(No Model.) 4 Sheets—Sheet 1.

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

AIR ENGINE.

No. 331,359. Patented Dec. 1, 1885.

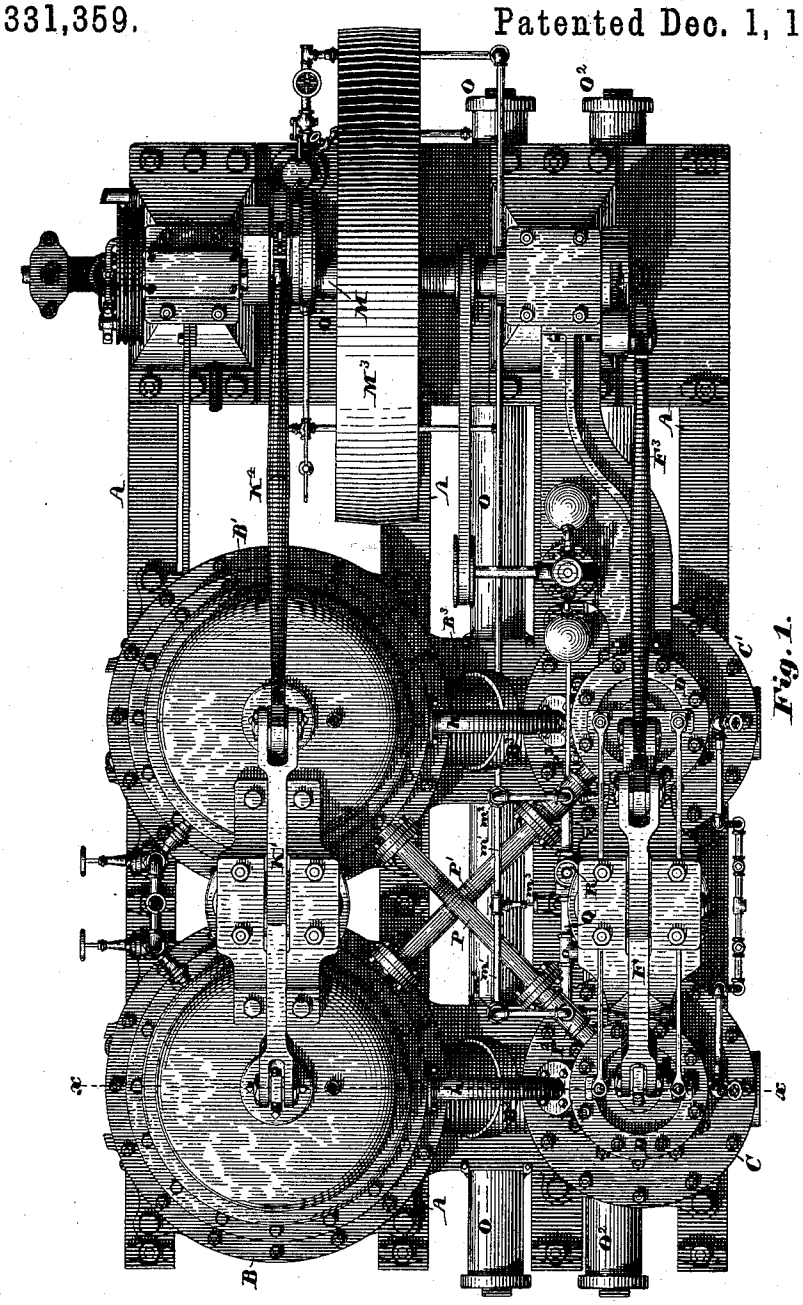


Fig. 1.

Witnesses:

Walter E. Lombard.

Frank E. Gray.

Inventors:

James A. Woodbury,
Joshua Merrill,
George Patten,
Edward F. Woodbury,

by W. E. Lombard Attorney.

(No Model.) 4 Sheets—Sheet 2.

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

AIR ENGINE.

No. 331,359. Patented Dec. 1, 1885.

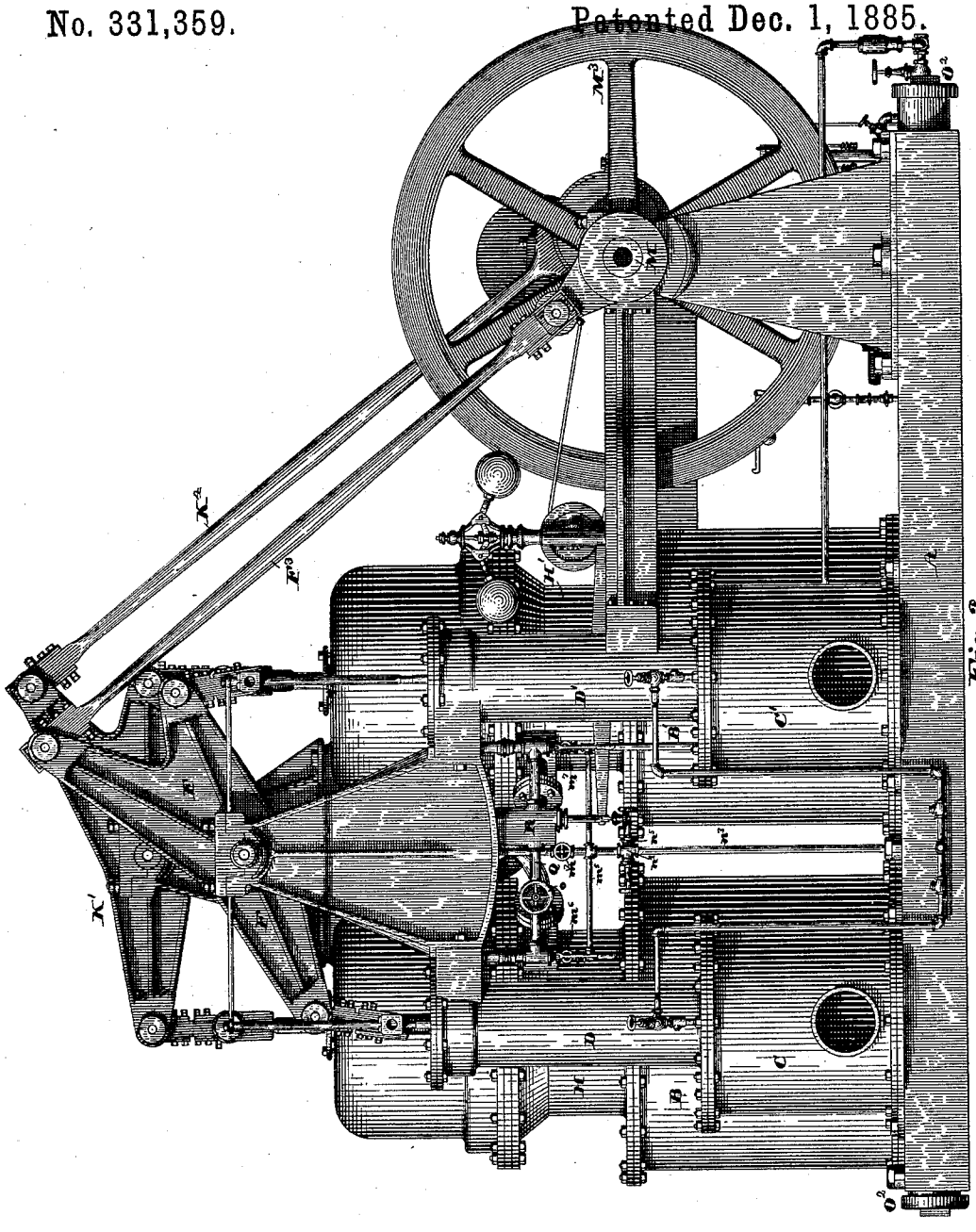


Fig. 2.

Witnesses:
Walter E. Lombard.
Frank E. Gray.

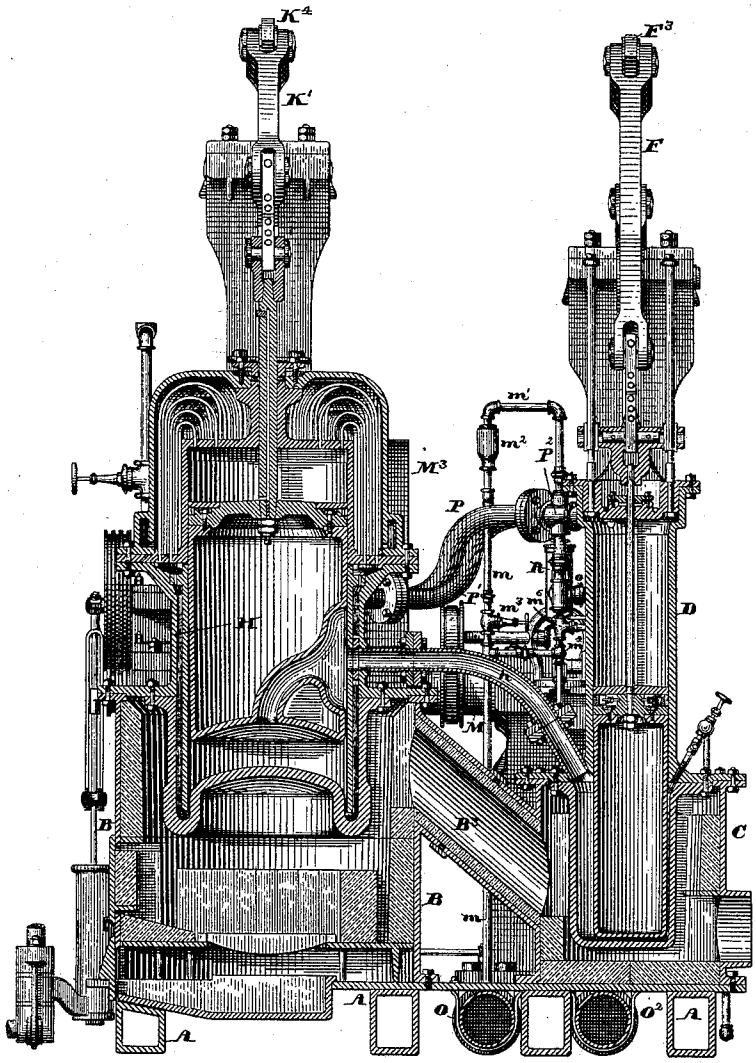
Inventors:
James A. Woodbury,
Joshua Merrill,
George Patten,
Edward F. Woodbury,
by N. C. Lombard Attorney.

(No Model.) 4 Sheets—Sheet 3.

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

AIR ENGINE.

No. 331,359. Patented Dec. 1, 1885.



Witnesses:
Walter E. Lombard.
Frank E. Gray.

Fig. 3.

Inventors:
James A. Woodbury,
Joshua Merrill,
George Patten,
Edward F. Woodbury,
by N. C. Lombard Attorney.

(No Model.) 4 Sheets—Sheet 4.

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

AIR ENGINE.

No. 331,359. Patented Dec. 1, 1885.

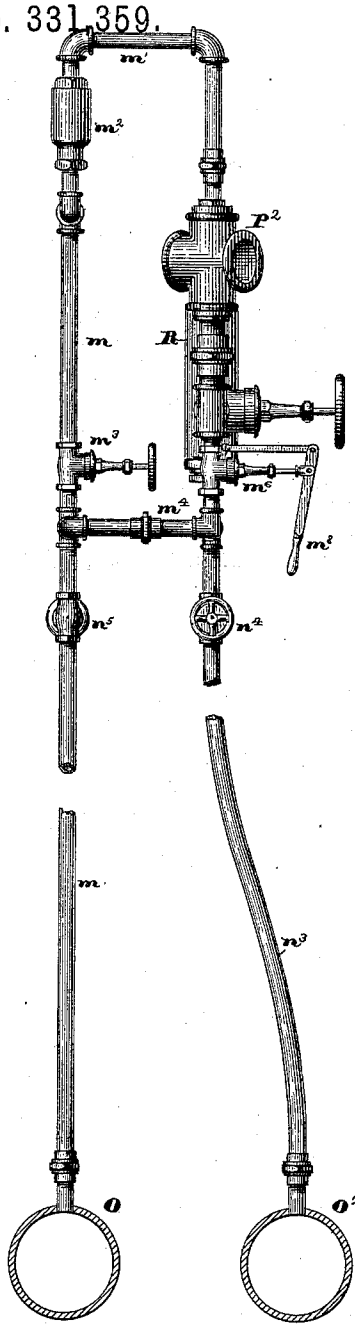


Fig. 5.

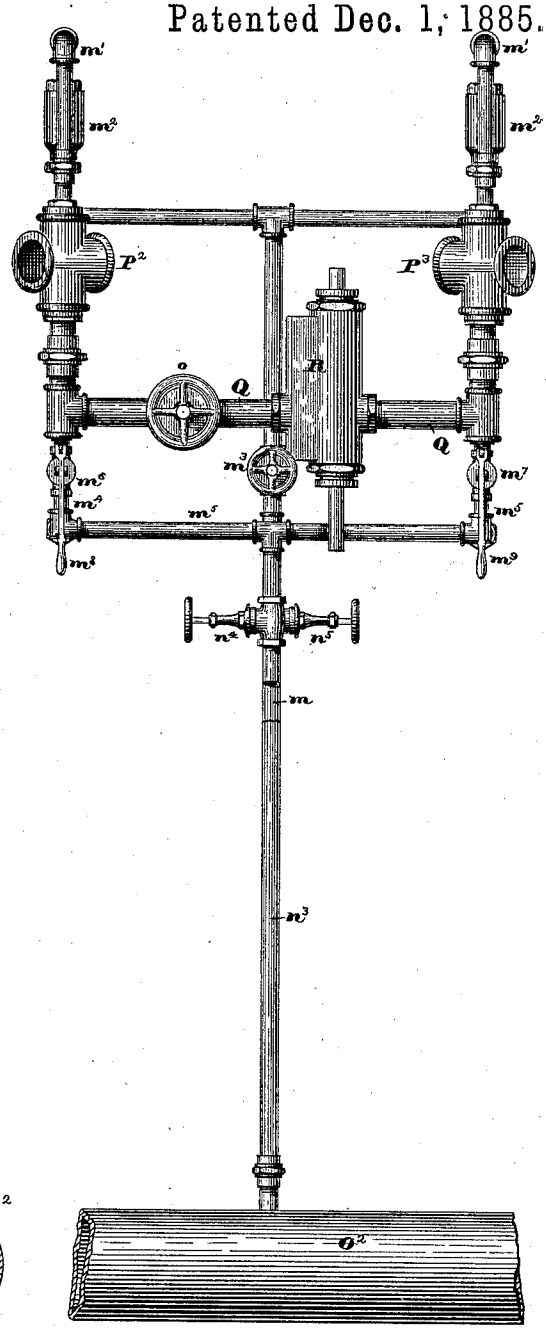


Fig. 4.

Witnesses:
Walter E. Lombard
Frank O. Gray.

Inventors:
James A. Woodbury,
Joshua Merrill,
George Patten,
Edward F. Woodbury,
by N. C. Lombard Attorney.

UNITED STATES PATENT OFFICE.

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

AIR-ENGINE.

SPECIFICATION forming part of Letters Patent No. 331,359, dated December 1, 1885.

Application filed April 13, 1885. Serial No. 162,038. (No model.)

To all whom it may concern:

Be it known that we, JAMES A. WOODBURY, of Winchester, in the county of Middlesex, and JOSHUA MERRILL, GEORGE PATTEN, and EDWARD F. WOODBURY, of Boston, in the county of Suffolk, and all of the State of Massachusetts, have invented jointly 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 air-engines, and especially to the means employed to start said engines from a state of rest; and it consists in certain novel arrangements and combinations of parts, which will be best understood by reference to the description of the drawings, and to the claims hereinafter given.

Figure 1 is the plan of an engine embodying our invention. Fig. 2 is a side elevation of the same. Fig. 3 is a sectional elevation of the same, the cutting plane being on line *x x* on Fig. 1. Fig. 4 is a front elevation of the pipes and valves connecting the reservoir or reservoirs with the cylinders; and Fig. 5 is an elevation of the same pipes and valves as viewed at right angles to Fig. 4, and showing the reservoir in transverse section.

In the drawings, A is the bed of the engine, B B′ the furnaces, C C′ the heating-chambers beneath the working-cylinders D and D′, respectively, and H and H′ are the regenerator-cylinders, all constructed and arranged and connected by pipes B^3, B^3, *h*, *h*, P, and P′, in precisely the same manner as described in another application of ours of even date herewith.

F and K′ are the walking-beams connected, respectively, to the reverser-pistons and the working-pistons by suitable piston-rods and links or connecting-rods, and by the connecting-rods F^3 and K'' to the cranks of the shaft M, carrying the fly-wheel M^3; and O is a cylindrical reservoir for containing air under pressure, and connected by suitable pipes and check-valves with an air-pump and with the cylinder, substantially as described in said other application.

Heretofore, so far as our knowledge extends, air-engines have been set in motion, after a suitable fire had been built beneath the piston or heater, by the operator turning the fly-wheel and its shaft about its axis or operating a side lever for moving the displacer-piston by hand. This may answer very well for small engines, but for large engines would be impractical, because of the power that would be required to revolve the fly-wheel in large engines. To obviate this difficulty is the object of our present invention, and to this end we avail ourselves of the pressure of air contained in the reservoir O or a second reservoir, O^2, to start the engine, by connecting said reservoir with the chambers above and below the several pistons, and providing a valve or valves for controlling and directing the flow of said compressed air into said cylinders, as will now be described. A reservoir, O, an air-pump, O′, pipes connecting said pump and reservoir and said reservoir with the interiors of the several cylinders, and devices for regulating the pressure within said reservoir, as well as a by-pass pipe, a piston-valve in said pipe, and a governor connected with and adapted to operate said valve to regulate the speed of the engine, are all constructed and arranged in the same manner as shown and described in another application of even date herewith.

In Figs. 4 and 5 of the drawings the reservoir O is connected with the cylinders of the engine for the purpose of supplying compressed air thereto for running the engine after it is once set in operation by means of the pipes *m* and *m′* and the four-way or + pipes P^2 and P^3, which form portions of the pipes P and P′, which connect the displacer and working-cylinders, as shown in Figs. 1 and 3.

Q is the by-pass pipe, connected at each end to the lower side of the four branch pipes P^2 and P^3, and provided with the stop-valve *o* and the regulating-valve R, all arranged as shown and adapted to operate substantially as described in our other application before cited.

The pipe *m* is provided with the stop-valve m^3, and the pipes *m′ m′* are each provided with a check-valve, m^2, all arranged and adapted to operate as described in said other application.

In order to render the compressed air in the reservoir O available for starting the engine, we connect the pipe *m* through the pipes m^4 and m^5 and the valves m^6 and m^7 with the by-

pass pipe Q at each end thereof, and through the vertical portions thereof with the four-way branches P^2 and P^3, as shown in Figs. 4 and 5.

The valves m^6 and m^7 are constructed and arranged so as to be easily operated by means of the hand-levers m^8 and m^9. (Shown in Figs. 4 and 5.)

The operation of starting the engine is as follows: A suitable fire having been built in each of the furnaces B and B', and allowed to burn till the air in the lower ends of the cylinders has become sufficiently heated, and the valve m^3 being closed, the operator grasps the hand-levers m^8 and m^9, one in each hand, and opens and closes the valves m^6 and m^7 alternately, so as to admit compressed air to the cylinders from the reservoir O first upon one side of the pistons and then upon the other, the alternate movements of said valves being timed by the movements of the pistons, as indicated by the positions of the walking-beam. When the fly-wheel has made a half-revolution or more, the valves m^6 and m^7 are closed and the valve m^3 is opened, when the engine will continue in operation so long as the fire is kept up, unless stopped by opening the valve R or by opening both of the valves m^6 and m^7 at the same instant, which will stop the engine by equalizing the pressure within the cylinders.

In the case of very large engines it is thought best to employ a separate reservoir, O^2, for starting the engine, the pressure in which will not be affected by the draft of air for running the engine. When this is done, the reservoir O^2 is connected by the pipe n^3 with the pipe m^5, and a stop-valve, n^4, is inserted in said pipe n^3 and an additional stop-valve, n^5, is inserted in the pipe m, all as shown in Figs. 4 and 5.

When it is desired to pump up the pressure in the reservoirs O and O^2, the valve m^3 is closed and the valves n^4 and n^5 are opened, and the air-pump is set in motion to force air into the reservoirs O and O^2 until the desired pressure is obtained, when the valve n^4 is closed and the valve m^3 is opened, thus placing the reservoir O in communication with the interiors of the cylinders, so that air will flow into said cylinders whenever the pressure in said cylinders falls below that in the reservoir O; but the pressure in the reservoir O^2 is not affected thereby, but is reserved for use in starting the engine the next time that it is to be started up after being stopped.

When the engine is stopped at night, the pressure in the cylinders is blown out through the blown-off cocks or valves w', as described in our other cited application. When it is desired to start the engine again, the valve n^5 is closed and the valve n^4 is opened, and then the valves m^6 and m^7 are manipulated by the hand-levers m^8 and m^9, as before described.

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

1. The method of starting air-engines in which the same body of air is used over and over without exhausting, which consists in alternately admitting air contained in a reservoir under pressure to opposite sides of the working-piston, as set forth.

2. In combination with the displacer and working-cylinders of an air-engine and their pistons, a reservoir constructed and arranged to contain air under pressure, pipes leading therefrom to and communicating with said cylinders upon opposite sides of said pistons, and a pair of valves in said pipes constructed and arranged to be operated by hand-levers to admit air under pressure first to one side of said pistons and then to the other, substantially as described.

3. In combination with the displacer and working-cylinders of an air-engine and their pistons, two reservoirs constructed and arranged to contain air under pressure, pipes connecting said reservoirs, valves in said connecting-pipes for opening or closing communication between them, pipes connecting each of said reservoirs with the interiors of said cylinders, and a pair of valves provided with hand-levers and arranged to be operated to control the admission of the air from one of said reservoirs alternately to opposite sides of said pistons, substantially as described.

In testimony whereof we have signed our names to this specification, in the presence of two subscribing witnesses, on this 27th day of March, A. D. 1885.

JAMES A. WOODBURY.
JOSHUA MERRILL.
GEORGE PATTEN.
EDWARD F. WOODBURY.

Witnesses:
WALTER E. LOMBARD,
FRANK E. BRAY.