H. BOLTHOFF.

COMPOUND ENGINE.

APPLICATION FILED JUNE 1, 1910.

999,432.

Patented Aug. 1, 1911.

4 SHEETS—SHEET 1.

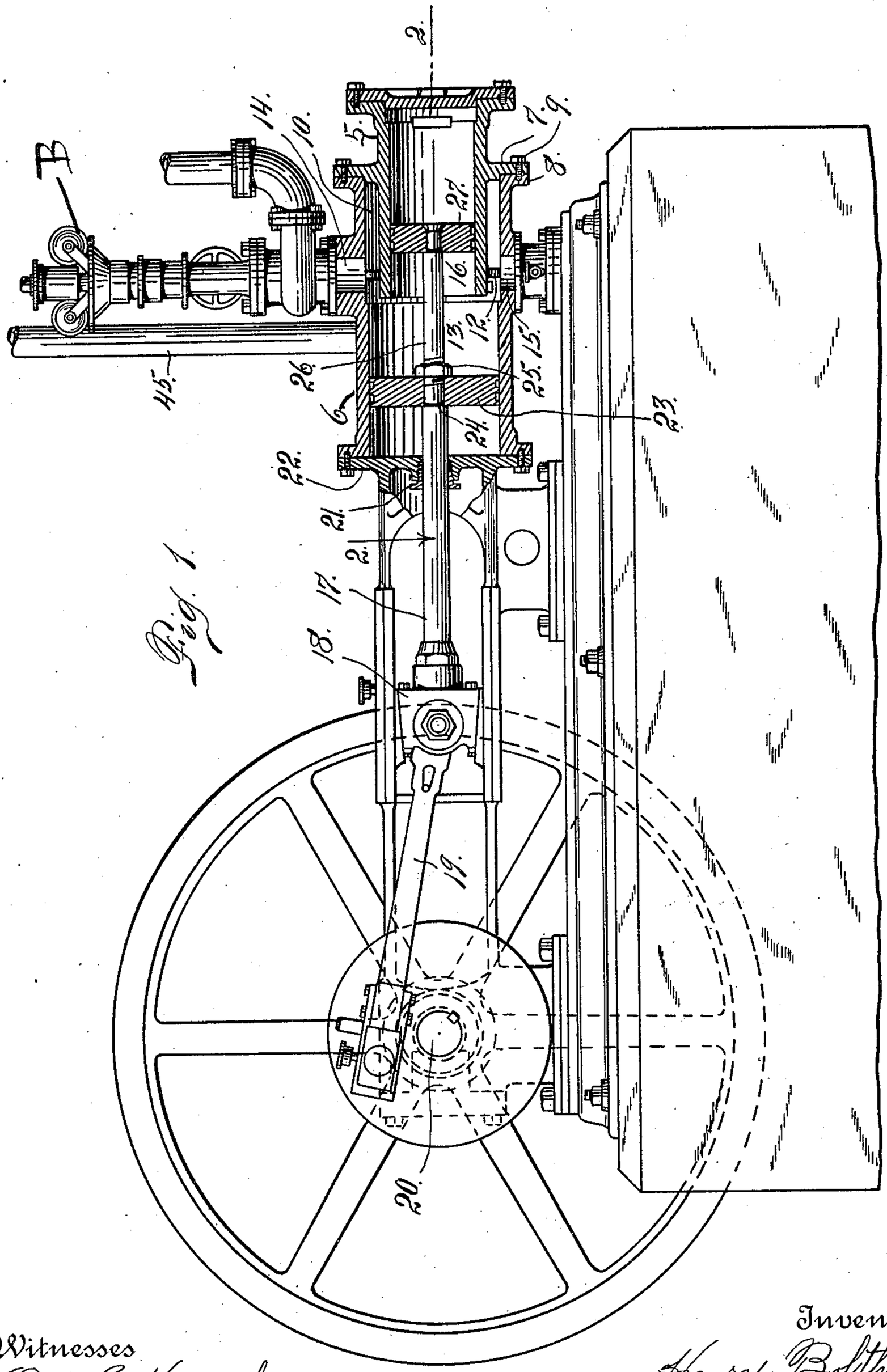

Fig. 1.

Witnesses

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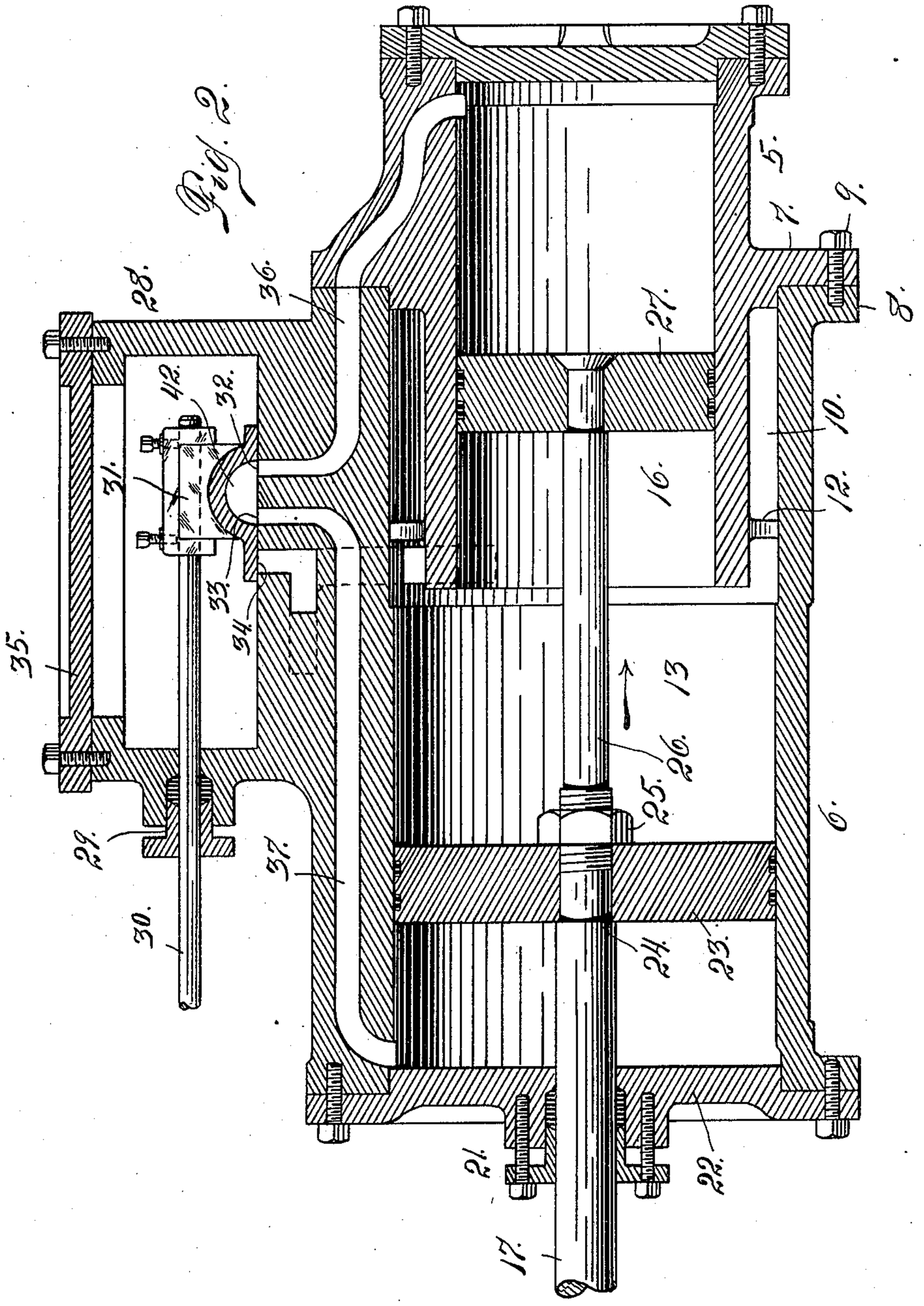

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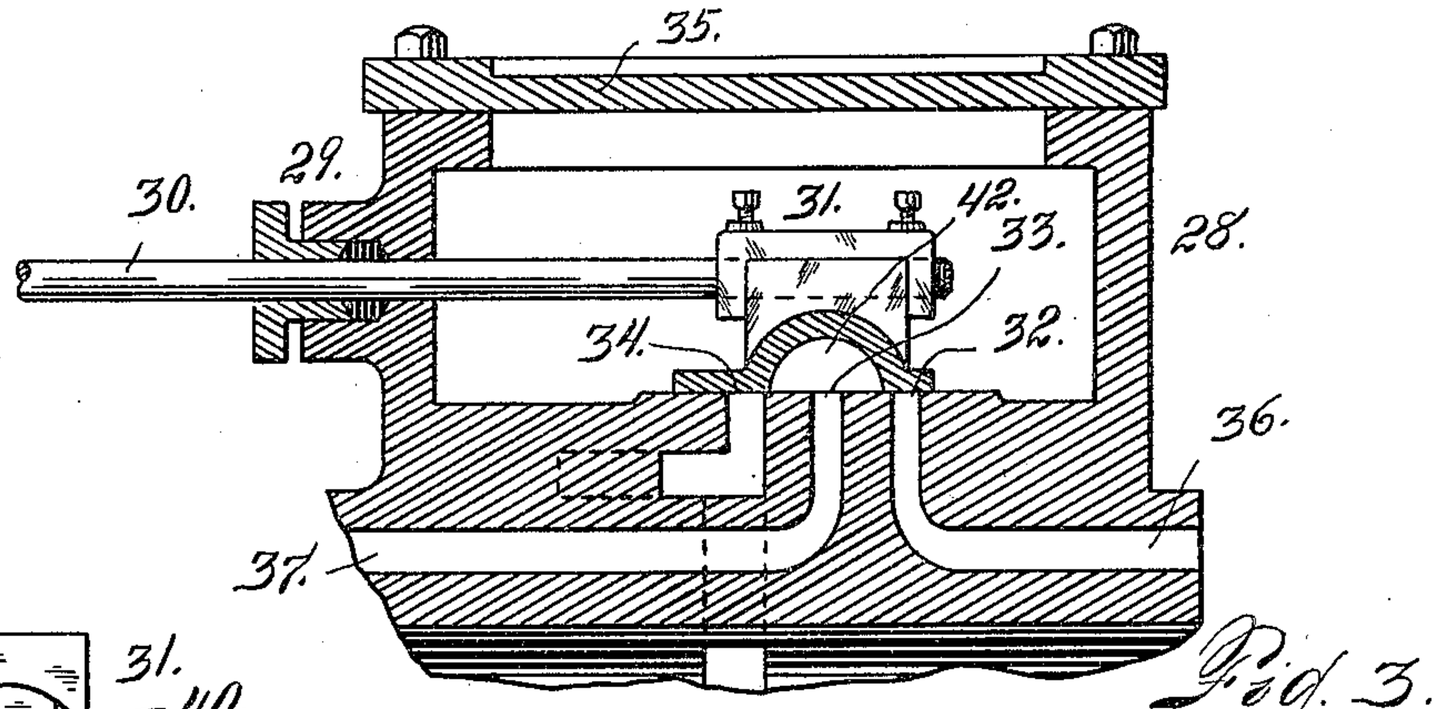

Fig. 3.

Fig. 6.

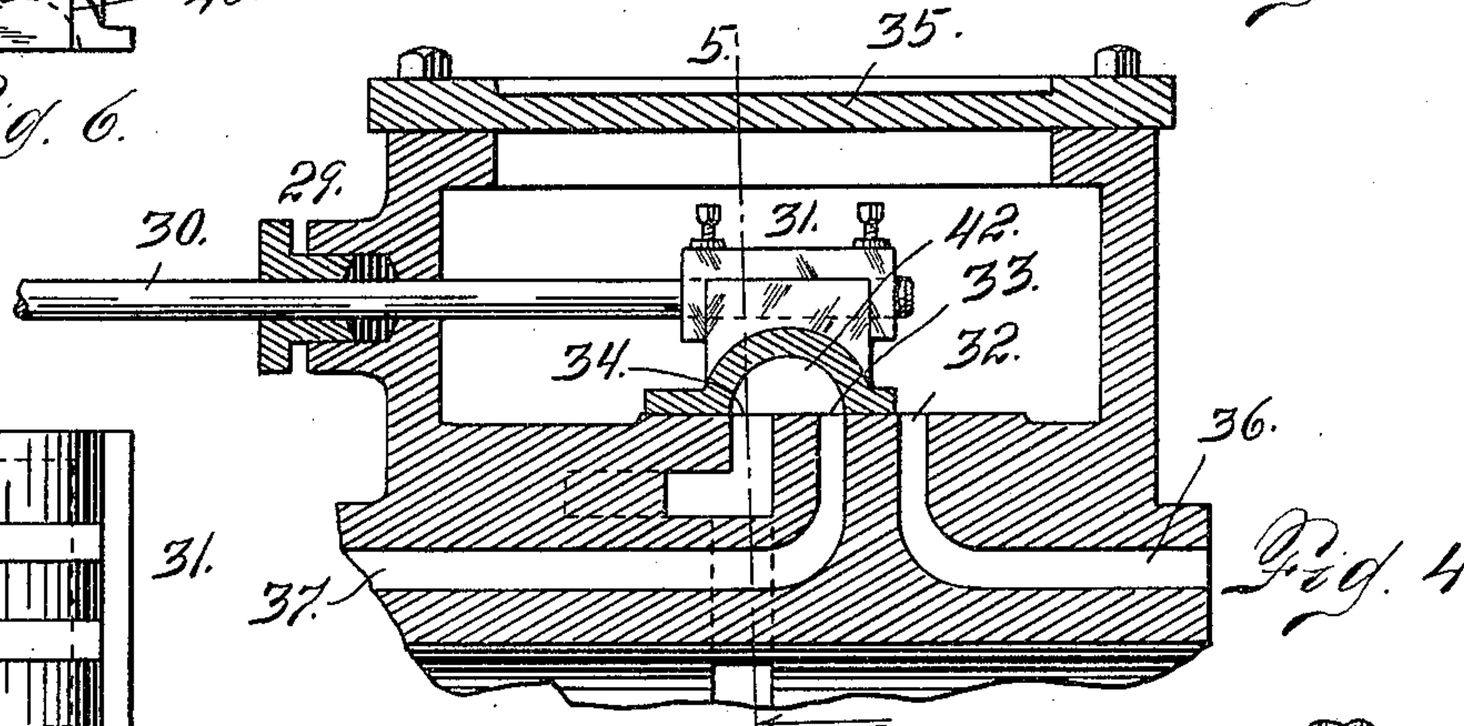

Fig. 4.

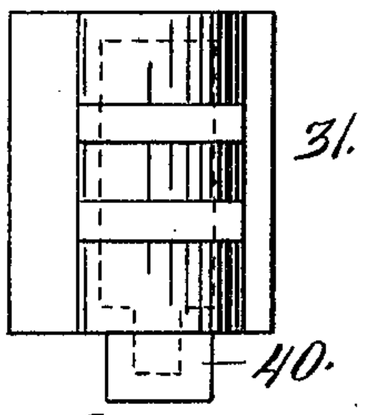

Fig. 7.

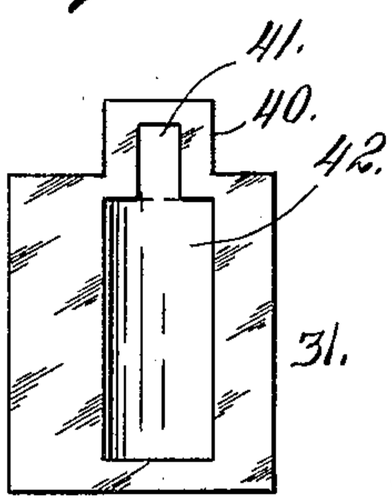

Fig. 8.

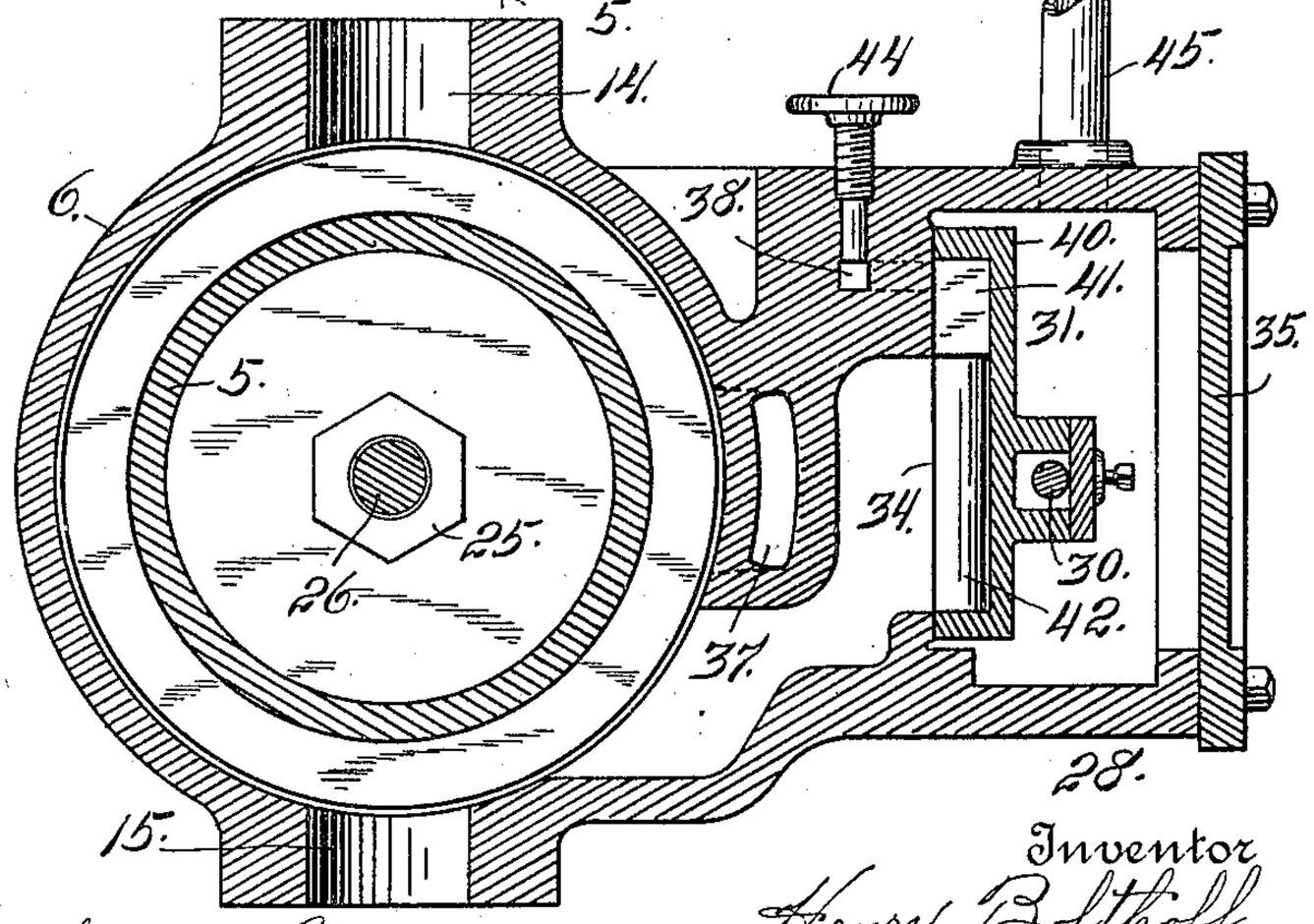

Fig. 5.

Witnesses

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4 SHEETS—SHEET 4.

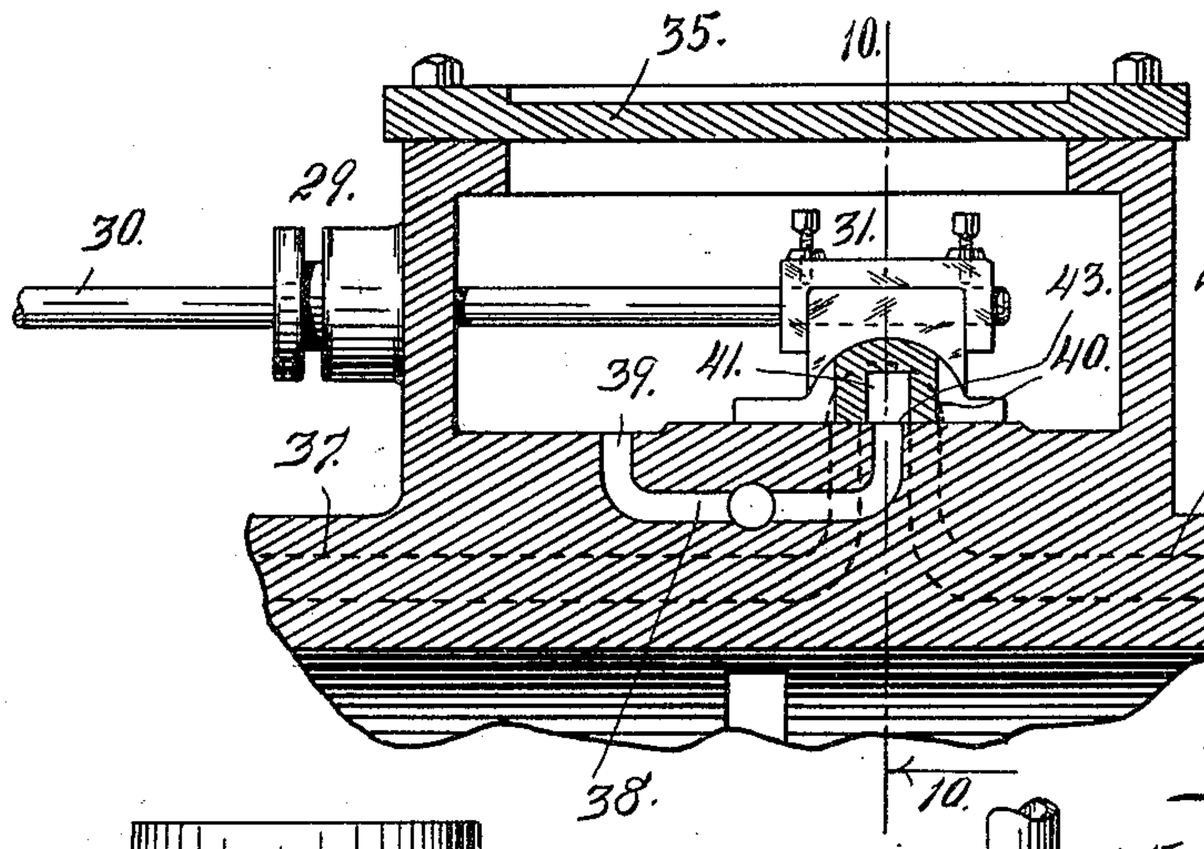

Fig. 9.

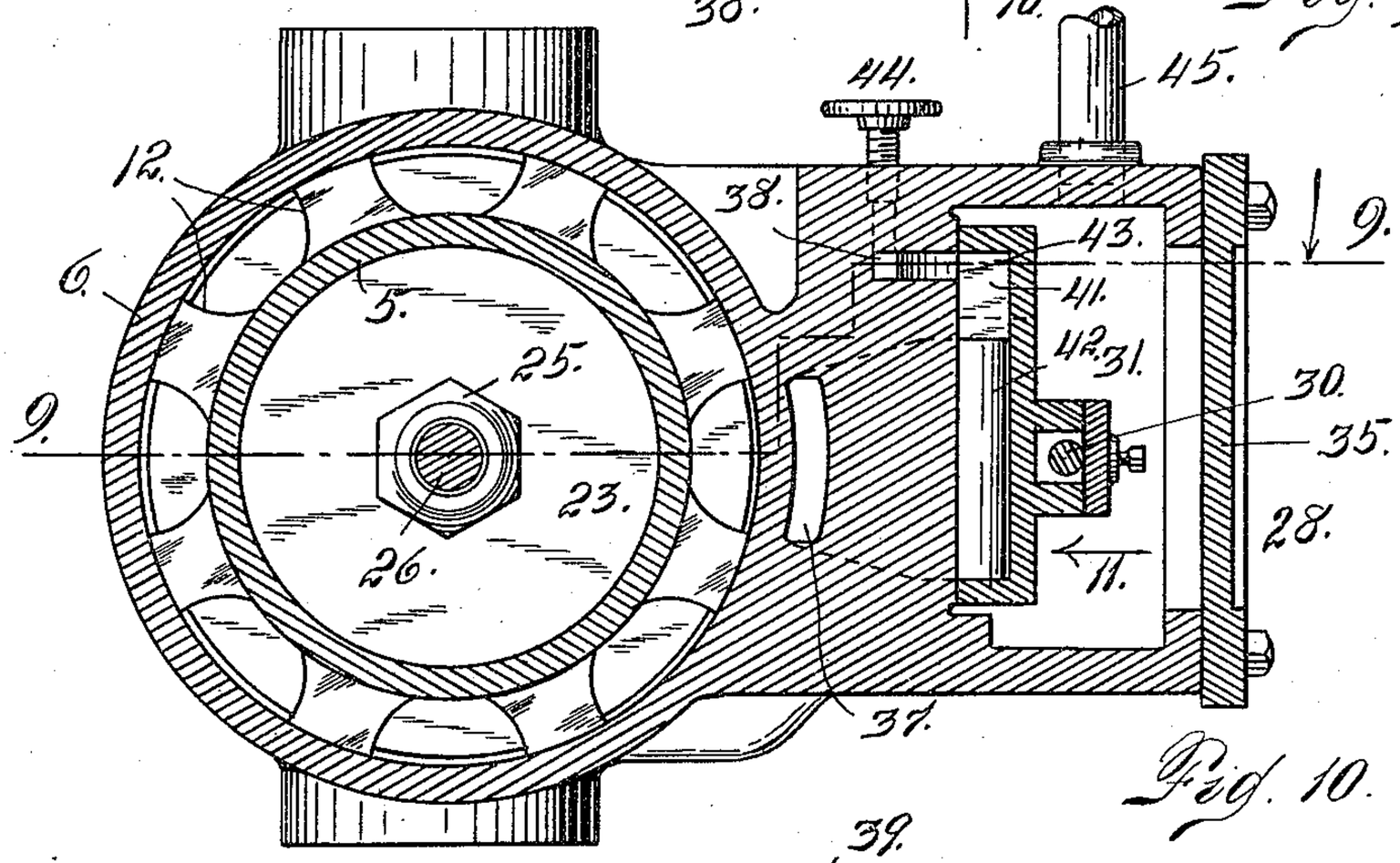

Fig. 10.

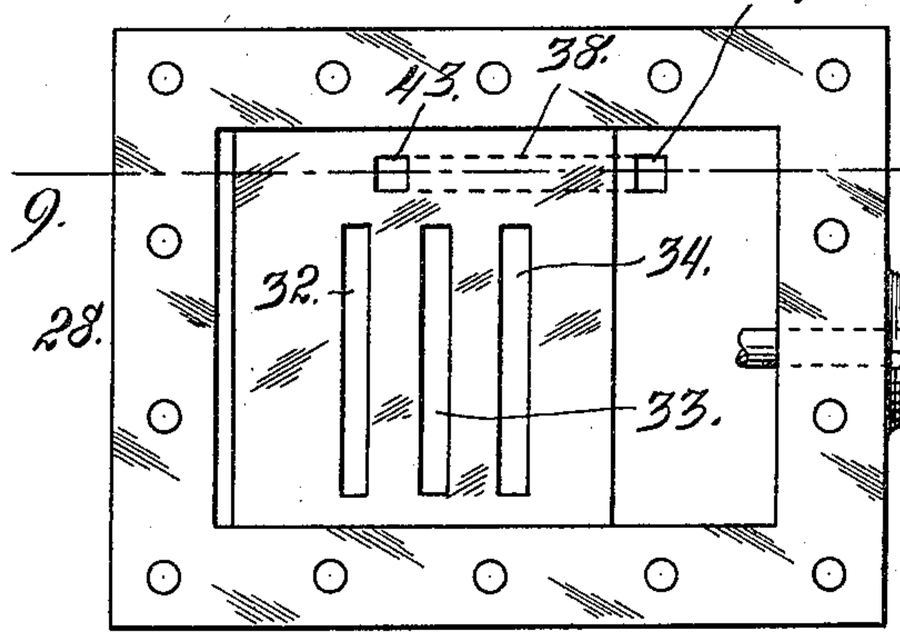

Fig. 11.

Witnesses

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UNITED STATES PATENT OFFICE.

HENRY BOLTHOFF, OF DENVER, COLORADO.

COMPOUND ENGINE.

999,432. Specification of Letters Patent. **Patented Aug. 1, 1911.**

Application filed June 1, 1910. Serial No. 564,442.

To all whom it may concern:

Be it known that I, HENRY BOLTHOFF, a citizen of the United States, residing in the city and county of Denver and State of Colorado, have invented certain new and useful Improvements in Compound Engines; and I do declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to the letters and figures of reference marked thereon, which form a part of this specification.

My invention relates to improvements in compound engines, my object being to provide a simple and efficient engine of this type which shall be so constructed that live steam or motive fluid may, if desired, be fed to the low pressure cylinder simultaneously with the exhaust steam or fluid from the high pressure cylinder.

Furthermore, my improved construction is so arranged that both cylinders are in alinement, the pistons working therein being mounted on the same rod, the arrangement being such that the live steam in the high-pressure cylinder only acts on the piston to drive the latter in one direction, while the movement of the piston rod in the opposite direction is accomplished through the agency of the exhaust steam in the low pressure cylinder, either alone or in combination with live steam admitted through a bypass which may if desired be placed in communication with the low pressure cylinder simultaneously with the placing of the latter in communication with the exhaust from the high-pressure cylinder.

Having briefly outlined my improved construction, I will proceed to describe the same in detail, reference being made to the accompanying drawing, in which is illustrated an embodiment thereof.

In this drawing: Figure 1 is a side view of my improved engine, shown partly in section and partly in elevation. Fig. 2 is a horizontal section taken on the line 2—2, Fig. 1, looking downwardly, the parts being shown on a larger scale. Fig. 3 is a sectional view of the steam chest similar to Fig. 2, but showing the slide valve in a different relative position. Fig. 4 is a similar view showing the slide valve in still another position. Fig. 5 is a vertical cross section taken on the line 5—5, Fig. 4. Figs. 6, 7 and 8 are an end elevation, plan view and underneath view, respectively, of the slide valve shown in detail. Fig. 9 is a section taken through the steam chest on the line 9—9, Figs. 10 and 11. Fig. 10 is a section taken on the line 10—10, Fig. 9. Fig. 11 is a side view of the steam chest with the detachable plate removed. This would be a view looking in the direction of arrow 11, Fig. 10.

The same reference characters indicate the same parts in all the views.

Let the numeral 5 designate the high-pressure cylinder and 6 the low-pressure cylinder, the two cylinders having their axes in alinement. The high-pressure or smaller cylinder is provided with an exteriorly projecting flange 7 formed on the cylinder 5, and secured to the flange 8 on the cylinder 6 by means of screws 9 or other suitable fastening devices. The shell of the cylinder 6 overlaps and partly incloses that of the cylinder 5, leaving an annular space 10 between the overlapping portions of the two cylinders, the latter being spaced within this annular chamber by means of lugs 12 formed on the shell of the smaller cylinder. The annular space 10 is in communication with the chamber 13 of the cylinder 6 and also in communication with an exhaust port 14 and a drain port 15. The chamber 13 of the cylinder 6 is in communication with the chamber 16 of the cylinder 5, the space between the pistons of these two cylinders being always in communication with the exhaust port 14. The piston rod 17, is connected with a cross head 18, the latter actuating a pitman 19 connected with the engine shaft 20 in the usual or any suitable manner. The piston rod 17 passes through a stuffing box 21 with which the head 22 of the low-pressure cylinder is equipped. Within the cylinder 6, the rod 17 is connected to a piston 23 which fits closely within its chamber 13 and is secured to said rod by means of a shoulder 24 on one side and a nut 25 on the other side. Beyond the piston 23, the piston rod is extended, being somewhat reduced in size, as indicated at 26. The forward extremity of the piston rod is connected to a piston 27 which fits closely within the chamber 16 of the cylinder 5. When the engine is in operation, the live steam entering the cylinder 5 forward of the piston, moves the latter toward the rear, while the exhaust steam from the cylinder 5 enters the cham-

ber of the cylinder 6 in the rear of the piston 23 and drives the same forwardly, either alone or in conjunction with motive fluid, simultaneously admitted from the steam chest, as hereinafter more fully explained.

Let the numeral 28 designate the steam chest, having a stuffing box 29 at one extremity, through which a stem 30 passes, the inner extremity of the stem being connected with a slide 31 for controlling the ports 32, 33 and 34, formed in the bottom of the steam chest or the side located directly opposite the plate 35. In the special construction shown in the drawing, the steam chest is mounted on one side of the shell of the cylinder 6. The shell of the cylinder forms one of the walls of the steam chest, and the slide valve is reciprocated thereon. The port 32 communicates with a passage 36 leading from the steam chest to the forward extremity of the cylinder 5; while the port 33 communicates with a passage 37 leading from the steam chest to the rear extremity of the cylinder 6. The port 34 is the exhaust port and leads to the annular space between the two cylinders. The ports 32 and 33, while they have the same volume as the passages with which they connect, are flattened out or made narrower in order that the opening or closing of the said ports by the action of the slide valve may be accomplished more quickly or by a less movement of the valve, than were the ports wider. This is believed to be an advantage in a construction of this character, since the more quickly the ports are thrown wide open or completely closed, where the necessity for opening and closing exists, the more positive will be the results obtained.

In order that some live steam may be admitted to the cylinder 6 in the rear of the piston, simultaneously with the admission of the exhaust from the cylinder 5, to effect the proper degree of pressure in the larger cylinder, I have provided the steam chest with a sort of by-pass 38, one extremity 39 of which is always open to the steam chest, and the slide valve is provided with an extension 40 having a recess 41 in communication with the chamber 42 of the valve. As heretofore stated, the extremity 39 of this by-pass is always open or in communication with the steam of the chest, while its opposite extremity 43 is so located that when the slide valve is in such position (see Fig. 2) that its chamber 42 is in communication with both ports 32 and 33, the recess 41 is in communication with the port 43 of the by-pass, thus allowing the steam from the chest to mingle with the exhaust steam from the cylinder 5 and pass through to the cylinder 6 in the rear of its piston 23. This by-pass 38 may, if desired, be closed against the passage of live steam through the instrumentality of a valve screw 44 which is threaded into the top of the steam chest and capable of sufficient movement to either open or close the by-pass which the valve screw is arranged to intersect and completely or partially close, as may be desired, for the purpose of regulating the passage of the live motive fluid to the chamber of the cylinder.

When the engine is in use, the steam or live motive fluid enters the steam chest through a pipe 45, and if we assume that the slide valve is in the position shown in Fig. 4, that is to say, whereby the port 32 of the passage 36 is uncovered or placed in communication with the steam or live fluid, the said fluid passes to the forward extremity of the cylinder 5 and acting upon the piston 27 drives the latter rearwardly. This live steam continues to act upon the said piston until it has reached any desired position in its rearward travel. The action of the slide valve may be arranged to cut off the live steam from the cylinder 5 at any desired point.

Assuming now that the piston 27 has reached a point in its rearward travel sufficiently advanced to require that the live steam be cut off from the cylinder 5, the slide valve will move toward the right (see Fig. 3) sufficiently to cover the port 32 and it may be assumed that this port remains covered to allow the live steam to complete the rearward stroke of the piston 27 by expansion, after which the continued movement of the slide valve toward the right, (see Fig. 2), places the two ports 32 and 33 in communication through the chamber 42 of the slide valve, and the exhaust from the cylinder 5 forward of the piston 27 flows through the passage 36, slide valve chamber 42 and the passage 37 entering the chamber 6 in the rear of the piston 23. At the same time, the recess 40 of the slide valve registering with the port 43 of the by-pass 48 (see Figs. 9 and 10), and the live fluid flows through said by-pass into the recess 40, and thence into the chamber 42 of the slide valve, passing thence with the exhaust fluid through the passage 37 to the cylinder 6 in the rear of the piston 23. As the piston 23 is of greater area than the piston 27, the fluid acting on the piston 23 will move both pistons forwardly, and force the motive fluid from forward of the piston 27, through passages 36 and 37, to the rear of the piston 23, and when the forward stroke is completed, the slide valve will be shifted toward the left (see Fig. 4) sufficiently to cause the chamber 42 of the slide valve to register with the two ports 33 and 34, the latter being the exhaust port, whereby the motive fluid in the rear of the piston 23 is allowed to exhaust through the passage 37, the chamber of the slide valve and the exhaust port of the annular space 10 between the cylinders 5 and 6, and thence through the exhaust

port 14. At the same time the port 32 is uncovered and the live fluid flows from the valve chest through the passage 36 to the cylinder 5 forward of the piston 27, and the latter, together with the piston 23 and the stem 17, are driven again toward the rear and the operation heretofore described is repeated. The live motive fluid introduced to the rear of the piston 23 serves to increase the efficiency of the propelling power of the engine, due to the additional pressure on the piston 23 afforded by the live motive fluid. This live motive fluid compensates for any leakage or condensation of the fluid primarily introduced forward of the piston 27.

A suitable governor mechanism B constructed to be operated by the engine in any suitable manner, is provided for controlling or regulating the exhaust port 14, whereby when the speed of the engine is accelerated the exhaust port 14, is regulated to retard the exit of the exhaust from between the two pistons 23 and 27, thus causing the same to be confined between the two pistons and form a fluid cushion to be acted upon by the forward travel of the larger piston to retard the speed of the engine. As the cylinder 5 is smaller in area than the cylinder 6, only a portion of the fluid will follow the piston 27 into the cylinder 5, while the remainder of the fluid will be compressed in the annular space 10 and the cylinder 6 to form a fluid cushion for the piston 23.

It will be understood that if it is not desired to utilize the live motive fluid in conjunction with the exhaust in the low pressure cylinder, the valve screw 44 may be adjusted to close the by-pass, in which event when the exhaust fluid from the high pressure cylinder will be utilized in the low pressure cylinder.

As heretofore explained, the efficiency of the operation of the engine when the fluid is acting on the piston of the low pressure cylinder, depends upon the difference in area between the faces of the two pistons 23 and 27.

Having thus described my invention, what I claim is:

1. In an engine, the combination of two cylinders, of unequal diameter, arranged in alinement and in communication with each other, pistons fitted in the respective cylinder members, a common rod upon which both pistons are mounted, a motive fluid chest and slide valve mechanism, the chest and cylinders having ports and passages for delivering live motive fluid to the forward extremity of the smaller cylinder and allowing it to pass to the rear extremity of the larger or low pressure cylinder, the chest also having a passage controlled by the slide valve mechanism for introducing live motive fluid with the motive fluid passing from the smaller cylinder into the larger extremity of each cylinder, and another passage controlled by the slide valve for allowing motive fluid to pass between the two pistons from the larger cylinder, the exhaust taking place from between the two pistons, and means governed by the speed of the engine for controlling the exhaust from between the two pistons.

2. In an engine, the combination of two cylinders of unequal diameter, arranged in alinement and in communication with each other, pistons fitted in the respective cylinder members, a common rod upon which both pistons are mounted, a motive fluid chest and slide valve mechanism, the chest and cylinders having ports and passages for delivering live motive fluid to the forward extremity of the smaller cylinder and allowing it to pass to the rear extremity of the larger or low pressure cylinder, the chest also having a passage controlled by the valve mechanism for simultaneously introducing live motive fluid with the motive fluid passing into the larger cylinder, and another passage controlled by the slide valve for allowing the motive fluid to pass between the pistons from the other cylinder, the exhaust to the atmosphere taking place from between the two pistons, and means governed by the speed of the engine for controlling the exhaust.

3. A compound engine, comprising high and low pressure cylinder members in axial alinement and in communication with each other, pistons fitted in the respective cylinders, the exhaust to the atmosphere taking place from between the two pistons, and means governed by the speed of the engine for controlling the exhaust from between the two pistons, a rod upon which both the pistons are mounted, the pistons being so arranged that they simultaneously occupy corresponding positions in the two cylinder members, a motive fluid chest and slide valve mechanism therein, the chest and cylinders having ports and passages controlled by the slide valve mechanism, for admitting live motive fluid into the forward extremity of the high pressure cylinder and simultaneously exhausting fluid from the low-pressure cylinder, between the pistons, and for conducting the exhaust from the forward extremity of the high pressure cylinder to the rear extremity of the low pressure cylinder, substantially as described.

4. In a motive fluid actuated engine, the combination of two cylinder members of different diameters arranged in axial alinement, the rear extremity of one cylinder being in communication with the forward extremity of the other cylinder, pistons fitted in the respective cylinders, a rod upon which both pistons are mounted, a motive fluid chest having ports in communication with passages leading to the forward ex-

tremity of one cylinder and to the rear extremity of the other cylinder, and a third port for exhaust purposes, communicating with a passage leading to the chamber of the cylinders between the two pistons, and a slide valve located in the motive fluid chest and operable to uncover the port in communication with the passage leading to the forward extremity of one cylinder, at the same time that the port communicating with the rear extremity of the other cylinder is placed in communication with the exhaust port through the slide valve chamber, the slide valve being also operable to close the exhaust port simultaneously with the placing of the other two ports in communication with each other through the slide valve chamber to allow the exhaust to pass from the forward extremity of the high pressure cylinder to the rear extremity of the low pressure cylinder, the exhaust taking place to the atmosphere from between the two pistons, and means governed by the speed of the engine for controlling the exhaust from between the pistons.

5. A compound engine comprising a high-pressure cylinder, a low pressure cylinder, the rear extremity of one cylinder being in communication with the forward extremity of the other cylinder and also constantly in communication with the exhaust, a steam chest having a port in communication with the forward extremity of the high pressure cylinder, another port in communication with the rear extremity of the low pressure cylinder, a third port for exhaust purposes, a by-pass having two ports, and a slide valve adapted to be manipulated to open the port communicating with the forward extremities of the high pressure cylinder simultaneously with the placing of the low pressure cylinder port in communication with the exhaust port through the slide valve chamber, the slide valve also being operable to place the high pressure cylinder port, the low pressure cylinder port and one port of the by-pass in communication with one another through the chamber of the slide valve, simultaneously with the closing of the exhaust port, the exhaust port being in communication with the interior of the two cylinders, between the two pistons, and means governed by the speed of the engine for controlling the exhaust from between the two pistons.

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

HENRY BOLTHOFF.

Witnesses:
HORTENSE UHLRICH,
ELIZABETH BOWEN.