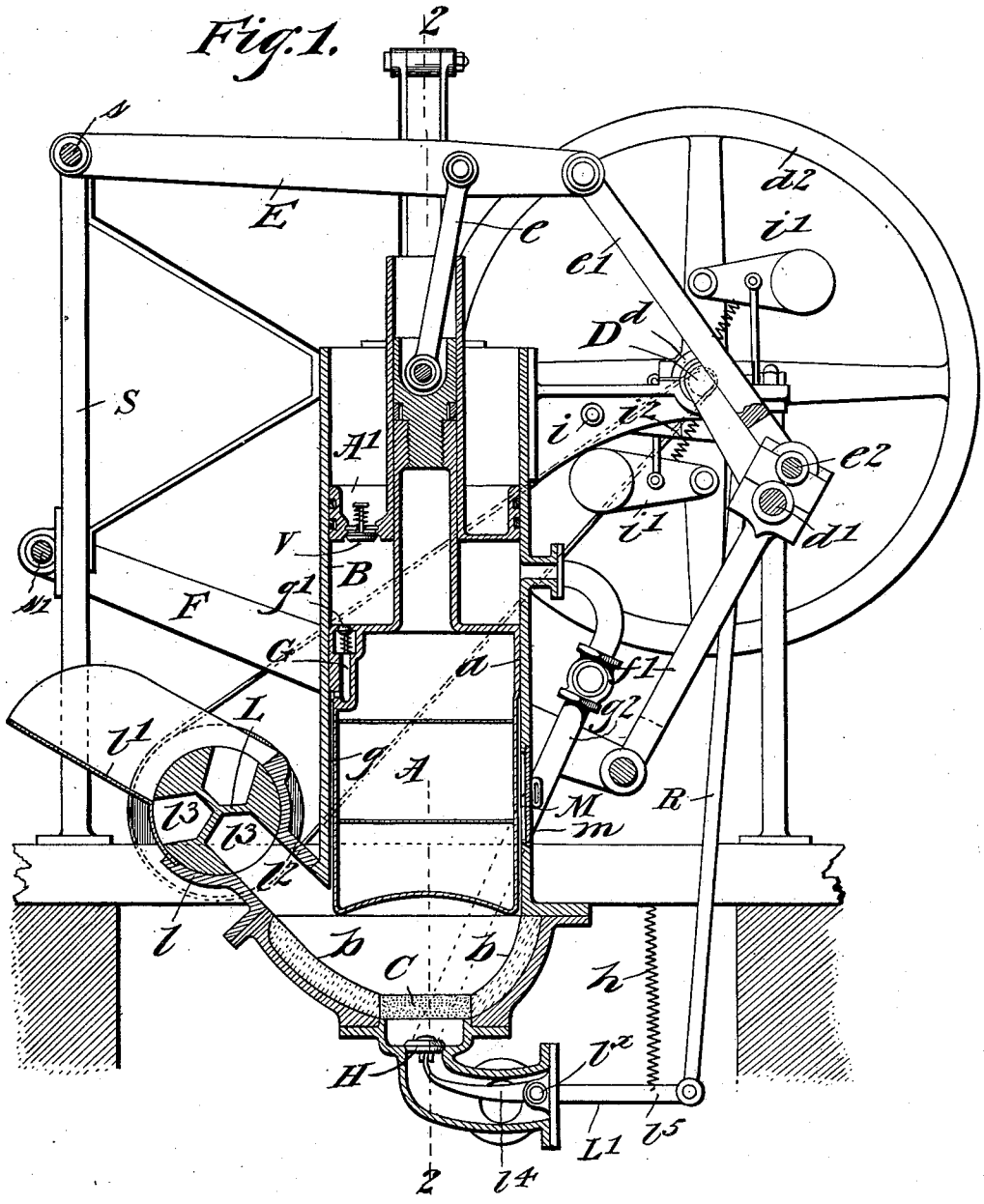
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W. TREWHELLA.

HOT AIR MOTOR.

No. 588,509. Patented Aug. 17, 1897.

Fig. 1.



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Fig. 2.

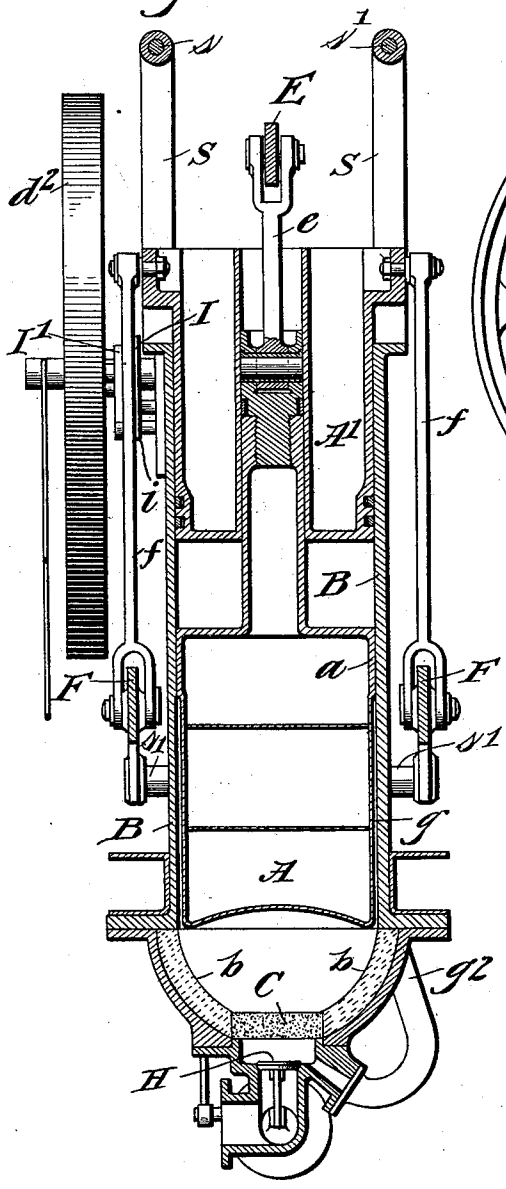


Fig. 4.

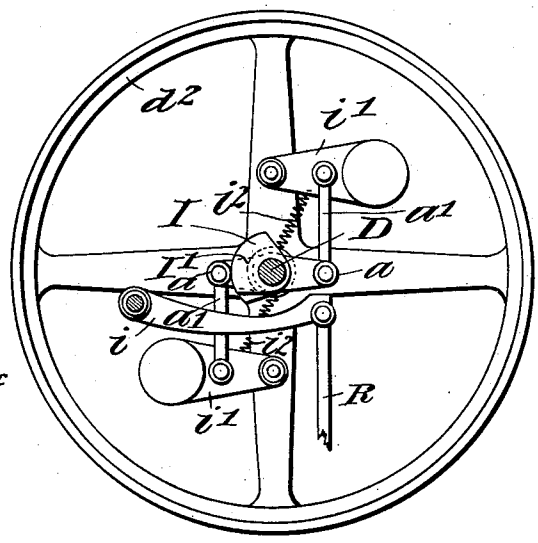
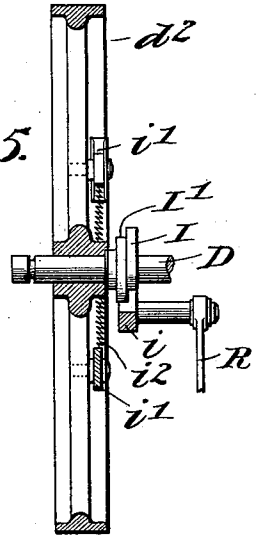


Fig. 5.



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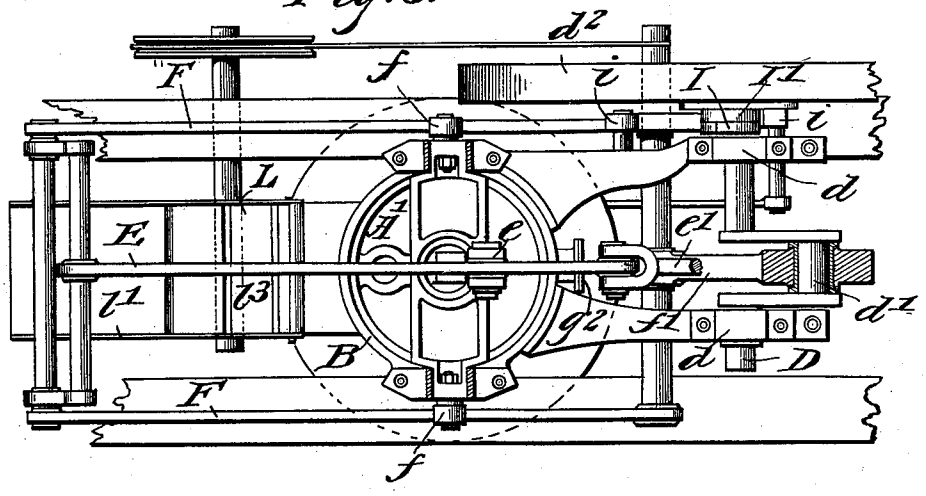
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Fig. 3.



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W. TREWHELLA.

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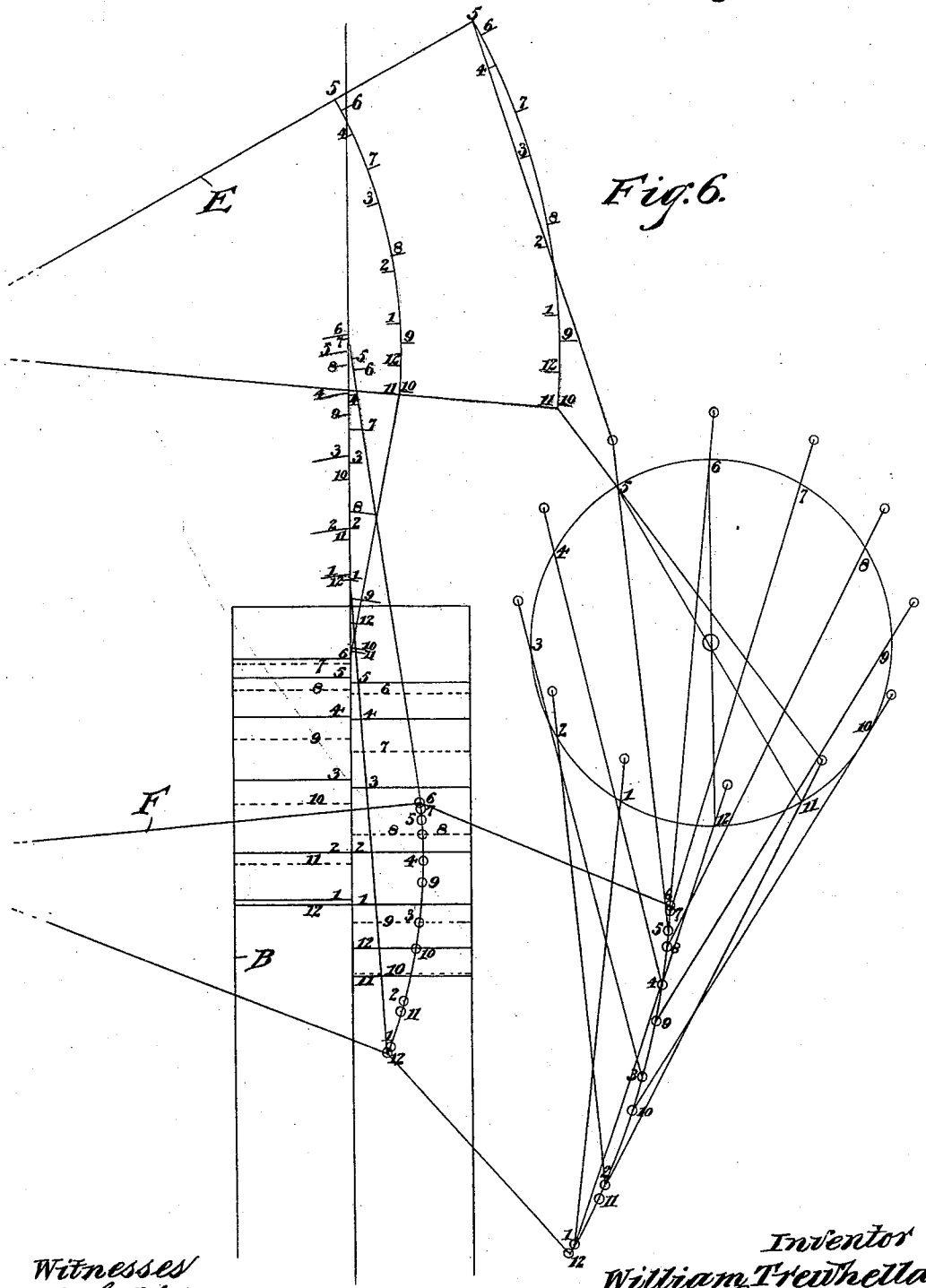


Fig. 6.

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UNITED STATES PATENT OFFICE.

WILLIAM TREWHELLA, OF TRENTHAM, VICTORIA, ASSIGNOR TO THE TRENTHAM ENGINEERING COMPANY, LIMITED, OF SAME PLACE.

HOT-AIR MOTOR.

SPECIFICATION forming part of Letters Patent No. 588,509, dated August 17, 1897.

Application filed May 25, 1895. Serial No. 550,603. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM TREWHELLA, engineer, a subject of the Queen of Great Britain, residing at Sunnyside, Trentham, in the British Colony of Victoria, have invented an Improved Hot-Air Motor, of which the following is a specification.

My invention has relation to hot-air engines; and it has for its object certain improvements whereby the construction of such engines is simplified and their durability materially increased, as will be fully described hereinafter and as shown in the accompanying drawings, in which—

Figure 1 is a vertical central sectional elevation of a hot-air engine embodying my improvements. Fig. 2 is a like view taken on line 2 2 of Fig. 1. Fig. 3 is a top plan view of the engine. Figs. 4 and 5 are respectively a side elevation and a vertical sectional view of the governor, and Fig. 6 is a diagrammatic view illustrating the movements of the pistons.

In the drawings, A and A′ indicate the distributing or displacer piston and the power-piston, respectively, and B the cylinder in which they work, the distributing or displacer piston A being used to force the air admitted between the two pistons into the heated lower end of the cylinder B through the pipe g^2, while the piston A′ transmits the force of the pressure resulting from the expansion of the air to the crank-shaft of the engine. The piston A′ is provided with an air-passage, in which is formed a seat for a check-valve V, that opens inwardly, and the relative movements of the pistons A and A′ are such that a fresh charge of air is taken in at each revolution of the crank-shaft D, the air after having done its work being expelled from the lower end of the cylinder by the displacer-piston A through a passage leading to the atmosphere controlled by a valve H, secured to an arm l^4 of a two-armed lever L′, fulcrumed at $l^\times$, whose arm l^5 is connected to one end of a rod R, the opposite end of which is connected with a lever i of the governor, which is constructed as follows:

On the crank-shaft D, Figs. 4 and 5, are two cams I and I′, close together and arranged to operate the aforesaid lever i, whose end is wide enough to have bearing on both of said cams. One of these cams—namely, the cam I—opens the exhaust-valve H, Figs. 1 and 2, and is rigidly secured to shaft D, while the cam I′ keeps said valve open until the proper time, when it is closed by any suitable means, as a weight, or, as shown in Fig. 1, by a spring h, secured to the arm l^5 of the valve-actuating lever L′ and to a fixed part of the engine, respectively.

The cam I′ is loose on crank-shaft D and is held in about the normal position shown in Fig. 4 by springs i^2, respectively connected with the fly-wheel d^2 and with weighted arms i', pivotally connected with the spokes of such fly-wheel, said weights being connected with the cam I′ by means of links a'.

Should the centrifugal force of the weighted arms be increased by an increase in the speed of the engine, the loose cam I′ will be moved backward in relation to the crank-shaft D, closing the exhaust-valve later and allowing more air to escape without passing into the hot end of the cylinder B, and consequently reducing the resultant pressure on the piston. When working at full power, this closing should take place at about two-thirds of the downstroke of the piston A′, the remainder of the stroke being devoted to the compression of the air in the cylinder; but should the speed of the engine become too great the centrifugal force of the weighted arms i' will overcome the tension of the springs i^2 and will cause said arms to fly outward, moving the cam I′ backward in relation to the shaft D, and consequently allowing the exhaust-valve H to close later, thereby causing some of the fresh air in the cylinder to pass away in the exhaust and thus reducing the compression. The reverse operation will take place when the speed is reduced, a suitable back-pressure valve (not shown) being in practice provided for said pipe g^2.

The crank-shaft D is mounted in suitable bearings d at one side of the cylinder B, while levers E and F are pivoted one above and the other below the level of the crank-shaft D upon a convenient support, preferably arranged on the opposite side of said cylinder, as shown in Figs. 1 and 3. The support is conveniently composed of two uprights S,

connected by cross-rods s and s', on which the levers E F are fulcrumed.

The lever F may be made in two parts—namely, two levers E F, one on either side of the cylinder, as shown—in order to reduce the length of the engine.

The upper lever E is connected by rod e with the upper or distributing piston A, while the lower lever F is connected by rods f or other suitable means with the upper or power piston A', both levers E F being connected with the crank-pin d on the crank of shaft D by connecting-rods e' f' either directly or by means of a joint e^2 on the end of the rods, as shown in Fig. 1. These connecting-rods are pivoted to the working levers at such points that during the greater part of the upstroke of the pistons A A' both connecting-rods e' f' are nearly in a straight line, thus keeping the working levers about the same distance apart and the two pistons practically together, as illustrated diagrammatically by the numerals 1 to 5 in Fig. 6, while on the downstroke they form a more acute angle with one another, bringing the levers E and F closer together and widening the space between the pistons A and A', as indicated by the numerals 6 to 12 in said Fig. 6. It will therefore be seen that on the downstroke the pistons gradually move farther apart until they reach that part of the stroke which is indicated by the numeral 9, when they will be farthest away from each other, after which they again approach until they reach the points marked 1, when they are practically together, being quite close at the points marked 2. The space between the pistons may be adjusted as found desirable by altering the lengths of the connecting-rods e' f' and the position at which they are pivoted to the levers E F, as will be readily understood.

Although the principle of using a distributing or displacing piston between the power-piston and the hot end of the cylinder is peculiarly adapted to the burning of fuel within the cylinder, (because it interposes a screen between the fire and the power-piston and also draws in a charge of cold air below the power-piston at each revolution,) its efficiency may be increased by allowing either the whole or a portion of the air passing from the space between the two pistons to the hot end of the cylinder to pass through a passage G or passages in the upper portion a of the distributing-piston (said upper portion closely fitting the cylinder) into an annular space g, surrounding the lower part of said distributing or displacer piston and down through this space into the fire, the return of such air being prevented by a valve g' in the passage G. In order that the air which goes through this passage into the hot end of the cylinder B may come in contact with the burning fuel, the bottom of said cylinder is made hemispherical, as shown at b, or of such a curve that the air may pass into the fuel without meeting any abrupt turnings or angles. The remainder of the air drawn into the space between the two pistons is forced into the hot end of the cylinder B through a pipe g^2, leading from about the center of the cylinder B to below the regenerator C, as shown in Figs. 1 and 2.

In order to reduce the loss through air remaining in the regenerator C at each stroke, it is preferably made of a mass of loose rounded articles, such as water-worn gravel, sand, or metallic spheres, which as they expose a large surface and thoroughly break up currents of air passing through them have a large heating and cooling effect, while the capacity of the spaces between the particles is small. Moreover, should these spaces become choked by dust or other matter the whole mass may be easily and quickly taken out, cleaned, and replaced, and thus the particles, and consequently the interstices, may be finer than would otherwise be practicable.

In order to feed fuel, such as charcoal or coke, into the furnace or lower end of the cylinder B of the engine without stopping it, the following arrangement may be used: A short cylindrical barrel or drum L is caused to revolve slowly in a curved seating l, attached to the side of the cylinder B above the fire in an air-tight manner in the seating l, which extends about half-way round said drum, as shown. Fitted around the other half of the circumference of the drum is a hopper l' to hold the fuel, the side of the hopper being open, so that the fuel rests against the drum. From the center of the seating l and leading into the furnace of the engine is a passage l^2, and round the circumference of the drum are formed a number of pockets l^3, which become filled with fuel in passing the hopper and discharge the same into the furnace through the passage l^2.

The feed-drum L may be revolved by any suitable means and power. It may receive motion from the crank-shaft, for instance, the speed of said drum being of course regulated according to the amount of fuel to be fed to the furnace in a certain time.

In starting the engine the following arrangement may be used, supposing the engine to be a small one: The fly-wheel is turned to such a position that the pistons A A' are near their highest point and the exhaust-valve H open. The fire is lighted through an opening M, provided for the purpose in the side of the lower end of the cylinder, and is blown up by a suitable bellows or blower held to the said opening, the smoke passing away through the exhaust. When the fire is properly lighted and the interior of the furnace-room is warm, this opening is closed by a door m, and the fly-wheel d^2 on the crank-shaft D is pulled round to cause the pistons to make their downstroke, and as the distributing-piston A moves at a greater speed than the power-piston a partial vacuum is formed in the space between said pistons, whereby the check-valve V is caused to open and air is

admitted to said space until the pistons are about to reach the limit of their downward stroke, at which time the power-piston A′ moves faster than the distributing-piston A, thereby compressing the air between the said pistons, causing the check-valve V to move to its seat, and simultaneously therewith the exhaust-valve H is closed and the air forced through pipe g^2 into the combustion-chamber of the cylinder B through the regenerator C, at which time the power-piston A′ has closed the port leading from the cylinder to the pipe g^2. Under the expansive power of the heated charge of air acting upon piston A and through the latter upon piston A′ the said pistons commence their upstroke.

The power-piston A moves at a greater speed than the distributing-piston for a short time when both pistons move at about the same speed, whereby the distance between them is kept uniform for the greater part of the upstroke or until they reach the limit of their upstroke, when they will again be practically together. As the pistons again move downwardly in the manner described the exhaust-valve H is opened and the spent charge of air driven out and a fresh charge of air drawn in, this being continued until the engine has acquired sufficient momentum to effect the downstroke of the pistons.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is—

1. In a hot-air engine the combination with a vertical power-cylinder, two pistons working therein and the crank-shaft, of levers fulcrumed at one end to fixed supports, parallel with and lying respectively above and below the plane of said shaft, rods connecting the free ends of the levers with the pin on the crank of the shaft and rods connecting the upper and lower levers respectively with the lower and upper pistons, for the purpose set forth.

2. In a hot-air engine the combination with a vertical power-cylinder, two pistons working therein, a crank-shaft on one side and two fixed supports on the opposite side of said cylinder, said fixed supports arranged respectively above and below the plane of said shaft and parallel therewith, of levers fulcrumed at one end to said support, rods connecting the opposite ends of said levers with the pin on the crank of the shaft, and rods connecting the upper and lower levers respectively, with the lower and upper pistons for the purpose set forth.

3. In a hot-air engine, the combination with a vertical power-cylinder, having a combustion-chamber in the lower part thereof, two pistons working in said cylinder, an exhaust-duct leading from the combustion-chamber, a valve for said duct, a regenerator interposed between said valve and the combustion-chamber and a cold-air pipe leading from the space between said regenerator and the exhaust-valve, to about the center of the power-cylinder, of a governor controlling said exhaust-valve and means for imparting to the pistons relative movements such as described, for the purpose set forth.

4. In a hot-air engine the combination with the crank-shaft, a vertical power-cylinder, provided with an air-heating chamber in its lower end, an exhaust-duct leading from said chamber, a valve for said duct controlled by a movable element of the engine, a pipe leading from about the longitudinal center of the cylinder to said air-heating chamber, a power-piston provided with a valved air-inlet passage, a distributing-piston below the same having a lower portion of less diameter than the cylinder, a valved air-passage in the upper larger portion of said piston leading to the space around the smaller portion, of mechanism for imparting to the two pistons relative movements such as described, for the purpose set forth.

WILLIAM TREWHELLA.

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