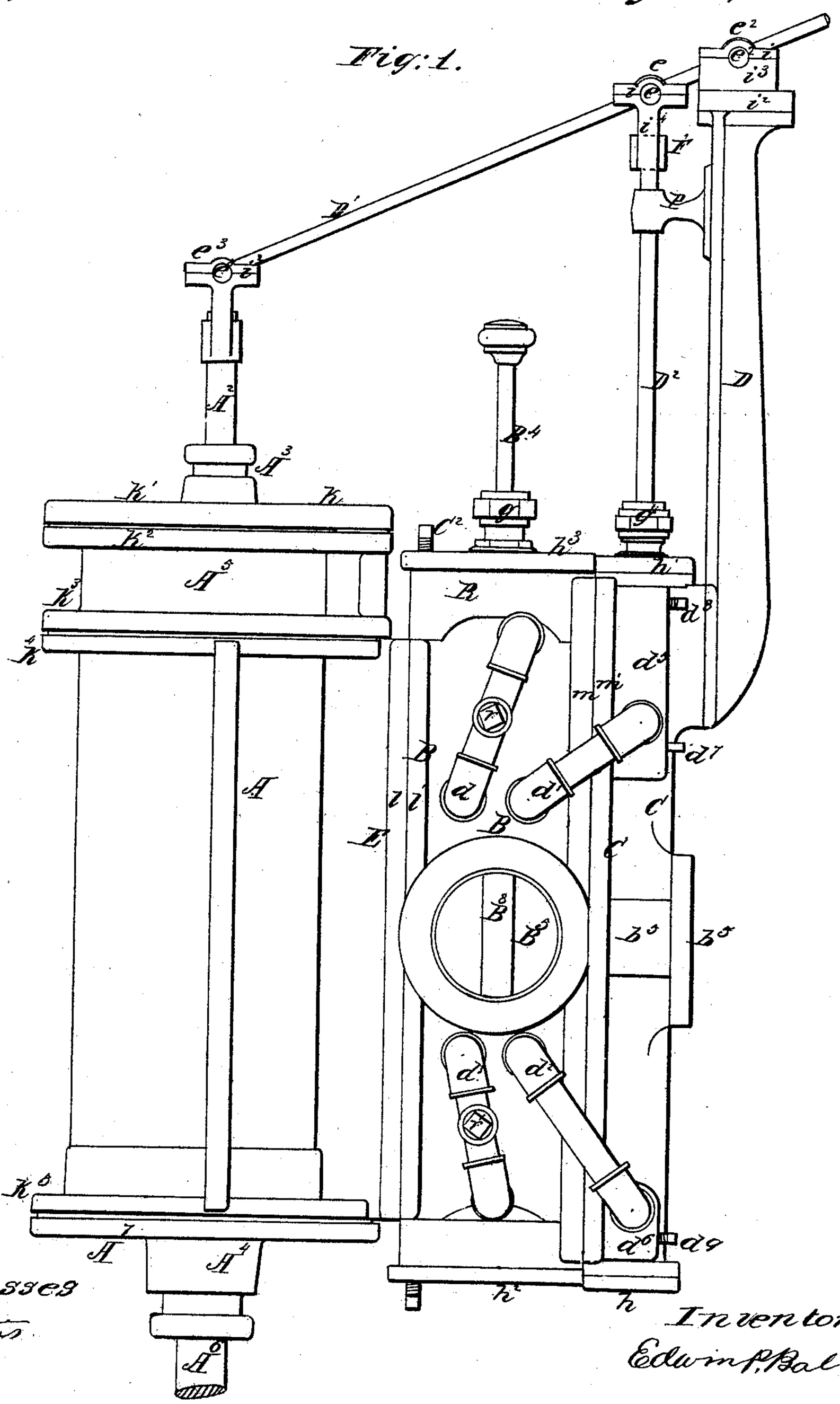
Sheet 1-4 Sheets.

E. P. Ball.

Steam Engine

No. 90,480. Patented May 25, 1869.

Fig: 1.



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Sheet 2-4 Sheets.

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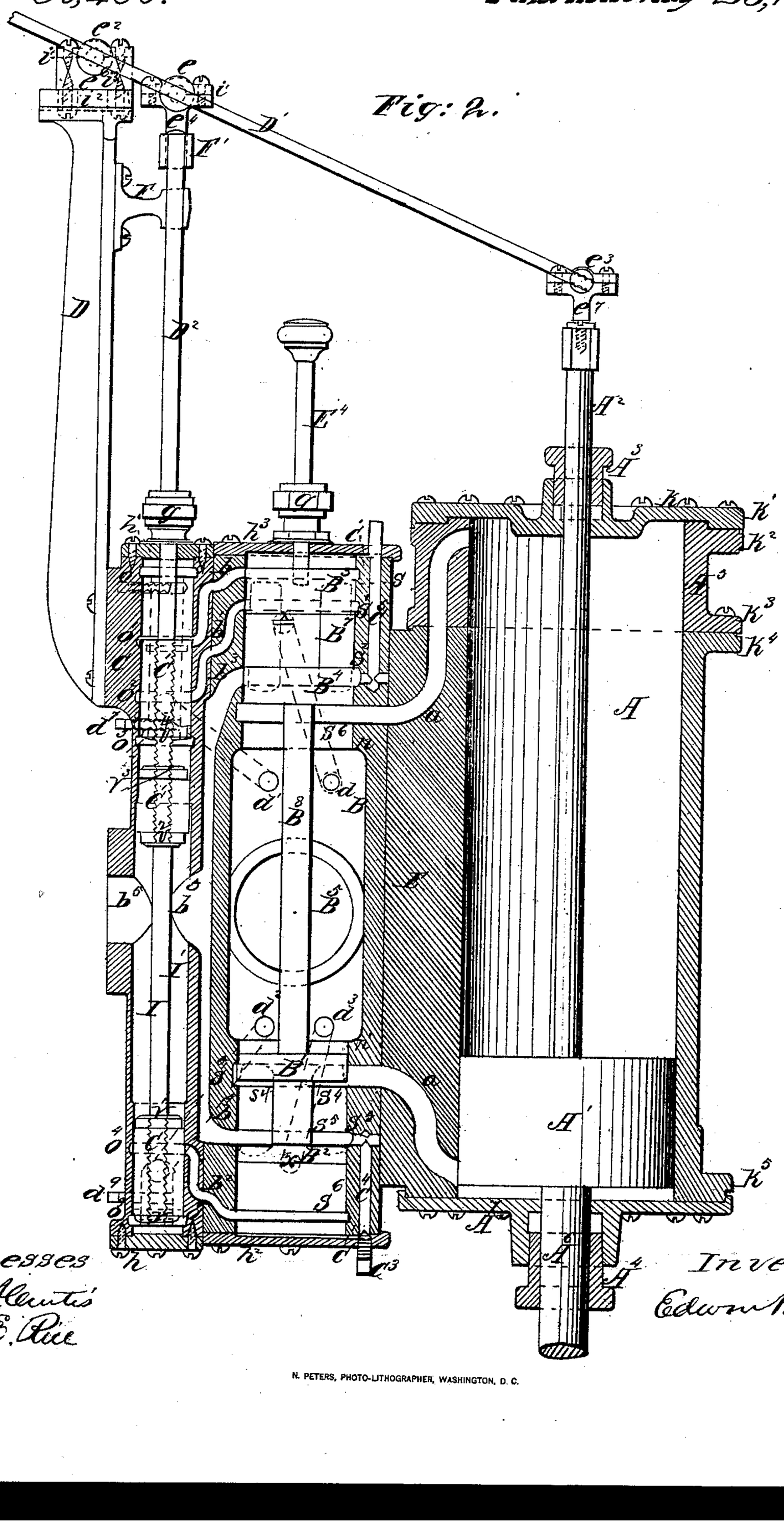
Steam Engine.

No. 90,480. Patented May 25, 1869.

Fig: 2.



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Steam Engine.

No. 90,480. Patented May 25, 1869.

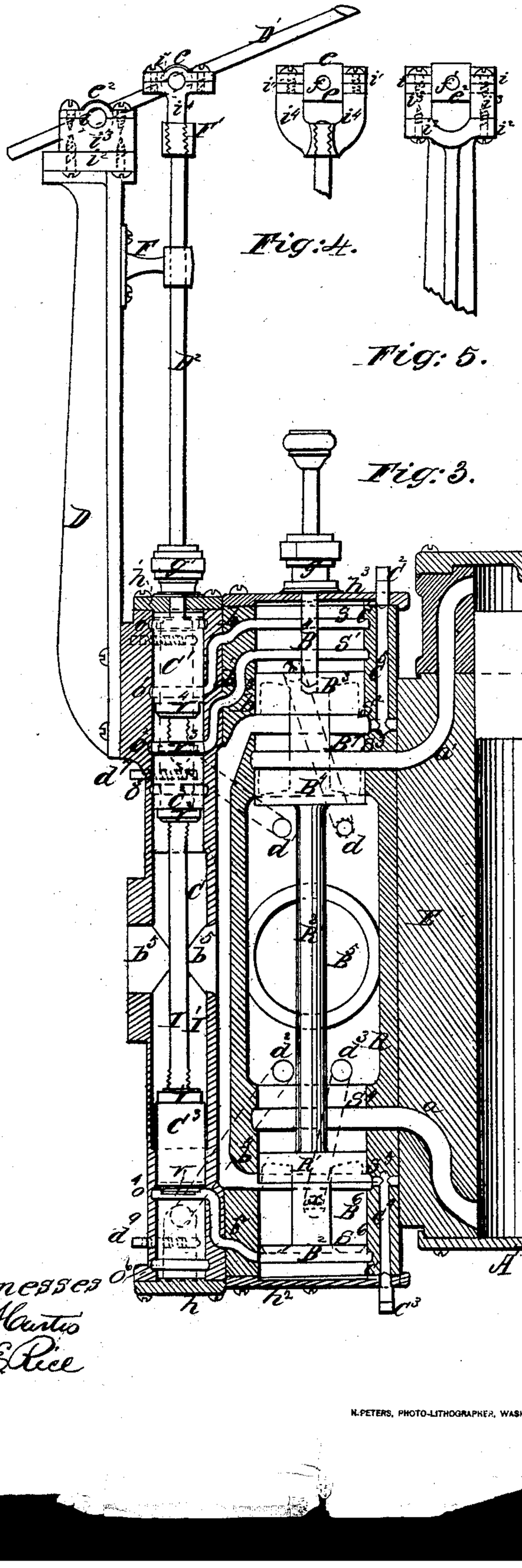


Fig. 4.

Fig. 5.

Fig. 3.

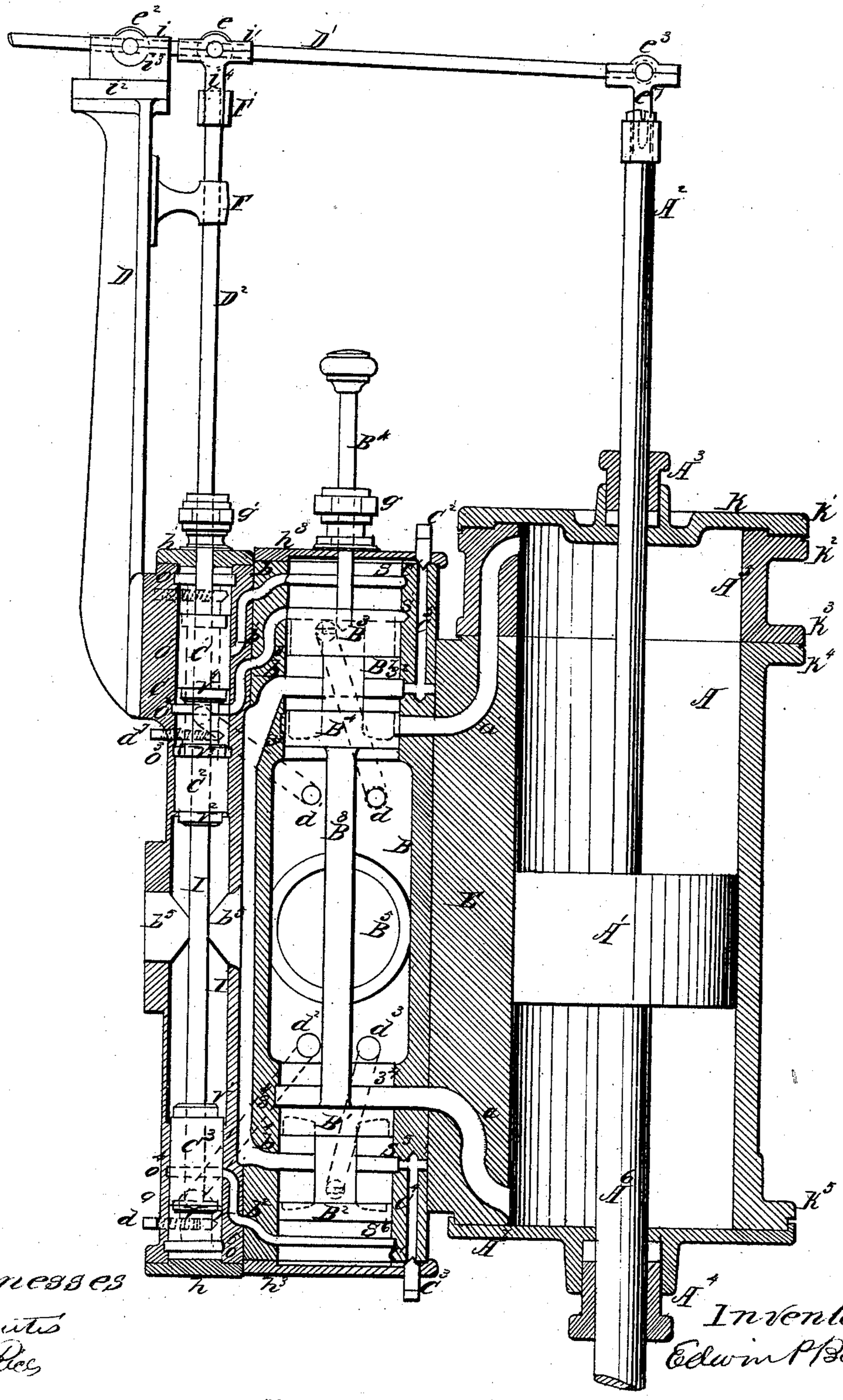
E. P. Ball.

Sheet 4-4 Sheets.

Steam Engine.

No. 90,480. Patented May 25, 1869.

Fig: 6.



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UNITED STATES PATENT OFFICE.

EDWIN P. BALL, OF CHICOPEE, MASSACHUSETTS.

IMPROVEMENT IN STEAM-ENGINES.

Specification forming part of Letters Patent No. **90,480**, dated May 25, 1869.

To all whom it may concern:

Be it known that I, EDWIN P. BALL, of Chicopee, in the county of Hampden and State of Massachusetts, have invented a new and useful Improvement in Steam-Engines; and I hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, making a part of this specification, and to the letters of reference marked thereon, in which—

Figure 1, Plate 1, shows a side elevation of the apparatus ready for operation. Fig. 2, Plate 2, is a vertical section through the cylinders, showing the details of construction, as seen from the opposite side to that shown in Plate 1. Fig. 3, Plate 3, is a similar sectional view, showing the piston and valves in another position. Fig. 4, Plate 3, is a front view of the connecting-trunnion on the valve-rod. Fig. 5, Plate 3, is a front view of the fulcrum or bearing for the lever which operates the valve; and Fig. 6, Plate 4, is a sectional view of the cylinders, showing the piston and valves in a different position from that shown in Plates 2 and 3.

My invention relates to steam-engines; and consists in the construction and arrangement of the same whereby the piston is connected with a primary valve by suitable rods, an intermediate valve being introduced between said primary valve and piston, the primary valve serving to control the exhaust-steam passing from the cylinder containing the intermediate valve, and said intermediate valve serving to control the admission of steam to the cylinder containing the piston, while both the valves and piston govern and control each other in their movements, and the whole operate with great regularity, precision, and ease, and without much of the jar and wear and tear of parts usually attendant upon the quick and rapid movement of heavy machinery operated by steam.

That others skilled in the art may be able to make and use my invention, I will proceed to describe its construction and the mode of its operation.

In the drawings, A represents the piston-cylinder, which is cast hollow and open at both ends, and with the flanges k^4 and k^5 thereon, said cylinder having upon one side the wing-piece E, with the ports a and a^1 therein; and for greater facility in making an examination as to the condition of the piston A^1 and its rings, when desirable, the piece A^5 is cast separately, with the flanges k^2 and k^3 thereon, by which flange k^3 the said piece A^5 is secured to the main cylinder A.

To the upper flange, k^2, is secured the head k, having the stuffing-box A^3 thereon, through which passes the piston-rod A^2, and to the lower flange, k^5, upon the cylinder A is secured the head A^7, having the stuffing-box A^4 thereon, through which passes the rod A^6, to the lower end of which may be attached a stamp-head for crushing or stamping ores; or a hammer or die may be attached thereto, which may be used as in the ordinary operations of a steam-hammer; or the lower head, A^7, may be solid, and without the stuffing-box A^4, and the piston may be used for any propelling-power desirable.

The outside of the wing-piece E is made plane or flat, and with a flange, l, thereon, as shown in Plate 1.

The cylinder B is cast hollow, open at both ends, and to each end is secured a head, h^2 h^3. The middle portion of the bore of said cylinder B, from n to n^1, is made somewhat larger than the part nearer the ends, and the aperture B^5 is made in the side of said cylinder. One side of this cylinder B, on the outside, is made plane or flat, with a flange, l^1, thereon, by means of which said cylinder B is secured to the wing-piece E of the cylinder A by bolts passing through said flange l^1, and also through the flange l on the wing-piece E.

In the upper part of the said cylinder B are made the annular grooves, s, s^1, s^2, and s^3, and in the lower part of said cylinder B are made the annular grooves, s^4, s^5, and s^6. Direct communication is made from the groove s^3 to the interior of the cylinder A, at its upper end, through the port a^1, and also from the groove s^4 to the lower interior portion of said cylinder A through the port a. The small port c^4 is made through the lower head, h^2, and up into the side of the cylinder B, communicating with the groove s^5, and the said hole, through the head h^2, has a screw-thread made therein, and a screw, c^3, having a conical end, is turned into said hole; and the same arrangement is made at the upper end of the cylinder, where c^5 is the small port, communicating

with the groove s^2 through the head h^3, and c^2 the screw fitting into the threaded hole made through the head h^3.

Operating within the cylinder B is the rod B^8, upon the upper end of which are the two cylindrical flanges or piston-heads B^3 and B^4, the thickness of B^3 being sufficient to cover the grooves s and s^1, while the thickness of the flange B^4 is sufficient to occupy the space between the top of the groove s^2 and the top of the groove s^3.

Upon the lower end of the rod B^8 are the two cylindrical flanges or heads B^1 and B^2, the thickness of B^1 being sufficient to cover the annular groove s^4, and the thickness of B^2 being sufficient to cover the annular groove s^6.

The distance between the flanges B^1 and B^2 is such that when the upper side of the lower flange B^2 is on the same horizontal plane with the lower side of the groove s^5, as shown in Plate 2, the lower side of the flange B^1 shall be a little above the lower side of the groove s^4.

The distance between the heads or flanges B^3 and B^4 is such that when the lower side of the flange B^3 is upon the same horizontal plane with the upper side of the groove s^2, as shown in Plate 3, the upper side of the flange B^4 is upon the same horizontal plane with the lower side of the groove s^3, and the length of the whole rod B^8, with the flanges B^1, B^2, B^3, and B^4 thereon, is such that when the rod B^8 is in the position shown in Plate 2, the top of the upper flange, B^3, being upon the same horizontal plane with the upper side of the groove s, the upper side of the lower flange, B^2, shall be on the same horizontal plane with the lower side of the groove s^5.

The length of the rod B^8, with the distances between the flanges, as thus explained, will determine the relative proportion of the rod B^8 with its flanges, which I denominate the "intermediate valve," to the cylinder B, with the grooves s, s^1, &c., made therein.

The bore of the cylinder B, in its upper and lower part, should be the same in diameter, and the flanges B^3, B^4, &c., should fit said bore properly to make them steam-tight, and said flanges may be cast somewhat hollow, as indicated by dotted lines in Plates 2, 3, and 4, if desirable, to save stock and give lightness to the valve.

The apertures d d^1 d^2 d^3 are made in the larger part of the cylinder B, through which the exhaust-steam escapes from certain portions of the machine, as will be hereinafter explained.

An aperture, x, is made in the upper part of the cylinder B at such height that when the valve B^8 is at its lowest position in the cylinder, as shown in Plate 3, Fig. 3, said aperture shall be just above the upper surface of the flange B^3, and an aperture, x^1, is made in the lower part of said cylinder at such height that when the said valve is in its highest position, as shown in Plate 2, Fig. 2, said opening shall be just below the lower surface of the lower flange, B^2, so that the exhaust-steam may escape from the upper and lower parts of the cylinder through the pipes and apertures d and d^3 into the exhaust-pipe.

The guide-rod B^4 operates through a stuffing-box, g, in the upper head of the cylinder B, by which to try the valve when necessary to ascertain its condition in its cylinder. The ports b, b^1, b^2, b^3, and b^4 are made in the cylinder B, and that side of said cylinder B is made flat, and having the flange m thereon, as shown in Plate 1.

The cylinder C is made smaller than B, and hollow, with the heads h and h^1 bolted to the upper and lower ends, the stuffing-box g being made in the upper head, h^1, through which operates the rod D^2. One side of the cylinder C is made flat, with a flange, m^1, thereon, by which it is secured to the cylinder B.

Within the cylinder C, and extending around its entire interior circumference, are made the annular grooves o, o^1, o^2, o^3, o^4, and o^5, the annular grooves s, s^1, s^2, s^3, s^4, s^5, and s^6 extending around the entire interior circumference of the cylinder B. In the same manner communication is made between the annular grooves o^1 and s, o^2 and s^1, and o^4 and s^6 through the ports b, b^1, and b^2, respectively, which are made partly in the cylinder B and partly in the cylinder C, for facility in casting.

The cylinder C has the aperture b^5 therein, which communicates with the annular groove s^2 in the upper part of the cylinder B through the port b^3, and also with the annular groove s^5 in the lower part of said cylinder through the port b^4.

Upon the outside of the cylinder C, at the upper part, is the protuberance d^5, as shown in Plate 1, which is hollow from top to bottom, only communicating with the interior of the cylinder C through two apertures, one at the top, opening into the annular groove o, and one at the bottom of said protuberance, opening into the annular groove o^3. Another aperture is made in the outside of said protuberance, which communicates with the enlarged middle portion of the cylinder B through the pipe and aperture d.

Another protuberance, d^6, is made upon the outside of the cylinder C, at the lower end, which is also hollow, and only communicates with the lower interior portion of said cylinder C through an aperture which opens into the annular groove o^5.

A threaded hole is made in the edge of the protuberance d^5 just below the annular groove o, into which is turned a screw, d^8, which is of sufficient diameter and length to entirely fill the hollow in the protuberance d^5 when said screw is turned in, and a similar screw is arranged for the lower part of said protuberance d^5, just above the annular groove o^3, and also for the lower protuberance d^6 just above the annular groove o^5. Communication is made from the interior of the protuberance d^6 with the middle interior portion of the cylinder B, or with the exhaust-pipe B^5 through the pipe

and aperture d^2. Upon the rod D^2 are the cylindrical flanges or projections C^1, C^2, and C^3, the lower side or end of the projection C^3 being upon the same horizontal plane with the upper side of the annular groove o^4. When the rod D^2 is at its highest position, as shown in Plate 3, the top of the upper flange, C^1, should be upon the same horizontal plane with the upper side of the annular groove o, the lower end of said flange C^1 being a little below the groove o^1, and the extreme top of the flange C^2 should be at about the lower side of the annular groove o^2, said flange extending down to a point below the groove o^3. The length of the lower flange, C^3, should be such that when its extreme lower end is upon the same horizontal plane with the upper side of the groove o^5 the top of said flange should be above the groove o^4, as shown in Plate 2, the small rod I, which connects the flanges C^1, C^2, and C^3, affording ample space for the steam to pass in through the pipe b^5.

To the upper part of the cylinder C, upon the side, is secured the stud or bearing D, which may be of sufficient length to accommodate the length of stroke, and at the top of which stud is the bearing i^2 in which are made two vertical slots parallel with the rod D, one in each side of the bearing i^2, through which are passed bolts or screws securing the sliding bearing i^3. A trunnion, e^2, having an aperture, f, therein, has its bearings in the slide i^3, caps i being secured to the slide i^3 to keep the ends of the trunnion always in place. At the top of the rod D^2 are the bearings i^4, with caps i^1, securing a similar trunnion, e, with an aperture, f, therein, properly in place. Both the trunnions e and e^2 are so properly secured in their bearings as to admit of a vertical reciprocating movement, and a guide, F, having a vertical aperture therein, is attached to the stud, through which guide passes the rod D^2, to keep it steady and in its proper vertical position. To the top of the piston-rod A^2 is attached a similar trunnion, e^3, to which trunnion is firmly attached the rod D^1, said rod passing through the apertures in the trunnions e and e^2, sliding freely to and fro in said apertures. A rod, A^6, attached to the piston A^1, passes down through the stuffing-box A^4 in the lower head of the cylinder A, and a stamp-head for crushing ore may be attached to the lower end of said rod.

Having thus described its construction, I will now proceed to describe the mode of its operation.

The parts of the machine being together and ready for operation, the piston A^1 being in the lower part of the cylinder, as shown in Plate 2, the intermediate valve, B^8, being in its highest position within the cylinder B, steam is admitted through the pipe b^5, passing through the port b^4 into the cylinder B between the flanges B^1 and B^2, through the port a, and into the cylinder A underneath the piston A^1. This forces the piston A^1 upward to the upper part of the cylinder A, the intermediate valve, B^8, remaining in its highest position until the piston A^1 has performed its entire upward stroke. This upward movement of the piston A^1, with its rod A^2, carries up also that end of the lever D^1 which is attached to the upper end of the rod A^2, and as the lever D^1 passes through the aperture in the trunnion at the top of the rod D^2 said rod D^2 is also carried upward, and with it the valve I, the vertical movement of the rod D^2 and the valve I being in proportion to the vertical movement of the piston-rod A^2 as the distance from e^2 to e is to the distance from e to e^3. The valve I being carried upward, the lower flange, C^3, is brought above the annular groove o^4, and the exhaust-steam passes out from beneath the lower flange, B^2, through the port b^2, into the lower part of the cylinder C, through the orifice in the lower annular groove, o^5, chamber d^6, pipe d^2, into the large exhaust-pipe B^5. The intermediate valve, B^8, then drops, and as the annular groove s^6 is a short distance above the bottom of the cylinder B, the said valve B^8 cushions against the steam which is collected in the lower end of the cylinder B below the annular groove s^6, and the steam which enters the small upper port c^5 c^1, to force down the intermediate valve, B^8, escapes through the aperture x in the side of the cylinder B, thus preventing any further downward force being exerted upon said valve B^8. As the piston A^1 moves down the valve I is also carried down until the lower end of the lower flange, C^3, passes the annular groove o^4, closing the port b^2, and the upper end of the flange C^2 passes below the annular groove o^3, which opens the aperture in said groove o^3, communicating with the small exhaust-chamber d^5 on the outside of the cylinder C. This position of the valve I is shown in Plate 4. The exhaust-steam is then free to pass out from the space in the upper end of the cylinder B, above the upper flange, B^3, through the port b^1, space in the cylinder C, between the two flanges C^1 and C^2, and small exhaust-chamber d^5 and pipe d^1, into the exhaust-pipe B^5. The steam admitted to the lower end of the cylinder B, beneath the flange B^2, through the port b^4 and smaller ports c^4 and c, forces up the intermediate valve, B^8, (the lower port, b^2, being stopped,) until the top of the upper flange, B^3, has just passed the annular groove s^1, when, the port b being still shut, the steam in the upper end of the cylinder B temporarily stops the intermediate valve, B^8, in its upward movement.

The piston A^1 having thus far made only a part of its downward movement, the intermediate valve, B^8, in its present position has cut off communication between the cylinder B and the upper part of the cylinder A by the flanges B^4 covering the annular groove s^3 communicating with the port a^1, and as the great weight of the stamp-head attached to the lower end of the rod A^6 accelerates the piston A^1 in its downward movement, there is no necessity that the piston A^1 should have the full force of the steam during its entire downward movement,

and the said piston A^1 performs the remainder of the downward movement under the expansive force of the steam already admitted into the cylinder above it, the exhaust-steam meanwhile passing out from beneath the piston A^1 through the port *a* into the exhaust-pipe B^5, all the space between the two flanges B^1 and B^4 of the intermediate valve, B^8, being exhaust-space. As the valve I is carried to its lowest position in the cylinder C by the downward movement of the piston A^1, when the top of the upper flange, C^1, passes below the annular groove o^1, the steam in the upper part of the cylinder B above the intermediate valve, B^8, is free to pass out through the port *b* into the upper part of the cylinder C, and from thence through the aperture in the upper annular groove *o*, through the small exhaust-chamber d^5, pipe d^1, and into the large exhaust-pipe B^5. This escape of the steam from the cylinder B above the upper flange, B^3, of the intermediate valve, B^8, permits said valve to fly up quickly until the top of the upper flange, B^3, covers or passes the upper annular groove, *s*, when the said valve B^8 cushions against the steam confined in the extreme upper part of said cylinder B above the said groove *s*, and the steam which enters the small lower ports, c^4 and *c*, to drive the intermediate valve, B^8, upward, passes out through the lower aperture x^1, thus preventing any further upward force being exerted by the steam.

If, in the adjustment of the machine, it should be found desirable to change slightly the length of the stroke of the valve I as compared with the stroke of the piston A^1, it may be easily and quickly done by unloosening the bolts or screws which secure the slide i^3 to its ways or rests i^2, moving the slide i^3 either toward or from the rod D^2 to its desired position, and then tightening said bolts or screws.

If it should be desirable to shorten the stroke of the piston A^1 at the upper end of the stroke, it may be done by turning the nut *v* upon the rod I and moving the lower head or flange, C^3, upward on its rod I the desired distance, and then securing it in place by the nuts *v* and v^1 above and below the head C^3. The ports b^2 and groove o^4 will then communicate sooner, and the intermediate valve, B^8, dropping sooner, the steam passes into the upper part of the cylinder A through the ports b^3 and a^1, shortening the stroke of the piston A^1 at the upper part. If it should be desirable to shorten the stroke of said piston at the lower end of the stroke, it may be done by moving down the head or flange C^1 upon the rod I and securing it in a similar manner by the nut v^4. This permits the steam to escape from the cylinder B above the intermediate valve, B^8, sooner, which permits the said valve B^8 to fly up quicker, admitting the steam into the lower end of the cylinder A sooner through the ports b^4 and *a*.

If it should be desirable to lengthen or shorten the cut-off for the upper end of cylinder A, it may be done by raising or depressing the middle flange or head, C^2, and securing it in place by the nuts v^2 and v^3 above and below said flange C^2. This permits the steam to escape through the port b^1 and annular groove o^3 sooner or later, according as said flange is depressed or raised, and permits the intermediate valve, B^8, to fly up sooner or later, cutting off the steam from the port a^1 correspondingly sooner or later, as the case may be.

It will be seen that the steam is admitted to the small ports c^5 and c^4 constantly, without reference to the stroke of either of the valves or of the piston; that the intermediate valve, B^8, when used in a vertical position, shall be balanced, the apertures *x* and x^1 in the cylinder are used, the steam which is admitted through either the port c^5 or c^4, and passing out through one of said apertures, operating to hold said intermediate valve always in the highest or lowest position.

The stop-cocks *r* and r^1 may be turned to regulate the size of the apertures *x* and x^1, in order to regulate the amount of steam passing through said apertures and prevent more waste of steam than is necessary, it being best to have said apertures as small as possible, while the amount of steam passing through shall be sufficient to keep the valve B^8 in its proper position at the ends of its stroke.

The intermediate valve, B^8, may be made to move quick or slow by turning the screws d^9, d^7, and d^8 either in or out, for, as the diameter of said screws fills the width of the small exhaust-chambers d^5 and d^6, it is evident that the space left for the passage of the exhaust-steam past the inner end of the said screws will regulate the time occupied in the passage of the steam from above and beneath the intermediate valve, B^8, as said space is large or small.

It will be seen that the movements of the primary valve I simply control the exhaust-passages *b*, b^1, and b^2 from the intermediate valve-cylinder, B, and that the intermediate valve, B^8, controls the admission of steam to the cylinder A both above and below the piston A^1.

It is evident that stop-cocks or perforated screws might be used in the place of the screws d^7, d^8, and d^9, for the purpose of regulating the escape of the steam from the cylinder B, as either would be an equivalent to the devices shown in the drawings, and the regulation of the escape of the steam from said cylinder I deem an important feature in my invention.

By making the valve I without the middle head, C^2, and by leaving out the port b^1, the intermediate valve, B^8, will make but one movement in its upward stroke, and the engine may then be used with great advantage for a greater variety of purposes.

Having thus described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. The primary valve I, with the ports *b*, b^1, and b^2, the intermediate valve, B^8, with the ports in the cylinder B, and the piston A^1, with the ports *a* and a^1, said valves and piston

operating to control each other in their movements, substantially as herein described.

2. The primary valve I in connection with the ports b, b^1, and b^2, and the port c^4, all operating to cause the intermediate valve, B^8, to perform two distinct movements during its entire upward stroke, substantially as set forth.

3. The devices for regulating the passage of the exhaust-steam from out the ends of the cylinder B, so that the intermediate valve B^8 may operate fast or slow during each stroke, substantially as herein described.

4. The exhaust-apertures x and x^1 in the cylinder B, in connection with small ports c^4 and c^5, for the purpose of retaining the intermediate valve, B^8, in its proper position while at rest at each end of its stroke, substantially as herein described.

5. The primary valve I, with the ports b, b^2, b^3, and b^4, the intermediate valve, B^8, with the ports c^4 and c^5, and the piston A^1, with the ports a and a^1, all constructed and arranged, substantially as and for the purposes specified.

E. P. BALL.

Witnesses:
T. A. CURTIS,
F. E. RICE.