(No Model.) 3 Sheets—Sheet 1.

R. CREUZBAUR.

STEAM ENGINE.

No. 332,502. Patented Dec. 15, 1885.

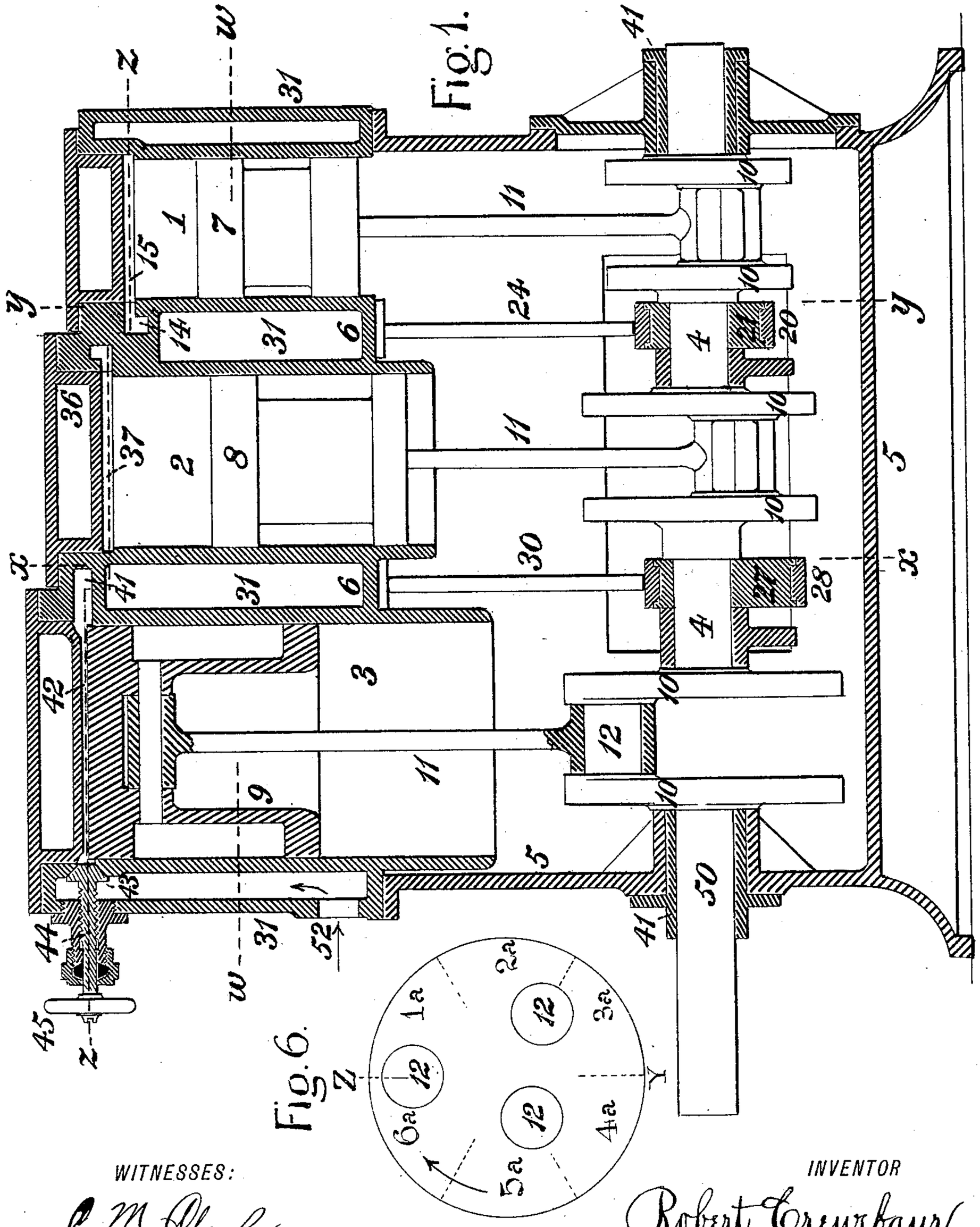

Fig. 1.

Fig. 6.

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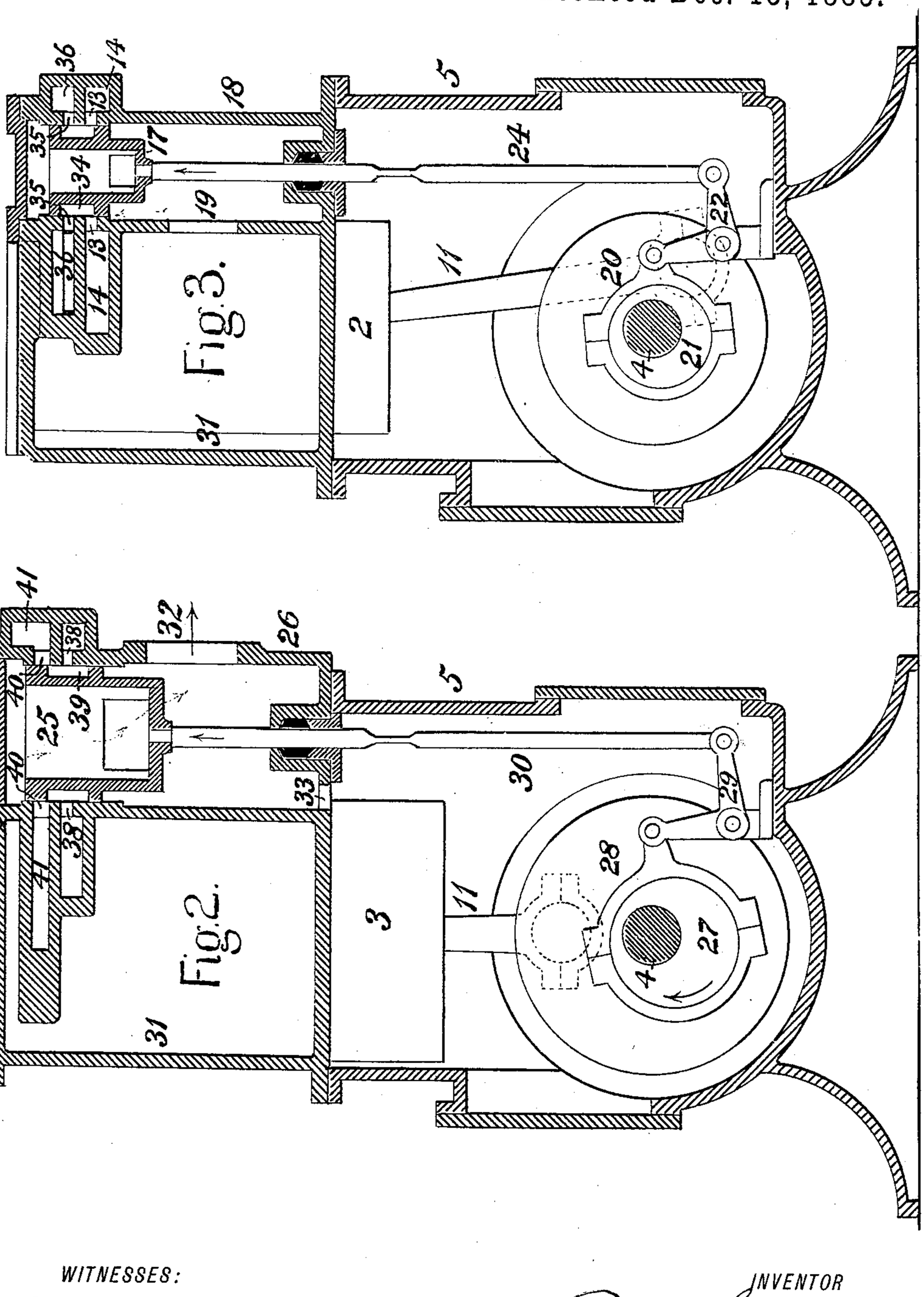

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3 Sheets—Sheet 3.

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Fig. 5.

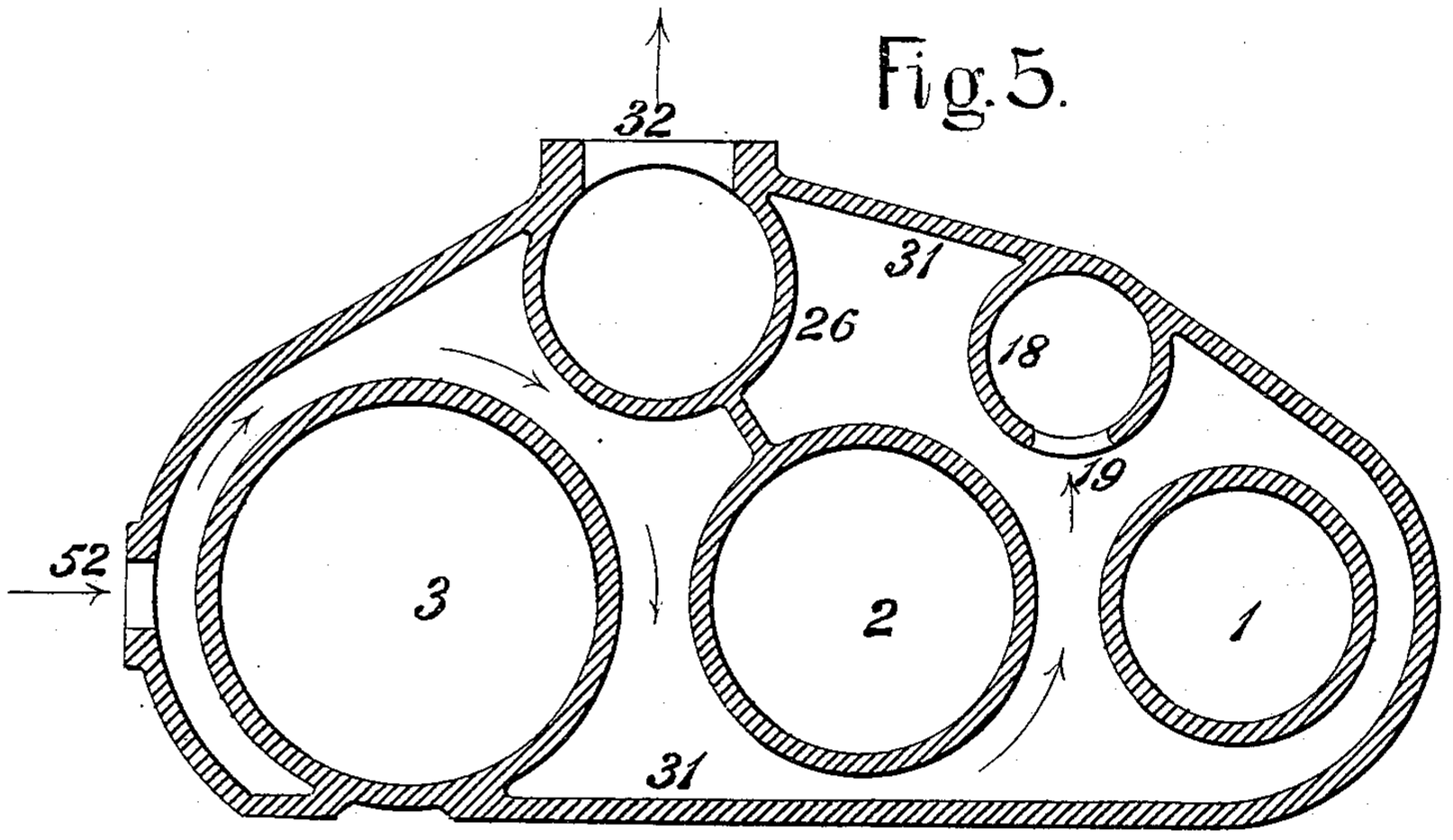
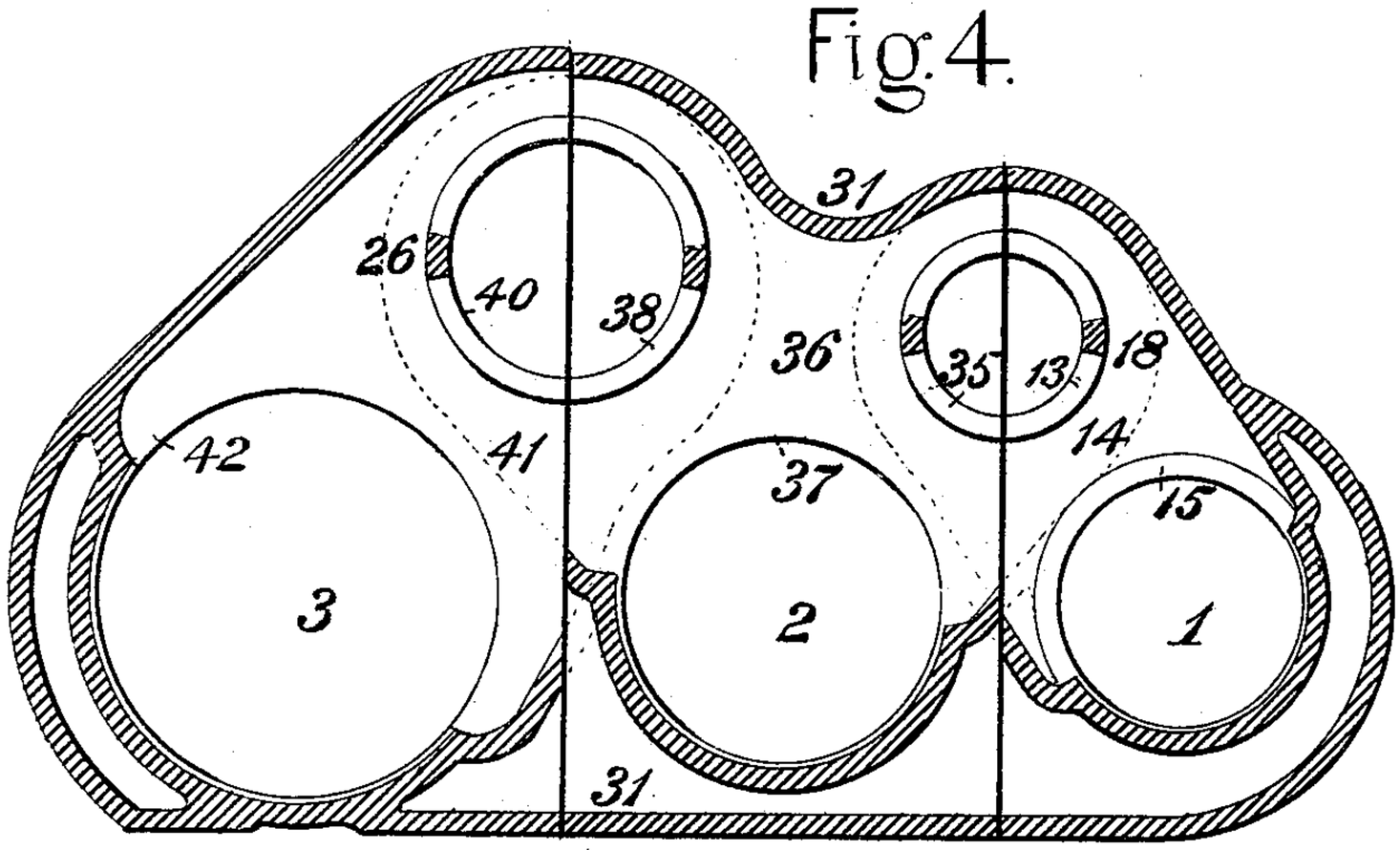


Fig. 4.



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UNITED STATES PATENT OFFICE.

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STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 332,502, dated December 15, 1885.

Application filed August 31, 1885. Serial No. 175,720. (No model.)

To all whom it may concern:

Be it known that I, ROBERT CREUZBAUR, of Brooklyn, in the county of Kings and State of New York, have invented certain new and useful Improvements in Steam-Engines, of which improvements the following is a specification.

My invention relates to single-acting engines having cylinders located side by side, with their pistons connected to independent cranks upon a common crank-shaft, and its objects are (*a*) to provide for supplying boiler-steam to a high-pressure cylinder, exhausting it therefrom to a low-pressure cylinder of greater capacity, thence exhausting it into a second low-pressure cylinder of further increased capacity, and finally exhausting it from said second low-pressure cylinder to the atmosphere or to a condenser; (*b*) to reduce the otherwise large difference in diameters of the several cylinders by progressively increasing the stroke of their pistons, so that by increase of stroke, together with comparatively small increase in diameter, the cylinder capacity requisite for the desired expansion may be attained; (*c*) to effect such location of the cylinder and valve ports as to materially reduce dead space and attain direct steam-passage; (*d*) to effect the distribution of steam in a three-cylinder compound engine by two reciprocating piston-valves located side and side with the cylinders; (*e*) to effect the operation of said distribution-valves by eccentrics through lever connections; (*f*) to return to the exhaust-steam from the high-pressure and primary low-pressure cylinders the heat lost in said cylinders by means of steam-jackets, to which superheated steam is admitted in its passage from the boiler to the high-pressure cylinder; (*g*) to provide for the direct admission of steam from the jacket to the low-pressure cylinders when starting the engine or otherwise, when required, and (*h*) to admit of expansion of the metal of the cylinders by extending their inner ends beyond the flanges by which they are connected to the crank-case.

The improvements claimed are hereinafter fully set forth.

In the accompanying drawings, Figure 1 is a vertical longitudinal central section through a steam-engine embodying my invention, the pistons of two cylinders being shown in elevation; Fig. 2, a vertical transverse section at the line *x x* of Fig. 1; Fig. 3, a similar section at the line *y y* of Fig. 1; Fig. 4, a horizontal section at the line *z z* of Fig. 1, with the direct-steam-admission valve omitted; Fig. 5, a similar section at the line *w w* of Fig. 1, and Fig. 6 a diagram illustrating the relative positions of the crank-pins.

My invention is illustrated as applied in a single-acting engine having a high-pressure cylinder, 1, a primary low-pressure or expansion cylinder, 2, of larger diameter, and a secondary low-pressure or expansion cylinder, 3, of larger diameter than the cylinder 2, said cylinders 1 2 3, which are open at their lower ends, being located side and side—that is, with their axes in parallel planes—and being secured by flanges 6 to the top of a closed crank-case or crank-shaft chamber, 5, having end bearings, 41, for the journals 50 of a crank-shaft, 4. The cylinders 1 2 3 are fitted, respectively, with long pistons 7 8 9 of the trunk class, and said pistons are coupled by connecting-rods 11 with crank-pins 12 upon three pairs of double cranks, 10 10 10, which are set at angles of one hundred and twenty degrees apart on the crank-shaft 4. A progressive increase in cylinder capacity is attained from the high-pressure cylinder 1 to the secondary low-pressure cylinder by increasing both the diameter and the length for piston-stroke of the cylinders, the drawings, for example, representing an engine in which the high-pressure cylinder 1 is of six inches diameter with four inches stroke, the primary low-pressure cylinder 2 of eight inches diameter with six inches stroke, and the secondary low-pressure-cylinder 3 of ten inches diameter with eight inches stroke. By thus increasing the stroke of the low-pressure or expansion cylinders 2 3, instead of attaining the requisite increased displacement of their pistons by their increase in diameter solely, the engine is made of more symmetrical construction, and the location of each cylinder-port opposite its corresponding valve-port is facilitated, thereby attaining direct steam-passages with a reduction of dead spaces.

The major portion of the cylinders and the space intervening between them is inclosed within a steam-jacket, 31, to which steam from

the boiler is admitted through a steam-pipe connected to a supply nozzle or flange, 52, on the side of the jacket adjacent to the secondary low-pressure cylinder 3, such steam circulating around the outside of the cylinders 3 and 2 in its passage to the high-pressure cylinder 1. The steam-jacket does not extend entirely to the inner ends of the cylinders 3 and 2, and need not extend to the inner end of the cylinder 1, its purpose being to heat by the supply-steam but little more than those portions of the cylinders to which working-steam driving the pistons is admitted. The inner ends of the cylinders 2 and 3 are extended into the crank-case below the flanges 6, by which they are secured to said case, and are thus housed and protected by the crank-case and free to expand and contract under variations of temperature.

Steam from the jacket is supplied to the upper or working end of the high-pressure cylinder 1 and exhausted therefrom to the primary low-pressure or expansion cylinder 2 by a high-pressure main or distribution valve, 17, of the piston type, working in a valve-chamber, 18, located within the jacket 31, adjacent to the cylinder 1, and receiving steam from the jacket through a port, 19. The valve 17 is actuated by an eccentric, 21, on the crank-shaft 4, said eccentric having its strap 20 coupled to the upper arm of a bell-crank lever, 23, journaled in the crank-case and having its lower arm coupled to the stem 24 of the valve 17. Steam exhausted from the high-pressure cylinder 1 is supplied to the primary low-pressure cylinder 2 through valve 17, then exhausted therefrom into the secondary low-pressure cylinder 3, and finally exhausted from the secondary low-pressure cylinder to the atmosphere or to a condenser by a low-pressure main or distribution valve, 25, of the piston type, working in a valve chamber, 26, located within the jacket 31, adjacent to the cylinders 2 and 3, and actuated by an eccentric, 27, on the crank-shaft 4, said eccentric having its strap 28 coupled to the upper arm of a bell-crank lever, 29, journaled in the crank-case and having its lower arm coupled to the stem 30 of the valve 25. It will be obvious that, if desired, the valves 17 and 25 may be operated directly by their respective eccentrics, the cylinders being in such case located sufficiently far apart and the valve-chambers being inclined relatively to the axis of the cylinders. The steam exhausted from the cylinder 3 is led through an exhaust-pipe connected to an exhaust nozzle or flange, 32, on the valve-chamber 26 to the atmosphere or to a condenser, and when exhausted into a condenser a connection must be made between the crank-case and condenser through the valve-chamber 26, as shown at 33, Fig. 2, for the purpose of preventing a higher pressure upon the under than the upper sides of the pistons during their exhausting strokes.

In operation steam from the boiler, which steam is preferably highly superheated, enters the jacket 31 through the supply-inlet 12, and traversing the jacket, as indicated by the arrows, enters the valve-chamber 18 through the supply-inlet 19. The heat contained in the superheated steam in excess of that admissible with safety to the working parts is transmitted through the cylinders to the steam performing work therein, and thus correspondingly supplies heat to compensate for that absorbed by the work done. The valve 17 being in its uppermost position, steam passes through the valve-chest ports 13 into a channel, 14, communicating with a cylinder-port, 15, leading into the cylinder 1 on the same level as the valve-chest ports 13, and the downward stroke of the piston 7 is thereby effected, the steam acting thereon through three-fourths of its stroke. In the downward traverse of the valve 17 the ports 13 are connected, through the exhaust cavity or recess 34 of the valve 17, with valve-chest ports 35, through which the steam passes from the cylinder 1 into a channel, 36, surrounding both the valve-chambers, and communicating with a cylinder-port, 37, leading into the cylinder 2 on the same level as the valve-chest ports 35; the piston 7 completes its downward stroke and commences its return-stroke, the steam above it continuing to be exhausted into the cylinder 2. The piston 8 of the cylinder 2 is meanwhile moved downward into position, as shown, the piston 9 of the cylinder 3 being then in position to commence its working-stroke. The drawings illustrate the relative positions of the three pistons and their respective crank-pins with the corresponding position of the valves 17 and 25. In such position the cylinder 1 continues to exhaust into the cylinder 2, and the latter commences to exhaust into the cylinder 3 through the valve-chest ports 38, exhaust cavity or recess 39 of the valve 25, valve-chest ports 40, channel 41, communicating with said ports, and cylinder-port 42, the latter leading into the cylinder 3 on the same level as the valve-chest ports 40.

Assuming the circle, Fig. 6, to indicate the path of the three crank-pins 12, turning to the right, Z representing the outer dead point of the pistons, the cylinders receive and exhaust steam substantially as follows, the circle being divided into six equal parts, as shown: The high-pressure cylinder 1 receives boiler-steam throughout parts 1^a and 2^a, exhausts into the primary low-pressure cylinder 2 throughout parts 3^a, 4^a, and 5^a, and cushions throughout 6^a. The primary low-pressure cylinder 2, receives steam from the cylinder 1 throughout parts 1^a, 2^a, and 3^a, exhausts into the secondary low-pressure cylinder 3 throughout 4^a and 5^a, and cushions during 6^a. The secondary low-pressure cylinder 3 receives steam from the primary low-pressure cylinder 2 throughout parts 1^a, 2^a, and 3^a, exhausts into the atmosphere or a condenser throughout 4^a and 5^a, and cushions during 6^a. The exhaust from the cylinder 3 passes through

the port 42, channel 41, valve-chest port 40, and interior of the valve 25 into the valve-chest 26, the valve 25 being in its lowest position, and escapes through the exhaust discharge-nozzle 32.

The total theoretical expansion in an engine proportioned as specified, and disregarding dead spaces and clearances, is 6.64 times, which, with the three cylinders and duly superheated steam, will be found fully practicable. The minimum and maximum work performed during a revolution of the crank-pins, divided into six parts, is as 100 to 236; two double-acting engines without expansion vary as 100 to 140, and one double-acting engine without expansion as 100 to 0.

In order to provide for the admission of steam from the jacket to the secondary low-pressure cylinder 3 on starting the engine or otherwise, when desired, for increase of power, a hand-operated direct-steam-admission valve, 43, is fitted to seat over an opening leading from the jacket 31 into the port 42 of the cylinder, its stem 44 being screw-threaded and engaging a nut in the stem-casing and being provided with an operating hand-wheel, 45, on its outer end. A similar valve may be applied to the primary low-pressure cylinder 2, if desired.

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

1. The combination of a high-pressure single-acting cylinder, a primary low-pressure or expansion single-acting cylinder of larger diameter, and a secondary low-pressure or expansion single-acting cylinder of still larger diameter, said cylinders being located side and side, and having their pistons coupled to crank-pins set at about one hundred and twenty degrees apart on a common crank-shaft, substantially as set forth.

2. In a compound engine, the combination of three single-acting cylinders of unequal capacity, respectively, located side and side, and one or more valve-chests having ports located directly opposite to and substantially in line with the steam-ports of said cylinders, substantially as set forth.

3. In a compound engine, the combination of three single-acting cylinders of unequal capacity, respectively, said cylinders being located side and side, and having their pistons coupled to crank-pins set at about one hundred and twenty degrees apart on a common crank-shaft, a main or distribution valve governing the distribution functions of the first or high-pressure cylinder, and a main or distribution valve common to the two low-pressure or expansion cylinders, substantially as set forth.

4. In a compound engine, the combination of a high-pressure cylinder, a primary low-pressure cylinder of larger capacity, a secondary low-pressure cylinder of still larger capacity, said cylinders being located side and side, and having their pistons coupled to crank-pins on a common crank-shaft, a distribution-valve feeding steam from the boiler into the high-pressure cylinder and exhausting it into the primary low-pressure cylinder, a distribution-valve exhausting steam from the primary low-pressure cylinder into the secondary low-pressure cylinder and from the secondary cylinder to the atmosphere or a condenser, and eccentrics fixed upon the crank-shaft and having their straps coupled to bell-crank levers, which are in turn coupled to the stems of the distribution-valves, substantially as set forth.

5. In a compound engine, the combination of three single-acting cylinders of unequal capacity, respectively, said cylinders being located side and side, and having their pistons coupled to crank-pins set at about one hundred and twenty degrees apart on a common crank-shaft, distribution-valves whereby steam is fed to the smallest cylinder and successively twice expanded in the two larger cylinders, and a steam-jacket substantially surrounding the cylinders and forming part of the passage-way for steam from the boiler to the valve-chest of the distributing-valve of the smallest cylinder, substantially as set forth.

6. In a compound-engine, the combination of three single-acting cylinders of unequal capacity, respectively, secured side and side to a closed crank-case or chamber, and a continuously-open port or passage connecting the crank-case with the exhaust-passage of the largest cylinder, substantially as set forth.

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