No. 757,009. PATENTED APR. 12, 1904.

C. C. WORTHINGTON.

STEAM ENGINE.

APPLICATION FILED MAY 16, 1899.

NO MODEL. 3 SHEETS—SHEET 1.

Fig. 2.

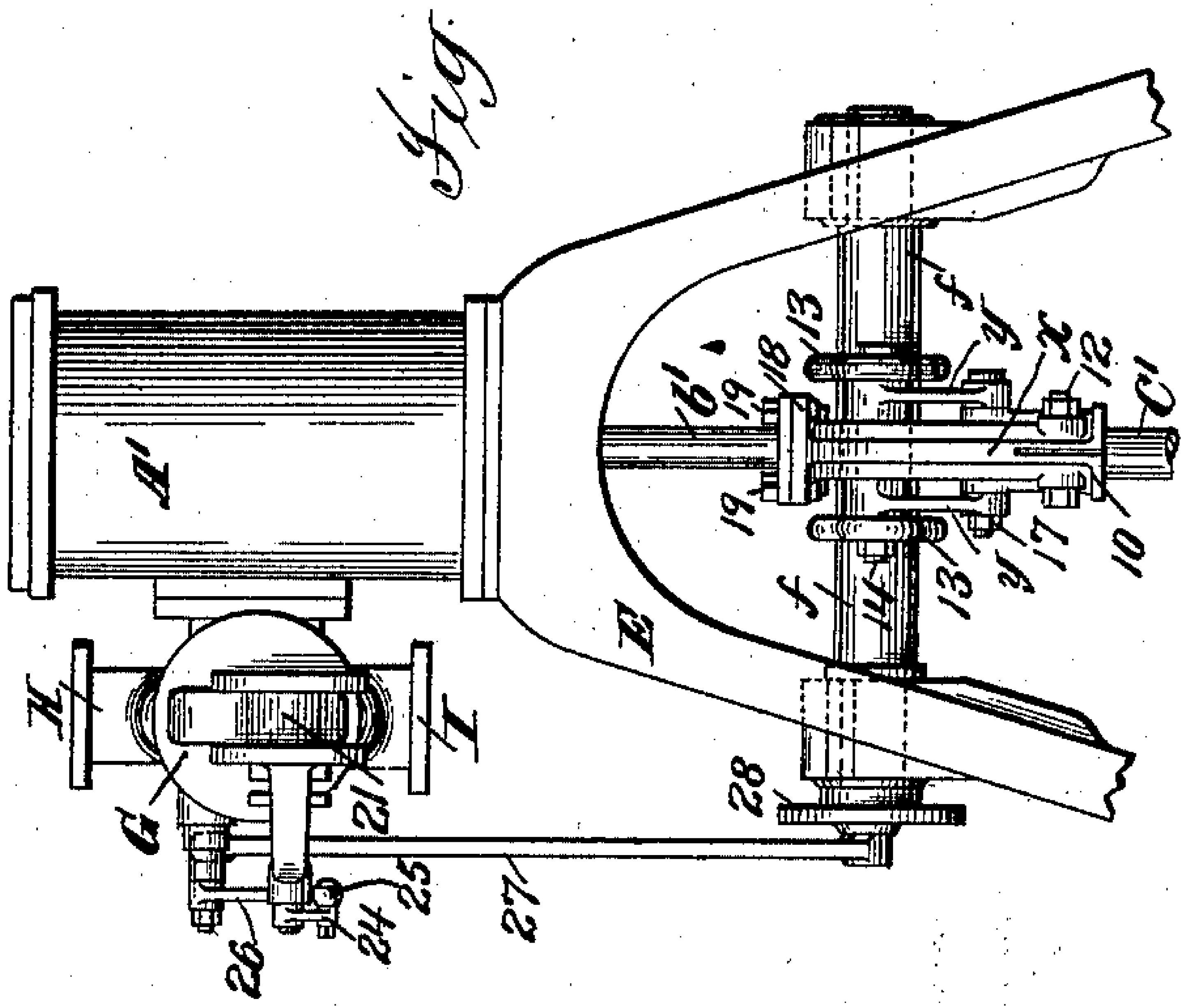


Fig. 3.

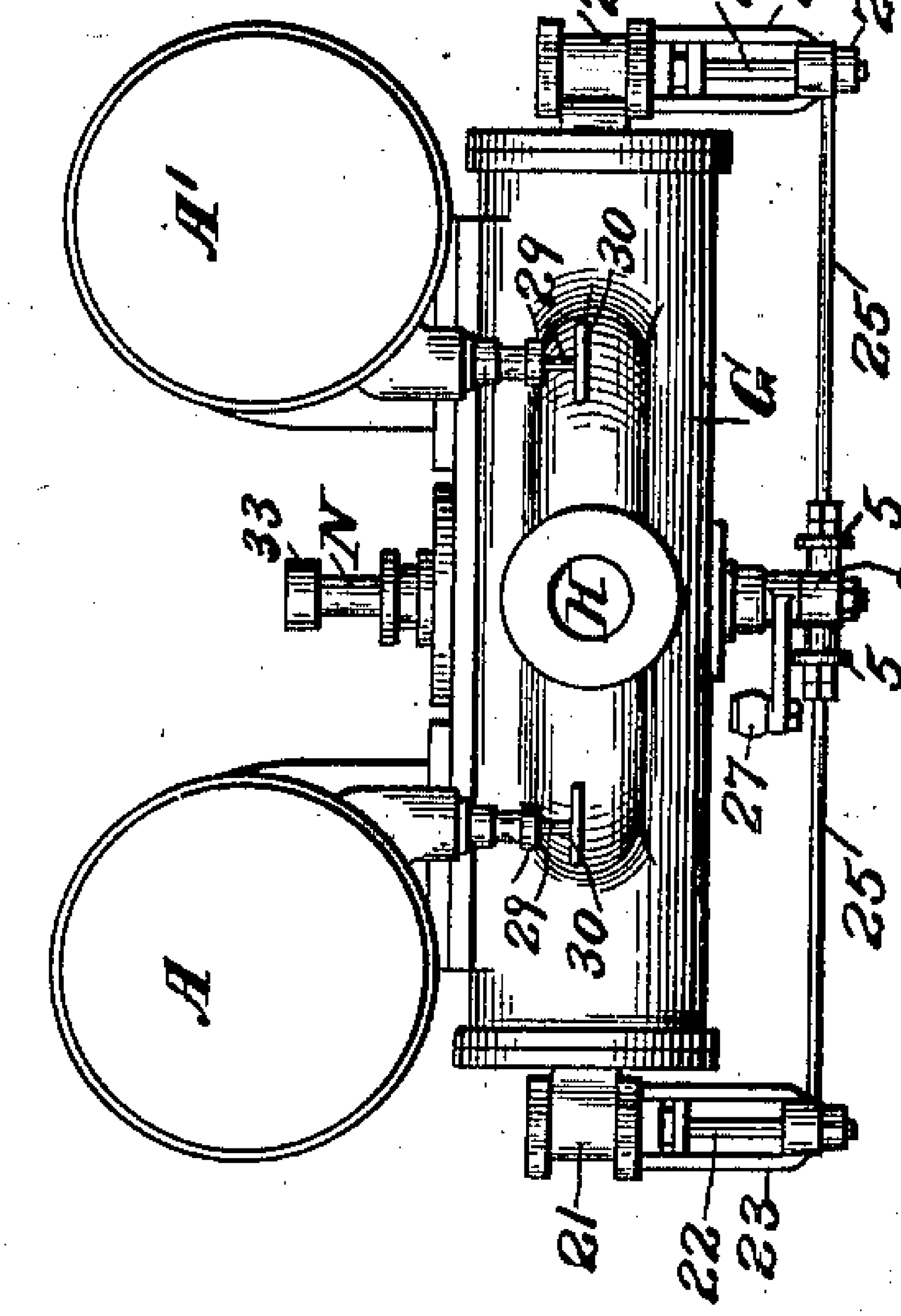
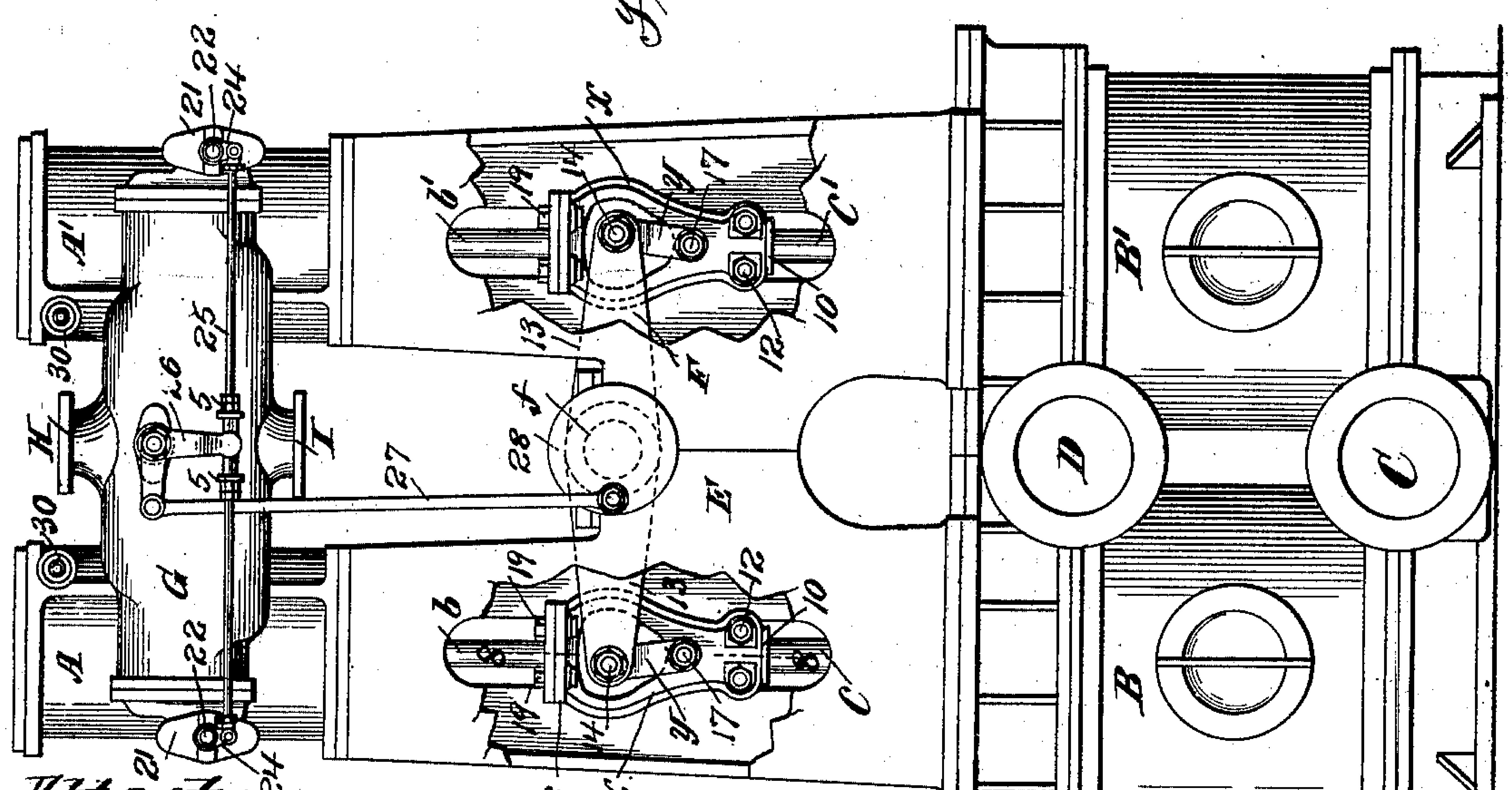


Fig. 1.



Attest:
T. F. Kehoe
J. A. Graves

Inventor Charles C. Worthington
By Philipp Phelps & Sawyer Attys

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

No. 757,009. PATENTED APR. 12, 1904.

C. C. WORTHINGTON.

STEAM ENGINE.

APPLICATION FILED MAY 16, 1899.

NO MODEL. 3 SHEETS—SHEET 2.

Fig. 4.

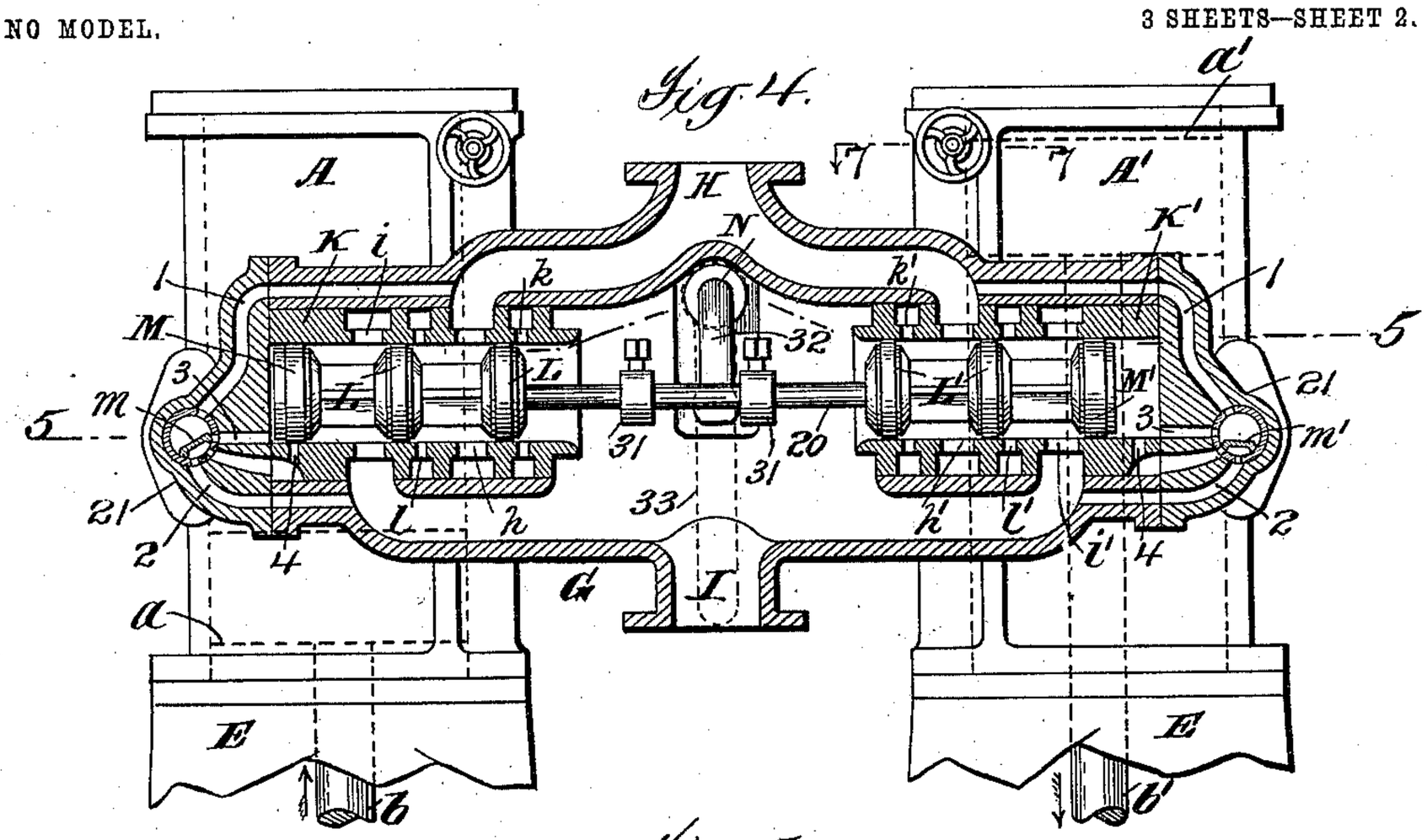


Fig. 5.

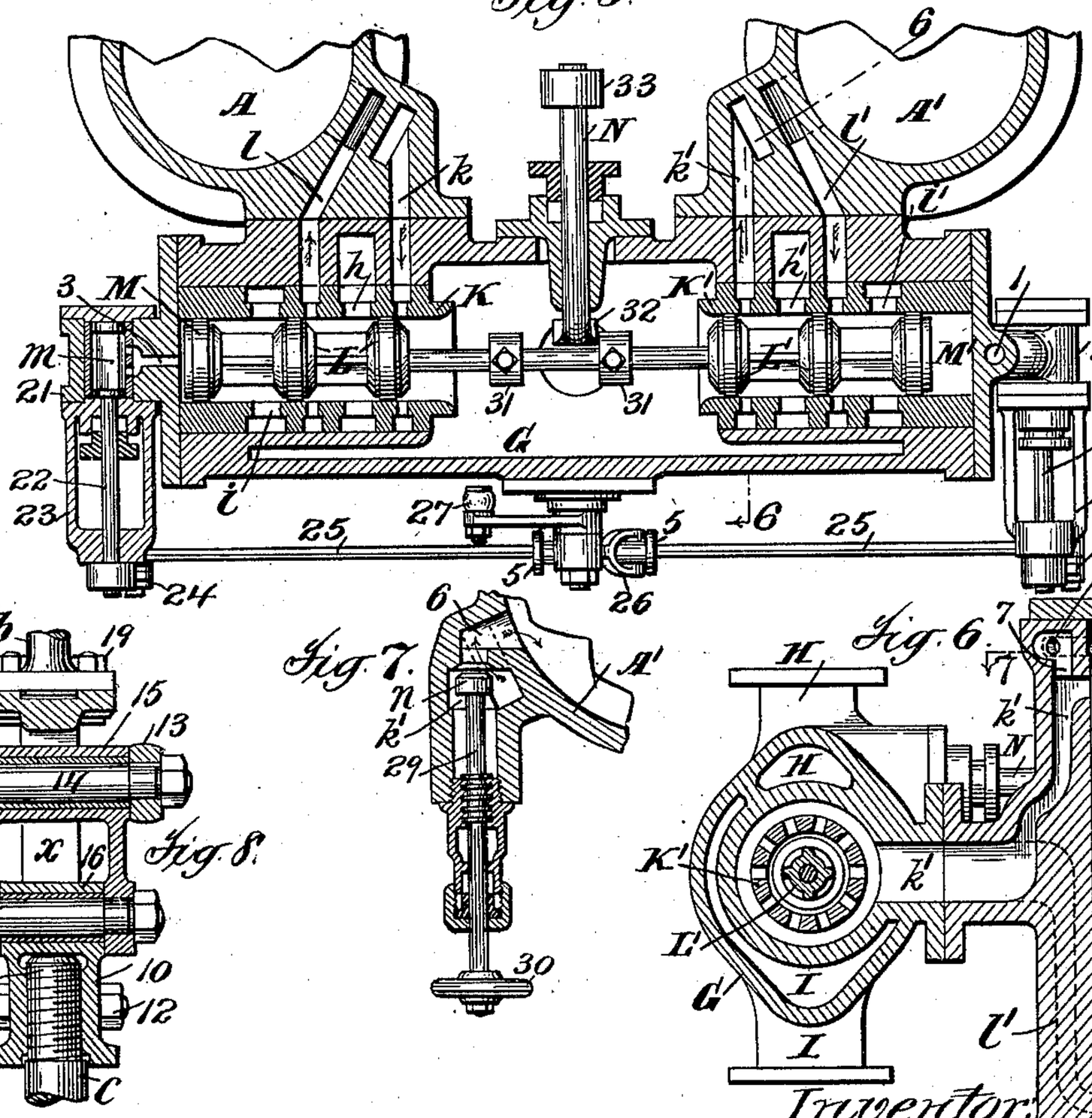


Fig. 7.

Fig. 8.

Fig. 6.

Attest:
P. F. Kehoe
J. A. Graves

Inventor:
Charles C. Worthington
By Philipp & Philipp & Harrison
Attys

No. 757,009. PATENTED APR. 12, 1904.

C. C. WORTHINGTON.

STEAM ENGINE.

APPLICATION FILED MAY 16, 1899.

NO MODEL. 3 SHEETS—SHEET 3.

Fig. 9.

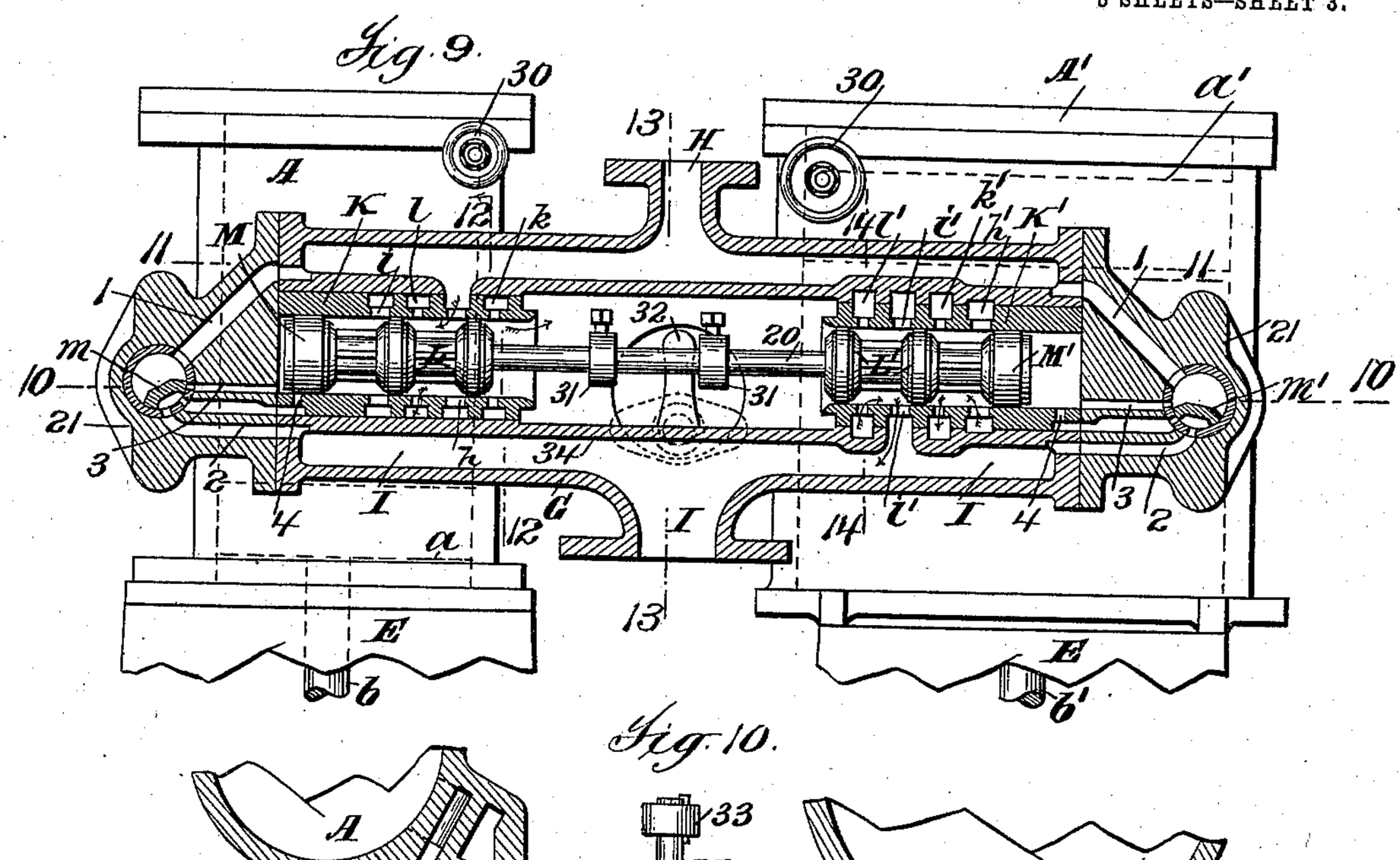


Fig. 10.

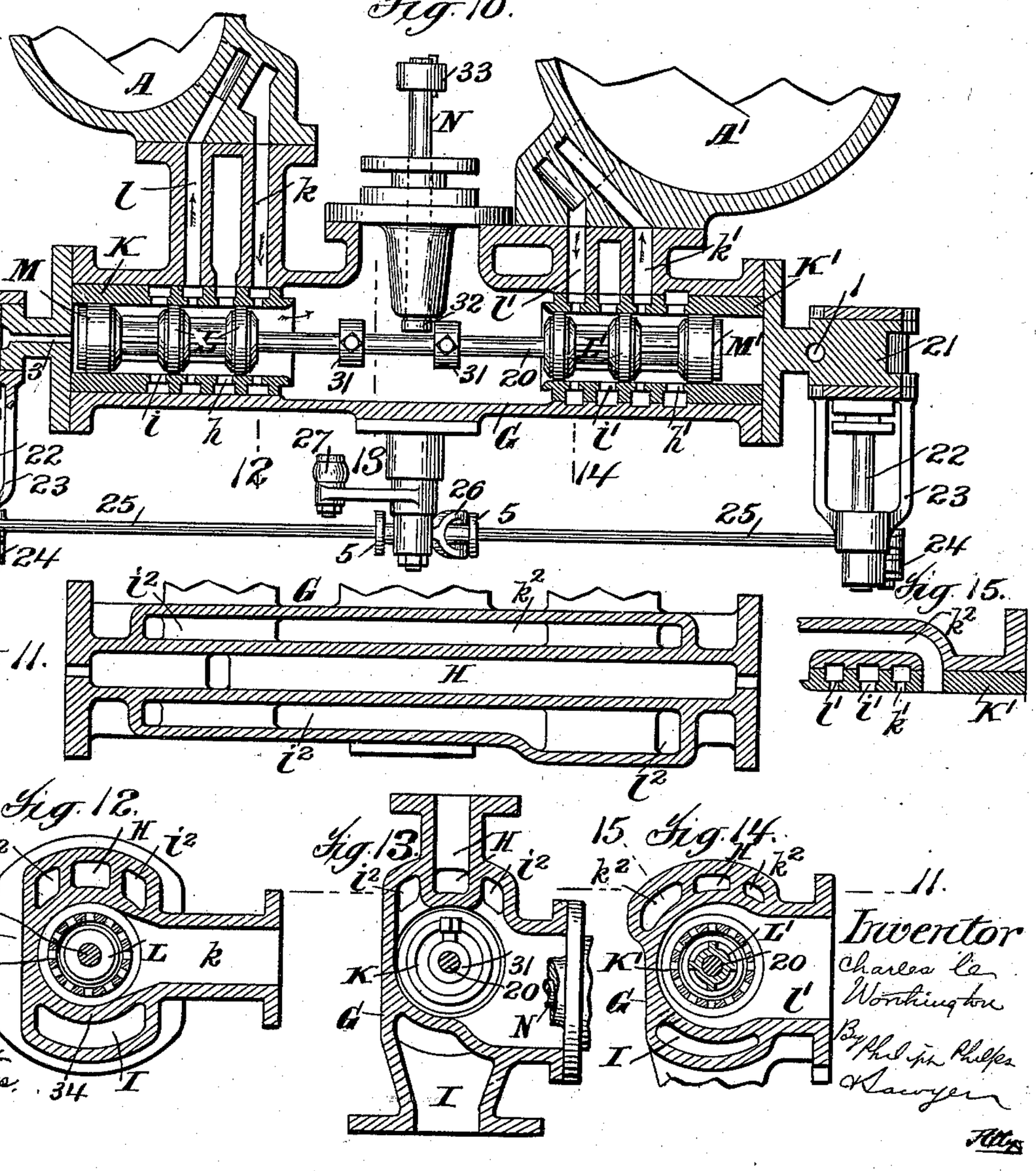


Fig. 11.

Fig. 15.

Fig. 12.

Fig. 13.

15. Fig. 14.

Attest:
C. F. Lyon
J. A. Davis.

Inventor
Charles C. Worthington
By Phil. J. Phillips
Attorneys

No. 757,009. Patented April 12, 1904.

UNITED STATES PATENT OFFICE.

CHARLES C. WORTHINGTON, OF DUNNFIELD, NEW JERSEY.

STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 757,009, dated April 12, 1904.

Application filed May 16, 1899. Serial No. 716,991. (No model.)

To all whom it may concern:

Be it known that I, CHARLES C. WORTHINGTON, a citizen of the United States, residing at Dunnfield, county of Warren, and State of New Jersey, have invented certain new and useful Improvements in Steam-Engines, fully described and represented in the following specification and the accompanying drawings, forming a part of the same.

The especial object of the present invention is to provide an improved vertical pump of that class in which two pump-cylinders are arranged side by side and operated together, the plunger-rods being usually connected by a rocking beam.

The invention embraces an improved valve-movement for such engines, an improved steam-chest and steam-valve construction including features of construction forming parts of the invention which are applicable also in other classes of steam-engines, and certain features of construction and combinations of parts in beam-pumps, all as fully described hereinafter and specifically pointed out in the claims.

For a full understanding of the invention a detailed description of a construction embodying all the features of the same as applied in their preferred form to an air-pump or similar pumping-engine of the beam-pump class will now be given in connection with the accompanying drawings, and the features forming the invention will then be specifically pointed out in the claims.

In the drawings, Figure 1 is a front elevation of the pumping-engine with two high-pressure cylinders, the frame being partly broken away to show the beam connections. Fig. 2 is a side elevation of the upper part of the engine. Fig. 3 is a plan view of the engine. Fig. 4 is a sectional elevation of the steam end of the engine, on an enlarged scale, the section being taken centrally through the steam-chest. Fig. 5 is a cross-section on the line 5 of Fig. 4. Fig. 6 is a vertical section on the line 6 of Fig. 5. Fig. 7 is a cross-section on the line 7 of Figs. 4 and 6. Fig. 8 is a detail section of the connections between the beam and piston-rods on the line 8 of Fig. 1. Fig. 9 is a view similar to Fig. 4, showing a compound steam-cylinder construction. Fig. 10 is a cross-section on the line 10 of Fig. 9. Fig. 11 is a partial cross-section on the line 11 of Fig. 9. Figs. 12, 13, and 14 are cross-sections of the steam-chest on, respectively, the lines 12, 13, and 14 of Fig. 9. Fig. 15 is a detail section on the line 15 of Fig. 14.

Referring now particularly to the construction shown in Figs. 1 to 8, A A′ are the steam-cylinders, and B B′ the corresponding pump-cylinders; *a a′*, the steam-pistons, having piston-rods *b b′*, which are connected to the plunger-rods *c c′* by connections presently to be described, so that the pistons *a a′* operate directly the plungers or buckets in the pump-cylinders B B′, which latter may be of any suitable construction. The pump-cylinders B B′ are shown as having the suction-main C, connecting with the suction-chamber at the lower end of the cylinder, and the force or delivery main D, connecting with the force-chamber at the upper end of the cylinders, as usual in such constructions. The steam-cylinders A A′ are shown as supported by an open frame E, rising from the top of the pump-cylinders; but it will be understood that the framework of the pumping-engine may be of any suitable form.

The rocking beam F has the journal *f*, by which it is mounted in suitable bearings in the front and rear frame-bars E, and this beam is connected at its opposite ends to the respective piston and plunger rods *b c* and *b′ c′* and the piston-rods connected to the plunger-rods by the following means, as shown in Figs. 1, 2, and 8. The connection of the two piston-rods being the same, a description of one will suffice, and the same references will be applied to both.

The piston-rod *b* is connected rigidly to a connecting-piece *x*, which is cut away centrally, so as to permit a beam connection to pass through the line of the piston-rod, and the lower end of this connecting-piece *x* is provided with a hub 10, screw-threaded internally and adapted to receive the screw-threaded end 11 of the plunger-rod *c*, and clamping-bolts 12 are used, by which the two parts of the split hub 10 are drawn up tight upon the end 11 of the plunger-rod after the latter is

screwed in, so as to make a rigid connection between the plunger-rod *c* and the connecting-piece *x*, the piston-rod *b* and plunger-rod *c* thus being connected so as to form, substantially, a single rigid rod. The beam F is formed of two parallel bars 13, and these bars are pivotally connected to link *y* by bolt 14, which passes through a hub 15 on the upper end of the link *y*, this hub 15 extending across the line of the piston-rod and the link *y* having two arms which embrace a bearing 16, formed in the connecting-piece *x* at the upper end of the hub 10 and to which the link *y* is pivotally connected by bolt 17. As the pistons move up and down, therefore, the beam F transmits the motion from one piston-rod to the other through the connecting-pieces *x* and links *y*, and by the construction shown, in which the piston-rods are divided and the link connections for the ends of the beam pass through and swing across the line of the piston-rods, there is secured an almost direct central pull between the piston-rods and beam in the line of the piston-rods, so as to avoid all tendency to twisting and to reduce to a minimum all side pressure longitudinally of or transversely to the beam.

The detachable connections between the two parts of the rod connecting the pistons and plungers is also of importance as affording a very convenient and efficient means of detaching the plunger and plunger-rod when required, while at the same time a rigid connection between the plunger-rod and the connecting-piece *x* and one that will not work loose is secured, it being necessary in detaching the plunger-rod only to loosen the clamping-bolts 12, when the plunger-rod may be unscrewed from the hub 10 and the plunger detached from the piston. The piston-rods are shown as connected to the connecting-pieces *x* by flanged heads 18 and bolts 19, and this construction will be found simple and efficient; but it will be understood that this connection and the form of the connecting-pieces may be varied, it being necessary only that the connecting-pieces *x* when formed separately from the piston-rods, which is preferable, shall be rigidly secured thereto, so as to assure a rigid connection between the pistons and plungers.

Referring now to the steam end of the engine, the steam-chest G is mounted upon one side of the cylinders A A′, extending across the space between the cylinders, and is provided with the steam-admission port H, entering at the top and branching to the opposite ends of the steam-chest, and with the exhaust-port I at the bottom of the steam-chest, communicating directly with the space inside the latter, the high-pressure steam passing through the admission-port H, which is closed, to the space within the valve-chest, directly to the valves and thus to the steam-cylinders, while the low-pressure steam is exhausted into the space within the steam-chest, and thus to the exhaust-pipe through port I.

The construction of the valves and valve-casings and the cylinder steam-ports is as follows: At opposite ends of the steam-chest G are valve-casings K K′, in which move piston-valves L L′, which control the admission and exhaust of steam to and from the respective cylinders A A′ through ports, as follows: The ports *h h′* are the continuations of the main induction-port H. Ports *i i″* are the exhaust-ports opening from the valve-casing to the space within the steam-chest G and the main exhaust-port I. Ports *k k′* are the cylinder admission and exhaust ports extending from the valve-casing to the upper ends of the cylinders, and ports *l l′* are the corresponding admission and exhaust ports for the lower ends of the cylinders. All these ports are preferably sectional ports extending entirely about the valve-casings, as usual in such piston-valve constructions. The valve-casings K K′ are open at their inner ends to the space within the steam-chest G, so that the exhaust from each cylinder is in turn through the exhaust-port *i* or *i″* and through the open end of the valve-casing K or K′ into the space within the steam-chest, as fully described hereinafter.

The piston-valves L L′ are carried by a valve-rod 20, extending centrally through the space within the steam-chest, this rod being shown as a single rod and unjointed. It will be understood, however, that the rod may be jointed to permit the valves to be somewhat out of line, if desired, and that the rod may be divided or the valves may be connected in any other suitable manner, so as to secure their movement together in both directions by the motor-pistons hereinafter described. Outside the respective piston-valves L L′ is an actuating-piston M M′, connected rigidly to the valves, so that the valves and their actuating-pistons, with connecting-rod 20, move together in both directions, and pressure upon each of the actuating-pistons M M′ is transmitted to both the piston-valves, the valves thus being actuated by the difference in pressure upon the two pistons M M′. These pistons M M′ are actuated by steam supplied and controlled as follows: The opposite ends of the steam-chest G are provided with heads 21, which are preferably formed separately from the steam-chest and secured thereto, as shown, so that the outer open ends of the valve-casings K K′ are closed by these heads when secured in place and steam-chambers thus formed outside the pistons M M′. In these casings 21 are valve-chambers which communicate by ports 1 with the admission-port H and by ports 2 with the space within the valve-casing and exhaust-port I and which communicate with the steam-chambers at the outer ends of the valve-casings K K′ outside of the pistons M M′ by admission-ports 3 and exhaust-ports 4, these ports 1 2 3 4 being controlled by

valves *m m'* at the respective ends of the steam-chest corresponding to the cylinders A A', these valves being shown as a common form of oscillating valves. The stems 22 of these valves *m m'* extend outside the valve-chambers, where they are supported in brackets 23 and are actuated through crank-arms 24 by a connecting-rod 25, which extends between the crank-arms of the two valves *m m'* at opposite ends of the steam-chest, and this rod 25 is actuated to oscillate the valves *m m'* as required by one arm of a bell-crank lever 26, mounted on the steam-chest and moving between adjustable collars 5 on the rod 25, so as to throw the rod 25 in opposite directions as it engages one or the other of the collars 5 in its movement in either direction, and this bell-crank lever 26 is connected by link 27 to a crank-disk 28 on the end of the journal *f* of the beam F, so that the movement of the beam F as rocked by the piston-rods on opposite sides of the engine throws the oscillating valves *m m'* in opposite directions through the crank-disk 28 and connections just described. The collars 5 are made adjustable, so as to vary the amount of lost motion between the bell-crank lever 26 and either of the collars, as desired, so as to secure the required operation of the valves *m m'*.

The ports *l l'* preferably communicate with the lower ends of the cylinders A A' close to the cylinder-head, no cushioning by the exhaust-steam in the lower ends of the cylinders being employed, so that a single admission and exhaust port may be used. The ports *k k'*, however, communicate with the upper ends of the cylinders A A' at a considerable distance below the cylinder-heads, so that the pistons pass over and close these ports before the end of the upstroke of the pistons is reached. Above these ports that are closed by the pistons *a a'*, however, are other ports 6, opening into the cylinder just inside the head and communicating with the cylinder-ports *k k'* by passages 7 in the cylinder-casing and forming continuations of the ports *k k'*, these ports 6 opening into the cylinder above the pistons *a a'* when they are at the end of the upstroke, so that these ports 6 are not closed by the pistons. These ports 6 are designed to permit a slow exhaust of the steam at the end of the upstroke after the port *k* or *k'* is closed by the piston *a* or *a'*, so as to secure a cushioning effect at the end of the upstroke of each piston with a gradual release of the cushioning-steam and to permit the steam to enter above the cushioned piston at the beginning of the next downstroke, as when separate admission and exhaust ports are used. For this purpose the ports 6 may be made of such small size as to secure the result desired and no adjustment be provided therefor; but preferably an adjustable valve will be used, so that the passage of steam from the cylinder through the port 6 may be regulated as desired. As shown in detail in Fig. 7, the communication between the passage 7 and the port 6 is controlled by a plug-valve *n*, provided with the usual screw-stem 29, extending through a stuffing-box and having handle 30 for adjusting the valve. With this throttling of the exhaust only at the end of the upstroke the free exhaust of the steam substantially throughout the upstroke is secured, while the assistance from the other piston through the beam F is normal, while at the end of the upstroke when the pull of the other piston is liable to be lessened—as, for instance, by the effect of water in the bottom of the cylinder when pumping water and air or by a decrease of vacuum at the bottom of the cylinder when pumping air alone—a back pressure on the piston which is just completing the upstroke is secured which keeps the beam connections between the pistons under tension, so as to secure a smooth uniform movement and prevent any jumping of the pistons and effects also the cushioning of the other piston on its downstroke through the beam connections independently of the increased resistance to the piston at the end of the downstroke referred to above, which increased resistance is variable and cannot be depended upon for uniform cushioning. With adjustable valves controlling the ports 6 also these ports may be entirely closed, as may be desirable in operating the pumping-engine under certain conditions, so that the usual cushioning without relief is secured at the end of the upstroke of the pistons, the admission of steam below the other piston for its upstroke being depended upon to start the downstroke of the cushioned piston through the beam F and connections and steam being admitted above the cushioned piston on its downstroke only after it has passed the cylinder-port *k* or *k'*.

As shown in the drawings, the valve-rod 20, connecting the valves L L', is provided with collars 31, preferably made adjustable, as shown, so as to secure just the movement desired, and between these collars 31 extends the arm 32 of a starting-lever N, which extends through a stuffing-box on the rear side of the casing of steam-chest G and is provided with a suitable handle 33 for operating it. This starting-lever N, when its arm 32 is in central position, is not moved by the collars 31 on valve-rod 20 as the valve is thrown in either direction; but the starting-lever is stationary during the operation of the engine. By means of the outside handle 33 of the valve-lever N, however, the lever may be moved so that by the engagement of the arm 32 with one or the other of the collars 31, according to the stopping position, the valves will be forced to left or right until the obstruction is removed and the steam-pressure alone can operate the engine properly. The starting-lever N may then be returned to central position by hand, or one of the collars 31

will return it to central position on the first movement of the rod 20 by the pistons M M′. As the pressure within the steam-chest G is only that of the exhaust-steam, but light packing of the starting-lever N in the steam-chest casing is required to prevent the escape of the exhaust-steam around the starting-lever, and this low pressure of the steam within the steam-chest G also reduces the difficulty of forming steam-tight joints in other parts of the steam-chest construction.

The operation of the construction will be understood from the preceding, with a brief general description.

As shown in Figs. 1 to 3, the pistons are on center, this position being selected simply for the purpose of illustrating the outside working parts of the engine. In Figs. 4 to 7, however, the steam end is shown with the steam-valves thrown to the left or toward cylinder A for starting the piston *a* on its upstroke and the piston *a′* on its downstroke.

In the position of Figs. 4 to 7 the lower arm of the bell-crank lever 26 has been thrown to the right from the central position shown in Fig. 1 by the rocking of the beam F and crank-disk 28 as the piston *a* completes its downstroke and the piston *a′* its upstroke, the lever 26 by engagement with collar 5 thus moving the connecting-rod 25 to the right, and thus through crank-arms 24 and valve-stems 22 oscillating the control-valves *m m′* into the position shown in Fig. 4, in which the valve *m* closes the connection between ports 1 and 3 and opens the connection between ports 2 and 4, so as to connect the space outside the piston M with the exhaust I, and the valve *m′* opens communication between the ports 1 3 and closes communication between the ports 2 4 at the opposite end of the steam-chest, so as to admit steam outside the piston M′. By thus admitting outside the piston M′ and exhausting outside the piston M the pistons, with the rod 20 and valves L L′, are moved to the left in the drawings and into the position shown in Figs. 4 and 5, the piston M covering the exhaust-port 4 near the end of the piston-stroke, so as to prevent further exhaust and cushion the piston, the pistons and valves then being held in the position shown in Figs. 4 and 5 by the balanced steam-pressure outside the two pistons until the control-valves *m m′* are shifted to reverse the movement of the pistons. As will be clear from an examination of Figs. 4 to 7, this movement of the valves L L′ connects induction-port H through port *h* and the valve-casing K to the cylinder-port *l*, so as to admit steam below the piston *a*, and the cylinder-port *k* to the exhaust I through the open inner end of the valve-casing K and the space within the steam-chest G, so as to exhaust from above the piston *a*. This movement also by valve L′ connects the admission-port H to the cylinder-port *k′* through the port *h′* and the valve-casing, so as to admit steam above the piston *a′* through the cylinder-port *k′*, passage 7, and port 6, as shown in Figs. 6 and 7, the direct connection of the port *k′* with the cylinder being now closed by the piston *a′* and the cylinder-port *l′* is connected to the exhaust I through the valve-casing and port *i′* and the space within the steam-chest G, so as to exhaust from below the piston *a′*. It will be seen that in this position with the valves L L′ fully thrown the collar 31 just comes into contact with the arm 32 of starting-lever N in its normal central position, so that the starting-lever is not moved as the valve is thrown, while by moving the starting-lever N by outside handle 33 the arm 32 may be made to engage this collar 31 or the other collar 31, and thus move the valves to the right or left, as may be required in starting the engine. The piston *a* of cylinder A now moves up and the piston *a′* of the cylinder A′ down for the next stroke, and the piston *a* as it approaches the end of its upstroke covers the cylinder-port *k*, so as to prevent further exhaust of steam directly through this port, and thus cushion and produce a back pressure on the piston *a*, which is gradually relieved by the slow escape of steam through the port 6 and passage 7 into the cylinder-port *k*, this back pressure keeping all the connections tight, so as to secure a smooth movement and at the same time cushion the piston *a* on its downstroke through the beam F and connections. As the pistons *a a′* reach the end of their respective strokes the depending arm of the bell-crank lever 26 by engagement with the left-hand collar 5 as the link 27 is raised by the movement of the beam F and crank-disk *f* moves the connecting-rod 25 to the left, and thus through crank-arms 24 and valve-stems 22 shifts the control-valves *m m′* from the position shown in Fig. 4, so as to reverse the positions of these valves, and thus admit steam outside the piston M and exhaust from the space outside the piston M′. The pistons M M′, with the rod 20 and valves L L′, are now moved to the right, so as to reverse the position of the valves from that shown in Figs. 4 and 5, and thus admit steam above and exhaust from below the piston *a* exactly as shown in Figs. 4 and 5 and above described in connection with piston *a′* and to admit steam below and exhaust from above piston *a′* exactly as shown in Figs. 4 and 5 and above described in connection with piston *a*. At the completion of this downstroke of the piston *a* and upstroke of the piston *a′* the control and main valves are again shifted and the pistons reversed, and thus the operation is continued.

It will be understood that the same operation may be secured with a single valve operated by pistons M M′ in the same manner and controlling the ports of both cylinders. I prefer, however, to use separate valves for the two cylinders, as this enables me to reduce the length of the ports and the clear-

ance-spaces and to use the same steam-chest on cylinders of different sizes. It is possible also to control the admission and exhaust of steam for actuating the pistons M M′ by a single valve instead of by separate valves, as shown; but a quicker and more efficient action with shorter ports is secured by the preferred construction shown. While, therefore, the invention includes certain features limited to separate steam-valves for the two cylinders and separate control-valves, as defined by the claims, it will be understood that the broader features of the invention are not thus limited. It will be understood also that while the piston-valves shown are preferred and certain constructions limited to piston-valves are made the subject of specific claims herein other forms of valves may be used in place of piston-valves in the constructions forming the subject-matter of the claims herein that are not thus limited.

The steam-chest and steam-valve construction shown in Figs. 1 to 5 and above described with certain modifications also forms a very simple, compact, and efficient steam chest and receiver construction for compound engines, the exhaust passing from the high-pressure to the low-pressure cylinder through the space within the valve-chest between the two valves, which space thus forms a receiver for the exhaust-steam in its passage to the low-pressure cylinder.

In Figs. 9 to 15 I have shown such a modified construction in which the engine and valves with all their operating parts are the same as previously described; but high and low pressure cylinders are used on the opposite sides, so as to use the steam expansively from one side to the other, and the steam-chest with its ports is constructed for the passage of the exhaust-steam from the high-pressure cylinder to the low-pressure cylinder and thence to the exhaust-pipe under the control of the valves L L′, the steam from both the auxiliary-valve chambers exhausting, as before, to the main exhaust. This valve-chest and valve construction for compound cylinders embodies features of construction which form parts of the present invention. In this modified construction the space inside the steam-chest G between the casings K K′ does not connect with the main exhaust-port I, but is closed thereto by a partition 34, so as to form a receiver for the exhaust of the high-pressure cylinder and from which the low-pressure cylinder takes its steam, below which receiver is the main exhaust-port I, formed in the steam-chest casing. The main admission and exhaust ports H I extend longitudinally of the valve-chest and from one end of the valve-chest to the other, so as to connect, respectively, with the admission and exhaust ports 1 2 of the auxiliary-valve chambers; but each of these ports H I has a port opening through the valve-casings K K′ and controlled by the piston-valves only at one end of the steam-chest, the admission-port H communicating with the valve L through port *h* for the admission of steam to the high-pressure cylinder A and the exhaust-port I communicating with the valve L′ through exhaust-port *i*′ for the exhaust of steam from the cylinder A′.

The arrangement of the exhaust-ports of the cylinder A and of the admission-ports of the cylinder A′ so as to conduct the exhaust-steam of the cylinder A to the cylinder A′ is as follows: The exhaust-port *i* of valve-casing K communicates through passages i^2, formed in the casing of steam-chest G, with the receiver within the steam-chest between the open ends of the casings K K′, this passage i^2 preferably being divided and arranged on opposite sides of port H, as shown in Figs. 11 to 13, although this is not essential. The cylinder-port *l* thus exhausts through port *i* and passage i^2 to the receiver, and the other cylinder-port *k* exhausts through its casing-port and the open end of the casing K directly into the receiver. The receiver communicates with the port *l*′ of cylinder A′ directly through the open inner end of the casing K′ and with the cylinder-port *k*′ of the cylinder A′ through passage k^2, formed in the casing of steam-chest G, this passage preferably being divided and arranged on opposite sides of the branch of the main induction-port H, which communicates with the auxiliary port 1 in the same manner as passage i^2 is divided at the other end of the steam-chest, although this is not essential. The operation of this compound-cylinder construction is as follows: The control-valves *m m*′ are actuated and the pistons M M′ and main valves L L′ shifted by the steam-pressure controlled by the valves *m m*′ in exactly the same manner as above described in connection with the construction shown in Figs. 1 to 8, and the connection of the cylinder-ports *k l* and *k*′ *l*′ through the valve-casings K K′ under the control of the valves is the same as above described, except that the exhaust from above the piston *a* through cylinder-port *k* passes through the receiver in the steam-chest to the port *l*′ and below the piston *a*′ and the exhaust from below the piston *a* through cylinder-port *l* passes through the receiver in the steam-chest to the cylinder-port *k*′ and above the piston *a*′ instead of the cylinder A exhausting to the main exhaust and cylinder A′ being supplied with steam from the main admission H, as in the construction previously described.

As shown in Figs. 9 to 15 and indicated by the arrows, steam is being admitted below the piston *a* through cylinder-port *l* and steam is being exhausted from above the piston *a* through cylinder-port *k* and the open end of valve-casing K into the receiver within the steam-chest and steam is being admitted from this receiver above the piston *a*′ through

passage k^2, the valve-casing, and cylinder-port k' and steam is being exhausted from below the piston a' through cylinder-port l' and the valve-casing K′ and port i' into the main exhaust-port I. When the valves L L′ are reversed from the position shown in Figs. 9 to 15 for the stroke of the pistons in the opposite direction, steam is exhausted from below the piston a through port l and the valve-casing, port i, and the passage i^2 into the receiver, and steam is admitted from the receiver through the open end of the valve-casing K′ directly to port l' and below the piston a', the admission above the piston a and exhaust from below the piston a' being through the cylinder-ports, valve-casing, and admission and exhaust ports h and i', as is clear from the drawings and previous description.

It will be understood that many modifications may be made in the constructions illustrated by those skilled in the art without departing from the invention and that many features forming parts of the invention may be used independently of the other parts of the invention and in engines of different classes from that illustrated and described. While a steam-cylinder in each side of the engine is shown, so that each of the pump plungers or buckets has its corresponding piston, it is apparent that some of the features of the invention are applicable also to that class of pumping-engines in which only one side has a steam-cylinder and the pump-plunger on the opposite side is actuated through the beam.

What I claim is—

1. The combination with two steam-cylinders, of a valve device controlling the ports of both cylinders, a reciprocating steam-actuated valve-rod upon which said valve device is mounted, and valve mechanism separate from said valve device and valve-rod controlling the admission and exhaust of steam for actuating said rod, substantially as described.

2. The combination with two steam-cylinders, of a valve device controlling the ports of both cylinders, a reciprocating steam-actuated valve-rod upon which said valve device is mounted, and valve mechanism separate from said valve device and valve-rod mechanically actuated by the engine and controlling the admission and exhaust of steam for actuating said rod, substantially as described.

3. The combination with two steam-cylinders, of a valve device controlling the ports of both cylinders, a reciprocating valve-rod carrying said valve device, pistons at opposite ends of said rod, and separate valves controlling the admission and exhaust of steam outside said pistons for moving the valves in opposite directions, substantially as described.

4. The combination with two steam-cylinders, of a piston-valve device controlling the ports of both cylinders, a reciprocating valve-rod carrying said valve device, valve-actuating pistons at opposite ends of said rod, and separate valves controlling the admission and exhaust of steam outside said actuating-pistons for moving the valves in opposite directions, substantially as described.

5. The combination with two steam-cylinders, of a valve device controlling the ports of both cylinders, a reciprocating valve-rod carrying said valve device, pistons on said rod for moving it in opposite directions, and valve mechanism separate from said valve device and valve-rod controlling the admission and exhaust of steam for actuating said pistons, and means for actuating said valve mechanism mechanically from a moving part of the engine, substantially as described.

6. The combination with two steam-cylinders, of a valve device controlling the ports of both cylinders, a reciprocating valve-rod carrying said valve device, pistons at opposite ends of said rod, and separate valves mechanically actuated by the engine and controlling the admission and exhaust of steam for actuating said pistons, substantially as described.

7. The combination with two steam-cylinders, of a piston-valve device controlling the ports of both cylinders, a reciprocating valve-rod carrying said valve device, pistons at opposite ends of said rod and separate valves mechanically actuated by the engine and controlling the admission and exhaust of steam outside said actuating-pistons for moving the valves in opposite directions, substantially as described.

8. The combination with two steam-cylinders, of separate valves controlling the ports of the two cylinders, a reciprocating valve-rod carrying said valves, pistons on said rod for moving it in opposite directions, and valve mechanism controlling the admission and exhaust of steam for actuating said pistons, substantially as described.

9. The combination with two steam-cylinders, of separate valves controlling the ports of the two cylinders, a reciprocating valve-rod carrying said valves, pistons at opposite ends of said rod, and separate valves controlling the admission and exhaust of steam outside said pistons for moving the valves in opposite directions, substantially as described.

10. The combination with two steam-cylinders, of separate piston-valves controlling the ports of the two cylinders, a reciprocating valve-rod carrying said valves, pistons on said rod for moving it in opposite directions, and valve mechanism controlling the admission and exhaust of steam for actuating said pistons to move the valves, substantially as described.

11. The combination with two steam-cylinders, of separate piston-valves controlling the ports of the two cylinders, a reciprocating valve-rod carrying said valves, pistons on said rod for moving it in opposite directions, and

valve mechanism mechanically actuated by the engine and controlling the admission and exhaust of steam for actuating said pistons, substantially as described.

12. The combination with two steam-cylinders, of separate valves controlling the ports of the two cylinders, a reciprocating valve-rod carrying said valves, pistons at opposite ends of said rod, and separate valves mechanically actuated by the engine and controlling the admission and exhaust of steam outside said pistons for moving the valves in opposite directions, substantially as described.

13. The combination with high and low pressure cylinders arranged side by side, their steam-ports, and connections for conducting steam from the high-pressure cylinder to the low-pressure cylinder, of a valve device controlling the ports of the two cylinders, a reciprocating valve-rod carrying said valve device, and valve mechanism separate from said valve device and valve-rod controlling the admission and exhaust of steam for actuating said rod, substantially as described.

14. The combination with high and low pressure cylinders arranged side by side, their steam-ports, and connections for conducting exhaust-steam from the high-pressure cylinder to the low-pressure cylinder, of separate valves controlling the ports of the two cylinders, a reciprocating valve-rod carrying said valves, pistons on said rod for moving it in opposite directions, and valve mechanism for controlling the admission and exhaust of steam for actuating said pistons, substantially as described.

15. The combination with high and low pressure cylinders arranged side by side, their steam-ports, and connections for conducting exhaust-steam from the high-pressure cylinder to the low-pressure cylinder, of separate valves controlling the ports of the two cylinders, a reciprocating valve-rod carrying said valves, pistons on said rod for moving it in opposite directions, and valve mechanism mechanically actuated by the engine and controlling the admission and exhaust of steam for actuating said pistons, substantially as described.

16. The combination with high and low pressure cylinders arranged side by side, their steam-ports and connections for conducting exhaust-steam from the high-pressure cylinder to the low-pressure cylinder, of separate valves controlling the ports of the two cylinders, a reciprocating valve-rod carrying said valves, pistons at opposite ends of said rod, and separate valves mechanically actuated by the engine and controlling the admission and exhaust of steam outside said pistons for moving the valves in opposite directions, substantially as described.

17. The combination with high and low pressure cylinders arranged side by side, their steam-ports and connections for conducting exhaust-steam from the high-pressure cylinder to the low-pressure cylinder, of separate piston-valves controlling the ports of the two cylinders, a reciprocating valve-rod carrying said valves, pistons on said rod for moving it in opposite directions, and valve mechanism mechanically actuated by the engine and controlling the admission and exhaust of steam for actuating said pistons, substantially as described.

18. The combination with the steam cylinder or cylinders, pump-cylinders, piston or pistons, plungers and rocking beam of a direct-acting beam-pump, of a valve device controlling the steam-ports, a reciprocating valve-rod carrying said valve device, pistons on said rod for moving it in opposite directions, and valve mechanism actuated by a moving part of the pump and controlling the admission and exhaust of steam for actuating said pistons on said member, substantially as described.

19. The combination with the steam cylinder or cylinders, pump-cylinders, piston or pistons, plungers and rocking beam of a direct-acting beam-pump, of a valve device controlling the steam-ports, a reciprocating valve-rod carrying said valve device, pistons at opposite ends of said rod, separate valves controlling the admission and exhaust of steam outside said pistons for moving the valve device in opposite directions, and means for actuating said separate valves from a moving part of the pump, substantially as described.

20. The combination with the steam cylinder or cylinders, pump-cylinders, piston or pistons, plungers and rocking beam of a direct-acting beam-pump, of a piston-valve device controlling the steam-ports, a reciprocating valve-rod carrying said valve device, valve-actuating pistons at opposite ends of said rod, control-valve mechanism controlling the admission and exhaust of steam outside said valve-actuating pistons for moving the valve device in opposite directions, and means for actuating said control-valve mechanism from a moving part of the pump, substantially as described.

21. The combination with the steam and pump cylinders, pistons, plungers and rocking beam of a direct-acting beam-pump, of separate valves controlling the ports of the two cylinders, a reciprocating valve-rod carrying said valves, pistons on said rod for moving it in opposite directions, valve mechanism controlling the admission and exhaust of steam for actuating said pistons, and means for actuating said valve mechanism from a moving part of the pump, substantially as described.

22. The combination with the steam and pump cylinders, pistons, plungers and rocking beam of a direct-acting beam-pump, of separate piston-valves controlling the ports of the two cylinders, a reciprocating valve-rod carrying said valves, pistons on said rod for moving it in opposite directions, valve mechanism

controlling the admission and exhaust of steam for actuating said pistons to move the valves, and means for actuating said valve mechanism from a moving part of the pump, substantially as described.

23. The combination with the steam and pump cylinders, pistons, plungers and rocking beam of a direct-acting beam-pump, of separate valves controlling the ports of the two cylinders, a reciprocating valve-rod carrying said valves, pistons at opposite ends of said rod, separate control-valves controlling the admission and exhaust of steam outside said pistons for moving the valves in opposite directions, and means for actuating said control-valves from a moving part of the pump, substantially as described.

24. The combination with the steam and pump cylinders, pistons, plungers and rocking beam of a direct-acting beam-pump, of separate piston-valves controlling the ports of the two cylinders, a reciprocating valve-rod carrying said valves, pistons at opposite ends of said rod, valve mechanism controlling the admission and exhaust of steam outside said pistons for moving the valves in opposite directions, and means for actuating said valve mechanism from a moving part of the pump, substantially as described.

25. In a compound direct-acting beam-pump, the combination with the high and low pressure cylinders arranged side by side, their steam-ports, and connections for conducting exhaust-steam from the high-pressure cylinder to the low-pressure cylinder, of separate valves controlling the ports of the two cylinders, a reciprocating valve-rod carrying said valves, pistons on said rod for moving it in opposite directions, valve mechanism for controlling the admission and exhaust of steam for actuating said pistons, and means for actuating said valve mechanism from a moving part of the pump, substantially as described.

26. In a compound direct-acting beam-pump, the combination with the high and low pressure cylinders arranged side by side, their steam-ports, and connections for conducting exhaust-steam from the high-pressure cylinder to the low-pressure cylinder, of separate valves controlling the ports of the two cylinders, a reciprocating valve-rod carrying said valves, pistons on said rod for moving it in opposite directions, separate control-valves controlling the admission and exhaust of steam for actuating said pistons, and means for actuating said control-valves from a moving part of the pump, substantially as described.

27. The combination with two steam-cylinders arranged side by side, of valve mechanism for said cylinders, a single steam-chest for said cylinders, and steam-ports for the cylinders controlled by said valve mechanism for admitting steam to one or both of the cylinders independently of the space within the valve-chest and for exhausting one or both of said cylinders to the space within the valve-chest, substantially as described.

28. The combination with two steam-cylinders arranged side by side, of separate valves for said cylinders, a single steam-chest for said cylinders, and separate steam-ports for the cylinders controlled by said valves for admitting steam to one or both of the cylinders independently of the space within the valve-chest and for exhausting one or both of said cylinders to the space within the valve-chest, substantially as described.

29. The combination with two steam-cylinders arranged side by side, of a steam-chest having valve-chambers and ports for the two cylinders at opposite ends of the chest, piston-valves for the two cylinders in said chambers, and means for moving said valves in opposite directions, substantially as described.

30. The combination with two steam-cylinders arranged side by side, of a steam-chest having valve-chambers and ports for the two cylinders at opposite ends of the chest, piston-valves for the two cylinders in said chambers, and connections between the valves whereby the valves move together in both directions, substantially as described.

31. The combination with two steam-cylinders arranged side by side, of a steam-chest having valve-chambers for the two cylinders at opposite ends of the chest, piston-valves for the two cylinders in said chambers, connections between the valves whereby the valves move together in both directions, and steam-ports for the cylinders controlled by said valves for admitting steam to one or both of the cylinders independently of the space within the valve-chest and for exhausting one or both of said cylinders to the space within the valve-chest, substantially as described.

32. The combination with high and low pressure cylinders arranged side by side, of a single steam-chest for the cylinders, valves for the two cylinders, and steam-ports for the cylinders controlled by said valves to admit steam to the high-pressure cylinder independently of the space within the steam-chest and to exhaust the high-pressure cylinder into the space within the steam-chest, and to admit steam to the low-pressure cylinder from the space within the steam-chest and to exhaust the low-pressure cylinder independently of the space within the steam-chest, substantially as described.

33. The combination with high and low pressure steam-cylinders arranged side by side, of a steam-chest having valve-chambers at opposite ends for the two cylinders, piston-valves in said chambers, and steam-ports controlled by said pistons to admit steam to the high-pressure cylinder independently of the space within the steam-chest and to exhaust the high-pressure cylinder into the space within the steam-chest, and to admit steam to the low-pressure cylinder from the space

within the steam-chest and to exhaust the low-pressure cylinder independently of the space within the steam-chest, substantially as described.

34. The combination with the steam-cylinder A, of steam-chest G having valve-chamber K, piston-valve L in said chamber, admission-port H connecting with the valve-chamber independently of the space within the steam-chest, exhaust-port I communicating with the space within the steam-chest, and ports controlled by said valve for admitting steam to the cylinder from admission-port H and for exhausting steam from cylinder A to the space within the steam-chest, substantially as described.

35. The combination with the high and low pressure cylinders A, A′, of steam-chest G, valve-chambers K, K′ at opposite ends of the steam-chest and opening into the space between the valve-chambers, piston-valves L, L′ in said valve-chambers, admission-port H connecting with the valve-chamber K independently of the space between the valve-chambers, exhaust-port I communicating with the valve-chamber K′, and ports controlled by said valves for admitting steam to the cylinder A from admission-port H and exhausting into the space between the valve-chambers and for admitting steam from the space between the valve-chambers to the cylinder A′ and exhausting from the cylinder A′ to the exhaust-port I, substantially as described.

36. The combination with the high and low pressure cylinders A, A′, of steam-chest G having valve-chambers K, K′ at opposite ends of the steam-chest and opening at their inner ends into the space between the valve-chambers, exhaust-passage i^2 and admission-passage k^2 connecting the outer ends of the valve-chambers with the space between the valve-chambers, admission-port H communicating with the valve-chamber K, exhaust-port I communicating with the valve-chamber K′, and ports controlled by said valves for admitting steam from admission-port H to the cylinder A and exhausting from cylinder A to the space between the valve-chambers from the inner end of valve-chamber K or through passage i^2 and for admitting steam to the cylinder A′ from the space between the valve-chambers through the inner end of the valve-chamber K or through passage k^2 and for exhausting from cylinder A′ through exhaust-port I, substantially as described.

37. The combination with steam-cylinders A, A′, of steam-chest G having valve-chambers K, K′, and piston-valves L, L′ in said chambers controlling the cylinder steam-ports and connected together, pistons M, M′ outside the valves, and steam-chambers for said pistons, substantially as described.

38. The combination with steam-cylinders A, A′, of steam-chest G having valve-chambers K, K′ and piston-valves L, L′ in said chambers controlling the cylinder steam-ports and connected together, pistons M, M′ outside the valves, steam-chambers for said pistons, admission and exhaust ports for said steam-chambers, and control-valves m, m' at opposite ends of the steam-chest, substantially as described.

39. The combination with steam-cylinders A, A′, of steam-chest G having valve-chambers K, K′ and piston-valves L, L′ in said chambers controlling the cylinder steam-ports and connected together, pistons M, M′ outside the valves, admission and exhaust ports 1, 2, 3, 4 at opposite ends of the steam-chest for admitting and exhausting steam outside said pistons, and control-valves m, m', substantially as described.

40. The combination with steam-cylinders A, A′, of steam-chest G having steam-ports for the two cylinders at opposite ends and admission and exhaust ports H, I, and valves controlling the ports for admitting steam from port H independently of the space within the steam-chest between the valves and for exhausting through said space, substantially as described.

41. The combination with steam-cylinders A, A′, of steam-chest G having valve-chambers K, K′ for two cylinders at opposite ends, admission and exhaust ports H, I, and ports connecting the cylinder-ports with the admission and exhaust ports H, I of the valve-chest, and connected piston-valves L, L′ in said valve-chambers controlling the cylinder steam-ports, substantially as described.

42. The combination with steam-cylinders A, A′, of steam-chest G having ports for the two cylinders at opposite ends, admission-port H connecting with one of the cylinders, exhaust-port I connecting with the other cylinder, and ports connecting each of said cylinders with the space within the valve-chest for conducting the exhaust from one cylinder through the valve-chest to the other cylinder and valves controlling said ports, substantially as described.

43. The combination with steam-cylinders A, A′, of steam-chest G having valve-chambers K, K′ at opposite ends, admission and exhaust ports H, I connecting respectively with valve-chambers K, K′, ports for connecting said valve-chambers with the steam-cylinder ports of two steam-cylinders, and passages i^2, k^2 connecting the outer exhaust-port of chamber K and the outer admission-port of chamber K′ with a receiver between the chambers with which the inner ports of the chambers connect and valves controlling said ports, substantially as described.

44. The combination with the steam and pump cylinders, pistons, plungers and rocking beam of a direct-acting beam-pump, of admission and exhaust ports for the steam-cylinders arranged to secure the closing of the exhaust-port in each cylinder by the piston

for cushioning at only one end of each cylinder, substantially as described.

45. The combination with the vertical steam and pump cylinders, pistons, plungers and rocking beam of a vertical direct-acting beam-pump, of admission and exhaust ports for the steam-cylinders arranged to secure the closing of the exhaust-port by the pistons for cushioning at only the upper ends of the cylinders, substantially as described.

46. The combination with the steam and pump cylinders, pistons, plungers and rocking beam of a direct-acting beam-pump, of a single port forming the admission and exhaust port for each end of each cylinder, the port at one end only of each cylinder being arranged to be closed by the pistons to cushion the latter, substantially as described.

47. The combination with the vertical steam and pump cylinders, pistons, plungers and rocking beam of a vertical direct-acting beam-pump, of a single port forming the admission and exhaust port for each end of each cylinder, the port at the upper end only of each cylinder being arranged to be closed by the pistons to cushion the latter, substantially as described.

48. The combination with the steam and pump cylinders, pistons, plungers and rocking beam of a direct-acting beam-pump, of a single port at each end of each cylinder forming the admission and exhaust port, said port at one end of each cylinder only having a main exhaust connection with the cylinder closed by the piston as it approaches the end of its stroke for cushioning and another connection with the cylinder outside of and not closed by the piston, substantially as described.

49. The combination with the steam and pump cylinders, pistons, plungers and rocking beam of a direct-acting beam-pump, of a single port at each end of each cylinder forming the admission and exhaust port, said port at one end of each cylinder only having a main exhaust connection with the cylinder closed by the piston as it approaches the end of its stroke for cushioning and another connection with the cylinder outside of and not closed by the piston, and an adjustable valve controlling said second connection with the cylinder for regulating the exhaust and admission through said connection, substantially as described.

50. The combination with two steam-cylinders and their pistons, and a rocking beam connecting said pistons, of ports for the admission and exhaust of steam, a valve mechanism arranged to permit the free exhaust of steam during the main part of each stroke and arranged to cushion each piston by the exhaust-steam at one end only of each cylinder and to permit the slow exhaust of the cushioning steam and the admission of steam behind the piston for beginning the next stroke, substantially as described.

51. The combination with two steam-cylinders, pistons and piston-rods, and a rocking beam connecting said piston-rods, of single admission and exhaust ports k, l, k', l' for the respective cylinders, said ports k, k' having a connection with the cylinder closed by the piston as it approaches the end of its stroke, passages 7 connecting said ports k, k' with the cylinder-ports 6 beyond the movement of the piston, and adjustable valves for controlling said ports 6, substantially as described.

52. In a beam-engine, the combination with a rod or plunger, of connecting-pieces x, beam F, links y connected to the connecting-pieces x and pivots 14 connecting the opposite ends of the beam F to the links y and extending through openings in the connecting-pieces x formed to permit the movement of the pivots across the line of the rods, substantially as described.

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

CHARLES C. WORTHINGTON.

Witnesses:
LOUIS R. ALBERGER,
BOWEN W. PIERSON.