S. WILCOX, Jr
HOT AIR ENGINE.

No. 27,180. Patented Feb. 14, 1860.

Fig. 3.

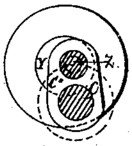


Fig. 1.

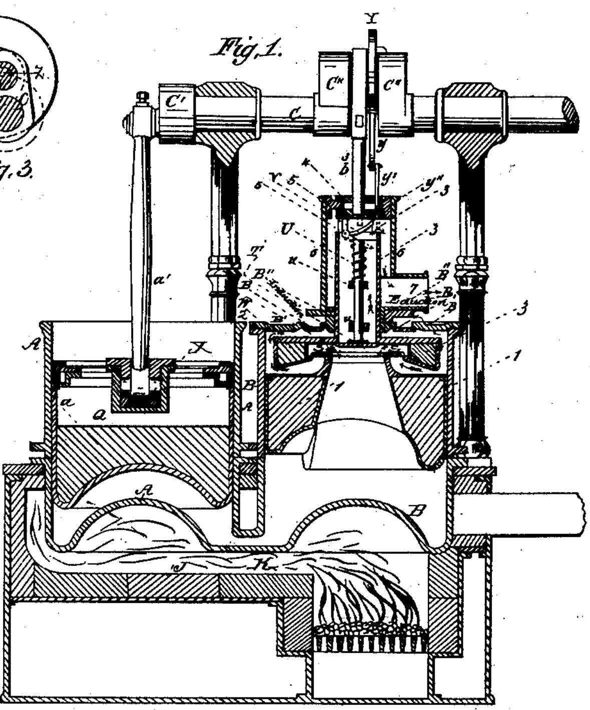
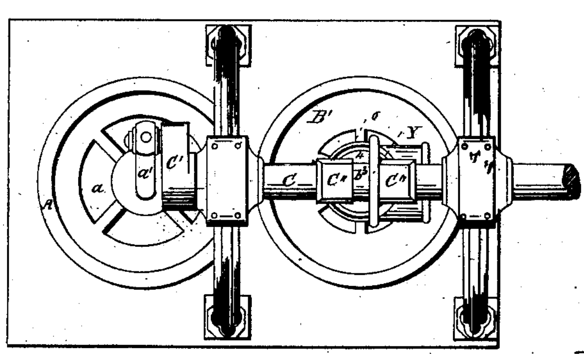


Fig. 2.



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UNITED STATES PATENT OFFICE.

STEPHEN WILCOX, JR., OF WESTERLY, RHODE ISLAND.

HOT-AIR ENGINE.

Specification of Letters Patent No. 27,180, dated February 14, 1860.

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 the Hot-Air Engine patented by me on the third day of May, 1859, Patent No. 23876; and I do hereby declare that the following is a full and exact description of the same, reference being had to the accompanying drawings, forming a portion of this specification, in which—

Figure 1, is a vertical section of the novel parts in the plane of the shaft, Fig. 2, a plan view of the same, and Fig. 3, a diagram showing the arrangement of the eccentric.

Similar characters of reference, indicate like parts in all the drawings.

In operating the engine patented by me on the third day of May 1859, a considerable loss of effect is experienced from the fact that heat is conveyed through the material of the changing piston, and imparted to the air immediately on its entering the space above it. The heat thus imparted to the air first received, causes it to expand and obstruct the ingress of that which should follow. The result of this defect is that less air is received than would be required in a cold state to fill the space formed by the sinking of the changing piston, and less power is therefore developed by the engine. It is also found that much heat is conveyed upward through the working piston and that the top of the same becomes so highly heated that the lubricating material is injuriously affected, unless much care is taken to prevent it. This evil can be only partially remedied by increasing the thickness of the piston, and any such increase of the material involves serious difficulties by increasing the size of the engine and the inertia of the parts.

The object of my invention is to diminish the loss of power due to the heating of the air above the changing piston, to overcome the difficulties due to the heating of the top of the working piston, and to exhaust the heated air through peculiarly arranged passages, and by the aid of means which are novel, and conducive to the efficiency and value of the engine.

The nature of my invention consists in making the changing piston in two parts, one above the other, and compelling the air in its passage from the cold to the hot side of the double piston thus formed, to traverse the space between the upper and lower parts, to convey away by convection, and to transmit to the parts below, all the heat which is conducted upward through the lower piston to the dividing space. By this means the upper portion of the piston—or the surface thereof which is presented to the contact of the entering air—is kept at a low temperature and the air drawn in with its full and proper volume.

The nature of my invention also consists in cooling the working piston by the circulation of the external air therein so that the bearing of the connecting rod is divided from the heated parts by the interposition of a space in which the air circulates freely, the connection between this bearing and the heated parts being only a thin shell of metal around the periphery.

My invention also consists in a peculiar arrangement of the valves and of a hollow piston rod, and of a surrounding case, whereby the escape of the air is effected through the piston and piston rod, with an advantage which will be subsequently explained.

My invention also consists in a peculiar means of producing and adjusting a differential motion in working the exhaust valve;—this latter being carried in the piston and being operated by the difference between the motion of the operating rods and the piston by a new and peculiar combination and arrangement of the parts.

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 denoted thereon.

A and B are two upright hollow cylinders of metal arranged in the manner, and designed to produce the effect of the corresponding parts in my patent before mentioned, dated May 3d, 1859. C, is the shaft carrying a fly wheel not represented and C′, C″ are the cranks fixed thereon as there explained. J, is masonry inclosing a suitable furnace k, for the production and application to the cylinder bottoms A and B of the heat generated by the combustion of the fuel on the grate. All these parts as also the connecting rods a' and b^3 correspond in their general structure and effect with the corresponding parts shown in my Patent of May 3d, 1859.

Instead of the changing piston heretofore

employed I construct my changing piston in two parts 1 and 2 as represented. The lower part 1 is thick, and filled with ashes, or other non-conducting material. The upper part 2 may be thinner, and is of less diameter as represented, so that a clear annular space exists between the periphery of the upper piston 2 and the interior of the cylinder B. The parts 1 and 2 are secured rigidly together by webs or other equivalent connections not represented, the connection parts being strong and inflexible, but not so massive as to be of much effect in conveying heat from 1 to 2. The center or axis of the lower piston 2 is hollowed out as represented, forming a cavity in which the air may flow freely up and down according to the position of the valves and the direction in which the pistons may be moving. I insert in this cavity the regenerator not represented which produces its usual effect in economizing heat. In the space between the two parts or pistons 1—2, I provide a suitable seat and an annular or other self-acting valve S which allows the air to flow at pleasure from the upper or cold side of the piston to the lower or hot side, but forbids its return.

The top of the changing cylinder B is closed by a cover B′ in which is provided an annular or other self-acting valve R which is arranged as represented, to allow the external air to flow at pleasure downward into the space between the cylinder cover B′ and the upper or cool piston 2, but forbids its return.

A hollow piston rod 3 is fixed to the upper piston 2 as represented. It is of suitable size to allow the easy escape of all the air. In its lower end is mounted a valve T which is capable when operated by suitable mechanism, of allowing the discharge of the exhaust air from the space under the pistons 1 and *a* into the hollow piston rod 3. The upper or outer end of the hollow piston rod 3, is of larger diameter than the part below as represented by 4. Large apertures 5, 5, are made in the side of the part 3 at the points represented directly below the enlarged portion 4. A cylindrical case 6 is fixed on the cylinder cover B′ which is tightly filled by the enlarged part 4 of the hollow piston rod 3. The portion of the cylinder cover B which is in contact with or immediately surrounding the smaller part of the hollow piston rod is packed so as to form a tight contact therewith as shown at B″ B″. A large opening is made in the hollow exterior case 6 near its base as represented by the nozzle 7 and to this a pipe not represented is connected which opens into the atmosphere outside of the engine-room or into the chimney.

When the valve T is opened by the mechanism described below, the air contained beneath the pistons 1 and 2 if of greater pressure than the external air, is allowed to flow out through the hollow piston rod 3, and the apertures 5, 5 into the annular space between the hollow rod 3, and the case 6 and escapes from thence through the nozzle 7 and the attached pipe into the external atmosphere. The length and arrangement of these parts must be such that the working piston and attached parts may change their position to the full extent without closing or obstructing the free escape of air through these channels, provided the exhaust valve T is held open. I construct my exhaust valve T in the form of a puppet valve, opening downward, and support it by a spring which is coiled around its stem as represented at U. The guides or steadiments, *u*, *u*, support the stem of this valve in the usual manner and keep it always concentric to the piston and to its seat.

The mechanism by which I actuate the valve T and obtain a suitable means of adjusting it relatively to the motion of the piston is as follows: I suspend to the point *v*, in the hollow piston rod 3, a suitable lever or toe, V, adapted to act on the upper extremity of the valve stem and depress it. I next make an eccentric of such throw as would, if mounted on the main shaft actuate the valve to the proper extent if it was not hinged to, and carried with the piston, but was hinged to a fixed point. I mount this eccentric on the crank pin Z. I connect the eccentric by the eccentric-rod *y*, to the vertical rod *y′*, which is carried in a guide in the top of the hollow piston rod. To the lower end of this I connect the vibrating extremity of the lever V, by a link *y″* as represented. The effect of this combination and arrangement is such that the rod *y′* has a motion very nearly corresponding with that of the piston rod 3, by reason of the fact that the eccentric Y, is mounted on the crank pin, and consequently travels around in a circle identical with that of the upper end of the connecting rod, but the motion differs from that of the piston and consequently from that of hinge *v* by an extent equal to what is usually termed the throw of the eccentric proper, Y. The eccentric being rightly adjusted it follows that at each revolution of the main shaft the eccentric Y by its connections *y*, *y′*, *y″*, V, opens the valve T and holds it open about half a revolution, during which time, air escapes freely from the space below into the atmosphere by the channel above described. It is not strictly correct to describe the eccentric Y as acting on the lever V by its "throw" in the ordinary sense of the term, because the throw of the eccentric Y is rigorously speaking, equal to twice the distance of its center, not from the center

of the crank pin Z, but from the center of the main shaft, C.

The valve T and lever V and connections are all worked with precisely the same motions as they would be with the connections y'', y', y, attached, not to a small eccentric mounted on the crank pin, but to a very large eccentric mounted on the main shaft C. Such an immense eccentric would, however be impracticable, and if practicable would not be equivalent, in effect, to this feature of my invention. It would be impracticable because room cannot be provided for its large diameter without giving such a great length to the connecting rod b^3 as would injuriously affect the motion of the piston, and because the friction of the mammoth eccentric ring would, so soon as the lubrication became deficient be very destructive. A point however in which my arrangement of the eccentric Y on the crank pin Z, is undoubtedly peculiar lies in the fact that the effect due to the adjustability of the eccentric Y on the crank pin Z cannot be obtained by any known means of mounting a mammoth eccentric on the main shaft.

By simply shifting the eccentric Y around in one direction or the other on the crank pin Z the time of the opening and closing of the valve T is changed without altering the extent of its opening, a very desirable effect, identical with that obtained on ordinary valve motions by shifting the eccentric upon the main shaft. The effect in this respect is the same as if the valve T and lever V were mounted on fixed parts and the eccentric Y was made adjustable on the main shaft C. The setting of valves by changing the angular position of an eccentric is well understood, and no difficulty will be experienced by any skilful engineer in effecting this and in changing the amount of "lead" or the relative time of the exhaust at pleasure; while with a mammoth eccentric on the main shaft to serve in its stead, such adjustment would be impossible without also and in a very extravagant degree changing the extent of opening of the valve.

The diagram Fig. 3, is intended to show the difference in this respect, the red circle showing the line in which the center of the eccentric is moved by shifting it around on the crank pin in my invention, and the blue line showing the line in which it would be moved by shifting a mammoth eccentric on the main shaft.

The operation of my engine as thus improved is as follows: At each revolution of the main shaft C, the center of the eccentric Y is depressed below the level of the center of the crank pin Z and in consequence the lever V, is depressed and made to assume the position relatively to the piston shown by the red outline. This opens, and holds open the valve T and allows the air below to freely escape through while the piston 1 and 2 descends. The descent of this piston causes the valve S, to close, and the valve R to open by the pressure of the external air, and the whole space formed above 2 and between it and the cylinder cover B′ is consequently filled with cold and dense air. A little before this descent is completed the exhaust valve T is released by the elevation of the lever Y and is allowed to close by the action of the spring U. The changing piston next commences to rise, and the induction valve R closes by the action of gentle springs, not represented, or by the rush of air endeavoring to escape, and the cold air now compressed by the rise of the changing piston, raises the valve S and allows a rapid flow of the air above 2, first through the annular space between it and the interior of the cylinder B, and then through the space between 2 and 1, as shown by the arrows, into the central passage W, which leads it to the space below the pistons, where it is heated and expanded, and serves to impel the engine by forcing up the piston a as explained in the specification of my Patent No. 23,876. When its useful effect is ended, it in turn is discharged through the valve T. By this conveyance of all the inducted air between this lower part 1 and the upper part 2 of the changing piston, all the heat which is conducted, or radiated upward into the top part 2 is very thoroughly removed by convection into the stream of air which is just in the act of leaving, and the inducted air instead of playing directly upon the hot top of the part 2 and becoming prematurely expanded with the ill effect of thereby preventing the spontaneous ingress of the full and proper quantum of air, plays upon a cool surface on the top of 2 and is not at that time allowed to come in contact with the lower part 1 except in the narrow annular space between 2 and B which is too small to be of much effect until the piston begins to ascend and an active draft through the piston is induced. By this improvement the power of a given engine is very greatly increased.

The form of the working piston a which I have adopted in my improvement is shown by the section in Fig. 1, very plainly. A clear space Q is allowed to extend quite across the piston with the exception of a thin shell at the periphery, and the lower extremity of the connecting rod a' is jointed to the piston a, not through the aid of a continuous plate, as heretofore, but of an open frame, or spider, which extends from the center to the circumference, forming a strong connection between the rod a' and the lower portion of the piston a but with

liberal openings through which the air may circulate. As the working piston *a* reciprocates rapidly, the agitation of the air contained in the space Q and of the air immediately above, is sufficient to induce a partial displacement of the contents at each stroke, so that the space Q is always filled with air at a comparatively low temperature, and thus the heat which is conducted upward to the rubbing surfaces, is very slight. Whereas were there no air space Q in the piston, or were it inclosed by the employment of a tight plate above, so that it would not be displaced in part at each stroke, the rubbing surfaces at the top of the piston would be compelled to sustain a much higher temperature, the heat at the bottom of the piston diffusing itself more uniformly throughout its whole substance.

Having now fully described my improvements in hot air engines what I claim as my invention, and desire to secure by Letters Patent, is,

1. The dividing of the changing piston into two parts 1—2 and conducting the air through the space between them in its transfer from the cold to the hot end of the cylinder, substantially as and for the purposes herein set forth.

2. Dividing the bearing X or its equivalent from the heated portion of the working piston by the space Q which space is in free communication with the external atmosphere so that the heat is conveyed away by convection substantially in the manner herein set forth.

3. The within described arrangement of the exhaust valve T, hollow piston rod 3, and 4, and guide case 6, or their respective equivalents, for the purposes herein set forth.

4. The combination and arrangement of the crank C″ Z, adjustable eccentric Y and eccentric rod and connections, or their respective equivalents for the purpose of working a valve the seat of which is carried in, or with, the piston substantially as above set forth.

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