(No Model.)

L. D'AURIA.

DIRECT ACTING PUMPING ENGINE.

No. 446,435. Patented Feb. 17, 1891.

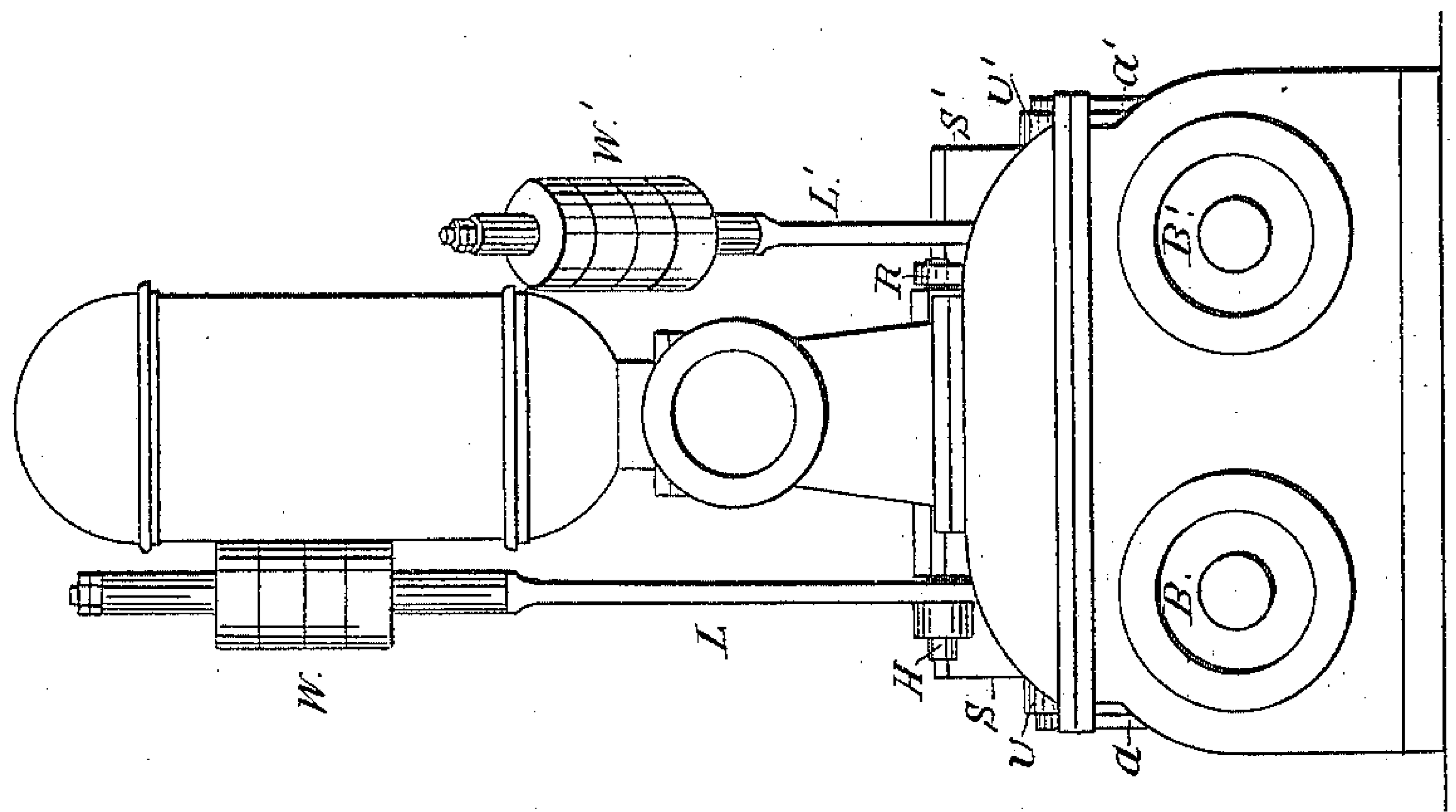

Fig. 2.

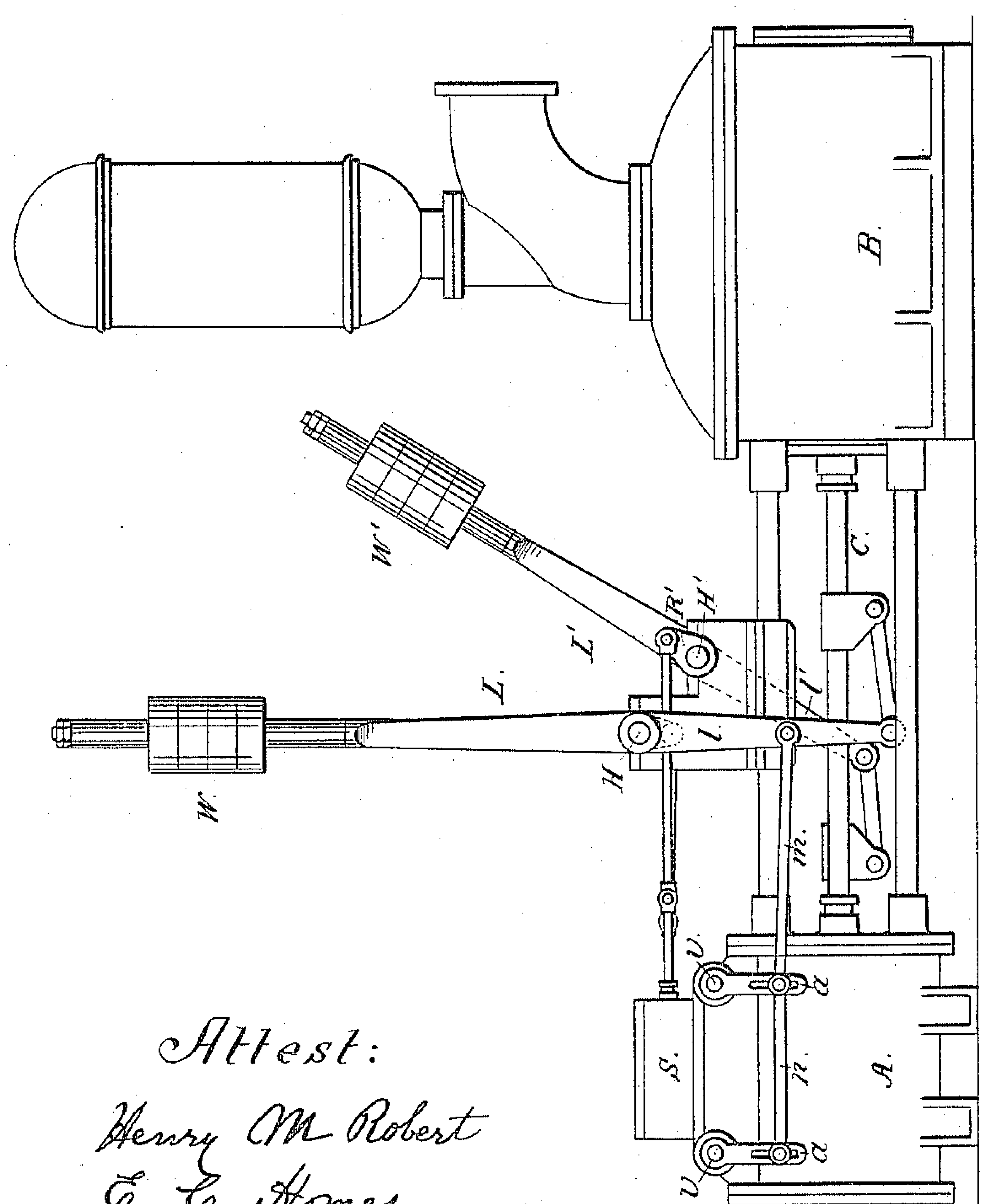

Fig. 1.

Attest:

Henry M. Robert

E. C. Homer

Inventor:

Luigi d'Auria

UNITED STATES PATENT OFFICE.

LUIGI D'AURIA, OF PHILADELPHIA, PENNSYLVANIA, ASSIGNOR OF ONE-HALF TO HENRY MARTYN ROBERT, OF SAME PLACE.

DIRECT-ACTING PUMPING-ENGINE.

SPECIFICATION forming part of Letters Patent No. 446,435, dated February 17, 1891.

Application filed February 7, 1888. Serial No. 263,304. (No model.)

To all whom it may concern:

Be it known that I, LUIGI D'AURIA, a subject of the King of Italy, residing at Philadelphia, in the State of Pennsylvania, have invented certain new and useful Improvements in Direct-Acting Pumping-Engines, of which the following is a specification.

My invention relates to the general class of direct-acting non-rotative steam pumping-engines, single or duplex, simple or compound. In direct-acting non-rotative steam pumping-engines, especially where steam is used expansively, the propelling force of the engine effectively employed in driving the pump is necessarily from the beginning up to a certain point of the stroke somewhat greater and for the remaining part of the stroke somewhat less than the total pressure exerted by the liquid column upon the pump-plunger while in motion. Hence during the former part of the stroke the excess of the effective propelling-force over the resistance of the pump performs an amount of work which, being solely expended in producing an acceleration, may be properly called "accelerative work." During the latter part of the stroke the excess of resistance over the effective propelling force gives place to a retarding work, which in a direct-acting non-rotative steam pumping-engine running smoothly must be equal to the accelerative work. Otherwise either the stroke will be shorter than normal or the piston will strike the cylinder-head.

Designers of this class of pumping-engines have always considered it to be absolutely necessary to maintain upon the pump-plunger under any circumstances an effective propelling force practically equal to or very slightly greater than the resistance of the pump. Consequently when steam is used expansively in such pumping-engines compensating devices are now employed which practically nullify the accelerative work incident thereto.

The object of my invention is to provide means whereby a direct-acting non-rotative steam pumping-engine may use steam expansively without compensating devices nullifying or reducing the accelerative work incident thereto.

In my investigation of the problem in question I have satisfied myself that the immediate effect of an increased accelerative work in a direct-acting non-rotative steam pumping-engine is the increase of its piston speed, and that when this speed exceeds a certain limit the action of the piston becomes concussive and spasmodic. Whatever this limit of piston speed may be in practice, the problem is to find means whereby the piston speed may be regulated and controlled under any grade of steam expansion without compensating devices. I have found that by adding to the requisite reciprocating parts of such an engine a supplemental reciprocating weight I can so regulate and control the piston speed under any accelerative work as to avoid concussion and spasmodic action. Such means is suggested by a new principle discovered by me, which, so far as can be expressed in ordinary language, is as follows:

In a direct-acting non-rotative steam pumping-engine using steam expansively the mean piston speed in feet per second varies from four and a half to five times the square root of the accelerative work in foot pounds, as herein defined, divided by the square root of the sum of the products obtained by multiplying each of the reciprocating weights in pounds set in motion at every stroke by the square of the velocity of its center of gravity or center of gyration expressed in terms of the velocity of the piston as unit. This sum of products may, for brevity, be called hereinafter "accelerated mean weight." Theoretically the accelerated mean weight should include the weight of the column of water confined between the level of the suction-chamber and the level of the air-chamber multiplied by the square of its velocity expressed in terms of the velocity of the piston as unit; but in practice this portion of the accelerated mean weight, so far as my invention is concerned, is supposed to be only a small fraction of the total, and its being neglected in the computation can only produce a slight difference in the value of the mean piston speed.

According to the above principle, in order to obtain a given piston speed the accelerated mean weight in pounds must be between twenty and twenty-five times the accelerative work in foot pounds divided by the square of the given piston speed in feet per second. The number twenty corresponds to the case when the accelerative work is performed by a constant accelerative force, and the retarding work is performed by a uniformly-increasing retarding force, which would be practically the case if steam were used expansively in a simple cylinder cutting off at about one-half of the stroke. The number twenty-five corresponds to the case when the accelerative work is performed by a uniformly-decreasing accelerating force and the retarding work by a uniformly-increasing retarding force, as before. Practically this is the case when steam is expanded in compound cylinders or when steam is cut off very early in the stroke.

For practical purposes it may be stated that in a direct-acting non-rotative steam pumping-engine the accelerated mean weight in pounds is approximately equal to twenty-three times the accelerative work in foot pounds divided by the square of the mean piston speed in feet per second.

Now suppose, for example, it is desired to ascertain the accelerated mean weight in pounds which it is necessary to put upon a direct-acting non-rotative steam pumping-engine in order to obtain a mean piston speed of two feet per second when steam is cut off at one-third of the stroke in a simple cylinder, the stroke being three feet, the diameter of the plunger twenty inches, and the total head two hundred feet. Assuming an even back-pressure upon the steam-piston and a constant pressure upon the plunger while in motion, the accelerative work would be about twelve thousand foot pounds, and consequently the accelerated mean weight would be twenty-three times twelve thousand divided by the square of two, or about seventy-five thousand pounds. If the weights of the requisite working parts of this pumping-engine computed in the manner herein defined will make up only, say, five thousand pounds of the required accelerated mean weight, then the remaining seventy thousand pounds must be supplemented by an additional weight, which, however, may be greatly reduced, provided its center of gravity or gyration moves with a velocity considerably greater than that of the piston. In fact, if the velocity of the center of gravity or gyration of the additional weight is three times greater than that of the piston, then in accordance with the definition already given of the accelerated mean weight the additional weight would have to be about seventy-eight hundred pounds or seventy thousand pounds divided by the square of three. This pumping-engine without such additional weight would acquire a mean piston speed of nearly seven and one-half feet per second, or nearly four hundred and fifty feet per minute, which is nearly double the speed attained by the best regulated crank and fly-wheel pumping-engines of the larger size. With such piston speed the engine of our example would never be able to reach the end of a single stroke without disastrous consequences, and this may serve to explain the reason why designers of direct-acting non-rotative steam pumping-engines have settled upon the condition that under all circumstances the accelerative work must be reduced to a minimum or practically nullified. Suppose, for instance, that by means of proper devices the accelerative work, instead of twelve thousand foot pounds, be reduced to, say, twelve hundred foot pounds. Then without additional weight the mean piston speed in feet per second would according to my principle be about four times the square root of twelve hundred divided by the square root of five thousand, (the latter being the assumed accelerated mean weight in pounds,) or about two feet per second. This is about the maximum piston speed at which direct-acting non-rotative steam pumping-engines of large size have ever been run. Now the total work absorbed by the pump in a single stroke is about eighty-one thousand foot pounds, of which the accelerative work of twelve hundred foot pounds only represents about one and one-half per cent. Hence it may be safely stated that direct-acting non-rotative steam pumping-engines as now constructed could never be made to work satisfactorily with an accelerative work exceeding two per cent. of the total work absorbed by the pump in a single stroke, for under such conditions, and even under the conditions assumed, these pumping-engines would acquire a piston speed far exceeding their safe limit, and their action would become concussive and spasmodic.

With the above percentage of accelerative work the accelerated mean weight in pounds in direct-acting non-rotative steam pumping-engines as heretofore constructed would be limited, therefore, to twenty-three times two per centum of the total work absorbed by the pump in a single stroke divided by the square of the mean piston speed in feet per second, or approximately such accelerated mean weight would be equal to one-half of the work in foot pounds absorbed by the pump in a single stroke divided by the square of the mean piston speed in feet per second.

In my invention I claim only such direct-acting non-rotative steam pumping-engines whose accelerated mean weight in pounds, as herein defined, exceeds the quotient obtained by dividing the total work in foot pounds absorbed by the pump in a single stroke by the square of the mean piston speed in feet per second.

In the accompanying drawings I have illustrated one of the various methods which may be used to increase the accelerated mean weight, although I do not confine myself to the details thereof.

Figure 1 is a side elevation, and Fig. 2 is an end view, of an ordinary duplex direct-acting non-rotative steam pumping-engine adapted to use steam expansively, in which—

A and B are the steam-cylinder and the pump-barrel of one side.

B′ is the pump-barrel of the other side and corresponding to another steam-cylinder A′. (Not shown.) The pistons of A and B are, as usual, carried by the same piston-rod C, and it is to be understood that the pistons of A′ and B′ are also mounted upon the same piston-rod C′. (Not shown.)

R and H and R′ and H′ are the cranks and shafts, and l and l' the vibrating arms ordinarily employed in duplex direct-acting non-rotative steam pumping-engines to operate the main valves in the steam-chests S and S′, and they are arranged as usual, so that the crank and shaft set in motion by one engine is made to operate the main steam-valve belonging to the other engine.

L and L′ are extensions of the arms l and l', and are loaded with the weights W and W′ for the purpose of increasing the accelerated mean weight. The position of the weights W and W′ can, as shown, be shifted on the arms L and L′, and as this shifting affects the accelerated mean weight it will affect also the piston speed, other things remaining the same.

V and V′ are cut-off valves adjusted in the steam-passages of each steam-cylinder and derive their motion from the engine to which they belong.

M and N are connecting-rods, and A the arms attached to the cut-off valves V of one side to operate said valves. The arms a are slotted in order to allow the point of cut-off being varied. A similar mechanism is employed to operate the cut-off valves V′ of the other side.

When this particular construction (or any other similar to it) is adopted, then in computing the accelerative work it must be remembered to subtract the amount of work absorbed by the additional reciprocating weight W or W′ in the action of being lifted from its lower to its higher vertical position during the first half of the stroke, which is retarding work. This amount of work in foot pounds is equal to the additional weight in pounds multiplied by the vertical lift of its center of gravity in feet, including the oscillating arm; but the additional reciprocating weights in my invention are not intended to act, and are not employed as compensating devices in the sense now understood, but simply as means to control and regulate the mean piston speed in the manner and according to the principle set forth. The reason, however, for preferring such construction is the economy of additional weight it affords over different constructions which I might otherwise use—as, for example, the increase of the weight of the pistons and piston-rods.

The arms l and l' may be extended downward instead of upward, and any other convenient form of cut-off valves and mechanism may be adopted.

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

1. The within-described art or method of regulating the mean piston speed in a direct-acting non-rotative steam-expanding pumping-engine, which consists in adding to the requisite reciprocating parts a supplemental reciprocating weight, which, with the weight of the requisite reciprocating parts, is so proportioned in relation to the accelerative work, as herein defined, as so to control the accelerated and retarded motion of the engine that concussion and spasmodic action shall be avoided.

2. A direct-acting non-rotative steam-expanding pumping-engine adapted to work under steam expansion sufficient to produce an accelerative work, as herein defined, exceeding four per cent. of the total work absorbed by the pump in a single stroke, and provided with an additional reciprocating weight, which, when in motion with the requisite working parts, will produce an accelerated mean weight in pounds, as herein defined, greater than the quotient obtained by dividing the total work in foot pounds absorbed by the pump in a single stroke by the square of the mean piston speed in feet per second.

3. In combination with a direct-acting non-rotative steam-expanding pumping-engine, an additional reciprocating weight or weights connected to and oscillating with the reciprocating parts of the pumping-engine and adapted to control the accelerated and retarded motion of the engine, thereby preventing concussion and spasmodic action, substantially as and for the purpose set forth.

4. In combination with a direct-acting non-rotative steam-expanding pumping-engine, an additional reciprocating weight or weights, as W W′, fixed or adjustable upon the arms L and L′, oscillating with and connected to the valve-operating arms l and l', as shown, and for the purpose specified.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

LUIGI D'AURIA.

Witnesses:

C. A. DOUGHERTY,

W. W. DOUGHERTY.