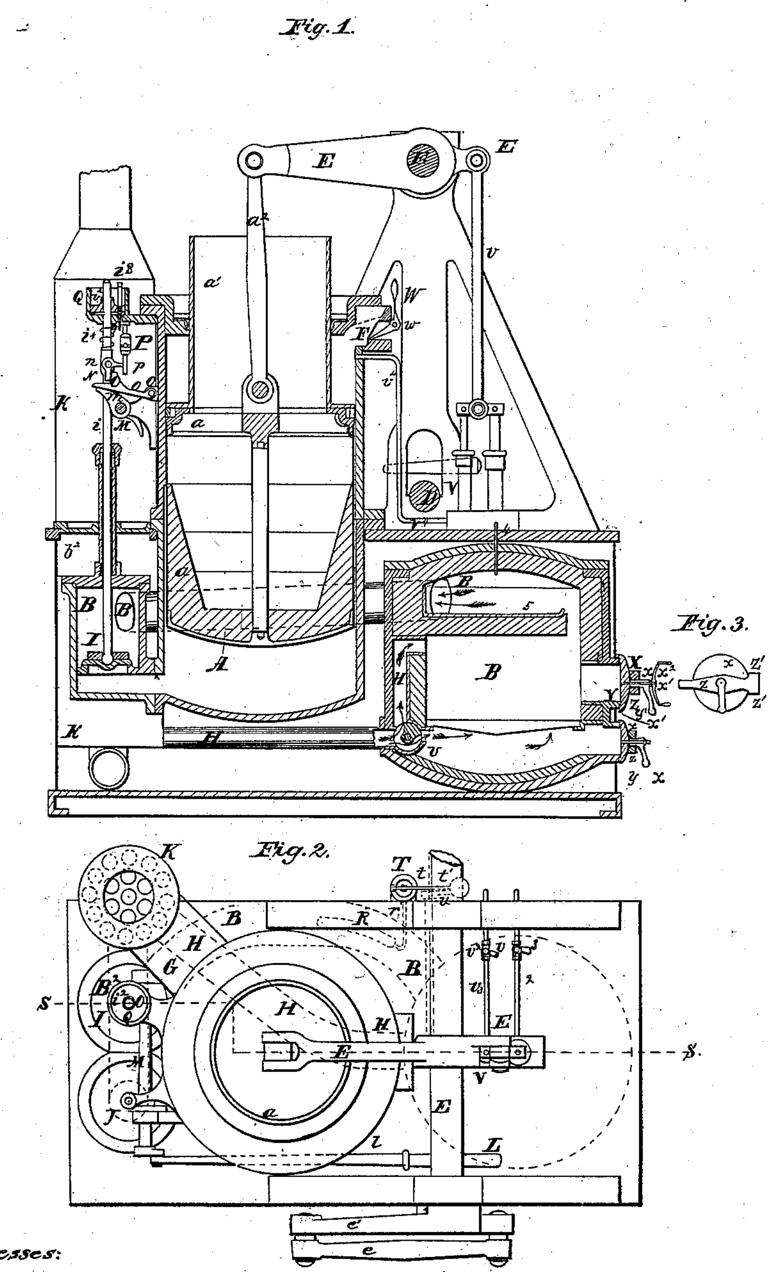
S. Wilcox, Jr.,

Air Engine,

No. 47,759. Patented May 16, 1865.



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IMPROVEMENT IN HOT-AIR ENGINES.

Specification forming part of Letters Patent No. 47,759, dated May 16, 1865; antedated May 5, 1865.

To all whom it may concern:

Be it known that I, STEPHEN WILCOX, Jr., of Westerly, in the county of Washington and State of Rhode Island, have invented certain new and useful Improvements in Hot-Air Engines; and I do hereby declare that the following is a full and exact description of the construction and operation of the same.

The accompanying drawings form a part of this specification.

Figure 1 is a vertical section showing the arrangement of all the principal parts. It is a section on the line S S in Fig. 2. Fig. 2 is a plan view; and Fig. 3 is a front view of the door and its connections, showing the peculiarities therein.

The drawings represent the novel parts, with so much of the other parts as is necessary to exhibit their relation thereto.

Similar letters of reference indicate like parts in all the drawings.

My engine is of the class in which the fire is subjected to pressure, and the gaseous products of combustion are passed through the working-cylinder. The air to support combustion is forced in by a pump. My engine is in these general features similar to that de scribed in the English patent of Sir George Cayley, dated about 1830.

My invention relates, first, to a certain novel use of a variable expansion-gear, so as to increase the working-pressure; second, to a certain construction and arrangement of the parts of such expansion-gear; third, to certain means for automatically controlling the proportions of hot and cold air used; fourth, to certain arrangements for absorbing and utilizing the heat due to compression; fifth, to certain means of relieving an engine from pressure, preparatory to replenishing the fire, or the like; sixth, to a certain construction and arrangement of the door and its connections to aid in keeping the same tightly fitted; and, seventh, to certain means of protecting from injury the ground delicate surfaces around the door.

To enable others skilled in the art to make and use my invention, I will proceed to describe its construction and operation by the aid of the drawings, and of the letters of reference marked thereon.

A is the cylinder; *a*, the piston, provided with a trunk, *a*′, which slides through a stuffing-box in the head of the cylinder A. The upper side of the piston *a* serves as a pump to receive and force in air to supply the combustion in the heater B, while the lower side of the piston *a* serves to receive the pressure of the heated and expanded products of combustion to impel the engine.

D is the main shaft, provided with a fly-wheel and crank.

E is a stout rocking shaft, mounted on a fixed framing above, and provided with arms E′ E^2, as represented, adapted to receive the motion from the piston *a* through the connection a^2, and to transmit the power to the crank on the shaft D through the connection *e*, as will be obvious. With each descent of the piston *a* and its connections air is drawn in through an inhaling-valve, F, and fills the space above the piston. With each ascent of the piston the inhaling-valve F closes, and the air is forced out through a delivery-valve (not represented) into a passage, G, (see Fig. 2,) and forced down through the regenerator K. From the base of this regenerator it issues, partially heated, through a pipe, H, and is carried into the heater B. The pipe H has a branch, H′, which enters the heater B above the fuel. The main pipe, on the contrary, enters the heater below the fuel. A valve, U, located as represented, is adapted to be easily turned, so as to throw more or less air below the fuel, as desired. If much air passes into the heater below the grate, so as to rise through the fire, the fire is increased greatly in intensity. When by turning the valve U less is thrown below and through the fire, and nearly all the air is thrown in above the fire, the combustion flags, and the heat becomes less intense. The hot products of combustion from the heater B pass (at a considerable pressure above the atmosphere) through the pipe B′ into the valve-chest B^2. From thence they are delivered into the lower end of the cylinder A, accordingly as the induction-valve I is opened and held open by the mechanism. After performing the duty of forcing up the piston *a*, the products of combustion are discharged through the corresponding eduction-valve J, which is also operated by the mechanism.

The regenerator K, I prefer to make in the form of an upright cylindrical vessel. It is filled with small tubes and introduced in the position represented. The fresh air is compelled to traverse a space between and around these tubes on its way into the lower part of the heater, and the products of combustion, in escaping from the engine through the eduction-valve J, are compelled to traverse through these tubes. The products of combustion heat these tubes, and the fresh air circulating through the space around them is thereby heated. By the operation of this regenerator heat is economized by being transferred from the outgoing to the ingoing air, in a manner which will be appreciated by those familiar with air-engineering.

L is an eccentric fixed on the shaft D and connected through the eccentric-rod *l* to an arm on the rocking-shaft M. On this rocker M are two toes, *m m'*, which are adapted to lift the induction-valve I and the eduction-valve J through their respective rods at the proper times.

I will now describe the features to which my invention more particularly relates.

N is a bell-crank lever pivoted on the valve-stem *i* of the induction-valve I by the pin *n*.

O is a lever having a fulcrum or pivot at *o* and high shoulder, O', adapted to lift the bell-crank lever N and its attachments whenever the toe *m* on the rock-shaft M rises, and to support it until the relation is disturbed.

P is a movable stop adjustable upon the upright rod *p*, and adapted to receive and be struck by the horizontal arm of the bell-crank lever, and to hold the latter down, so as to turn the said lever partially around and cause its lower end to slip off from the shoulder O'. So soon as this occurs the valve ceases to be supported by the bell-crank, and falls, carrying the latter with it. This action may be induced earlier or later in the stroke, according as the stop P is adjusted higher or lower.

In all conditions of the parts the induction-valve will be elevated simultaneously with the commencement of the upward stroke of the piston *a;* but when the stop O is highest the said valve I will not be tripped, but will be returned to its seat at the time the piston has about completed its upstroke, thus performing a full stroke, or nearly so, under the direct pressure of the products of combustion from the heater B, while if the stop P is set lower the said induction-valve I will be liberated at a certain period by the slipping off of the lever N from the shoulder O'. The induction-valve I, so soon as free, will fall rapidly, and have the effect to "cut off" the admission of gases to the lower portion of the cylinder A some time before the end of the stroke. By raising and lowering the stop P to different extents the period at which the cut-off takes place may be adjusted with great nicety. By allowing the stop P to stand at its highest position, and following the piston with the gases from the heater in a continuous current during the full stroke, I allow a certain amount of pressure to accumulate in the interior of the engine. The effect of lowering the stop P, so as to cut off early, is to accumulate a higher pressure therein, because, while the supply of air thereto remains the same, a smaller volume of air is taken away at each stroke. The heat in the furnace is increased in consequence of the higher pressure of the air therein. It is well established that the combustion of fuel under a high pressure induces a greater intensity of heat than the burning of the same fuel under a low pressure. The cause is generally ascribed to the closer approximation of the particles of the air, which facilitates the union of great quantities of oxygen with the fuel very rapidly. In consequence of the greater intensity of the heat in my furnace, the combustion is more perfect and complete. In other words, the admission of air above the grate to consume the carbonic oxide and the hydrocarbons and particles of free carbon is made more effectual, and all the fuel used is more completely burned, and I believe that less free oxygen necessarily escapes.

The variations in the point of cut-off necessary to control the engine are slight, and I work habitually with a much higher pressure in the furnace than has previously obtained in such engines. I can adjust the position of the stop P, by a fly-ball or other automatic governor, (not represented,) so as to make the speed self-adjusting, and can manage it in all respects as I would an adjustable cut-off of similar character on a steam-engine.

Q is a controlling-chamber or valve-checker.

i^2 is a piston fixed on the top of the induction-valve rod *i*, and adapted to fit easily in the cylindrical interior of the controlling-chamber Q.

q is a hole in the lower end of the controlling-chamber Q, and i^3 is a screw-plug tapped through the piston i^2, and provided with a slender neck which extends downward through the hole *q*, and is adapted to be acted on by a wrench applied above. Above this slender neck the screw-plug i^3 is of such size as to very nearly fill the hole *q*. When the valve I is liberated, it falls rapidly, in obedience to gravity and to the spring i^4, until the thick part of the screw-plug i^3 enters the hole *q*, and thereby checks the rapid escape of the air in the bottom of the controlling-chamber Q. The air remaining below the piston i^2 in the controlling-chamber Q then commences to act by its elasticity, thereby resisting compression, and consequently resisting the descent of the induction-valve I. By turning the screw-plug i^3, so as to increase and diminish the resistance of the air in this manner at pleasure, I am able to allow a very rapid closing of the induction-valve I without experiencing any sensible slamming on its seat.

R (see Fig. 2) is a slender vessel containing mercury. It is inserted in the hot products of combustion flowing through the pipe B', and is connected by the pipe *r* to the space beneath the loaded diaphragm T. This diaphragm is connected through the lever *t* and connection t' with the lever u, which operates the freely-turning valve U. The latter, as before explained, directs more or less of the fresh air below the grate, and consequently urges the fire more or less, according as the lever t is elevated or depressed. The effect is to regulate the temperature of the issuing gases so as never to exceed the heat the working-cylinder can endure, and to maintain a great uniformity under all conditions.

V (see Figs. 1 and 2) is a small single-acting pump operated by the connection v from the rocking lever E^2. It is supplied with water through a pipe, v^3, from a tank, (not represented,) and at each descent of the piston a its contents are discharged into and caused to mingle with the air in the upper part of the cylinder A. When the piston a rises, it compresses the air above it, and thereby develops much heat, which heat is absorbed in part by this water. The water thus heated is ultimately discharged with the air through the pipe G into the regenerator K, where the heat thus received becomes available to aid in transforming it into steam, which steam passes, thus mingled with the air, into and through the heater B.

It is generally known that water or steam in small quantities does not prevent, but promotes combustion. I do not believe that it is itself actually burned; but I believe, as the result of much observation, that its presence promotes the union of the oxygen with the other matter present, and reduces the quantity of free oxygen passing away up the stack. The steam introduced in the manner above described also adds to the quantity of the gaseous matter acting on the piston, and thereby tends to add to their pressure. It also contributes by its effect on the adhesion of the burning fuel or ashes, or in some way not well understood, to the clearness of the fire. The water introduced by the pumps V therefore performs several important functions: first, it lowers the temperature of the compressed fresh air in the upper part of the cylinder A, and thus reduces the resistance to its compression, and allows the use of leather or other delicate packing, and of correspondingly delicate valves at that point; second, it keeps the cylinder A and piston a cool, and thus by keeping the air cool while it is inhaled allows the reception of a larger quantity of fresh air at each stroke; and, third, it supplies moisture, in the form either of steam or of water highly heated, to promote the combustion and increase the pressure of the gaseous matter.

The capacity of the pump V is so small that an excess of water can never be delivered above what can be disposed of by the engine; but it may be of advantage sometimes to reduce the quantity much below the full capacity of the pump.

V' is the handle by which is adjusted a stop-cock, V^2, in the pipe V^3, through which pipe water is received by the pump V from a tank. (Not represented.) The cock V^2 is usually half closed. By opening farther more water is delivered into the pump, and by shutting it closer less water is so delivered.

My furnace B is always supplied with a thick bed of coal, and the whole of its fire-brick surfaces are very intensely heated; but the supply of air, being all forced in through the pumping operation, is necessarily limited, and this limits the rate of combustion.

The addition of small quantities of water increases the heat of the fire, as above explained.

I believe that more moisture can be introduced with benefit into the heated gases to act mechanically as simply steam than it will usually be advisable to admit with the air to support combustion. In order to effect this, I provide means for supplying water in certain quantities through another channel, which will be described further on, with the novelties which I have invented in connection therewith.

W is a hand-lever turning on the center w, and adapted by changing its position to press inward, and consequently to throw out of use the inhaling-valve F at will. When this lever W is erect, as represented, it allows the engine to perform and operate with a considerable pressure in its interior, as described; but so soon as it is depressed into the position indicated in red outline it holds the inhaling-valve F constantly open, and allows the air which is inhaled by the downstroke of the piston a to be freely exhaled through the same passage by the upstroke of the same. In this condition the engine immediately loses its pressure. This is desirable at times for brief periods, especially for firing the furnace.

I propose, where two or more of my engines are applied to rotate one common shaft, to adopt this mode of relief to each engine alternately, and, replenishing the furnace thereof with coal, or elevating the handle W to the position indicated by the dark lines, the air inhaled is imprisoned and compressed, because the inhaling-valve F now closes during the upstroke of the piston a, and the pressure within the engine rises to its proper working stage.

X X are the doors through which the coal is introduced and the ashes removed.

Z is an arm hinged in the usual manner to the side of the door-frame by hinges. (Not represented.) A stout hollow bolt, x, is tapped through the arm Z, and carries in its interior a cylindrical stem, x', which is fixed to the center of the door X. A shoulder or head, x^2, near the outer end of the stem x', rests against the outer face of the arm Z. On turning the hollow bolt x so as to move it outward the door X is drawn outward, and the bar or arm Z may then be raised slightly, like a stout latch, and the door be opened. After the fire has been properly attended to, the door is closed by swinging around on the hinges Z', and is latched, as before. Next, by turning the hollow bolt x in the opposite direction, so as to move it inward, the slack is all taken up and the door is pressed very tightly to its seat, so as to endure the pressure in the interior of the furnace without allowing any sensible leakage. The hollow bolt *x* is provided with a handle or arm, as represented, to allow it to be conveniently operated in either direction to confine or release the door X. The door is circular. When the hollow bolt *x* around the center-pin *x'* is screwed outward, as described, it holds the door X loosely; but by turning it inward a few threads it is tightened. In the loosened condition of the parts the door X may be turned around by the aid of a dog screwed upon the rod *x'* and ground upon its seat, in a manner familiar to engineers, in order to fit the surfaces of the door and of the door-frame tightly together. The dog may be of any convenient form. One form is represented in red outline.

Y is the surface of the door-frame, which is thus ground smooth to receive the corresponding surface, X, of the door.

Y' is a lip or flange which projects outwardly adjacent to the surface Y in the manner represented.

X' is a lip which projects inwardly from the door in the position represented. The purpose of these lips X' and Y' is to defend and protect the delicately-ground surfaces X and Y of the door and door-frame when the door is standing open.

It is found in practice that unless some such provision is made the finely-ground surfaces are liable to be struck by the coal or by the shovels or other tools employed and so seriously marred as to prevent their fitting tightly together without very frequent grinding.

I will now conclude the description of my apparatus by indicating the means whereby I manufacture steam to mingle with the products of combustion, in addition to that made from the water injected through the pipe v^4. These means are very simple. 1 is a pump operated by a connection from an arm, E^2, on the main rocking shaft E. 2 is a pipe leading water to the pump 1 from a tank. (Not represented.) 3 is a stop-cock in the pipe 2, adapted to control the amount of water admitted to the pump 1, it being intended that the pump shall usually receive not so much as its capacity would admit. 4 is a delivery-pipe which throws the water from the pump 1 into the heated gases. 5 is a broad and shallow pan adapted to receive the water from the pipe 4, and from which pan the water is rapidly evaporated. I have represented this pan as lying immediately upon a fire-brick diaphragm within the heater. The water may be admitted in a fine shower upon this pan or upon a pan within the pipe B', which leads to the valve I, as may be found preferable. In either position it is evident that the intensely-heated products of combustion will give up a portion of their heat to the water and cause the production of steam, and that the effects will be to lower the temperature of the gases directly and to produce a mixture of air and steam the temperature of which will be still lower, while the volume or the pressure will be augmented by the addition of the steam. The effect is to yield a greater power and to cause the working parts of the engine to endure better.

I regulate the heat of the products of combustion passing through pipe B' to the engine by varying the quantity of water admitted. If my cock V^2 is opened so as to throw more water into the heater B, the temperature of the products of combustion is diminished. In this condition I can without injury to any part put all the air through the fire by driving it all through the lower branch, H, instead of driving a part through the upper branch, H', of the air-pipe. When this is effected, either automatically or by hand, the power of my engine is, of course, very greatly increased. The reverse movement of the handle V', by reducing the opening of the cock V^2, has the effect to raise the temperature in the apparatus and to diminish the power of my engine. When the engine works too weakly or too slowly, I open the cock V^2 a little farther and admit more water and generate a larger volume of steam. When the engine works too strongly or too rapidly, I shut the cock V^2 more closely and admit less water, and consequently produce a smaller volume of steam. I thus control the power of the engine by this means. Substantially the same effect would result from adjusting the cock 3 so as to admit more or less water at the other point—to wit, directly into the heater B, in lieu of through the regenerator K and connections. I prefer for several reasons to vary the supply at that point, instead of at the one above described. One reason is, that as the water introduced through the pump V' has a duty to perform of absorbing the heat of compression, which is nearly uniform, it is well to make it of small size and allow it to be always filled. The other may be larger, as above described, and may work usually only part full. I therefore consider the cock 3 the usual regulating-cock for my engine.

I apply to my apparatus a safety-valve, (not represented,) to provide against an overpressure in any possible contingency. I take care to maintain so high a temperature that the vapor is always dry and superheated.

Some of the advantages due to certain features of my invention may be separately enumerated as follows:

First. By reason of my variable cut-off mechanism, related as described to an engine operating by the pressure of the gases in the combustion-chamber or heater, I am able, by varying the degree of expansion of the products of combustion in the cylinder, to control the power at will, so as to regulate the speed and to accumulate the pressure in the engine, and to work generally at a higher pressure and attain more perfect combustion than is possible with the previously-known modes of controlling the power of such engines.

Second. By reason of the employment of my controlling-chamber Q, hole q, controlling-piston i^2, and screw-plug i^3, related as described to the valve I and its connections, I am able to adjust and control the descent or drop of the valve I, so as to allow it to close very rapidly and without slamming, by the aid of very simple and durable mechanism, and without the necessity for any water or other dense fluid.

Third. By reason of my mercury-vessel R being subject to the heat of the products of combustion, and connected by the pipe r, so as by its vapor to operate the loaded diaphragm T and its connections, and of my lever t being connected so as to operate the valve U, as described, I am able to regulate the temperature of the gaseous matter flowing to the cylinder A, so as to avoid burning or injuring the working parts. This portion of my invention may be used either alone or in connection with other modes of regulating heat.

Fourth. By reason of the fact that the water delivered through the cock V^2, to absorb the heat of compression and add by its expansive force to the working-power of the engine, is delivered at each stroke by gravity through the passage G, I avoid the accumulation of water in the working-cylinder, and consequently the shocks and danger of fracture which attend the performance of such double function in the manner shown in the English patent of 1858, No. 969.

Fifth. By reason of the fact that my inhaling-valve F can by the means described be held open during the complete revolution of the engine at will, I am able very readily to relieve the interior of the engine from pressure and allow the door to be opened to supply fuel or the like, and also insure the cooling of the upper portion of the cylinder A and piston a by the active circulation of the air during such process. By releasing the inhaling-valve I can set the engine in full operation so soon as the door is again secured. I effect both of these operations with very little labor.

Sixth. By reason of the fact that my door X is circular and is connected to the stout hinged bar Z only by the hollow bolt x and stem x', I am able, by a very simple construction of the parts, to insure that the door may be opened and closed very easily and when closed may retain the gases very tightly, and to very readily release the door and grind it upon its seat by rotating or partly turning it around backward and forward around its center x' with little labor and delay.

Seventh. By reason of my lip X' adjacent to the ground surface X on the door and my lip Y' adjacent to the ground surface Y on the door-frame, I protect the ground surfaces effectually against all the ordinary violence which tends to indent and abrade such surfaces.

Having now fully described my invention, what I claim as new therein, and desire to secure by Letters Patent, is as follows:

1. In combination with an engine in which the combustion is conducted under the working-pressure, the employment of an adjustable cut-off mechanism arranged to operate therewith substantially in the manner and for the purposes herein set forth.

2. The controlling-chamber Q, orifice q, and screw-plug i^3, arranged relatively to the piston i^2 and to the induction-valve I and its connections substantially as and for the purpose herein set forth.

3. The combination of the thermostat R T, or its equivalent, with the regulating-valve U, the two channels H and H′, and the engine A a, the whole being so arranged as to automatically control the proportions of air relatively to the gaseous products of combustion actuating the engine, substantially in the manner and for the purpose herein set forth.

4. The pump V and pipes v^4 and G, or their equivalents, arranged relatively to the compressing parts A a and heating parts B, &c., or their equivalents, substantially as herein described, so that I can cause the water to perform the several functions in the manner herein set forth.

5. The arrangement of the inhaling-valve F and lever W, or its equivalent, substantially as and for the purpose herein set forth.

6. Connecting the circular door X to the hinged bar or arm Z by the hollow bolt x and stem x', or their equivalents, so that the door may be readily released and ground and again secured, in the manner substantially as herein set forth.

7. The guard-lips X' and Y', arranged relatively to the door X of the furnace and to the ground surfaces on the same and on the door-frame Y, substantially as and for the purposes herein set forth.

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