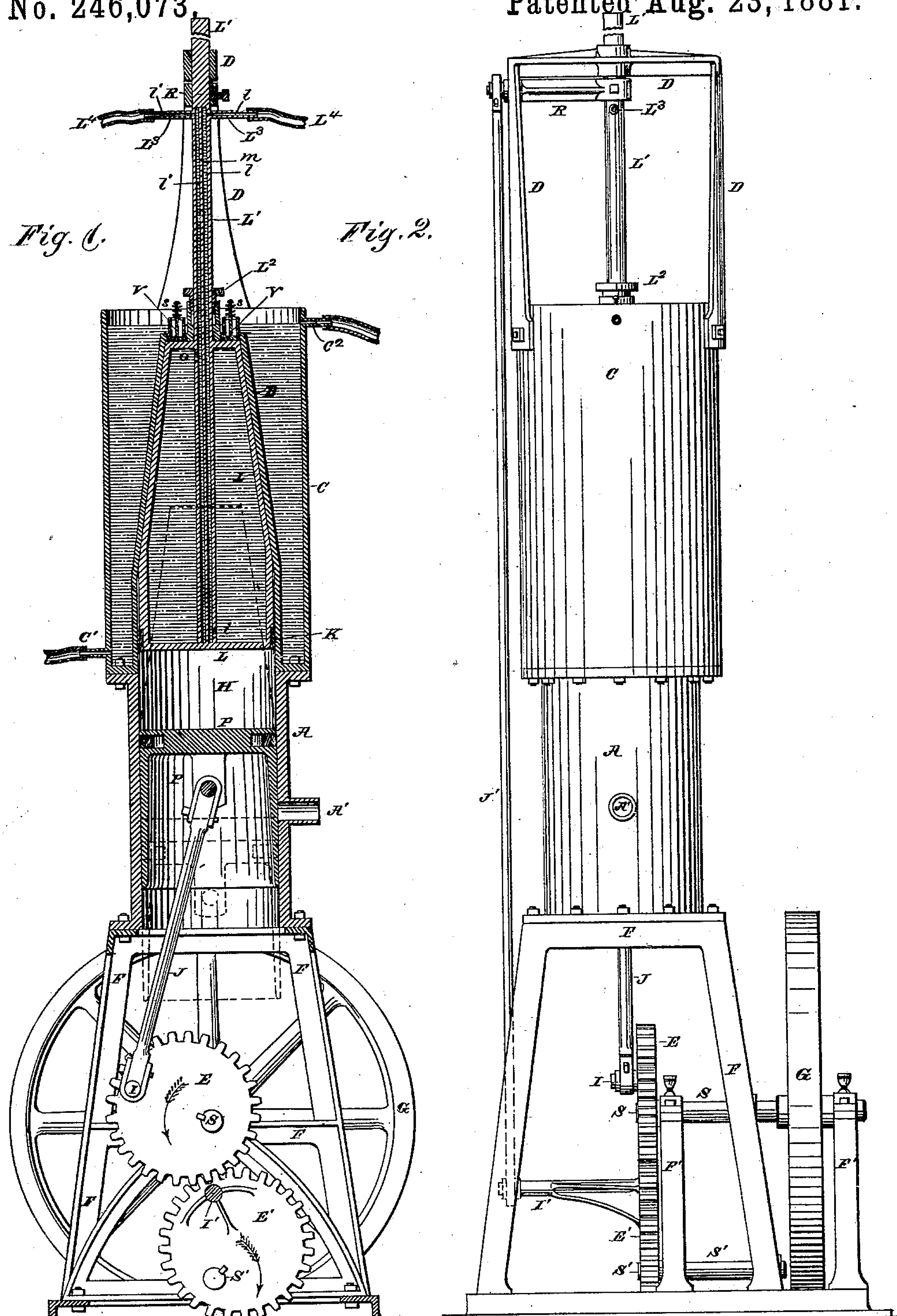
(No Model.) 2 Sheets—Sheet 1.

J. P. & O. G. BURNHAM.

AIR COOLING MACHINE.

No. 246,073. Patented Aug. 23, 1881.



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(No Model.) 2 Sheets—Sheet 2.

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Fig. 3.

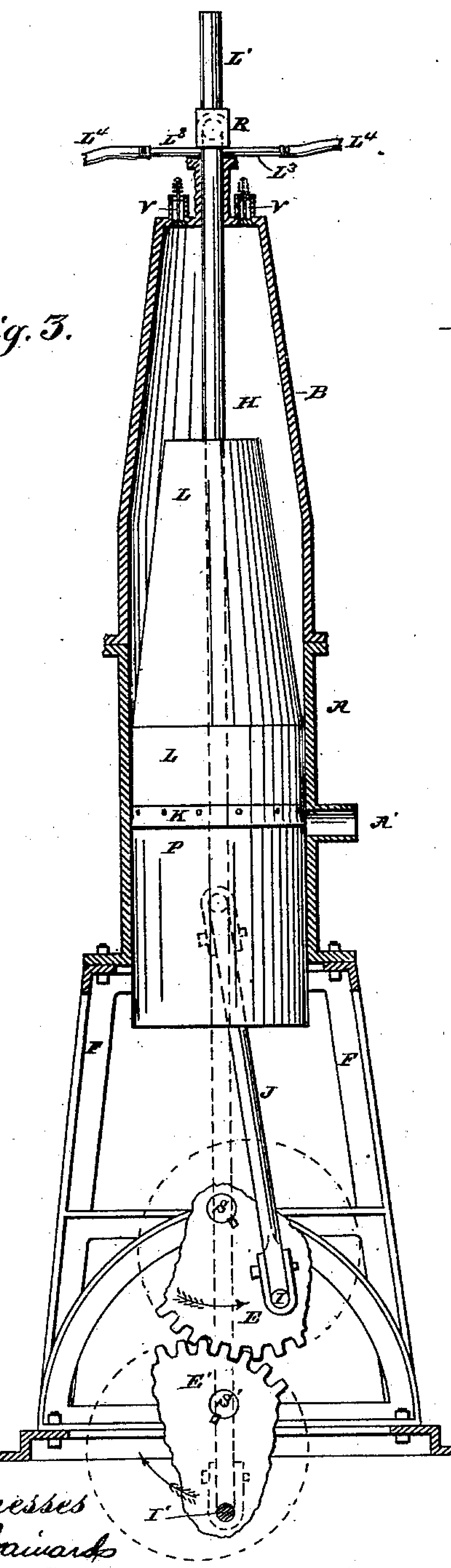
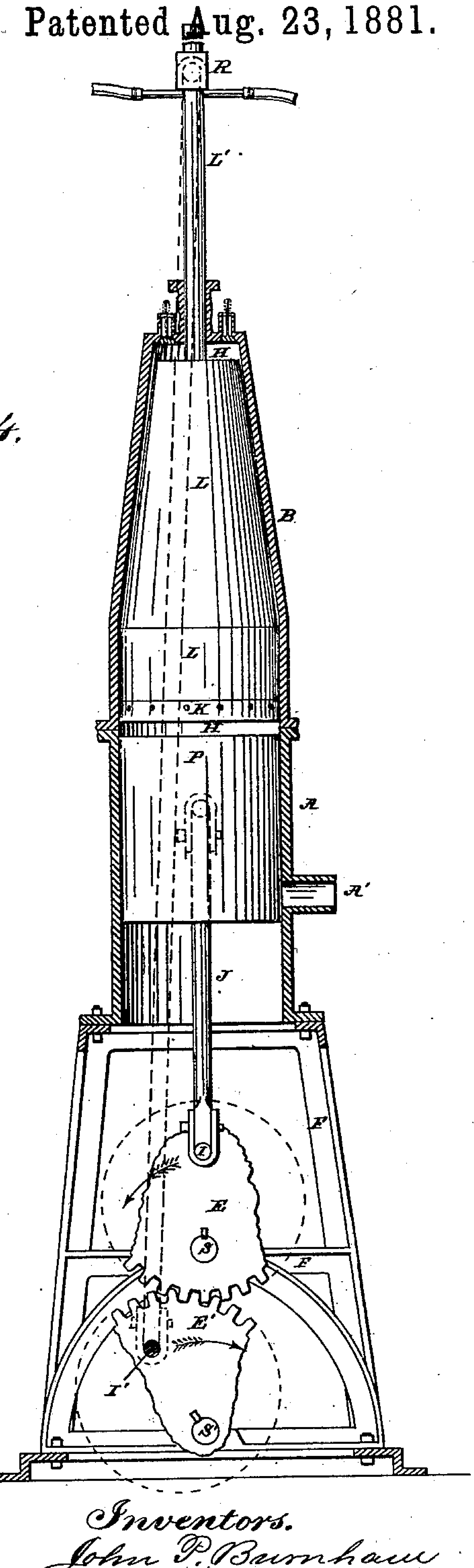


Fig. 4.



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UNITED STATES PATENT OFFICE.

JOHN P. BURNHAM AND OLIVER G. BURNHAM, OF CHICAGO, ILLINOIS.

AIR-COOLING MACHINE.

SPECIFICATION forming part of Letters Patent No. 246,073, dated August 23, 1881.

Application filed May 6, 1881. (No model.)

To all whom it may concern:

Be it known that we, JOHN P. BURNHAM and OLIVER G. BURNHAM, both of Chicago, in the State of Illinois, have invented certain new and useful Improvements in Air-Cooling Machines; and we 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 single-chambered machines for cooling air and other similar fluids by the method of successive compression and expansion thereof.

It is a fault in a class of machines for cooling air by compression and expansion that the heat developed by compression of the air is abstracted from a considerable part of the air-body subsequently to its compression. As a result, there is a tendency to expansion in the air being compressed, which adds to the resistance opposing the compressing force, or, in other words, which makes a greater power necessary to drive the machine. To remedy this fault machines of another class have been devised, in which sprays of water are injected into the compressing-chamber during the act of compression. This method obviously produces a moisture in the air which it is difficult to remove, and which for many purposes is highly objectionable.

Another fault common in machines of this general class, which have but a single chamber, is that the air is expanded in contact with the same surfaces upon which it is compressed and cooled. In consequence, a considerable part of the heat abstracted from the air while it is under pressure is returned thereto while it is being expanded, and in so far the effectiveness and economy of the machine are impaired.

As primary objects of our present invention herein set forth, we seek, first, by purely mechanical means and in a single chamber, to simultaneously compress the air and abstract its heat; and, second, to expand the air in contact with other surfaces than those through which the cooling agent operates while it is being compressed.

Further objects of our invention are to provide in a single-chambered machine such a construction as will, in the expansion of the air, recover very largely the power expended in its compression; to dispense with valves at the openings of the expansion-space, and generally to produce a machine more simple in its construction and economical in its operation, while not less effective in its results, than the machines heretofore in use for cooling air by the method mentioned.

To these ends our invention consists in the several novel features of construction and operation and in the several combinations of devices hereinafter described and claimed.

Figure 1 of the drawings is a central vertical section of our machine. Fig. 2 is an elevation thereof; and Figs. 3 and 4 are fragmentary views, intended to show certain positions of the moving parts by which compression and expansion are successively effected.

H is the single chamber containing the working parts. Said chamber is here shown as being inclosed by the shell A B, of which A is a cylinder, open at the top and bottom and supported on the frame F, and B is an extension of A, cylindrical for a lower portion of its length, and having its upper and principal portion conical and closed at the top.

C is a water-tank surrounding the part B of the shell described. Said tank is provided with an inlet, C′, at the bottom and an outlet, C^2, at the top, by which the water of the tank may be constantly changed as it becomes heated.

Within the cylindro-conical chamber H two moving parts effect the induction, the compression, the expansion, and the expulsion of the air. One of these is a piston, P, which works in the cylinder A, and the other is a cylindro-conical plunger, L, fitted to the upper interior of the chamber H, and having its lower or cylindric portion of less diameter than the cylinder A.

K is an expansion-packing, of leather or other suitable material, applied about the lower margin of the plunger and adapted by its contraction to allow air from above the plunger to pass downward about the same at this point when the plunger rises, but by its expansion to prevent its passage upward when the plunger falls.

V V are valves in the upper end of the shell A B, arranged to open downward and to close by springs *s*, and A′ is a lateral opening in the cylinder A, leading out of the chamber H. The piston P has long bearing-surface, and closes the outlet A′, except when at the bottom of its stroke. The piston P and plunger L described are driven out of time in the manner and by the means next described.

S is a drive-shaft mounted in pillow-blocks F′, and provided with a heavy drive-pulley and balance-wheel, G. Said shaft is also provided at its extremity with the eccentric gear-wheel E, having a crank-pin, I. A pitman, J, connects this crank-pin with the piston P, as clearly shown in Fig. 1. Beneath the shaft S the shaft S′ is mounted in suitable bearings, carrying the eccentric gear-wheel E′, which has an equal number of cogs with E, meshes therewith, and is driven thereby. A long crank-pin, I′, projects from the wheel E′, (being suitably braced to give strength, as shown in Fig. 2,) to the extremity of which is attached the pitman J′. This pitman similarly connects with the arm R on the rod L′ of the plunger L, and is of such length as to carry the plunger in its upstroke to the top of the chamber H, as seen in Fig. 1. The relative movements of the plunger and piston will be understood from the sectional Figs. 1, 3, and 4, wherein it will be first noticed that the crank-pin I is set somewhat in advance of the pin I′, so that the changes of direction of movement by the piston are made before those of the plunger. Otherwise the parts are connected so that the plunger and piston proximate at the beginning of the upstroke of the plunger at a point in the cylinder A about opposite which the center of the outlet A′ is located. From this point upward they continue near together until the piston has completed its upstroke—say opposite the top of the cylinder A. Here the plunger leaves the piston and rises to the top of the chamber H, while the piston reverses its motion and is brought nearly half its stroke downward, as seen in Fig. 1, before the plunger begins to follow. The lowest positions of the plunger and piston are shown by dotted lines in Fig. 1. The unequal lengths of the pitmen J and J′, as shown, contribute to give a nearly uniform upward speed of the piston and plunger from their positions shown in Fig. 3 to those shown in Fig. 4, and also increase the rapidity of the separation of these parts in their downstroke.

In the descent of the plunger from its highest position (shown in Fig. 1) it is plain that the check-valves V will be opened inward and air admitted above the plunger. In Fig. 3 the plunger is at rest at the bottom of its stroke, the space above it is filled with air just admitted, and the spring-valves have automatically closed. As the plunger and piston subsequently rise together the body of air referred to is compressed, the compression thereof being substantially completed on the termination of the piston's upstroke. At this time the air stands above and about the plunger, exposed in a thin body to contact with the cooling-surface of the shell B, embraced within the water of tank C, as seen in Fig. 4. When the plunger here leaves the piston to complete its upstroke the air passes downward past the packing K into the space between the adjacent faces of the plunger and piston. Thus it will be noted that as the air, while under severe compression, is confined within cooling-surfaces, to which it is exposed in a thin body, the generation and abstraction of heat are practically simultaneous, and that therefore little or no tendency to expansion from increased temperature can be present to augment the resistance to the compressing force of the machine. When the plunger has forced the compressed air from above and around to beneath itself, as above described, or, in other words, when the plunger has reached the end of its upstroke, the piston has commenced to move rapidly downward, producing a space above it and within the cylinder A, in which the air is expanded. The proportions of the parts are preferably so contrived as to make this space equal to the original volume of uncompressed air admitted less its reduction by lowered temperature, when the top of the piston reaches the top of the outlet A′, so that said air is expelled under normal pressure of one atmosphere. The air is forced out through the passage A′ mainly by the plunger in its further descent, and in small part by the piston, which rises to meet or proximate the plunger at a point about opposite the center of said outlet, as before stated, and as shown in Fig. 1.

It will again be noted that while the compression and cooling are effected within the shell B, the expansion is accomplished in the cylinder A. There is therefore no possibility of returning to the air in its expansion any appreciable part of the heat taken therefrom, as would be the case were the expansion and compression effected wholly or in considerable part within the cooling-walls B.

In order to more effectively cool the air in the act of compression, the plunger L and its rod L′ are made hollow, as indicated in Fig. 1, the rod being continued to the bottom of the plunger. A current of water is maintained through said plunger by means of the following devices: The plunger-rod L′ may be a tube, having inserted therein a central diaphragm, *m*, dividing said tube into two passages, *l* and *l′*, which are continued through the lateral arms L^3 L^3, projecting from the tubular rod near its top. The inlet to the interior of the plunger is here shown to be the passage *l*, which opens at *i*, near the bottom of the plunger, and the outlet is shown to be *l′*, which opens within the plunger, near the top, at *o*. Flexible tubes L^4, one of them connected with a source of water-supply and the other directed to a proper point of discharge, are continuations of the passages

l and l', and permit the constant change of the water within the plunger while the latter is in motion. The rod L′ is steadied above the arm R by the guide-frame D, and runs in a suitable stuffing-box, L^2, in the top of the shell B.

As a result of the construction described, wherein the compression and expansion of the air are effected in one and the same chamber and against the same piston, no loss of power is suffered by friction in the passage of the air through narrow and valved apertures usually employed in this class of machines. So, also, by the direct connection of the parts, as shown, in addition to the feature of a single chamber mentioned, the entire expansive force of the air, after the abstraction of its heat, is available as a compensation for that expended in its compression. The piston P operating, as described, to open and close the outlet A′, no valves are required at this point, and the trouble and inconvenience from freezing and other causes attending the use of such valves are wholly obviated.

The plunger L may be a cylinder for its entire length, working within a cylindric shell, B, of larger size; but such construction would not be so effective as the conical form of these parts shown, because a less proportion of the air above said cylinder would be exposed to the cooling-surface, and the tendency to expansion in the air being compressed would not, therefore, be so effectively counteracted as in the construction shown. The plunger may also be made of a series of short cylinders, successively narrowing toward the top, like a cone-pulley, running within a correspondingly-formed shell, B; but such form of shell and plunger would be open to the same objection as the wholly cylindric form mentioned. Moreover, in either of these suggested forms a much larger body of compressed air would remain about the plunger than in the form shown, preventing the quick action of the valves V.

The plunger may be conical for a greater part of its length than is shown in the drawings, or wholly conical; but there is an advantage in the cylindro-conical forms here given it—namely, to thereby confine the air admitted above the cylinder more completely within the cooling-shell B in the act of compressing it.

It may be added that but for the purpose of recovering, through the expansion of the air, power expended in its compression, the piston P might be dispensed with and a practical cooler would still remain. In this case the expansible packing K might be made to yield only to such pressure from above as would give the desired compression to the air above the plunger; or, instead of the expansible packing K as a means of releasing the compressed air, an annular enlargement may be provided in the chamber H, above the lower margin of which the bottom of the plunger will be carried near the completion of its upstroke, into which enlargement the air would be first compressed, and from which it would be finally released, both by the upstroke of the plunger. These elements, therefore, may without the piston constitute an operative mechanism.

We do not wish to limit ourselves to the eccentric gear-wheels E and E′ as means of giving the requisite movements to the plunger and piston, as cams or cranks actuated by other arrangements of eccentric gears may be employed for this purpose; nor is it essential to our invention that the plunger and piston have the precise relative movements in all respects as herein at length described. These gears have advantages of perfect certainty of action and of allowing a high speed, if required, which, with their less cost, makes them desirable. There are advantages in the conical or tapered form of plunger and its inclosing shell that would appear if said plunger and shell were combined with other features of construction in air-cooling and air-compressing mechanism than those here shown. Thus by this form of the parts named it is obviously practicable to move the plunger without friction of surface contact, and at the same time to wholly exclude the air from its apex and about its sides. This form of plunger and shell will be useful in apparatus for merely compressing air for power purposes, the plunger being rigidly connected with the piston, (with a space between them,) and the conical shell being attached to the piston-cylinder in extension thereof.

We claim as our invention—

1. In an air-cooling machine, the shell inclosing the chamber H, provided with an inlet-valve, V, and a suitable outlet, the surrounding cooler, and the reciprocating plunger smaller than and arranged within the shell, combined with each other and with suitable actuating mechanism, substantially as described, whereby air is admitted at the valve V, is compressed and cooled about the plunger, and is discharged at the end of the plunger opposite that at which it is admitted, as set forth.

2. In an air-cooling machine, the shell A B, inclosing a chamber, H, having a valved inlet and an outlet passage suitably arranged, combined with the piston P and plunger L, and with actuating mechanism, whereby the piston and plunger are given differential movement within the chamber, substantially as and for the purposes set forth.

3. In the air-cooler described, wherein the air is compressed about the plunger and is passed from one end to the other thereof, the valved shell A B, having its upper portion conical or tapering, combined with the plunger of corresponding form, substantially as described, and for the purposes stated.

4. In the air-cooler described, wherein the air is compressed and passes about the plunger from one end to the other thereof, the plunger L, made hollow and provided with a rod, L′, having passages l and l', connected as

shown and described, and for the purposes set forth.

5. Combined with the plunger L, having the rod L′ and the piston P together arranged to work in the common chamber H, the actuating mechanism described, consisting of the eccentric gear-wheels E and E′, suitably mounted and driven, and connecting-rods J and J′, arranged and connected as shown, whereby said plunger and piston are differentially impelled, substantially as described.

6. In the air-cooling machine described, the cylinder A, having the outlet A′, combined with the elongated piston P, arranged to open and close said outlet, substantially as described.

7. In an air-cooling or air-compressing machine, the conical or tapering plunger L, combined with the valved shell B, of form corresponding with the plunger, and having an extension, A, of uniform diameter, substantially as described.

In testimony that we claim the foregoing as our invention we affix our signatures in presence of two witnesses.

JOHN P. BURNHAM.
OLIVER G. BURNHAM.

Witnesses:
M. E. DAYTON,
JESSE COX, Jr.