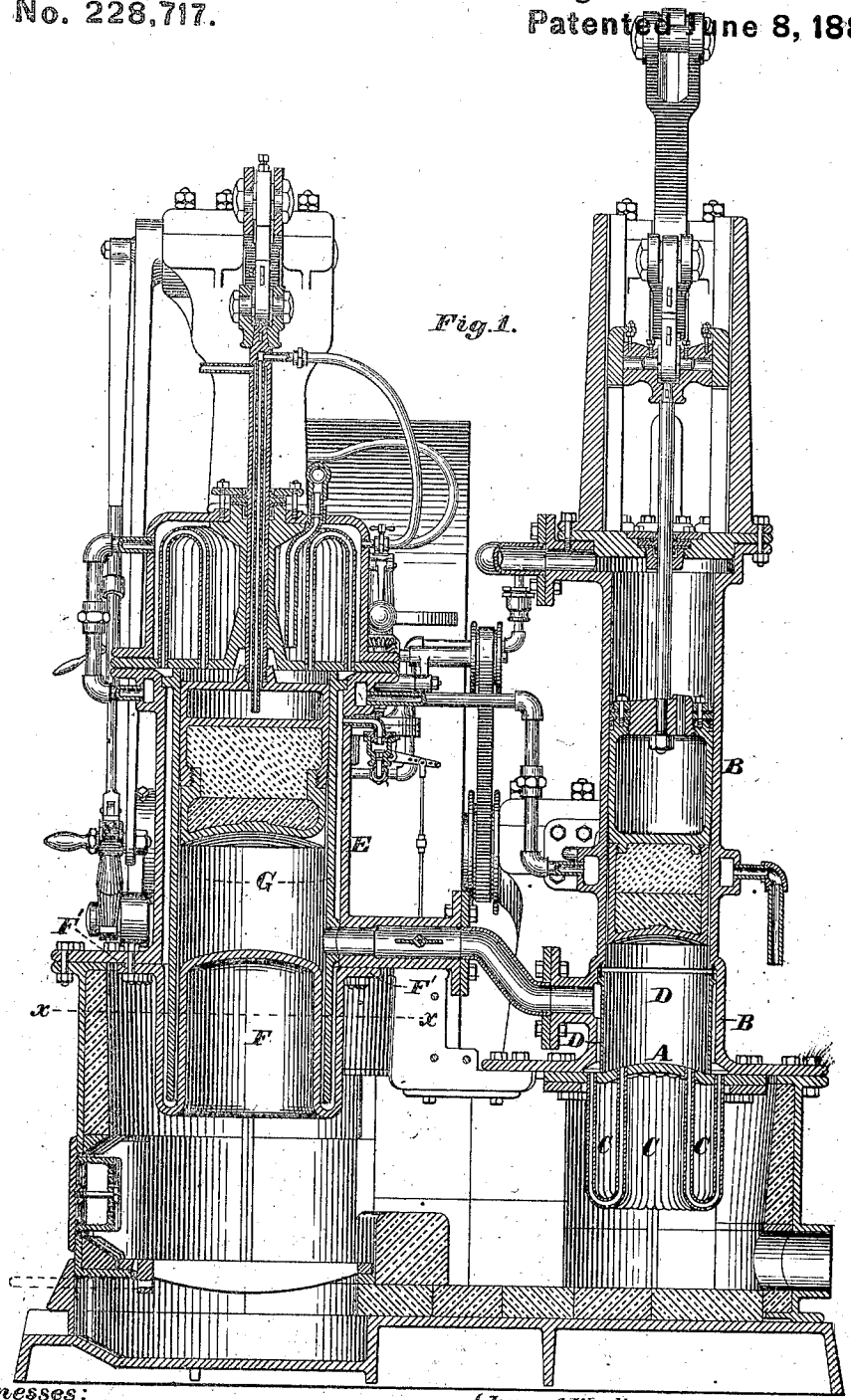
(No Model.) 2 Sheets—Sheet 1

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

Heaters for Air-Engines.

No. 228,717. Patented June 8, 1880.

Fig. 1.



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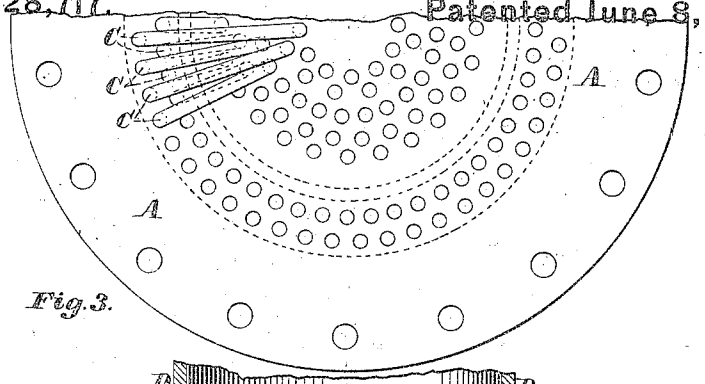

Fig. 3.

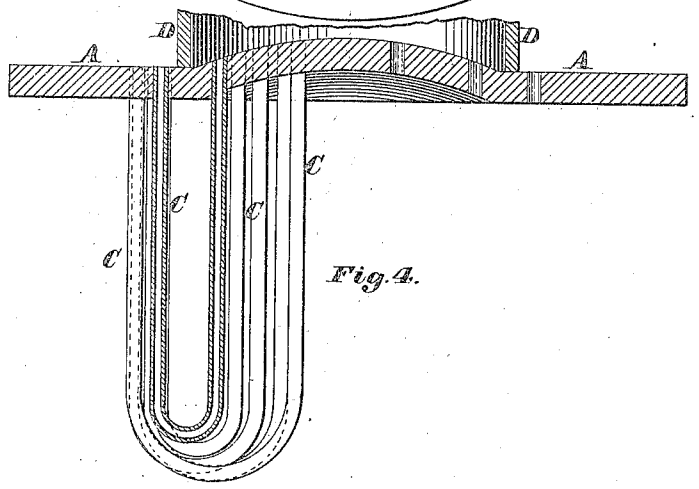

Fig. 4.

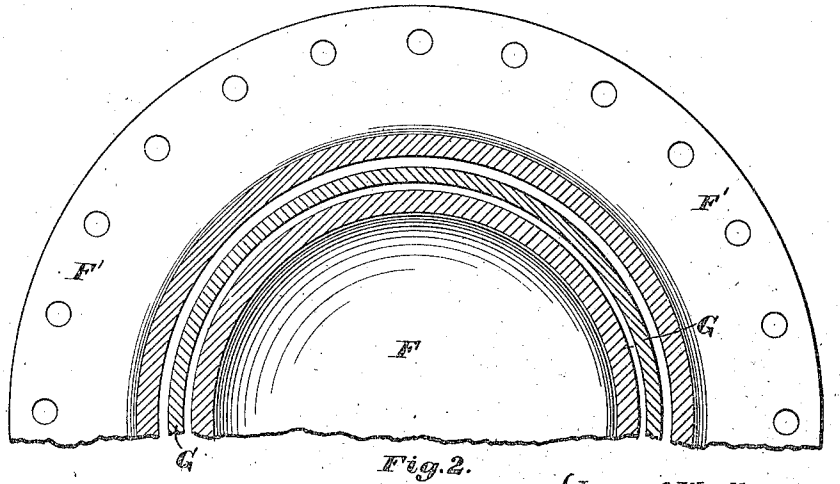

Fig. 2.

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UNITED STATES PATENT OFFICE.

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

HEATER FOR AIR-ENGINES.

SPECIFICATION forming part of Letters Patent No. 228,717, dated June 8, 1880.

Application filed May 5, 1880. (No model.)

To all whom it may concern:

Be it known that we, JAMES A. WOODBURY, JOSHUA MERRILL, GEO. 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 Heaters for Air-Engines, of which the following, taken in connection with the accompanying drawings, is a specification.

Our invention relates to the construction of heaters for air-engines, and has for its object the production of heaters that are much better adapted to resist the destructive effects of the heat to which they are subjected than the heaters heretofore in use, and at the same time be comparatively non-corrosive; and it consists, first, in a tubular heater the tubes of which are made of nickel.

It further consists in a tubular heater for air-engines the tubes of which are composed of a mixture of nickel with other metals, whereby such other metals are rendered comparatively non-corrosive and capable of resisting the injurious effects of high heats.

It further consists in constructing the heater of an air-engine of a composition of cast-iron and nickel united while in a fused state.

It further consists in combining nickel with cast-iron while in a fused state.

It further consists in a tubular heater for air-engines having its head made of a composition of nickel and cast-iron and its tubes made of nickel or a mixture of nickel with iron, steel, or copper, whereby the heater is rendered comparatively non-destructible and capable of having its several parts united by brazing.

Figure 1 of the drawings is a vertical section of an air-engine illustrating the formation and arrangement of our improved heater. Fig. 2 is a transverse section of the heater of the reverser, the cutting-plane being on line *x x* on Fig. 1, looking upward. Fig. 3 is a partial inverted plan of the heater of a working-cylinder; and Fig. 4 is a central vertical section of same, showing only one each of the different-formed tubes. Figs. 2, 3, and 4 are drawn to scale one-fourth full size.

The engine shown in Fig. 1 is of substantially the same construction, except as to the heaters, as that described in another application filed in the Patent Office by the present applicants December 31, 1879, and as the present invention relates only to the heaters, the other parts of the engine need not be described in this specification in detail.

In Figs. 3 and 4, A is the lower cylinder-head of the working-cylinder B, to which it is bolted from the under side, said head being cast from a metal composed largely of iron, with which is mixed a small percentage of nickel, which may be varied considerably, according to the quality of the work required, ranging from three to thirty per cent., though we prefer a mixture of about twenty-five per cent. of nickel to seventy-five per cent. of iron.

C C are a series of U-shaped tubes, having both ends set in the head A in such a position that one end opens into the interior of the inner cylinder or lining, D, of the working-cylinder, and the other end opens into the space between said lining and the cylinder B.

In some instances we make the tubes C C of pure nickel, and in cheaper engines we make them of a mixture of nickel with other metals, which other metals predominate in about the proportions above described, and said tubes are firmly secured in the head A by brazing, which is rendered possible by combining nickel with the cast-iron by fusion, as above described.

Another form of heater is shown in vertical section in Fig. 1 as applied to the lower end of the reverser-cylinder E, composed of a double-walled cylindrical casting, F, provided with a flange, F′, by which it is bolted to the cylinder E, its double walls forming between them an annular chamber closed at its lower end and open at its upper end, into which the lower end of the inner reverser-cylinder, G, located within and concentric with the reverser-cylinder E, projects, as shown in Fig. 1.

The heater F is composed of cast-iron containing a percentage of nickel, as heretofore described, by which it is rendered comparatively non-destructible by the action of high heats, such as it is liable to be subjected to in air-engines, and also non-corrosive.

Heretofore serious difficulties have been encountered in operating air-engines success-

fully on account of the destructibility of the heaters, occasioned by the high heats to which they are necessarily subjected, and the fact that a continuous circulation of air takes place over the inner surface of the heaters while the hot gaseous products of combustion are constantly acting upon their exterior surfaces.

Iron, steel, and copper, of which heaters for air-engines have heretofore been constructed, when subjected to the action of high heats under the conditions above set forth, oxidize very rapidly, the oxide flakes off so as to present a fresh metallic surface to the action of the hot air and gaseous products of combustion, a new coating of oxide is formed, which in turn flakes off, and so the process of oxidation continues until the heater is destroyed or rendered useless for the purposes for which it was designed.

In order to overcome these difficulties we have entered into a series of practical tests with the view of discovering, if possible, a material from which heaters could be constructed that would withstand the destructive effects of high heats applied thereto, as before described.

Our first test in this direction was the construction of a heater of ordinary material plated with nickel, in doing which we found that the nickel could not be deposited evenly over the whole exterior of the heater, and little or none upon the interior of the tubes, and the result of a practical trial of it was, that oxidation commenced at once upon the inside of the tube, and in a very short time the plating upon the exterior of the tubes flaked off, when of course the heater was practically no better than if it had not been plated.

Our next test was with nickel, which, after a long exposure to a high heat, showed no appreciable waste, and although a very thin coating of oxide was found upon its surface it did not flake off, but remained upon the surface, and thus protected the metal from further oxidation.

We then tested mixtures of nickel and copper and nickel and iron in various proportions, all of which we found would resist the corrosive or destructive effects of the hot gases much better than iron or copper alone; but the most satisfactory result was obtained with a mixture of twenty-five per cent. nickel and seventy-five per cent. cast-iron, this test showing just about the same amount of oxidation as in the case of the test with nickel alone, the oxide remaining upon the surface of the metal and protecting it from further oxidation, as in the case of the nickel test, and the metal showed no appreciable waste or depreciation, while cast-iron alone subjected to the same test showed a depreciation of twenty-five per cent., and copper and wrought-iron under the same test each depreciated more than fifty per cent.

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

1. In an air-engine, a tubular heater the tubes of which are made of nickel, substantially as and for the purpose described.

2. In an air-engine, a tubular heater the tubes of which are composed of a mixture of nickel with other metals, substantially as and for the purposes described.

3. In an air-engine, a heater composed of cast-iron and nickel fused together, substantially as and for the purposes described.

4. In an air-engine, a heater made of nickel or a mixture of nickel with other metals, substantially as described.

5. In an air-engine, a tubular heater having its head cast from a metal composed of iron and nickel fused together and its tubes made from nickel or a mixture of nickel with other metals, substantially as and for the purposes described.

6. In an air-engine, the combination of the annular heater F, bolted to the lower end of the reverser-cylinder E, and the inner reverser-cylinder, G, extending from the under side of the cooler, secured to the upper end of the reverser-cylinder E, nearly to the bottom of the annular chamber in said heater, substantially as described.

Executed at Boston, Massachusetts, this 3d day of May, A. D. 1880.

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GEORGE PATTEN.
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