S. Wilcox, Jr.,

Air Engine.

№ 50,061. Patented Sep. 19, 1865.

Fig. 1

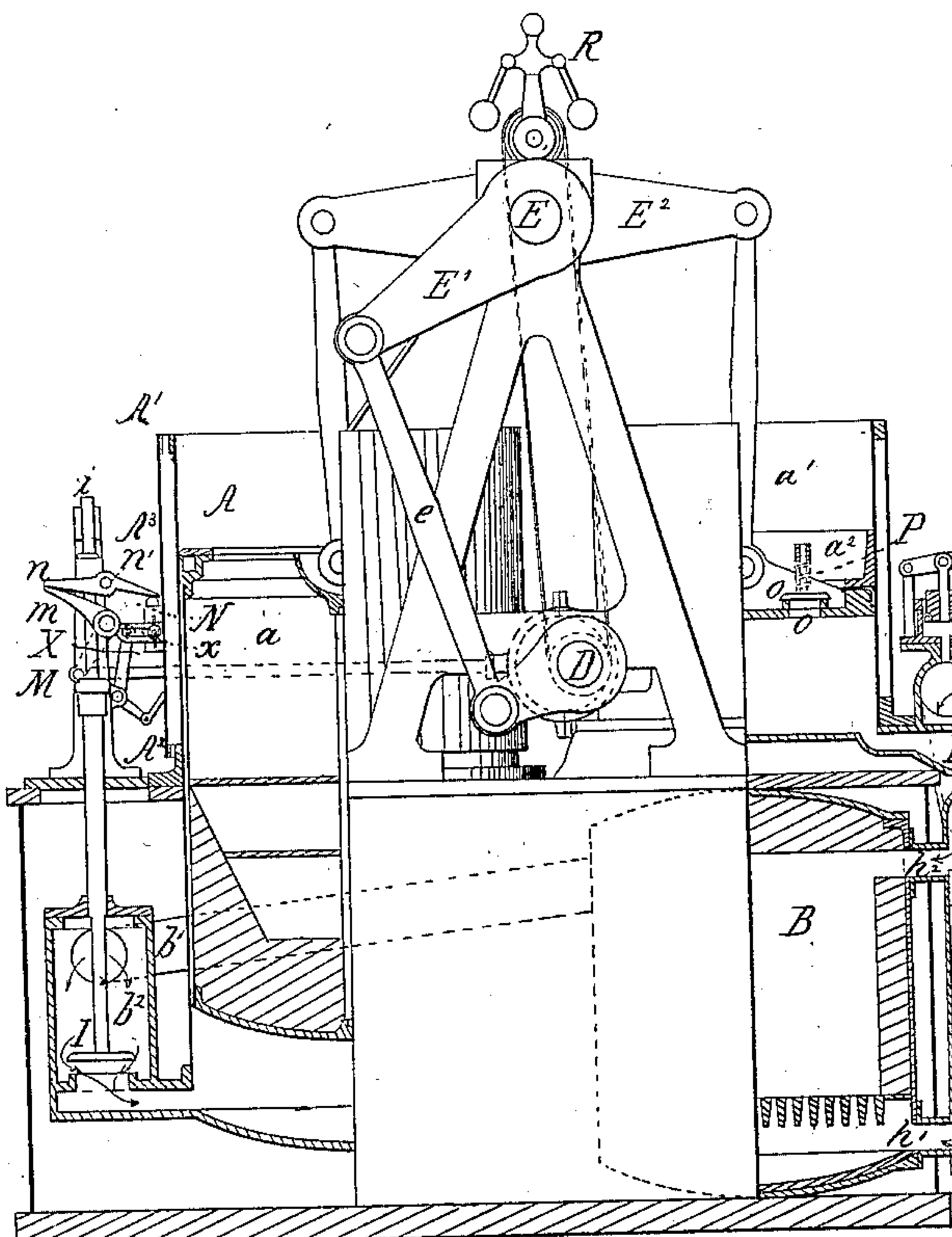
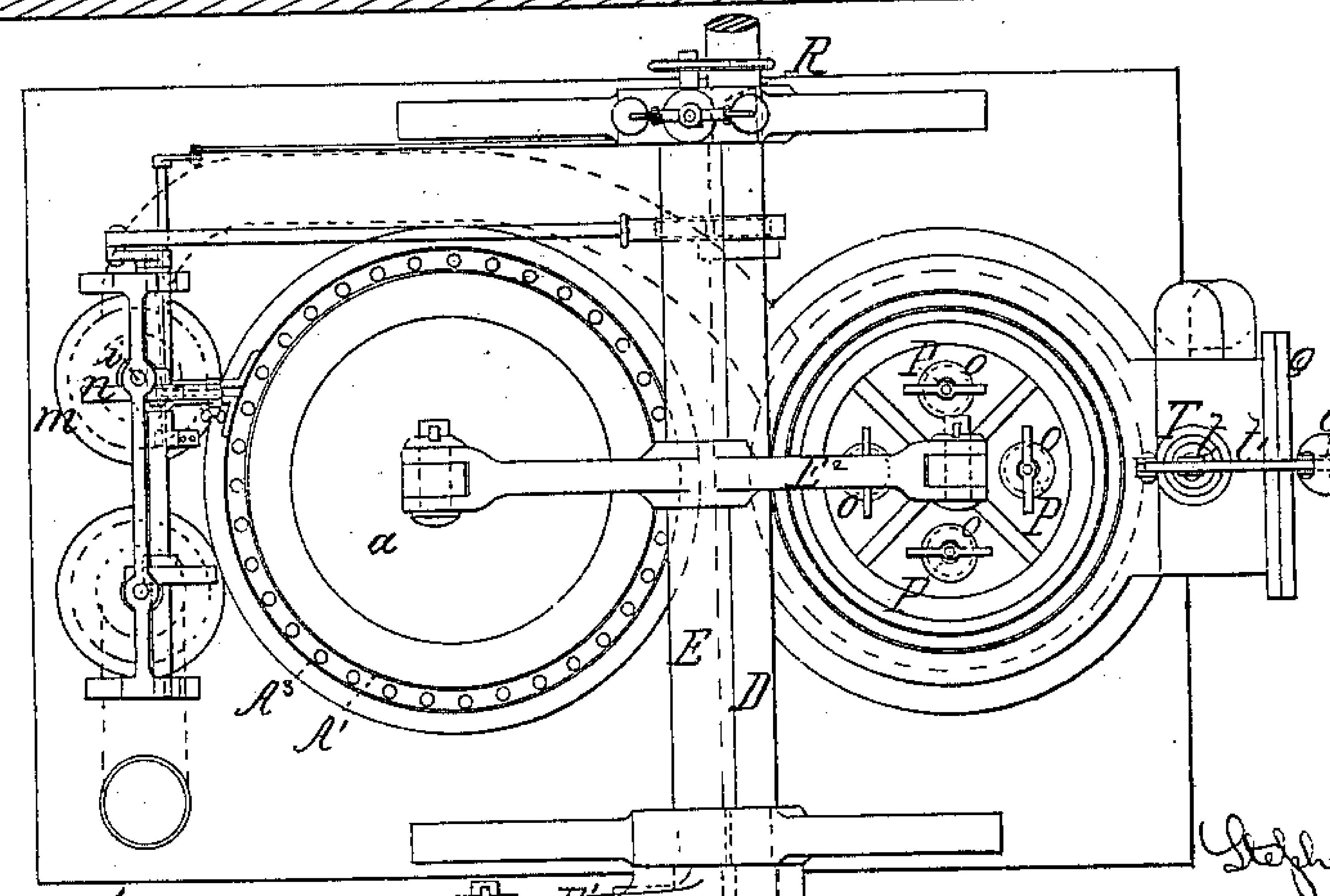



Fig. 2

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# UNITED STATES PATENT OFFICE.

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

## IMPROVEMENT IN AIR-ENGINES.

Specification forming part of Letters Patent No. **50,061**, dated September 19, 1865; antedated September 9, 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 thereof.

The accompanying drawings form a part of this specification.

Figure 1 is a side elevation, partly in section. Fig. 2 is a plan view.

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

My improvements are applicable to a great variety of constructions. They relate chiefly to the regulation and equalization of the temperature and pressure in the furnace and in the working parts of the engine. By their aid an engine may be subjected to great and sudden variations in the load and to great irregularities in the fire without endangering the destruction of any parts by overheating or experiencing any great variations in the rate of working.

Means have been represented in some of my prior patents for regulating the temperature and pressure by the expansion of mercury or other fluid inclosed in a manner analogous to that adapted in thermometers. The action of such device is too slow. My present invention regulates rapidly and is far more effective.

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 main cylinder, and $a$ the main piston. The latter is made of great depth, with a packing at the upper edge and non-conducting material in the lower part, as usual.

B is a heater or furnace, into which the air is forced by a powerful compressing-pump, $a'$.

The several main working parts in the engine are connected together and operate each other in the obvious manner.

The main shaft D receives a rotary motion and the piston $a^2$ of the compressing-pump $a'$ receives a reciprocating motion from the vertical reciprocations of the main piston $a$ through the agency of the stout rocking shaft E, with its arms $E'$ $E^2$ and the several connecting rods or links represented. The air is pumped or forced into the furnace B, and is there heated and expanded, after which it flows through a pipe, $b'$, to the valve-chest $b^2$, and from thence, on the lifting of the induction-valve I at the proper time, it flows into the main cylinder A, below the working-piston $a$, and forces it up. Before the completion of the upstroke the induction-valve I closes, and when the upstroke is completed the air below the piston $a$ is discharged freely into the atmosphere through an eduction-valve. (Not represented.) This allows the piston $a$ to descend without resistance, after which the round of operation is repeated. Each reciprocation of the main piston $a$ compels a corresponding reciprocation of the compressing-piston $a^2$, at each ascent of which air is drawn freely from the atmosphere through the inhaling-valve F, and at each descent the air previously inhaled is expelled through the delivery-valve G, and thence through the passage H and one or both the connecting-passages $h'$ $h^2$ into the furnace B, the portions of the air which shall pass through the respective passages $h'$ $h^2$ being determined by the position of the slide-valve $g$, which is balanced by the weight $g'$, and is adapted to be very easily moved by turning the lever $v$.

My invention makes the pressure in the engine correspond to the resistance by automatically varying the temperature of the air to suit the variations of the load. The means by which I effect this is as follows: A small piston, $t$, is mounted in a vertical cylinder, T, the lower end of which is connected with the passage H by means of the aperture $j$. This piston $t$ is adapted to move tightly and easily in its cylinder, and is weighted by a lever, $t'$, which is connected by a rod, $t^2$, to the lever $v$. Whenever the pressure in the passage H exceeds the proper amount the piston $t$ is forced up by this pressure, and by raising the lever $t'$ and the connection $t^2$ and lever $v$ it depresses the sliding valve $g$ and closes, or partly closes, the passage $h'$, through which the air from H is admitted beneath the grate, and opens wide the passage $h^2$, through which the air from H is admitted above the fire. The consequence of this change is that so much more air is admitted above the fire and so much less is admitted below to rise through the fuel and promote combustion that less heat is generated than before, and the pressure immediately falls to the proper point. If the fire gets too low, so that the pressure is reduced below the proper point, the piston $t$ sinks and the slide-valve $g$ rises, thus admitting more air below the grate to come in contact with the fuel and support the combustion.

The action of this apparatus is very rapid. The instant the pressure rises above or sinks below the proper point it causes a corresponding movement of the piston $t$. There is necessarily some friction on any tightly-packed piston; but this friction may by proper care be made moderate in amount. There is in my engine a fluctuation in the pressure at each stroke, which, although not sufficient under proper conditions to induce an actual movement of the piston $t$ up and down at each stroke, is very nearly sufficient to do so. In other words, the friction of the piston $t$ and of the several parts connected thereto is almost overcome at each stroke by the variations of pressure in the furnace and its connections accruing from the intermittent pumping in and using out of the air. Now, a very little increase in the pressure above the ordinary maximum in each revolution induces a movement of the piston $t$ upward at the proper point in the revolution, and a very little diminution of the pressure below the proper minimum induces a corresponding downward movement of the piston $t$ at another point in the revolution. Thus the ordinary fluctuations of pressure at each stroke aid in compelling the piston $t$ to yield more readily to any irregularities.

The toe $m$, fixed on the rock-shaft M, which is operated by an eccentric, as usual, tends to lift the induction-valve I to a uniform height at each revolution under all circumstances. The working of the shaft M never varies; but the motion which it imparts to the valve I is varied by a simple device now to be described

A lever, $n$, is mounted on the valve-stem $i$ by the aid of the pivot $n'$. N is a movable fulcrum, adapted to slide easily along the horizontal slot $x$ in the bracket X, thereby controlling the motion of the valve I. At each upward movement of the arm $m$ it lifts the outer end of the lever $n$, and the lever $n$, through the aid of the pivot $n'$ and the fulcrum N, raises the valve-stem $i$, and consequently opens the valve I, which remains open until the return movement of the toe $m$ allows the lever $n$ and its connection to descend; but the height to which the valve I is raised, and consequently the extent to which the passage for the air into the working-cylinder A is open, varies according as the fulcrum N is moved along the slot $x$. When that fulcrum is moved away from the pivot $n'$ the valve I is lifted higher, and when the fulcrum N is moved nearer to the pivot $n'$ the valve I is lifted to a less extent at each revolution. This device differs from a variable cut-off in the fact that it allows the valve I to close at the same point in each revolution, whether the fulcrum N be in one position or another.

The change in the position of the fulcrum N does not change the time of opening or of closing the valve I, but only the extent of its opening. It has the effect to choke or throttle the current of air past the valve I whenever the engine tends to run too fast. The fulcrum N is moved along the horizontal slot $x$ by the action of a governor, R. The connection is made by the bell-crank lever represented or by other obvious means, and the effect is to cause N to move to the left or toward the pivot $n'$ whenever the fly-balls lift too high in consequence of a too high velocity in the engine. Whenever the velocity gets too low and the balls of the governor sink the change induces a movement of the fulcrum N in the opposite direction. Thus the adjustment of the position of the fulcrum N and the amount of throttling are determined automatically by the action of the governor.

It is obviously possible to accumulate pressure in the furnace B and its connections to a dangerous extent. I provide against this by the use of a safety-valve peculiarly arranged in such manner as to insure its certain and efficient action, and so as to become to some extent a regulator of speed as well as pressure.

O is the safety-valve, mounted on an aperture in the compressing-piston $a^2$, and is held down thereon by its own gravity and by the tension of the coiled spring P. The total force holding this valve to its seat is so proportioned to the area of the passage $o$, which it covers, that the valve shall be ordinarily held to its seat with a force just equal to the maximum pressure which is intended to be carried in the furnace. The force which is due to the gravity of the valve itself is small compared with that due to the spring P; but by changing the weight of the valve and the stiffness of the spring the amount may be varied to any desired extent.

The weight of the valve O performs an important function due to its inertia. The piston $a^2$, on which it is mounted, reciprocates rapidly up and down. During the first half of its descent it is increasing its velocity and during the last half it is decreasing its velocity. These differences of conditions render available the inertia of the valve O to diminish or increase the force with which it is held to its seat at different points of the stroke, and thus to facilitate its opening and closing by aiding to overcome friction, stickiness, &c. During the earliest part of the descent of the piston $a^2$ it is simply compressing the air beneath it; but before it has reached its half-stroke the air beneath it has been compressed to such extent that it commences to be delivered through the valve G. Now, if the air is to escape at all through the safety-valve O, it will commence to do so at this point, and the piston not having yet slackened its speed, the valve O is not so firmly pressed to its seat as it is during the last half of its stroke. This facilitates the opening at that point. It takes more pressure to open an ordinary safety-valve than it does to keep it open after it is once raised, and for that reason it is desirable to have the force holding the valve O to its seat less at this point than at a later period, to overcome the tendency to stick to its seat and the friction of the rubbing parts. In short, the inertia of the valve O, by causing it to press less firmly upon its seat during the first half of its descent and press more firmly during the last half, tends thereby to aid the valve in opening and closing at each stroke, and operates very effectually to prevent the accumulation of pressure to any destructive extent in the apparatus. This peculiarity, by which the inertia of the mass is made available to both open and close the safety-valve at the proper times, may not be very readily understood, but mechanics will be able from the above to construct and use the apparatus, and will be able, with attention, to see that the inertia of the mass O, by contributing to separate it (the safety-valve) from the piston $a^2$ during the early portion of its downstroke and to urge it to its seat during the closing portion, tends to induce a lifting of the safety-valve, and a consequent delivery of the air through the same during a short portion of each stroke, so soon as the pressure begins to be excessive. The period during which the safety-valve will remain open increases as the pressure in the furnace increases, so as longer to resist the increasing tenuency to close; and as (unlike a safety-valve on a steam-boiler) it is never necessary to discharge all the fluid through this safety-valve, the apparatus is very desirably secured against any too high pressure.

A further advantage of mounting the safety-valve on the pump-piston is, that it becomes a regulator of speed as well as of pressure. The speed of the piston is such that a weighted valve would be thrown from its seat at every stroke. Now, by properly proportioning the opening, weight, and spring, a slight increase of speed above the normal point will cause the valve to rise without any increase of pressure, thus preventing the engine from racing under any circumstances.

It may be remarked that the devices previously described will ordinarily avoid a necessity for blowing much air through the safety-valve.

It will be observed that the cylindrical portion of my working-cylinder A is represented as formed of very thin material. I employ in practice sheet-iron of the best quality and about one-sixteenth of an inch thick. This is preferable to cast-iron, not only on account of the small cost of material and the slight labor required in forming it, but also on account of its trifling conduction of heat from the lower to the upper portion. I rivet it at its upper edge to a stout ring of cast-iron or other suitable material (indicated by A′,) and at its lower edge to a corresponding ring, $A^2$, fixed in the brick-work. I perforate these rings A′ $A^2$ with vertical holes, as represented, and rivet to their exterior a corresponding case, $A^3$, of very thin sheet-iron, (Russia iron, by preference,) extending around the cylinder at a little distance therefrom, and forming a mechanical protection against injuries to the inner or true cylinder. I secure these rings by means of rivets countersunk so as to present no projecting surfaces on the inside of the cylinder. The space between the cylinder A and the exterior case, $A^3$, is freely ventilated by the aid of the holes in the rings A′ and $A^2$, cool air coming in constantly through $A^2$, and the same flowing out at a higher temperature through the ring A′.

I form the compressing-cylinder *a′* in a similar manner to the working-cylinder A, above described; but I do not deem it so important to ventilate the space between the compressing-cylinder and its inclosing-case.

I construct and arrange the valves F and G and their seats and connections in a manner which allows them to be very cheaply and easily made and to be very easily accessible for examination or repairs. The mode of doing this is indicated quite clearly in Fig. 1. Each valve is formed with an iron or other rigid plate of an area a little larger than the aperture which the valve is to cover, and with a sheet of leather, vulcanized rubber, or cloth, or other flexible material. The seats of these valves are parallel to each other, and are easily prepared by planing or otherwise to any degree of nicety that may be required.

The bonnet Q, held in place by bolts, (not represented), may be very readily removed and applied. Its removal allows the valves F and G to be very readily removed, and, returning it to its place and securing it by bolts, the valves F and G are firmly and safely held.

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

First. By reason of the fact that my sensitive apparatus *t* and its connections, worked by changes of pressure, operate the directing apparatus *g* so as to turn more or less air below the fire in the manner represented, I am able to rapidly raise and lower the temperature of the air, and to correspondingly change the vigor of the fire by the same simple mechanism, thus tending to keep the pressure uniform for the time being, and preparing the fire to maintain a persistence in that condition, if necessary. I am able by this expedient to keep the temperature of the air in my apparatus at the lowest allowable point under all conditions, and this contributes to the durability of my engine.

Second. By reason of my construction and arrangement of the parts N *n n′ m*, adapted to raise the induction-valve I to variable heights and to lower it to its seat in uniform periods, I am able to throttle or choke the admission of air from the furnace B to the working-cylinder A by the induction-valve itself without varying the point of cut off, and consequently without much varying the terminal pressure. This avoids any evil effects to be apprehended from a partial vacuum at the end of the stroke, is cheaper to construct than an additional throttle-valve, and is not liable to be choked like an ordinary throttle in such an engine, because on each lifting of the induction-valve I it clears itself of any ashes or cinders which may catch under it.

Third. By reason of the fact that my safety-valve, opening outward to discharge fluid when the pressure accumulates, is mounted in the compressing-cylinder $a'$, and is carried vertically and rapidly on the piston $a^2$ and held down upon its seat by the aid of the spring P, I am able to make its inertia available to overcome the friction obstructing its motion, and avoid the liability of its sticking down, and to aid in regulating the motion of the engine.

Fourth. By reason of the fact that my cylinders A and $a'$ are of sheet metal, I am able to construct them more cheaply, and to keep them cooler at the upper end, where the packing is applied, and to make the engine much lighter.

Fifth. By reason of the fact that my protection $A^3$ surrounds the sheet-metal cylinder A, with a free circulation of the external air through the space between, as represented, I am able effectually to protect the thin metal from injury by any ordinary slight accident without materially increasing the heat in the metal.

Sixth. By reason of the fact that my valves G and F are mounted in the manner described on seats cast on the cylinder, as represented, and held in place by the single bonnet Q in the manner shown, I am able to produce and finish them easily without labor in fitting, to save fastenings in holding the valves, and to gain easy access to the whole by the removal of a single part when desired.

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

1. Automatically regulating the proportions of air passing over and through the fire by the variations in the pressure of the air, substantially in the manner and for the purpose herein set forth.

2. Causing the induction-valve I to act as a variable throttle-valve while maintaining a uniform, or nearly uniform, point of cut-off, substantially in the manner and for the purpose herein set forth.

3. Mounting the safety-valves O on the compressing-piston $a^2$ of a hot-air engine, substantially as and for the purpose herein set forth.

4. Constructing the cylinder A or pump $a'$, or both, of sheet metal, in the manner and for the purpose herein set forth.

5. In connection with the last, the ventilated jacket or protection $A^3$, constructed and arranged substantially in the manner herein set forth.

6. The within-described arrangement of the bonnet Q and the valves F and G, with their seats and passages cast on the cylinder, and arranged substantially in the manner and for the purposes herein set forth.

STEPHEN WILCOX, Jr.

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