(No Model.)

3 Sheets—Sheet 1.

W. A. P. BICKNELL.

PUMPING ENGINE.

No. 354,091.

Patented Dec. 14, 1886.

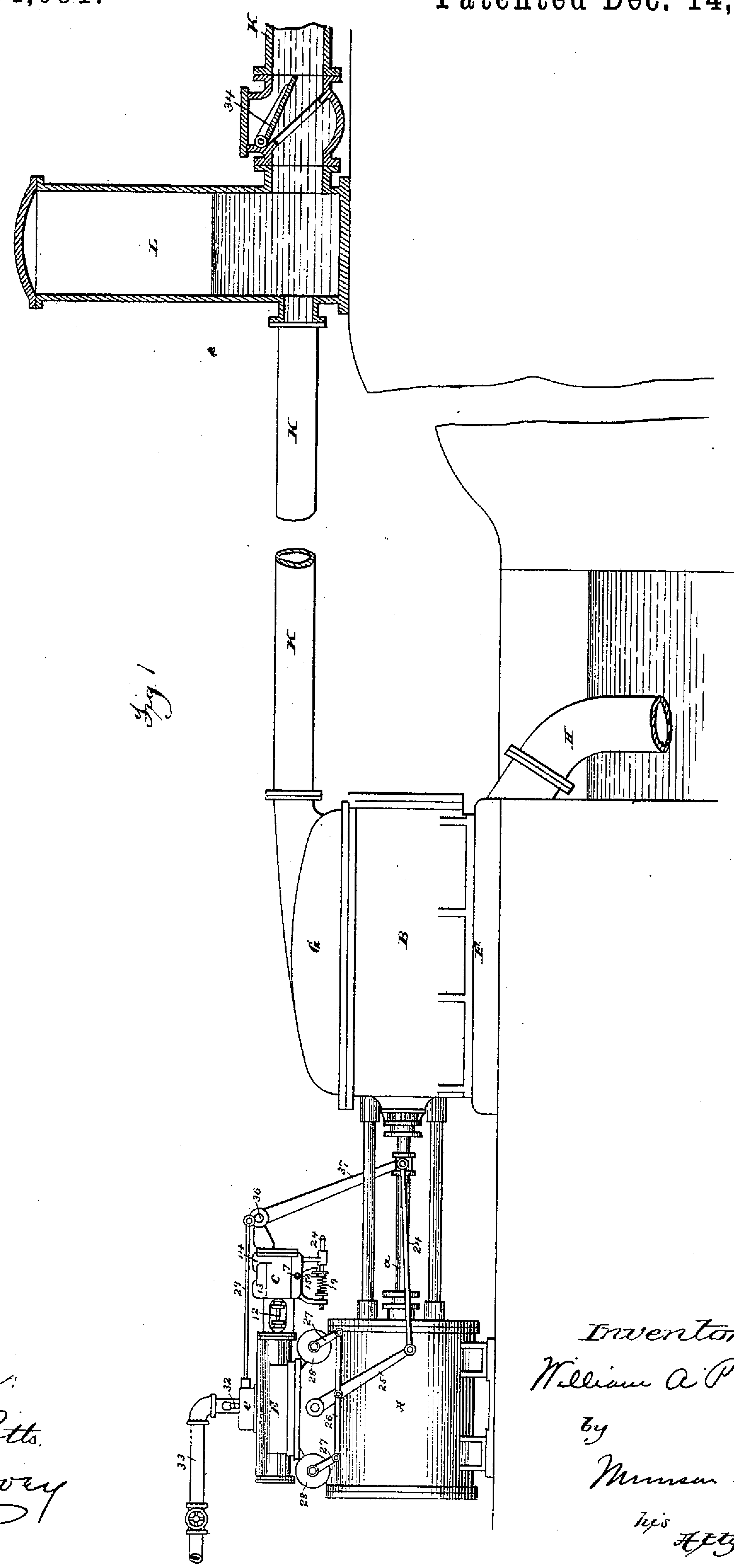

Fig. 1

Attest:
Geo. H. Botts.
J. A. Hovey

Inventor:
William A. P. Bicknell
by
Munson & Philipp
his Attys.

(No Model.)

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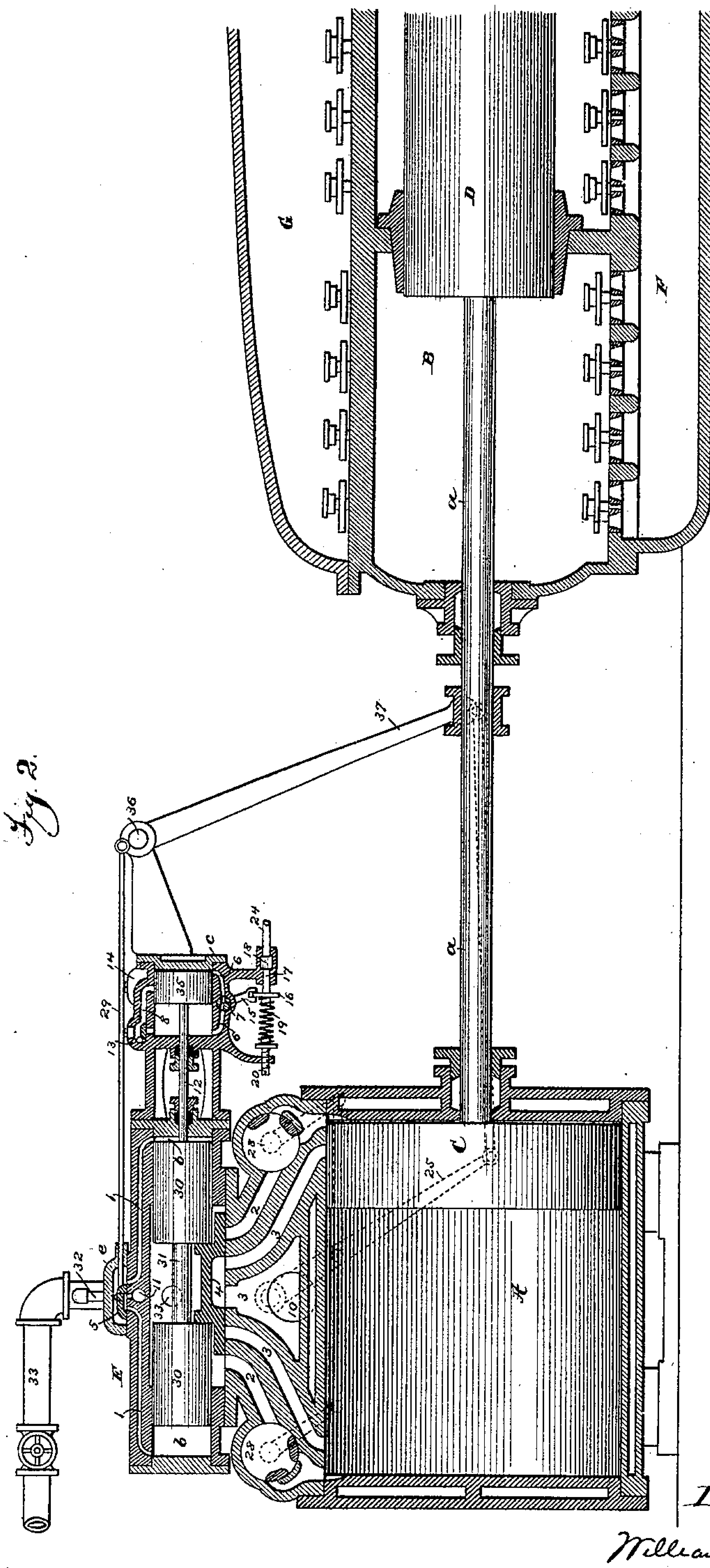
Fig. 2.



Attest:

Geo. H. Botts.

J. A. Hovey

Inventor:

William A P Bicknell

by

Munson & Philipp

his Attys:

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3 Sheets—Sheet 3.

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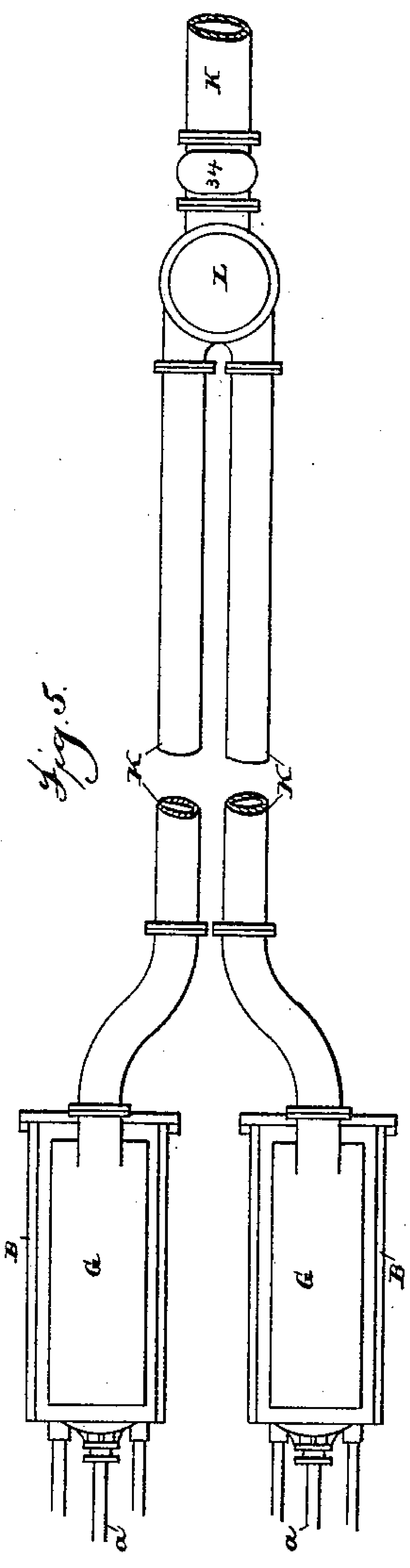

Fig. 5.

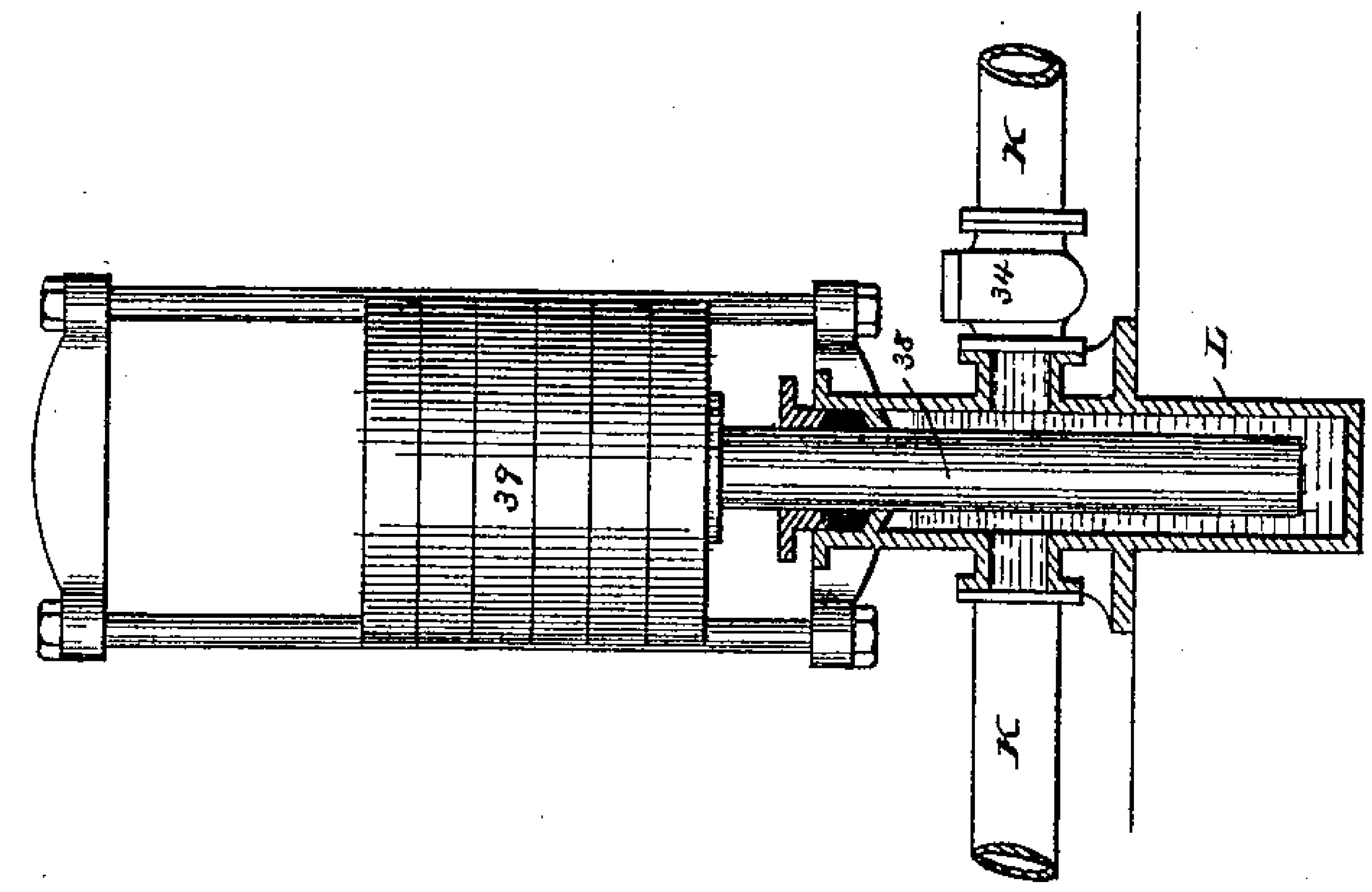

Fig. 4.

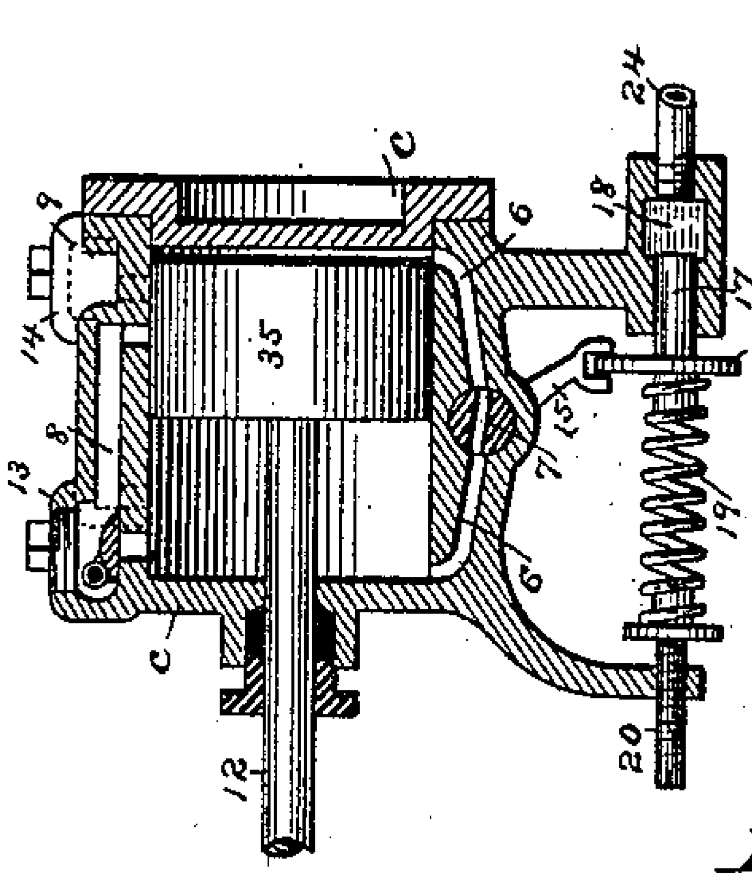

Fig. 3.

Attest:
Geo. H. Botts.
J. A. Hovey

Inventor:
William A P Bicknell
by
Munson Philipp
his Attys.

N. PETERS, Photo-Lithographer, Washington, D. C.

UNITED STATES PATENT OFFICE.

WILLIAM A. P. BICKNELL, OF NEW YORK, N. Y., ASSIGNOR TO WILLIAM A. PERRY AND CHARLES C. WORTHINGTON, BOTH OF SAME PLACE.

PUMPING-ENGINE.

SPECIFICATION forming part of Letters Patent No. 354,091, dated December 14, 1886.

Application filed August 4, 1886. Serial No. 209,956. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM A. P. BICKNELL, a citizen of the United States, residing at New York, county of New York, and State of New York, have invented certain new and useful Improvements in Pumping-Engines, fully described and represented in the following specification and the accompanying drawings, forming a part of the same.

This invention relates to that general class of engines which are known as "direct-acting," and particularly to an engine of this class which is designed for pumping liquids, or, in other words, a direct-acting pumping-engine. In an engine of this class, the same as in other classes of engines, it is of course desirable, for the sake of economy, to use the steam expansively. This has heretofore been accomplished in some cases by the use of compound cylinders, and in some cases by the employment of one or more auxiliary or compensating cylinders and pistons, which is or are arranged to act in opposition to the main steam piston or pistons during the first part of the stroke of the engine, and in conjunction therewith during the last part of the stroke, as shown and described in the United States Letters Patent granted to C. C. Worthington, January 29, 1884, No. 292,525, and in several subsequent patents to the same inventor.

It is the object of the present invention to provide means by which the steam can be used expansively in a direct-acting pumping-engine without the employment of compound cylinders or other means for securing an even distribution of the power throughout the entire stroke, and yet without resulting in a spasmodic or noisy action of the engine or an irregular discharge of the liquid from the force-main.

My invention is based upon the discovery that where the force-main of the pump is of sufficient length the moving column of liquid in the force-main can, by reason of its inertia, be made to perform the same or substantially the same function as a fly-wheel—that is to say, the column of liquid can, by reason of its inertia, be made to absorb or take up the excess of power developed by the engine during the first part of the stroke, when the pressure in the steam cylinder or cylinders is greatest, and will then give up this absorbed power, so as to aid the engine during the last part of the stroke, when the pressure in the steam cylinder or cylinders is reduced by reason of the expansion of the steam. In order that the column in the main may perform this function, it is of course necessary that the usual air-chamber which is located at or near the force-chamber should be omitted.

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

Figure 1 is a side elevation, partly in section, of a single direct-acting pumping-engine embodying my invention. Fig. 2 is a sectional elevation, upon an enlarged scale, of the steam end of the engine, or engine proper, and a part of the water end of the engine, or pump proper. Fig. 3 is a sectional elevation, upon a still larger scale, of the cataract apparatus for controlling the operation of the main steam-valve. Fig. 4 illustrates a modification, which will be hereinafter explained; and Fig. 5 is a diagrammatic plan view illustrating the manner in which the invention may be applied to a duplex pumping-engine.

Referring particularly to Figs. 1 and 2, it is to be understood that A represents the steam-cylinder, and B the water-cylinder, of an ordinary single direct-acting pumping-engine. The piston C of the steam-cylinder is connected directly to the plunger D of the water-cylinder by the piston-rod *a*, in the usual manner. The cylinder A is provided with the usual induction and exhaust ports, 2 3, which are controlled by an ordinary slide-valve, 4. The water-cylinder B is provided with the usual suction and force chambers, F G, the former of which communicates with the suction main H, and the latter with the force-main K. The force-chamber G is not provided with the usual air-chamber to equalize the flow from the force-chamber to the main, but the force-main is provided at a considerable distance from the pump with what I term an "equalizer," which is arranged to exert a yielding pressure upon the column of water in the force-main at that point, and thus permit the portion of the column which is between the equalizer and the pump to move at a varying velocity without affecting substantially the velocity of the column beyond the equalizer.

The equalizer may be made in different ways. As shown in Fig. 1, it consists of an air-chamber, L, which is about the size of or slightly larger than the air-chamber usually located at the force-chamber. The distance which the equalizer should be removed from the pump—that is to say, the length of the column of liquid in the force-main between the equalizer and the pump—will depend largely upon the diameter of the force-main, the size of the pump, the length of the stroke, the speed at which it is run, the head against which the pump is working, and the weight of the liquid being pumped. Assuming the liquid to be pumped to be water, the diameter of the force-main twelve inches, the diameter of the pump-plunger twenty inches, the length of stroke thirty-six inches, the number of strokes per minute forty, and the head two hundred feet, the length of the column between the pump and the equalizer should be about five hundred feet.

The force-main K will preferably be provided just beyond the equalizer with a check-valve, 34, the purpose of which is to prevent the reaction of the column of liquid in the main beyond the equalizer, and also to prevent that part of the force-main from becoming emptied in case it should be found necessary to take the pump to pieces for any purpose.

The valve 4 of the cylinder A may be operated in any of the ways common in this class of engines. The valve-operating mechanism will, however, preferably be of the form shown, which will now be described. The valve-chest E of the cylinder A is so formed as to provide at its ends two small cylinders, *b*, into which fit pistons or plungers 30, which are connected by a rod, 31, and are arranged so that their inner ends abut against the opposite sides of a projection formed on the top of the valve 4. The small cylinders *b* are provided with single induction and discharge ports 1, which are controlled by a small slide-valve, 5, located in a small steam-chest, *e*, on the top of the steam-chest E.

Steam is admitted to the chests E *e* through the usual induction-pipes, 32 33, and, after being used in the cylinders A *b*, is exhausted into the usual exhaust-pipes, 10 11. The inner one of the pistons 30 is provided with a rod, 12, which passes through the end of the steam-chest and is connected to a small piston, 35, which works in a cylinder, *c*, located at the end of the steam-chest E. The cylinder *c* is filled with oil or other liquid, and is provided with a duct, 6, which extends from end to end of the cylinder, and is controlled by a cock or valve, 7, by which the duct can be opened to a greater or less extent, so as to regulate the circulation of the liquid from one side to the other of the piston 35. In addition to the duct 6, the cylinder *c* is provided with two ducts, 8 9, which extend from the opposite ends of the cylinder, and open into the cylinder at points distant from its ends about two-thirds of its length. These ducts are controlled by outwardly-opening check-valves 13 14, which are arranged as best shown in Fig. 3. The valve 5 is provided with a rod, 29, which passes through the end of the steam-chest *e*, and is connected to a short arm extending from a rock-shaft, 36, having a second arm, 37, the lower end of which is connected to the piston-rod *a* in any of the common ways.

The engine may be provided with any suitable form of cut-off apparatus. The apparatus which is shown for this purpose is of substantially the same form as that shown in the Letters Patent No. 292,525, before referred to. It consists of two oscillating plugs or valves, 28, which are arranged in the induction-ports 2, and are provided with arms 27, which are connected by a rod, 26, which is in turn connected to a lever, 25, which is connected by a rod, 24, with the piston-rod *a*.

The operation of the engine thus organized is as follows: In describing this operation it will be assumed that the engine is in operation and that the parts are in the position shown in Figs. 1 and 2, the engine having just completed its inward stroke. It will be observed that just before the parts arrive in this position the arm 37 will have rocked the shaft 36, so as to move the valve 5 into position to permit the steam to enter the inner one of the cylinders *b*, and at the same time permit the steam already in the outer one of the cylinders *b* to be exhausted. As the steam enters the inner one of the cylinders *b*, it will move the pistons 30 35 outward, and thereby commence to shift the valve 4. This will take place just before or just as the piston C arrives at the end of its stroke, as shown in Fig. 1. As the pistons 30 35 are thus moved, the liquid in the cylinder *c* will be forced to circulate through the duct 6 from one side to the other of the piston 35, and the duct 6 being comparatively small, the liquid will flow through it slowly, thereby preventing the pistons 30 35 from moving quickly, so as to shift the valve 4 suddenly. This slow movement of the pistons 30 and the valve will prevent the live steam from being admitted in front of the piston C before it has fairly come to rest, and will secure the necessary pause or dwell at the end of the stroke, to permit the column of liquid between the pump and the equalizer to come to rest and the pump-valves to come to their seats without slamming, and to prevent undue strain upon the engine. The duration of the pause at the end of the stroke can be readily varied and regulated by adjusting the cock or valve 7 of the cataract apparatus, so as to permit the liquid to circulate more or less rapidly through the duct 6. The pistons 30, thus set in motion, will continue to move the valve 4 slowly until the valve commences to uncover the induction-port 2 at the inner end of the cylinder A, so as to admit steam behind the piston C, to start it upon its outward stroke. As soon as this takes place, it is desirable that the valve 4 should make the remainder of its stroke quickly, so as to fully open the induction-port 2 as quickly as possible. This is accomplished by means of the duct 8 and valve 13. It will be observed that during the first part of the movement of the pistons 30 35 the piston 35 covers the inner end of the duct 8, but just as the valve 4 commences to uncover the port 2 the inner end of the duct 8 is uncovered by the piston 35, and this permits the liquid in the cylinder *c* to raise the valve 13 and flow freely through the duct 8 to the other side of the piston 35, so as to offer very little resistance to the piston, and allow it and the pistons 30 and the valve 4 to be moved quickly by the steam for the remainder of their stroke.

As soon as the valve has been shifted, as just described, the full pressure of the steam will be exerted upon the piston C, to start it upon its outward stroke, and the power thus developed will be expended in starting and moving the column of liquid in the force-main. During the first part of the stroke, when the steam is acting at full pressure on the piston C, the power developed by the engine will be in excess of what is required to move the column of liquid at the mean or average velocity required, and the consequence will be that this excess of power will be expended in accelerating the velocity of the column, and thus the column will, as the piston approaches the middle of the stroke, acquire a greater velocity than is required. This extra velocity will not be imparted to the whole column, however, but only to that part of the column which is between the pump and the equalizer, and will result in compressing the air in the chamber L. After the engine has made a part of its stroke—say about one-third, more or less—the valve 28 at the inner end of the cylinder A will arrive in position to cut off the further admission of steam to the cylinder, and the piston C will proceed upon and complete its stroke under the expansive force of the steam already in the cylinder. As the steam expands in the cylinder, its pressure of course decreases, thus reducing the power of the engine until, as it nears the end of the stroke, the power will fall below what is required to move the column of liquid in the force-main. That part of the column between the pump and the equalizer, having, however, been accelerated during the first part of the stroke, will, by reason of its inertia, aided by the decreasing power of the engine, continue in motion, but at a decreasing velocity during the last part of the stroke, and thus permit the engine to complete its stroke. During the last part of the stroke, and during the pause before the commencement of the next stroke, the air in the chamber L, which was compressed during the first part of the stroke, will expand, and thus maintain a uniform or practically uniform pressure at that point, and secure a uniform flow of the liquid through that portion of the force-main beyond the air-chamber and a uniform discharge of the liquid from the force-main.

From what has been said it will be seen that that portion of the column of liquid in the force main which is between the pump and the equalizer is made, by reason of its inertia, to perform the same function as a fly-wheel—that is to say, it takes up the excess of power developed by the engine during the first part of the stroke, when the power is greater than is required, and gives off this power during the last part of the stroke, when the power developed by the engine is less than is required. It will be seen, however, that this result could not take place if the pump were provided with the usual air-chamber at or near the force-chamber, as in such case the excess of pressure of the steam at the commencement of the stroke would simply impart additional velocity to the pump-plunger, which would cause the air in the air-chamber of the pump to be compressed, but would not impart any additional velocity to the column in the force-main. From this it would result that when the steam-pressure was reduced during the last part of the stroke by the expansion of the steam the air in the chamber would expand and offer the same or substantially the same resistance to the pump-plunger, and as a result the engine would not be able to complete its stroke.

As the piston C arrives at the end of its outward stroke, it will cover the exhaust-port 3, and be brought to rest in the usual manner by cushioning upon the small amount of steam confined in the end of the cylinder. Just before the piston C arrives at the end of its stroke the valve 5 will be shifted so as to open the port 1, to admit steam to the outer one of the cylinders *b*, and the piston C will then make its inward stroke in the same manner as just described.

When the engine is in operation, the column of liquid in the force-main may not, owing to its inertia, come to rest at once upon the completion of the stroke of the piston C and plunger D, but continue to move in the main during the pause or dwell of the piston and plunger. This movement of the column will have a tendency to draw the liquid through the pump, and will raise all of the suction and force valves, as indicated in Fig. 2; but the pause of the engine at the end of the stroke will allow time for that portion of the column between the pump and the equalizer to come to rest, so that the valves will come to their seats and not be slammed by the starting of the plunger upon its return-stroke.

It has already been stated that the pause or dwell of the piston C at the end of the stroke can be readily varied by adjusting the cock or valve 7 so as to permit the liquid in the cylinder C to circulate more or less rapidly from one side to the other of the piston 35. From this it follows that the cock or valve 7 can be made to operate as a governor to regulate the speed of the engine. For this purpose the cock 7 is provided with an arm, 15, which is bifurcated at its end and straddles a disk, 16, which is secured to the end of a small plunger, 17, which enters a small cylinder or chamber, 18, formed below the cylinder *c*, as best shown in Fig. 3. The chamber 18 communicates by a pipe, 24, with the force-main K at or beyond the equalizer. The disk 16 is provided with a spring, 19, which is arranged to act in opposition to the plunger 17, and is of sufficient strength to just counteract the pressure which exists in the main when the engine is operating at its normal speed. From this arrangement it results that whenever the pressure in the main is increased beyond the proper point this increased pressure will be communicated to the plunger 17, and will overcome the tension of the spring 19 and operate the cock 7, so as to check the flow of the liquid from one side to the other of the piston 35, and thus lengthen the pause of the piston C at the end of the stroke. As soon as the pressure in the force-main is reduced, the spring 19 will again open the cock 7. The spring 19 is provided with an adjusting-screw, 20, by which its tension can be regulated, as may be required.

From what has been said it will be seen that the volume of air in the chamber L is, in effect, a cushion or spring—or, in other words, a yielding connection—interposed between that part of the column of liquid which is beyond the air-chamber and that part which is between the air-chamber and the pump, its function being to permit the part of the column next to the pump to move at varying velocities without materially affecting the velocity of the part beyond the air-chamber. This being the case, it is apparent that other means than the volume of confined air may be employed to effect the same result. For example, as illustrated in Fig. 4, the equalizer is in the form of an accumulator, and accomplishes the same result. As shown in said figure, the chamber L, instead of being filled with a body of air, is provided with a plunger, 38, which is acted on by suitable weights, 39. The action of the equalizer thus formed is the same as the body of confined air. As the velocity of the column of liquid between the chamber L and the pump is accelerated and its pressure increased during the first part of the stroke, the plunger 38 will be raised, and as the velocity and pressure decreases during the last part of the stroke the plunger will fall. Of course it will be understood that the plunger 38 may be acted on by a spring, instead of being weighted, or that the chamber L may be a cylinder having a piston which is acted on by either a weight or spring. Since the action of the body of confined air or the weighted or spring-pressed plunger or piston is, in effect, but a yielding weight or connection interposed between the two parts of the column in the force-main, it is evident that any form of equalizer which will perform this function will secure the desired effect, and will therefore be within the scope of the invention. In some cases the equalizer may consist of a simple stand-pipe located at the point occupied by the chamber L. In such case the liquid will simply rise in the stand-pipe during the first part of the stroke and fall back to its normal level during the last part of the stroke. When a stand-pipe with an open end is employed, it must of course be somewhat higher than the head against which the pump is working.

The present invention can be applied to duplex as well as to single pumping-engines. In such case each side of the engine will be provided with an independent force-main extending from the pump to the chamber L, as illustrated in Fig. 5. From the chamber L only a single main is necessary; or two or more independent pumps may be connected to the chamber L in the same manner as the two sides of the duplex engine.

What I claim is—

1. The combination, with a pump, of the force-main connected thereto without the intervention of an air-chamber and an equalizer, substantially such as described, located at such a distance from the pump that the column of liquid in the main between the equalizer and the pump will have sufficient inertia to perform the function of a fly-wheel, and arranged to exert a yielding pressure upon the column in the main, whereby that portion of the column between the equalizer and the pump may move at varying velocities without affecting substantially the velocity of the column beyond the equalizer, substantially as described.

2. The combination, with the pump, of the force-main connected thereto without the intervention of an air-chamber and an equalizer consisting of the chamber L, containing a volume of confined air located at such a distance from the pump that the column of liquid in the main between the equalizer and the pump will have sufficient inertia to perform the function of a fly-wheel, and arranged to exert a yielding pressure upon the column in the main, whereby that portion of the column between the equalizer and the pump may move at varying velocities without affecting substantially the velocity of the column beyond the equalizer, substantially as described.

3. The combination, with the cylinder *c*, having the duct 6, and the piston 35, forming the cataract apparatus, of the cock or valve 7, the chamber 18, having the plunger 17, connected to said cock or valve, and the pipe 24, connecting said chamber with the force-main K, substantially as and for the purposes set forth.

4. The cataract apparatus consisting of the piston 35 and the cylinder *c*, having the duct 6, and the ducts 8 9, provided with the valves 13 14, substantially as described.

5. The combination, with a direct-acting

pumping-engine and its force-main, of an equalizer, substantially such as described, located at such a distance from the pump that the column of liquid in the main between the equalizer and the pump will have sufficient inertia to perform the function of a fly-wheel, and arranged to exert a yielding pressure upon the column in the main, whereby that portion of the column between the equalizer and the pump may move at varying velocities without affecting substantially the velocity of the column beyond the equalizer, and means, substantially such as described, whereby the speed of the engine is regulated by varying the length of the pause of the engine at the end of each stroke, substantially as described.

6. The combination, with a direct-acting pumping-engine and its force-main, of an equalizer, substantially such as described, located at such a distance from the pump that the column of liquid in the main between the equalizer and the pump will have sufficient inertia to perform the function of a fly-wheel, and arranged to exert a yielding pressure upon the column in the main, whereby that portion of the column between the equalizer and the pump may move at varying velocities without affecting substantially the velocity of the column beyond the equalizer, and means, substantially such as described, whereby the main valve of the engine is moved slowly up to the point where the admission of steam begins and quickly thereafter, substantially as described.

7. The combination, with the pump and its force-main, of an equalizer, substantially such as described, located in the force-main and arranged to permit the inertia of the column in the main to aid the engine during the last part of the stroke, thereby permitting the steam to be used expansively, substantially as described.

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

W. A. P. BICKNELL.

Witnesses:
JAMES A. HOVEY,
JAS. J. KENNEDY.