(No Model.) 2 Sheets—Sheet 1.

A. BALL.

STEAM ENGINE.

No. 426,612. Patented Apr. 29, 1890.

Fig. 1.

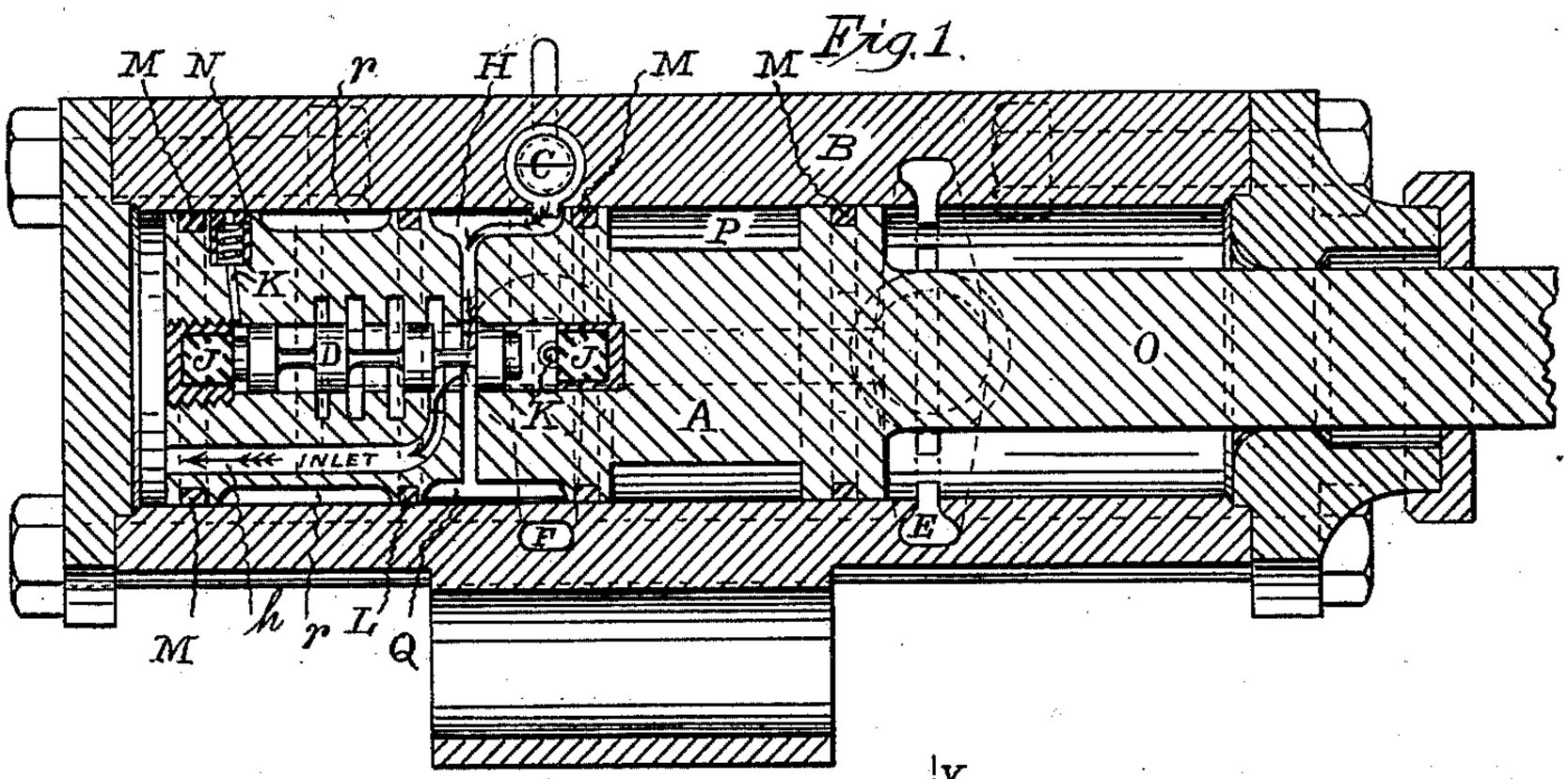


Fig. 2.

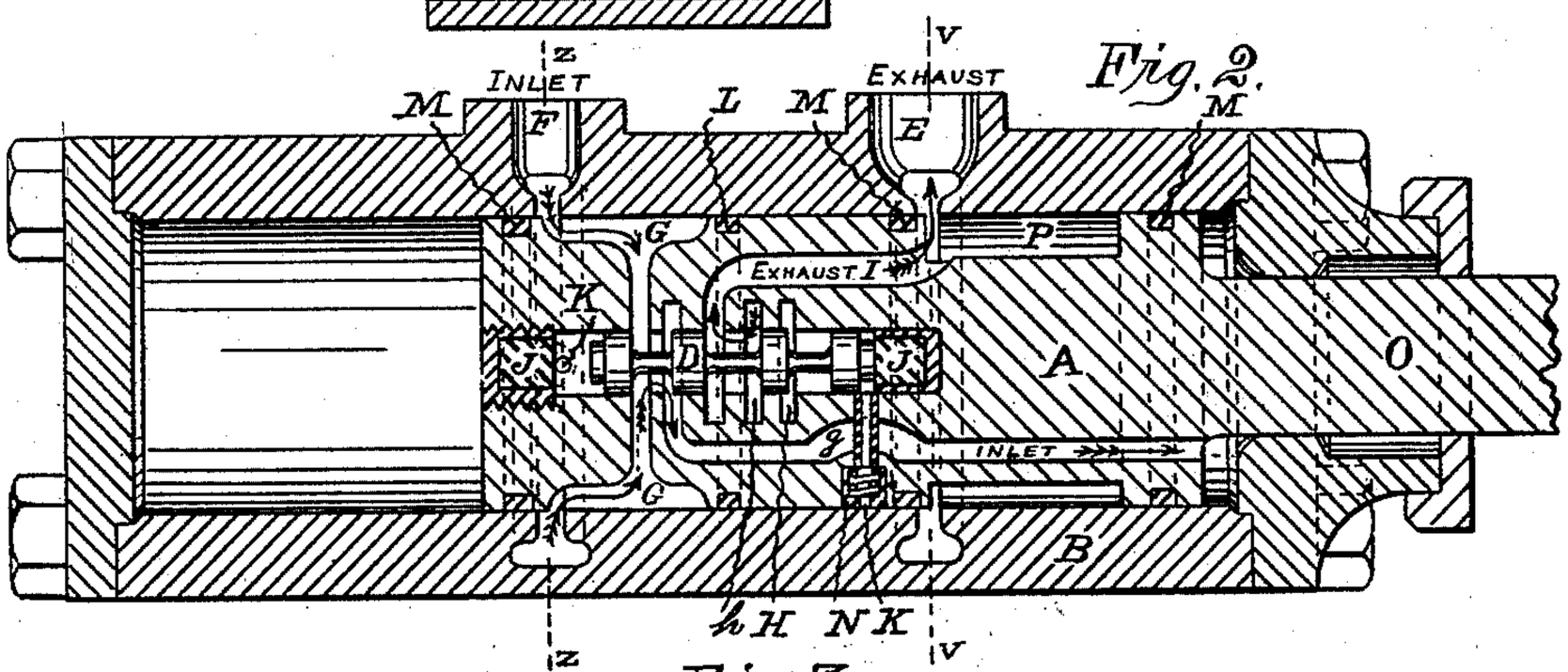
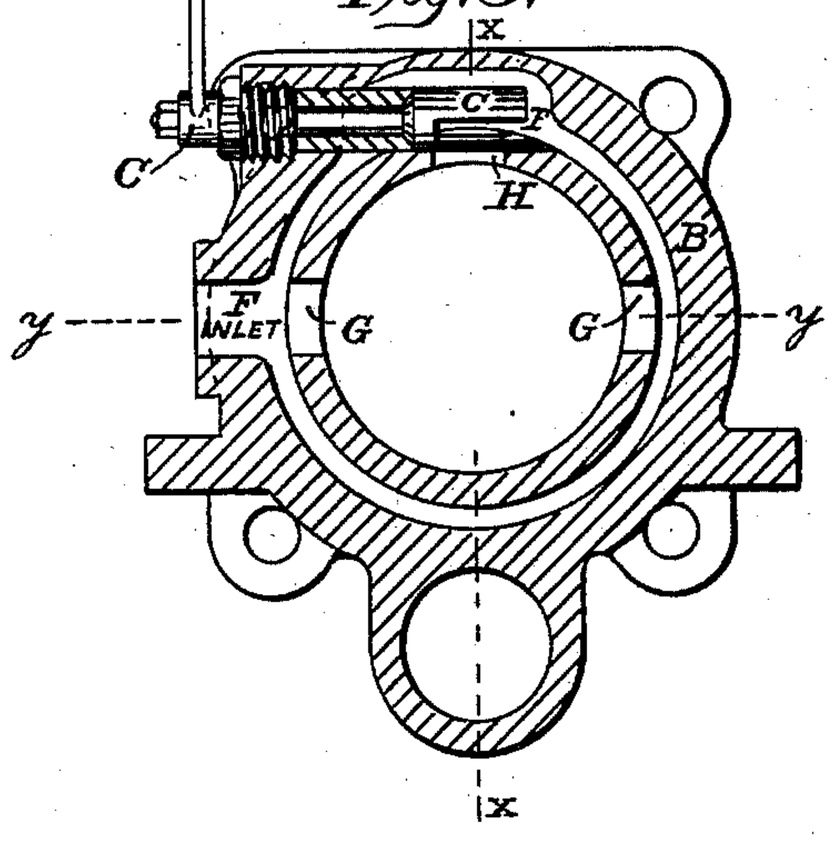


Fig. 3.



Albert Ball

INVENTOR

WITNESSES:

Frank L. Dyer

E. K. Berry,

by Geo. H. Dyer

ATTORNEY

(No Model.) 2 Sheets—Sheet 2.

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Fig. 5

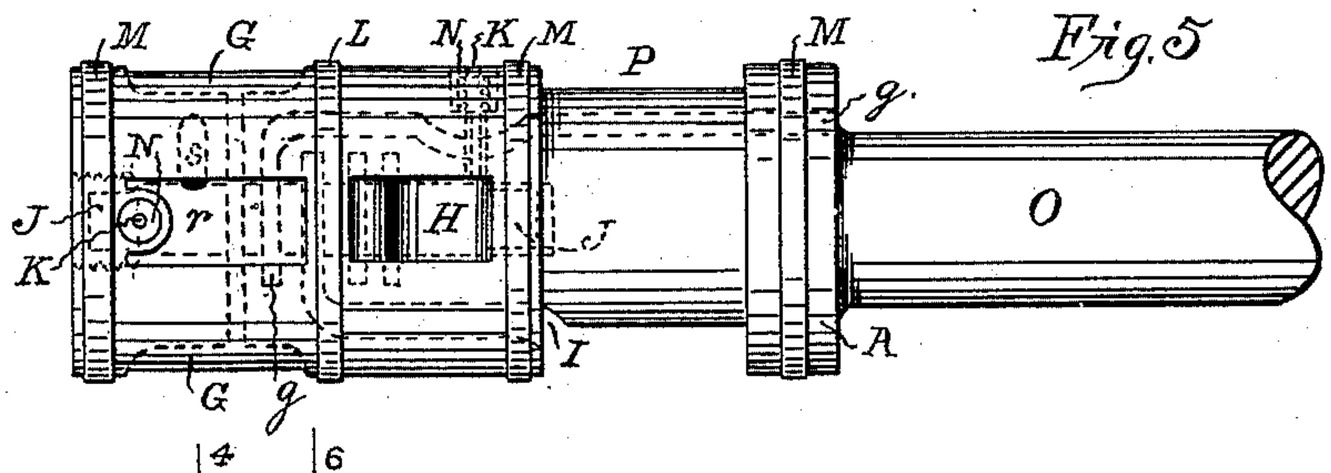


Fig. 6.

Fig. 7.

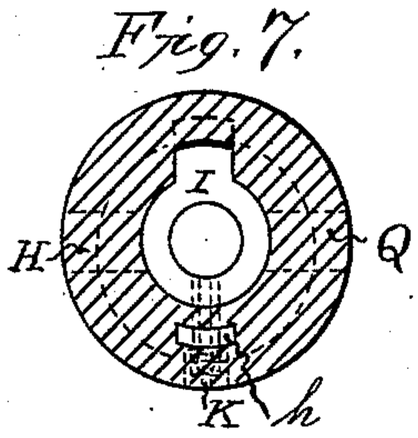


Fig. 4.

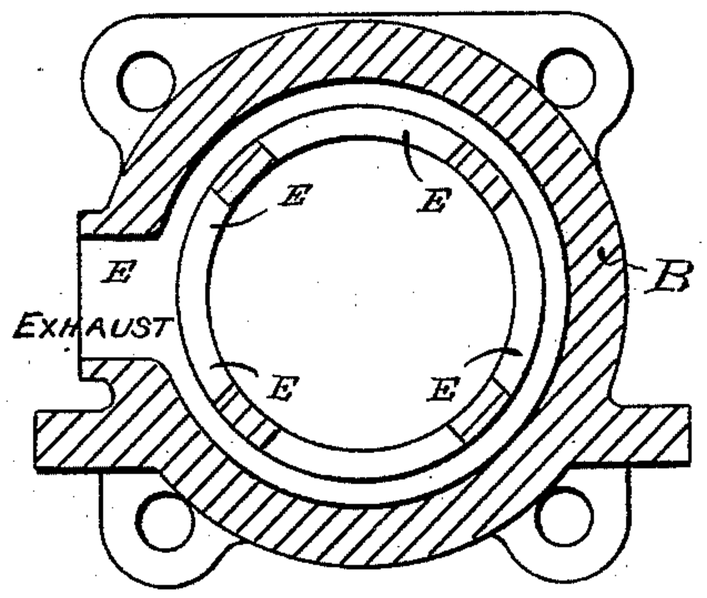


Fig. 8.

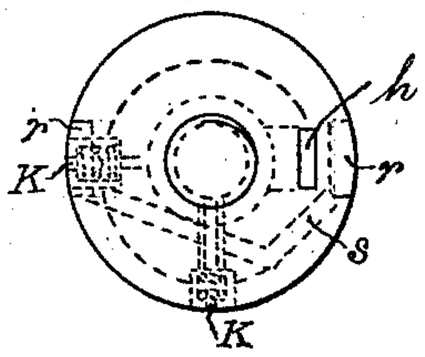


Fig. 9.

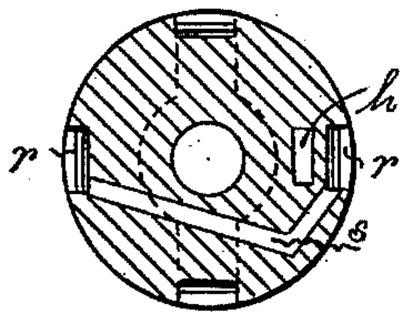
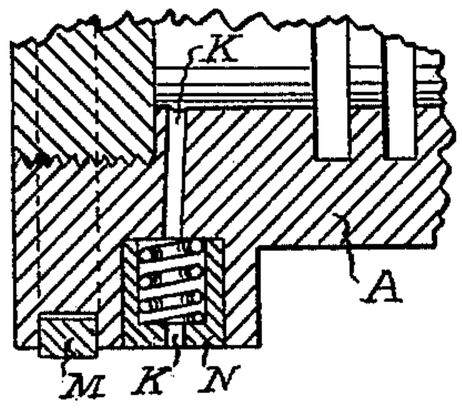


Fig. 10.



WITNESSES:

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INVENTOR

by Geo. W. Dyer

ATTORNEY

UNITED STATES PATENT OFFICE.

ALBERT BALL, OF CLAREMONT, NEW HAMPSHIRE, ASSIGNOR TO THE SULLIVAN MACHINE COMPANY, OF SAME PLACE.

STEAM-ENGINE.

SPECIFICATION forming part of Letters Patent No. 426,612, dated April 29, 1890.

Application filed March 30, 1889. Serial No. 305,487. (No model.)

To all whom it may concern:

Be it known that I, ALBERT BALL, a citizen of the United States, residing at Claremont, in the county of Sullivan and State of New Hampshire, have invented certain new and useful Improvements in Direct-Acting Steam-Engines; and I do hereby declare the following to be a full, clear, and exact description of the invention, which will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to improvements in direct-acting engines to be driven by steam or other elastic fluid, (all which will be included in this specification under the name of "steam,") whose valves are moved by steam, and has for its object the obtaining the most powerful blow with the least steam. This engine is designed especially to drive a gang of drills for my rock-quarrying machine, for which I have obtained Letters Patent; but it can be used for many other purposes.

My invention consists, primarily, in having the valve inclosed within the piston in a novel manner, and, secondarily, in having the exhaust-port located through the side of the cylinder in such manner as to exhaust from the upstroke direct when at full stroke and from the downstroke through the piston (preferably) to the same exhaust-port, the bringing the steam through one port in the side of the cylinder to the piston, whence it is carried around the piston to three or more different points of the piston (where the amount of steam to the top end of the cylinder can be regulated by a plug-valve) and distributed in such way as to balance the piston in its work in the cylinder, so as to avoid side pressure, and thence carried both ways through the piston to the respective ends of the piston. My engine gives an absolutely "dead" blow.

In the accompanying drawings like letters designate corresponding parts.

Figure 1 shows a longitudinal sectional view of the cylinder and piston with part of piston-rod at the points *x x*, Fig. 3, with the valve shown whole. Fig. 2 shows a longitudinal sectional view of the cylinder and piston with part of piston-rod at the points *y y*, Fig. 3, with the valve shown whole. Fig. 3 shows a cross-sectional view of the cylinder at the points *z z*, Fig. 2, with the plug-valve for regulating the steam admitted to the upper end of piston shown whole. Fig. 4 shows a cross-sectional view of the cylinder at the points *v v*, Fig. 2. Fig. 5 shows a side view of the piston, with part of piston-rod at quarter-turn to that shown in Fig. 1, with the side which is shown at the top in Fig. 1 in front. Fig. 6 shows a side view of the piston, with part of piston-rod at quarter-turn to that shown in Fig. 2, with the side which is shown at the bottom in Fig. 2 in front. Fig. 7 shows a cross-sectional view of the piston through the exhaust-port at 6 7, Fig. 6. Fig. 8 shows a top end view of the piston. Fig. 9 shows a cross-sectional view of the piston at 4 5, Fig. 6. Fig. 10 is an enlarged longitudinal sectional view of a part of the piston for the object of showing the packing of one of the reversing-ports to valve, for which I have made separate application for Letters Patent, filed April 2, 1889, and numbered serially 305,739.

A is the piston, to which is attached a section of the piston-rod O.

B is the cylinder.

C C, Fig. 3, is a plug-valve wherewith I regulate the amount of steam to be delivered at the upper end. In some cases the weight of the piston and rod with the tool-clamp and tools furnishes sufficient impulse, and then I can shut off altogether the steam from the upper end.

D is the balanced valve, which is thrown to and fro in the inside of the piston on the line of the movement of the piston and partakes of its momentum force, but which is driven by direct steam, and in its movement controls the direction of the steam delivered to the piston.

E is the exhaust through the side of the cylinder.

F is the inlet through the side of the cylinder to G G, inlet and cut-off pockets in the piston for the lower end, and to H, inlet and cut-off pocket for the upper end. From the pockets G G the passage *g* carries steam down through the piston into the cylinder at the lower end of the piston at the side of the piston-rod for the upstroke, while from the

pocket H the passage *h* carries steam up through the piston into the cylinder above the piston for the down stroke or blow.

I is the passage for the exhaust-steam into the annular space P, cut around the piston near its lower end. This annular space is preferably cut eccentric with the larger space on the same side with the exhaust-port, so as to give as much space as possible without unnecesarily weakening the piston. It is made annular, so as not to throw the piston out of balance.

L is the cut-off ring on the piston separating the pockets G G and the pocket H.

M M M are packing-rings.

N, Figs. 1, 2, 5, and 6, is the packing to reversing-ports.

Q is a balancing steam-cavity on the opposite side to the inlet-pocket H, and *r r*, Figs. 5, 6, and 9, are balancing-pockets just above the inlet-pocket H and its balance Q. These pockets *r r* are connected, Fig. 9, by a steam-passage S.

K K are reversing-ports for working the valve D.

J J are "buffers" or stops for the valve.

Suitable exhausts for the valve are provided, but not shown in the drawings.

The practical working of my engine is as follows: Fig. 2 shows the cylinder and piston and valve as ordinarily at rest. When the steam is turned on, it passes from the inlet and passage F and the inlet-pockets G G through the upper valve-space in the valve-seat, as indicated by the arrow, down through the passage *g* to the lower end of the piston, and forces the piston up until the cut-off ring L passes the inlet F. The flow of live steam is then cut off and the steam below the piston works expansively until the lower packing-ring M passes the exhaust-port E. When the reversing-port N, Fig. 2, reaches the inlet F, the steam throws the valve up. This is simultaneous with the bottom of the piston passing the exhaust-port. While the annular space P is passing the exhaust-port in the cylinder the steam above the piston has been free to escape through the passage *h* across the middle valve-space in the valve-seat and out into the annular exhaust-space and the exhaust-port. After the space P has passed the exhaust-port, (which occurs before the reversal of the valve,) the steam above the piston is compressed (in common until the valve is reversed with that in the space P and passage *h*) and forms a cushion. At the end of the upward stroke the piston and valve are as shown in Fig. 1. The steam for the downstroke passes through the inlet H, through the lower valve-space in the valve-seat, and through the passage *h*, as indicated by the arrows, Fig. 1. The steam works direct until the cut-off ring L passes the inlet and thereafter expansively until the blow is given. The blow is usually given before the full stroke, and in such case the impetus reverses the valve and changes the direction of steam. If the blow be not given before the reversing-port N, Fig. 1, reaches the inlet H, the steam reverses the valve.

One novel feature of the valve is that the reversing comes in the same direction as the travel of the piston. It is free to move as soon as the cut-off L passes the respective inlet, and if for any reason the stroke of the piston is shortened the momentum reverses the valve without steam. In the downward travel of the piston the steam that is below is free to escape up through the passage *g* and across the same place in the valve-seat through the lower valve-space and into the same exhaust-passage as on the upward stroke. I use two inlet-ports, but only one exhaust. I can use a very small valve, and it works very easily and with the utmost certainty and economy. The shorter the stroke the more rapidly it is made and the quicker the blow.

Among the great advantages of my engine are—

First. The blow given is with the full force of the steam and without any steam-cushion to be overcome, while on the upstroke there is a steam-cushion.

Second. There are very few pieces and the fragile parts are out of the way and protected.

Third. Because of the freedom and momentum of the valve the engine is efficient at full stroke, or at a very small part stroke; but, what I deem a great advantage, it is most efficient on the downstroke at a point just before the valve would be reversed by steam, so as to have an absolutely dead blow without cushion.

Fourth. I utilize by my cut-off the expansiveness of the steam.

Fifth. By my system of balance-pockets I reduce the wear of the engine to a minimum.

Sixth. I can reduce or increase the blow by regulating the flow of steam to the upper end of the piston without affecting the amount of steam furnished to the lower end, where the work is uniform and needs no change.

It is obvious that on work where no variation is required in the supply of steam to the top of the piston the amount of steam can be governed by changing the size of the steam-passage *h*, and then the swing-valve C becomes unnecessary, and instead of the openings G G and H and passage F an annular space in the cylinder or piston can be used.

What I claim as my invention, and desire to secure by Letters Patent, is as follows:

1. A direct-acting steam-engine comprising a cylinder, a piston within the cylinder, a steam-valve within the piston, an elongated port G on the piston and communicating with said valve, and an inlet-passage F in the cylinder and connecting with said elongated port, substantially as set forth.

2. In a direct-acting engine, the combination of a cylinder with inlet and exhaust ports, a piston with passages opening therefrom through said piston to the respective

ends thereof, a valve in said piston, and balanced cavities or pockets *r r* on opposite sides of said piston, with passage through said piston between said pockets, substantially as and for the purposes described.

3. In a direct-acting engine, in combination with a cylinder with inlet and exhaust ports, a piston provided with inside passages and valve, and with a balancing-cavity Q on the outside of said piston opposite to and communicating with the inlet-opening of the passage *h*, leading to the upper end of said piston, substantially as and for the purposes described.

4. In a direct-acting engine, the cylinder provided with inlet-port and distributing-passage F, a piston working therein provided with internal steam-passages *g h*, to connect, respectively, with inlet-openings G and H in said piston and cylinder, a cut-off ring L on said piston separating said ports G and H on the circumference of said piston, and a balanced valve D on the inside of said piston, in combination with the exhaust-passage I and an annular exhaust-space P, substantially as and for the purposes described.

5. In a direct-acting engine, the combination of a cylinder provided with suitable inlet and exhaust ports and a piston working therein provided with internal steam-passages and valve and with an annular exhaust-space P within the piston, so that the exhaust-steam will be balanced thereto, substantially as and for the purposes described.

6. In a direct-acting engine, the combination of a cylinder B, the inlet-port and steam-passage F, the openings G G, the opening H, with regulating swing-valve C, the piston A, with internal passages *g* and *h* to the respective ends of said piston, the inclosed balanced valve D, with valve-reversing passages K K, the exhaust-passage I, the annular exhaust-space P, with exhaust-port E, the cut-off L, and the balancing-pockets Q and *r r*, substantially as and for the purposes described.

7. In a direct-acting steam-engine, the combination of a cylinder having inlet and exhaust passages, a piston provided with elongated port G and an annular space P cut therein, a cut-off or packing ring L at the end of said port G, a balanced valve within the piston, and passages connecting said port G and space P around this valve.

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

ALBERT BALL.

Witnesses:
FRANK A. BALL,
GEO. O. BALL.