

I. H. BOYER.  
 COMPOUND ENGINE.  
 APPLICATION FILED JAN. 9, 1906.

Fig. 1.

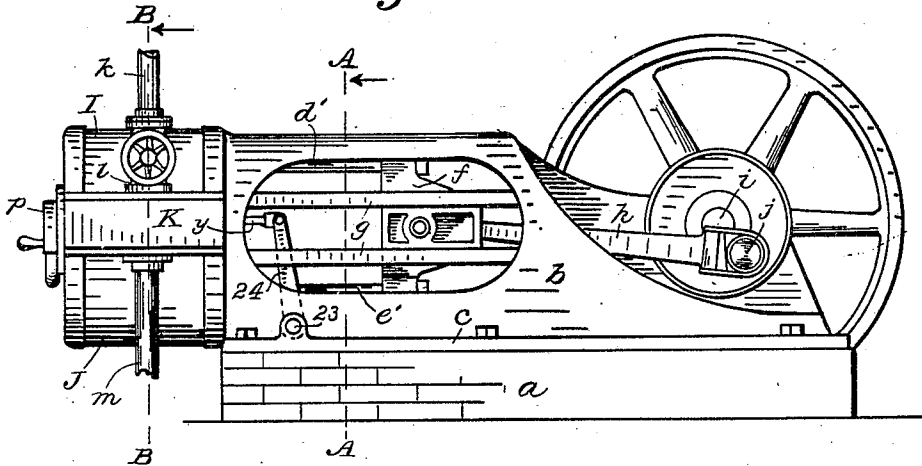


Fig. 2.

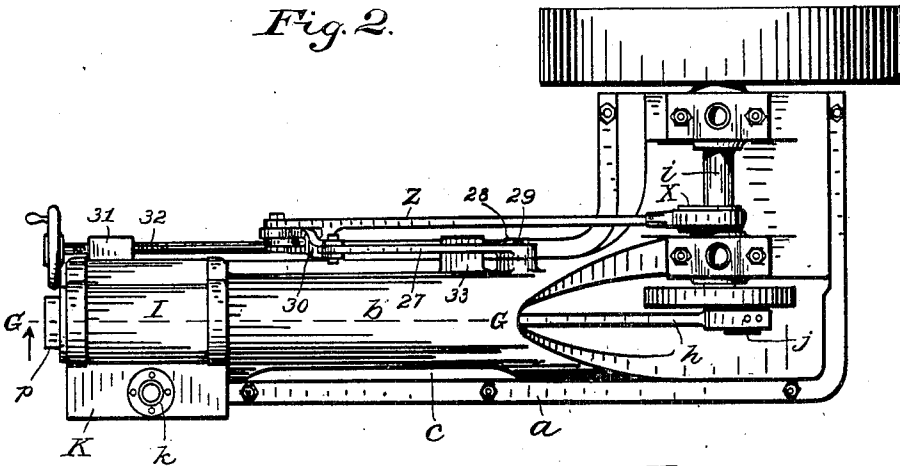


Fig. 3.

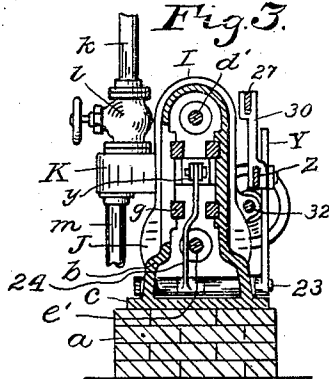
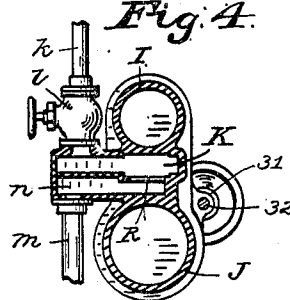


Fig. 4.



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Fig. 5.

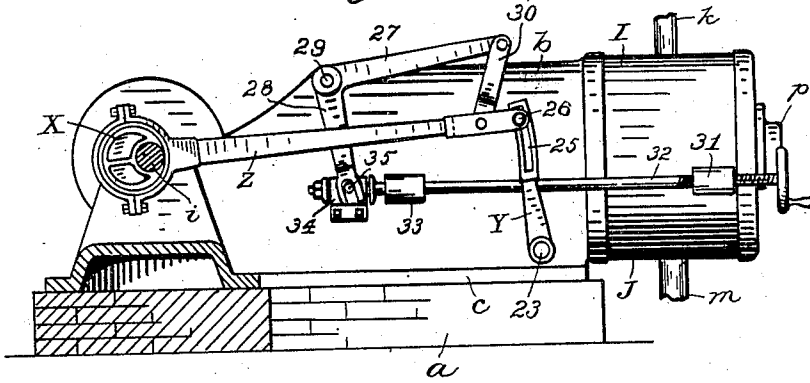


Fig. 7.

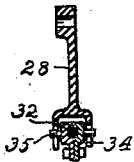


Fig. 6.

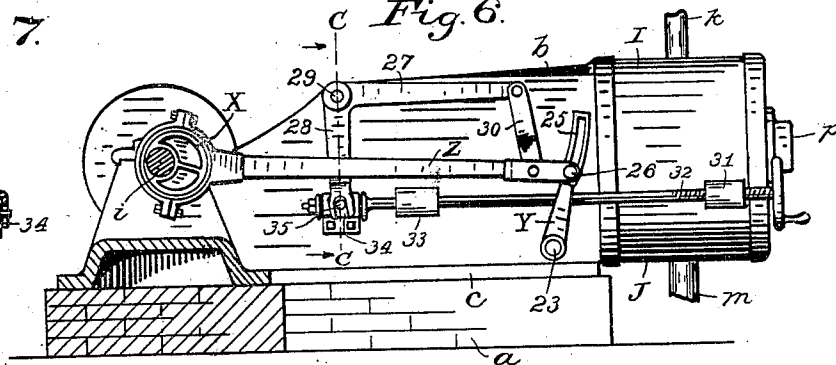


Fig. 8.

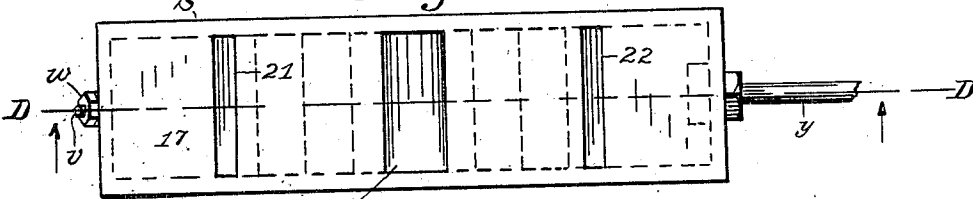


Fig. 9.

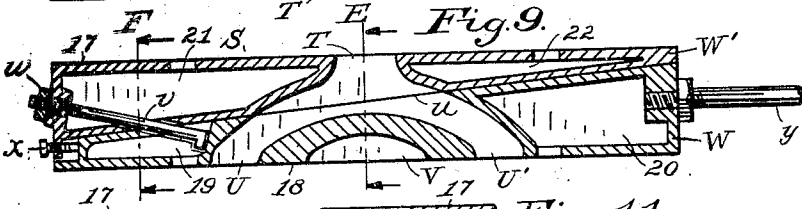


Fig. 10.

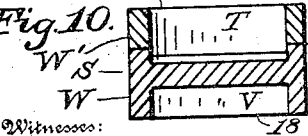
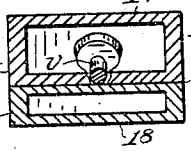


Fig. 11.



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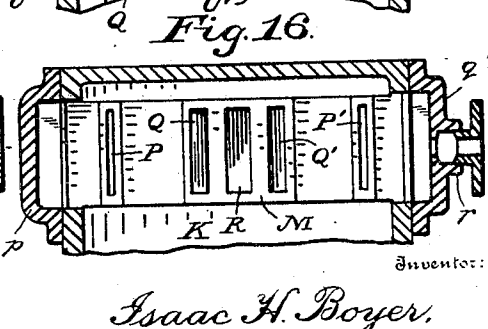
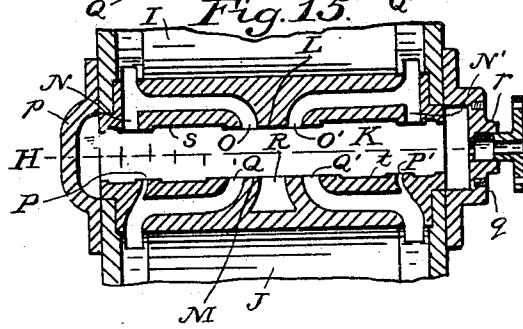
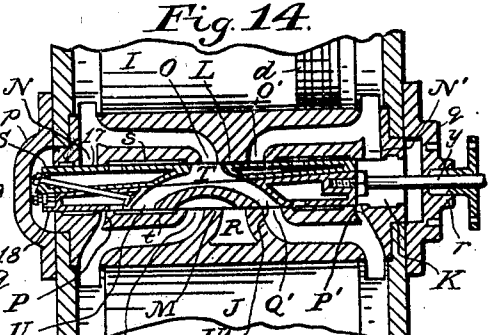
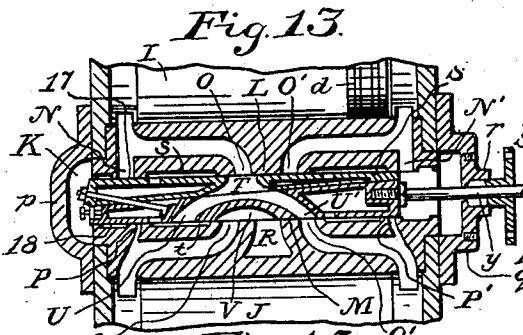
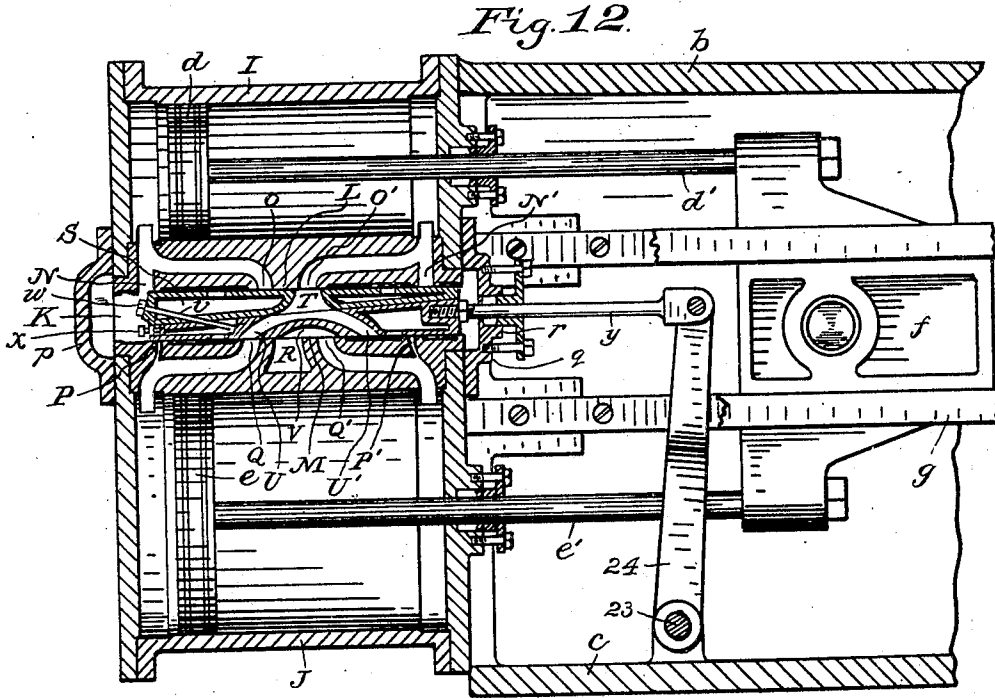
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# UNITED STATES PATENT OFFICE.

ISAAC H. BOYER, OF MUNCIE, INDIANA.

## COMPOUND ENGINE.

No. 837,785.

Specification of Letters Patent.

Patented Dec. 4, 1906.

Application filed January 9, 1906. Serial No. 295,214.

*To all whom it may concern:*

Be it known that I, ISAAC H. BOYER, a citizen of the United States, residing at Muncie, in the county of Delaware and State of Indiana, have invented new and useful Improvements in Compound Engines; and I do declare the following to be a full, clear, and exact description of the invention, reference being had to the accompanying drawings, and to the letters and figures of reference marked thereon, which form a part of this specification.

This invention relates to steam-engines, whether locomotive or stationary, of the compound type that may be operated at will partially with high-pressure steam in the low-pressure cylinder at the beginning of each stroke of the pistons, the invention having reference particularly to the steam-valve that controls the flow of steam into and out of the engine-cylinders to the valve-chamber and the steam-ports and to means for operating the valve.

Objects of the invention are to improve the construction of compound engines, particularly the main valves and appurtenances thereof, to the end that such engines may be simplified in detail and be rendered durable and economical in use; to provide a valve capable of controlling the flow of steam into and out of a high-pressure and a low-pressure cylinder working as a compound engine, and to also control the admission of high-pressure steam to the low-pressure cylinder for augmenting the power of the engine under abnormally heavy loads or for assisting in starting the engine before compounding occurs, another object being to provide simple means for operating the valve, so as to attain the above-mentioned results.

The hereinbefore-mentioned objects are attained in the present invention which consists in providing a compound engine with a single valve for a pair of cylinders capable of controlling all passages of steam into and out of both cylinders, a valve-chamber having ports connecting with the cylinders, the valve-chamber having opposing valve-seats with a novel arrangement of ports therein, and mechanism for operating the valve for compound operation capable of abnormally increasing the travel of the valve to admit high-pressure steam to the low-pressure cyl-

inder at pleasure; and the invention consists, further, in the novel valve and arrangement thereof and in the novel parts and the combinations and arrangements of parts as hereinafter particularly described, and referred to in the accompanying claims.

Referring to the drawings, Figure 1 is a side elevation of a stationary engine having the improvements embodied therein; Fig. 2, a top plan thereof; Fig. 3, a transverse sectional view on the line A A in Fig. 1; Fig. 4, a fragmentary transverse sectional view on the line B B in Fig. 1; Fig. 5, a side elevation of the main parts of the engine, a portion being in section, showing the valve-gear set for normal or compound operation; Fig. 6, a view similar to that in the preceding figure with the difference that the valve-gear is shifted for initial high-pressure admission as well as for compound operation; Fig. 7, a fragmentary transverse sectional view on the line C C in Fig. 6; Fig. 8, a top plan of the improved main or steam valve; Fig. 9, a vertical sectional view of the valve on the line D D in Fig. 8; Fig. 10, a transverse sectional view of the valve on the line E in Fig. 9; Fig. 11, a transverse sectional view of the valve on the line F in Fig. 9; Fig. 12, a fragmentary vertical longitudinal sectional view as on the line G G in Fig. 2; Figs. 13 and 14, fragmentary sectional views, also on the line G G, with the main valve in different positions; Fig. 15, a fragmentary sectional view similar to Figs. 13 and 14, except that the valve is omitted; and Fig. 16 a fragmentary horizontal sectional view as on the line H in Fig. 15, showing a plan of the valve-seat for the low-pressure cylinder.

Similar reference characters in the different figures of the drawings designate corresponding elements or features.

For the purposes of conveniently disclosing the invention a stationary type of engine is illustrated and the valve-chamber is arranged compactly between two cylinders; but it is to be understood that the invention is applicable to locomotives or to portable engines and that the valve-chamber and valve may be arranged in various positions convenient to the cylinders.

In the drawings, *a* designates a suitable foundation; *b*, an engine-frame having a base mounted on the foundation; *I*, a high-pres-

sure cylinder, and J a relatively larger low-pressure cylinder, both cylinders mounted on the engine-frame; *d*, the high-pressure piston and *d'* the piston-rod thereof; *e*, the low-pressure piston, and *e'* the piston-rod thereof; *f*, the cross-head attached to the piston-rods *d'* and *e'* and mounted in suitable guides, as *g*; *h*, the pitman or connecting-rod; *i*, the main shaft or axle of an engine; *j*, the crank-pin; *K*, the valve-chamber or steam-chest, in the present case arranged between the cylinders I and J and extending beyond the sides thereof; *k*, the steam-pipe with a throttle-valve *l* for admitting steam to the valve-chamber; *m*, the exhaust-pipe connecting with an exhaust-passage *n*. All of these features may be variously constructed, as may be desired, excepting the valve-chamber which may be otherwise arranged relatively to the cylinders, and will be further described.

In a practical embodiment of the invention the valve-chamber is formed with suitable walls and is preferably somewhat longer than the cylinders I and J, the ends of the valve-chamber being provided with removable heads *p* and *q*, the latter having a packing-box *r*. In the valve-chamber are two plane-faced valve-seats L and M, parallel one to the other.

The valve-seat L is associated with the high-pressure cylinder I, and two steam-ports N and N' extend from the face of the valve-seat to the cylinder I, one at either end thereof. Also two exhaust-ports O and O' extend from the middle portion of the face of the valve-seat L to the cylinder I, one port to either end of the cylinder and preferably by connecting with the steam-ports N and N', as indicated in Figs. 12 to 15. In the face of the valve-seat L are recesses *s* into which valve-oil may be introduced.

The valve-seat M is associated with the low-pressure cylinder J, and two relatively narrow auxiliary or high-pressure steam-ports P and P' extend from the face of the valve-seat to the cylinder J, one at either end thereof, two low-pressure steam-ports Q and Q' extending from the face of the middle portion of the valve-seat, one to the port P and the other one to the port P'. Also an exhaust-port R extends from the middle portion of the valve-seat M between the ports Q and Q' to the port *n* for the escape of the exhaust-steam from the low-pressure cylinder. Recesses *t* are formed in the valve-seat M to receive lubricating-oil. The ports P and P' are closer one to the other than are the ports N and N' and nearly opposite to them.

The main valve S that operates in connection with the valve-seats L and M is of the sliding-type, and it has two plane faces 17 and 18 parallel one to the other, the face 17 seating against the valve-seat L and the face 18

seating against the valve-seat M. The longitudinal dimension of the valve is such as to enable the valve to cover not only the ports P and P', but also the ports N and N' at one time and have a suitable amount of lap, and the high-pressure steam may be admitted to the ports past the ends of the valve when the latter is in operation. A crossover-port T extends from the middle of the face 17 of the valve into the body thereof, and two crossover-ports U and U' extend from different parts of the face 18 of the valve to the port T, so that when the valve moves the port T may permit the exhaust-steam (or low-pressure steam) from cylinder I to cross over either from the port O or the port O' to the low-pressure cylinder J, through either the ports U and Q or the ports U' and Q'. In the middle of the face 18 is an exhaust-cavity V to permit the exhaust-steam to pass from the cylinder J either through the port Q or the port Q' to the port R.

The main valve may be variously constructed so that both working faces thereof may operate close to their valve-seats, a simple form of two-part adjustable valve being herein illustrated, (see particularly Figs. 9, 10, and 11,) in which a main part W and a companion part W' are each of wedge form suitably held together, the joint *u* of the two parts being inclined to the working faces of the valve. A lug-bolt *v* and nut *w* connect the two parts and afford means for adjusting the parts so as to expand the valve, a stop-screw *x* being used to resist accidental expansion to an undesirable degree. Oil-cavities 19 and 20 are formed in the part W and similar cavities are formed in the part W', opening in the faces of the valve. A valve-stem *y* is attached to the part W of the valve and extends through the packing-box *r*.

In order to operate the valve S, various mechanisms may be provided, a simple form being herein shown as serving to illustrate the invention, in which an eccentric X, attached to the shaft *i*, is employed as a motive agent. A rock-shaft 23 is mounted in the engine-frame *b*, preferably near the base *c*, and a rocker-arm 24 is secured fixedly to the rock-shaft and pivoted to the valve-stem *y*. A rocker-arm Y is secured fixedly also to the rock-shaft and has a slot 25 therein whereby the eccentric-rod Z is connected movably to the rocker-arms by means of a link-die 26, the eccentric-rod being controlled and shifted laterally by a bell-crank having arms 27 and 28 and mounted on a pivot 29, that is supported by the frame *b*, there being a link 30 pivoted to the arm 27 and also to the rod Z. A head-block 31 is suitably supported and has a screw-rod 32 mounted therein that extends through a suitably-supported bearing 33 to the arm 28, to which the screw-rod is suitably con-

nected, as by a sleeve 34, having pivots 35  
 extending through slots in the arm 28, the  
 screw-rod having collars at opposite sides of  
 the sleeve, so that when the screw-rod ro-  
 tates it will move longitudinally and move  
 the arm 28, and therefore shift the rod Z  
 where it connects in the slot 25 either toward  
 or away from the shaft 23, thus enabling the  
 eccentric to move the valve-stem  $y$  with  
 more or less amount of travel, the travel of  
 the valve, therefore, being greatest when the  
 link-die 26 is nearer to the rock-shaft 23 and  
 normal when the link-die is farthest re-  
 moved from the rock-shaft. The mechan-  
 ism of course may be modified so that the  
 valve may be made to cut off steam at vari-  
 ous points of the piston-strokes, and various  
 other modifications may fairly be made with-  
 in the scope and intent of the invention.

In practical use steam should be admitted  
 to the valve-chamber K from a suitable  
 steam-plant. The relative arrangement of  
 the pistons, the crank-pin, the eccentric, and  
 the valve and the movements thereof in op-  
 eration being understood, it may be assumed  
 that the crank-pin has passed a dead-center  
 and stopped, as in Fig. 1, with the valve S in  
 the position shown in Fig. 14, the eccentric  
 X and rod Z being in the positions shown in  
 Fig. 6. Now the high-pressure steam may  
 enter the port N' to start the piston  $d$  and  
 also enter the port P' to the cylinder J and  
 also flow through the port Q, thence through  
 the cross-over ports U' and T and the port O  
 into the cylinder I to the opposite side of the  
 piston  $d$ . The steam acting on the rela-  
 tively large piston of the low-pressure cylin-  
 der J will start the engine, together with the  
 steam applied to the piston  $d$  through the  
 port N', the steam at the opposite side of the  
 piston  $d$  being of large volume and readily  
 compressible momentarily and serving as a  
 balance to prevent the live steam from acting  
 too suddenly upon the larger piston. After  
 a slight movement of the engine the valve  
 will promptly close the auxiliary port P' and  
 still leave the port N' open and also leave the  
 crossover-ports open, as in Fig. 13, and the  
 movement of the valve may be accelerated,  
 if desired, by operating the screw-rod 32 so  
 as to shift the rod Z to the opposite end of  
 the slot 25, as in Fig. 5, and compounding  
 will then begin, the steam exhausting from  
 the cylinder I through the port O into the  
 port P', the valve advancing and closing the  
 port N' at the predetermined point of cut-off  
 of the steam. With the pistons in the posi-  
 tions indicated in Fig. 12 the valve will ad-  
 mit steam into the port N and permit the  
 exhaust-steam to pass from the cylinder I  
 into the cylinder J to move the piston  $e$  to-  
 ward the opposite end of the cylinder than  
 that in which the piston is shown, and in  
 this figure it may be assumed that the valve

has already admitted high-pressure steam  
 into the auxiliary port P or is about to open  
 this port. When the rocker-arm Y is oper-  
 ated by the rod Z, as in Fig. 5, the valve will  
 travel sufficiently to open the ports N and N',  
 but not the auxiliary ports P and P', the en-  
 gine thus working as compound, and when  
 the rod Z is shifted so as to operate the rock-  
 er-arm Y, as in Fig. 6, the valve will have in-  
 creased length of travel and will therefore  
 open the auxiliary ports P and P', so that a  
 small quantity of high-pressure steam will be  
 admitted to the piston  $e$  at either beginning-  
 point of its stroke. Other movements of the  
 mechanism and results will be understood  
 from the foregoing description.

Having thus described the invention, what  
 is claimed as new is—

1. An engine including a plurality of steam-  
 cylinders having admission-ports and also  
 combined admission and outlet ports com-  
 municating with the ends thereof, coupled  
 pistons in the cylinders, and a movable valve  
 covering all of the admission-ports in mid-  
 position and having a crossover-port for the  
 passage of actuating fluid to the front of an  
 advancing piston while admitting fluid to the  
 rear of both advancing pistons.

2. An engine including a plurality of steam-  
 cylinders provided with a movable valve hav-  
 ing variable extent of travel, there being ini-  
 tial admission-ports and outlet-ports extend-  
 ing from the valve to the cylinders and cov-  
 ered by the valve in mid-position, means for  
 operating the valve normally to open and  
 close the admission-ports to one of the cylin-  
 ders only, and means for operating the valve  
 with augmented extent of travel of the valve  
 to open the initial admission-ports to an-  
 other one of the cylinders, there being ports  
 between the plurality of cylinders opened  
 and closed by the valve with either normal or  
 augmented travel.

3. An engine including a plurality of steam-  
 cylinders with pistons movable therein, a  
 valve-chamber having two opposing valve-  
 seats therein, one of the valve-seats hav-  
 ing two inlet-ports and two outlet-ports ex-  
 tending therefrom to one of the cylinders, and the  
 other one of the valve-seats having two com-  
 bined inlet and outlet ports and also two au-  
 xiliary inlet-ports extending therefrom to an-  
 other one of the cylinders, and having also an  
 exhaust-port extending from the valve-seat  
 exteriorly to the cylinders and the valve-  
 chamber, and a valve in the valve-chamber  
 movable against the two valve-seats pro-  
 vided with crossover-ports and controlling  
 the flow of steam through all of the ports to  
 and from the piston.

4. An engine including a plurality of steam-  
 cylinders with pistons movable therein, a  
 valve-chamber having two opposing valve-  
 seats therein, one of the valve-seats having

two exhaust-ports extending from the middle portion thereof to opposite ends of one of the cylinders and having also two inlet-ports extending from the end portions of the valve-seat to the ends of the cylinder, and the other one of the valve-seats having two combined inlet and exhaust ports extending from the middle portion thereof to opposite ends of another one of the cylinders, and a valve in the valve-chamber movable against the two valve-seats and having a single crossover-port in one side thereof for receiving exhaust-steam from either one of the exhaust-ports of one of the cylinders and having also two crossover-ports in the opposite side thereof communicating with the single crossover-port for conveying the exhaust-steam to either one of the combined inlet and exhaust ports of the other one of the cylinders, the valve controlling the admission of steam to the two inlet-ports.

5. An engine including a plurality of steam-cylinders with pistons movable therein, a valve-chamber between the cylinders having two opposing valve-seats therein, one of the valve-seats having two inlet-ports and also two exhaust-ports extending therefrom to one of the cylinders, and the other one of the valve-seats having two combined inlet and exhaust ports and two auxiliary inlet-ports extending therefrom to another one of the cylinders, and having also an exhaust-port between the two combined inlet and exhaust ports, and a valve in the valve-chamber movable against the two valve-seats provided with crossover-ports extending therethrough for conducting exhaust-steam from the exhaust-ports of one cylinder to the combined inlet and exhaust ports of another cylinder, and provided also with an exhaust-cavity for conducting exhaust-steam from either one of the combined inlet and exhaust ports to the exhaust-port, the valve normally controlling the admission of steam to the inlet-ports of one cylinder and provided with means for abnormally augmenting the travel thereof to admit steam from the valve-chamber into either one of the auxiliary inlet-ports of the other cylinder.

6. An engine including a high-pressure steam-cylinder, a relatively larger low-pressure steam-cylinder, a valve-chamber having therein a valve-seat for the high-pressure steam-cylinder and also a valve-seat for the low-pressure steam-cylinder, with inlet and outlet ports extending from the valve-seats to the cylinders, one of the valve-seats having two auxiliary inlet-ports extending therefrom to the low-pressure cylinder, a valve in the valve-chamber movable against both of the valve-seats and in mid-position extending over all of the ports of the two valve-seats, means for normally operating the valve so as to constantly close

the auxiliary inlet-ports and open or close the other ports for admitting high-pressure steam to the high-pressure steam-cylinder and conducting therefrom the exhaust-steam to the low-pressure steam-cylinder, the valve having crossover-ports therethrough for conveying the exhaust-steam and also having an exhaust-cavity for releasing the exhaust-steam from the low-pressure steam-cylinder, and means for varying the travel of the valve to open or close the auxiliary inlet-ports.

7. An engine including a plurality of steam-cylinders, a valve-chamber having two opposing plane-face valve-seats therein and ports extending from the valve-seats to the steam-cylinders, two of the ports being inlet-ports each extending from an end portion of one valve-seat to the corresponding end of one of the cylinders, and two of the ports being auxiliary inlet-ports each extending from an end portion of the opposing valve-seat to the corresponding end of another steam-cylinder and spaced apart farther than the two inlet-ports, there being also crossover and exhaust ports, a valve in the valve-chamber movable against the two valve-seats and having an exhaust-cavity and also crossover-ports therein, means for normally operating the valve for opening or closing the crossover and the exhaust ports and also the inlet-ports and preventing the opening of the auxiliary inlet-ports, and means for increasing the extent of the travel of the valve for opening or closing the auxiliary inlet-ports.

8. An engine including a pair of cylinders of different diameters, a valve-chamber having two opposing valve-seats therein provided with oil-recesses in the faces thereof, with ports extending from the valve-seats to the cylinders, and a valve in the valve-chamber having two plane faces parallel one to the other, one face movable against one of the valve-seats and the other face movable against the other one of the valve-seats, the valve having oil-cavities therein and provided with crossover-ports extending there-through for conducting steam from the smaller to the larger of the pair of cylinders through the ports that extend from the valve-seats to the cylinders.

9. An engine including a pair of cylinders of different diameters provided with a valve-chamber interposed between the two cylinders and having two opposing plane-face valve-seats therein, one for each cylinder, one valve-seat having two ports extending from the middle portion thereof to opposite ends of the smaller cylinder, and the other valve-seat having two ports extending from the middle portion thereof to the larger cylinder, each valve-seat having also two ports extending from the end portions thereof to

the respective cylinders, and a two-faced valve in the valve-chamber movable against the two valve-seats and having a single crossover-port extending from one of the faces thereof inwardly and two other crossover-ports extending from the other face thereof to the single crossover-port providing direct passages for steam from the smaller one to the larger one of the pair of

cylinders, the valve controlling the flow of steam through the ports that extend from the end portions of the valve-seats.

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

ISAAC H. BOYER.

Witnesses:

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E. T. SILVIUS.