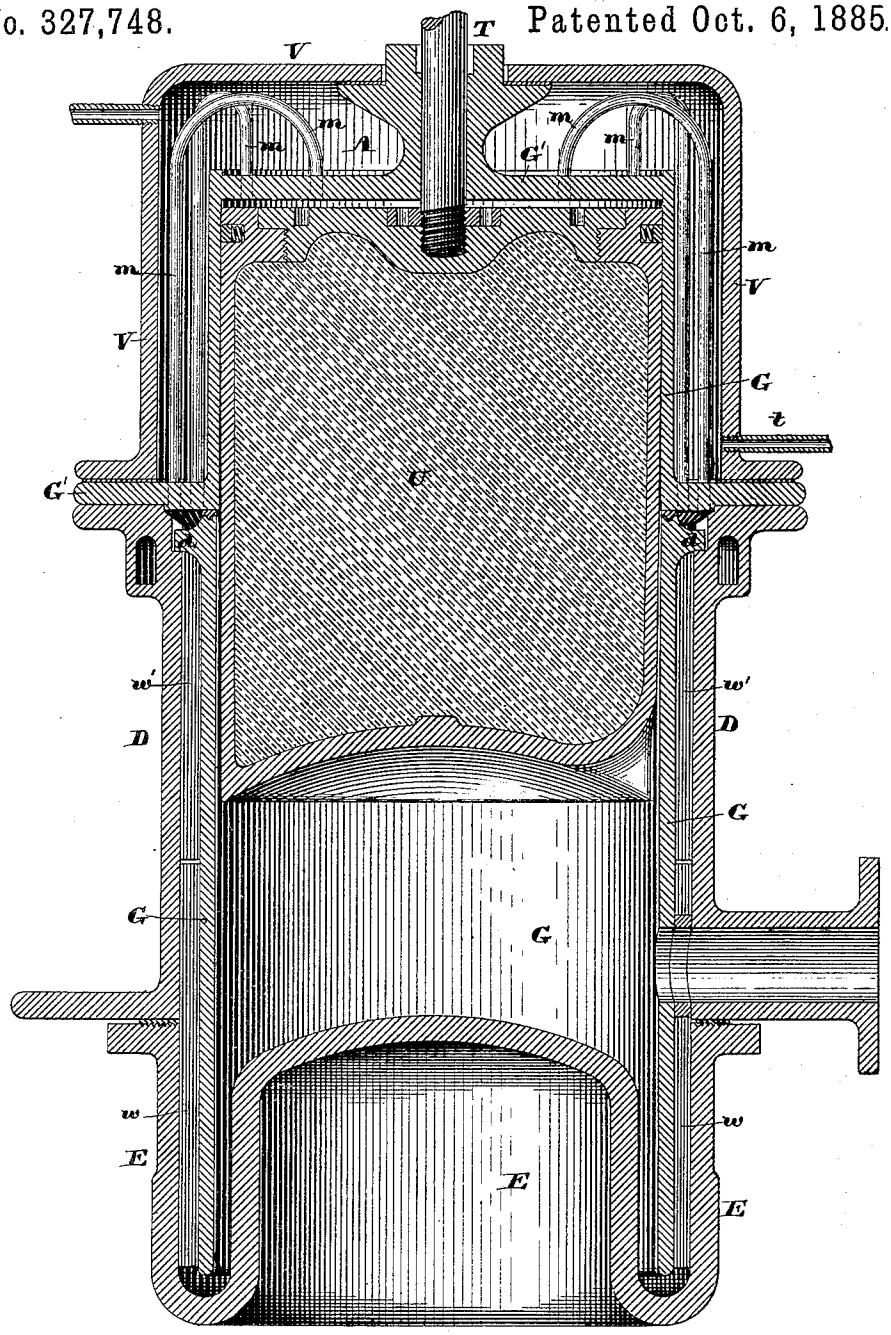
(No Model.)

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

HOT AIR ENGINE.

No. 327,748. Patented Oct. 6, 1885.



Witnesses:
Walter E. Lombard
William H. Parry

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

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

UNITED STATES PATENT OFFICE.

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

HOT-AIR ENGINE.

SPECIFICATION forming part of Letters Patent No. 327,748, dated October 6, 1885.

Application filed January 23, 1885. Serial No. 153,777. (No model.)

To all whom it may concern:

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

Our invention relates to air-engines, and particularly to that class of such engines in which air of greater density than common air is used and is alternately heated and cooled over and over again without exhausting the same; and it consists in a novel construction, arrangement, and combination of the several parts which constitute the heater, regenerator, and cooler, which will be readily understood by reference to the description of the drawings, and to the claims, to be hereinafter given.

The accompanying drawing represents a central vertical section through the reverser-cylinder, the heater, the cooler, and the regenerator of an air-engine embodying our invention.

In the drawing, D is a short cylinder, which is bolted to and supported by the furnace-casing, (not shown,) as described in another application of ours filed June 7, 1881, No. 35,137, of which this is a division. To the lower flange of the cylinder D is bolted the annular heater E, which extends downward therefrom into the combustion-chamber. (Not shown.)

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 interior diameter of the cylinder D and the outer wall of the heater E, 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, closed at its upper end, and provided with an upwardly-projecting central hub through a suitable opening, in which works the piston-rod T, to the lower end of which is attached the piston U, the upper end of which is provided with a packing-ring arranged to work air-tight in the cylinder G′.

V is the outer casing of the cooling-chamber provided with a base-flange which rests upon the flange of the cylinder G′ and is bolted with it to the upper end of the cylinder D, said casing being made in the form of an inverted cup, with a small hole in the center of its upper end, through which the central hub of the cylinder G′ projects, said casing V being firmly secured to said hub with a packed joint, thereby forming a cooling-chamber, A, which surrounds and incloses the periphery of the reverser-cylinder G′, within which the packing-ring of the piston U works, and the whole upper end of said cylinder G′ except the small area occupied by the central hub which forms the bearing of the piston-rod T.

Two circular rows or series of thin copper pipes, *m m*, are arranged in the cooling-chamber A, the lower ends of which are inserted through the flange of the reverser-cylinder G, and their upper ends have formed therein semicircular bands and are inserted through openings in the upper end or head of said cylinder G′ so as to open into the interior of the reverser-cylinder directly above the upper end of the piston U, as shown.

In consequence of our arrangement of the cooling-chamber surrounding the periphery of that portion of the reverser-cylinder which is above the piston U when it is in its lowest position, and nearly the entire upper end of said cylinder, we obtain a greatly-increased area of cooling-surface upon the cylinder G′ itself, and we are also enabled to very largely increase the area of pipe-cooling surface by inserting more pipes than can be used when the cooling-chamber does not cover the upper end of the reverser-cylinder.

This is a very important feature of our invention, as the effectiveness of an air-engine depends almost entirely upon the rapidity

with which the air can be alternately heated and cooled; and it has been demonstrated that while there is comparatively little trouble experienced in heating the air so long as the heater lasts or does not burn out, great difficulties have been experienced in cooling the air with sufficient rapidity, which difficulties we claim to have overcome by the construction of the cooler here shown and described.

Another very important factor in an air-engine, as an aid in the rapid heating and cooling of the air, is the regenerator, a passage through which the air passes from the heater to the cooling-chamber, and vice versa, and when the hot air gives off a considerable percentage of its heat in passing from the heating-chamber to the cooling-chamber and takes it up again as it passes to the heating-chamber again after having been cooled in the cooling-chamber.

It has been demonstrated by actual experiment that copper plates in the regenerator are the most effective in extracting heat from and giving it off to the air passing through said regenerator; but we have also found by practical test that copper will not withstand the corroding or disintegrating action of grate heat as well as iron, and hence we divide our regenerator-plates circumferentially into two sections, and make those plates *w* in the lower section or nearest to the fire of iron, and those in the upper section of copper. By this means we obtain the most effective result consistent with durability.

The upper end of the cylinder D is counter bored to form therein an expansion of its inner periphery sufficient to allow both rows of the pipes *m m* to open into and communicate with the regenerator-chamber, as shown.

The water for cooling the air enters the cooling-chamber through the pipe *l'*, and after traversing the cooling-chamber is discharged therefrom through the pipe. (Shown near the upper left-hand corner of the casing V.)

The cooler herein described and claimed is shown and described but not claimed in the Letters Patent Nos. 289,484 and 289,485, granted to us December 4, 1883, the applications for which were filed May 16, 1883, and all of the features shown, described, and claimed in this application originally formed a part of an application of ours filed June 7, 1881, No. 35,137, of which this application is a division.

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

1. In an air-engine provided with an annular regenerator-chamber surrounding and inclosing the reverser-cylinder and extending to or into the heater, two sets of regenerator-plates in said regenerator-chamber, the lower set made of iron and the upper set made of copper, substantially as and for the purposes described.

2. In an air-engine, a cooler-chamber surrounding and inclosing the periphery of that portion of the reverser-cylinder in which the packing of the reverser-piston works and the whole upper end of said reverser-cylinder except a central hub for a guide for the reverser piston-rod, substantially as described.

3. The combination of the reverser-cylinder G', the water-chamber A, surrounding and inclosing the periphery and upper end of said cylinder, and two rows of bent pipes, *m m*, having their lower ends inserted through the flange of the cylinder G' and their upper ends inserted through the head of said cylinder, substantially as described.

In testimony whereof we have signed our names to this specification, in the presence of two subscribing witnesses, on this 13th day of January, A. D. 1885.

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

Witnesses:
N. C. LOMBARD,
WALTER E. LOMBARD.