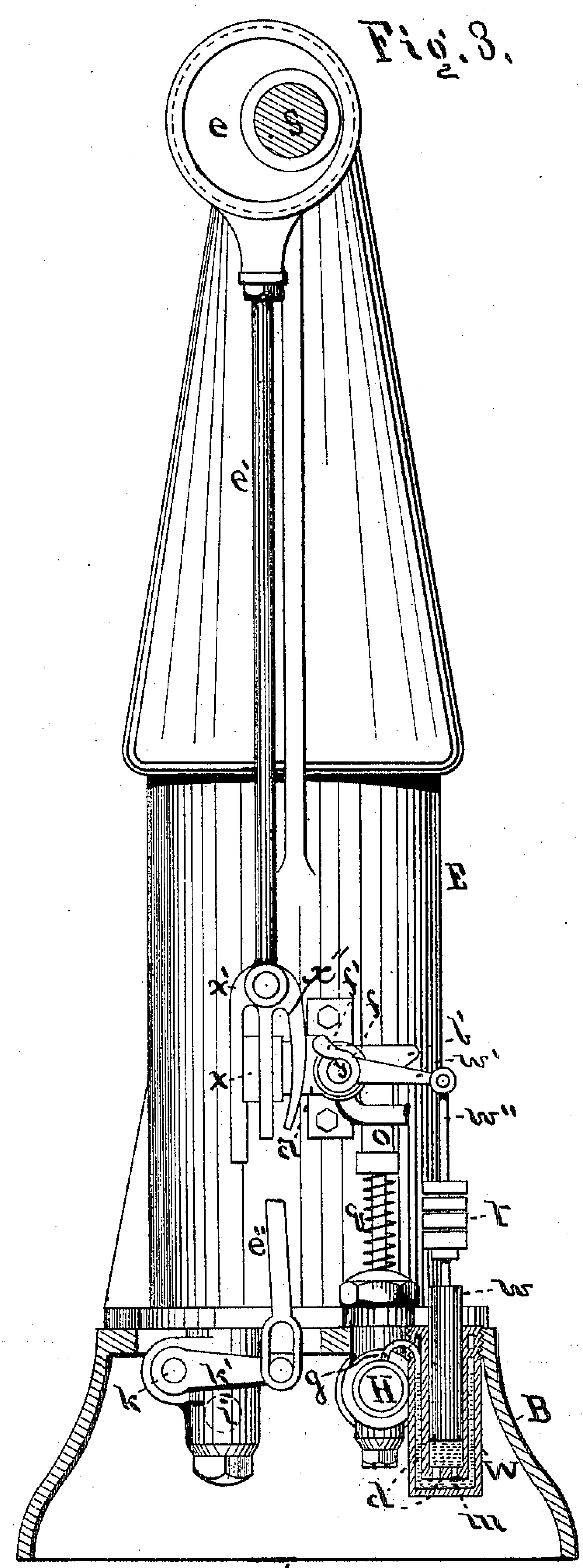


Fig. 3.



Witnesses.
John Tregoning
John H. Graham

Inventors.
Addison G. Waterhouse
Benjamin B. Brewer
per. B. B. Hard their Atty.

UNITED STATES PATENT OFFICE.

ADDISON G. WATERHOUSE, OF HARTFORD, CONNECTICUT, AND BENJAMIN B. BREWER, OF SACRAMENTO, CALIFORNIA, ASSIGNORS OF ONE-THIRD TO FRANK G. WATERHOUSE, OF SACRAMENTO, CALIFORNIA.

REFRIGERATING-MACHINE.

SPECIFICATION forming part of Letters Patent No. 302,607, dated July 29, 1884.

Application filed March 26, 1884. (No model.)

To all whom it may concern:

Be it known that we, ADDISON G. WATERHOUSE, of the city of Hartford, State of Connecticut, and BENJAMIN B. BREWER, of the city of Sacramento, State of California, both citizens of the United States, have invented new and useful Improvements in Refrigerating-Machines, of which the following is a specification.

Our invention relates to that class of refrigerating-machines in which cold is produced by means of the alternate compression and expansion of air or gases in which air is first compressed; second, cooled off while in a compressed state; third, allowed to expand, and in so expanding made to perform work which is employed to assist in the work of compressing the air.

Our invention consists in the method by which work is performed by the expanding air, and in the method by which such work is governed and the compressed air controlled, so as not to rise above or fall below a set pressure.

In the accompanying drawings, Figure 1 is a side elevation of a machine embodying our invention. Fig. 2 is an enlarged side elevation of the cylinder and valve of Fig. 1. Fig. 3 is a sectional elevation of part of Fig. 2. Fig. 4 is a sectional plan of Fig. 2. Fig. 5 is a sectional detail.

In Fig. 1 is shown a shaft, S, with cranks *c* and *c'* at each end, set diametrically opposite to each other. On the shaft is a heavy fly-wheel, F, and a pulley, P, through which power is transmitted to the machine. The shaft S is supported by the side frames of the two cylinders C and E. The crank *e* works a piston in cylinder C through the connecting-rod shown, while the crank C' works a piston in cylinder E in the same manner, the cranks being set so that as one piston is moving up the other is moving down. The object of cylinder C is to compress air or gas, (hereinafter we will call it all "air,") and force it into the cooling-pipe H and the receiving-chamber H', say, at a pressure of one hundred and fifty pounds per square inch. By thus compressing air heat is being produced in the air in inverse proportion to the decrease of the volume of air by compression. This heat may be used in producing power by causing part of the pipe H to run through the water used in the boiler of the driving-engine. By absorbing the heat in the pipe H by water or surrounding bodies we reduce the heat of the air in H until it has been lowered to the temperature of surrounding bodies, and has a pressure, say, of one hundred and fifty pounds to the square inch, less the amount due to the decrease of heat, so that at every downward stroke of the piston of C a cylinderful of air is compressed and forced into the pipe H, where it is cooled off and stored in the receiver H', while at every upward stroke of the piston in cylinder E some compressed air is allowed to escape under the piston of the same, which, by pressure in entering and by its effort to expand, forces the piston of E upward, which imparts power to the fly-wheel F, and assists the motor in compressing the air in C. After the air in E has expanded to its normal pressure, and all of its expanding force has been expended in raising the piston in E, the air, after having expanded, has decreased in temperature inversely as it has increased in volume, which renders it extremely cold, and in this condition it is exhausted or expelled into the pipe R, where it is used to absorb the heat of objects surrounding the pipe R—such as water to be frozen—or for any of the purposes for which extremely cold air may be employed. The air in R can be conducted back and used over again by recompressing it in cylinder C; or the pipe R may be dispensed with and the air from E may be allowed to escape for the purpose of cooling the surrounding air or for cooling the air in houses, rooms, &c. It will be seen that in compressing the air in the pipe H to a pressure, say, of one hundred and fifty pounds to the square inch a certain amount can be allowed to escape in the cylinder E for doing work. If too much escapes, the pressure in H will be reduced by E faster than it can be supplied by C, and if too little is allowed to escape in E the pressure in H will increase until the piston in C cannot be worked. To avoid this and to maintain an even pressure in H, so that only the proper amount of air will enter E at every stroke while still preserving a given pressure in the pipe H, is what constitutes the leading feature of our invention.

In Fig. 2, C is the compressing-cylinder, provided with piston C′, worked by crank c. At the bottom of C are two check-valves, r and v, combined in one casting. The inlet-valve r is composed of rubber held in its place by the central nut, u, screwed around the central ejecting-passage, p. r rises, as shown, at every upward stroke of C′, and admits the air through the pipe R and the annular recess V into the cylinder C; but the air is prevented from returning by the falling of valve r during the downward stroke of C′; but as the air which has been drawn in C is compressed by the downward stroke of C′ it presses the valve v away from its seat and forces the air through the opening p into the pipe H. Valve v, being a check-valve, prevents the escape of the air through the opening in which it entered. So it will be seen that at every upward stroke of the piston C′ the cylinder C is filled with air, and at every downward stroke the air is compressed and forced into pipe H, where it is cooled off and stored in the chamber H′, as shown in Fig. 1. We will now assume that the air has been compressed to $\frac{1}{x}$ of its normal volume and forced into pipe H and therein cooled off and at a pressure of one hundred and fifty pounds per square inch. We will also assume that at every stroke the cylinder E is filled nearly $\frac{1}{x}$ full of compressed air, wherein it expands x times, and in so doing does work, as before described. The result is an apparatus that, first, compresses the air; second, cools the compressed air off; third, uses the power exerted by the air in expanding to its original volume; fourth, makes use of the cooled condition of the expanded air for refrigerating purposes.

We do not claim, broadly, a machine that will perform the above functions, as we know that the same has been performed before; but the following features we claim as new:

In order to govern or control the pressure of air in the pipe H, and make use of the expansive effect of said compressed air in performing the greatest amount of work, as stated, and still maintaining the pressure in H at a given point, we use an automatic valve and gear, through the means of which the exact amount of air which can be allowed to escape at every stroke in the cylinder E is regulated by the pressure of air in the pipe H. This we accomplish as follows: In Figs. 3 and 4 is shown a cylinder, W, placed in the bed B. This cylinder is provided with a cylindrical plunger, w, which is free to move up and down in the cylinder W, and is made air-tight by U or other suitable packing. Around the outside of the cylinder W is a closed recess, d, to which the air-tube g leads from the compressed-air pipe H. In the bottom of the cylinder W are small apertures m, which communicate from the cylinder W to the recess d. This recess is partly filled with oil, so that as the air enters through g into this recess d it presses upon the surface of the oil and forces it through the apertures m up against the piston w, which causes w to rise and fall with the varying pressure of the air in H. The plunger w is provided with a connecting-rod, w'', which communicates to a lever, w'. On the rod w'' or plunger w are placed weights t, which will correspond to any required pressure in H—say one hundred and fifty pounds to the square inch. So if the pressure in H exceeds one hundred and fifty pounds, the plunger w will move up, and if it falls below one hundred and fifty pounds the plunger will be forced down by the weights t, so that the movement of w will correspond to the pressure of the air in H. As w is connected by means of w'' to the lever w', which works the trip-off cam of the crab-claw x, the same as used on the valve-crank of the Corliss engine, this crab-claw is fixed to the lower end of the eccentric-rod e', and is worked by the eccentric e on the shaft S. The crab-claw x works the lever d, causing the rocker-shaft y to oscillate. A sword-arm lever, b, is connected to rocker-shaft y, which, when rocked downward, presses upon the valve-stem O, which opens valve z and allows the compressed air in H to enter the cylinder E. After the crab-claw x slips from its catch on lever a, the spring g', together with the pressure of air under the valve z, closes the valve and forces the arm b back to its horizontal position. To the eccentric-rod e' is attached a short valve-rod, e'', which communicates to the lever k and works the exhaust-valve I. The eccentric e is set on the shaft S, so as to raise the valve I as soon as the piston E′ has reached the top of its stroke, and to keep the valve open until E′ has completed its downward stroke, which will allow all of the air which has been expanded in E to be forced into the refrigerating-pipe R. As soon as the piston E′ completes its downward stroke and the eccentric has closed valve I, the crab-claw x raises the lever a, which presses down the arm b and opens the valve z, as stated, which allows the compressed air to enter under the piston E′; while the crab-claw x is moving up its bent arm x'' strikes the cam-lug t, and causes the grip x to liberate the lever a. The time when the crab-claw slips off and allows the valve z to close in relation to the various positions that the piston has reached in its upward stroke is regulated by the position of the cam f', which is fixed to the sleeve f, to which the lever w' is attached and worked by the piston or plunger w, so that the valve z is closed at various points during the upward stroke of the piston E′, which variation is governed by the pressure of air in the pipe H, as stated.

Fig. 4 shows a sectional plan of Fig. 2, showing bed B, cylinder C, with the apertures *v*, for drawing in air, and the opening *p*, for expelling air into the pipe H. The cylinder E is also shown with the opening H″ for compressed air to enter, and opening R′, through which the cold expanded air is expelled. There is also shown a plan of the valve-working mechanism, consisting of the rocker-shaft *y*, lever *a*, crab-claw *x*, sword-arm *b*, that presses down the stem O of the valve *z*, also the governing-cylinder *w*, connecting-rod *w″*, lever *w′*, and cam-sleeve *f*, to which cam *f′* is attached for effecting the trip off of the crab-claw.

Though we have explained a complete working mechanism for performing every part of the work, there is nothing essentially peculiar about either the valves, valve-working mechanism, or cylinders, as other forms and parts would answer the same purposes.

Instead of single-acting cylinders, those of a double-acting kind may be used. Therefore we do not confine ourselves to the exact form of mechanism shown, and, as it is our intention to make other and further applications for patents relating to this invention, we reserve the right to do so.

What we claim as our invention is—

1. A refrigerating-machine in which the relative amount of air or gas which is being compressed and the amount which is used expansively for power is regulated by the pressure of air varying from any given pressure, substantially as and for the purposes as set forth.

2. The combination of the cylinder C, pipe H, and cylinder E with an automatic cut-off operated by the pressure of the air in pipe H, substantially as and for the purposes set forth.

3. The combination of cylinder C, crank *c*, shaft S, crank *c′*, cylinder E, and automatic cut-off *x*, operated by the pressure of air or gas compressed by cylinder C, and acting upon a piston, *w*, substantially as and for the purposes as set forth.

4. In a refrigerating-machine consisting of a compressing-engine, a pressure pipe or receiver, and an expanding-engine, through which the power rendered by the compressed air in expanding to an increased volume is employed to assist in the work of compressing the air, an automatic governing mechanism operated by the rise and fall of the pressure of air, whereby the amount of air admitted at each stroke to the expanding-engine is regulated, substantially as and for the purposes as set forth.

5. The governor W, worked by the pressure of air or gas in H, for controlling the amount of air or gas allowed to enter the cylinder E, substantially as and for the purposes as set forth.

ADDISON G. WATERHOUSE.
BENJAMIN B. BREWER.

Witnesses:
BARTON B. WARD,
G. L. WATERHOUSE,
S. S. SOUTHWORTH,
A. J. THOMAS.