(No Model.)

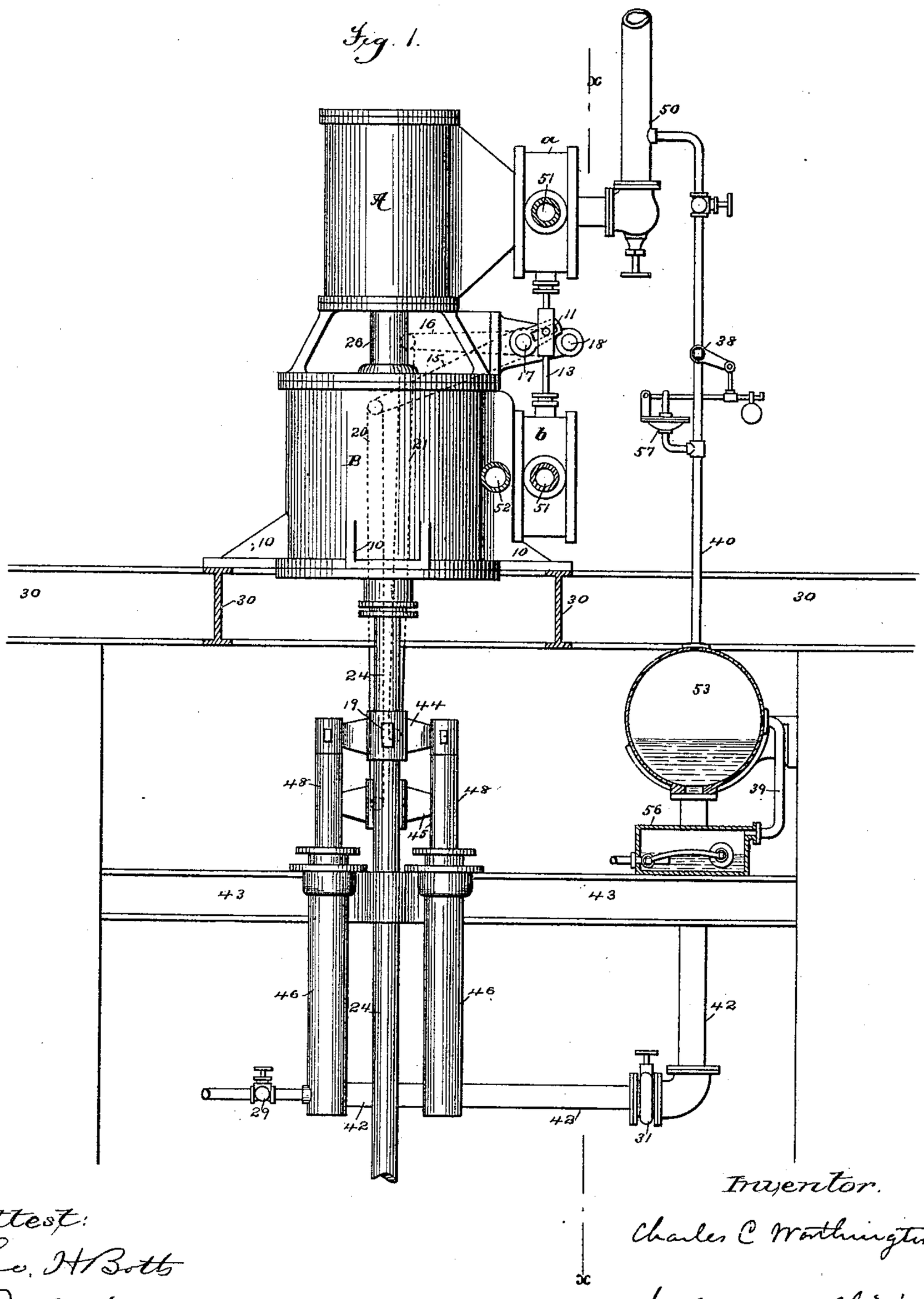
4 Sheets—Sheet 1.

C. C. WORTHINGTON.

DIRECT ACTING ENGINE.

No. 354,030. Patented Dec. 7, 1886.

Fig. 1.



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(No Model.)

4 Sheets—Sheet 2.

C. C. WORTHINGTON.

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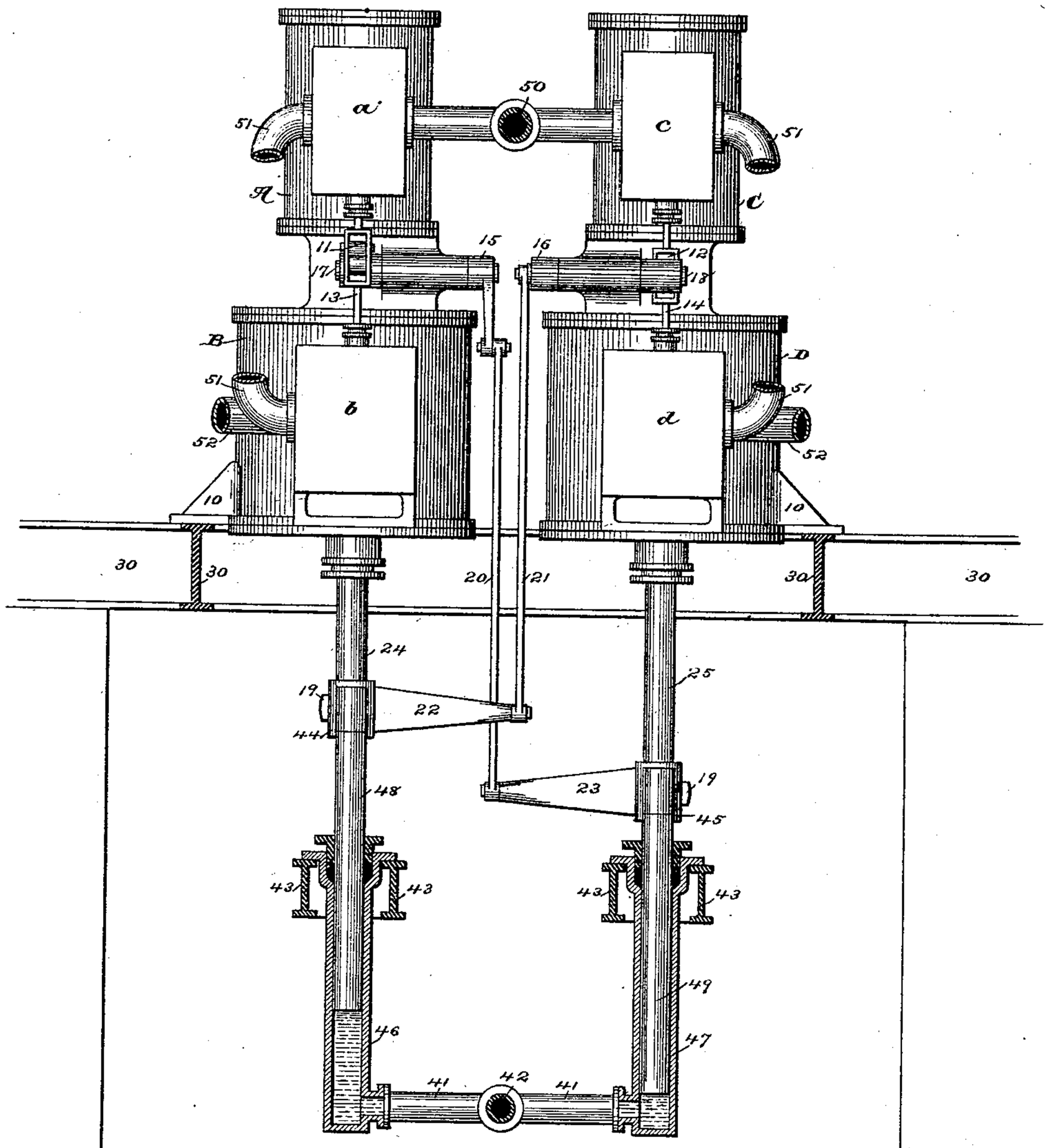
Fig 2.



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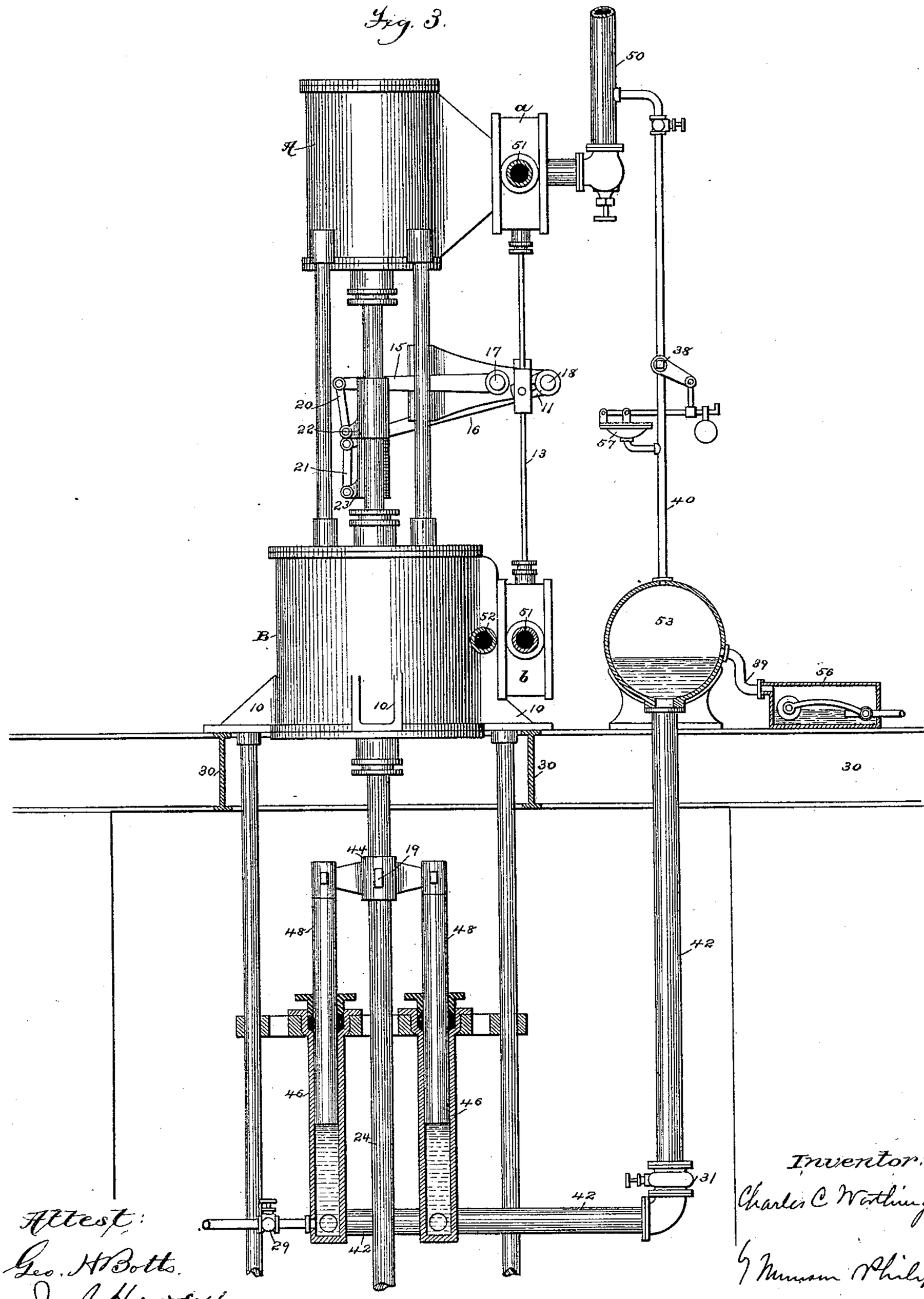
(No Model.) 4 Sheets—Sheet 3.

C. C. WORTHINGTON.

DIRECT ACTING ENGINE.

No. 354,030. Patented Dec. 7, 1886.

Fig. 3.



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4 Sheets—Sheet 4.

C. C. WORTHINGTON.

DIRECT ACTING ENGINE.

No. 354,030. Patented Dec. 7, 1886.

Fig. 4.

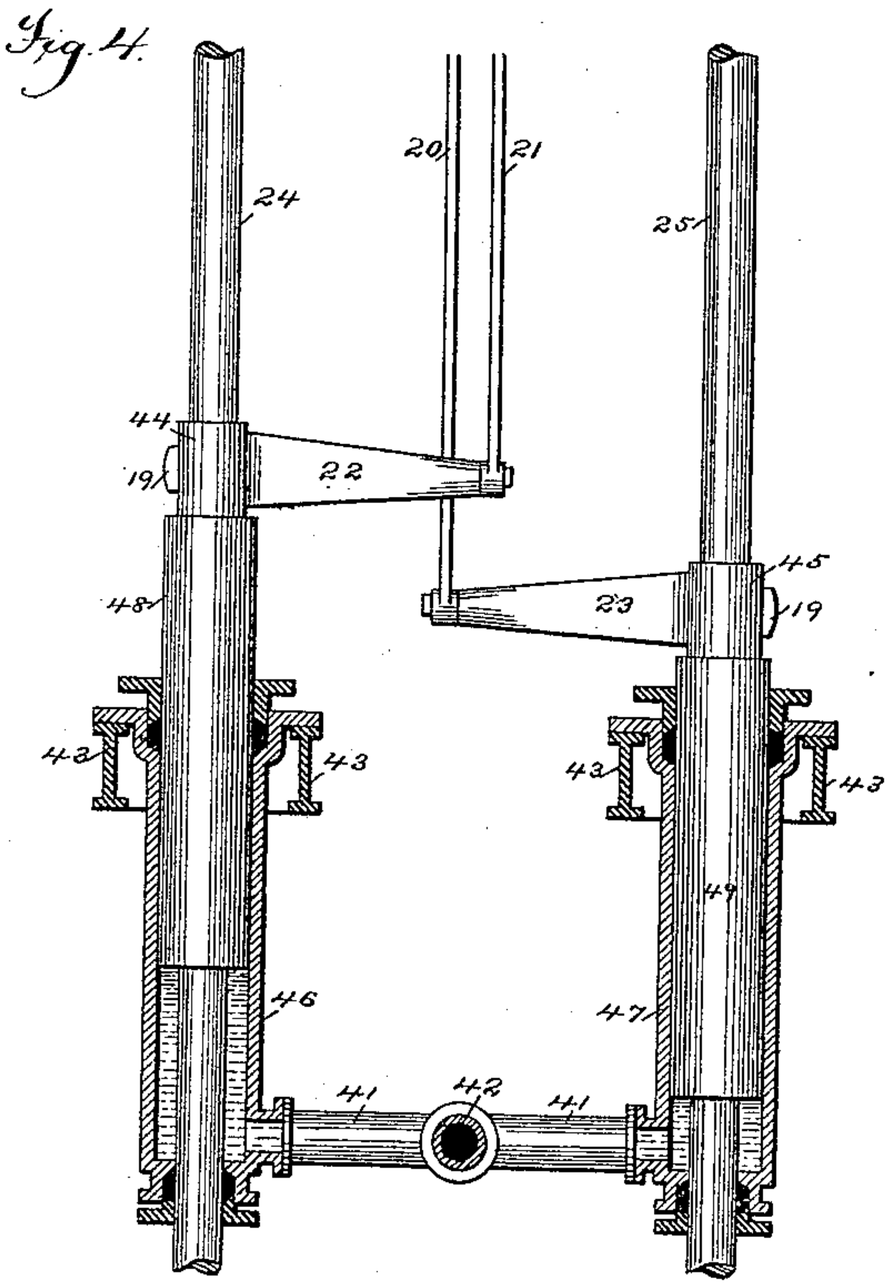
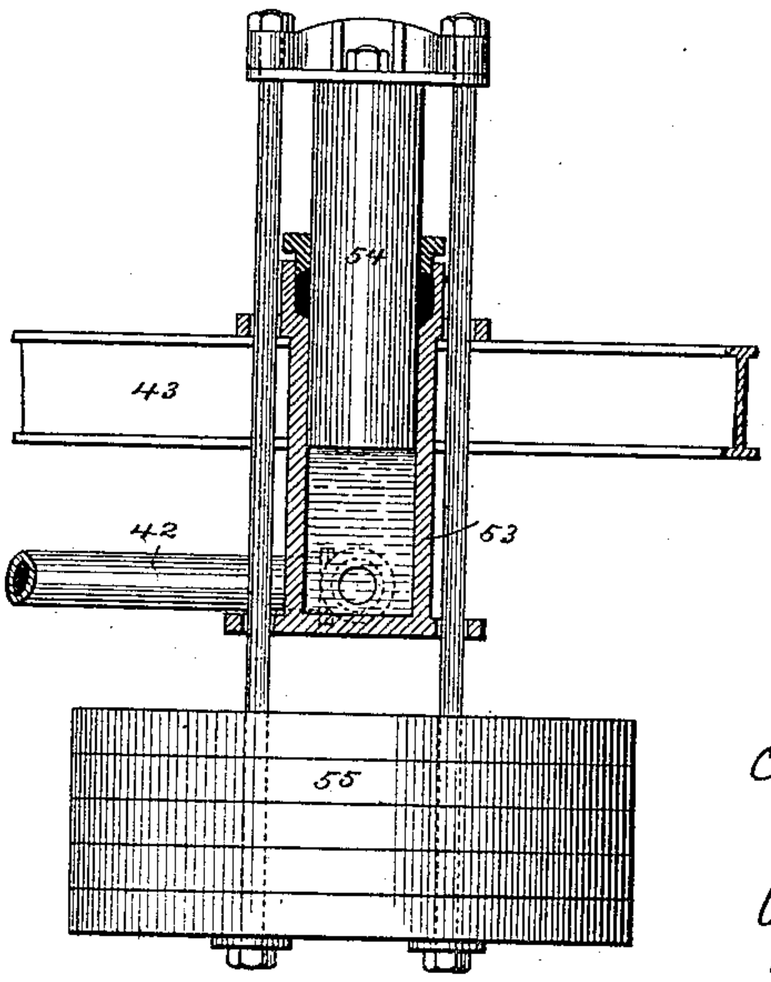


Fig. 5.



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UNITED STATES PATENT OFFICE.

CHARLES C. WORTHINGTON, OF IRVINGTON, NEW YORK.

DIRECT-ACTING ENGINE.

SPECIFICATION forming part of Letters Patent No. 354,030, dated December 7, 1886.

Application filed June 29, 1886. Serial No. 206,583. (No model.)

To all whom it may concern:

Be it known that I, CHARLES C. WORTHINGTON, a citizen of the United States, residing at Irvington, county of Westchester, and State of New York, have invented certain new and useful Improvements in Direct-Acting Engines, fully described and represented in the following specification and the accompanying drawings, forming a part of the same.

This invention relates generally to that class of engines which are known as "direct-acting engines," but more particularly to a duplex engine of this class which is arranged to act vertically and is provided with compound cylinders.

As a full understanding of the invention can be best imparted by a detailed description of the organization and operation of an engine embodying the same, all preliminary description will be omitted and a full description given, reference being had to the accompanying drawings, in which—

Figure 1 is a side elevation, certain parts being shown in section, of the steam end of a vertical compound duplex pumping-engine embodying the present invention. Fig. 2 is a front elevation of the same, taken on the line *x x* of Fig. 1, certain of the parts being shown in section. Fig. 3 is a view similar to Fig. 1, certain of the other parts being, however, in section, showing a modified organization of certain of the parts; and Figs. 4 and 5 illustrate other modifications, which will be hereinafter explained.

Referring to said drawings, it is to be understood that the steam end of the engine therein shown consists of four steam-cylinders, A B C D, which are arranged in pairs, and to operate upon the compound principle, the pair A B forming one side and the pair C D the other side of the duplex engine. The cylinders for each side of the engine are arranged vertically and one above the other, the larger or expansion cylinders, B D, being provided with projections 10, by which they are supported upon suitable beams, 30, above a pit, while the smaller or high-pressure cylinders, A C, are supported upon and a short distance from the upper heads of the larger cylinders.

The cylinders A B and C D are provided with the usual steam-chests, *a b* and *c d*, containing ordinary slide-valves (not shown) for controlling the admission and exhaust of the steam to and from the cylinders. The two valves for each side of the engine are, in the case shown, connected to a single valve-rod, and these rods 13 14 are provided with the usual connections, consisting of arms 11 12, rock-shafts 17 18, arms 15 16, and rods 20 21, which latter are connected to arms 22 23, extending from the main piston-rods 24 25, these connections being so arranged that the valves for each side of the engine are operated by the other in the manner common in duplex engines. The valve-rod for each side of the engine may, if preferred, be made in two parts. The pistons of the two cylinders forming each side of the engine are attached to a single rod, and these rods 24 25 pass downward through the lower heads of the larger cylinders, B D, and enter the pit, where they are connected directly to the plungers or pistons of the water end of the engine, which is not shown, but may be of any of the ordinary constructions, and is also arranged vertically.

It will be observed from the foregoing that the arms 11 12 for operating the valve-rods 13 14 are connected to these rods between the steam-chests *a b* and *c d*, respectively, instead of to extensions of the rods passing through the lower ends of the chests *b d*, as is common. By reason of this arrangement of the connections only one stuffing-box is required in each of the steam-chests, which not only simplifies the construction but reduces the friction upon the valve-rods.

In the organization shown in Figs. 1 and 2 the arm 22 23, to which the rods 20 21 for operating the valves are connected, are secured to the piston-rods below the cylinders B D, the rods 20 21 being arranged to extend between the cylinders. This arrangement requires the cylinders A C to be raised only a short distance above the cylinders B D, and as a consequence the cylinders are connected by tubular bearings 26, through which the piston-rods 24 25 pass, thus avoiding the necessity of employing stuffing-boxes.

In the organization shown in Fig. 3 the arms 22 23, instead of being located below the cylinders B D, are located between the cylinders A C and B D, and the rods 20 21 are cor-

respondingly shortened. This arrangement makes it necessary to raise the cylinders A C a greater distance from the cylinders B D. Except in these particulars, the organization shown in Fig. 3 is substantially the same as that shown in Figs. 1 and 2.

The steam is admitted to the steam-chests *a c* through the induction-pipe 50, and after performing its work in cylinders A C is exhausted through the pipes 51, and passes either directly or through a tank into the steam-chests *b d*, from which it passes to the cylinders B D, in which it acts expansively, after which it is exhausted through the pipes 52 and passes to the condenser or to the open air. This manner of using the steam is common in compound engines, and will be readily understood by those familiar with this class of engines.

In a direct-acting engine in which there is no fly-wheel or other heavy moving part provided for the purpose of storing up and equalizing the power, it is necessary, in order to prevent the engine from acting spasmodically, not only that the power developed by the engine should be uniform, or nearly so, through the entire length of the stroke, but also that it should be the same upon the strokes in each direction. It is therefore necessary, in the case of a vertical engine of this class, to provide means for balancing or counteracting the weight of the steam-pistons, the piston-rods, and the pump-plungers, as otherwise the power developed by the engine would be greater upon the downstrokes than upon the upstrokes—that is to say, upon the downstrokes the power developed would be equal to the pressure of the steam plus the weight of the steam piston or pistons, the piston-rod, and the pump-plunger, while upon the upstrokes the power developed would be equal to the pressure of the steam minus the weight of these parts, and this would cause the engine to act spasmodically. To overcome this the piston-rods 24 25 are each provided below their cylinders B D with one or more auxiliary pistons or plungers, 48 49, which work in auxiliary cylinders 46 47, and are arranged to act in opposition to the main steam-pistons during their downstrokes and in conjunction with them during their upstrokes. As shown in Figs. 1, 2, and 3, each of the piston-rods 24 25 is provided with two of the auxiliary pistons or plungers, which are located upon opposite sides of the rods and are connected to the rods by cross-heads 44 45, from which cross-heads also extend the arms 22 23, which operate the rods 20 21.

The auxiliary cylinders 46 47 are supported upon beams 43, which extend across the pit below the steam-cylinders, and are connected at their lower ends by a pipe, 42, and branches 41 with a tank or reservoir, 53, which is partly filled with a liquid—such as water or oil—which liquid also fills the pipes 42 41 and the cylinders 46 47 below the plungers. The liquid in the tank 53 is maintained at the proper pressure in any suitable or convenient manner. This may be accomplished in several ways. As shown in Figs. 1 and 3, the tank 53 is connected by a pipe, 40, with the steam-pipe 50, so that the liquid in the tank 53 is subjected to the steam-pressure. The tank 53 may, however, communicate with the air-chamber of the pump; or the tank 53 may be supplied with air under pressure by a suitable air-compressor operated by the engine or otherwise. In any of these cases the pressure upon the surface of the liquid in the tank 53 simply amounts to so much weight, and from this it follows that the tank may be in the form of a cylinder, as shown in Fig. 5, and be provided with a plunger or piston, as 54, which acts upon the surface of the liquid. In this case the plunger 54 may be acted on by liquid or fluid pressure, or may be provided with suitable weights, as 55, and will form an accumulator for maintaining the liquid under the proper pressure.

The plungers or pistons 48 49 are of such size that when the normal pressure exists in the tank 53 or upon the liquid which acts upon the plungers the upward pressure upon the plungers will be sufficient or about sufficient to overcome the weight of the steam-pistons, the piston-rods, and the plungers or pistons of the pump. From this it results that upon the downward strokes the resistance offered by the plungers equals the weight of the steam-pistons, &c., and reduces the power developed by the engine, while upon the upward strokes the assistance afforded by these plungers equals the weight of the steam-pistons, &c., and increases the power developed by the engine, thus making the power developed by the engine upon the up and down strokes equal or practically equal.

It will of course be seen that it is not necessary that there should be two of the cylinders 46 47 and plungers 48 49 for each side of the engine. In Fig. 4 an arrangement is shown in which only one cylinder and plunger are employed. In this case the single plungers are formed by an enlargement of the piston-rods 24 25.

When the pressure in the tank 53 is direct steam-pressure, there will of course be more or less condensation in the tank, which will add to the water in the tank. In such case, therefore, it will be desirable to provide the tank with an overflow-pipe, as 39, which communicates with a steam trap, 56, and by which the water, when it rises above a certain height in the tank, is drawn off and discharged. In order to regulate the pressure in the tank 53, the pipe 40 may be provided with a cock or valve, as 38, which is controlled by an ordinary pressure-regulator, as 57. By this means the pressure in the tank can readily be maintained at any desired point below that in the pipe 50. When the accumulator is employed, as in Fig. 5, the pressure upon the pistons or plungers 48 49 can readily be varied and regu-

lated by adding or removing one or more of the weights 55.

In the organization shown in Figs. 1, 2, and 3 the cylinders 46 47 and plungers 48 49 also perform another important function in connection with an engine organized in the manner shown in the present case. It will readily be seen that in an engine thus organized the only practical way to obtain access to the cylinders B D is by removing the lower heads of the cylinders, and it will readily be understood that this, particularly in the case of a large engine, would be an extremely difficult operation.

It will be observed that the cross-heads 44 45 are secured to the rods 24 25 by keys 19, which can, when desired, be removed, so as to allow the cross-heads to slide freely along the rods. It will also be observed that the plungers 48 49 and cylinders 46 47 are of such length that when the cross-heads are allowed to slide freely along the piston-rods they (the cross-heads) can be allowed to move upward until they are arrested by the stuffing-boxes on the cylinder-heads. When, therefore, it is desired to remove a cylinder-head, the key 19 is removed. The pressure in the tank 53 will then move the plungers upward until the cross-head 44 or 45 rests against the stuffing box in the cylinder-head. The valve or gate 31 is then closed, so as to hold the plungers and cross-head in this position. The bolts of the cylinder-head can then be removed without danger of the head falling from its place. By then opening the cock or valve 29 the liquid will be drawn slowly out of the cylinders, thus allowing the plungers to move slowly downward and lower the head away from the cylinder and give access to its interior. When the head is to be restored to position, the cock or valve 29 is closed and the valve or gate 31 opened. The pressure in the tank 53 will then raise the plungers and carry the head back to position to be bolted to the cylinder.

The proper amount of liquid can be maintained in the tank 53 by means of a small force-pump, or in any other suitable manner.

Although the improvements constituting the present invention are herein shown as embodied in a duplex engine, it will readily be seen that they are for the most part equally applicable to single engines, and also that certain of the improvements are equally applicable to engines which do not use the compound cylinders.

What I claim is—

1. The combination, with the two cylinders, steam-chests, and valves of a compound engine, of connections for operating said valves, which are connected to the main piston-rod between said cylinders and to the valve rod or rods between said steam-chest, substantially as described.

2. The combination, with the cylinders, steam-chests, and valves of a compound duplex engine, of the rock-shafts 17 18, each connected to the valve-rod of one side of the engine between the steam-chests and to the main piston-rod of the opposite side of the engine, substantially as described.

3. The combination, with a vertical engine, of one or more cylinders, as 46 47, and pistons or plungers, as 48 49, which are supplied with a liquid under pressure and are arranged to act in opposition to the main piston or pistons during the downstroke of the latter and in conjunction therewith during the upstroke, substantially as described.

4. The combination, with a pumping-engine in which the pump rod or rods is or are vertical or substantially vertical, of one or more auxiliary cylinders and pistons or plungers, as 46 47 48 49, which are supplied with a liquid under the pressure of a gas, and are arranged to act in opposition to the main piston or pistons or plunger or plungers during the downstroke of the latter and in conjunction therewith during the upstroke, substantially as described.

5. The combination, with a vertical direct-acting engine, of one or more auxiliary cylinders which are located below the main cylinder or cylinders and have a piston or pistons or plunger or plungers which is or are connected to a cross-head which is detachably connected to the main piston-rod, substantially as and for the purpose set forth.

6. The combination, with the main piston-rod of a vertical engine, of one or more auxiliary cylinders and pistons or plungers, the pipe 42, and tank 53, containing a liquid, connections between said tank and a steam supply, and a steam-trap for withdrawing the surplus liquid from the tank, substantially as described.

7. The combination, with a vertical direct-acting engine, of one or more auxiliary cylinders located below the main steam cylinder or cylinders, and having a piston or pistons or plunger or plungers which is or are connected to a cross-head which is detachably connected to the main piston-rod, and the cocks or valves 31 29, substantially as described.

8. The combination, with a vertical engine, of one or more auxiliary cylinders, as 46 or 47, having a piston or pistons or plunger or plungers which is or are arranged to act in opposition to the main piston or pistons during the downstroke of the latter and in conjunction therewith during the upstroke, and an automatic pressure-regulator, 57, for regulating the power exerted by the auxiliary piston or pistons or plunger or plungers, substantially as described.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

CHAS. C. WORTHINGTON.

Witnesses:
T. H. PALMER,
GEO. H. GRAHAM.