No. 730,873. PATENTED JUNE 16, 1903.

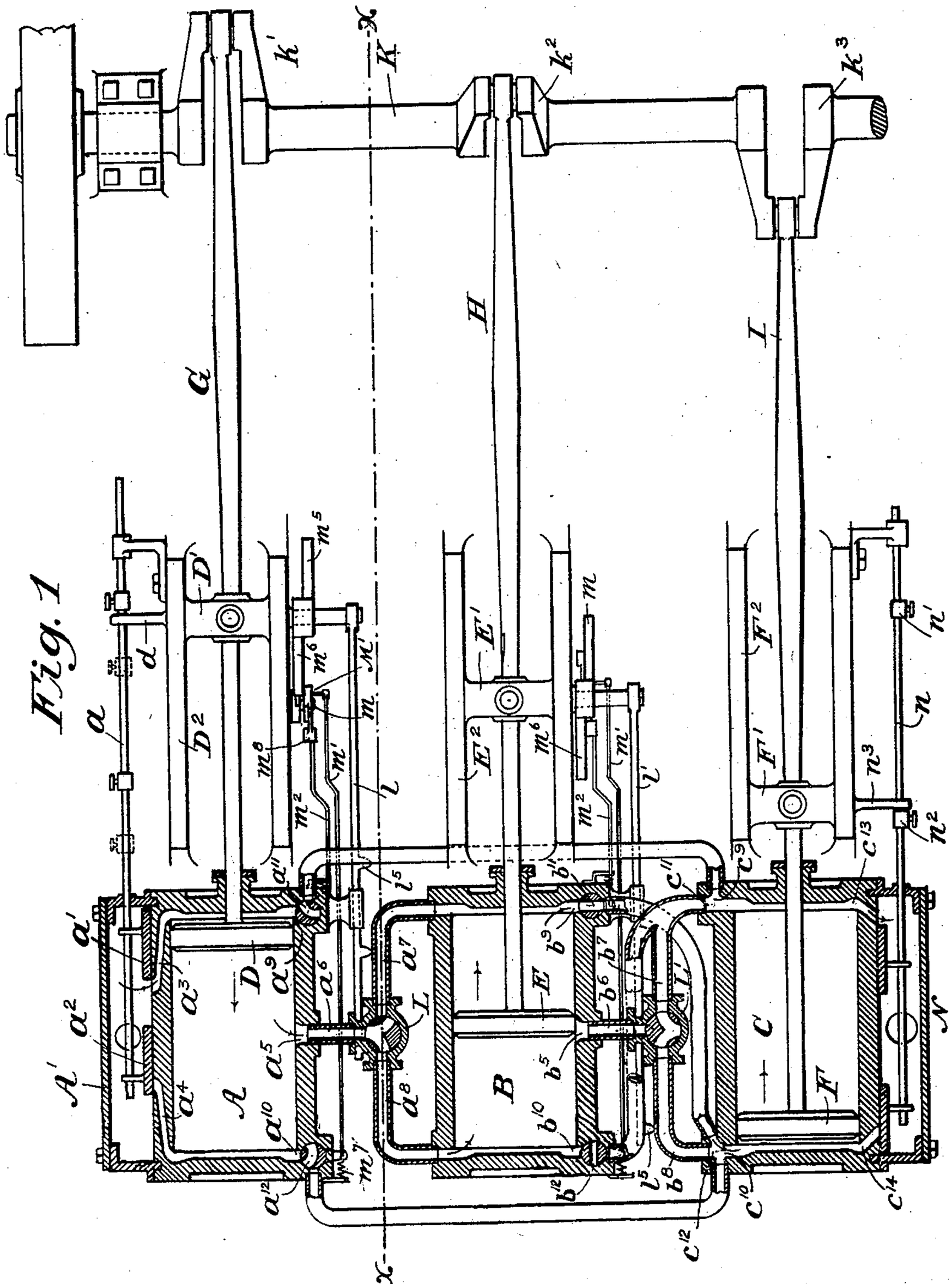
W. L. CASADAY.

COMPOUND RECIPROCATING STEAM ENGINE.

APPLICATION FILED JAN. 11, 1900.

NO MODEL. 3 SHEETS—SHEET 1.

Fig. 1



Witnesses:-
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NO MODEL. 3 SHEETS—SHEET 2.

Fig. 3

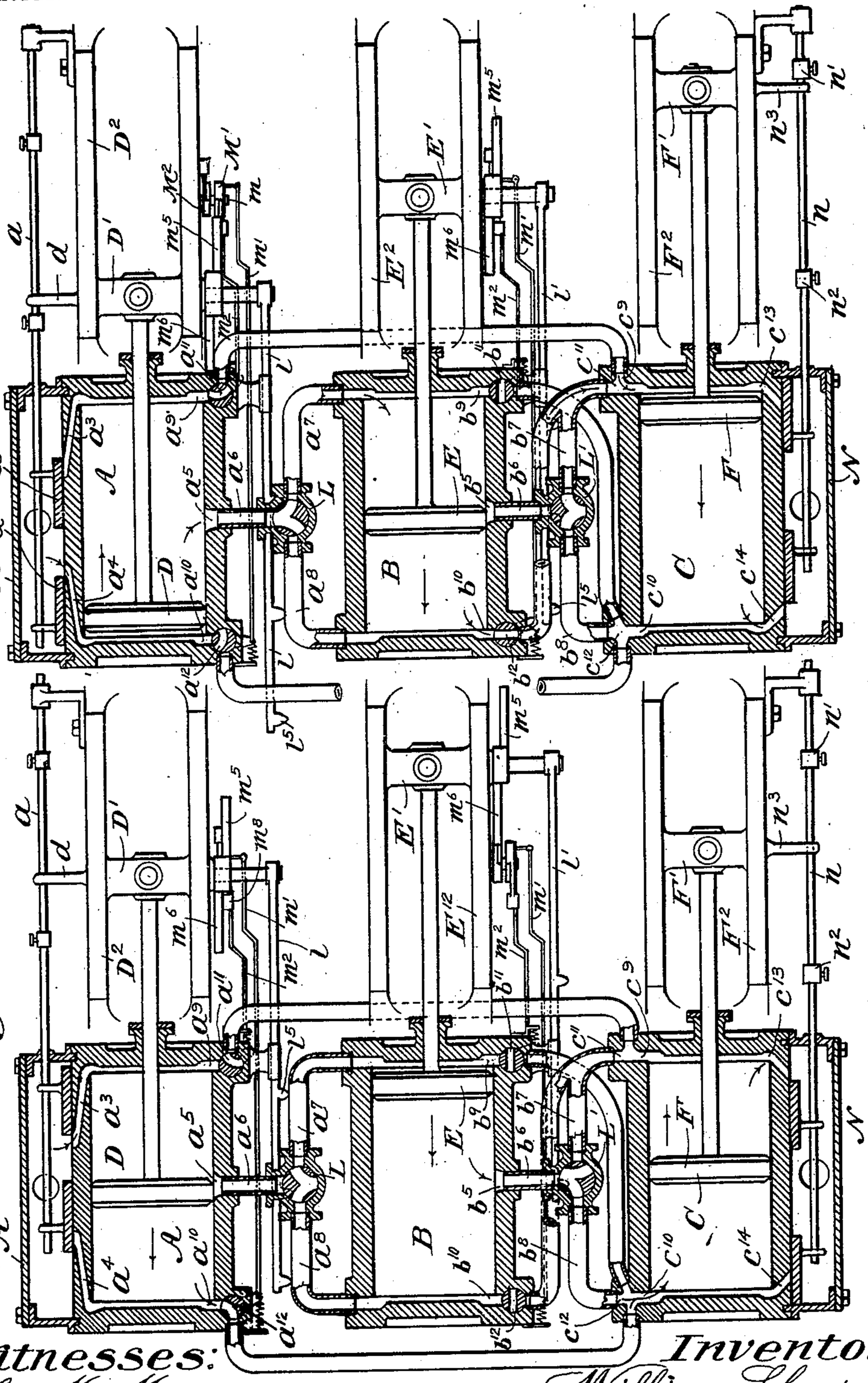

Fig. 2

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NO MODEL. 3 SHEETS—SHEET 3.

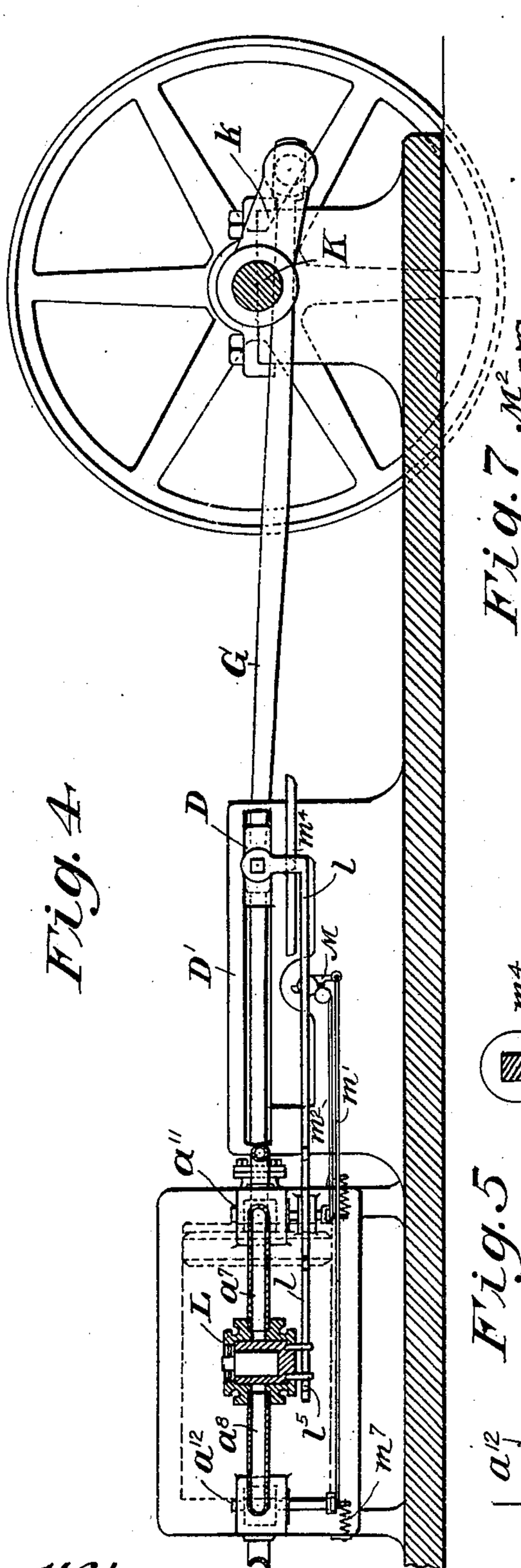

Fig. 4.

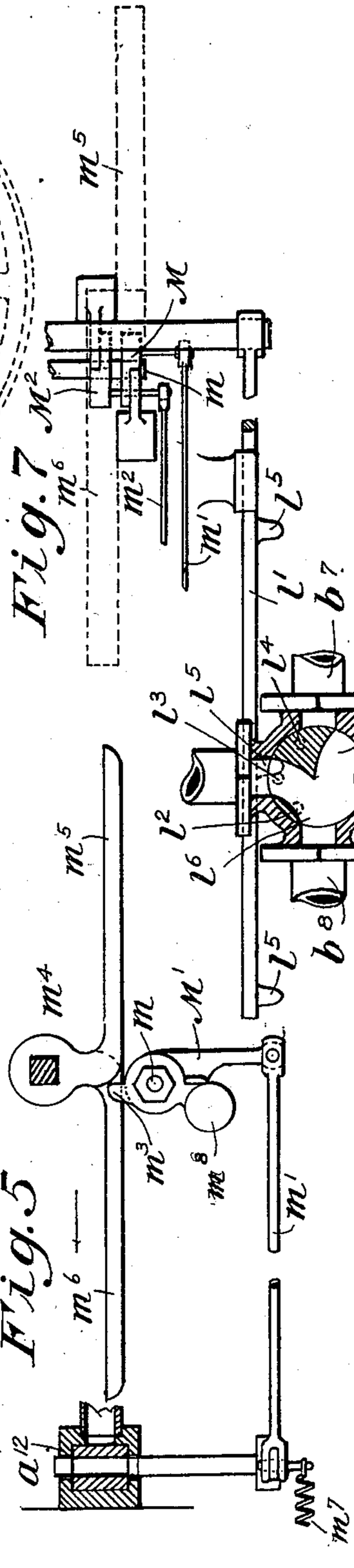

Fig. 7.

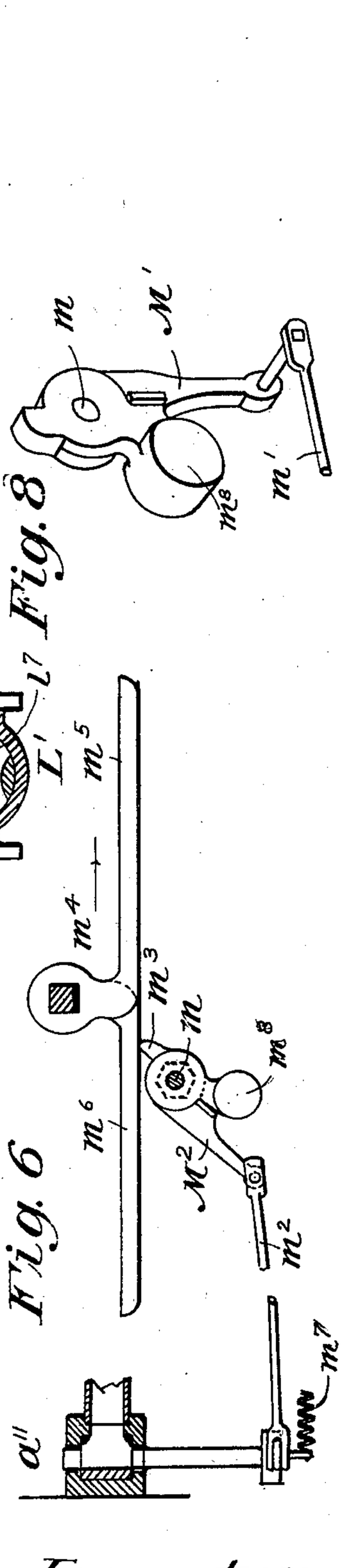

Fig. 8.

Fig. 5.

Fig. 6.

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No. 730,873. Patented June 16, 1903.

UNITED STATES PATENT OFFICE.

WILLIAM L. CASADAY, OF SOUTH BEND, INDIANA.

COMPOUND RECIPROCATING STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 730,873, dated June 16, 1903.

Application filed January 11, 1900. Serial No. 1,104. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM L. CASADAY, a citizen of the United States, residing at South Bend, in the county of St. Joseph and State of Indiana, have invented certain new and useful Improvements in Compound Reciprocating Steam-Engines, of which the following is a specification.

The object of my invention is to provide a compound reciprocating engine of simple and inexpensive design comprising cylinders of equal diameter and length of stroke placed parallel to each other, so that they may be all connected directly to the same engine-shaft and adapted to provide a constantly-increasing capacity to receive steam of the initial pressure and in accordance with the demands of the pistons to their variable speed during the rotation of the crank-shaft.

My invention consists, as may be stated in general terms, in providing a plurality of cylinders of the ordinary reciprocating-engine type with a novel form and arrangement of valve-gear and pipe or port connections, the pistons of the engines being coupled to a driving-shaft having cranks set at ninety degrees for each successive engine and adapted to control and operate the valves in such manner that the exhaust-steam will pass unobstrubtedly and expand to the fullest extent required from one cylinder to the other of the series, the degree of expansion being determined by the number of cylinders employed.

In the accompanying drawings, Figure 1 is a plan view of a set of three single engines connected to an engine-shaft wherein the piston of the first or high-pressure cylinder is at the beginning of its back stroke; Fig. 2, a plan view of said cylinders, their pistons being in the position assumed when the first piston has just passed the middle of its back stroke; Fig. 3, a plan view similar to Fig. 2 with the piston in position assumed when the first piston is at the beginning of its forward stroke; Fig. 4, a vertical sectional elevation in line $x\,x$ of Fig. 1. Figs. 5 and 6 are side elevations in detail of the valve-gear for operating the valves of the end exhaust-ports; Fig. 7, a plan view of the said valve-gear and also a sectional plan of the middle exhaust-valve and gear for operating it; and Fig. 8, a perspective view of the dog for operating the valve-gear, as shown in elevation in Figs. 5 and 6.

The cylinders A, B, and C of the triple-expansion engine have respectively pistons D, E, and F and connecting-rods G, H, and I, connected to a crank-shaft K, the latter having cranks k' k^2 k^3 set at right angles successively to each other, the pistons having a cross-head D′, E′, and F′ and guide-rods D^2, E^2, and F^2, respectively, to rotate the shaft by the reciprocation of the pistons in the usual way. The cross-head D′ of the piston D has a tappet-arm d, which projects laterally therefrom to engage with stop-blocks adjustably secured to a valve-rod a, carrying slide-valves a' and a^2, within a steam-chest A′ of the first cylinder to admit steam to the opposite ends of the cylinder through ports a^3 a^4, respectively, at suitable intervals, regulated in a well-known manner. The middle exhaust-port a^5 of the first cylinder A is located on the side of the cylinder adjacent to the second cylinder B, at the middle thereof, and communicates through a steam-pipe a^6 and branch pipes a^7 a^8 to the ends of the second cylinder B, the admission of the exhaust-steam thereto being controlled by an oscillatory valve L, which is operated by suitable means—in this instance by a spur-rod l, connected to the cross-head D′ and extending to a point opposite the middle line of the piston, thus to open the exhaust L alternately to the opposite ends of the second cylinder B when the piston of the first engine has reached the middle of the stroke. A similar oscillatory valve L′, adapted to steam-pipe b^6 and branch pipes b^7 b^8, admits steam from the middle exhaust-port b^5 to the inlet-ports c^9 c^{10} at the ends of the cylinder C and transfers the steam which has been expanded in the cylinders A and B to the third cylinder C for further expansion. The oscillatory valve L′, it will be seen, is operated by a spur-rod l' from the cross-head E′ at suitable intervals, as described with reference to the valve L, and while the piston E is passing the middle of its stroke pins l^2 l^3 l^4 upon the said valves being pushed aside by the spurs l^5 to open the three-way ports l^6 l^7 of the valve alternately to the branch ports leading to the ends of the cylinder. The middle exhaust-port a^5

is closed to the steam in advance of the piston after the latter has passed the port, and the steam contained therein in the case of cylinder A is conducted directly to the adjacent ends of the third cylinder C, the piston F of which, it will be observed, is set to travel always in the direction directly reverse to that of the piston D, because of the opposite relation to the crank k' and k^3 upon the crank-shaft. The steam thus contained in the cylinder A at the last half of its stroke is transferred to the cylinder C when its piston F is traveling through the last half of its stroke, the exhaust-steam from the second cylinder B being transferred to the cylinder C during the first half-stroke of its piston F through pipes or ports leading from end exhaust-ports b^9 b^{10}, the second cylinder B, to the receiving-ports c^{11} c^{12} at the opposite ends of the third cylinder. A valve-gear, similar to that employed to control the end exhaust-ports a^{10} a^{11} of cylinder A, is employed to control the exhaust-ports b^9 and b^{10} of the cylinder B, and in this instance consists of oscillatory valves a^{11} and a^{12} of cylinder A and similar valves b^{11} and b^{12} of cylinder B, the said valves being connected, respectively, by rods m' and m^2 with oscillatory dogs M' M², supported one alongside of the other upon pins m, fitted upon the middle of the respective guide-rods D² and E², a hinged spur m^3, connected to each of said dogs M' and M² making contact with a zigzag horizontal plate m^4, secured by a bolt to the middle of the cross-heads of the engines, one end, m^5, of the zigzag plate serving to operate the dog M' and the other end, m^6, thereof serving to operate the dog M² and hold them down to hold open the end exhaust-valves a^{11} a^{12} and b^{11} b^{12} from near the middle to near the end of the strokes of the respective pistons A and B, the said valves being quickly closed by a spring m^7, pulling upon the valve-arms, valve-rods, the dogs thus effecting a quick closure of the end exhaust-valves immediately before the steam-admission valves upon the opposite sides of the cylinder are opened. The hinged spur m^3 of the dogs M' M² will give way upon the return movement of the zigzag plate and when the latter has passed will be drawn by a counterweight m^8 or spring back to position to allow the dogs to be acted upon upon the return movement of the zigzag plate.

A slide-valve such as shown to open the cylinder A may be used to operate the exhaust-valves; but the movement of the valves would not be so quick as that described.

A Corliss valve-gear could be employed upon high-duty engines; but they are more expensive than the model form of gear herein described. A simple slide-valve N, having a stem n and tappet-blocks n' n^2, operated by an arm n^3, projecting laterally from the cross-head F' of engine C, may be employed to open and close the exhaust-ports c^{13} c^{14} of said engine. The steam passing through them being of greatly diminished pressure does not require a quickly-operating valve.

It is apparent that a fourth cylinder could be added to receive the exhaust from the cylinder C, as C receives its exhaust from cylinder B; but it is in most cases preferable to conduct the exhaust from cylinder C through steam-jackets surrounding the several cylinders to a hot-well or condenser. The pressures within the several cylinders become generally equalized, a greater volume of steam passing from the exhausting-cylinder at the end and slow movement of the piston of said cylinder to fill and follow up the piston of the receiving-cylinder during the rapid movement of the latter at the middle of its stroke. This equalization of pressures upon the various pistons connected, as shown, to a quarter-crank drive-shaft will give a steady movement to the engine and admits of its being lightly built and well adapted to vehicles, such as street-cars and road-wagons, the exhaust being effectively employed and reduced to minimum for condensation and easily muffled to render the vehicle noiseless.

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

1. A compound engine comprising a high-pressure cylinder a low-pressure cylinder-valve controlled steam-ports at the ends of the high-pressure cylinder and an exhaust-pipe leading from a port at the middle of the high-pressure cylinder to the ends of the low-pressure cylinder, and valve-controlled exhaust-pipes leading from the ends of the high-pressure cylinder, substantially as described.

2. In a compound engine the combination with the high-pressure cylinder having steam-valve-controlled ports leading to the ends thereof and valve-controlled exhaust-ports leading from the ends thereof, a low-pressure cylinder an exhaust-pipe leading from a port at the middle of the high-pressure-cylinder branch pipes therefrom to the end of the low-pressure cylinder and a three-way valve adapted to control the admission of the exhaust from the middle of the high-pressure cylinder alternately to the opposite ends of the low-pressure cylinder, substantially as described.

3. In a compound engine the combination with the two cylinders the first cylinder having valve-controlled ports at the ends thereof of the intermediate valve-controlled ports leading from the middle of the first cylinder to the ends of the second cylinder and a third cylinder having valve-controlled ports connecting the ends thereof with the ends of the first cylinder.

4. In a compound engine the combination with the two cylinders of the intermediate valve-controlled ports leading from the middle of the first cylinder to the ends of the second cylinder, the first cylinder having valve-controlled ports at the ends thereof, a third cylinder having valve-controlled ports

leading from the ends thereof to the opposite ends of the first cylinder and intermediate valve-controlled ports connecting the ends of the second cylinder to the opposite ends of the third cylinder.

5. In a compound engine the combination of the plurality of engines connected to the cranks of a common shaft, each set at right angles to the next adjacent crank, valve-controlled steam-ports adapted to the first engine and valve-controlled exhaust-ports adapted to the last engine of the set, intermediate valve-controlled middle exhaust-ports connecting the middle of the first cylinder with the ends of the adjacent cylinder and valve-controlled end exhaust-ports connecting the ends of the first cylinder with the ends of the succeeding cylinder.

6. In a compound engine the combination of a plurality of engines connected to the cranks of a common shaft, each set at right angles to each other, valve-controlled in steam-ports adapted to oppositely-moving engines, exhaust-ports leading from the ends of the first to the second cylinders of the oppositely-moving engines and an engine connected to a crank at right angles to the cranks upon the common shaft to which the oppositely-moving engines are connected and exhaust-pipes connecting the middle of the first cylinder with the ends of a succeeding cylinder and a valve to control said exhaust-pipes.

7. In a reciprocating triple compound engine the combination of the three engines having cylinders of substantially equal dimensions connected to a driving-shaft having cranks set successively thereon at right angles to each other of the steam slide valves and ports controlling admission to the first, the exhaust-pipes connecting the ends of the first cylinder with the ends of an expansion-cylinder, the oscillatory valves and valve-gear to open and close said valves respectively while the piston is moving from near the middle to near the end of its stroke, and an exhaust-pipe leading from the middle of the first cylinder to the ends of the second cylinder set at quarter-stroke therewith and an oscillatory valve moved in reverse direction near the middle of the stroke of the first piston, substantially as described.

8. In a compound reciprocating engine, a cylinder having valve-controlled steam and exhaust ports at the ends thereof, an exhaust-port and branch pipes leading from the middle of said cylinder, an oscillatory valve adapted to alternately open and close said exhaust-port alternately to said branch pipes as the piston passes the middle of its stroke, oscillatory valves adapted to control the exhaust-ports at the ends of the cylinder, and a valve-gear adapted to open and close the said valves alternately as the piston passes the middle and as it is near the ends of its stroke, substantially as described.

9. In a steam-engine, the combination with a plurality of cylinders, their pistons and cross-heads, of a single shaft driven therefrom, a supply-pipe connected with one of said cylinders, an exhaust-pipe and branch pipe leading therefrom and connecting with the remaining cylinders, an oscillatory three-way valve located between each two adjacent cylinders and connecting said exhaust-pipes and branch pipes, rods operated from the cross-heads controlling the motion of said three-way valves, each of said cylinders being connected with the shaft at a right angle with the adjacent cylinders.

10. In a steam-engine, the combination with a high-pressure and a plurality of low-pressure cylinders, their connecting-rods, piston-rods, pistons and cross-heads, of a single shaft driven from said cylinders, a steam-pipe connecting with the high-pressure cylinder, exhaust-pipes and branch pipes connecting the high-pressure with one of the low-pressure cylinders and similar pipes connecting the low-pressure cylinders with each other, an oscillatory three-way valve connecting the exhaust-pipes and branch pipes between each pair of cylinders, means operated from the cross-heads for actuating said valves and oscillatory valves at each end of each cylinder and also operated from the cross-heads, said cylinders being each operatively connected with the shaft at right angles with the connections for the remaining cylinders.

11. In a steam-engine the combination with the engine-cylinder of oscillatory valves at the ends thereof, a horizontal plate secured to the cross-head to project at equal distances from the center thereof, and reciprocate therewith dogs pivotally supported upon fixed pins connected to the oscillatory valves and spurs adapted to be operated by the horizontal plate when the latter moves in both directions and to engage with said dogs to operate said oscillatory valves when moved in one direction only.

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