(No Model.) 2 Sheets—Sheet 1.

H. H. WESTINGHOUSE.

STEAM ENGINE.

No. 373,323. Patented Nov. 15, 1887.

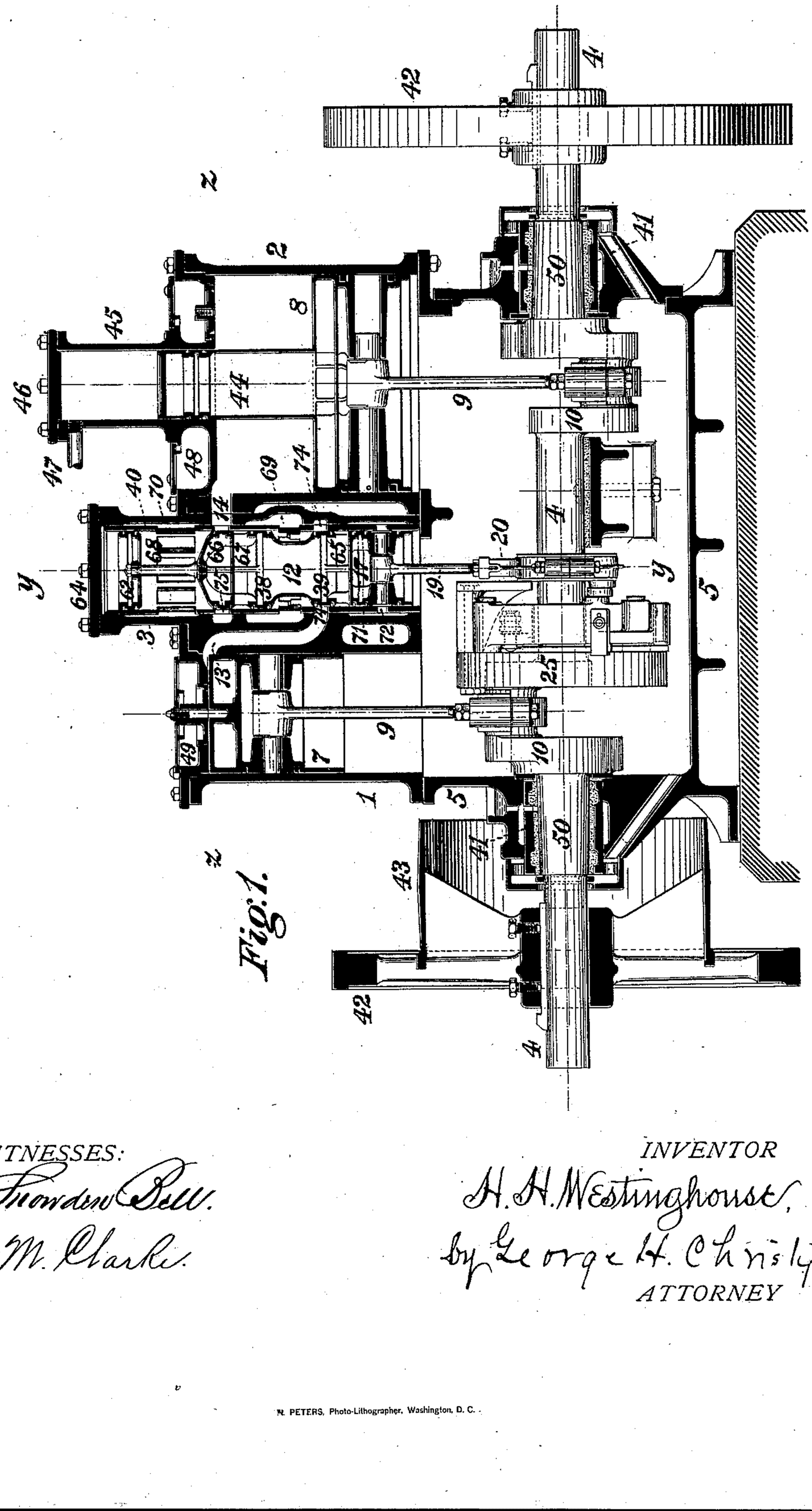

Fig. 1.

WITNESSES:

J. Snowden Bell.

C. M. Clarke.

INVENTOR

H. H. Westinghouse,

by George H. Christy

ATTORNEY

N. PETERS, Photo-Lithographer, Washington, D. C.

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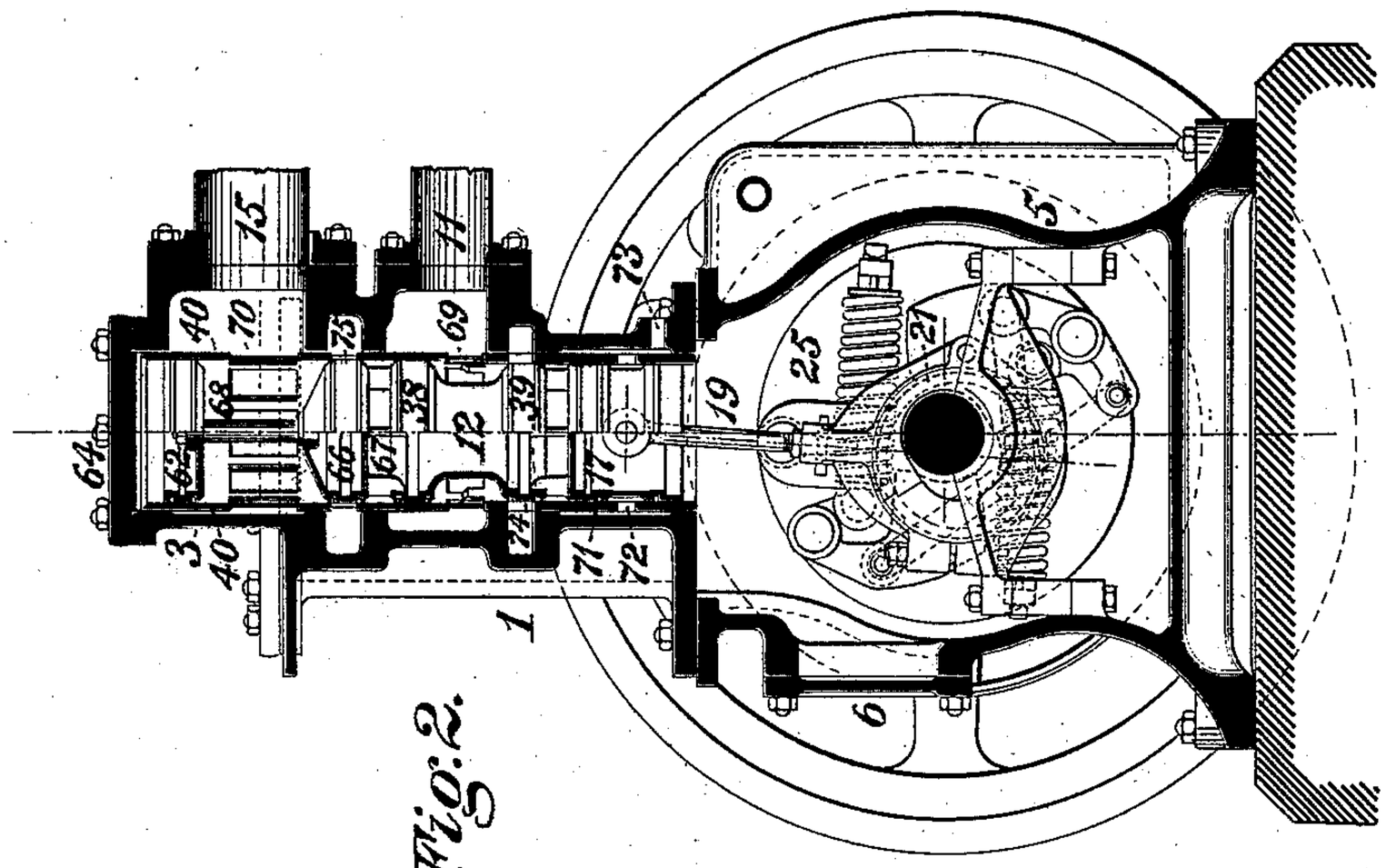

Fig. 2.

Fig. 3.

WITNESSES:

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UNITED STATES PATENT OFFICE.

H. HERMAN WESTINGHOUSE, OF NEW YORK, N. Y., ASSIGNOR TO THE WESTINGHOUSE MACHINE COMPANY, OF PITTSBURG, PENNSYLVANIA.

STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 373,323, dated November 15, 1887.

Application filed August 20, 1885. Serial No. 174,878. (No model.)

To all whom it may concern:

Be it known that I, H. HERMAN WESTINGHOUSE, residing at New York, in the county of New York and State of New York, a citizen of the United States, have invented or discovered certain new and useful Improvements in Steam-Engines, of which improvements the following is a specification.

In the accompanying drawings, which make part of this specification, Figure 1 is a vertical longitudinal section through a steam-engine embodying my invention at the line *x x* of Fig. 3; Fig. 2, a vertical transverse section through the same at the line *y y* of Fig. 1, and Fig. 3 a horizontal section at the line *z z* of Fig. 1.

My invention relates to single-acting steam-engines of the class in which two or more cylinders are located in parallel planes at right angles to a common crank-shaft, the pistons of the several cylinders being connected, independently one of the other, to separate crank-pins on said shaft, an instance of which is exemplified in Reissued Letters Patent of the United States No. 10,603, granted and issued to The Westinghouse Machine Company, as my assignee, May 26, 1885.

The object of my invention is to provide an engine of such general type of simple and comparatively inexpensive construction, adapted to the effective utilization of steam upon the compound principle in which close and accurate regulation of speed, as well as economy of steam, may be insured by the employment of automatic cut-off mechanism governing the distribution of both the high and the low pressure cylinders.

To this end my invention, generally stated, consists in the combination of a high-pressure and a low-pressure single-acting cylinder, a steam-chest common to both cylinders, and ports so located as to cause the maximum of clearance to be between the valve and the high-pressure cylinder and to reduce to a minimum the clearance between the valve and low-pressure cylinder; also, in the combination of a high-pressure and a low-pressure single-acting cylinder and a valve and ports adapted to first admit steam from the boiler to the high-pressure cylinder around the exterior of the valve, then to admit the exhaust of the high-pressure cylinder to the low-pressure cylinder through the interior of the valve, and finally to discharge the exhaust of the low-pressure cylinder to the atmosphere, or to a condenser at one end of the valve; also, in the combination of a high-pressure single-acting cylinder having a valve chest or chamber cast integral therewith, and a low-pressure single-acting cylinder secured to the valve-chest through the port or steam-entrance of the low-pressure cylinder.

The improvements claimed are hereinafter fully set forth.

In the practice of my invention I provide a high-pressure cylinder, 1, having a valve chest or chamber, 3, cast upon its side, and a low-pressure cylinder, 2, of larger diameter, which is secured to the high-pressure cylinder and valve-chamber by bolts passing through flanges 18 on the valve-chamber and low-pressure cylinder, the plane of connection passing through the steam-port 14 of the low-pressure cylinder. The cylinders and interposed valve-chamber, which are thus located as closely together as practicable and connected with a single joint, which can readily be made without expensive fitting, are secured upon the top of a closed crank-case, 2, which constitutes the bed or support of the engine and likewise serves as a tank or receptacle for the lubricating material of the crank-shaft journals and crank-pins. A removable bonnet, 6, secured upon one side of the crank-case over an opening therein, enables access to be had to the interior of the case when desired.

The high and low pressure cylinders 1 2 are fitted, respectively, with pistons 7 8, which are coupled by connecting-rods 9 9 to crank-pins set oppositely, or at an angle of one hundred and eighty degrees, upon a pair of double cranks, 10 10, formed upon a crank-shaft, 4, having journals 50, mounted in bearings 41 in the ends of the crank-case 5, and carrying one or more balance-wheels, 42, and a belt-pulley, 43. A balancing-piston, 44, is formed upon or secured to the low-pressure piston 8, on the upper or steam side thereof, said balancing-piston working in a cylinder, 45, secured to the head 48 of the low-pressure cylinder. The

cylinder 45 is closed at top by a head, 46, and communicates with the boiler or main steam-pipe by a steam-supply pipe, 47.

Steam is supplied to the valve-chamber 3 from the boiler by a steam-pipe, 11, secured to a flange or nozzle on the side of the valve-chamber, and is supplied to and exhausted from the upper ends of the high and low pressure cylinders 1 2 by a main or distribution valve, 12, performing the distribution functions of both cylinders and actuated by an automatic cut-off mechanism consisting of an eccentric, 21, which is pivoted to the supporting disk or carrier 25 of a centrifugal governor or regulator fixed upon the crank-shaft, and is provided with a slot fitting freely on the crank-shaft, so as to be adapted to be moved transversely to the crank-line by said governor in accordance with variations of pressure or resistance, or both, and thereby to vary the traverse of the distribution-valve and correspondingly cut off steam from the high and low pressure cylinders at earlier or later periods in the stroke. The eccentric 21 is connected to the distribution-valve 12 by an eccentric-rod, 19, secured at one end to the eccentric-strap 20, and coupled at the other to a pin fixed in the lower end of the valve. The governor or regulator herein illustrated does not, *per se*, form part of my present invention, and being, moreover, fully set forth in Letters Patent No. 303,085, dated August 5, 1884, need not be herein at length described.

The main or steam-distribution valve 12, which fits accurately in and is reciprocated within a sleeve or bushing, 40, secured in the valve-chamber 3, is composed of upper and lower main or steam-admission pistons, 38 39, connected by an intermediate hollow or tubular body portion, a lower guide-piston, 17, connected to the lower main piston, 39, by bars, between which are formed a series of high-pressure exhaust-ports, 65, an exhaust-piston, 66, connected to the upper main piston, 38, by bars, between which are formed a series of low-pressure supply-ports, 67, and an upper balance-piston, 62, connected by a rod or stem, 68, to the exhaust-piston 66. Steam is admitted to the interior of the bushing 40 from the steam-pipe 11 and valve-chamber 3, through supply-ports 69, so located as to be included between the main pistons 38 39 at all points of the traverse of the valve, and is exhausted from the bushing through exhaust-ports 70, located between the exhaust-piston 66 and balance-piston 62, to the exhaust-pipe 15, and thence to the atmosphere, or to a condenser.

The admission and exhaust of steam from the boiler to and from the high-pressure cylinder 1 are effected through a port or passage, 13, leading from the top of the high-pressure cylinder to a series of ports, 74, located in such position in the bushing 40 as to be alternately uncovered and covered by the lower steam-piston, 39, of the valve, and the exhaust-steam from the high-pressure cylinder is admitted to and exhausted from the low-pressure cylinder 2 through a short straight port or passage, 14, leading from the top of the low-pressure cylinder into the valve-chamber and communicating with a series of ports, 75, located in such position in the bushing as to be alternately uncovered and covered by the exhaust-piston 66. It will thus be seen that the maximum clearance is between the valve and high-pressure cylinder, the clearance between the valve and low-pressure cylinder being reduced to the minimum amount possible—to wit, the thickness of metal of the cylinder, valve-chamber, and bushing. The bushing 40, which is open at both ends, fits the valve-chamber 3 tightly at and near each of its ends. The top of the valve-chamber is closed by a tight head or cap, 64, and in order to prevent the escape of steam which may leak past the lower piston, 39, and guide-piston 17 into the crank-case an annular recess, 71, is formed in the lower valve-chamber, 3, around that portion of the bushing 40 in which the guide-piston works, said recess communicating with the interior of the bushing by ports 72 therein, and being provided with a suitable discharge port, 73.

In operation steam from the boiler is admitted from the steam-pipe 11 through the ports 69, between the main pistons 38 39, and around its central tubular body, and in the downward movement of the valve passes through the ports 74 and passage 13 to the upper end of the high-pressure cylinder 1 and effects the downward and working stroke of its piston 7. In the upward movement of the valve the steam which has effected the downward stroke of the high-pressure piston is exhausted through the passage 13, ports 74, tubular body of the valve, and upper ports, 67, thereof into the ports 75 and 14 and low-pressure cylinder 2, effecting the downward stroke of its piston 8, its action being supplemented by the pressure of steam from the boiler upon the balancing-piston 44 of the low-pressure cylinder. In the succeeding downward traverse of the valve the exhaust-piston 66 uncovers the ports 75, and thereby placing the port 14 in communication with the exhaust-ports 76 the steam which has effected the downward stroke of the low-pressure piston is exhausted through the ports 14, 75, and 70 to the exhaust-pipe 15, and thence to the atmosphere, or to a condenser, as the case may be.

It will be seen that the objection which obtains in prevailing constructions of compound engines of the Woolf type—to wit., that of expansion between the cylinders without performance of work—is substantially removed, as but a small fraction of clearance is apportioned to the low-pressure cylinder, and the steam from the high-pressure cylinder is exhausted directly thereinto from the valve. The steam is not wholly exhausted at each stroke from the passage leading from the high-pressure to the low-pressure cylinder—that is, from the interior of the tubular body of the valve—but is entrapped therein under a

pressure equal to the pressure in the low-pressure cylinder at the point of cut-off, and is surrounded on the outside of the valve by the live steam from the boiler, which exerts a reheating action, tending to vaporize any water of condensation in the steam exhausted from the high-pressure cylinder which may be due to expansion or other causes. The coincident variation of the point of cut-off in both cylinders in correspondence with variations of speed and resistance effected by the action of an automatic cut-off mechanism upon a distribution-valve common to both cylinders insures a close degree of regulation and thereby a substantially constant speed and economical consumption of steam. Undue upward pressure upon the low-pressure piston on its upward stroke, due to the action of atmospheric pressure in the crank case against a vacuum or partial vacuum on the upper side of the piston, is prevented by the pressure on the balancing-piston 44, and such pressure acts, together with the pressure on the main piston 8, to effect the downward stroke.

A special advantage of the balancing cylinder and piston is developed in its employment in connection with automatic cut-off mechanism, as it is possible for the latter to effect so early a cut-off in the high-pressure cylinder as to give an insufficient terminal in the low-pressure cylinder to start the piston of the latter on its downward stroke. The avoidance of such objection is indispensable to the proper working of a single-acting engine, and as the balancing-piston is constantly subject to the pressure of steam from the boiler it will be seen that under the above construction a sufficiency of initial pressure upon the low-pressure piston is insured at the shortest cut-off that can be effected.

I disclaim herein a compound engine having a single valve governing the distribution of both its cylinders and actuated by an eccentric which is movable transversely to the crank-line and is coupled to a governor, as the same forms the subject-matter of my Letters Patent No. 340,021, dated April 13, 1886.

I claim herein as my invention—

1. The combination of a high-pressure single-acting cylinder, a low-pressure single-acting cylinder of larger diameter, pistons fitting said cylinders and coupled to crank-pins upon a common crank-shaft, a single main or distribution valve working in a valve-chamber between said cylinders and governing the supply and exhaust of steam to and from the same, a steam-port extending from the steam-supply end of the high-pressure cylinder to a point in the valve-chamber below said end, and a steam-port extending directly or substantially in right line from the steam-supply end of the low-pressure cylinder to the valve-chamber and of a length practically equal to the thickness of metal of the low-pressure cylinder and valve-chamber, substantially as set forth.

2. The combination of a high-pressure single-acting cylinder, a low-pressure single-acting cylinder of larger diameter, pistons fitting said cylinders and coupled to crank-pins upon a common crank-shaft, and a single main or distribution valve working in a valve-chamber having delivery, supply, and exhaust ports and governing the supply and exhaust of steam to and from both of said cylinders, said valve having two main pistons connected by a tubular body and an exhaust-piston adjacent to one of its ends and separated therefrom by a series of ports, and being adapted to first admit steam from the boiler around its body to the high-pressure cylinder, then to admit steam exhausted from the high-pressure cylinder through its body and below its exhaust-piston to the low-pressure cylinder, and finally to deliver the exhaust-steam of the low-pressure cylinder above its exhaust-piston to an exhaust-pipe, substantially as set forth.

3. The combination of a high-pressure single-acting cylinder, a low-pressure single-acting cylinder of larger diameter, a single main or distribution valve governing the supply and exhaust of steam to and from both of said cylinders and working within a valve-chamber interposed between the cylinders, and a fixed sleeve or bushing inclosing said valve and having ports communicating with an annular recess in the valve-chamber adapted to receive leakage from the interior of the bushing, substantially as set forth.

4. The combination of a high-pressure single-acting cylinder having a valve-chamber cast integral therewith, and a steam-port extending from one of its ends to said chamber, and a low-pressure single-acting cylinder of larger diameter having a port extending from one of its ends directly to its shell and secured to the high-pressure cylinder by bolts passing through flanges abutting in the plane of the outer face of the steam-port of the low-pressure cylinder, substantially as set forth.

In testimony whereof I have hereunto set my hand.

H. H. WESTINGHOUSE.

Witnesses:
J. SNOWDEN BELL,
G. W. WILLIAMS.