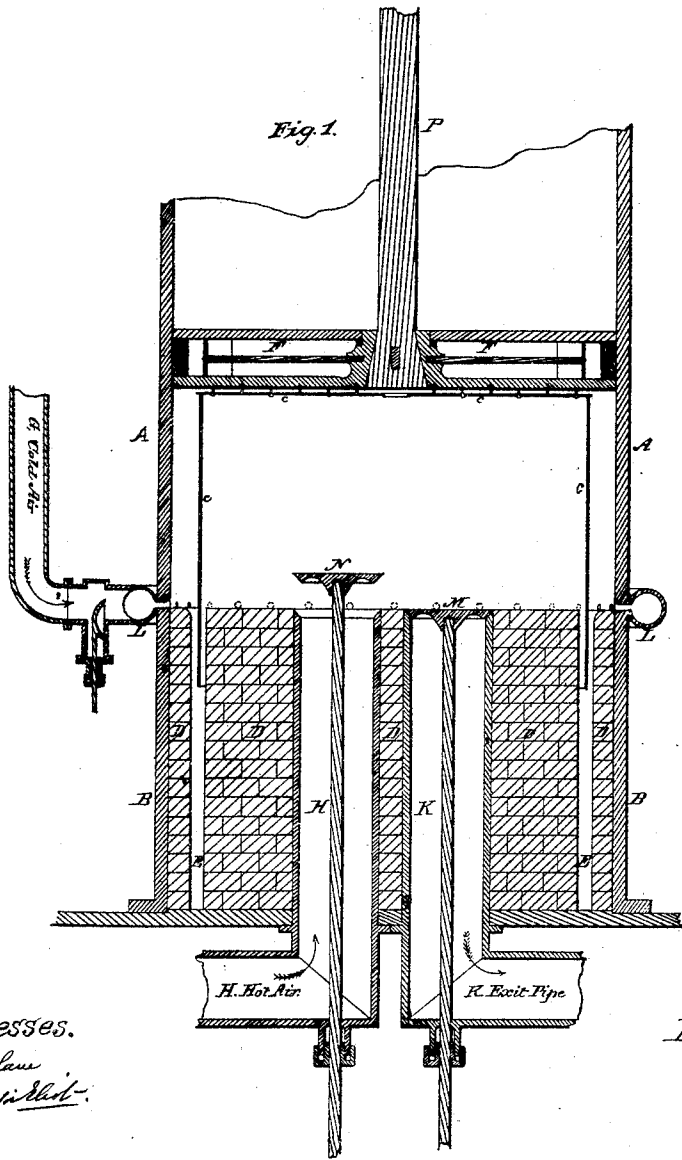


B. F. CRAIG.  
HOT AIR ENGINE.

No. 26,837.

Patented Jan. 17, 1860.



*Witnesses.*  
*J. H. Lane*  
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*Inventor.*  
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# UNITED STATES PATENT OFFICE.

BENJAMIN F. CRAIG, OF WASHINGTON, DISTRICT OF COLUMBIA.

## HOT-AIR ENGINE.

Specification of Letters Patent No. 26,837, dated January 17, 1860.

*To all whom it may concern:*

Be it known that I, BENJAMIN FANEUIL CRAIG, of Washington, in the District of Columbia, have invented a new and Improved Method of Using Heated Air as a Motive Power; and I do hereby declare that the following is a full and exact description thereof, reference being had to the accompanying drawings and to the letters of reference marked thereon.

My improvement consists in communicating motion to the piston of a hot air engine by means of two separate currents of compressed air or other gaseous matter: the said currents having different temperatures. The improvement is particularly designed for those forms of engine in which air, after being compressed by an air pump, is highly heated, and then by its elastic pressure made to give motion to a piston. The objections heretofore found to such engines, arise from the injurious effects of the contact of hot air with the sides of the cylinder, and with other working parts, and to obviate these objections, I provide means for preventing such contact; and this I do by causing a current of cooler air or of other gas or vapor or of a liquid convertible into vapor to enter the cylinder by a different passage from that traversed by the hot air, and to circulate in contact with the parts which it is designed to protect.

The form of hot air engine to which my improvement is especially applicable, is that which has most commonly been proposed as a means of using heated air as a motive agent, and which consists of three distinct parts (viz.) 1st An air pump, or condensing apparatus, by which air is subjected to compression, as a preliminary to the process of heating it. 2d A vessel or chamber in which the compressed air is heated, either by means of a metallic heating surface, or by being brought into direct contact with fuel that is made to burn in an air tight chamber. 3rd A working part consisting of one or more cylinders. It can easily be understood that in such an engine the air must pass from the compressing pump into the heating chamber; and from thence, after being heated and consequently augmented in bulk, into the working cylinder, where it acts on a piston of greater diameter than the piston of the compressing pump. It is evident, upon considering the mode of working of such an engine, that the actual tension or working

pressure of the hot air will be due, rather to the compression given to it before being heated, than to the effect of the heat: the air being allowed to expand and to enter the working cylinder without change of pressure, so that the bulk of the air is increased by the heat, but not its tension.

Physical investigations have shown that the employment of high temperature and pressure is necessary to the economical working of a hot air engine, but to the employment of a high temperature an objection lies in the injurious effect of great heat upon rubbing and lubricated surfaces, and the efforts of inventors have been directed to this as the great and almost the only difficulty in the way of the substitution of hot air engines for steam engines. The means heretofore used to meet this objection consist in making the piston work in a part of the cylinder to which the hot air has not free access, and in interposing between the working piston and the hot air some protecting body, either in the form of an appendage to the piston, as in Cayley's patent of 1837, or as a separate piston as in Ericsson's more recent patents. A jacket of cold water has also been employed to keep that part of the cylinder in which the piston moves cool.

The means which I propose for attaining the desired end differ from the foregoing and may be used in addition to them. I cause the air from the compressing pump to reach the working cylinder by two routes; that which comes by one route being heated in its passage, while that which comes by the other remains cool: to effect this, in addition to the usual passage from the compressing pump to the heating chamber, and thence to the cylinder, a separate pipe is used which leads from the pump directly to the cylinder: the termination of this pipe is shown attached to the cylinder in the drawing and model accompanying this specification. The cooler air, as will be seen, enters the cylinder outside of the hotter, and is thus made to envelop it; and, to prevent a premature mixing of the two currents, an arrangement of the cylinder and piston such as that described further on or some equivalent of it is adopted.

My improvement is also meant to meet the difficulty which arises in that form of engine in which the compressed air is passed through a fire, and the products of combustion used as a motive agent: such, for example, as the

engines of Cayley and of Bennett. The difficulty alluded to arises from the dust, which is carried along with the gaseous products of combustion, and proves as destructive to the cylinder as the high temperature. The arrangement described in this specification will be seen to be a protection against both causes of destruction.

To enable others to make and use my invention I will proceed to describe it by reference to the accompanying drawings.

A A B B is a cylinder of which the upper part A A is of the usual construction, but the lower part B B is lined and partly filled with brick, fireclay, or other suitable material. In this filling there are three cavities: 1st H, a tube for the entrance of hot and compressed air; 2d K, a similar tube for the exit of the air after its expansion or performance of work by raising the piston; 3rd E, a narrow circular hollow space or annulus close to the outer wall of the cylinder.

The piston head F F has attached to it a cup c c c c, which I prefer to make of thin sheets of metal and single or double according to the size of the cylinder, the total thickness of the cup being such as just to allow it to move without friction in the annular space E into which it is meant to be received. The connection of this cup with the lower face of the piston head is by means of short and narrow rods, sections of which are shown in the drawing, or by thin plates of metal or other methods by which a moderately firm attachment can be secured without preventing the passage of air between the cup and the piston head. In the center of the base of the cup there is a small opening.

At L is shown a pipe which surrounds the cylinder at the junction of the parts A A and B B: this pipe opens into the cylinder by numerous small apertures, and its purpose is to convey cold air, which it receives from the compressing pump of the engine through the pipe G, to that part of the cylinder which is exterior to the cup c c c c.

The working of the engine is as follows. The valve N being open and the valve M closed hot air from a suitable reservoir of

compressed and heated air enters through H and by its expansive force raises the piston, and at the same time cold air from a condensing pump enters through L at an equal or at a somewhat greater pressure, fills that space in the cylinder which is exterior to the cup c c c c, and assists in raising the piston: while this is taking place there will be some mixing of the two bodies of air under the edges of the cup and through the hole in its base. The valve N and also the valve through which the pipe L receives air in a state of compression are now closed, and when the up stroke of the piston is completed by the expansion of the air already in the cylinder the valve M is opened, and the piston descends, driving out the exhausted air through K.

If sufficient heat still remains in this exhausted air it may be used to generate steam, which steam, after having acquired a suitable pressure, may be allowed to pass into the pipe L, where it may replace wholly or in part the compressed air which has been described as passing through that pipe.

I do not confine myself to a particular form of cylinder and piston, but may use certain others in which the parts have their relative position somewhat changed and in which certain appliances are introduced to meet such changes; but in general I prefer the form shown in the drawing.

What I claim as my invention and desire to secure by Letters Patent is—

The introduction into the cylinder of a hot air engine of two separate bodies or currents of gaseous matter one of which is much cooler than the other, and the hotter of which is controlled and limited by the action of the cooler and by the form and arrangement of the piston and cylinder to such an extent as that it does not come into contact with those working parts which its heat would injure: substantially as above described.

BENJAMIN F. CRAIG.

Witnesses:

J. H. LANE,  
JOHNSON ELIOT.