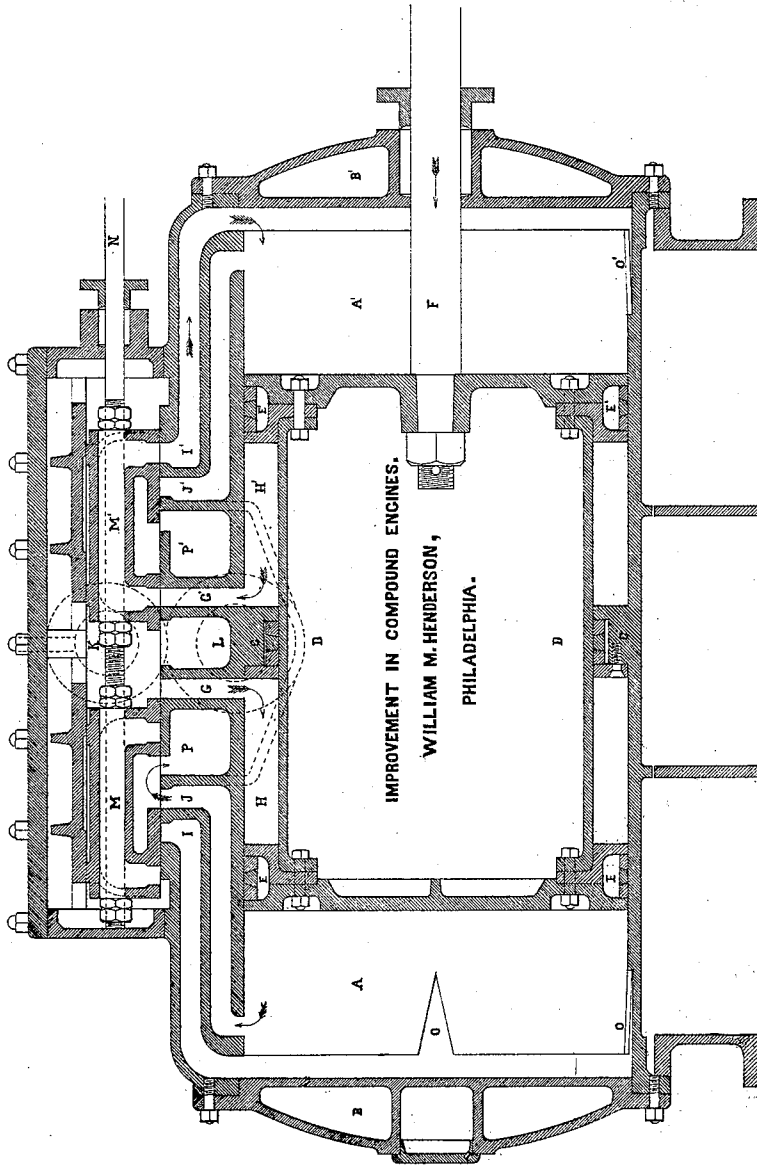


*W. M. Henderson,*

*Compound Engine.*

*No. 10,617.*

*Patented Apr. 5. 1870*



WITNESSES.

*M. J. Britton*  
*J. R. Stopping*

*William M. Henderson*  
*Inventor.*

# UNITED STATES PATENT OFFICE.

WILLIAM M. HENDERSON, OF PHILADELPHIA, PENNSYLVANIA.

## IMPROVEMENT IN DIRECT-ACTING COMPOUND STEAM-ENGINES.

Specification forming part of Letters Patent No. **101,617**, dated April 5, 1870.

I, WILLIAM M. HENDERSON, of the city of Philadelphia and State of Pennsylvania, have invented certain Improvements in Direct-action Compound Steam-Engines, of which the following is a specification:

This invention is intended to apply to that class of reciprocating steam-engines which operate without the use of rotating fly-wheels, as commonly employed for blast-engines and pumping purposes, but more particularly as an improvement upon the invention of Jonathan Dickson, patented in England March 29, 1838, No. 7,439, for a duplex steam-engine, in which each engine is made to actuate the inlet and outlet valves governing the motive power of the other, without the use of eccentric motion, by making the opposite piston and rod to work the valves of the opposite cylinder.

The principal object to be attained is the employment of Woolf's principle of high and low pressure or compound steam-cylinders, in which high-pressure steam, after acting upon the piston of a cylinder of small diameter, is transferred to another of large dimensions, there to exert its remaining useful force by expansion.

The invention having special reference to the manner of cushioning the steam-pistons at the ends of each stroke, as will be hereafter more fully described, reference being had to the accompanying drawings, and to the letters of reference marked thereon, which shows a longitudinal section of this improvement in compound engines, exhibiting the combined cylinders, with the general arrangement of the pistons, ports, and valves.

A is a steam-cylinder, closed at each end by heads B B', and divided into two equal parts by an abutment, c, formed into a stuffing-box, and packed with metallic packing-rings, as shown.

D is a hollow trunk, turned to suit the bore of this stuffing-box, its extremities fitted with piston-heads E E', at a distance apart equal to the length of the stroke of the engine, added the width of the central abutment, and the clearance allowed.

Each piston-head of the trunk is furnished with packing-rings in the usual manner, turned to fit the bore of the cylinder A, which is about twice the usual length of single-cylin-

der engines, in order to permit each piston E E' to have the stroke determined upon.

The piston-rod F is attached to the trunk D, as shown, and passes through a stuffing-box in the front head B'. G G' are ports for admitting the live steam from the steam-chest to the annular cylinders H H', formed by the above-described combination of parts. I I' are transfer-ports for conducting the steam from the annular or high-pressure cylinders to the low-pressure cylinders A A', and J J' are the eduction-ports for exhausting the spent steam. K is where the steam enters the chest from the boilers, and L, where the exhaust-pipe connects to convey away the steam after having performed its double duty. M M' are two similar slide-valves, connected and moved together by a valve-stem, N. Each valve has a steam-passage or port cored through it, as shown, arranged to establish at the proper time a communication between the ports G and I, for the purpose of conducting the live steam from the high-pressure cylinder to the low, as before described. In other respects the faces of these valves are made to coincide with the ports over which they play, as represented. O O' are small V-shaped cavities, arranged at each end of the bore of the cylinder, and cut down to the level of the counter-bore, the apex of each V pointing toward each other. There are cushioning-passages for arresting the pistons E E' at the ends of their stroke.

The distribution of the steam is effected as follows: Referring to the drawing, we find the pistons at the center of their stroke, and indicated to be traveling from right to left, the valves being at the end of their throw. Live steam is being admitted by the port G, while the spent steam from the previous stroke is being exhausted from the other side of the piston-head E, by the port J, into the exhaust-chamber P, communicating with L, where the exhaust-pipe conveys it away in the usual manner to the condenser, or discharging it into the atmosphere, as the case may be.

It will at the same time be observed that the charge of live steam from the previous stroke, after impelling the piston E' to the right, is led by the ports G', M', and I' to the low-pressure cylinder A', where it materially

assists the efforts of the live steam pressing upon the piston-head E', by exerting its expansive force upon the greater area presented by the face of the piston G'.

The effective area here is reduced to that of the trunk only, as the steam in expanding within the low-pressure cylinder, reacts with a back pressure upon the annular or high-pressure cylinder, as will be at once apparent by an examination of the action of the valve M'. This, however, does no harm, and nothing is lost in consequence; it only becomes necessary to make the low-pressure cylinder somewhat larger to allow for it.

It will be observed that when the piston E approaches the end of its stroke it passes over the exhaust-port J, effectually shutting off all communication between the end of the cylinder A and the condenser or atmosphere, the engine being condensing or non-condensing, and that this obviously takes place just before the inner edge of the piston-head E passes over the cushion passage O; otherwise there would be a waste of steam. As it is, no loss is entailed, as the little steam which passes by the cushion-ports is merely in advance of the main body, which immediately afterward pours over by the port in the valve M, when it comes into position. In other words, the cushion-ports prevent the piston from going too far, in case the valves do not come up to time, and which is not to be entirely depended

upon, not being operated by such fixed mechanism as the eccentric adjusted upon a fly-wheel shaft.

By arranging the V-shaped passages as described, with the apex pointing toward each other, the cushioning is effected in a very gradual manner, and the pistons will not be so suddenly checked as would be the case if these passages opened abruptly.

With a further view of regulating the cushioning power to a greater degree of nicety, the steam might be conveyed by a closed passage fitted with a valve in place of the countersunk V-passages described.

I claim as my invention—

In a compound engine as described, where the opposite faces of each piston present an unequal area, the arrangement of the cushion passages O O' and eduction-ports J J', or their equivalents, in combination with the piston-heads E E', in such manner that each piston will be cushioned at the ends of its stroke by the same motive power which drives them, passing directly from the lesser area of the piston to the greater, by special ports or passages, arranged substantially in the manner and for the purpose represented.

WILLIAM M. HENDERSON.

Witnesses:

N. J. BRINTON,  
J. B. TOPPING.