(No Model.) 7 Sheets—Sheet 1.

J. PLAYER.

COMPOUND ENGINE.

No. 481,056. Patented Aug. 16, 1892.

FIG. 1.

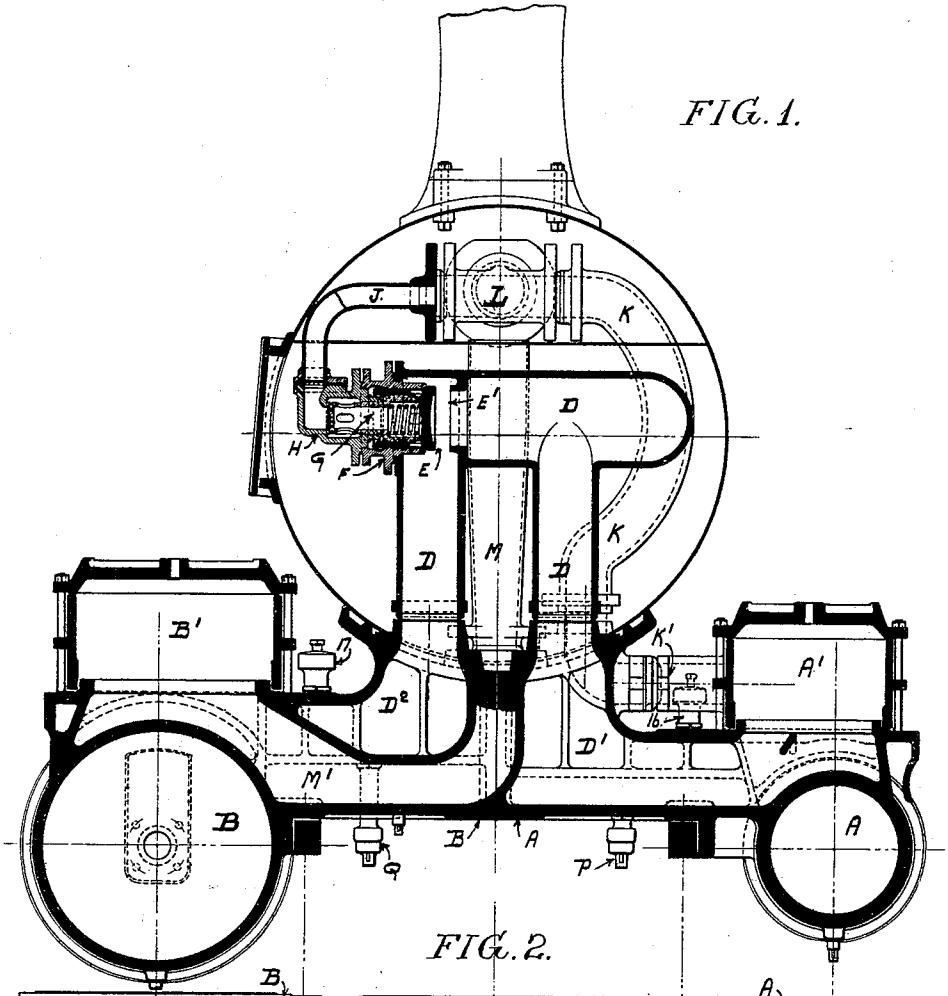

FIG. 2.

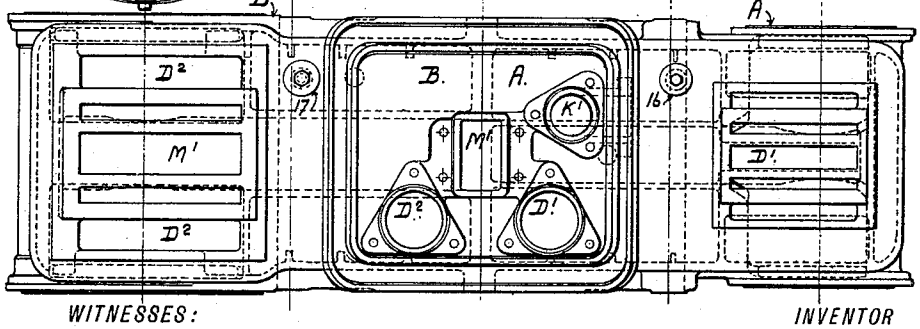

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FIG. 3.

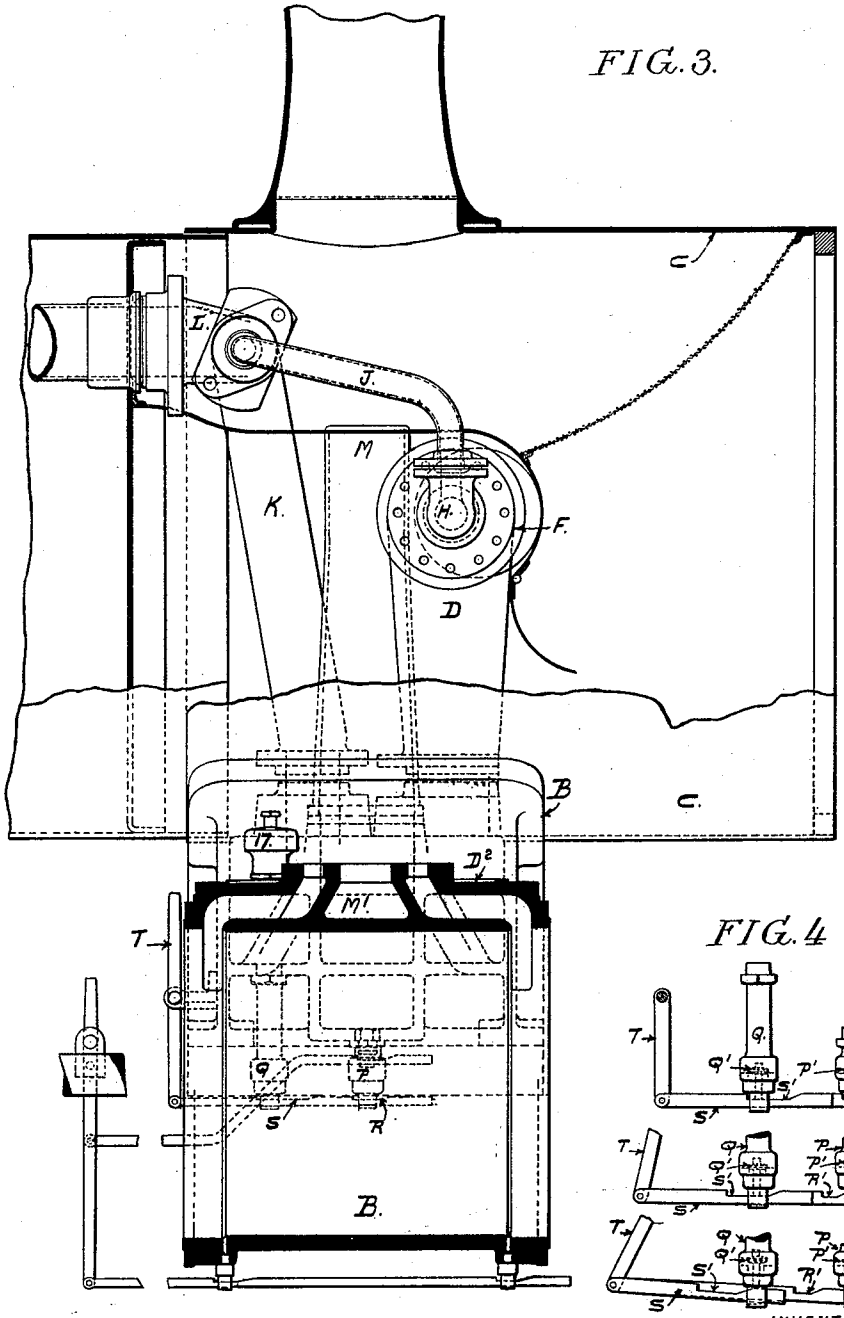

FIG. 4

FIG. 5

FIG. 6.

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FIG. 7.

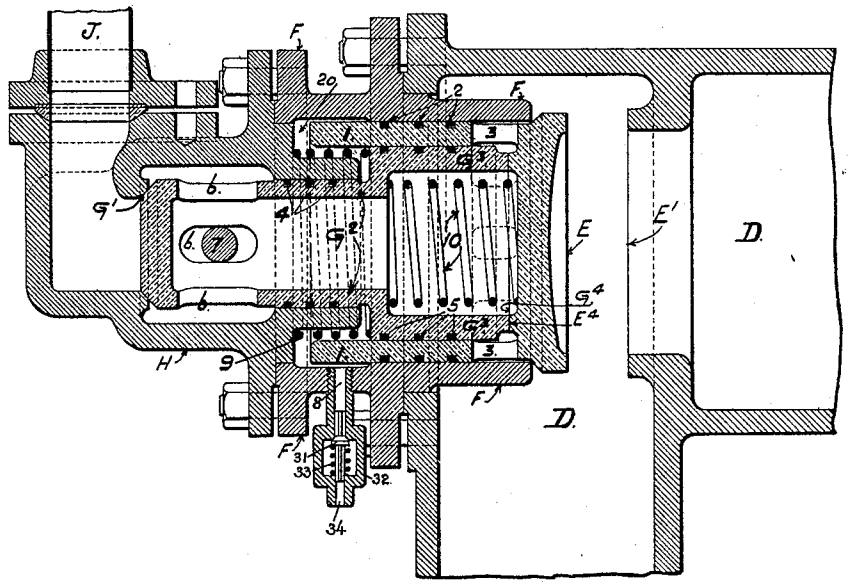
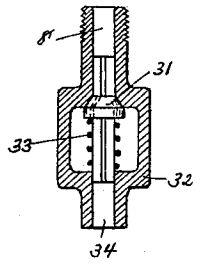


FIG. 17.



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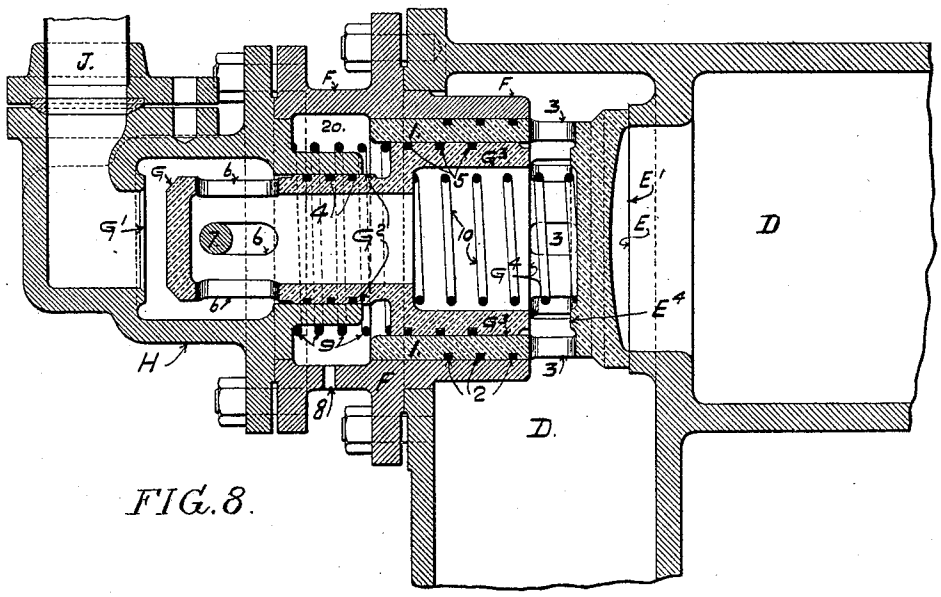

FIG. 8.

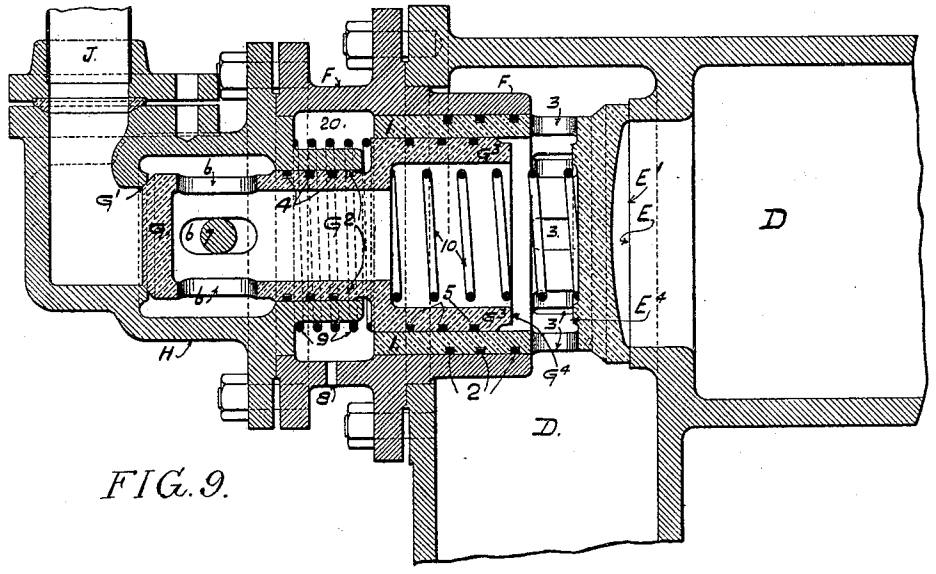

FIG. 9.

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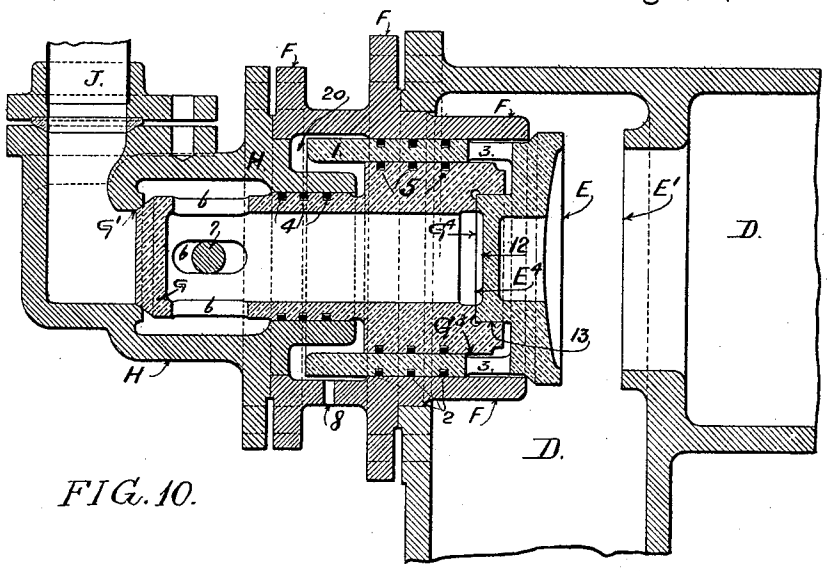

FIG. 10.

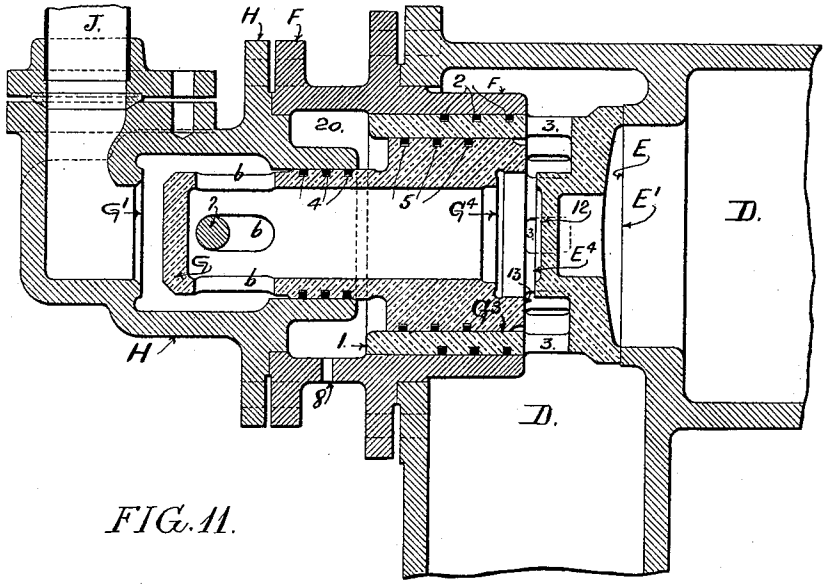

FIG. 11.

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FIG. 12.

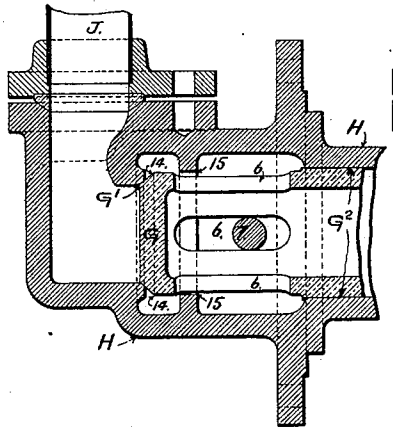

FIG. 13.

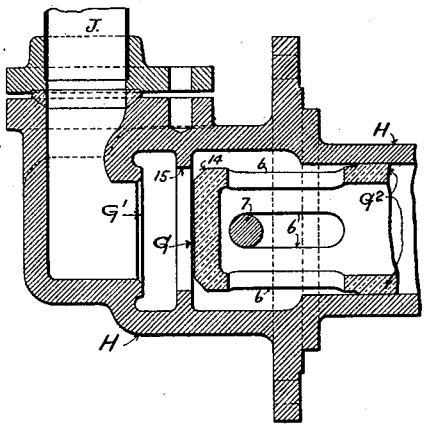

FIG. 14.

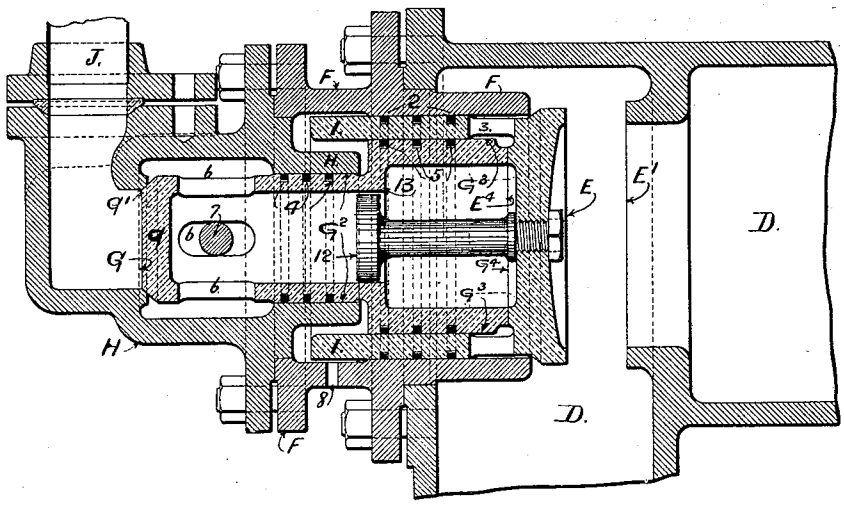

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FIG. 15.

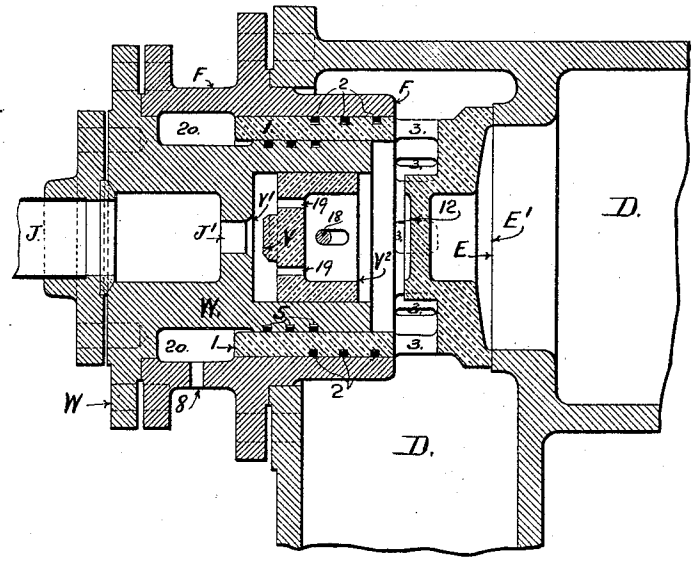
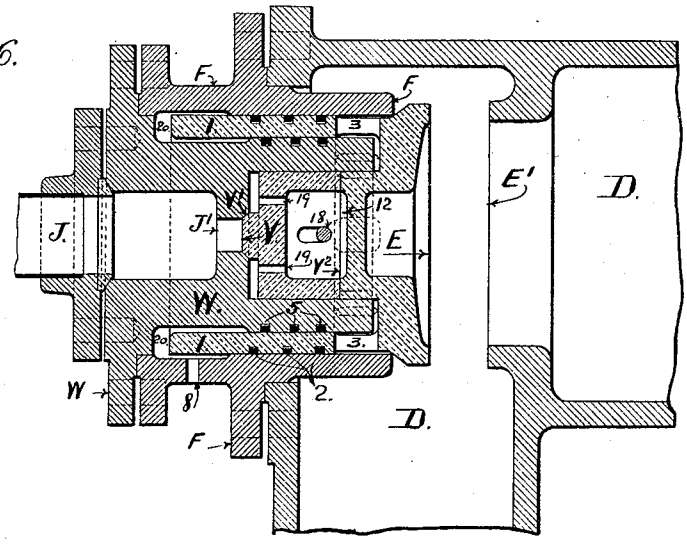


FIG. 16.



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UNITED STATES PATENT OFFICE.

JOHN PLAYER, OF DUNKIRK, NEW YORK, ASSIGNOR TO THE BROOKS LOCOMOTIVE WORKS, OF SAME PLACE.

COMPOUND ENGINE.

SPECIFICATION forming part of Letters Patent No. 481,056, dated August 16, 1892.

Application filed February 24, 1892. Serial No. 422,630. (No model.)

To all whom it may concern:

Be it known that I, JOHN PLAYER, a resident of Dunkirk, Chautauqua county, New York, have invented certain Improvements in Compound Engines, of which the following is a specification.

My invention relates to compound locomotives or other engines of that type in which for the purpose of obtaining full power at starting high-pressure steam is employed in both cylinders simultaneously, that portion which is admitted to the large or low-pressure cylinder being automatically reduced in pressure and controlled at such pressure that the mean effective pressure on both sides of the engine is equalized or regulated in any desired ratio.

The objects of my invention are, first, to automatically reduce the pressure of the live steam admitted to the large or low-pressure cylinder, so that the mean effective pressure on the large or low-pressure piston at starting may be equal to that on the small or high-pressure piston or be regulated in any desired ratio, and to automatically regulate this supply of live steam at reduced pressure to the low-pressure cylinder and to prevent this pressure from working against the back of the small or high-pressure piston; second, to automatically cut off the supply of live steam to the low-pressure cylinder at a period when the pressure in the high-pressure side of the receiver is the same as that on the low-pressure side and to simultaneously open connections between the two ends of the receiver, so that the exhaust-steam from the high-pressure cylinder may flow direct through the receiver into the low-pressure steam-chest and act upon the low-pressure piston; third, to provide means whereby the engine-man can at all times obtain complete control of the engine in the same manner as a simple engine when switching, running onto turn-tables, into engine-houses, and in all cases where it is necessary to move the engine only a short distance. These objects I attain in the following manner: First, by introducing into the receiver-pipe or steam-passage between the high and low pressure cylinders a combined admission, pressure-regulating, and intercepting-valve, which immediately upon opening the throttle-valve or regulator admits live steam at reduced pressure to the low-pressure cylinder, this pressure being regulated in such ratio as desired, the intercepting-valve at the same time automatically closing, preventing the live-steam pressure from working against the high-pressure piston, the reducing-valve remaining open until such time as the pressure in the receiver-pipe on the high-pressure side of the intercepting-valve becomes equal to or slightly in excess of that on the low-pressure side, when, secondly, the pressure-regulating valve automatically closes and the intercepting-valve opens simultaneously, the first cutting off the supply of live steam to the low-pressure cylinder and the second opening connection between the two ends of the receiver and allowing the high-pressure exhaust-steam to act directly on the low-pressure piston and at the same time locking the pressure-regulating valve upon its seat and preventing the further admission of live steam to the low-pressure cylinder. These valves remain in this position during the time the throttle-valve is open, but are automatically opened as soon as the steam is shut off, and remain so until the throttle is again opened, when the above-described operations are repeated.

The subject-matter is hereinafter specifically designated, and clearly set forth in the accompanying drawings, which show so much of a locomotive-engine embodying my improvements as is necessary to illustrate the subject-matter thereof. Some of these improvements may be used without the others and on machines differing somewhat in their details of construction from those herein shown, and they are equally as applicable to stationary and marine engines as to a locomotive.

Figure 1 is a transverse sectional view through the high and low pressure cylinders, steam-chests, smoke-box, receiver, intercepting-valve, and pressure-regulating valve, and connected parts, showing intercepting-valve located in the smoke-box. Fig. 2 is a plan view of the high and low pressure cylinders. Fig. 3 is a longitudinal sectional view taken partly through the low-pressure cylinder and through the smoke-box, showing the receiver-

pipe and intercepting-valve located therein. This view also shows the controlling-valves. Figs. 4, 5, and 6 show the controlling-valves in different positions. These valves are connected to a suitable lever in the cab. Figs. 7, 8, and 9 show the intercepting-valve and pressure-regulating valve in detail in different positions. Figs. 10 and 11 illustrate a modification of the combined valves. Figs. 12 and 13 show a modified form of pressure-regulating valve. Fig. 14 is a view showing another modification of the intercepting-valve and pressure-regulating valve. Figs. 15 and 16 show a form of intercepting-valve when used without the pressure-regulating valve. Fig. 17 is an enlarged view of the check-valve shown in Fig. 7.

Parts not specifically described herein are of ordinary and well-known construction.

Referring to Figs. 1, 2, and 3, A is the small or high-pressure cylinder and saddle, and B the large or low-pressure cylinder and saddle, of a compound engine, arranged on opposite sides of the locomotive and connected together in the manner as cylinders of single-expansion engines.

A′ and B′ are the steam-chests of the respective cylinders.

C is the smoke-box.

D is the receiver-pipe and superheater, located in the smoke-box and connected at one end to the exhaust-port of the high-pressure cylinder through the passage D′ and at the other end to the admission-ports of the low-pressure steam-chest through the passage D^2. These passages D′ and D^2 are purposely enlarged to the full area of each cylinder-saddle in order to obtain the greatest amount of receiver capacity possible.

E is the intercepting-valve. Its casing F in the present instance is located in the receiver-pipe D. The valve closes against a seat E′.

G is the pressure-regulating valve, and H is its casting. The valve G works within the intercepting-valve E.

J is the high-pressure steam-pipe, connecting with the T-head L, through which high-pressure steam is admitted to the pressure-regulating valve G.

K is the steam-pipe, connecting with the T-pipe L, through which steam is admitted to the high-pressure steam-chest A′.

M is the exhaust-pipe, connecting with the exhaust-passage M′ in the low-pressure cylinder-saddle.

Figs. 4, 5, and 6 show the controlling-valves, by the use of which the engine-man is enabled to control the movement of the engine the same as a single-expansion locomotive. These valves P′ and Q′ are ordinary flat valves working in their respective casings P and Q, operated by the slotted rods R and S, connected to a suitable lever in the cab by the lever T, and having the inclined slots R′ and S′, arranged as shown in the drawings. The valve P′ is attached to the bottom of the receiver D′ on the high-pressure side and the valve Q′ is attached to the bottom of the receiver D^2 on the low-pressure side of the intercepting-valve.

Figs. 7, 8, and 9 show an intercepting-valve E, with its seat E′ and casing F, which has working within it a pressure-regulating valve G in its casing or chamber H, to which is connected the high-pressure steam-pipe J. This intercepting-valve is shown of the disk type, with an annular projection 1, forming a balancing device fitted with packing-rings 2 and having slots or passages 3, through which the reduced high-pressure steam passes into the receiver on the low-pressure side. The pressure-regulating valve G is an ordinary-type plug-valve having hollow extensions G^2 and G^3, of different external areas, fitted with packing-rings 4 and 5, working in its chamber H and in the interior of the annular extension of the intercepting-valve, respectively. This valve is provided at its smaller extremity with passages 6, through which the high-pressure steam is admitted into the interior of the valve and allowed to operate on the large end G^3, thereby reducing the pressure in proportion to the area of the part G^3 to the part G^2. The large end of this valve is provided with a seat G^4, which when the intercepting-valve opens forms a steam-tight joint with the similar seat E^4 on the intercepting-valve, thereby allowing the whole area of the intercepting-valve to become operative upon the reducing-valve, keeping it closed when the pressure in the receiver D is considerably below the pressure which would be required to keep the reducing-valve closed on account of the difference in areas of the valve itself, or, in other words, the excess of area of the intercepting-valve is utilized to secure an increased difference in areas between the large and small ends of the reducing-valve, thus keeping it closed under a lower pressure than is necessary for starting the locomotive. The travel of the pressure-regulating valve is limited in any suitable manner, preferably by a stop-pin 7, which passes through a slot 6 in the valve, thereby preventing the pressure-regulating valve from having the full travel of the intercepting-valve and also preventing the pressure regulating valve from closing on the seat E^4 of the intercepting-valve when the intercepting-valve itself is closed, so that the full area of the passages 3 in the intercepting-valve E may be utilized for the passage of the reduced-pressure steam into the receiver on the low-pressure side. The intercepting-valve chamber F is provided with a leakage-hole 8, whereby the differential areas of the intercepting-valve and of the pressure-regulating valve may at all times be exposed to the atmosphere in order to secure their proper working. This leakage-hole may be provided with a check-valve 31, working in its casing 32 and held to its seat by the spring 33 and having an opening 34, connecting with the atmosphere, as shown

in Fig. 7. The casing is screwed into the leakage-hole 8 and is used to prevent the too-rapid closing of the intercepting-valve E when steam is admitted through the pressure-regulating valve G. It also serves to prevent the chattering of the intercepting-valve when running without steam. In Figs. 7, 8, and 9 the form of pressure-regulating valve shown is provided with a stiff spring 9 of known capacity, which operates against the large area of the valve and is intended to keep the valve G off its seat G′ at all times when the throttle is closed. The intercepting-valve E is also provided with a spring 10 of less capacity than the spring 9, which operates to keep the intercepting-valve E against its seat E′ at all times when the engine is at rest.

In Fig. 14 an intercepting and pressure-regulating valve of somewhat different form is shown, the chief difference being that the compression-springs described as used with the valves shown in Figs. 7, 8, and 9 are dispensed with, and in their place a plunger 12 is attached to the inside of the intercepting-valve and operates in the cavity 13 of the pressure regulating valve G. This plunger is of such area that when steam is admitted to the small end of the pressure-regulating valve G it opens the valve until it reaches the limit of travel against the stop 7, when the steam passes through the passage 6 into the cavity 13 and operates upon the plunger 12, attached to the intercepting-valve, thus causing the intercepting-valve to close against its seat E′, and also forms a cut-off edge, which renders the pressure-regulating valve more sensitive. The other portions of these valves and casings are similar to those described for the valves shown in Fig. 7.

Figs. 12 and 13 show a modification of the pressure-regulating valve G and of its seat G′. In this view the intercepting and pressure-regulating valves are of similar form to those elsewhere shown, with the exception that the small or cut-off end of the pressure-regulating valve is provided with an additional cut-off edge 14, working inside an extension of the seat G′, forming an external cut-off edge 15. These two edges cut off the supply of steam before the valve G reaches its seat G′, thus forming a dash-pot which prevents the too-rapid closing of this valve. When the dash-pot is used, it is necessary to increase the travel of the valve G an amount equivalent to the length of additional travel in the dash-pot.

Figs. 10 and 11 show another form of intercepting and pressure-regulating valve of the same general construction as those previously described, with the exception that the plunger 12 shown in Fig. 14, instead of being made separate and attached to the intercepting-valve, is cast solid with the valve itself. The end of this plunger 12 is provided with a seat E^4, which closes against the seat G^4 on the pressure-regulating valve G. The area of this seat, however, being less than the high-pressure area G^2 of the pressure-regulating valve, this area is reduced in order to compel the pressure-regulating valve to travel its full limit before the intercepting-valve closes, the projection 12 on the intercepting-valve forming a cut-off edge in the cavity 13 of the pressure-regulating valve G in a similar manner to that described for the valve shown in Fig. 14.

In Figs. 1, 2, and 3 are also shown the excess-pressure valves 16 and 17, located on the high and low-pressure sides of the receiver, respectively. These valves are used to prevent an excess pressure accumulating in either end of the receiver, which would be injurious to the working parts of the engine.

Figs. 15 and 16 show an intercepting-valve E, working in its casing F in a similar manner to those previously described, with the exception that this valve is arranged without any pressure-regulating valve, the high-pressure steam in this case, instead of being automatically reduced in pressure by the pressure-regulating valve G previously described, is throttled through a small opening J′, this opening being provided at its inner extremity with the valve-seat V′, against which the valve V is arranged to close, said valve being provided with a stop 18 to limit its travel and with suitable openings or steam-passages 19 to permit the escape of the throttle-steam into the receiver through the passages 3 in the annular balancing-ring 1 on the back of the intercepting-valve E, at the same time causing the intercepting-valve to close against its seal E′. The valve V works within its casing W, which is provided with packing-rings 4 and made in such a manner as to form the interior of the balancing-chamber 20 for the annular balancing-ring 1 of the intercepting-valve. This balancing-chamber is provided with a leakage-hole 8, connecting with the atmosphere in the same manner as previously described. The intercepting-valve E is provided with a projection 12, which is arranged to operate upon the extension V^2 of the admission-valve V, causing the same to close against its seat V′, thereby cutting off any further supply of live steam.

My improvements consist in the combination, with the high and low pressure cylinders of a compound locomotive or other engine and with the receiver pipe or passages, of a combined intercepting and pressure-regulating valve arranged as shown in the drawings and so proportioned that upon opening the throttle-valve live steam is admitted through the connecting-pipe to the pressure-regulating valve, causing the same to open. The steam then passes through the hollow extension of different external areas and causes the intercepting-valve to close. The steam then acts upon the enlarged end of the pressure-regulating valve, causing a reduction of pressure in proportion to the relative areas of the two ends. This reduced pressure fills the receiver pipe and passages on the low-pressure side of the intercepting-valve, also the low-pressure steam-chest, acting upon the

low-pressure piston as soon as the slide-valve opens the admission-ports, thus enabling the engine to start with the cranks in any position in a similar manner to a single-expansion engine. This flow of reduced-pressure steam is kept up until the pressure on the high-pressure side of the intercepting-valve becomes equal to or slightly in excess of the reduced live-steam pressure on the low-pressure side. The intercepting-valve then automatically opens connection between both ends of the receiver and seats itself on the enlarged end of the pressure-regulating valve, thus giving this valve an increase of area on its large end and causing it to remain seated against the full pressure of the live steam in the connecting-pipe at a considerable reduction of pressure in the receiver from the original pressure used in starting the locomotive. The intercepting-valve, however, contrary to the action of other intercepting-valves hitherto introduced, does not leave its seat at the first exhaust from the high-pressure cylinder, but remains seated until the pressure in both sides of the receiver is approximately equal, thus preventing any sudden reduction of pressure in the low-pressure cylinder and consequent loss of power.

My improvements in the intercepting-valve consist in the use of an annular balancing-ring attached to the back of the valve, working in the valve-casing, and forming a guide for the valve, this annular ring being provided with packing-rings and suitable openings for the exit of the reduced-pressure live steam which is allowed to pass through the pressure-regulating valve. The high-pressure end of the pressure-regulating valve is arranged to work within its own casing, while the low-pressure end of said valve works within the annular balancing-ring of the intercepting-valve. The cavity in the back end of the intercepting-valve chamber is provided with a leakage-hole, so that the balancing-areas of the intercepting-valve and pressure-regulating valve may at all times be subjected to atmospheric pressure, in order to secure their respective movements at the proper time, these two valves in combination forming a duplex pressure-regulating valve; or, in other words, the pressure-regulating valve is so proportioned as to admit live steam at the proper pressure for starting the locomotive, and the intercepting-valve is arranged to automatically lock the pressure-regulating valve against its seat during any further reduction of pressure, thus preventing any escape of live steam from the connecting-pipe into the receiver while the engine is working. The fact that the intercepting-valve is so proportioned as not to open connection between the two ends of the receiver until after the working pressure is established therein enables my improved locomotive to exert far greater power at starting than is possible with other forms of intercepting-valves. The leakage-hole in the intercepting-valve balancing-chamber may be provided with a check-valve, the object of which is to retard the motion of the intercepting-valve and prevent its slamming against its seat by forming a partial vacuum in the balancing-chamber. This vacuum is soon destroyed by the leakage of air past the packing-rings. This check-valve also serves to prevent the chattering of the intercepting-valve when running without steam caused by the intermittent pressure and vacuum in the receiver due to forcing air into the receiver by the high-pressure piston and exhausting it therefrom by the larger low-pressure piston. The check-valve retains a sufficient vacuum on the back of the valves to prevent them chattering. This check-valve may also be arranged with a minute leakage-groove, as shown by dotted lines in Fig. 17, to permit the admission of air slowly, in order to destroy the vacuum.

In order to give the engine-man full control over the operation of the locomotive at all times, especially when moving the engine a few feet in either direction, as is frequently necessary when running onto turn-tables, into engine-houses, and in coupling to cars, I provide what I term "controlling-valves." These valves, as previously described, are attached to the under side of the receiver, one on the high-pressure and the other on the low-pressure side of the intercepting-valve. They may, however, be attached to the receiver or passages in any other location desirable. It is, moreover, not necessary to use the valve on the low-pressure side, or they can both be omitted at discretion. These valves are connected to a suitable lever in the cab of the locomotive. The engine-man when desiring to move the locomotive a short distance moves this lever so as only to open the valve attached to the high-pressure side of the receiver. This valve is of sufficient area to allow the exhaust-steam from the high-pressure cylinder to pass out into the atmosphere instead of accumulating in the receiver and finally causing the intercepting-valve to open. While this valve remains open, the locomotive is operated as a single-expansion engine, the whole amount of steam used in the low-pressure cylinder being admitted through the pressure-regulating valve. When the engine-man wishes to stop the locomotive in any desired position without the use of brakes, he moves the controlling-valve lever into its farthest position. This causes the valve on the low-pressure side of the receiver to open as well and allows the escape of any steam collected therein after the throttle-valve has been closed, thus preventing any further movement of the low-pressure piston. These valves can also be used when starting to allow the escape of condensed steam from both sides of the receiver. The valves, being of the snifting type, allow the admission of air to the receiver, and subsequently to the low-pressure piston, when the engine is running with the throttle shut. This prevents the chattering of the

low-pressure slide-valve when running with steam shut off.

My improved locomotive operates as follows: When the engine comes to rest after running with the throttle shut, the intercepting-valve, unless provided with springs, will be found open and seated against the pressure-regulating valve, the pressure-regulating valve itself being closed, as shown in Fig. 7. When, however, the intercepting-valve is provided with springs, it will be found closed against its seat and the pressure-regulating valve will be open, as shown in Fig. 8. These springs are simply provided to quietly return the valves to this position, in order to prevent slamming when steam is admitted. In practice, however, it has been found that these springs are unnecessary, and in order to secure a more sensitive action of the pressure-regulating valve a cut-off plunger 12 is provided, working within the cut-off chamber 13 of the pressure-regulating valve. (See Fig. 14.) This keeps the pressure-regulating valve in a more accurate state of equilibrium during the admission of steam. When the throttle-valve is opened, live steam is admitted to the high-pressure steam-chest through the steam-pipe K and passages K′ and operates upon the high-pressure piston in the ordinary manner. At the same time steam is admitted to the high-pressure end of the pressure-regulating valve through the connecting-pipe J, causing the valve to open, and, passing through the slots 6 and thence through the hollow portion of the valve, causes the intercepting-valve to close against its seat, as shown in Fig. 8. This steam flows through the passages in the intercepting-valve into the low-pressure end of the receiver, and, acting upon the large end of the pressure-regulating valve, causes it to partially close as soon as the requisite pressure is obtained, and thereafter regulates the amount of steam admitted by the pressure-regulating valve, maintaining an even pressure in the receiver. The reduced-pressure steam thus admitted to the receiver acts upon the low-pressure piston in the ordinary manner. As soon, however, as the high-pressure cylinder has exhausted sufficient steam into the high-pressure end of the receiver to overbalance the intercepting-valve this valve opens automatically, at the same time locking the pressure-regulating valve against its seat. (See Fig. 9.) The exhaust-steam from the high-pressure cylinder flows through the receiver and acts directly upon the low-pressure piston, the pressure of this exhaust-steam, even when considerably reduced, being sufficient to keep the pressure-regulating valve closed through the action of the duplex valve at all times. As soon as the throttle-valve is closed the intercepting-valve and pressure-regulating valve assume the positions shown in Figs. 9, 14, and 16, allowing the passage of air, a portion of which is forced through the receiver by the high-pressure piston and the remainder induced through the controlling-valve on the under side of the high-pressure end of the receiver. These valves remain in this position until the throttle is again opened, when the above-described operations are repeated. It will thus readily be seen that with my improved combination live steam at a suitable working pressure is permitted to act upon the low-pressure piston at all times in starting and that steam at this pressure is maintained in the low-pressure side of the receiver and prevented from working against the high-pressure piston until such time as the high-pressure end of the receiver becomes charged with exhaust-steam from the high-pressure cylinder at approximately the same pressure, whereupon the intercepting-valve, acting in combination with the pressure-regulating valve, permanently cuts off any further supply of live steam to the low-pressure cylinder and permits the direct passage of the exhaust-steam from the high-pressure into the low-pressure cylinder. This combination also prevents the passage of live steam admitted through the pressure-regulating valve from passing into the high-pressure end of the receiver and thus acting upon the back of the high-pressure piston.

In the above description of my improvements I have only referred to a locomotive or other engine of the two-cylinder type. My improvements, however, are equally applicable to a locomotive or other engine having a greater number of high and low pressure cylinders, whether arranged parallel to one another or on the tandem principle. In case of a four-cylinder engine there can be employed two sets of intercepting and pressure-regulating valves, one set for each pair of cylinders, or the engine may be arranged so that only one set is required.

The above-described improvements are mainly intended to be applied to a compound engine of the receiver type and are equally applicable to triple or quadruple as well as double expansion engines.

I do not claim in this application the specific construction of the valves shown in Figs. 10, 11, and 14, as they are claimed in an application filed April 14, 1892, Serial No. 429,145, and I do not claim in this application the specific construction of valve shown in Figs. 15 and 16, as said valve is claimed in the application filed April 15, 1892, Serial No. 429,267.

I claim as my invention—

1. In a combined admission and intercepting valve for compound engines, the combination of a receiver-casing forming a communication between the high and the low pressure cylinders, an intercepting-valve therefor, a live-steam passage communicating with the low-pressure end of the receiver, and an admission-valve therefor capable of movement independently of the intercepting-valve, but arranged in such relation to the intercepting-valve that said admission-valve will be opened and the intercepting-valve will be closed by the live steam and the admission-valve will

be acted upon and closed by the intercepting-valve when the pressure against the latter has reached the proper point, substantially as described.

2. In a combined intercepting and reducing valve for compound engines, the combination of the two valves movable independently of each other as regards the closing of the intercepting-valve and the governing movement of the reducing-valve, but so combined that as the intercepting-valve is opened by the high-pressure exhaust-steam it will act upon and close the reducing-valve, substantially as specified.

3. The combination, with the receiver pipe or passages of a compound locomotive or other engine, of the intercepting-valve having an annular balancing device and steam-passages, and the intercepting-valve casing having its chamber connected to the atmosphere, and the pressure-regulating valve having an enlarged end and working within the annular part of the intercepting-valve and its small or high-pressure end working within its own casing, to which is attached the live-steam-pressure pipe, substantially as set forth.

4. In a combined intercepting and reducing valve for compound engines, the combination of the two valves movable independently of each other as regards the closing of the intercepting-valve and the governing movement of the reducing-valve, but so combined that the opening of the intercepting-valve causes the reducing-valve to close, and a stop for limiting the opening movement of the reducing-valve, substantially as specified.

5. The combination, in a compound engine, of the intercepting-valve and the reducing-valve working within said intercepting-valve, said intercepting-valve being of a greater area and having a greater stroke than the reducing-valve, whereby it allows the reducing-valve to have free movement when it (the intercepting-valve is closed) but will close the reducing-valve when it opens, substantially as set forth.

6. The combination of the high and low pressure cylinders, the passage from the high-pressure cylinder to the low-pressure cylinder, an intercepting-valve for closing said passage, a live-steam inlet to said passage, and a reducing-valve for controlling the flow of steam from said live-steam inlet, said reducing-valve being on a line with and acted upon by the intercepting-valve, the said reducing-valve having a limited movement from its seat independent of the intercepting-valve, substantially as described.

7. The combination, in a compound engine, of the passage from the high to the low pressure cylinder, a live-steam inlet, and a reducing-valve adapted to close said inlet, the back of said valve being greater in area than the face of the valve, with an intercepting-valve for closing the passage between the high and low pressure cylinders, said intercepting-valve acting upon the reducing-valve and having a greater area than said valve, whereby the reducing-valve is held closed by the reduced pressure in the passage, substantially as described.

8. The combination of the passages between the high and low pressure cylinders, the live-steam-inlet pipe to said passage, a reducing-valve adapted to close said pipe, the back of said valve being of greater area than its face, a stop to limit the outward movement of said valve, and an intercepting-valve adapted to close the passage between the high and low pressure cylinders and adapted to a projection on the reducing-valve, the movement of the intercepting-valve being greater than that of the reducing-valve, so that steam can pass around and through the reducing-valve and between it and the intercepting-valve, substantially as described.

9. The combination of the valve-casing, the reducing-valve adapted thereto, a spring acting to keep the reducing-valve off its seat, and an intercepting-valve also guided in the valve-casing, with a spring of less strength than the reducing-valve spring, said spring being situated between the back of the reducing-valve and the intercepting-valve, so that when the engine is at rest the intercepting-valve will close the passage between the high and low pressure cylinders and the reducing-valve will be opened to allow the live steam to act upon the low-pressure piston, substantially as described.

10. The combination, in a compound engine, of the high and low pressure cylinders, a passage between the two, an intercepting-valve for closing said passage, a live-steam inlet to the low-pressure valve-chest, a valve regulating the flow of steam through said inlet, and valves situated in the passage, one valve on each side of the intercepting-valve, with mechanism for operating said valves, substantially as described.

11. The combination of the high and low pressure cylinders, a passage between the two cylinders, an intercepting-valve in said passage, a controlled live-steam inlet to the low-pressure valve-chest, and valves in the passage, one on each side of the intercepting-valve, with mechanism for operating said valves, said mechanism being so arranged as to first open the valve on the high-pressure side and then open the valve on the low-pressure side, substantially as described.

12. The combination, with the receiver pipe or passages of a compound locomotive or other engine, of the pressure-regulating valve, the regulating-valve casing having its chamber connected to the atmosphere, the connecting-pipe, the regulating-valve stop limiting the travel of the valve, the steam-passages in said valve connecting with its hollow chamber, and the annular balancing device of the intercepting-valve working upon said pressure-regulating valve and equalized to the atmosphere, as and for the purpose set forth.

13. The combination, with the receiver-pipe

of a compound locomotive or other engine, of the pressure-regulating valve working within its chamber, regulated in travel by its stop, and working within the annular balancing device attached to the intercepting-valve, said pressure-regulating valve having a seat on its small end closing against the live-steam pressure, and another seat at its large end closing against the intercepting-valve, as and for the purpose set forth.

14. The combination, with the receiver-pipe or passages of a compound locomotive or other engine, of the live-steam pipe connecting with the pressure-regulating valve-casing, the regulating-valve casing, the regulating-valve, its seat, its stop, its hollow steam-passages, the intercepting-valve casing having its balancing-chamber connected to the atmosphere, and the intercepting-valve with its annular balancing device and steam-passages working outside the pressure-regulating valve and within its own casing and having one seat to close the opening in the receiver-pipe and another seat to close against the regulating-valve, with the spring for holding the regulating-valve off its seat and a spring of lighter capacity for closing the intercepting-valve against its seat, as and for the purpose set forth.

15. The combination, with the receiver pipe or passages of a compound locomotive or other engine, of the live-steam pipe connecting with the pressure-regulating-valve casing, the regulating-valve casing, the regulating-valve, its seat, its stop, its hollow steam-passages, the intercepting-valve casing having its balancing-chamber connected to the atmosphere, and the intercepting-valve with its annular balancing device and steam-passages working outside the pressure-regulating valve and within its own casing and having one seat to close the opening in the receiver-pipe and another seat to close against the regulating-valve, with the cut-off plunger attached to the intercepting-valve, working within the cut-off chamber in the regulating-valve, as and for the purpose set forth.

16. The combination, with the receiver pipe or passages of a compound locomotive or other engine, of the intercepting-valve having an annular balancing device and steam-passages and interior seat, with a pressure-regulating valve working within and seating itself against said valve at its larger extremity and having its smaller extremity seating itself in its casing against the high-pressure steam and its travel regulated by a stop, said high-pressure end of this valve working within a dash-pot, as and for the purpose set forth.

17. The combination, in a compound engine, of the valve-casing, a chamber for exhaust-steam from the high-pressure cylinder, a passage communicating with the said chamber and with the low-pressure steam-chest, a live-steam passage communicating with the valve-casing, and a reducing-valve and an intercepting-valve movable independently of each other as regards the closing of the intercepting-valve and the governing movement of the reducing-valve, the valves being automatically operated on starting by steam acting directly upon the reducing-valve to open the same and directly upon the intercepting-valve to close the same, substantially as specified.

18. The combination, with the receiver pipe or passages of a compound locomotive or other engine, of the controlling-valves attached to the receiver and operated by a suitable lever and so arranged that the steam collected in both the high and low pressure ends of the receiver may be permitted to escape independently or simultaneously when desired, as and for the purpose set forth.

19. The combination of an intercepting-valve and the casing forming an intercepting-valve balancing-chamber with a check-valve arranged to prevent or retard the admission of air to said chamber and at the same time allow it to exhaust freely and also permit any leakage to escape to the atmosphere, as and for the purpose set forth.

20. The combination, in a compound engine, of a valve-casing, a chamber for exhaust-steam from the high-pressure cylinder, a passage communicating with the said chamber and with the low-pressure steam-chest, a live-steam passage communicating with the valve-casing, and a reducing-valve and an intercepting-valve movable independently of each other as regards the closing of the intercepting-valve and governing the movement of the reducing-valve, the valves being automatically operated on starting by steam acting directly upon the reducing-valve, the said steam holding the intercepting-valve to its seat until the time when steam in the high-pressure chamber overcomes the pressure of the reduced steam in the low-pressure passage, when the intercepting-valve automatically opens and closes the live-steam passage, substantially as specified.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

JOHN PLAYER.

Witnesses:
EUGENE ELTERICH,
HENRY HOWSON.