(No Model.) 2 Sheets—Sheet 1.

H. W. FORSLUND.

COMPOUND STEAM ENGINE.

No. 573,869. Patented Dec. 29, 1896.

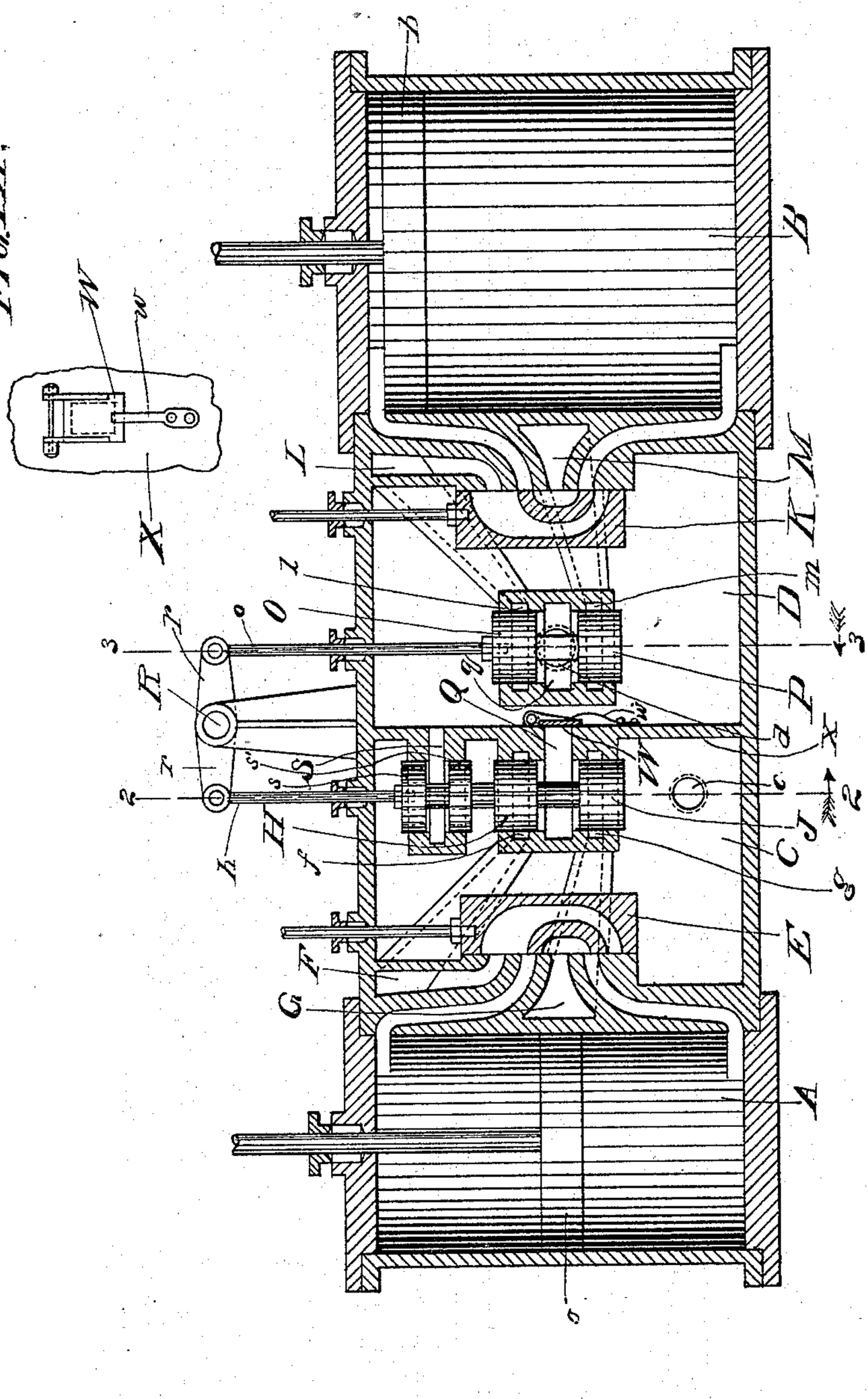

FIG. 1.

Witnesses
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(No Model.)

2 Sheets—Sheet 2.

H. W. FORSLUND.

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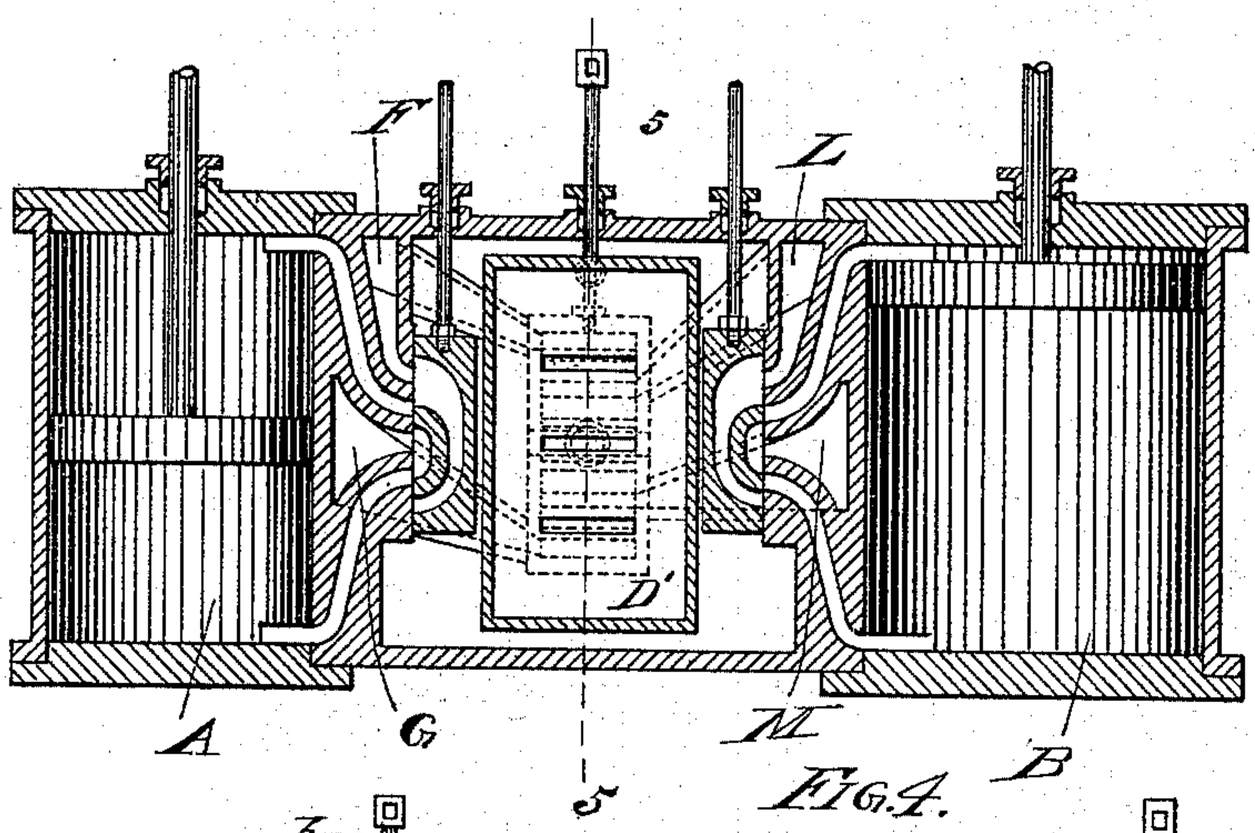

FIG. 4.

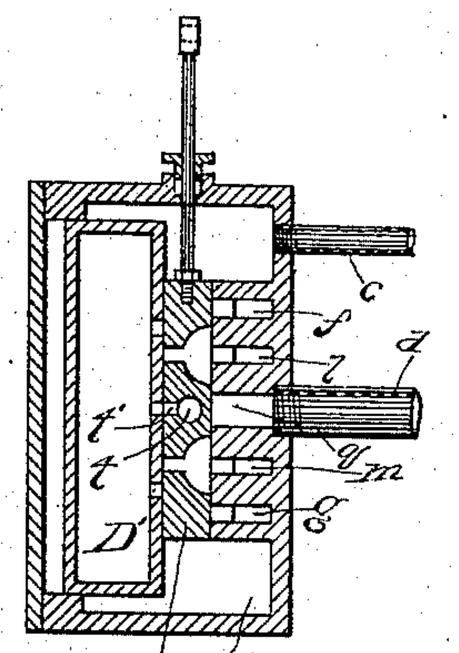

FIG. 5.

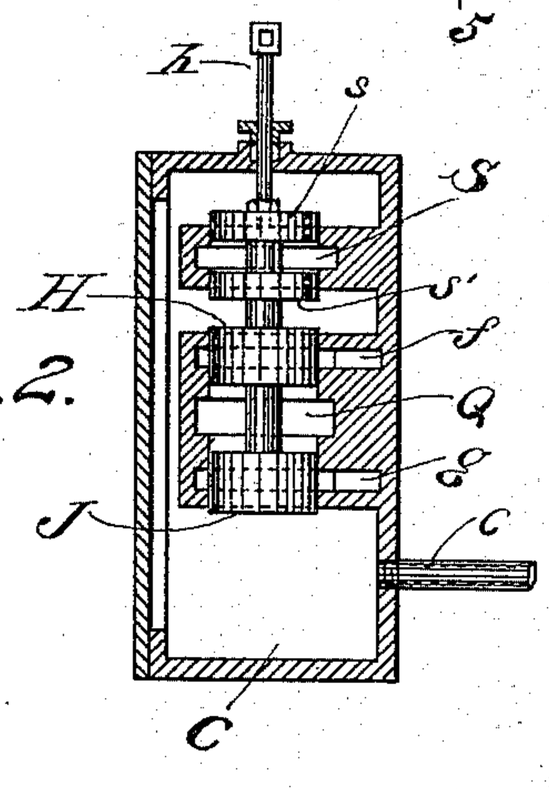

FIG. 2.

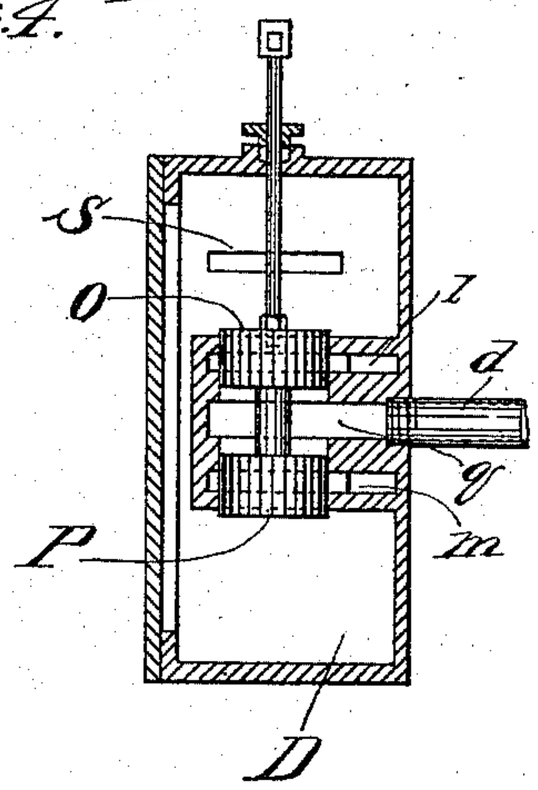

FIG. 3.

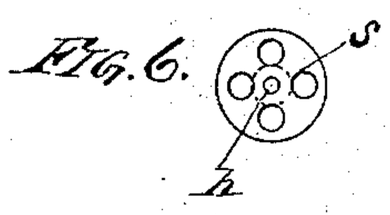

FIG. 6.

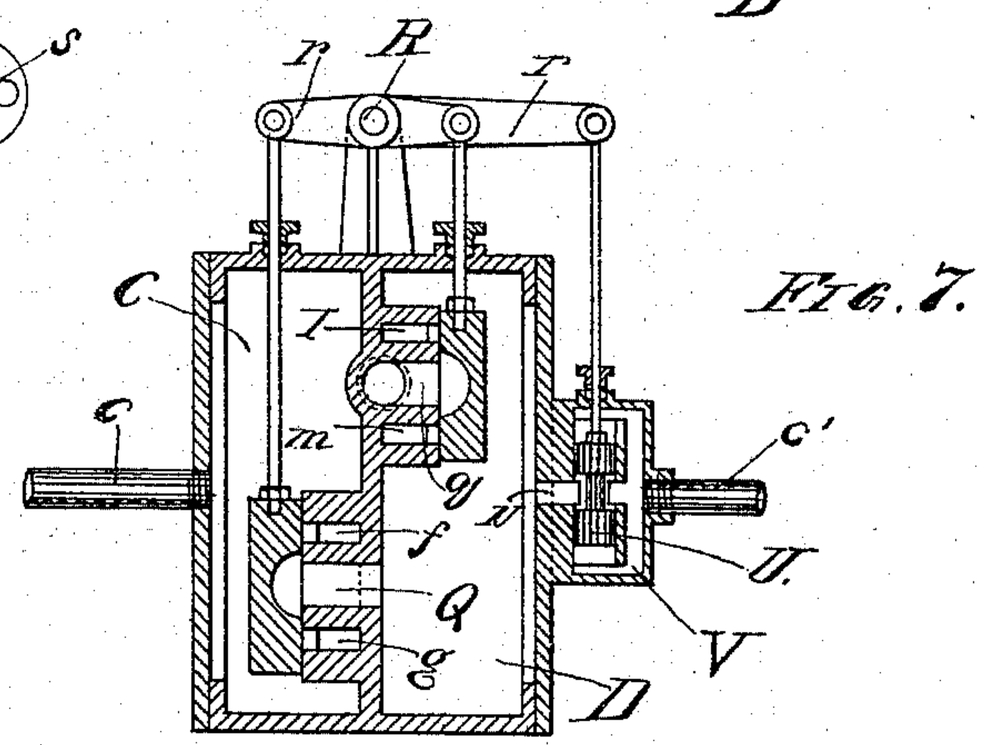

FIG. 7.

Witnesses
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UNITED STATES PATENT OFFICE.

HUGO W. FORSLUND, OF CHICAGO, ILLINOIS.

COMPOUND STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 573,869, dated December 29, 1896.

Application filed July 12, 1895. Serial No. 555,805. (No model.)

To all whom it may concern:

Be it known that I, HUGO W. FORSLUND, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Compound Steam-Engines; and I do declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to the letters of reference marked thereon, which form a part of this specification.

This invention relates to compound engines, its object being to provide an improved throttle or starting valve system by means of which the low-pressure cylinder may be directly served with live steam for starting.

The invention consists of such a construction and arrangement of valves that the steam-pressure is opened directly to and cut off from the low-pressure cylinder as the valves are shifted for starting the engine.

In the drawings I show, in Figure 1, a longitudinal section of the engine through its cylinders and steam-chests. Fig. 1[A] is a view of the check-valve. Figs. 2 and 3 are sectional views on the lines 2 2 and 3 3, respectively, of Fig. 1. Fig. 4 is a view similar to Fig. 1, showing a modified form of the low-pressure cylinder and of the valve system. Fig. 5 is a sectional view on the line 5 5 of Fig. 4. Fig. 6 is a detail of one of the valves. Fig. 7 is a sectional view of the steam-chest, showing another modification thereof and of the valve system.

The invention is intended more particularly for use in connection with engines in which the pistons are set a half-stroke apart, as shown, and is especially serviceable when the engine stops with the high-pressure-cylinder crank on a dead-center.

In Fig. 1 the preferred construction is shown, A indicating the high-pressure and B the low-pressure cylinder, and *a b* their respective pistons. The steam-chest C serves the cylinder A, and the steam-chest D serves the cylinder B. These chests may be cast integrally, a partition X separating them. The steam-service is through the pipe *c* entering the chest C.

The cylinder A is provided with steam-passages a' a^2, leading one to each of its ends from the seat of a slide-valve E, which is provided with a central cavity *e* and a passage *e'*, opening through its face upon both sides of the cavity *e* and extending over the latter. Steam-passages F G are cored in the walls of the steam-chest C in the usual manner, the passage G opening through the seat of the valve E between the passages a' a^2, and the passage F opening through the seat of said valve outside of those two passages. The relation of the passages F G a' a^2 as they open through the seat of the valve E is such that the cavity *e* may cover simultaneously either the passages G and a^2 or the passages G and a', and the ends of the passage *e'* in the valve *e* are so spaced apart that they will register simultaneously with the passages F and a', and the end of the passage *e'* which coöperates with the passage F is enlarged, so that when the valve *e* is properly shifted the passages F and a^2 are brought into communication through its enlargement. When the valve *e* is in the last-named position, the smaller end of the passage *e'* is closed and the passages G and a' are in communication through the cavity *e*. The space between the ends of the passages a' a^2 opening through the seat of the valve *e* is such that these passages may be simultaneously closed by the solid portions of the face of the valve between the cavity *e* and the ends of the passage *e'*.

The passages F G open to the interior of the steam-chest C through the ports *f g*, respectively, which are controlled by piston-valves H J, mounted upon a common stem *h*.

The cylinder B and the steam-chest D are brought into communication by means of a system of passages and valves corresponding in all particulars to those of the cylinder A and chest C and comprising the cylinder-passages b' b^2, the slide-valve K, having a central cavity *k* and a passage *k'*, the steam-passages L M, cored in the walls of the chest D and opening to the seat of the valve K, the one upon the outside of the ends of the passages b' b^2 and the other between such passages and to the interior of the chest D, through the ports *l m*, respectively, which are controlled by the piston-valves O P, mounted upon a common stem *o*. The final exhaust is through

the pipe *d*, leading from a port *q*, situated between the ports *l m* and covered by the cylinder within which the piston-valves O P reciprocate, so that it may be opened to either one of these ports by the shifting of the valves.

A port Q opens from the chest D through the partition X to the seats of the valves H J and between the valves, so that it may be opened to either of the ports *f g*. A check-valve W is so placed as to prevent back pressure from the chest D through the port Q, and is preferably provided with a spring, as *w*, for holding it normally to its seat.

The stems of both sets of valves H J and O P are connected with the rock-shaft R by means of the crank-arms *r r*. I have not regarded it as necessary to show the means for operating the shaft R. As the valves H J are shifted to uncover one of the ports *f g* to the chest C and the other to the port Q, the valves O P are shifted to uncover one of the ports *l m* to the chest D and the other to the port *q*, so that the steam exhausted from the cylinder A is utilized in the cylinder B.

Two ring-valves *s s'* are mounted upon the stem *h*. These valves are seated within an aperture through a mass of metal cast upon the wall X and within which is formed a port S, opening to the chest D and extending inwardly to the seats of the valves *s s'*. The web securing one or both of these valves to the stem *h* is apertured, as indicated in Fig. 6. The valves *s s'* are so located upon the stem *h* that the port S is uncovered and between them when the valves H J and O P are centered to close the ports *f g* and *l m*, and is closed by one of them when these valves are shifted to admit steam to the cylinders.

It will be seen that when the port S is uncovered between the valves *s s'* the steam will pass through the apertures in the web of these valves and enter the chest D, and will be cut off from this chest upon the movement of the valves to start the engine. By this arrangement of valves and ports the engine is provided with a chest full of steam for use in the low-pressure cylinder in starting.

When the engine is in the position shown in Fig. 1, it is at rest, the steam-passages *f g* and *l m* being closed, respectively, by the valves H G and O P. The passage S is uncovered, so that steam enters therethrough into the chest D. In order to start the engine, the rock-shaft R may be turned so as to cause an inthrust of the valve-stem *h* and a withdrawal of the valve-stem *o*. By this action the passage S is covered by the ring *s*, the port *f* is opened to the chest C, the port *g* is opened to the passage Q, the port *m* is opened to the steam-chest D, and the port *l* to the port *d*. Steam enters the cylinder A through the port *f*, a passage F, the enlarged end of the passage *e'*, and the passage a^2, and is exhausted from that cylinder through the passage *a'*, the valve-cavity *e*, the passage G, the port *g*, and the passage Q into the steam-chest D. Steam enters the passage M through the port *m*, and as soon as the distributing-valve K is moved inwardly the steam enters the cylinder B through the cavity K and the passage b^2, steam being exhausted from this cylinder through the passage *b'*, the valve-passage *k'*, the passage L, the ports *l q*, and the pipe *d*.

Should it be desired to start the engine in the reverse direction, the rock-shaft R is turned so as to withdraw the valve-stem *h* and thrust inwardly the stem *o*, thereby uncovering the port *g* to the steam-chest C, the port *f* to the passage Q, the port *l* to the chest D, and the port *m* to the port *q*, the passage S being closed by the ring-valve *s'*. Steam now circulates through the steam-passages as before, but in exactly the opposite direction.

In the modification shown in Figs. 4 and 5 the steam is delivered from the high to the low pressure cylinder without passing through an intermediate chest, but a chest D' for providing a supply of steam for the low-pressure cylinder in starting is located within the steam-chest C, and is utilized by the following valve arrangement.

The ports *f*, *g*, *l*, *m*, and *q*, each serving the same purpose as in the construction shown in Fig. 1, open in a line through a common valve-seat, the port *q* being in the middle, the ports *l* and *m* being next to it, and the ports *f g* being at the ends of the line. A double **D**-valve T, having in its face cavities Y *y*, is used for controlling these ports, and the back of this valve is in sliding contact with one wall of the steam-chest D'. The port Y' opens through the back of the valve T from the cavity Y, and a similar port *y'* opens through the back of the valve from the cavity *y*. The valve T is apertured transversely between the cavities Y *y*, as indicated at *t*, and a port *t'* opens through the back of the valve from this aperture. That portion of the wall of the chest D' which is covered by the valve T is provided with three ports *d'*, d^2, and d^3, the last of which registers with the port *t'* when the valve is centered, the other two being closed. The ports *f*, *g*, *l*, *m*, and *q* are so spaced apart and the width of the cavities Y *y* is such that an inthrust of the valve from its central position uncovers the port *f* to the steam-chest C, connects the ports *l* and *q* through the cavity Y, and connects the ports *m* and *g* through the cavity *y*. An outward movement of the valve from its central position uncovers the port *g* to the steam-chest C and connects the ports *m* and *q* through the cavity *y* and the ports *f* and *l* through the cavity Y.

When the valve is in its central position, as shown in Fig. 5, steam enters the chest D' through the aperture *t* and port *t'*. An inthrust of the valve from its central position cuts off the steam-chest D' from the chest C and causes the ports *y'* and d^2 to register. The port *f* being now open to the chest C, steam enters it, and passing through the passage F, the enlarged end of the passage *e'* of the dis-

tributing-valve of the cylinder A, and through the passage a^2 enters the cylinder A, and the steam in the opposite end of the cylinder is forced out by the advance of the piston a through the passage a', the cavity e, the passage G, the port g, the cavity y, the port m, the passage M, the cavity k, and the passage b^2 to the cylinder B, this cylinder exhausting from its opposite end through the passage b', the passage k', the passage L, and the port l to the exhaust-port q. The steam exhausting, as above stated, from the cylinder A is supplemented by the contents of the steam-chest d' passing through the ports d^2 and y' to the cavity y, and by its expansive force assists in starting the engine. It will be seen that if the engine has stopped with the piston of the cylinder A centered and the piston of the cylinder B at the half-stroke the opening of the port f would be ineffectual to start the engine, because the distributing-valve of the cylinder A would then be centered, but the quantity of steam within the chest D' would be sufficient to start the engine by its direct pressure upon the piston of the cylinder B.

It will be understood that an outward movement of the valve T from its central position would start the engine in the direction opposite to that resulting from the inward movement of the valve, the steam passing through the various passages as before, but in the opposite direction.

In Fig. 7 a form of construction is shown in which two valve-chests C D are used as in Fig. 1, but with D-valves to control the ports of the passages leading to the cylinders. This porting being the same as in Fig. 1, it need not be described. The chest D is, however, served with live steam when the engine is at rest by means of an independent service-pipe c' entering through a port u, controlled by a piston-valve U, mounted within a small chest V exterior to the chest D. The valve U is actuated by means of a crank-arm r', attached to the rock-shaft R, and its movements with reference to the cut-off valves so timed that the port u is opened when the throttle-valves are centered. The chest V is employed in order that the valve U may be balanced.

The three forms of construction are broadly alike, the chamber for receiving a definite amount of live steam before the engine is started and valve mechanism for cutting this chamber off from the boiler and opening it to the low-pressure cylinder being present in each of them.

The use of the supplemental chest for the low-pressure cylinder is preferable, as it provides a considerable volume of steam for expansion into the cylinder. I do not, however, desire to be limited to the use of a supplemental steam-chest, as any construction of valves which will admit a measured quantity of steam directly to the low-pressure cylinder before the engine is in motion in order that it may act expansively to start the engine, and which will cut that cylinder off from direct communication with the source of pressure as the valves are shifted to throw the steam into the high-pressure cylinder, comes within the scope of my invention.

While I have shown the invention as adapted to a reversible engine and as carried into effect in connection with the reverse gear of the engine, it is equally applicable to any type of compound engine, as it may be utilized in connection with a simple throttle-valve, with a change or reversing valve or system of valves, or with any other form of reversing-gear which performs the function of starting the engine.

In illustrating the invention I have selected a form of reversing-gear which includes the throttle-valve and into which it is easily incorporated, though it is equally applicable to all forms.

While I show the valves to be so arranged as to open the pressure to the chest of the low-pressure cylinder as it is cut off from the high-pressure cylinder, I do not desire to be limited to such construction, as any form which supplies the low-pressure cylinder with direct pressure while its piston is still motionless and cuts off such pressure as it is opened to the high-pressure cylinder is included within the invention.

I claim as my invention—

1. The combination, in a compound engine, of a high and a low pressure cylinder, a separate steam-chest, steam and exhaust passages and a distributing-valve for each cylinder, a passage for conveying steam directly from the source of pressure to the chest of the low-pressure cylinder, and valve mechanism, substantially as described, for controlling the steam and exhaust passages and the direct steam-passage to the chest of the low-pressure cylinder, such valve mechanism being operatively connected and so disposed that the said low-pressure-cylinder chest is opened to the source of pressure when the steam and exhaust passages are closed, and cut off from the source of pressure and opened to the low-pressure cylinder when said steam and exhaust passages are opened.

2. In a compound engine having a high and a low pressure cylinder, each cylinder having a distributing-valve, a steam-chest, and steam and exhaust passages for communication between the cylinder and its chest, the combination with such parts of passages for serving both chests with direct steam pressure, a valve for controlling the direct steam-passage to the chest of the low-pressure cylinder, and valve mechanism, substantially as described, for controlling the passages leading from the chests to the cylinders, such direct-steam-passage valve and valve mechanism for controlling the said cylinder-passages being operatively connected and relatively so disposed that they open and close their respective passages in alternation.

3. In a compound engine having a high and

a low pressure cylinder, each cylinder having a distributing-valve, a steam-chest, and steam and exhaust passages for communication between the cylinder and its chest, the combination with such parts of passages for serving both chests with direct steam-pressure, a valve for controlling the direct steam-passage to the chest of the low-pressure cylinder, valve mechanism, substantially as described, for controlling the passages leading from the chests to the cylinders, such direct-steam-passage valve and valve mechanism for controlling the said cylinder-passages being operatively connected and relatively so disposed that they open and close their respective passages in alternation, a passage whereby the exhaust from the high-pressure cylinder is discharged to the chest of the low-pressure cylinder, and a check-valve for such passage, closable by pressure within the low-pressure-cylinder chest.

4. The combination, in a compound engine, of a high and a low pressure cylinder, steam and exhaust passages leading to each cylinder, distributing-valves for each cylinder, a passage leading from the source of pressure, and an exhaust-port, with controlling-valve mechanism, substantially as described, for simultaneously opening the steam-passage of the high-pressure cylinder to the passage leading from the source of pressure, bringing the exhaust-passage of the high-pressure cylinder into communication with the steam-passage of the low-pressure cylinder and opening the exhaust-passage of the low-pressure cylinder to the exhaust-port, a chest having passages for communicating with the source of pressure and with the steam and exhaust passages of the low-pressure cylinder, and valve mechanism, substantially as described, for controlling the passages of such chest, such valve mechanism being operatively connected with the controlling-valve mechanism and so disposed with reference thereto that it cuts off the chest from the source of pressure and opens it to the steam-passage of the low-pressure cylinder when the steam-passage of the high-pressure cylinder is opened to the passage leading from the source of pressure, and opens such chest to the source of pressure and cuts it off from the low-pressure cylinder when the high-pressure cylinder is cut off from the passage leading from the source of pressure.

5. In a compound engine having a high and a low pressure cylinder, a steam-passage leading to the high-pressure cylinder, a passage leading from the high-pressure to the low-pressure cylinder, an exhaust-passage leading from the low-pressure cylinder, and starting-valve mechanism for controlling the steam-passage leading to the high-pressure cylinder, the combination with such parts, of a chest for supplying the low-pressure cylinder with a measured quantity of steam for starting, and having passages for communicating with the source of pressure and with the passage leading from the high to the low pressure cylinder, and valve mechanism, substantially as described, for controlling the passages of such chest, said valve mechanism being operatively connected with the starting-valve mechanism and so disposed with reference thereto that it cuts the chest off from the source of pressure and opens it to the passage to the low-pressure cylinder when the starting-valve mechanism is shifted to start the engine and opens such chest to the source of pressure and cuts it off from the passage to the low-pressure cylinder when the starting-valve mechanism is shifted to stop the engine.

6. In a compound engine having a high and a low pressure cylinder, a steam-passage leading to the high-pressure cylinder, a passage leading from the high-pressure to the low-pressure cylinder, a check-valve located in said passage to prevent back pressure, an exhaust-passage leading from the low-pressure cylinder, and starting-valve mechanism for controlling the steam-passage leading to the high-pressure cylinder, the combination with such parts, of a chest for supplying the low-pressure cylinder with a measured quantity of steam for starting, and having passages for communicating with the source of pressure and with the passage leading from the high to the low pressure cylinder between the check-valve and the low-pressure cylinder, and valve mechanism, substantially as described, for controlling the passages of such chest, said valve mechanism being operatively connected with the starting-valve mechanism and so disposed with reference thereto that it cuts the chest off from the source of pressure and opens it to the passage to the low-pressure cylinder when the starting-valve mechanism is shifted to start the engine and opens such chest to the source of pressure and cuts it off from the passage to the low-pressure cylinder when the starting-valve mechanism is shifted to stop the engine.

7. The combination in an engine having a primary or high-pressure cylinder and a secondary or low-pressure cylinder, of a steam-chest for each cylinder, two passages leading from each chest to its cylinder, a steam-pipe leading to the chest of the primary cylinder, an exhaust-port for the primary cylinder opening into the chest of the secondary cylinder, an exhaust-port for the low-pressure cylinder, a passage connecting the two chests, a valve for controlling the connection between each chest and the passages leading to its coöperating cylinder and between such passages and their coöperating exhaust-port, and a valve for controlling the passage connecting the two chests, said several valves being operatively connected and so disposed that the chests are open to each other when the cylinder-passages are closed and are cut off from each other when the cylinder-passages are open.

8. In a compound engine having high and low pressure cylinders, a separate steam-chest for each cylinder, passages leading from each

chest to its coöperating cylinder, an exhaust-port for the high-pressure cylinder discharging into the chest of the low-pressure cylinder, an exhaust-port for the low-pressure cylinder, operatively-connected cut-off valves for the passages and exhaust-ports leading from each chest, and a steam-passage leading from the source of pressure to each chest, the combination with such parts of a valve controlling the passage from the source of pressure to the chest of the low-pressure cylinder, such valve being operatively connected with the cut-off valves and so disposed relatively thereto that the passage from the source of power to the chest of the low-pressure cylinder and the passages from the chests are opened in alternation.

9. The combination in an engine having a primary or high-pressure cylinder and a secondary or low-pressure cylinder, of a steam-chest for each cylinder, two passages leading from each chest to its cylinder, a steam-pipe leading to the chest of the primary cylinder, an exhaust-port for the primary cylinder opening into the chest of the secondary cylinder, a check-valve covering such port, an exhaust-port for the low-pressure cylinder, a passage connecting the two chests, a valve for controlling the connection between each chest and the passages leading to its coöperating cylinder and between such passages and the exhaust-port of their coöperating cylinder, and a valve for controlling the passage connecting the two chests, said several valves being operatively connected and so disposed that the chests are open to each other when the cylinder-passages are closed and are cut off from each other when the cylinder-passages are open.

10. The combination in a compound engine with the high and low pressure cylinders, of an independent steam-chest for each cylinder, steam and exhaust passages leading from each chest to its coöperating cylinder, an exhaust-port leading from the chest of the high-pressure cylinder to the chest of the low-pressure cylinder, an exhaust-port for the low-pressure cylinder, a passage communicating between the chests, a valve for controlling the steam and exhaust passages of each cylinder, such valves being operatively connected so as to move together, a valve for the passage communicating between the chests and operativly connected with the controlling-valves and being so disposed that it opens said passage when the controlling-valves close the steam and exhaust passages and closes said passage when the controlling-valves open the steam and exhaust passages.

11. The combination in a compound engine having a primary and a secondary cylinder each provided with a piston, steam-passages and distributing-valves, of a steam-passage leading from the source of pressure to the distributing-valve of each cylinder independently of the other, a valve for controlling the steam-passage to the primary cylinder, two valves for controlling the passage to the secondary cylinder and being located at different points in said passage, said three passage-controlling valves being mechanically connected so as to move simultaneously and being so disposed relatively with reference to such connection that the valve more remote from the secondary cylinder and controlling its steam-passage moves reversely as to the other two valves, and means for operating such valves.

12. The combination in a compound engine having a primary and a secondary cylinder each provided with a piston, steam and exhaust passages and distributing-valves, of a steam-passage leading from the source of pressure to the distributing-valve of each cylinder independently of the other, a valve for controlling the steam-passage to the primary cylinder, two valves for controlling the passage to the secondary cylinder and being located at different points in said passage, said three passage-controlling valves being mechanically connected so as to move simultaneously and being so disposed relatively with reference to such connection that the valve more remote from the secondary cylinder and controlling its steam-passage moves reversely as to the other two valves, and means for operating such valves, the exhaust-passage of the primary cylinder discharging into the steam-service passage of the secondary cylinder between its two valves, and a check-valve located in said exhaust-passage.

In testimony whereof I affix my signature in the presence of two witnesses.

HUGO W. FORSLUND.

Witnesses:
SPENCER WARD,
MILO B. GILLSON.