F. E. NORTON.

CONTROLLING VALVE GEAR FOR COMPOUND ENGINES.

APPLICATION FILED JULY 29, 1909.

1,004,296. **Patented Sept. 26, 1911.**

2 SHEETS—SHEET 1.

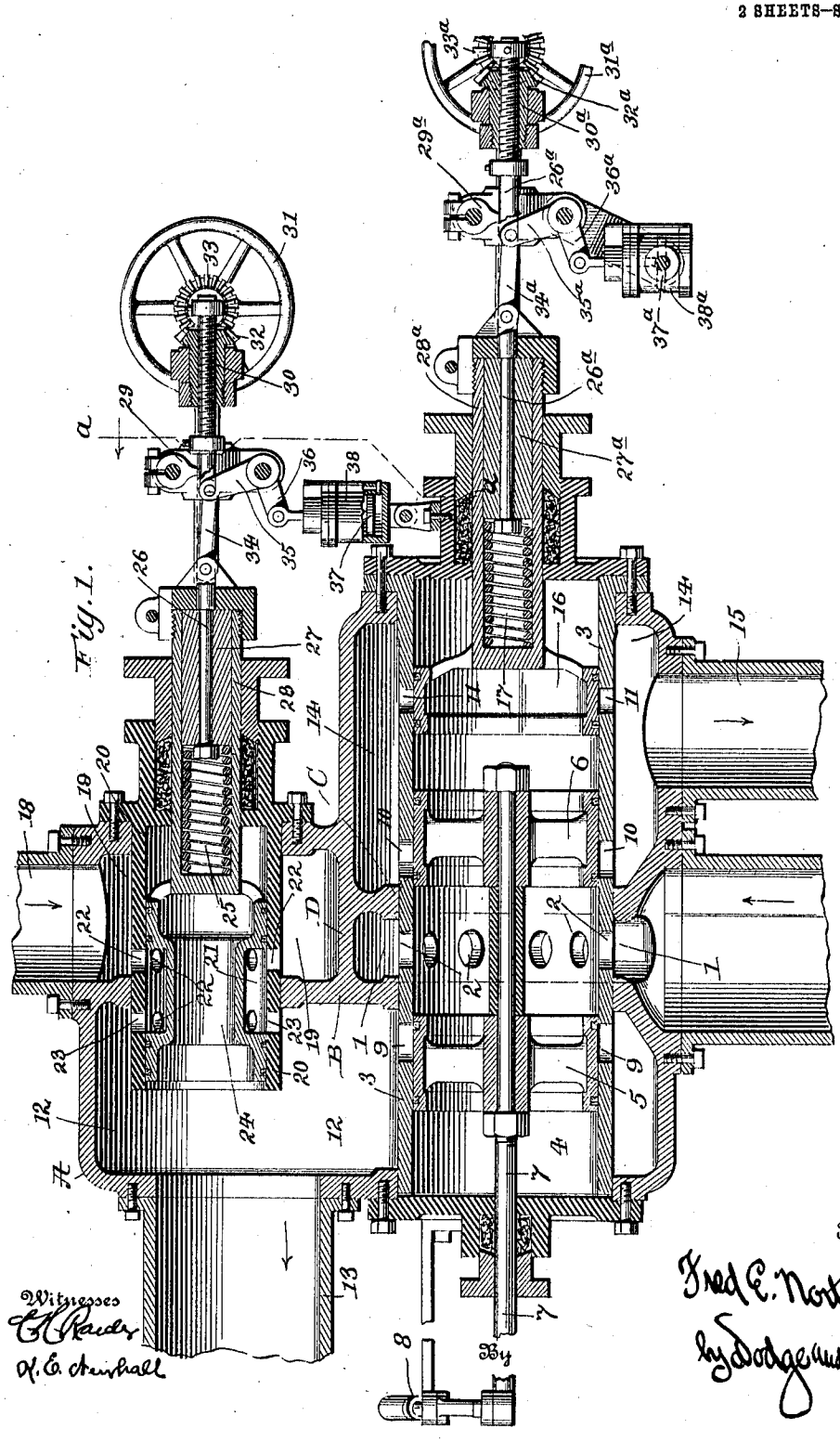

Fig. 1.

Witnesses
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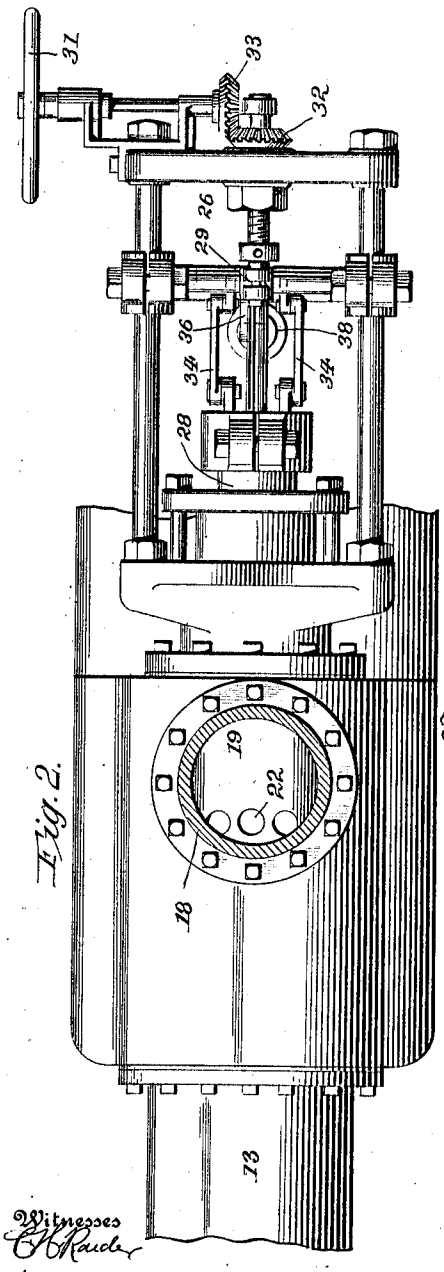

Fig. 2.

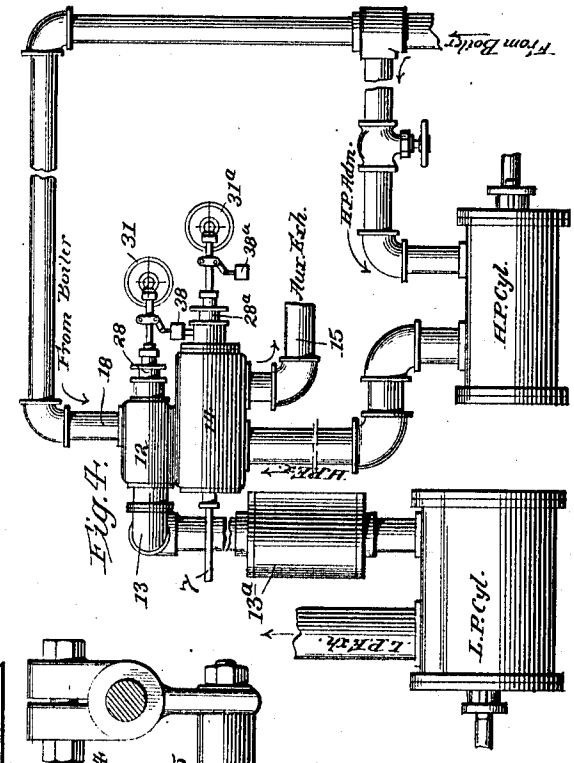

Fig. 4.

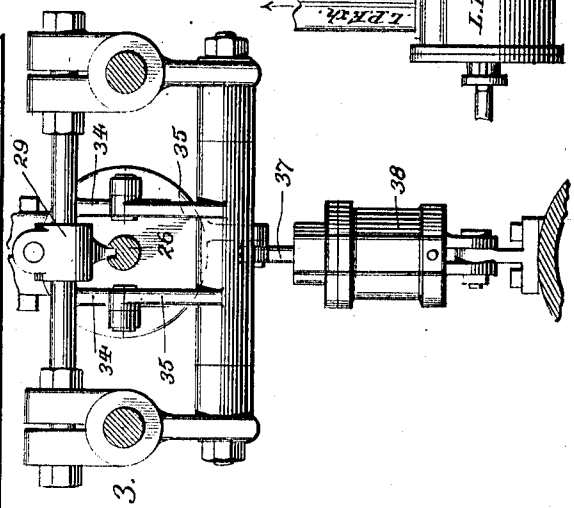

Fig. 3.

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UNITED STATES PATENT OFFICE.

FRED E. NORTON, OF YOUNGSTOWN, OHIO.

CONTROLLING-VALVE GEAR FOR COMPOUND ENGINES.

1,004,296. Specification of Letters Patent. Patented Sept. 26, 1911.

Application filed July 29, 1909. Serial No. 510,250.

To all whom it may concern:

Be it known that I, FRED E. NORTON, a citizen of the United States, residing at Youngstown, in the county of Mahoning and State of Ohio, have invented certain new and useful Improvements in Controlling-Valve Gears for Compound Engines, of which the following is a specification.

My invention relates to starting and controlling valve gears for compound engines, and is applicable more particularly to that type of compound engine in which the high pressure and low pressure units are complete and independent engines using the steam successively, there being no mechanical connection between their shafts, valve gears, or the like, so that each operates independently of the other, except in so far as their using the same steam may limit them. Such engines are in common use in the blowing plants of blast furnaces, each cylinder being provided with a separate piston, crank and fly-wheel, and each driving a separate blowing tub.

In the operation of blast furnaces, it is necessary frequently to slow down one or both engines, and often it is desirable to run the high pressure engine alone, or the low pressure alone, (using reduced pressure boiler steam). This result is customarily secured by placing throttle and stop valves in the piping between the high and low pressure cylinders, and providing a separate throttle and a pressure-reducing valve for admitting boiler steam at reduced pressure to the low pressure cylinder. A safety valve is placed on the receiver, or on the pipe between the high and low pressure cylinders, to allow the high pressure cylinder to exhaust outboard in case receiver pressure builds up too high. These valves are all separate, and all save the safety and reducing valves are manually operated. Properly manipulated and with due regard to sequence, they produce the desired results with fair success, but it is obvious that the opening or closing of the wrong valves, or the opening or closing of the right valves in the wrong sequence, may cause one or both of the engines to stop. Cessation of the blast, which would follow stoppage of both engines, is a serious matter in blast furnace operation, one of the consequent dangers being serious explosions of gases that work back into the blowing tubs from the furnace.

My invention, which I shall now proceed to describe, performs all the functions of the above-mentioned valves, many of them automatically; renders it impossible to start or stop both engines by the manipulation of a single valve, and makes it impossible for the accidental stoppage of one engine to cause stoppage of the other. In my description I explain the invention as applied to blowing engines, but do not mean to limit myself thereto, as it is obviously applicable, without change, to any type of disconnected compound engine, reciprocating or other; and whether it use steam or some other fluid medium capable of successive expansions. As will also appear, the apparatus is applicable to compound engines of the connected type, where it would serve as a starting gear, as a means for running the engine "simple" (*i. e.* both cylinders using the steam under single expansion), and as a means for controlling the receiver pressure; but it is in connection with compound engines of the disconnected type that the fullest benefits of the invention are realized, and with which I primarily design to use it.

Referring to the appended drawings: Figure 1 is a longitudinal sectional elevation of apparatus embodying my invention; Fig. 2 is a plan view of the upper portion of Fig. 1, the lower portion being cut away to avoid confusion of parts; Fig. 3 is a transverse sectional view on the line *a—a* Fig. 1, drawn on an enlarged scale; Fig. 4, a diagram of the engine cylinders, piping, etc.

The same numerals refer to the same parts throughout the drawings.

Referring to Fig. 1, it will be seen that my controlling valve gear, in the embodiment here shown, employs a casing or shell A, preferably of cast iron and having certain internal walls or partitions B, C and D, cast integral with it. Projecting into the interior of the shell A, and passing through and making tight fit with the partitions B and C, are two cylindrical shells 3 and 20, which are forced into place and further held by bolts, and which may be arranged with their axes parallel, as shown. It will be noted that I thus secure two cylindrical chambers 4 and 21, suitable to the reception of sliding valves, later to be described, a series of annular chambers 1, 12 and 14 surrounding the cylindrical chamber 4, and a series of annular chambers 12 and 19 surrounding the cylindrical chamber 21. It

will further be noted that communication is had from the cylindrical chambers 4 and 21 to their respective surrounding annular chambers by ports 2, 9, 10, 11 and 22, formed in the cylindrical shells, and that the end of chamber 21 opens directly into chamber 12. Pipe connections with the annular chambers, best seen in Fig. 4, are had as follows: Chamber 1 to the high pressure engine exhaust; chamber 12 to the low pressure engine admission; chamber 14 to atmosphere or condenser; chamber 19 to boiler.

Still referring particularly to Fig. 1, it will be seen that the annular chamber 1 connected by a suitable pipe to the exhaust side of the high pressure cylinder, communicates with the valve chamber 4 through ports 2, in the valve chamber walls 3. Spider frame valves 5 and 6 are slidable in the chamber 4 by means of the rod 7 to which they are rigidly attached by nuts and distance piece, as shown. The rod 7 may be moved longitudinally by the hand lever 8, so as to cover and uncover ports 9 and 10, the valves 5 and 6 being so positioned on the rod 7 that ports 2 are never covered by valve 5 or 6 within the limits of their travel; that both ports 9 and ports 10 are closed in their mid position; and that ports 9 are closed when ports 10 are open, and vice versa.

Ports 9 lead to chamber 12, whence communication is had through pipe 13 to the receiver 13^a, or to the admission side of the low pressure cylinder, if there be no receiver distinct from the pipe, which itself constitutes a receiver to the extent of its capacity. Ports 10 lead to annular chamber 14, whence communication is had through pipe 15 to the condenser or to the atmosphere, as preferred. This pipe 15 I shall hereafter call an "auxiliary exhaust connection." Additional ports 11 are located in the walls 3 beyond the travel of valve 6, and lead to chamber 14 which communicates by pipe 15 with the condenser or atmosphere. These ports 11 are normally closed by a valve 16 held in its closing position by a spring 17, and capable of being forced to an opening position against pressure or resistance of said spring by an excess of pressure in the chamber 4. The pressure in chamber 4, requisite to force the valve to said opening position, may be varied or determined by changing the compression of spring 17 in any suitable manner, but I prefer the one illustrated, and shall later describe it in detail.

The pipe 18 brings steam from the boiler, and communicates with the annular chamber 19 surrounding the shell 20 of the valve cylinder and communicating therewith by the ports 22. The valve cylinder further communicates, by means of ports 23, with the chamber 12 which is connected, as before stated, by pipe 13 to the receiver or admission side of the low pressure cylinder. Sliding in the valve cylinder 20 is the valve piston 24, normally held in its open position, as shown, by the spring 25, but capable of being forced to the right to a closing position by pressure in chamber 12 acting upon the end of plunger 28. Positive closure is also had by moving rod 26 to the right, through the engagement of abutment 27 with the end of plunger 28. In the open position steam passes from pipe 18 through chamber 19, through ports 22, along the contracted portion of the valve piston, and thence through ports 23 into chamber 12.

The pressure in chamber 12 which determines the opening and closing of valve 24 may be varied or determined by changing the compression of spring 25. This is accomplished in the same manner that changing of the compression of spring 17 is accomplished, and as the two mechanisms are identical in construction and operation, they will here be described simultaneously, like numerals indicating like parts in the two mechanisms, the letter "a" being appended to one set to distinguish it from the other.

Referring now to all three figures; the compression of spring 25 (17) is varied by the longitudinal movement of the rod 26 (26^a) carrying the abutment 27 (27^a), against which one end of the spring bears. This block and rod are capable of sliding within the plunger sleeve 28 (28^a) on the end of the valve 24 (16), in opposition to the spring's pressure. The rod 26 (26^a) is threaded at the outer end, and has near its middle a key-way engaged by a finger 29 (29^a) fixed on the frame, whereby the rod is prevented from rotating (see Fig. 3). On the end of the rod is a nut 30 (30^a) swiveled in a projection of the frame. The rotation of this nut by the hand-wheel 31 (31^a) through the gears 32 and 33 (32^a and 33^a), causes the rod 26 (26^a) to move longitudinally, thus varying the stress on the spring 25 (17) at the opening position of the valve 24 (16); or in other words, varying the position of the abutment against which the spring rests, and the compression necessary to permit the valve to move to opening position.

From an examination of the drawing it will be obvious that valve 24 serves a dual purpose. First it is an adjustable pressure reducing valve; and second it is a positively controlled throttle valve. When rod 26 is drawn to the extreme right the valve is positively closed. As the rod is moved to the left, the opening tendency is increased and the valve begins to act as a reducing valve, maintaining a very low pressure in chamber 12. As the rod 26 is forced further to the left the pressure maintained in 12 is increased. I shall use the term "combined

throttle and pressure reducing valve", to embrace any valve performing this dual function.

Sudden movements of the valve may be checked by the following mechanism: Links 34 (34ª) connect the plunger sleeve 28 (28ª) which is an extension of the valve piston, to one arm of a bell-crank lever 35 (35ª), to whose other arm 36 (36ª) is attached a piston 37 (37ª) working in a pivoted dash pot 38 (38ª). This provision is not essential to a satisfactory embodiment of my invention, but smoother action is secured by its use.

In order that the functions of the apparatus may be fully understood, I give below a few of the operations carried out. Others will readily suggest themselves to those familiar with engine handling.

Assuming both engines at rest, the high pressure engine may be started by opening the throttle on the steam pipe in the usual manner. The best position of valves 5 and 6 for this would be to the right, so as to open port 10 and give a free exhaust from the high pressure cylinder, but regardless of the position of valves 5 and 6 the high pressure engine will start, as valve 16 will open ports 11 under pressure in chamber 4, unless the low pressure engine starts and relieves this pressure. Assuming, however, that valves 5 and 6 are to the right, giving free exhaust through ports 10 and closing ports 9, the low pressure engine would next be started by manipulating valve 24 by means of handwheel 31 until open enough to start and run the low pressure engine on boiler steam from pipe 18. It will be noted that valve 24 will act as a pressure reducing valve, controlling the pressure in chamber 12 through the agency of said pressure's action on the end of plunger sleeve 28, and the opposition or resistance of spring 25 thereto. The conditions now are: Valves 5 and 6 to the right; ports 9 and 11 closed; ports 10 open; ports 23 open partially and variably, and maintaining approximately constant pressure in chamber 12; both engines running on boiler steam. It will be noted that in this condition the high pressure engine exhausts only against atmospheric or condenser pressure, and that the initial pressure in the low pressure engine may be varied within a considerable range. To compound the engines, spring 17 is adjusted to a pressure very slightly higher than the desired receiver pressure (an adjustment seldom requiring attention); then spring 25 is set so that valve 24 will open at a pressure very slightly below desired receiver pressure; lastly, valves 5 and 6 are moved to their extreme left positions by means of handle 8 acting on rod 7. The engines will now operate "compound". Conditions are now: Ports 9 open; ports 10 closed; ports 23 closed, but ready to open if pressure in chamber 12 falls; ports 11 closed but ready to open if pressure in chamber 4 rises. Hence if high pressure engine be accidentally stopped, valve 24 will open and supply steam to low pressure engine, so that it will continue to run. If low pressure engine be accidentally stopped, valve 16 will open ports 11, and allow high pressure engine to exhaust into pipe 15 so that it will continue to run. Normal method of stopping either engine: First convert to single expansion operation by moving valves 5 and 6 to the right; then to stop high pressure engine alone close throttle, or to stop low pressure engine alone, draw valve 24 to closed position by the action of wheel 31.

Besides ease of manipulation and freedom from accidental stoppage, there are other advantages accruing from the arrangement shown, but as these will readily occur to any one understanding the mechanism, it is needless to enumerate them.

It is obvious that the valve cylinders 3 and 20 might be cast integral with shell A, but it is more convenient and satisfactory to form them separately, and introduce them through the walls or partitions, as shown.

Having thus described the invention, what I claim is:—

1. The combination of a source of fluid under pressure; a high pressure cylinder; a low pressure cylinder adapted to receive fluid from the high pressure cylinder; connections between the source of fluid and the admission to the low pressure cylinder; a valve adapted to control the flow of fluid through said connections; a plunger subject to the pressure at the admission side of the low pressure cylinder and urging said valve to the closed position; a spring urging said valve to the open position; means for varying the stress on the spring; and a movable member operable from a point external to the device to engage said valve and force it to a closed position.

2. The combination of a source of fluid under pressure; a high pressure cylinder; a low pressure cylinder adapted to receive fluid from the high pressure cylinder; connections between the source of fluid and the admission to the low pressure cylinder; a valve adapted to control the flow of fluid through said connections; a plunger subject to the pressure at the admission side of the low pressure cylinder and urging said valve to the closed position; a spring urging said valve to the open position; and an abutment, movable in opposite directions from a point without the apparatus and adapted when moved in one direction to increase the stress on said spring and when in the opposite direction to reduce such stress and then engage said valve and move it toward closed position.

3. The combination of a source of expansible fluid under pressure; a high pressure cylinder; a low pressure cylinder; connections between the source of fluid and the admission to the low pressure cylinder; a valve controlling the flow of fluid through said connections and adapted to be urged to a closing position by the pressure of admission to the low pressure cylinder; a spring urging said valve to its open position; means for varying the stress on said spring; means movable from a point outside of the apparatus for engaging said valve and moving it positively to a closed position; an auxiliary exhaust connection; connected valves movable simultaneously to open communication alternately from the high pressure exhaust either to the low pressure admission or to the auxiliary connection; and a relief valve subject to the pressure of high pressure cylinder exhaust and adapted to open communication to said auxiliary exhaust connection.

4. The combination of a source of expansible fluid under pressure; a high pressure cylinder; a low pressure cylinder; connections between the source of fluid and the admission to the low pressure cylinder; a valve controlling the flow of fluid through said connections and adapted to be urged to a closing position by the pressure of admission to the low pressure cylinder; a spring urging said valve to its open position; means for varying the stress on said spring; means movable from a point outside of the apparatus for engaging said valve and moving it positively to a closed position; an auxiliary exhaust connection; connected valves movable simultaneously to open communication alternately from the high pressure exhaust either to the low pressure admission or to the auxiliary connection; a relief valve urged toward its opening position by the pressure of high pressure cylinder exhaust; a yielding support for said relief valve resisting such movement; and means for varying the resistance of said yielding support.

5. The combination of a source of expansible fluid under pressure; a high pressure cylinder; a receiver; a low pressure cylinder; connections between the source of fluid and the receiver; a valve controlling the passage of fluid through said connections and adapted to be urged to its closing position by the pressure in the receiver; a spring urging said valve to its open position; means operable from a point outside the apparatus for varying the stress on said spring; means operable from a point outside the apparatus for engaging said valve and moving it positively to a closed position; an auxiliary exhaust connection; connected valves movable simultaneously to open communication alternately from the high pressure exhaust either to the low pressure admission or to the auxiliary exhaust connection; a relief valve urged toward its open position by the pressure of high pressure exhaust; a yielding support for said valve; and means operable from a point without the apparatus for adjusting the resistance of said yielding support.

6. In combination with a high pressure cylinder, a low pressure cylinder, and a source of expansible fluid under pressure; a combined throttle and pressure-reducing valve located between the source of fluid under pressure and the admission to the low pressure cylinder and comprising a shell having chambers 12 and 19; a tubular valve shell 20 provided with ports 22 and 23 leading to the chambers 19 and 12 respectively; a valve 24 slidable in said shell and having a reduced portion between its ends of a length sufficient to bridge the ports 22 and 23; a hollow plunger 28 connected to said valve and moved by pressure in chamber 12; a spring 25 located in said hollow plunger and resisting said movement; and a movable abutment 27 acting as a support for said spring when moved in one direction and engaging with and serving to move the tubular plunger positively when moved in the opposite direction.

7. In combination with a high pressure cylinder, a low pressure cylinder, and a source of expansible fluid under pressure; a combined throttle and pressure-reducing valve located between the source of fluid under pressure and the admission to the low pressure cylinder and comprising a shell having chambers 12 and 19; a tubular valve shell 20 provided with ports 22 and 23 leading to the chambers 19 and 12 respectively; a valve 24 sliding in said shell and having a reduced portion between its ends of a length sufficient to bridge the ports 22 and 23; a hollow plunger 28 connected to said valve and moved by pressure in chamber 12; a spring 25 located in said hollow plunger and resisting said movement; a movable abutment 27 acting as a support for said spring when moved in one direction and engaging with and serving to move the tubular plunger positively when moved in the opposite direction; a retarding device adapted to check sudden movements; and mechanical connection between said device and plunger 28.

8. In an apparatus for starting and controlling compound engines, in combination with a high pressure and a low pressure cylinder, and a source of expansible fluid under pressure; a relief valve subject to the pressure of the exhaust from the high pressure cylinder and normally closing ports opening to the atmosphere, said valve comprising a shell 3 having ports 11; a spider-form valve 16 movable over said ports and having a tubular plunger 28[a]; a spring 17 located

within said tubular plunger; an abutment 27^a located within said neck and forming an abutment for the spring 17; a rod 26^a connected with said abutment and having a threaded portion; a swiveled nut 30^a encircling said threaded portion and provided with a pinion 32^a; a second pinion 33^a meshing with the pinion 32^a; and a hand-wheel 31^a connected with and serving to rotate the pinion 33^a.

9. In an apparatus for starting and controlling compound engines, in combination with a high pressure and a low pressure cylinder, and a source of expansible fluid under pressure; a relief valve subject to the pressure of the exhaust from the high pressure cylinder and normally closing ports opening to the atmosphere, said valve comprising a shell 3 having ports 11, a spider-form valve 16 movable over said ports and having a tubular plunger 28^a, a spring 17 located within said tubular plunger, an abutment 27^a located within said plunger and forming an abutment for the spring 17, a rod 26^a connected with said abutment and having a threaded portion, a swiveled nut 30^a encircling said threaded portion and provided with a pinion 32^a, a second pinion 33^a meshing with the pinion 32^a, a hand-wheel 31^a connected with and serving to rotate the pinion 33^a, a retarding device adapted to check sudden movements, and mechanical connection between said device and the plunger 28^a.

10. The herein described starting and controlling apparatus for compound engines, comprising in combination a shell or casing having chambers 12, 19, 1 and 14, said chamber 19 having an inlet for live steam, chamber 12 having an outlet for the passage of steam to the receiver and low pressure cylinder, chamber 1 having an inlet for exhaust steam from the high pressure cylinder, and chamber 14 having an auxiliary exhaust outlet; a valve shell 20 extending from chamber 19 into chamber 12 and having an open end in the latter chamber and ports 22 and 23 opening into the respective chambers 19 and 12; a valve shell 3 passing through chambers 12, 1 and 14 and having ports 9 and 2 in chambers 12 and 1 respectively, and two sets of ports 10 and 11 in chamber 14; a valve 24 movable within shell 20 and adapted to close port 23, and having an intermediate reduced portion forming a connecting passage between ports 22 and 23, said valve being exposed at its end to the pressure in chamber 12; means for adjusting valve 24 with reference to said ports; a yielding support for said valve between the valve and its actuating rod; connected valves 5 and 6 movable within shell 3 and adapted to close ports 9 and 10 simultaneously and to open either of said ports and close the other; means for moving said valve; a valve 16 adapted to open and close ports 11 under variation of pressure in chamber 4; and a yielding support for said valve between the valve and its actuating rod.

11. In controlling mechanism for compound engines, a combined throttle and pressure-reducing valve comprising in combination a valve chamber; a valve seat in said chamber; suitable ports in said seat; a valve member moving on said seat; a plunger mechanism adapted to move the valve under pressure in the chamber to which fluid is delivered; a movable abutment; connections for moving said abutment from a point outside the apparatus; a spring interposed between said abutment and said valve member and opposing the motion imparted by said plunger mechanism; and a member connected to said valve and engaged by said abutment so that the abutment may impart positive motion to the valve in a direction coincident with that imparted by said plunger mechanism.

12. In controlling mechanisms for compound engines, a combined throttle and pressure-reducing valve comprising in combination a valve chamber; a valve seat in said chamber; suitable ports in said seat; a valve member moving on said seat; a plunger mechanism adapted to move the valve under pressure in the chamber to which fluid is delivered; a movable abutment; connections for moving said abutment from a point outside the apparatus; a spring interposed between said abutment and said valve member and opposing the motion imparted by said plunger mechanism; and a member connected to said valve and engaged by said abutment so that the abutment may impart positive motion to the valve in a direction coincident with that imparted by said plunger mechanism; a retarding device to oppose sudden movement; and mechanical connection between said device and the valve member.

13. A controlling valve gear for compound engines of the disconnected type, comprising in combination, a converting-valve chamber; an auxiliary exhaust connection; a valve seat in said chamber; ports in said seat connected to the high pressure exhaust, low pressure admission and the auxiliary exhaust connection respectively; a valve movable in said chamber, adapted to connect the high pressure exhaust either to the low pressure admission or to the auxiliary exhaust; mechanical means for moving said valve; a second valve seat in said converting-valve chamber; ports in said second valve seat, leading to the auxiliary exhaust; a valve on said second valve seat adapted to be moved by pressure in said valve chamber so as to uncover said ports; a spring normally holding said valve in its closed position; means for adjusting said

spring; a second valve chamber; a valve seat in said chamber; ports in said seat connected to the boiler and to the receiver; a valve moving on said seat and adapted to open and close communication between said ports; a plunger mechanism tending to move said valve to the closed position under pressure in the receiver; a spring opposing said motion; and means for manually adjusting the spring.

14. A controlling gear for compound engines of the disconnected type comprising in combination, a converting-valve chamber; an auxiliary exhaust connection; a valve seat in said converting-valve chamber; ports in said seat connected to the high pressure exhaust, low pressure admission and the auxiliary connection respectively; a valve movable in said chamber, adapted to connect the high pressure exhaust either to the low pressure admission or to the auxiliary exhaust; mechanical means for moving said valve; a second valve seat; ports in said second seat leading to the auxiliary exhaust; a valve on said seat adapted to be moved by pressure of the high pressure engine exhaust so as to uncover said ports; a spring normally holding said valve in its closed position; means for adjusting said spring; a second valve chamber; a valve seat in said second chamber; ports in said seat connected to the boiler and to the receiver; a valve on said seat adapted to open and close communication between said ports; a plunger mechanism tending to move said valve to a closed position under pressure in the receiver; a spring opposing said motion; and means for manually adjusting the spring.

15. The combination of a source of expansible fluid under pressure; a high pressure cylinder; a low pressure cylinder; connections between the source of fluid and the admission to the low pressure cylinder; a valve controlling the flow of fluid through said connections and adapted to be urged to closing position by the pressure of low pressure admission; a spring urging said valve to its open position; an abutment movable in opposite directions from a point outside the apparatus, and adapted when moved in one direction to increase the stress on the spring and when in the opposite direction to decrease said stress and then engage and move the valve toward closed position; an auxiliary exhaust connection; connected valves movable simultaneously to open communication alternately from the high pressure exhaust either to the low pressure admission or to the auxiliary exhaust connection; and a relief valve opening under high pressure exhaust pressure and giving connection to the auxiliary exhaust connection.

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

FRED E. NORTON.

Witnesses:
J. H. LONG,
DAVID THOMAS, Jr.