(No Model.)

2 Sheets—Sheet 1.

H. B. HALVORSEN.

STEAM ENGINE.

No. 573,216. Patented Dec. 15, 1896.

Fig. 1.

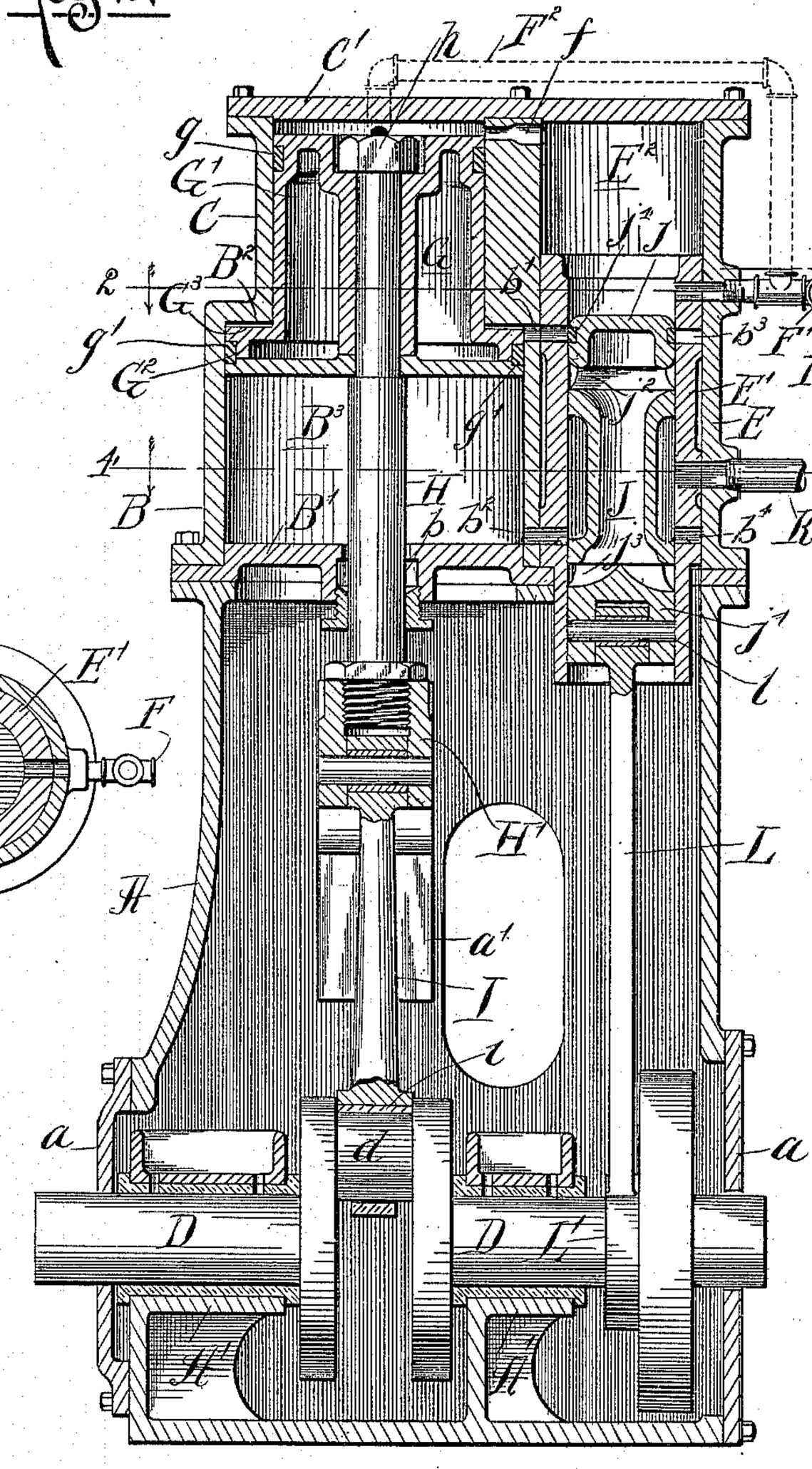
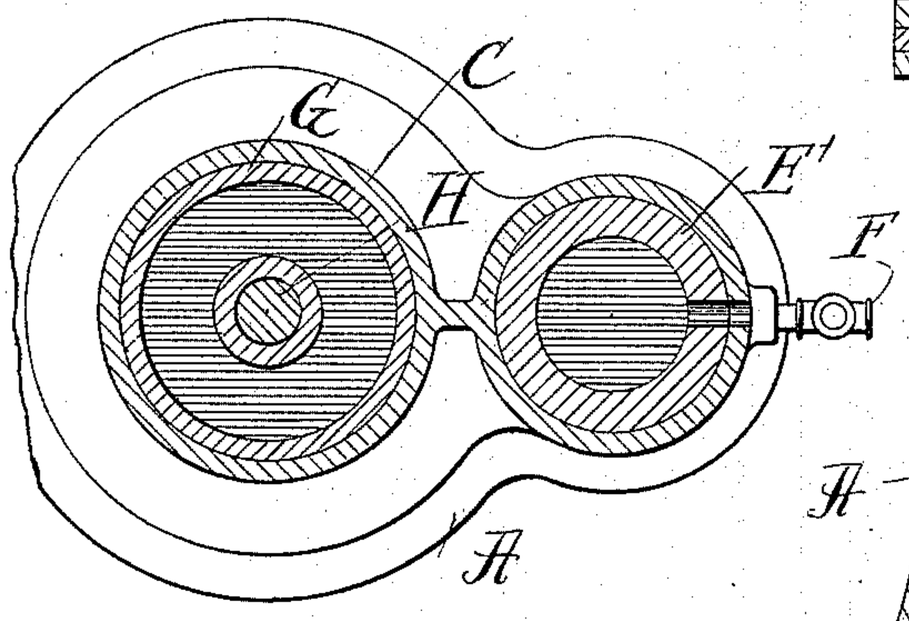


Fig. 2.



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(No Model.) 2 Sheets—Sheet 2.

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Fig. 4.

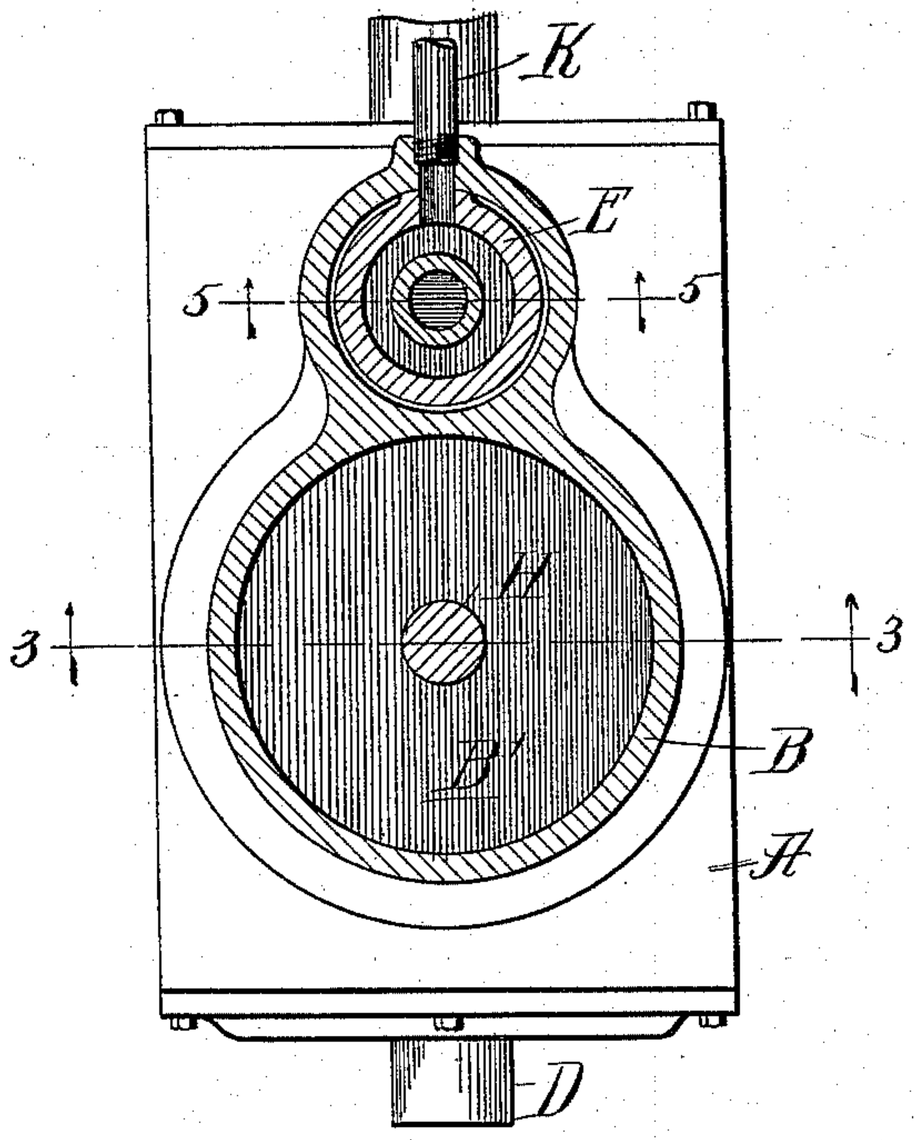


Fig. 5.

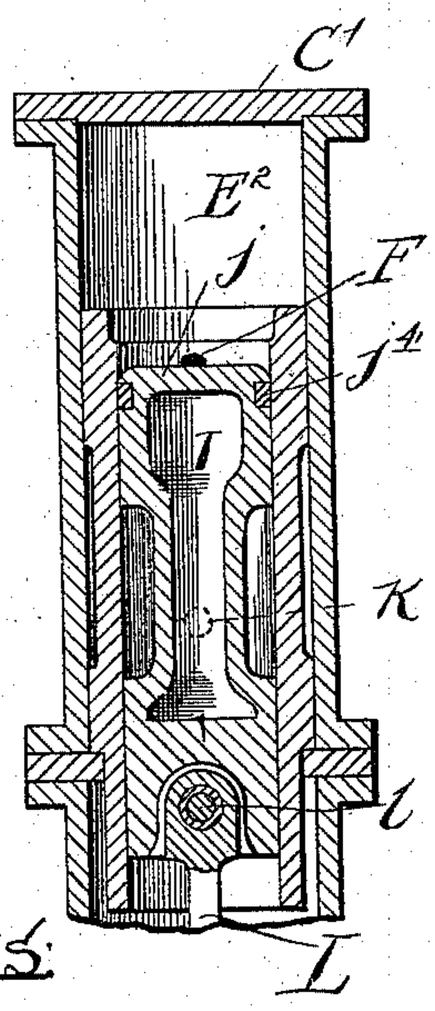
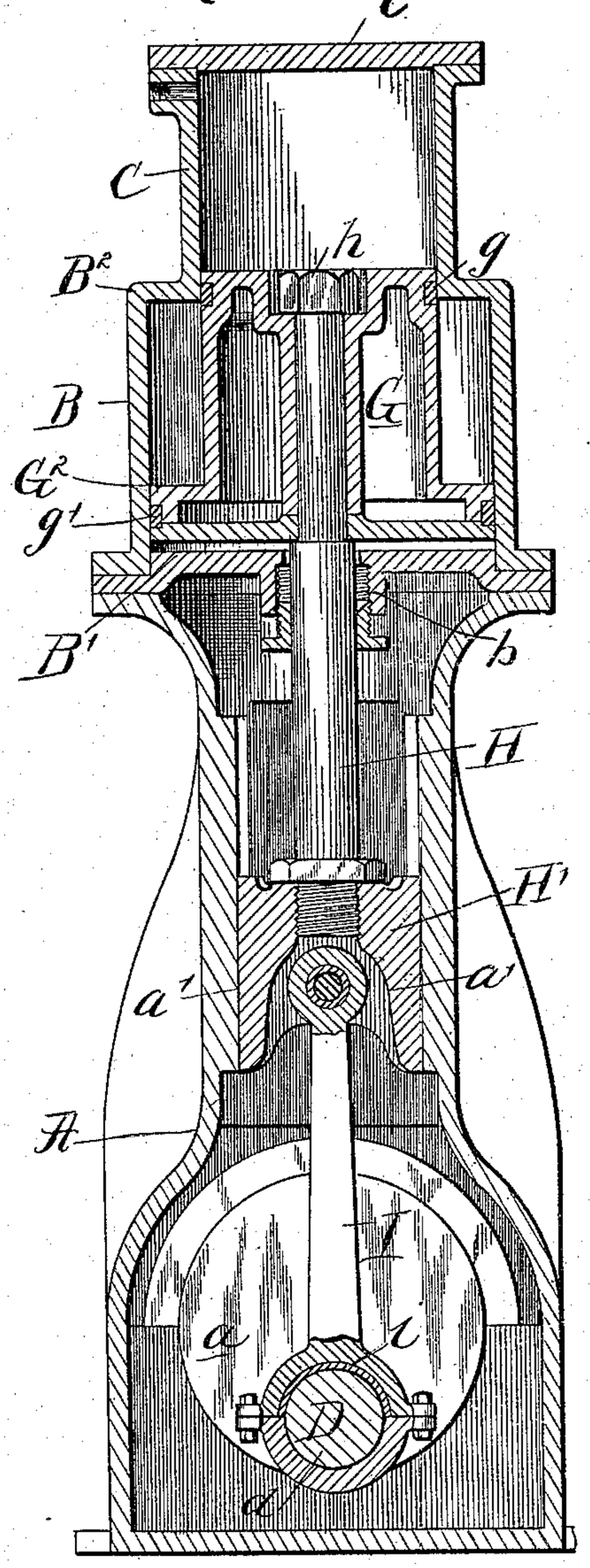


Fig. 3.



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UNITED STATES PATENT OFFICE.

HALBERT B. HALVORSEN, OF CHICAGO, ILLINOIS, ASSIGNOR OF ONE-HALF TO WILLIAM K. MILLHOLLAND, OF SAME PLACE.

STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 573,216, dated December 15, 1896.

Application filed June 6, 1896. Serial No. 594,471. (No model.)

To all whom it may concern:

Be it known that I, HALBERT B. HALVORSEN, of Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Steam-Engines; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, and to the letters of reference marked thereon, which form a part of this specification.

My invention relates to single-acting compound engines of and more especially to means for maintaining a constant pressure on the piston-rod and parts connected therewith in a direction toward or against the crank-pin of the crank-shaft.

The invention also includes improvements in engines of the character described in other respects, as will hereinafter appear.

The invention is shown in the accompanying drawings as embodied in a compound engine having two connected cylinders of different diameters, and a trunk-piston having parts of different diameters fitting within the said cylinders and which is attached to the piston-rod connected with the crank-shaft by the usual connecting-rod. The main features of invention may, however, be embodied in an engine having more than two cylinders, and which parts, in other respects, are constructed and arranged otherwise than in the engine herein shown.

In the said drawings, Figure 1 is a view in central vertical section taken in a plane passing through the central axis of the crank-shaft. Fig. 2 is a plan section taken on line 2 2 of Fig. 1. Fig. 3 is a central vertical section taken on a direction transverse to the crank-shaft on line 3 3 of Fig. 4. Fig. 4 is a plan section taken on line 4 4 of Fig. 1. Fig. 5 is a vertical section taken through the steam-chest on line 5 5 of Fig. 4.

In said drawings, A indicates the usual housing or frame, which constitutes the base of the engine and to the top of which the engine-cylinders B and C are attached. Said cylinders are of different diameters and open one into the other.

D indicates the crank-shaft of the engine, which is mounted in bearings A′ A′ in the lower part of the housing A, which latter is provided with removable plates *a a*, through which the crank-shaft passes and which, when removed, afford access to the crank-shaft and its bearings.

The cylinders B and C are shown as cast in one piece with each other and with the steam-chest E, which is located at one side of the same. The upper cylinder C is the smaller, and the lower cylinder B the larger, one. The lower end of the cylinder B is closed by means of a head B′, the marginal part of which is inserted between the lower end of the cylinder B and the upper end of the housing, and which is secured to the cylinder by the same bolts which secure the cylinder to the housing. The cylinder C is closed at its upper end by means of a head C′, which is herein shown as extended over and adapted to form the head of a steam-chest E. A steam-supply pipe F, leading from the boiler, furnishes steam to the upper end of the steam-chest E, and the upper end of the cylinder C is connected with the upper part of the steam-chest by means of a port or passage *f*.

G indicates the piston, which is of trunk-form and consists of a smaller upper part G′, fitting within the cylinder C, and a lower larger part G^2, which fits in the cylinder B. The upper smaller part of the piston is shown as provided with a packing-ring *g* at its upper end, and the larger part G^2 is similarly provided with a packing-ring *g′*. The upper or smaller cylinder is subject to steam under pressure from the boiler, coming from the upper part of the steam-chest, which is in constant communication with the steam-supply pipe F through the port *f*. The annular space B^2 at the upper space of the larger cylinder B, between the upper part of the piston G and the wall of the said cylinder, constitutes the high-pressure cylinder or space in which the steam operates at boiler-pressure to drive the piston, the steam in such space acting, obviously, on the annular surface G^3 of the piston, which forms the top of the enlarged part G^2 thereof. The lower part B^3 of the cylinder B constitutes the low-pressure cylinder or space in which

the exhaust-steam from the high-pressure cylinder acts expansively on the entire area of the lower end of the piston.

H is the piston-rod, which is attached to the piston G and passes through a suitable gland or stuffing-box *b* in the lower head B′ of the larger cylinder and is attached at its lower end to the cross-head H′, which moves in suitable guides *a′ a′* in the housing A. Said cross-head is connected with the crank-pin *d* of the crank-shaft by means of the connecting-rod I, (herein shown as provided with the bearing-bars *i*,) which engages the upper part of the crank-pin only. As herein shown, the said piston consists of an upper inverted-cup-shaped casting having a recess at its upper end to receive a clamping-nut, and a bottom plate which rests on a shoulder of the piston-rod H and which is held in contact with the upper part or hollow casting by means of a nut *h*, secured to the upper end of the piston-rod and acting to clamp the two parts of the piston closely together.

Within the valve-chest E is located a hollow piston-valve I′, having the form of a hollow cylinder closed at both ends by means of end walls *j j′* and having the central reduced portion, which forms the exhaust-steam space of the valve-chest. Said valve is provided at its ends with annular ports j^2 j^3, which operate in connection with steam-ports *b′* and b^2 at the upper and lower ends of the cylinder B. Said valve-chest is shown as provided with a cylindric lining E′, which contains annular grooves b^3 b^4, which communicate with the cylinder-ports *b′* b^2, so as to afford passage for the steam into and out of the valve throughout the entire circumference of the same. An exhaust-pipe K is connected with the exhaust-steam space formed by the central reduced part of the valve J, said exhaust-port being brought in the reciprocatory motion of the valve intermittingly into communication with the port b^2, which is the exhaust-port of the low-pressure cylinder, in a familiar manner. The interior of the hollow piston-valve forms the passage for the said exhaust-steam from the high to the low pressure steam-space of the cylinder, and for this purpose the valve-ports j^2 j^3 are arranged at approximately the same distance apart as the steam-ports *b′* b^2, so that when the piston is at the upper limit of its stroke and the ports of the valve opposite the cylinder-ports the exhaust-steam from the high-pressure cylinder will be free to pass or expand into the low-pressure cylinder. Live steam from the boiler is delivered to the upper part of the steam-chest only and is admitted to the port *b′* at the downward limit of the stroke of the valve when the upper end of the piston passes below the upper margin of said steam-port.

The valve J is shown as being actuated from the crank-shaft D by means of an eccentric-rod L, which engages an eccentric L′ on the shaft and has pivotal connection directly with the lower end of the valve by means of a pivot-pin *l*. Said valve, as shown, is provided between the port j^2 and its upper end with a packing-ring j^4 to prevent the leakage of live steam past the upper part of the valve to the said port.

It will be noted that the valve J is not a balanced valve, but that it is subject at its upper end to the steam-pressure of the valve-chest, by which the eccentric-rod connections are maintained constantly in bearing against each other in one direction.

The steam-supply pipe F is provided with a hand-actuated throttling-valve F′, by which the steam supply may be cut off or controlled. I have shown in dotted lines at F^2, Fig. 1, a steam-pipe leading directly from the upper end of the cylinder C to the steam-pipe F outside of said valve F′. When this pipe F^2 is used, the port *f* will be omitted, and steam for cushioning the cylinder will pass directly from the steam-pipe to the said cylinder without passing through the steam-chest. When the pipe F′ is employed, the steam-chest may, of course, be made shorter than that illustrated, said steam-chest being shown in the drawings as made to extend to the end of the cylinder C, so as to form a steam space or chamber of considerable area. Said steam-pipe may be provided with a hand-actuated valve F^3, or a similar valve may be placed in the port or passage *f* in order to control the influx of steam to and its escape from the upper end of the cylinder. By partially closing said valve the escape of steam may be retarded in the back stroke of the piston to such an extent that the steam will be compressed to some extent in the cylinder, thus forming a steam-cushion adapted to gradually retard the movement of the piston as it reaches the limit of its upstroke. The passage *f* may, however, be so proportioned as to partially confine the steam, and thereby give such cushioning effect as is found desirable without the use of a valve for varying the size of the steam-passage. Moreover, when a steam-chamber is present, such as is formed by the upper end of the steam-chest, compressing of steam in the back stroke of the piston may take place mainly in said chamber, and the extent of compression and back pressure will depend upon the size of the opening afforded by the said valve F′.

In the operation of the engine constructed as shown the small part G′ of the piston is subjected continuously to the action of the steam at boiler-pressure, the steam entering through the steam chest and port *f* on the downstroke and being forced in the upstroke of the piston from the cylinder backwardly into the steam-chest and to a greater or less extent backwardly through the steam-supply pipe to the boiler. When the upper end of the cylinder C is connected directly with the boiler by the steam-pipe F′ and the main steam-pipe F, as shown in dotted lines in Fig. 1, the steam will be forced backward

from the said cylinder through the said steam-pipes into the boiler in the upstroke of the piston, a desired cushioning effect being produced by partially closing the valve F^3, if this shall be found to be necessary or desirable. I prefer, however, to employ the construction shown in Fig. 1, wherein the steam-chamber E^2 is provided in the steam-chest, for the reason that steam will more quickly and rapidly follow the piston as the latter moves outwardly in case the steam comes from the chamber E^2 than it would if it came through the steam-supply pipe, by reason of the friction necessarily due to its passage through the pipe and because said chamber E^2 affords a space in which the steam may be compressed to cushion the stroke of the piston. In the advance or working stroke of the piston steam enters the high-pressure steam-space through the port b' at the time the piston-valve is at the outer or lower limit of its stroke, and the piston is advanced by steam at boiler-pressure acting on the annular surface or shoulder G^3 of the piston and also by the steam acting on the upper end of the piston in the cylinder C, so that on the out or down stroke the piston is subject to the action of the steam at or near boiler-pressure on a total piston surface or area equal to the area of the large cylinder B. When the piston reaches the downward limit of its stroke, communication is established between the port b' and the port b^2 through the hollow piston-valve, and steam then expands from the space above to the space below the larger or lower part of the piston, and the exhaust-steam from the high-pressure cylinder so expanding acts against the lower face of the piston with a pressure which is not quite sufficient to overcome the pressure of the live steam in the smaller cylinder, the intent being that such pressure of the live steam in the smaller cylinder shall be practically counterbalanced by the pressure of the expanding or low-pressure steam in the larger cylinder, while at the same time the action of the low-pressure steam is not relied upon to actually move the piston into its back stroke. The movement of the piston and connected parts thereof in the back stroke is actually accomplished by the energy stored up in the balance-wheel and other rotating parts attached to the crank-shaft, (or from the action of another similar engine on the same crank-shaft in case the engine be a double one,) so that the pressure of the connecting-rod comes always in the same direction on the crank-pin. Notwithstanding the action of the low-pressure steam on the under side of the piston, therefore, the engine operates as a single-acting engine and not as a double-acting or reciprocating engine. In other words, all the advantages are obtained of a single-acting "single-thrust" engine, from the fact that the connecting-rod is always in constant bearing in one direction upon the crank-pin, and the wearing away of parts of the bearing therefore affords no looseness of the parts and does not give rise to pounding, which necessarily occurs in double-acting engines after the parts of the bearings become so worn as to be loose or to give lost motion.

Single-acting compound engines have heretofore been made having two connected cylinders of different diameters with pistons in both cylinders connected by a piston-rod and wherein a constant steam-pressure is maintained in the space between the pistons and in which high and low pressure steam acts upon the outer ends of the large and small piston, so that the boiler or cushioning pressure acts against the high-pressure steam and the working stroke is accomplished by the low-pressure steam acting on the larger piston against the cushioning pressure acting on the difference in areas between the two pistons. It has also been proposed, in a single-acting compound engine having two separate cylinders arranged end to end and having pistons attached to a common piston-rod working in the two cylinders, to employ steam at boiler-pressure in the outer end of the smaller cylinder and to counterbalance the same by high-pressure steam in the inner end of the smaller cylinder, the low-pressure steam in such instance acting on the large piston in the same direction as the steam from the boiler, it being obvious in this construction that the cushion-pressure is counterbalanced by high-pressure steam and acts in the same direction as the low-pressure steam. My improved engine differs from those above described by the employment of a trunk form of piston and the employment of the exhaust or low-pressure steam to counterbalance the cushioning pressure, which acts on the end of the smaller piston, while the high-pressure steam acts on the difference in areas between the two pistons in the same direction as the cushioning-pressure. This construction has the advantage of securing the desired result in an engine of compact simple character, wherein the passage for conveying steam from the high to the low pressure cylinder is reduced to a minimum and the liability of loss of power by condensation of steam is greatly lessened.

Obviously an engine embracing the novel features of construction described may be used in connection with an air-cushion instead of steam as a cushioning means, and I do not therefore desire to be limited to the use of steam as a means of maintaining a constant pressure in one direction on the connected pistons, although I consider the employment of steam preferable for the reason that by the use of steam the energy required to compress the air is saved, while at the same time a desired cushioning or retarding effect may be produced by properly limiting or controlling the outward passage of steam through the steam-passage by which the live steam is supplied to the engine-cylinder.

Obviously an engine embodying my invention may be a double or quadruple expansion engine instead of a compound engine, and if desired several sets of cylinders and pistons may be employed in connection with a single crank-shaft.

Obviously, so far as the general construction of the engine is concerned, the arrangement of the valves may be different from that shown. Moreover, the engine-cylinders may be arranged in inverted position as compared with those shown. In other words, the smaller piston and cylinder may be nearest the crank-shaft, in which case the connecting-rod will exert a constant pull on the crank-pin instead of a constant push or thrust thereon, as in the construction illustrated. In either case the result will be the same, namely, a constant pressure or thrust of the connecting-rod bearing in one direction against the crank-pin.

I claim as my invention—

1. The combination with a plurality of connected cylinders of different diameters opening one into the other, of connected pistons therein of which the smaller piston is of trunk form and is subject to continuous pressure giving a constant pressure on the crank-pin in both the forward and backward stroke of the piston and the larger piston is subject on its surface exterior to the smaller or trunk piston to high-pressure steam acting in the same direction as the continuous pressure on the smaller piston; said larger piston being also subject to low-pressure steam acting on its full area to counterbalance the continuous pressure on the smaller piston.

2. A steam-engine comprising two connected cylinders of different diameters opening one into the other and connected pistons within the cylinders of which the smaller piston is of trunk form, the smaller of said cylinders being in constant communication with the steam-boiler so that the steam therein exerts a constant pressure in one direction on the smaller piston and the larger cylinder being constructed to receive steam at both ends, the high-pressure steam acting on the surface of the larger piston outside of the smaller one, in the same direction as the constant pressure from the boiler, and the low-pressure steam acting on the full area of the larger piston in opposition to said constant pressure of steam from the boiler.

3. A steam-engine comprising two connected cylinders of different diameters and connected pistons within the cylinders of which the smaller piston is of trunk form, the smaller of said cylinders being in constant communincation with the steam-boiler so that the steam therein exerts a constant pressure in one direction on the smaller piston and the larger cylinder being constructed to receive steam at both ends, the high-pressure steam acting on the surface of the larger piston outside of the smaller one, in the same direction as the constant pressure from the boiler, and the low-pressure steam acting on the full area of the larger piston in opposition to said constant pressure of steam from the boiler, the said larger cylinder being provided with a steam-valve to control the admission and exit of steam to and from the same.

In testimony that I claim the foregoing as my invention I affix my signature, in presence of two witnesses, this 12th day of May, A. D. 1896.

HALBERT B. HALVORSEN.

Witnesses:
C. CLARENCE POOLE,
WILLIAM L. HALL.