(No Model.) 4 Sheets—Sheet 1.

G. WESTINGHOUSE, Jr., & F. M. RITES.

COMPOUND ENGINE.

No. 405,812. Patented June 25, 1889.

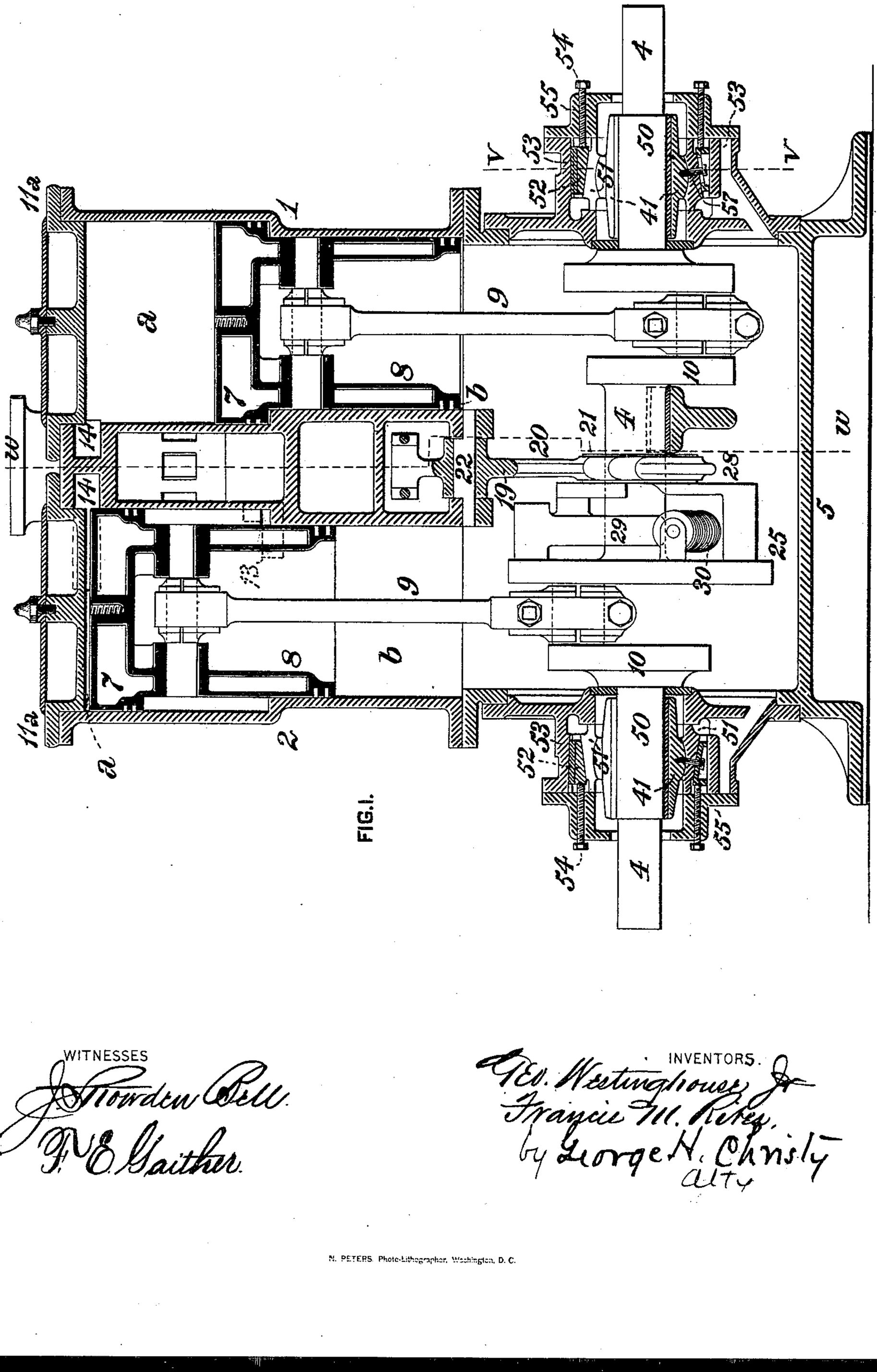

FIG. I.

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(No Model.) 4 Sheets—Sheet 2.

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COMPOUND ENGINE.

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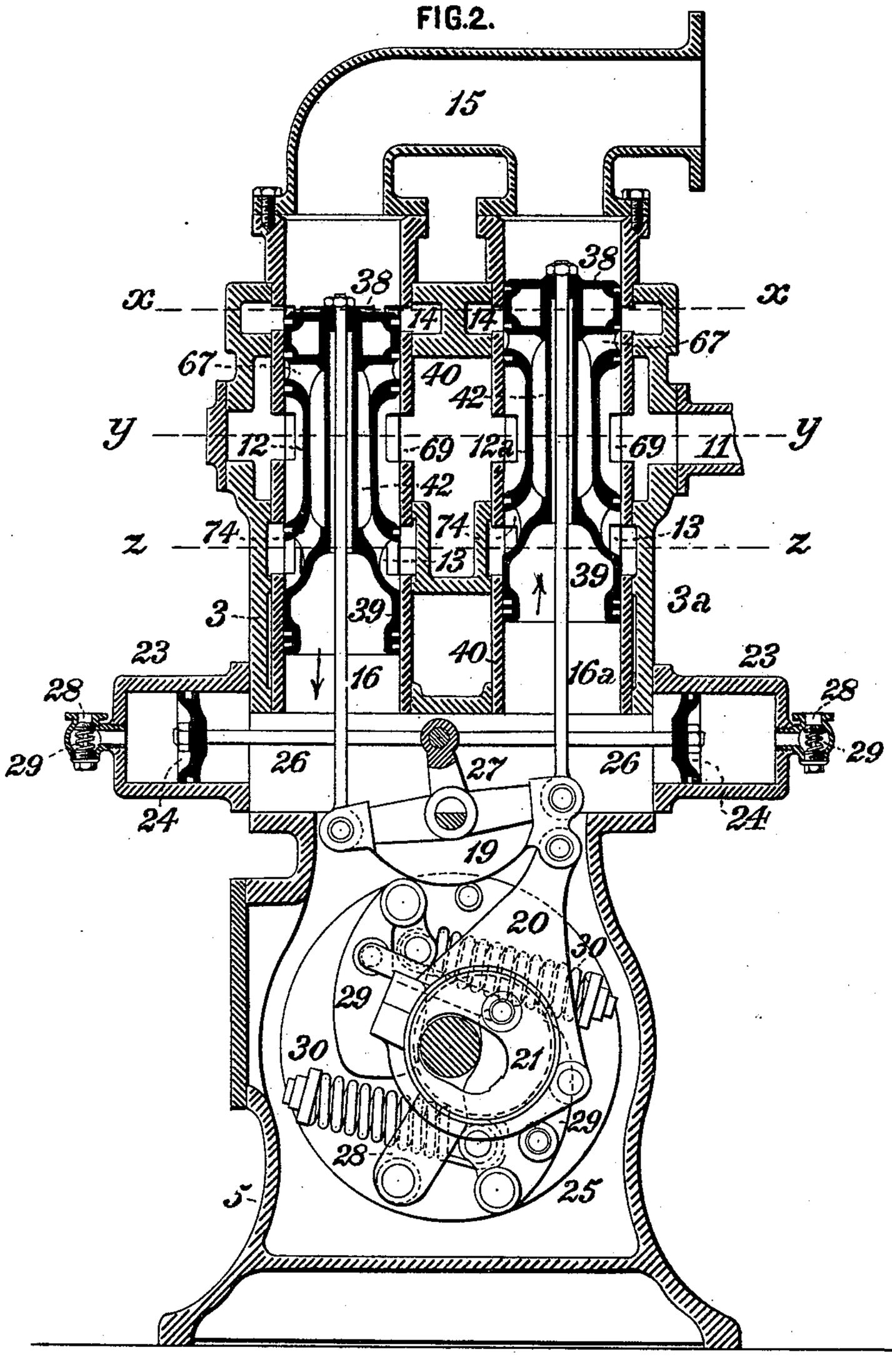
FIG. 2.



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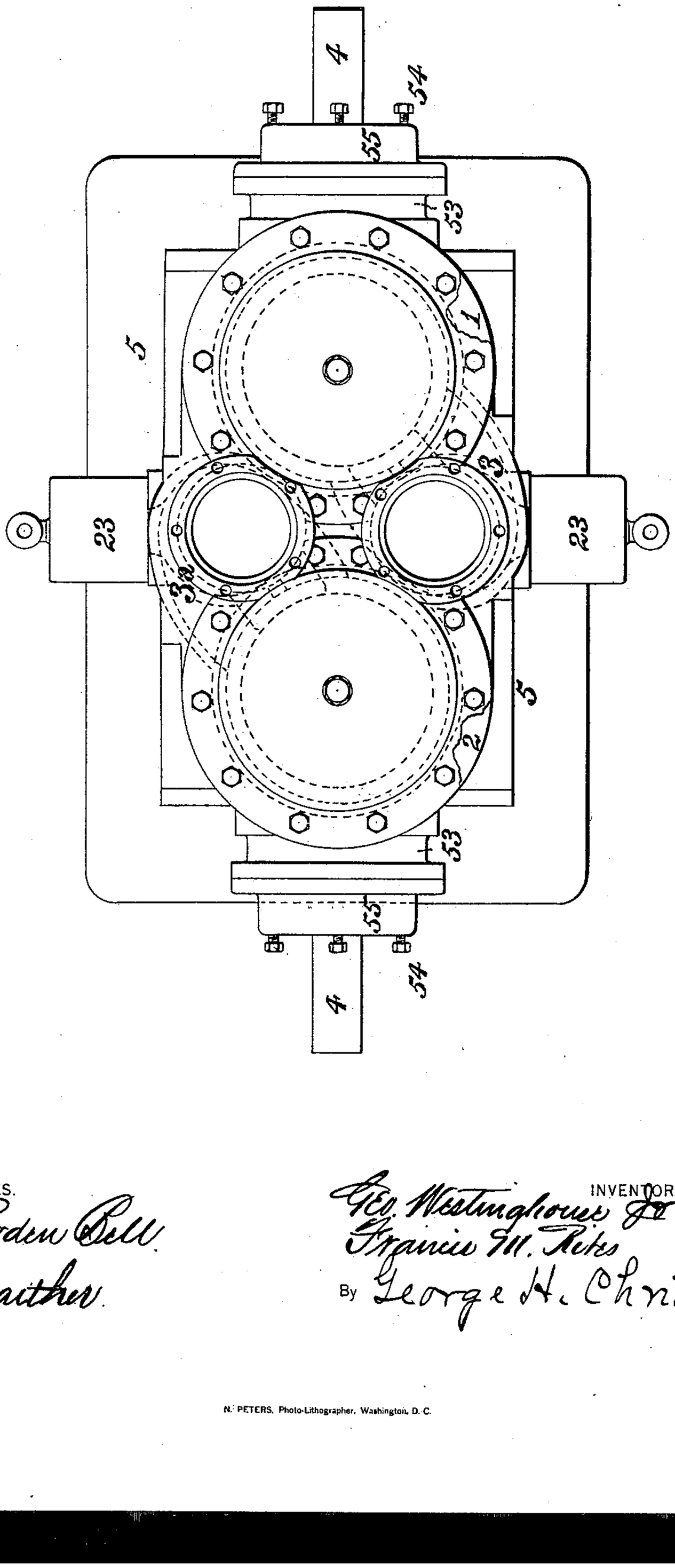
G. WESTINGHOUSE, Jr., & F. M. RITES.

COMPOUND ENGINE.

No. 405,812. Patented June 25, 1889.

FIG. 3.



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(No Model.) 4 Sheets—Sheet 4.

G. WESTINGHOUSE, Jr., & F. M. RITES.

COMPOUND ENGINE.

No. 405,812. Patented June 25, 1889.

FIG. 4.

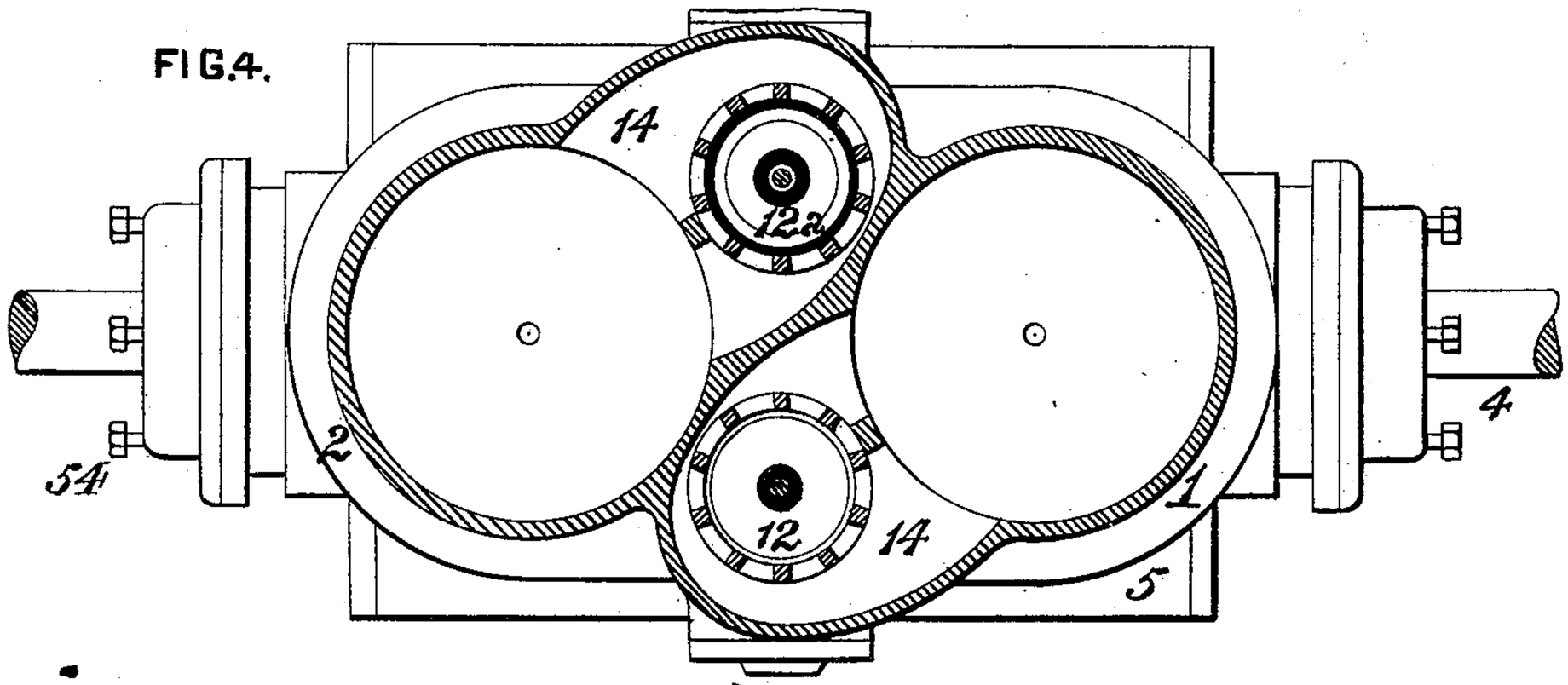


FIG. 5.

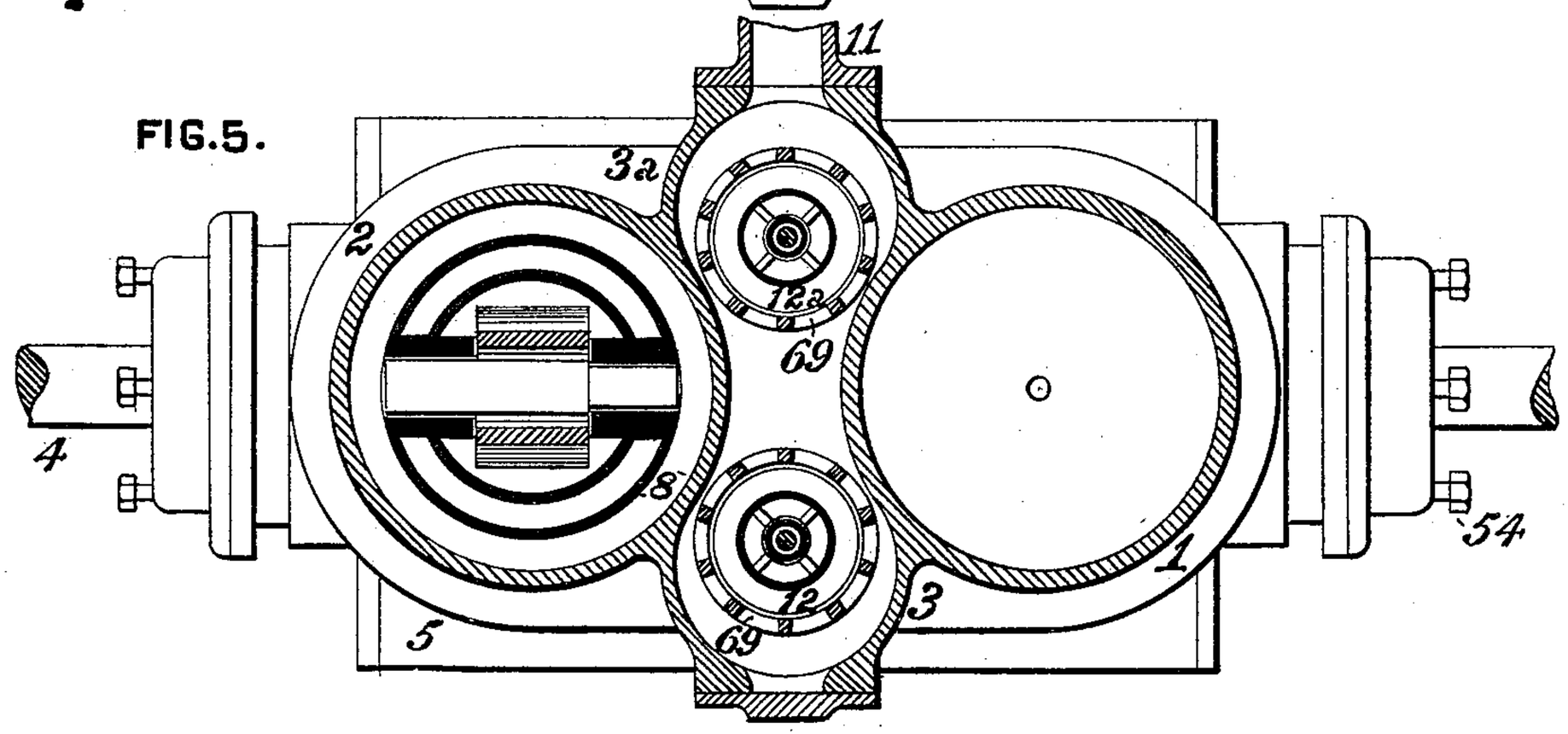
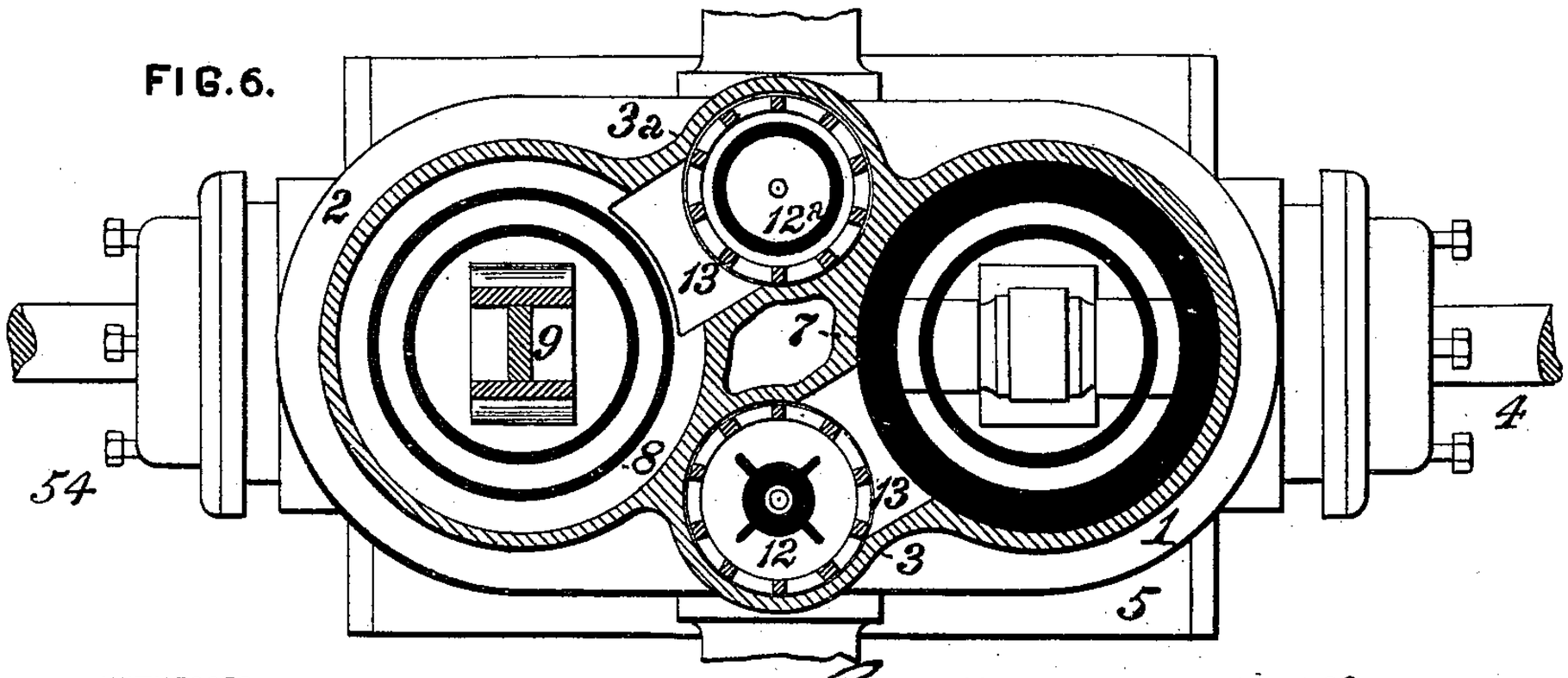


FIG. 6.



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UNITED STATES PATENT OFFICE.

GEORGE WESTINGHOUSE, JR., AND FRANCIS M. RITES, OF PITTSBURG, PENNSYLVANIA.

COMPOUND ENGINE.

SPECIFICATION forming part of Letters Patent No. 405,812, dated June 25, 1889.

Application filed February 16, 1889. Serial No. 300,166. (No model.)

To all whom it may concern:

Be it known that we, GEORGE WESTINGHOUSE, Jr., and FRANCIS M. RITES, citizens of the United States, residing at Pittsburg, in the county of Allegheny and State of Pennsylvania, have invented or discovered certain new and useful Improvements in Compound Engines, of which improvements the following is a specification.

Our invention relates to single-acting engines of the class in which a closed crank-case is employed; and its object is to provide a duplex compound engine of such type, the leading features of which shall be simplicity and compactness of construction and the capacity of developing comparatively high power within a limited space.

To this end our invention consists in certain novel combinations hereinafter fully set forth.

In the accompanying drawings, Figure 1 is a vertical longitudinal central section through a compound engine embodying our invention; Fig. 2, a vertical transverse section at the line *w w* of Fig. 1; Fig. 3, a plan or top view; and Figs. 4, 5, and 6, horizontal sections at the lines *x x*, *y y*, and *z z*, respectively, of Fig. 2.

In the practice of our invention we provide a pair of cylinders 1 2, which are preferably cast integral and with their axes parallel and at such distance apart as will admit of the interposition of two valve-chests 3 3^a, which are also cast integral with the cylinders, and are located on opposite sides of a plane passing through the axes of the cylinders. Each of the cylinders 1 2 is cast and bored out to two different diameters, the larger portions *a*, which extend from the upper ends of the cylinders to or about the middle thereof, being steam-spaces, and the smaller portions *b*, extending from the lower ends of the cylinders to the larger portions, serving only as inclosures for the trunks of the pistons, to be presently described. The cylinders are closed at top by heads 11^a, and are secured by bolts passing through flanges cast around their lower ends, which are open, to the top of a closed crank-case 5, which forms the bed or support of the engine and serves as a receptacle for the lubricating material of the crank-shaft journals and crank-pins.

Each cylinder is fitted with a piston 7, which is properly adapted to the larger bore *a*, and is formed integral with a trunk 8, fitting the smaller bore *b*, the spaces between the peripheries of the trunks 8 and the walls of the larger bores *a* being the high-pressure spaces, or those in which steam-pressure is initially exerted, and the spaces above the pistons 7 being the low-pressure spaces, or those into which steam is exhausted to effect the downward strokes of the pistons. The pistons are coupled by connecting-rods 9 to crank-pins set oppositely, or one hundred and eighty degrees apart, upon a pair of double cranks 10 10, formed upon a crank-shaft 4, having journals 50, mounted in bearings 41, which are supported adjustably in the ends of the crank-case 5. Both upward and downward pressure being exerted upon the pistons, the connecting-rods should be suitably constructed to admit of lost motion and wear at both ends being taken up from the lower end, and a construction desirably adapted for the purpose is set forth in a separate application, Serial No. 300,179, filed of even date herewith by George Westinghouse, Jr.

Steam or other motive fluid is supplied to the valve-chests 3 3^a by a steam-pipe 11, secured to a flange or nozzle upon either of the valve-chests, one being provided upon each chest to admit of the attachment of the steam-pipe on either side, as preferred, the opposite opening being closed by a cap. The valve-chests are lined with sleeves or bushings 40, the spaces within which communicate with the steam-pipe and one with the other through the space intervening between the bushings, by means of a series of supply-ports 69, formed in the latter. Steam is supplied to and exhausted from the cylinder-spaces above the pistons from and to the interior of the bushings 40 through ports 14, leading from the bushings to the upper ends of the cylinders, and is finally exhausted from the bushings to the atmosphere through an exhaust-pipe 15, having branches connected to the upper ends of the bushings.

The distribution functions of the cylinders 1 2 are performed, respectively, by two similar distribution-valves 12 12ª, working in the valve-chests 3 and 3ª, said valves being secured upon valve-stems 16 and 16ª, and coincidently reciprocated in relatively-opposite directions by a single automatic cut-off mechanism consisting of an eccentric 21, which is pivoted by an arm 28 to a centrifugal governor or regulator composed of a supporting disk or carrier 25, fixed upon one of the crank-arms, weights 29, pivoted to the disk and coupled to the eccentric, and centripetally-acting springs 30, connected to the weights and to the disk.

The eccentric 21 is provided with a slot fitting freely around the crank-shaft, so as to be adapted to be moved transversely to the crank-line by the governor in accordance with variations of pressure or resistance, or both, and thereby to vary the traverse of the distribution-valves 12 12ª, and correspondingly cut-off steam from the cylinders at earlier or later periods of the stroke of the pistons. The upper section of the eccentric-strap 20, which is prolonged so as to serve as an eccentric-rod, is coupled to a rocker 19, which is journaled at its center upon a bearing-pin 22, fixed to the bottom of the cylinder-casting between the cylinders and in line vertically with the crank-shaft. The rocker 19, which by the movement of the eccentric is oscillated about the axis of its bearing-pin 22, is provided with two arms extending in opposite directions therefrom, to the outer ends of which arms the valve-stems 16 16ª are coupled, coincident reciprocating movement in opposite directions being thereby imparted to the distribution-valves 12 12ª. The special form of governor illustrated is not claimed as of our present invention, and any other suitable and preferred construction thereof may be substituted, as desired.

In order to counteract the inertia of the distribution-valves and enable the same to be controlled by a governor sufficiently light and compact to be employed within the restricted limits of the crank-case, we provide an inertia balance consisting of a pair of balance-pistons 24, fitted to traverse at right angles to the planes of motion of the valves in chambers 23, secured to the lower ends of the cylinder-casting or to the crank-case, and open at their inner ends to the latter, said pistons being coupled by rods 26 to an upwardly-projecting arm 27 on the rocker 19, so as to be reciprocated coincidently with the valves by the movements of said rocker. Inwardly-opening check-valves 28, held to their seats by springs 29, control passages leading from the outer ends of the chambers 23 to the atmosphere, air being exhausted in the chambers 23 in the inward movements of each of said pistons and compressed in its outward movements, as in the construction set forth in the patent of Francis M. Rites, No. 342,307, dated May 18, 1886, which *per se* is not herein claimed.

Each of the main or distribution valves 12 12ª is composed of a hollow or tubular body 42 and upper and lower end pistons 38 and 39, between which pistons, respectively, and the tubular bodies there are formed low-pressure supply-ports 67, adapted to communicate intermittently with the low-pressure cylinder-ports 14 and high-pressure supply-ports 74, which are continuously in communication with high-pressure-cylinder ports 13, leading from the valve-bushings 40 into the larger bores *a* of the cylinders 1 2 below the pistons 7. The interior of the tubular body of each valve constitutes a clearance-chamber, which thus communicates continuously with a high-pressure-cylinder space.

Steam admitted from the boiler by the steam-pipe 11 passes into each of the valve-chests and around the tubular bodies of the valves through the ports 69 and in and by the downward movement of each valve is admitted through the port 13 of the cylinder controlled by said valve to the annular space within the bore of said cylinder below its piston 7, effecting the upward stroke of said piston. In the ensuing upward movement of the valve its lip or leading edge above the ports 74 closes communication between the valve-chest and cylinder-space below the piston at a point in the stroke of the piston determined by the governor, thereby effecting high-pressure cut-off, the remainder of the upward stroke being made by the expansion of the steam in the annular cylinder-space port 13, and tubular body of the valve up to the lower face of the upper valve-piston 38. In and by the further upward movement of the valve, and when the piston 7 has attained the upper limit of its stroke the valve-ports 67 are brought into communication with the low-pressure-cylinder port 14, thereby admitting the steam which is contained in the annular cylinder-space below the piston, the port 13, and the tubular body 42 into the larger cylindrical space above the piston 7. Such admission effects the preliminary portion of the downward stroke of the piston 7 under compound expansion exerted between the smaller annular high-pressure-cylinder space below the piston and around the trunk 8 thereof, and the larger cylindrical low-pressure-cylinder space above the piston. The distribution-valve has meanwhile commenced its downward movement, in the course of which, at a point regulated by the governor, its upper end piston 38 closes the low-pressure-cylinder port 14, thereby cutting off the supply to the low-pressure-cylinder space, and by closing the outlet from the tubular body of the valve, which, as before stated, constitutes a clearance-chamber, coincidently commencing high-pressure compression. The remaining portion of the downward stroke of the piston is effected under simple expansion—

that is to say, by the expansion of the steam inclosed in the cylinder above the piston, the steam inclosed in the annular cylinder-space below the piston, the port 13, and the tubular body 42 of the valve, being meanwhile in and by the downward stroke of the piston compressed at its terminal to substantially initial pressure. The continued downward movement of the valve effects the exhaust of the steam from the space above the piston through the port 14 into the exhaust-pipe 15, and admits steam, as before described, for the next succeeding upward stroke to the annular cylinder-space below the piston through the port 13, the new supply not being required to fill the tubular valve-body 42, and hence being exempt from reduction of pressure, as the previous supply contained in the valve-body is of equal pressure and is utilized with the new supply in the exertion of such pressure upon the annular lower face of the piston in the upward stroke about to be made. The operation of one valve only has been described, as that of the other is identical therewith, the movements of the two valves being effected through the rocker 19 in opposite directions in accordance with the opposite crank-connections of the pistons whose distribution functions are performed by the respective valves.

Our improvements enable the capacity of high power and the advantageous utilization of both simple and compound expansion to be attained in an engine occupying but small space and involving no complication or liability to derangement of its parts and no material increase of mechanism as compared with simple or non-compound engines of the same general type. The trunks which work in relatively-opposite directions in the lower spaces communicating with the crank-case being of equal diameters, displacement is equalized and the objectionable results due to unequal displacement are obviated without the necessity of employing, as heretofore, special means for such purpose.

We claim as our invention and desire to secure by Letters Patent—

1. In a compound engine, the combination, substantially as set forth, of two cylinders each bored out to a larger and a smaller diameter in the upper and lower portions, respectively, of its length, trunk-pistons fitting said cylinders, a crank-shaft journaled in bearings below the cylinders and provided with oppositely-set cranks, connecting-rods coupling the pistons to the pins of said cranks, and two distribution-valves which are reciprocated in respectively opposite directions by connections from the crank-shaft, each of said valves controlling the supply and exhaust ports of one of the cylinders.

2. In a compound engine, the combination, substantially as set forth, of two cylinders each bored out to a larger and a smaller diameter in the upper and lower portions, respectively, of its length, trunk-pistons fitting said cylinders, a crank-shaft journaled in bearings below the cylinders and provided with oppositely-set cranks, connecting-rods coupling the pistons to the pins of said cranks, two distribution-valves each controlling the supply and exhaust ports of one of the cylinders, and a single automatic cut-off mechanism coupled to and actuating said distribution-valves.

3. In a compound engine, the combination, substantially as set forth, of two cylinders, each bored out to a larger and a smaller diameter in the upper and lower portions, respectively, of its length, trunk-pistons fitting said cylinders, a crank-shaft journaled in bearings below the cylinders and provided with oppositely-set cranks, connecting-rods coupling the pistons to the pins of said cranks, two distribution-valves each controlling the supply and exhaust ports of one of the cylinders, a centrifugal governor or regulator fixed upon the crank, an adjustable eccentric which is coupled to and varied in position by the governor, and an oscillating rocker having its arms coupled to the strap of said eccentric and to the stems of the distribution-valves.

4. In a compound engine, the combination, substantially as set forth, of two cylinders each bored out to a larger and a smaller diameter in the upper and lower portions, respectively, of its length, trunk-pistons fitting said cylinders, a crank-shaft journaled in bearings below the cylinders and provided with oppositely-set cranks, connecting-rods coupling the pistons to the pins of said cranks, two distribution-valves which are reciprocated in respectively opposite directions by connections from the crank-shaft, each controlling the supply and exhaust ports of one of the cylinders, and an inertia balance composed of two pistons each working in a cylinder containing expansive fluid, said pistons being coupled one to the other and to the stems of the distribution-valves, so as to be reciprocated coincidently with said valves and to effect alternate expansion and compression of the fluid in the cylinders.

5. In a compound engine, the combination, substantially as set forth, of two cylinders each bored out to a larger and a smaller diameter in the upper and lower portions, respectively, of its length, trunk-pistons fitting said cylinders, a crank-shaft journaled in bearings below the cylinders and provided with oppositely-set cranks, connecting-rods coupling the pistons to the pins of said cranks, two valve-chests communicating by ports one with the other and with a common supply-pipe and communicating independently with a common exhaust-pipe, ports leading from each valve-chest into one of the cylinders adjacent to opposite ends of its larger bore, and a pair of distribution-valves reciprocating in the valve-chests, each of said valves having a tubular body, a pair of end pistons, and a

series of ports interposed between the body and the end pistons, said valves being adapted to supply steam to the lower cylinder-ports from the spaces around their bodies to transfer steam through their ports and bodies from the lower to the upper cylinder-ports and to exhaust steam from the upper cylinder-ports by their upper end pistons.

In testimony whereof we have hereunto set our hands.

GEO. WESTINGHOUSE, JR.
FRANCIS M. RITES.

Witnesses:
J. SNOWDEN BELL,
R. H. WHITTLESEY.