4 Sheets—Sheet 1.

B. F. McKINLEY.

Hot-Air Engine.

No. 206,597. Patented July 30, 1878.

Fig. 1.

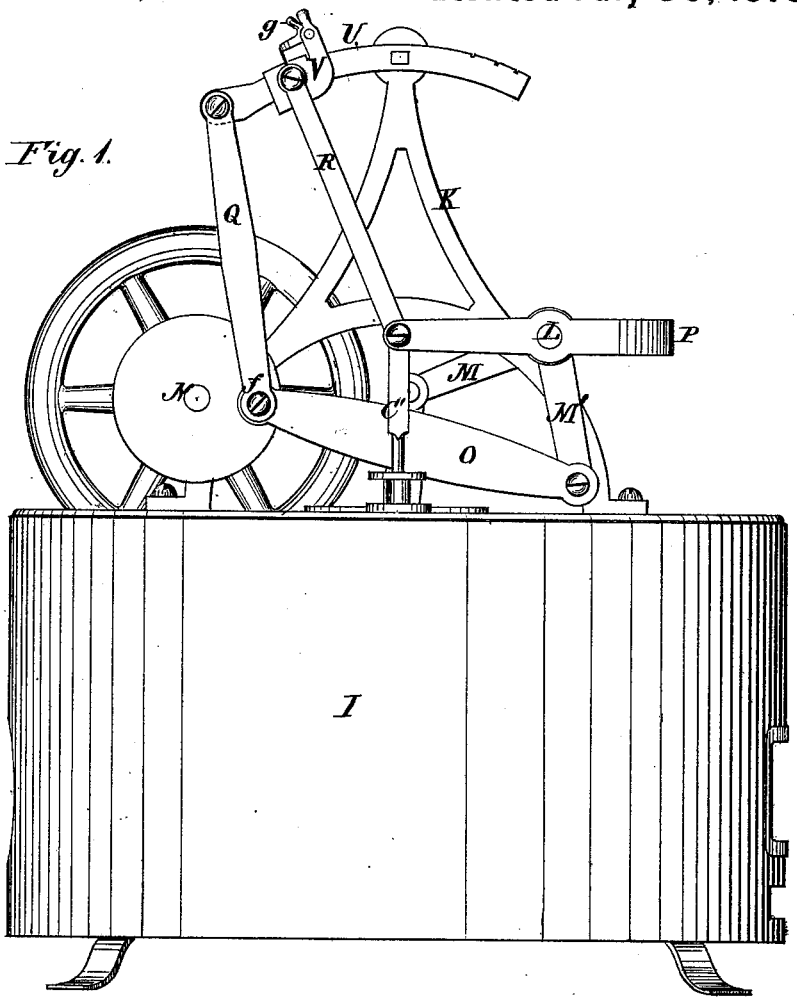

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Fig. 2.

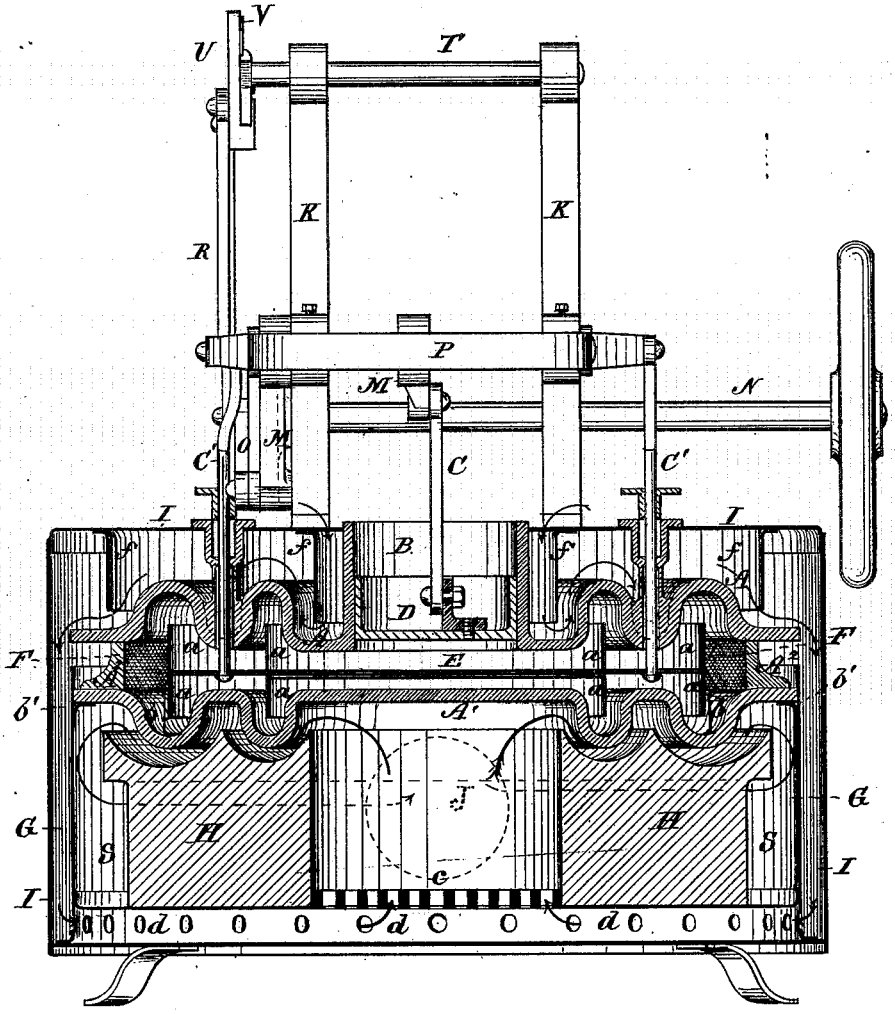

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Fig. 3.

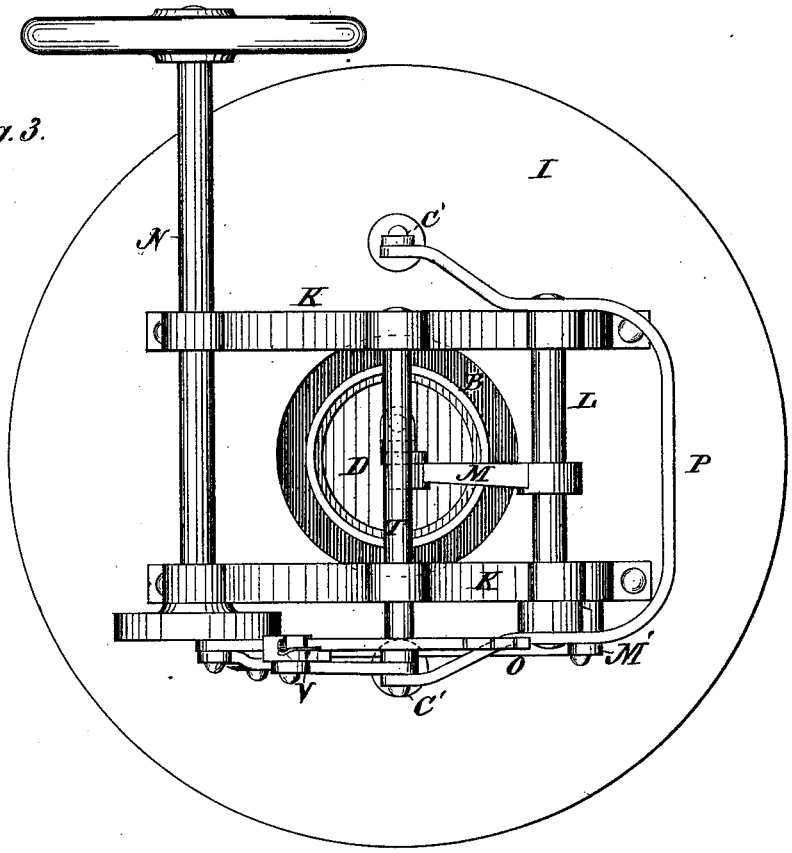

Fig. 6

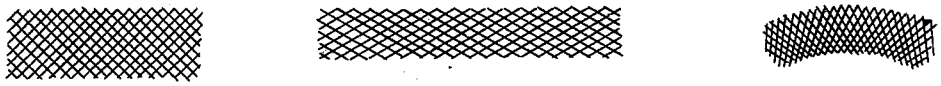

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Fig. 4.

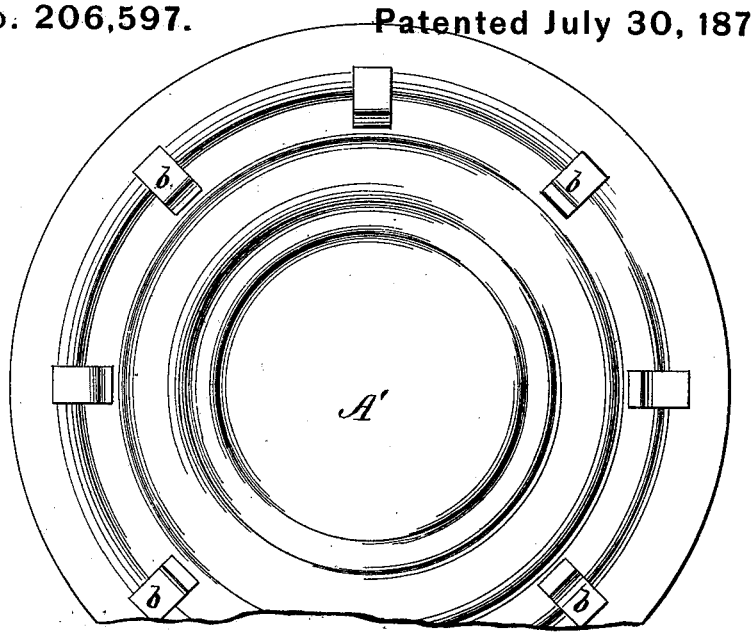
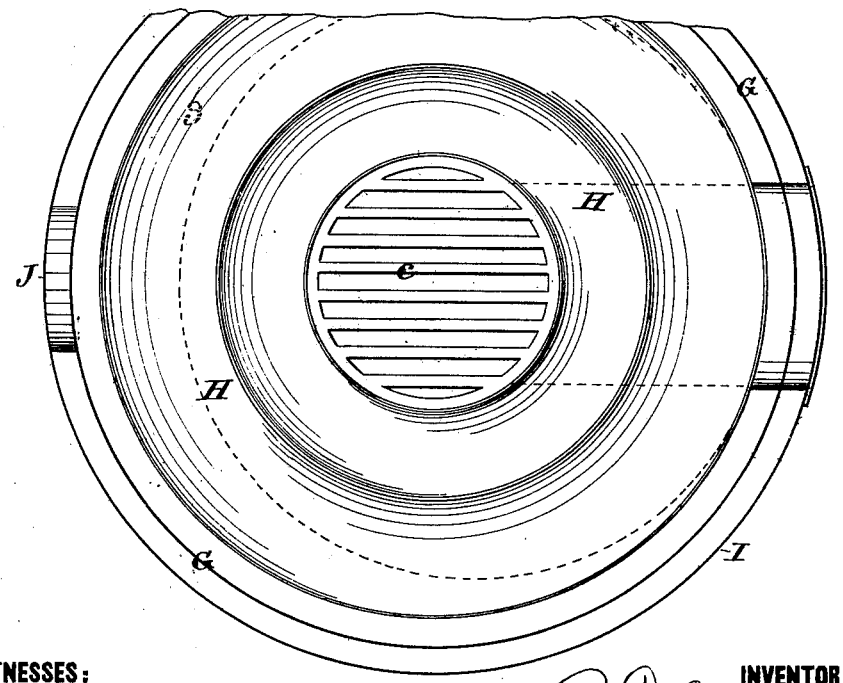


Fig. 5.



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UNITED STATES PATENT OFFICE.

BENJAMIN F. McKINLEY, OF MORNING VIEW, KENTUCKY.

IMPROVEMENT IN HOT-AIR ENGINES.

Specification forming part of Letters Patent No. **206,597**, dated July 30, 1878; application filed March 30, 1878.

To all whom it may concern:

Be it known that I, BENJAMIN F. McKINLEY, of Morning View, in the county of Kenton and State of Kentucky, have invented a new and Improved Hot-Air Engine; and I do hereby declare that the following is a full, clear, and exact description of the same, reference being had to the accompanying drawing, forming part of this specification, in which—

Figure 1 is a side elevation; Fig. 2, a vertical central section. Fig. 3 is a plan view; Fig. 4, a detail plan view of the lower disk of the regenerating-chamber, partly broken away; Fig. 5, a detail plan of the furnace-bed, with the regenerating-chamber removed, also partly broken away. Fig. 6 are details, illustrating the different shapes which a piece of wire-cloth may be made to assume when cut diagonally.

My invention is an improvement in hot-air engines, designed to secure a greater degree of efficiency by increasing the difference of temperature in the regenerating-chamber, and to adapt the engine to be readily regulated, reversed, or thrown out of action.

The general form of engine upon which my improvement is based is that in which a regenerating-chamber containing a displacer is combined with a working cylinder and piston, which cylinder and chamber have intercommunication, and which piston and displacer are geared together to operate in succession, so that as the displacer moves in one direction heated air from the regenerating-chamber is forced through a regenerating-packing of woven wires, which absorbs the heat, and, by producing a partial vacuum, draws back the working piston, which movement of the working piston causes the displacer to move in the opposite direction, and force the comparatively cooled air back through the woven-wire regenerating-surfaces, which, in giving up their heat to the air, cause it to expand and force outwardly the working piston, thus securing a continuous action by the alternate passage of the air and its differential expansion in a closed chamber.

My improvements consist, first, in the form of the regenerating-chamber, constructed of two corrugated disks, and combined with a disk-shaped displacer, having circular wings entering the corrugation, and an annular stationary regenerating-surface about the periphery of the same and within the chamber, whereby a greater degree of heat is secured for the heating-surface, a lower temperature for the cooling-surface, and a more winding or tortuous passage given to the traversing currents.

The invention also further consists in the construction and arrangement of the regenerating-surfaces; in the construction and arrangement of the furnace; and in the means for controlling the speed, reversing the engine, or for stopping the action of the same, as hereinafter more fully described.

In the drawing, Fig. 2, A represents the upper disk; A^1, the lower disk; and A^2, an intermediate collar, which, when bolted together with ground joints, constitute the regenerating-chamber. Both these disks are formed with concentric corrugations, which give an increased superficial area to both the outer and inner surfaces of the chamber. Centrally from the upper disk rises a cylinder, B, which is in open communication below with the regenerating-chamber, and is open, also, at the top, to permit the passage of the pitman C in connecting with the cup-shaped piston D, working in said cylinder. E is the displacer. This consists of a disk made of several layers of sheet metal, to prevent lateral transmission of heat, and provided with concentric wings *a*, adapted to enter the annular recesses formed by the corrugation. Just outside of this displacer, and upon seats *b*, Figs. 2 and 4, secured between the lower disk, A^2, and collar A^1, is arranged an annular regenerator, F, which consists of a stationary packing of woven-wire cloth.

Now, the regenerating-chamber being located above a furnace, and the piston D and displacer E being connected, through their rods C and C′ C′, with the working machinery above, so that the piston moves after the displacer and in the same direction with it, it will be seen that as the displacer rises it forces the comparatively cool air, which is above it, down through the regenerating wire packing, which, in giving up its heat to the air thus forced through, causes the air to expand,

which drives the working piston up and starts the displacer down. As the displacer descends, then the hot air below the same, next to the furnace, is forced through the regenerating-wires, and in surrendering its heat to said wires and to the cooler upper corrugated plate is caused to contract, which brings the piston down and starts the displacer up again for a repetition of the same action.

The heating-surface below being increased by the corrugations of the lower disk, and the cooling-surface above being increased by the corrugations in the upper disk, it will be seen that a greater difference of temperature of the air in the chamber above and below the displacer is attained. This difference is rendered still greater by the tortuous or winding passages of the air in moving around the displacer, and the fact that toward the ends of the stroke of the displacer the wings of the same approach more closely the surfaces of the corrugated disks, and thus compel the currents to be brought into closer and more intimate relation to the walls of the chamber to be heated or cooled thereby, as the case may be. Thus it will be seen that the efficiency of the engine is considerably increased by increasing the margin of difference in temperature upon which the operation of this class of engines depends.

A peculiar feature of the concentrically-corrugated plates, as distinguished from the heater-bottoms of other engines having a single return fold, is that the plates can be made of any required size without buckling by the expansion from the heat, the expansion being taken up at each corrugation, and at the same time the corrugations tend to strengthen the plates and prevent springing under pressure, yielding radially but not laterally.

Instead of forming the upper disk of the regenerating-chamber with a cylinder for the working piston opening directly into the same, said regenerating-chamber may connect, through suitable pipes, with a cylinder removed from the same.

In arranging the regenerating-chamber it is supported upon lugs b', attached to the furnace-casing G, in which casing is arranged centrally the grate c for the fire, about which rises a wall of iron or fire-brick, H, Figs. 2 and 5, whose upper surface is corrugated, to bring the flames and hot currents from the furnace into direct contact with the corrugations of the regenerating-chamber.

I is an outer cylindrical casing surrounding the whole lower portion of the engine, and opening only at its top immediately above the working cylinder. To the under side of the top portion of this casing are attached concentric pendent flanges f, which descend into the channels of the upper corrugated disks. Said casing, with its flanges, serves to control the direction of the currents of air which feed the furnace, and involves a feature of great merit. In taking the air from the exterior of the case just at this point, it will be seen that the cold air is brought first in contact with the upper portion of the regenerating-case, which requires to be kept cool, thus still further increasing the difference in the temperature within the regenerating-chamber; and to the extent that it secures this desirable result for the upper portion of the regenerating-chamber, to the same extent, also, does it secure a better result for the furnace, for the reason that the air becomes, to some extent, heated before it reaches the furnace, and both makes a hotter fire and economizes fuel. As the air passes in at the opening in the case I at the top, it passes down the annular space between the outer case, I, and inner case, G, then passes laterally through the holes d beneath the wall H to the grate. Then as the flames and products of combustion pass upwardly they strike the bottom of the lower disk, A^1, of the regenerating-chamber, and, spreading radially, pass between the upper corrugated surface of the wall H and the lower corrugated surface of the regenerating-chamber, passing over the edges of said wall downwardly into a circumferential flue, S, in between the wall and case G, and thence out through an escape-pipe, J.

In constructing the regenerating wire packing-ring, I have found that the stamping out of annular pieces of the same diameter is wasteful in the extreme, and is also objectionable for other reasons. In overcoming these objections I cut the wire in straight strips diagonally to the weaving, (see Fig. 6,) and pack these strips separately in the seat for the same in the regenerating-chamber. By cutting the strips in straight pieces I utilize all of the wire-cloth, while by cutting the same diagonally I have found that it permits the wire-sections to be bent round in any shape without buckling, and causes the section to adjust itself to the irregularities of the seat to form a tight packing, which compels the air to pass through the meshes or interstices. This peculiar action of the diagonally-cut section in adjusting itself to varying transverse dimension is due to the principle of the lazy-tongs, the laps of the wires corresponding to the joints of the said well-known mechanical movement.

In connecting the pitmen C and C′ C′ of the working piston and displacer, respectively, for continuous operation and for stopping or reversing the engine, a frame-work, K, is mounted upon the outer case, I, in which frame, in bearings upon one side, is arranged a horizontal rock-shaft, L. This shaft is provided with an arm, M, which connects with the pitman C of the working piston, and an arm, M′, at right angles to M, which arm M′ imparts motion to a horizontal shaft, N, journaled upon the opposite side of the frame, through the connecting-rod O and the crank-pin f, attached to a disk upon said drive-shaft N.

The pitmen C′ C′ of the displacer, which pass up through the regenerating-chamber through packing-boxes extending through holes in the outer case, I, are connected for simultaneous

operation through a U-shaped lever-frame, P, one end of which receives an oscillating movement from the crank-pin *f* on the drive-shaft through the connecting-rods Q R and an adjustable link-motion. This link-motion consists of a rock-shaft, T, arranged in bearings in the top of the frame, and provided with a notched arc-shaped vibrating lever, U, whose end is jointed to the connecting-rod Q. Upon the arc-shaped lever is arranged a sliding head, V, jointed to the pitman R, connecting with the U-shaped lever-frame, and carrying a detent, *g*, which engages with the notches of the said arc-shaped lever.

The length of stroke of the displacer, it will be seen, will depend upon the distance from the center of the rock-shaft T of the sliding box V—a longer stroke being used for a greater speed, and vice versa.

To stop the engine, the box is placed upon the center of the rock-shaft T; and to reverse the engine, it is thrown upon the opposite side of the said rock-shaft.

One peculiarity and special adaptation of the form of link-motion to the engine thus described is that the movement of the box V gives the initial movement to the displacer, which is always necessary to start the action of the engine.

Having thus described my invention, what I claim as new is—

1. A hot-air-engine regenerator, consisting of two corrugated disks or plates, combined with a reciprocating displacer having wings adapted to enter the corrugation of the disks, and a regenerating annular packing of finely-divided metallic pieces arranged about the periphery of same.

2. The combination of an imperforate reciprocating displacer with an annular packing of finely-divided metallic pieces arranged about the periphery of and in contact with said displacer, substantially as described.

3. In a hot-air engine, a reciprocating displacer made variable as to length of stroke, whereby the motion of the engine may be controlled, substantially as described.

4. The vibrating lever U, connected at one end with the driving mechanism, in combination with the sliding and adjustable head V, pitman R, and displacer, substantially as set forth.

5. In a hot-air engine, the regenerating annular packing F, composed of straight strips of wire-cloth, cut diagonally to the weaving and bent into shape, as set forth.

6. The case T, having at the top concentric pendent flanges *f* and a central opening for the air, in combination with a regenerating-chamber composed of concentrically-corrugated disks, and a working cylinder, B, arranged concentrically with respect to the opening in the case, substantially as shown and described.

7. The combination, with the regenerating-chamber of a hot-air engine, of a furnace having a wall, H, with a corrugated upper surface and an outside annular exit-flue about the same, substantially as described.

8. The combination, with the regenerating-chamber of an air-engine, of a furnace having a wall, H, with an annular exit-flue, the case G, having inlet-holes *d*, and the outer case, I, having an inlet at the cool side of the regenerator, substantially as and for the purpose described.

9. The combination of the pitmen C and C′ of the working piston and the displacer, the main rock-shaft L, having arm M M′, the connecting-rod O, crank-pin *f*, shaft N, connecting-rod Q, rock-shaft and vibrating lever T U, sliding head V, pitman R, and U-shaped lever-frame P, substantially as and for the purpose described.

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Witnesses:
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