(No Model.) 2 Sheets—Sheet 1.

J. A. WOODBURY, J. MERRILL, G. PATTEN & E. F. WOODBURY.

AIR ENGINE.

No. 324,062. Patented Aug. 11, 1885.

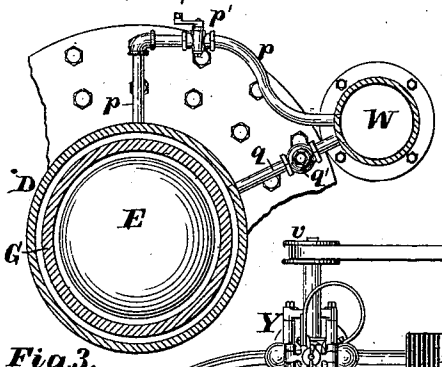

Fig. 3.

Fig. 1.

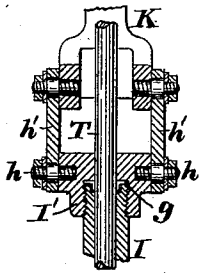

Fig. 4.

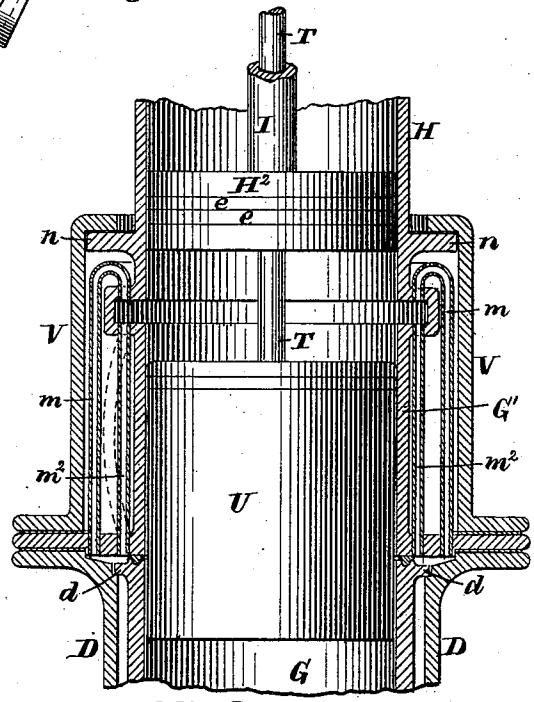

Fig. 5.

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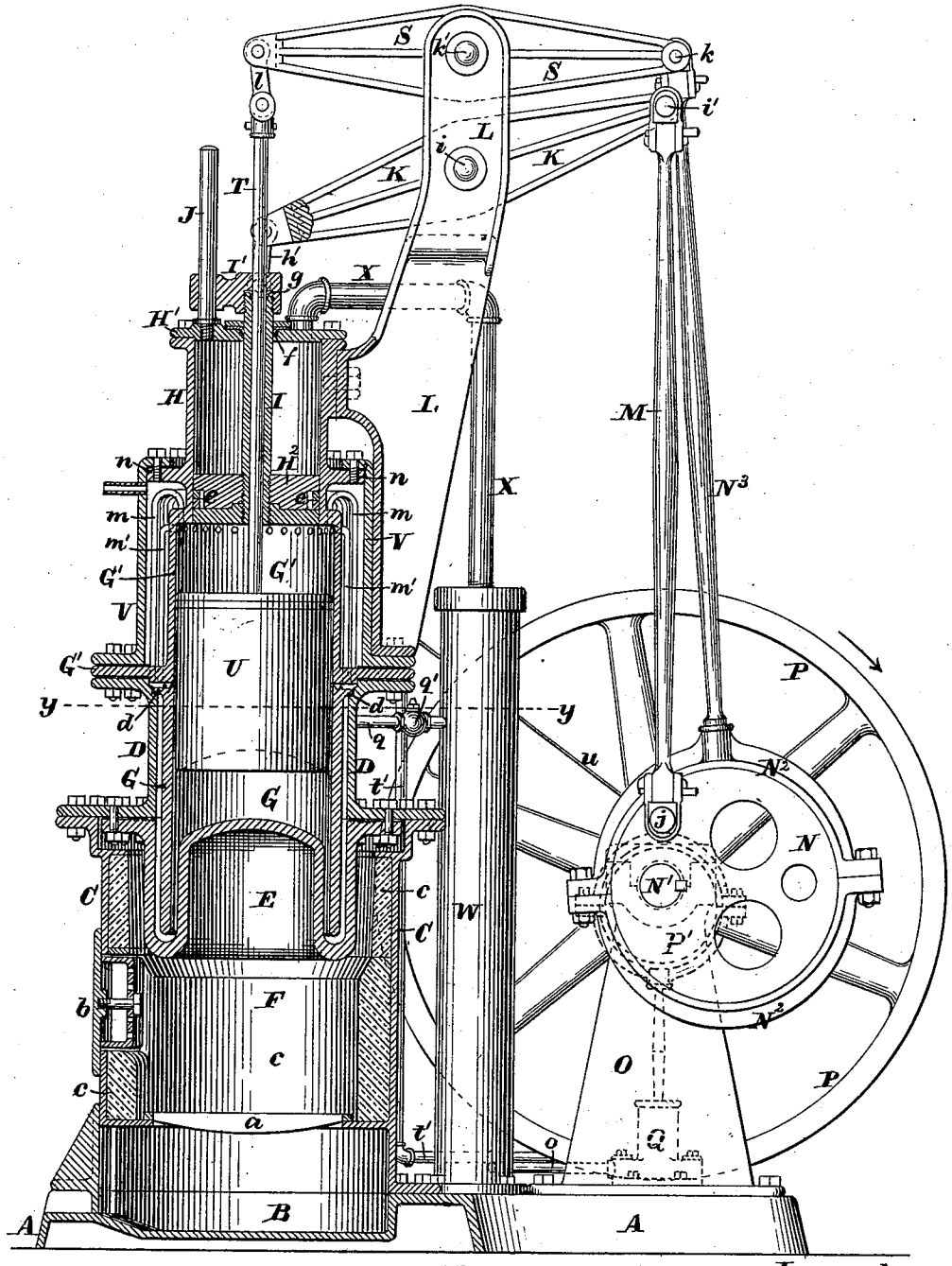

Fig. 2.

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UNITED STATES PATENT OFFICE.

JAMES A. WOODBURY, JOSHUA MERRILL, GEORGE PATTEN, AND EDWARD FRANKLIN WOODBURY, OF BOSTON, MASSACHUSETTS.

AIR-ENGINE.

SPECIFICATION forming part of Letters Patent No. 324,062, dated August 11, 1885.

Application filed June 7, 1881. (No model.)

To all whom it may concern:

Be it known that we, JAMES A. WOODBURY, JOSHUA MERRILL, GEORGE PATTEN, and EDWARD F. WOODBURY, all of Boston, in the county of Suffolk and State of Massachusetts, have invented certain new and useful Improvements in Air-Engines, of which the following, taken in connection with the accompanying drawings, is a specification.

Our invention relates to that class of air engines in which air is used without exhausting it, the same body of air being used over and over; and it consists in certain details of construction and arrangement and combinations of parts, which will be readily understood by reference to the description of the drawings, and to the claims to be hereinafter given.

Figure 1 of the drawings is a plan of an engine embodying our invention. Fig. 2 is a vertical section on line *x x* on Fig. 1. Fig. 3 is a partial horizontal section on line *y y* on Fig. 2. Fig. 4 is a detail section on line *z z* on Fig. 1, enlarged. Fig. 5 is a partial vertical section through reverser, working-cylinder, and cooler, and illustrating a modification of the construction of the cooler.

A is the bed-plate of the engine, in the upper side of which is formed the lower portion of the ash-pit B.

C is the furnace-casing, bolted to said bed-plate, and provided with the grate *a* and fire-door *b*, and lined with fire-brick *c*. To the upper end of the furnace-casing C is bolted the short cylinder D, to the under side of the lower flange of which is bolted the annular heater E, which extends downward therefrom into the combustion-chamber F.

G is the lower section of the reverser-cylinder, supported by lugs *d d*, projecting from its upper end, upon a shoulder formed in the inner periphery of the cylinder D near its upper end, said cylinder G having an exterior diameter somewhat less than the inner diameters of the cylinder D and the outer wall of the heater E to form a regenerator-chamber, and extending downward into the annular space between the outer and inner vertical walls of the heater, all in a well-known manner. To the upper end of the cylinder D is bolted the upper section, G′, of the reverser-cylinder, cast in one piece with the working-cylinder H, the exterior diameter of which is made somewhat smaller than the inner diameter of the reverser-cylinder, and having its upper end closed by the head H′.

H² is the working-piston, provided with packing-rings *e e*, and firmly secured to the lower end of the hollow piston-rod I, which extends upward through the head H′ and the cupped packing *f*, set in said head, and has its upper end screwed into the cross-head I′ against the cupped packing-ring *g*, as shown in Figs. 2 and 4. The cross-head I′ has its bearing upon and is guided in its upward and downward movements by the rod J, and has formed thereon or set therein two wrist-pins, *h h*, to receive the lower ends of the two links *h′ h′*, the upper ends of which are pivoted to opposite sides of the forked end of the beam K, which has its bearing on the center *i* in the stand L, and is provided at its other end with the wrist-pin *i′*, to receive the upper end of the connecting-rod M, the lower end of which embraces the crank-pin *j*, set in the side of the eccentric N, firmly secured upon one end of the shaft N′. The shaft N′ is mounted in bearings in the pillow-blocks O and O′, and carries the fly-wheel P, the eccentric P′, for operating the air-pump Q, the pulley R, and crank R′. The eccentric N is provided with the strap N² and rod N³, the upper end of which rod embraces the wrist-pin *k*, set in one end of the beam S, which is located directly above the beam K, and has its bearing on the center *k′* in the stand L, and is connected at its other end by the link *l* to the upper end of the piston-rod T, as shown in Figs. 1 and 2. The piston-rod T has its bearing in the hollow piston-rod I, and is guided thereby in its upward and downward movements, its upper end passing between the arms of the forked end of the beam K, and its lower end being firmly connected to the reverser-piston U, which is provided with a metal packing-ring near its upper end, arranged to fit closely to the interior of the upper section, G′, of the reverser-cylinder, in which it reciprocates, said upper section, G′, of the reverser-cylinder being made of sufficient length to cover the full stroke of said packing-ring, and the piston U

being so formed that that portion thereof which descends into the lower section, G, of the reverser-cylinder will not touch said cylinder. The upper end of the short cylinder D is counterbored or enlarged for a short distance, so as to form an enlarged annular space just beneath the flange of the upper section, G′, of the reverser-cylinder, which flange has drilled through it, directly over said annular space, a series of holes, in which are set and firmly secured the bent tubes *m m′*, which extend upward therefrom, and have their upper ends secured in holes formed in said upper section, G′, of the reverser at or near its upper end, some of said tubes, as *m*, having a half-turn bend formed in their upper ends, and are inserted in vertical holes formed in the upper radial wall or head of the cylinder G′, and the others, as *m′*, having only a quarter-turn bend made in their upper ends, and have their ends inserted in holes formed in the vertical wall of said cylinder, and radial to the axis of said cylinder, said pipes or tubes being arranged all around said cylinder at about equal distances from each other, and inclosed by the casing V, which is firmly bolted at its lower end to the flange of the section G′ of the reverser, and at its upper end to the flange *n*, cast upon and projecting outward from the working-cylinder H at a suitable height above the upper end of the reverser-cylinder G′, thereby forming a cooling-chamber surrounding and inclosing the periphery of the upper section of the reverser-cylinder and a portion of its upper end, as shown in Fig. 2.

A modification of the mode of applying the cooling-pipes is shown in Fig. 5, applicable in cases where the working-cylinder is made of the same diameter as the reverser-cylinder, in which a short annular enlargement of the bore of the cylinder is made at the junction of the working and reverser cylinders, and one set of the pipes are constructed similar to the pipes *m*, (shown in Fig. 2,) and the others are inserted directly through the lower wall of said enlargement, as seen at m^2.

In order to allow for unequal expansion and contraction, these pipes m^2 may be curved outward between their connections, as shown in dotted lines, or they may be bent spirally partially around the cylinder.

In Fig. 6 is illustrated a construction of the reverser-cylinder and cooler according to our improved plan adapted to use in an engine having its working-cylinder arranged at one side of the reverser instead of in the same axial line therewith, in which G and G′ are the two sections of the reverser-cylinder; D, the regenerator-cylinder; E, the heater; *m m*, the cooler-pipes, and V the cooler casing.

W is the supply tank or reservoir, into which air is forced by means of the air-pump Q and the pipe *o*, said pump being provided with suitable valves to prevent the return of the air. The upper end of the tank W is connected by the large pipe X with the upper end of the working-cylinder, and by the pipes *p* and *q* with the annular regenerator-chamber, the pipe *p* being provided with a suitable valve, *p′*, connected with and operated by the governor Y, and the pipe *q* with the check-valve *q′*, these latter pipes and valves and the governor constituting the regulating apparatus of the engine, their operation being as follows: The chambers above and below the working-piston and the reverser-piston being filled with air at the same pressure as that in the tank W, and a fire being built in the furnace, the air beneath the reverser-piston will be expanded and its pressure increased, and being forced through the regenerator and cooling-pipes by the descent of the reverser-piston, it reacts upon the working-piston and moves it to the extreme of its upward stroke, at which time the reverser-piston has performed one-half of its upward stroke, causing the air above it to be forced back through the cooling-pipes and the regenerator to the chamber beneath the reverser-piston, which causes a reduction of the pressure between said piston and the working-piston, and thus enables the working-piston to be moved through its downward stroke by the combined action of gravity and the momentum of the fly-wheel. If at any time the engine should run too fast, the governor Y will open the valve *p′*, and thus allow the surplus pressure in the reverser to escape into the tank W. If, on the other hand, for any reason, the pressure in the reverser should be reduced below that in the tank W, the check-valve *q′* would open and allow air to pass from the tank to the reverser till the pressure is equalized.

Z is a water-pump, the plunger of which is operated by the crank R′ and the connecting-rod *r*, and is provided with suitable inlet and discharge valves, the inlet-pipe *s*, and discharge-pipe *t*, through which water may be forced to any desired point. A smaller pipe, *t′*, branches from the pipe *t*, and leads to the cooling-chamber within the casing V. A belt, *u*, leads from the pulley R on the shaft N to the pulley *v* on the governor Y, as a means of imparting motion thereto.

What we claim as new, and desire to secure by Letters Patent of the United States, is—

1. In an air-engine, an air-cooling chamber surrounding and inclosing a portion of the periphery and a portion of one end of the reverser-cylinder, substantially as and for the purposes described.

2. In an air-engine having a working-cylinder and a reverser-cylinder arranged to use the same body of air over and over, a reverser-piston provided with a packing-ring to move therewith, in combination with a cooling-chamber surrounding and inclosing that portion of the reverser-cylinder in which said packing-ring moves, substantially as and for the purposes described.

3. A reverser-cylinder divided transversely into two parts at a point below the lowest position of the packing-ring of the reverser-piston, substantially as described.

4. A reverser-cylinder divided transversely at or near the middle of its length, in combination with air-cooling pipes extending from said division of the reverser upward, and communicating with the interior of said reverser at or near its top end, substantially as described.

5. The combination of a reverser-piston provided with a packing-ring, a cooler surrounding and inclosing that portion of the reverser-cylinder in which said packing-ring moves, and a regenerator communicating with said cooler and with the chamber below the reverser-piston, substantially as described.

6. The combination, in an air-engine, of a reverser-cylinder, a regenerator, and a cooler around and outside of the upper portion of the periphery of said cylinder, and leading from said regenerator to the interior of said reverser-cylinder, substantially as described.

7. In a single-acting air-engine, a passage connecting the chambers on opposite sides of the working-piston, in combination with a governor and a valve connected therewith for controlling the passage of air from one of said chambers to the other, substantially as described.

8. In a single-acting air-engine, a passage leading from the chamber at one end of the working-piston to the chamber at the opposite end of the working-piston, in combination with a valve and governor for controlling the passage of air from the chamber above the working-piston to the chamber below the same, and a check-valve for controlling the passage of air from the supply-tank to the chamber below the working-piston, substantially as and for the purposes described.

9. The combination of the tubular piston-rod I, having secured to one end thereof the piston H^2 of the working-cylinder, and to the other end the cross-head I′, the guide-rod J, the piston-rod T, having its bearing in said tubular rod I, and connected at its lower end to the reverser-piston U, and the cupped packing *f*, all arranged and adapted to operate substantially as described.

10. In combination with a working-cylinder and a reverser-cylinder arranged end to end, with their axes in the same line, and each provided with a reciprocating piston, two beams, arranged one above the other, with their pivotal bearing in the same stand, and adapted to oscillate in the same vertical plane, and means of connecting said beams to said pistons, substantially as described.

11. In combination with two beams arranged one above the other, with their pivotal bearings in the same stand, and adapted to oscillate in the same vertical plane, the eccentric N, and rod N^3, connecting with one beam, and the crank-pin *j*, set in the side of the eccentric N, and the rod M, leading from said pin to the other beam, substantially as described.

Executed at Boston this 4th day of June, A. D. 1881.

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