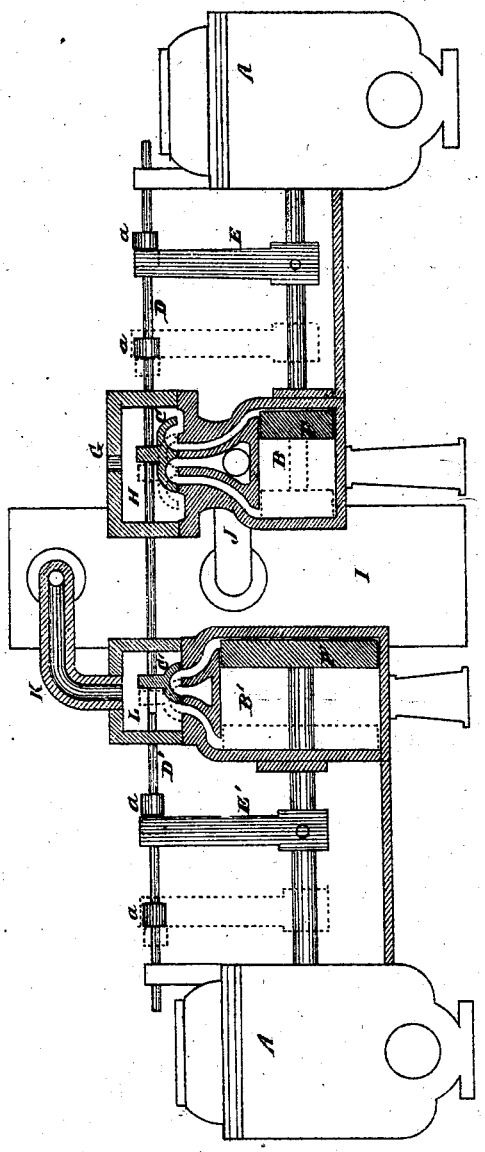
H. R. WORTHINGTON.

Improvement in Steam-Pumping Engines.

No. 116,131. Patented June 20, 1871.

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# UNITED STATES PATENT OFFICE.

HENRY R. WORTHINGTON, OF NEW YORK, N. Y.

## IMPROVEMENT IN STEAM PUMPING-ENGINES.

Specification forming part of Letters Patent No. 116,131, dated June 20, 1871.

*To all whom it may concern:*

Be it known that I, HENRY R. WORTHINGTON, of the city, county, and State of New York, have invented a new and Improved Steam Pumping-Engine; and I do hereby declare that the following is a full and exact description thereof, reference being had to the accompanying drawing forming a part of this specification and to the letters of reference marked thereon.

The object of my invention is an improvement in the arrangement of devices for using steam expansively in that form of engine known as the duplex engine, invented by myself, which said invention is secured to me by Letters Patent bearing date July 19, 1859. The nature of my invention consists in improvements of a duplex engine in such a manner as to greatly reduce the cost of construction and at the same time retain all its effectiveness and utility. It more particularly consists in construction and arrangement of two steam-cylinders of different sizes. The piston-rod of each cylinder operates the slide-valve of the other. Between the said two steam-cylinders is located an equalizer or steam-tank, through which the steam passes on its way from the smaller cylinder to the larger cylinder.

It is obvious that the pressure of steam upon the piston must be maintained with great uniformity at all points of the stroke, for the reason that the pressure of water against the pump-piston is at all times uniform. Any excess of pressure upon the piston above what is required to produce motion is, therefore, unprofitably expended, while the least deficiency is hurtful, as manifested by the retardation or perhaps the entire cessation of motion.

This difficulty practically manifests itself in the engine under consideration by a failure to reach the termination of the prescribed stroke, thus entailing a loss by or from clearance at either end. The first part of the stroke, in such case, is performed with greater rapidity than the latter part. The motion of one piston, therefore, anticipates to a certain extent that of the other, producing the irregularity of motion and loss of steam above mentioned. To obviate this difficulty it has been found necessary to proportion the high-pressure steam-cylinder and expanding-cylinder within smaller limits than would otherwise be profitable. It may be stated that a ratio of expansion of more than three and a half to one, in this form of engine, can only be obtained with difficulty. Various restraining devices pertaining to the exhaust vacuum and the supply of steam have also been found necessary.

In my improved method, which is the subject of this invention, the steam, after being first used upon a piston—called the direct-pressure piston—through the length of one stroke, is released or expanded into a tank or receiver having a capacity much greater than that of the steam-cylinder. In my experiments I have found eight to one a satisfactory proportion. In this tank the steam is expanded to a low pressure, and is drawn from thence to operate on the second cylinder the same as if from the boiler.

In order to a full understanding of this method of using steam in the peculiar engine known as the Worthington duplex engine, it is necessary to understand that form of engine and its peculiarities of motion. These are fully explained in the patent above referred to. The reciprocal action of one steam-piston on the steam-valves belonging to the other is its vital peculiarity and the one which makes it obvious that there is no fixed or arbitrary termination to the stroke, but only one imposed by the motion of the other engine.

When it is desired to use the steam expansively on this form of engine it can only be done properly by employing a compound steam-cylinder. This renders four steam-cylinders and pistons necessary for one such engine, besides entailing great expense in many details of construction. In place of this secondary or expanding-cylinder I substitute a tank or receiver of about eight times the cubic capacity of the smaller steam-cylinder. Assuming that the piston has just completed one stroke from left to right, leaving the cylinder full of steam at a pressure of eighty pounds above vacuum, this steam, being exhausted into the tank by the proper action of the valve motion, is afterward allowed to work, at the reduced pressure consequent on its expansion within the tank, upon the second or expanding or larger cylinder. This said cylinder is shown as having a capacity of four times that of the first or high-pressure cylinder. On examining the condition of pressures after the engine has made

a few strokes and come to a permanent state it will be found that, under the assumed terminal pressure of eighty pounds above zero, in the first or smaller steam-cylinder, the highest pressure that can be shown in the tank is not more than twenty-six and two-thirds pounds above zero, and the lowest is not less than twenty pounds above zero. Within these narrow limits the variation of the propelling pressure upon the second or expanding cylinder is confined. In general terms, we have upon one piston a force of eighty pounds, less an average back pressure of twenty-three and one-third pounds, leaving an average effective force of fifty-six and two-thirds pounds operating on each square inch; and upon the second or expanding piston we have the average effective pressure from the tank of twenty-three and one-third pounds on each square inch. While these propelling forces are of nearly uniform intensity throughout the stroke they may still be unequal in absolute amount. This inequality can be adjusted by adding more or less to the area of the pumps on which the pistons respectively operate. With these adjustments properly made the duplex engine will be found to fulfill its required functions with the greatest accuracy, and, at the same time, a machine of equal effectiveness cost much less than one of the old form of construction.

To enable others skilled in the art to make and use my invention, I will proceed more particularly to describe its construction and operation.

The figure represents a longitudinal sectional elevation of the steam-cylinders, pipes, and valve-rods, and a side elevation of the tank and pumps.

A and A′ represent the pumps, which are worked by my improved method of expanding steam. These are not shown in section, nor is their form of construction indicated with exactness, as they may be of any of the well-known and approved forms. B and B′ are two steam-cylinders, of suitable capacity to correspond with the pumps. The cylinder B is smaller than the cylinder B′, for the purpose of using the steam by expansion in the latter. C and C′ are the slide-valves, worked by means of valve-rods or bars D and D′. The rod of the piston of the high-pressure or smaller cylinder operates the slide-valve in the larger cylinder, while, at the same time, the piston-rod of the larger cylinder operates the valve in the smaller cylinder. The rods D D′ are provided with suitable bearings, in which they work. On each of these rods are tappets *a a*, secured at proper points on the said rods, against which the arms or bars E E′ strike to move or work the slide-valves.

It may be observed that the tappet form of valve motion, herein shown and described, is not suitable for larger forms of engines, being too concussive and sudden in its action. For large engines the steam-valves, which may be of any approved form, whether sliding or poppet, should be moved through the intervention of levers that effect a gradual movement of the valve, almost similar to that produced by the eccentric of a crank-engine. The plainer form of tappet-valve motion is shown and described herein as being simpler to describe and represent. The calculation of pressures is based upon a form of valve motion which moves the valve at the middle of the stroke and not at the end, as is the case with a tappet.

The bars or rods E E′ are secured to the piston-rods of the steam-cylinders and pumps. F F′ are the pistons of the steam-cylinders. G represents a section of a steam-pipe connected to the steam-chest H. I is a tank, located between the cylinders B and B′, into which the steam exhausts from the cylinder B through the exhaust-pipe J. From this tank I the steam is conducted through the steam-pipe K into the steam-chest L to drive the piston in the cylinder B′. A cubic capacity of this cylinder of eight times that of the steam-cylinder B is found to work with satisfactory results. The proportion of the steam-cylinder B to the pump-cylinder A is as one to four; but this proportion may be varied in practice.

Having thus described my invention, what I claim as new, and desire to secure by Letters Patent of the United States, is—

A duplex engine, consisting of two independently-acting steam-cylinders of different sizes, the movement of the piston in the high-pressure or smaller cylinder operating the valve of the larger or low-pressure cylinder, the piston of which, in turn, operates the valve of the high-pressure or smaller cylinder, between which said cylinders is interposed an equalizer or reservoir admitting the steam from the high-pressure and delivering it into the low-pressure or larger cylinder, all constructed, arranged, and operating substantially as herein shown and described, and for the purposes set forth.

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Witnesses:

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