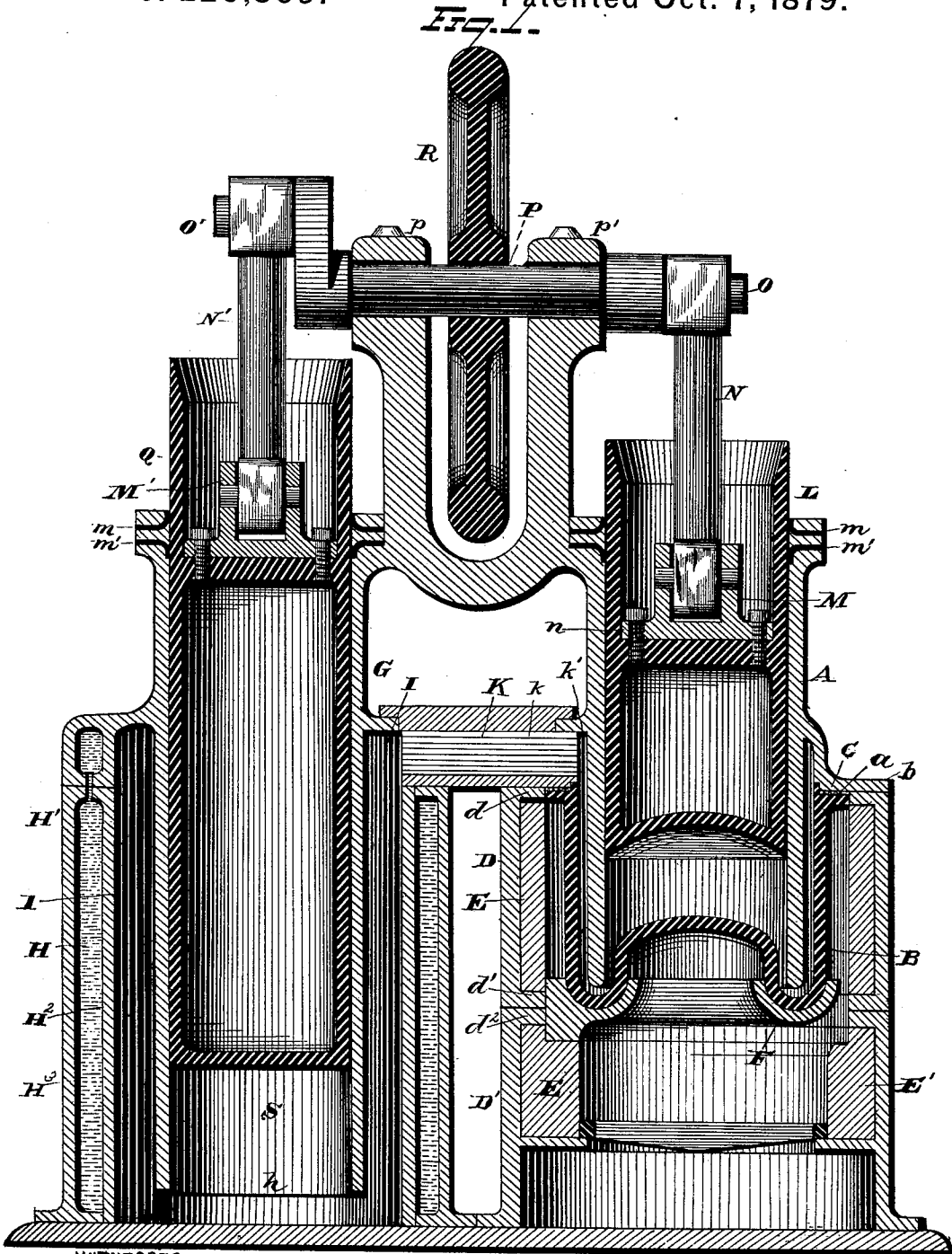


A. K. RIDER.  
Hot-Air Engine.

No. 220,309.

Patented Oct. 7, 1879.



WITNESSES  
*C. J. Nottingham*  
*A. M. Bright*

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Fig. 2.

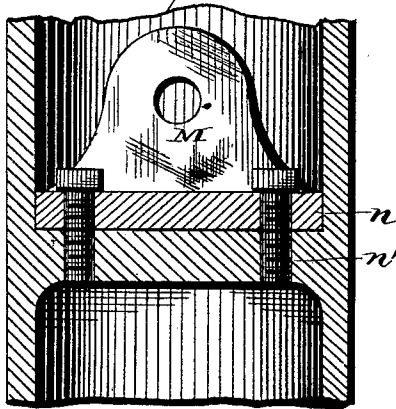
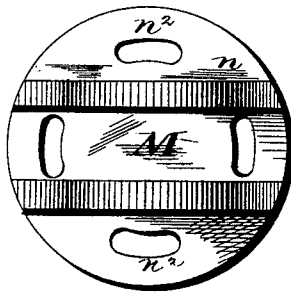


Fig. 3.



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# UNITED STATES PATENT OFFICE.

ALEXANDER K. RIDER, OF WALDEN, NEW YORK, ASSIGNOR TO THOMAS J. RIDER, OF SAME PLACE.

## IMPROVEMENT IN HOT-AIR ENGINES.

Specification forming part of Letters Patent No. **220,309**, dated October 7, 1879; application filed August 27, 1879.

*To all whom it may concern:*

Be it known that I, ALEX. K. RIDER, of Walden, in the county of Orange and State of New York, have invented certain new and useful Improvements in Hot-Air Engines; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it pertains to make and use it, reference being had to the accompanying drawings, which form part of this specification.

My invention relates to an improvement in air-engines.

The class of air-engines to which my improvement pertains is that wherein atmospheric air or other gaseous fluid or vapor is alternately and continuously compressed, heated, expanded, and cooled, the air being reused except such portion of the air or gaseous fluid as may be required to make up the leakage.

The object of my invention is to provide an air-engine of such construction as will insure greater efficiency, capability, and durability as compared with air-engines of this class that have heretofore been manufactured; and a further object is to facilitate the construction of the different parts of the engine, and provide for the convenient and ready removal or substitution of such parts as it may be necessary to remove for repairs.

My invention consists, first, in an air-engine provided with an air-passage extending from the regenerator chamber or passage downwardly between the cooling surface or cylinder and compression-cylinder, whereby a uniform and efficient cooling-surface is insured, and hence the air supplied to the compression-cylinder will be of even and uniform temperature throughout the different parts of the stroke of the compression-piston.

My invention further consists in an air-engine provided with a compression-cylinder extending above and below the regenerator chamber or passage, and an air-passage extending from the regenerator to the lower end of the compression-cylinder, whereby oil or other lubricant is prevented from entering and obstructing the regenerator chamber or passage.

My invention further consists in an air-engine provided with a compression-cylinder extending above and below the regenerator chamber or passage, an annular air-passage around the compression-cylinder extending from the regenerator to the lower end of the compression-cylinder, and an annular water jacket or space encircling said annular air-passage.

My invention further consists in an air-engine provided with a sectional fire-chamber, to allow of the ready removal and replacement of the heater when it has become impaired and unfit for further use.

My invention further consists in an air-engine provided with a sectional fire-chamber, said sections provided with inwardly-projecting flanges, which serve to support the lining and afford means for securing the sections in proper position.

My invention further consists in an air-engine having an asbestos packing-ring interposed between the heater-flange and power-cylinder, to insure a tight and elastic joint between such parts.

My invention further consists in an air-engine provided with a heater constructed of hard white iron, which is very refractory, and will withstand a high degree of heat for a much longer period than the ordinary soft-iron heaters.

My invention further consists in an air-engine having either or both the power and compression pistons provided with a knuckle-joint for the attachment of the lower end of the connecting-rod, said joint constructed with an enlarged base and adapted to be adjusted circumferentially.

In the accompanying drawings, Figure 1 is a view, partly in vertical section and part in side elevation, of my improved hot-air engine. Fig. 2 is a detached view, in vertical section, of the knuckle-joint, and Fig. 3 is a plan view of the same.

A represents the hot-air or power cylinder, and is situated directly over the fire or combustion chamber of the engine. B is the heater, the upper end of which is constructed with an outwardly-projecting flange, *a*, which is provided with any desired number of holes, for the secure attachment of the heater to the

cylinder A by means of bolts. Between the flange *a* of the heater and the flange *b* of the cylinder A is interposed an asbestos packing-ring or gasket, C, which serves to make a practically air-tight joint, and, further, to form an elastic joint, thereby enabling the heater to be firmly bolted to the cylinder without danger of cracking the heater-flange by reason of any uneven warping of the same, due to unequal expansion or contraction of the metal. The heater is made of hard white iron, which possesses sufficient density and hardness to resist for a great length of time the oxidating and disintegrating action of the fire.

Heretofore heaters for air-engines have been found defective, for the reason that they have been made of cast metal, such as common cast-iron, chilled iron, cast-steel, and cast malleable iron, and it has been found that such metals cannot withstand the action of the fire the desired length of time, owing to the oxidating and disintegrating action of the flames in heaters thus constructed.

In the manufacture of my improved heater, I preferably employ a mixture consisting of one-half charcoal iron and one half anthracite iron, and, to secure a smooth face joint to the heater-flange, cast the heater in the same manner; and by the apparatus described and claimed in Letters Patent granted to me September 9, 1879, I am enabled to cast the heater so perfect that I can dispense with facing and drilling, and I therefore use in its construction, as better adapted to the purpose, hard white cast-iron in which the proportion of carbon usually associated with cast-iron is reduced to such extent that the carbon is chemically combined with the molecules of the iron, and not, as in the soft iron, loosely dispersed among and between the crystals. The crystallization of the hard white iron is consequently much finer and denser, and as the primary crystals are in closer contact, the metal is much harder and more impervious to the oxidating-gases of the fire, and consequently much more durable and refractory than soft iron.

The grade of iron I prefer to use is that generally used for the production of malleable-iron castings—namely, charcoal white iron; but I can use a portion of ordinary anthracite white iron with the charcoal iron without seriously affecting the result. In fact, any pure and clean white iron will answer the purpose.

D D' represent the upper and lower sections of the fire-box. The upper section, D, is constructed with an inwardly-projecting flange, *d*, which is bolted to the power-cylinder, and at its lower end provided with an inwardly-projecting flange, *d'*, and rests upon and is secured to a flange, *d''*, formed on the upper end of the lower section, D'. A lining, E, of refractory material is placed in the upper section, D, and is supported by the flanges *d* *d'*. The lower section, D', which constitutes the fuel-chamber, is also provided with a refractory lining, E'.

A shield, F, of refractory material, and made either of independent sections or in a single piece, is located beneath the lower end of the heater, and serves to prevent the direct contact of the flames therewith. Shield F is located so that its periphery will overlap the joint between the upper and lower sections of the fire-box, and thereby protect the same, and further prevent the escape of hot air from between said joint.

If desired, I may place a packing of asbestos between the joints formed by the adjacent flanges of the upper and lower sections of the fire-box. While I have shown the fire-box as being constructed of two sections, I would have it understood that I do not limit myself to the exact construction, as more than two sections may be employed, if desired.

Heretofore in this class of engines it has been necessary to take the main parts of the engine apart in order to replace or repair the heater. By my improved construction of sectional fire-box I obviate this difficulty, as the section or sections thereof can be readily removed, and allow of the ready and convenient removal and replacement of the heater, without disturbing or disconnecting the several parts of the engine.

G represents the compression-cylinder, which extends down nearly to the base of the engine. H is a cooler, consisting of the outer shell, H<sup>1</sup>, and inner shell, H<sup>2</sup>, together forming an intervening space, H<sup>3</sup>, within which a current of cold water is kept in constant circulation, to keep the walls of the cooler at a comparatively low degree of temperature. The inner shell, H<sup>2</sup>, of the cooler is of sufficiently greater diameter than the compression cylinder G to form an intervening annular air-passage, I, which extends from the top to the bottom of the cooler, and communicates freely with the lower and open end, *h*, of the compression-cylinder.

K is a regenerator-chamber, within which the plates *k* are arranged in either a vertical, horizontal, or other desired position. Regenerator-chamber K connects at one end with the air-passage *k'* at a point above the heater in the fire-box, while the other end of the regenerator-passage communicates with the annular air-passage around the compression-cylinder and within the upper portion of the cooler. This construction and arrangement of parts is of great value and importance, as will hereinafter be explained.

L represents the hot or power piston, which is fitted in the power-cylinder, and in its downward stroke descends into the heater, which surrounds the power-cylinder.

The upper end of piston L is provided with a connecting-rod knuckle, M, to which the lower end of connecting-rod N is journaled, the upper end being fitted to a crank, O, on the crank-shaft P.

In the compression-cylinder is fitted the compression-piston Q, which fits the cylinder

snugly throughout its length, and extends when at the bottom of its stroke down to the base of the engine.

Compression-piston Q is provided with a connecting-rod knuckle, M', to which the lower end of the connecting-rod N' is journaled, the upper end of the latter being fitted to the crank O' on the crank-shaft P.

Cranks O O' are arranged at nearly a right angle to each other, the power-crank O being in advance in the direction of revolution.

R is a fly-wheel, attached to the crank-shaft P at a point between the bearings *p p'*.

Both the power and compression pistons are preferably of the type known as trunk-pistons, which are packed by cup-leathers *m m'* and follower, the latter of such form as to support the leather at the corner formed by the junction of the follower and piston, substantially as described in English patent of Robert Ogilvie, dated May 13, 1871. These cup-leather packings are arranged in pairs, the lap of the under one being turned down to resist the internal pressure, while the lap of the upper packing is turned upward to prevent the oil from entering too freely. The followers are placed between each pair of packings, as clearly shown in Fig. 1 of the drawings.

The connecting-rod knuckles M M' are each provided with a base, *n*, of practically the same diameter as the inner diameter of the piston, said base being secured to the diaphragm *n'*, formed in the piston.

The base *n* of the knuckle is provided with a number of elongated or arc-shaped slots, *n<sup>2</sup>*, to receive the bolts or studs which serve to fasten it to the piston, the slotted holes allowing an easy circumferential adjustment of the knuckle, to enable the end bearings of the connecting-rod to be brought in parallelism with each other, and thus insure the perfect adjustment and operation of the wearing parts of the connecting-rod-knuckle bearings and cranks on the crank-shaft.

The operation of the engine is briefly as follows: Assuming the compression-piston to be at the top of its stroke, it will, on descending, compress the air below it until, by the rise of the power-piston, the air will be transferred into the heater under the power-piston, on which it will act by its pressure and increased volume due to the heating. As the power-piston now rises the whole of the charge of the air will occupy the hot or power cylinder till the rise of the compression-piston will cause its transfer into compression-chamber under the compression-piston, where the operation will be repeated at the next revolution. In the meantime the air in passing through the regenerator leaves and takes up a portion of the heat at each revolution.

When the air flows from the regenerator to the compression-cylinder it is desirable that it shall be rapidly cooled and subjected to a uniform decrease in temperature irrespective of the position of the compression-piston.

Many radical defects have heretofore existed in hot-air engines of this type in this regard—to wit, in the rapid and uniform cooling of the air as it enters the compression-cylinder; and as an illustration of such defective construction of hot-air engines, reference is made to the form of hot-air engines shown and described in Letters Patent No. 167,568, granted to me September 7, 1875. In this latter instance the regenerator-chamber is in direct communication with an annular air-passage surrounding the compression-piston, the current of air being conveyed through the restricted annular passage formed between the piston and the inner surface of the cooler. This construction is objectionable and defective for several reasons. The annular-cooling-passage varies in length, according to the position of the compression-piston. When the piston is on its upstroke the cooling-passage is shortened to such an extent as to render the operation of cooling only partially effective.

In my improved construction the air entering the compression-cylinder from the regenerator is caused to flow downwardly a certain fixed distance in direct contact with the cooling-surface, and then beneath the compression-cylinder and into the compression-chamber S, located below the compression-piston.

Another defect in the construction of engines above referred to is as follows: The hot air flowing into the compression-cylinder from the regenerator comes in direct contact with the surface of the compression-piston, and as it flows in quite a strong current it operates to rapidly evaporate the lubricant on the piston, and thus necessitate the employment of an undue amount of oil or other lubricant, but also operates to leave the residuum of the lubricant adhering to the surface of the piston, and cause the latter to offer considerable resistance to its free and easy operation.

In my improved hot-air engine this defect is obviated, as the inflowing current of hot air from the regenerator is prevented from coming in direct contact with the surface or periphery of the compression-piston by reason of the compression-cylinder, which serves as the inner wall of the air-passage, and operates to deflect the current of air and convey it directly to the compression-chamber, below the lower end of the compression-piston.

Again, when the compression-piston operates in direct contact with the mouth or opening of the regenerator, the oil used in lubrication will enter the regenerator-chamber and obstruct the regenerator. This defect is obviated in my improvement, as the compression-cylinder extends above and below the regenerator, and serves as an effectual seal in preventing any oil from entering the regenerator-chamber.

It is evident that many slight changes in the construction and arrangement of parts of my improved engine may be resorted to without departing from the spirit of my invention, and

hence I do not limit myself to the exact construction shown and described; but,

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

1. In a hot-air engine, the compression-cylinder arranged to extend downward into the cooler and form an air-passage leading from the regenerator-chamber to the bottom of the compression-cylinder, substantially as set forth.

2. In a hot-air engine, the compression-cylinder arranged to extend downward into the cooler and form an annular air-passage extending from the regenerator to the compression-chamber in the lower open end of the compression-cylinder, substantially as set forth.

3. In a hot-air engine, the compression-cylinder arranged to extend above and below the regenerator, and an annular air-passage connecting the regenerator-chamber with the lower and open end of the compression-cylinder, substantially as set forth.

4. In a hot-air engine, the connecting-rod connected to the piston by means of a knuckle having a broad base, and adapted to be adjusted circumferentially, substantially as set forth.

5. In a hot-air engine, the fire-box thereof formed of removable sections, to allow of the

ready removal and replacement of the heater, substantially as set forth.

6. In a hot-air engine, the fire-box made in sections, each section provided with an inwardly-projecting flange and lined with refractory metal, substantially as set forth.

7. In a hot-air engine, a packing-ring or gasket formed of asbestos, and interposed between the flanges of the heater and power-cylinder, substantially as and for the purpose set forth.

8. A heater for hot-air engines composed of hard white cast-iron, substantially as set forth.

9. In a hot-air engine, the compression-chamber S, located below the compression-cylinder, and communicating with the regenerator by an air-passage which allows the air to flow upwardly into said compression-chamber from an annular air-passage surrounding the compression-cylinder, substantially as and for the purpose set forth.

In testimony that I claim the foregoing I have hereunto set my hand this 23d day of August, 1879.

ALEXANDER K. RIDER.

Witnesses:

H. B. WOOSTER,

W. G. RUTHERFORD.