August 4, 1913.

DRAWING

9,909

A careful search has been made this day for the original drawing or a photolithographic copy of the same, for the purpose of reproducing the said drawing to form a part of this book, but at this time nothing can be found from which a reproduction can be made.

Finis D. Morris,

Chief of Division E.

AWK

UNITED STATES PATENT OFFICE.

AUSTIN OLCOTT WILLCOX, OF PHILADELPHIA, PENNSYLVANIA.

HOT-AIR ENGINE.

Specification of Letters Patent No. 9,909, dated August 2, 1853.

To all whom it may concern:

Be it known that I, AUSTIN O. WILLCOX, of the city and county of Philadelphia and State of Pennsylvania, have invented a new and improved caloric air-engine for the purpose of producing motive power by the alternate expansion and contraction of air or other aeriform fluids by the agency of heat; and I do hereby declare that the following is a full and exact description thereof, reference being had to the accompanying drawings, making part of this specification.

Figure 1 being a vertical section through the centers of the cylinders; Fig. 2, a transverse vertical section in the line *x x* of Fig. 1, and Fig. 3 a horizontal section of one of the pistons in the line *y y* of Fig. 1.

Like letters designate corresponding parts in all the figures.

I employ, as a medium, air, or any other convenient aeriform fluids, which is to be contained in a tight reservoir. Said reservoir may consist of any number of vessels, of any suitable form, and situated where most convenient. In the drawings, it is represented as composed of two chambers E, E, one on each side of the engine, and communicating freely with each other through a pipe, *a*. These chambers are also to serve as refrigerators, for reducing the temperature of the air to the proper degree, after passing through the engine. For this purpose, they may be surrounded with narrow spaces *c*, *c*, to be kept filled with cold water; or the water may be caused to pass through the reservoir in pipes; or any equivalent means may be employed. In marine engines, it is best to make the reservoir of a number of pipes, to be distributed in the sides of the vessel, so that the water of the sea will serve to cool the air therein. I employ any required pressure of the medium—several atmospheres if desired—and generally use more pressure than a single atmosphere.

A condensing pump *b*, is applied to the reservoir for the purpose of condensing the air therein to the required pressure. An ordinary safety-valve may also be applied thereto to prevent producing too great a pressure.

In the application of the medium to produce power, I use two cylinders B, C, both on one axis, head to head, or more conveniently side by side, as represented in the drawings, so as to operate alternately on opposite ends of the working-beam A. The air within them is heated directly from the furnaces D, D, below; so that it operates only to lift the pistons H, I, which are, each in turn, carried down again by their own weight, and by the power of the other cylinder while ascending. The upper heads of the cylinders are closed, in order to shut out the external atmosphere, and for other reasons hereinafter to be set forth. I usually inclose each cylinder within a jacket *f*, of any material, which is a bad conductor of heat; and outside of this I place a concentric vessel *e*, open at the top and surrounding an annular space between it and said jacket, to be filled with water, for the purpose of keeping the temperature of the cylinder sufficiently low to prevent injuring the lubricating fluid of the piston inside. Since the heat acts most powerfully on the lower part of the cylinder, and with gradually diminishing effect toward the top thereof, the cooling effect of the water is correspondingly adjusted by making the protecting jacket *f*, thinnest at the bottom, and gradually thicker toward the top, in a ratio to be ascertained by calculation or experiment, but for which no certain rule can be given.

I usually employ two piston rods P, P, for each piston, arranged as shown in the drawings; and have them descend through the bottom of the cylinder. These piston-rods are hollow, whereby they serve also as pipes for supplying the air to the cylinders. Their lower ends are hinged to joint pipes *t*, *t*, which connect them with the stationary induction pipe *k*, and enable them to traverse their strokes without disturbing the supply of air, or even varying the capacity of the whole supply pipes. The connecting-rods N, N, are hinged to the piston-rods, in the manner shown in the drawings.

Each cylinder is supplied with a proper amount of air for each stroke from a supply-chamber G, of the requisite capacity for that purpose. Its own contents are renewed from the reservoir, at each stroke of the pistons, by means of a double-acting transferring cylinder F, whose piston R, is connected by a rod *u*, with the working-beam A, and the length of whose stroke is such as to displace as much cold air as will supply the working cylinder B, or C, when heated

to the proper degree. The air is brought from the reservoir through a pipe *d*, into a chamber M, at the side of the transferring cylinder. Only one supply-chamber *d*, is represented in the drawings; but it is preferable to have two supply-chambers, one for each working cylinder, which are to be alternately connected with, and cut off from, the transferring cylinder by their self acting valves, so that, while either is supplying its working cylinder, it shall be cut off from said transferring cylinder and, at the same time, the other chamber shall be charging. The object of this arrangement is to cause the pressure of air from the supply-chamber into the working-cylinder to diminish correspondingly with the diminished assistance to its ingress, as the piston rises; in order that the air may enter the working-cylinder in as large a volume as possible, for the purpose of receiving from the renovating disks, while passing through them, as much of their accumulated heat as it can, thus requiring a less supply of heat from the furnace below to produce the requisite expansion; and also to obviate the difficulty, which would otherwise be experienced, in making the induction valves *p*, *p*, operate at the proper moment. The upper end of each cylinder is closed by a head, to exclude the external atmosphere. It is made convex at the top, and plane at the bottom, in order to inclose a space S, whence a pipe *r*, extends to the reservoir, through which the air is discharged from the cylinder. A self-acting valve *m*, opens upward from the cylinder into said chamber S, so as to allow free exit to the air above the piston, but not to permit any to return into the cylinder, when the pressure therein becomes less than in the reservoir.

Each piston is a "renovator," and is constructed in the following manner:—In the upper part of the piston is a compartment *h*, into which the piston-rod pipes P, P, open. Below this, is a second compartment, of the proper capacity, and is filled with a great number of thin, numerously perforated metallic disks, wire gauze, woven metallic strips, or any other arrangement by which a very great number of interstices, and metallic surfaces are produced. Below this renovating compartment is a hollow head *i*, for the purpose of preventing the heat below the piston from operating immediately against said renovating compartment. Apertures *l*, *l*, &c., furnish a free communication between the renovating compartment and the compartment *h*, and also with the cylinder below the piston. The pipes P, P, are closed at the top with slide-valves, *p*, *p*, arranged as shown in Fig. 3, and operated by a rod *s*, which slides up and down with the piston, and is caused to vibrate at the proper moment sufficiently to operate the valves, by means of any suitable and well-known device. Another valve *n*, operated in a similar manner by the rod *s*, regulates the communication between the chamber *h*, and the cylinder above the piston.

The piston H, in the drawings, is represented as just commencing its downward movement. Its valves *p*, *p*, are closed, so as to exclude the cold air from the supply chamber; and its valve *n*, is opened, to allow the escape of air up through the piston. As the piston descends, the heated air from the cylinder below rushes up through it, imparting a large portion of its heat to the renovator *g*, and occupies the space in the cylinder above the piston. As it loses so much of its heat, its expansive force becomes much lessened, and thus constantly increases the facility of the passage of air through the piston. Its expansive force, at the same time, being less than that of the air in the reservoir; since, being nearly as low in temperature as the cold air therein, it occupies proportionally as much greater space, as the capacity of the cylinder is greater than the capacity of the condensing cylinder F; the valve *m*, is closed, and prevents the return of cold air from said reservoir to the cylinder. On the piston's reaching the bottom of the cylinder, its valves *p*, *p*, are opened, and the valve *n*, shut, ready for the ascending movement; which will be illustrated by the movement of the piston I, as follows:—The cold air rushes from the supply chamber G, into the compartment *h*, of said piston and thence down through the renovator *g*, (which was heated in its last descending movement,) whence it receives a large amount of heat, expanded by which it enters the cylinder below the piston, and there being still further heated by the furnace below, it causes the piston to ascend; during which movement, the air above the piston is driven into the reservoir. The valves *p*, *p*, are closed as soon as the requisite amount of air has been received into the cylinder to finish the stroke; which happens before the piston reaches the top of the cylinder; but the valve *n*, is not opened till the piston completes its upward movement.

The effective power of the engine is to the actual pressure of air below the piston as the volume of air, when cold, is to its volume when heated, after deducting the usual loss by friction, &c.; or, in other words, as the capacity of the transferring cylinder F, is to the capacity of each working cylinder; and, when the diameters of said transferring and working cylinders are equal, this ratio will be as the comparative lengths of their respective strokes. Any desirable amount of pressure on the pistons is produced by condensing the medium, thus forming a powerful engine, which occupies comparatively little space. The engine is rendered more

compact by having the renovator in the piston itself, and by applying the fire immediately under the cylinder.

I do not claim the use of renovating disks outside of the working cylinder, either when alternately traveling through the heated and cold air, or when stationary and alternately transmitting heated and cold air, as I am aware such have been before used; but

What I do claim as my invention and desire to secure by Letters Patent, is—

1. Placing the economizing disks *g*, within, or attaching them to, the driving piston itself, whereby I am enabled to effect the complete rarefaction of the heated air, while the piston is descending, and before the cold air is again let into the cylinder, substantially in the manner and for the purposes herein described.

2. I also claim inclosing the exhaust end of each single-acting working cylinder, with an air-tight head, when combined with a self-acting valve *m*, which opens from said exhaust end of the cylinder into the eduction pipe *r*, in order to exclude the external atmosphere, and also for the double purpose of enabling any degree of rarefaction to take place within the exhaust end of the cylinder, without the return of air from the reservoir E, and to allow the spent air finally to escape to said reservoir, substantially as herein set forth.

3. I also claim, inclosing each working-cylinder within a jacket *f*, (of any suitable material,) regularly increasing in thickness, from the bottom to the top, in such a manner that, when it is surrounded by water, or other fluids, the temperature of the working-cylinder will be kept reduced to a proper and nearly uniform degree, (without much waste of heat,) so as not to injure the lubricating fluid inside; whereby I am enabled to apply the heat of the furnace immediately under said cylinder, thus obviating the use of an expansion-heater, substantially as herein described.

The above specification of my new and improved caloric air engine, for the purpose of producing motive power by the alternate expansion and contraction of air, or other aeriform fluids, by the agency of heat, signed by me this third day of June 1853.

AUSTIN O. WILLCOX.

Witnesses:

J. S. BROWN,

GEO. A. C. SMITH.