(No Model.) 3 Sheets—Sheet 1.

C. C. WORTHINGTON.

DIRECT ACTING PUMPING ENGINE.

No. 504,644. Patented Sept. 5, 1893.

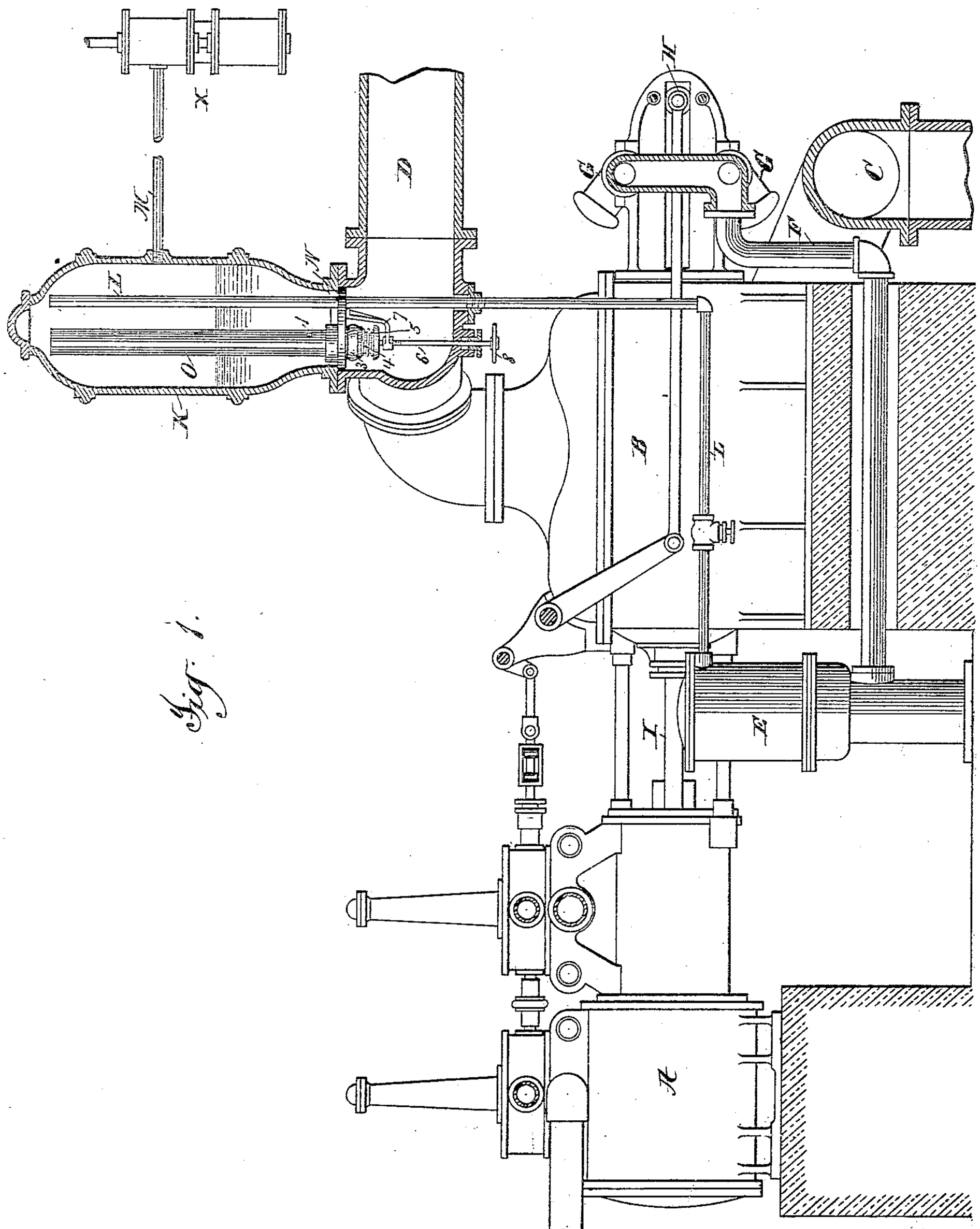

Fig. 1.

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Thos. F. Kehoe.

Inventor:
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by
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(No Model.) 3 Sheets—Sheet 2.

C. C. WORTHINGTON.

DIRECT ACTING PUMPING ENGINE.

No. 504,644. Patented Sept. 5, 1893.

Fig. 3.

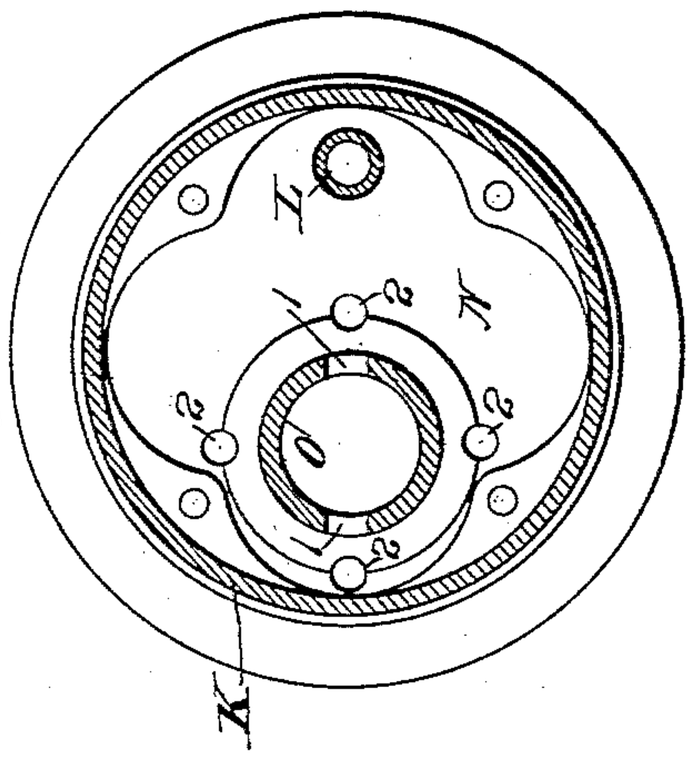


Fig. 4.

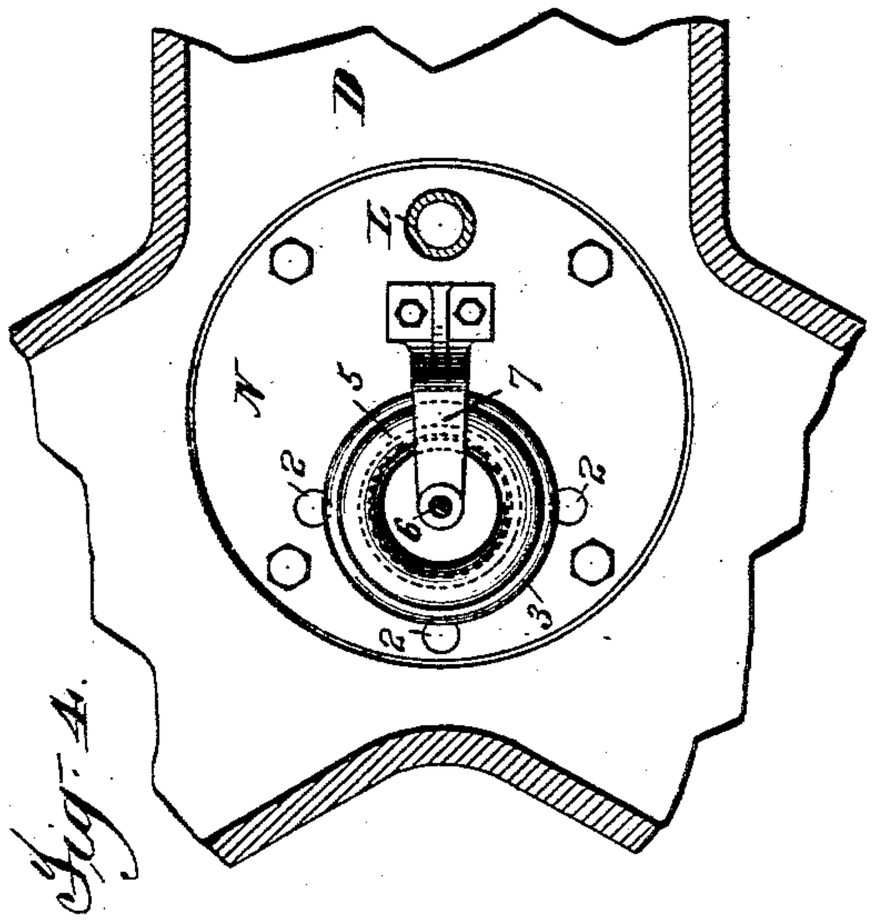
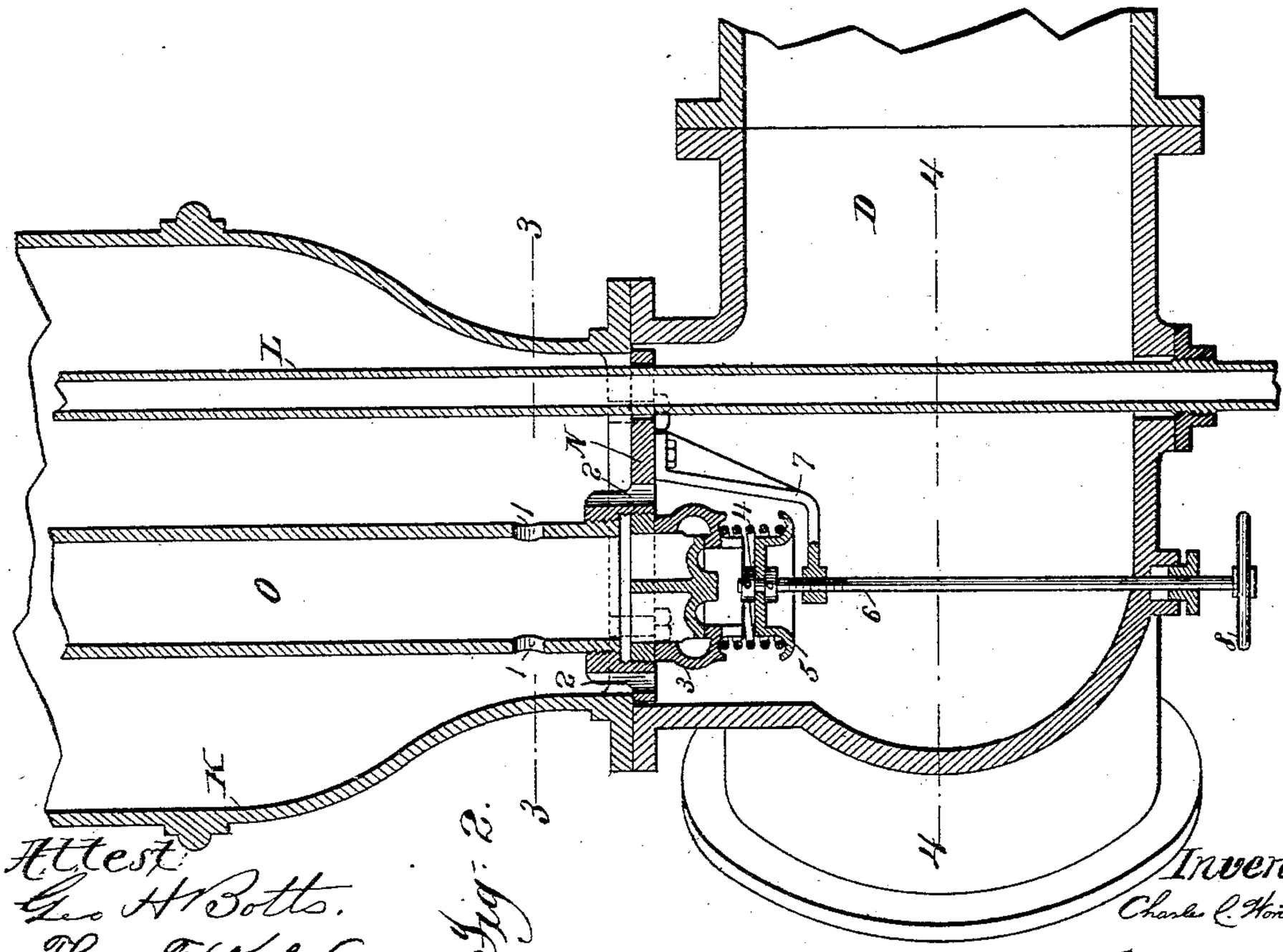


Fig. 2.



Attest:
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(No Model.) 3 Sheets—Sheet 3.

C. C. WORTHINGTON.

DIRECT ACTING PUMPING ENGINE.

No. 504,644. Patented Sept. 5, 1893.

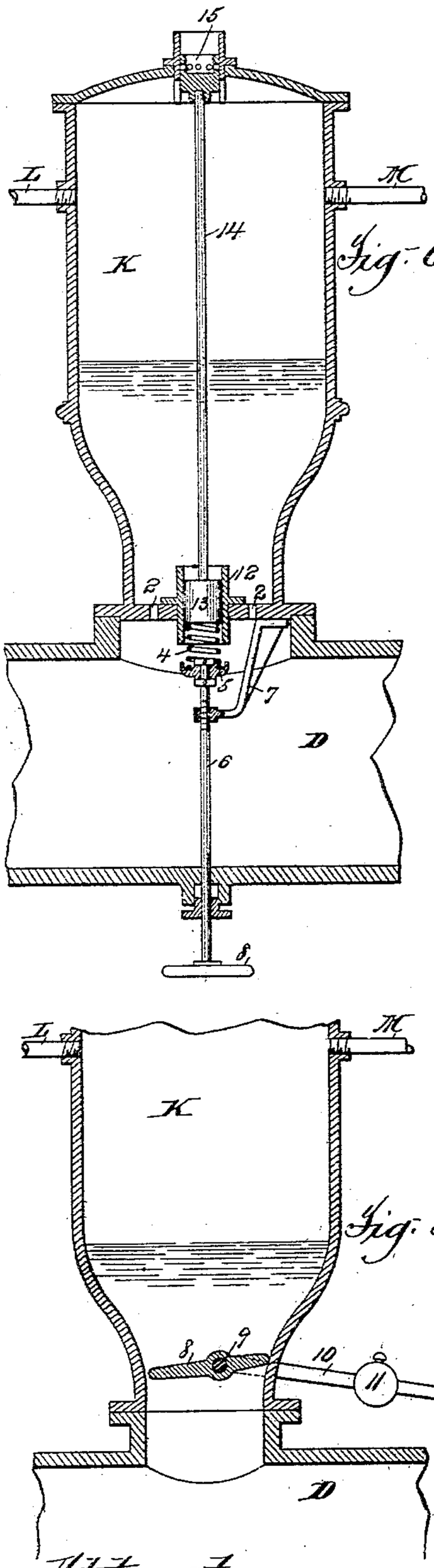

Fig. 6.

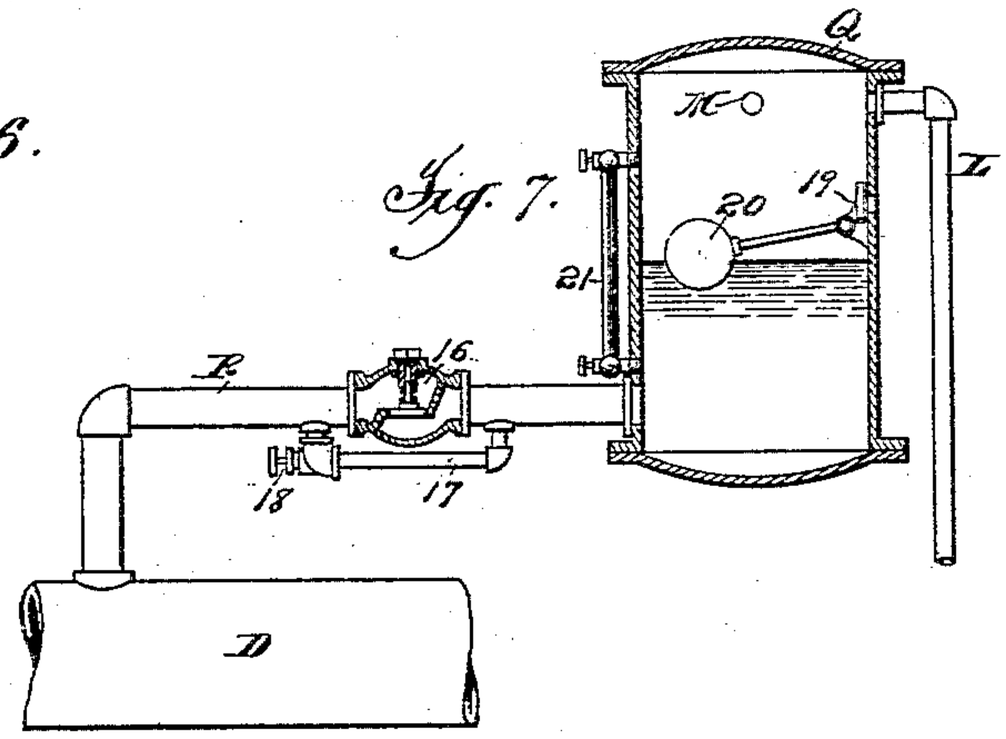

Fig. 7.

Fig. 5.

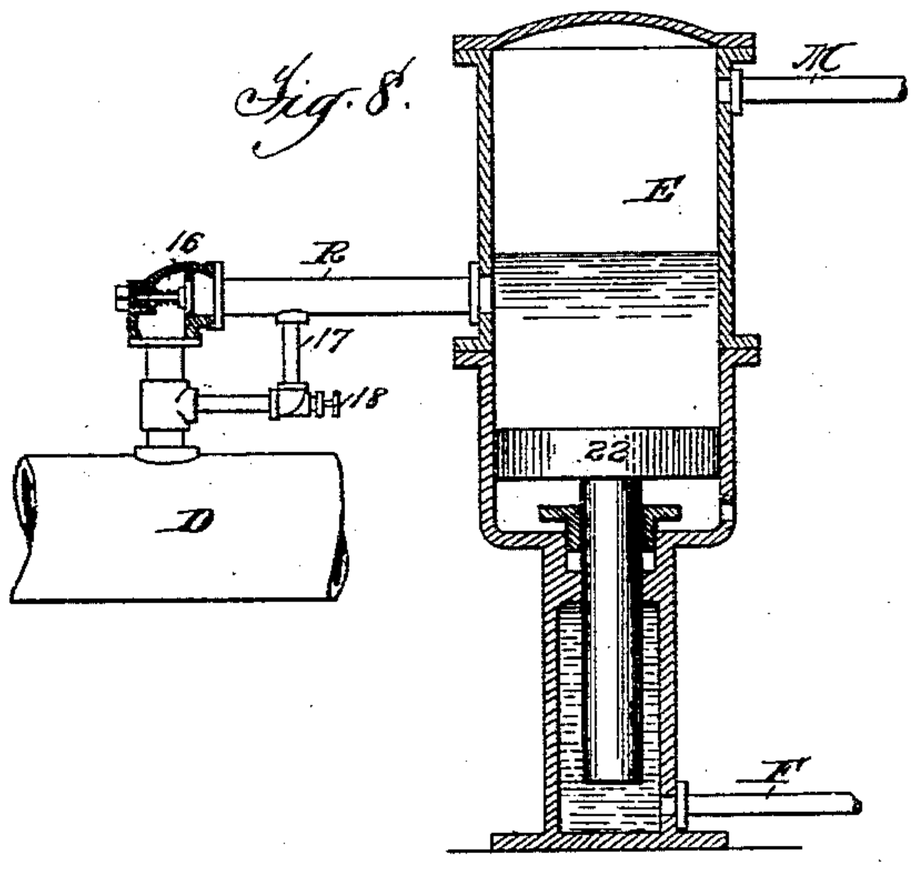

Fig. 8.

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UNITED STATES PATENT OFFICE.

CHARLES C. WORTHINGTON, OF IRVINGTON, NEW YORK.

DIRECT-ACTING PUMPING-ENGINE.

SPECIFICATION forming part of Letters Patent No. 504,644, dated September 5, 1893.

Application filed June 9, 1892. Renewed February 7, 1893. Serial No. 461,398. (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 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 class of direct-acting engines in which one or more compensating cylinders and pistons are employed to act in opposition to the main piston or pistons during one part of the stroke and in conjunction therewith during another part of the stroke. The motor fluid which operates upon the compensating pistons in engines of this class may be steam, air, water or other fluid. Where air or water is employed as the motor fluid, the necessary pressure is preferably derived either directly from the force main of the pump or through an accumulator by which this pressure is increased.

The improvements constituting the present invention are especially applicable to those engines in which the pressure for the compensating cylinders is thus derived from the force main, the object being to provide a construction by which the pressure shall be dependent on and vary gradually with changes in the force pressure, shall not be increased suddenly by a sudden increase in force pressure, but shall be relieved quickly upon a sudden reduction of force pressure.

In direct acting pumps employing compensating cylinders the pressure in the force main is subject to sudden variations due to various causes. Any sudden increase in the force pressure, if transmitted directly to the accumulator and compensating cylinders, produces an undesirable shock upon the compensating cylinders, and in case of a sudden fall of the force main pressure, the compensating cylinders, if continued under full pressure, cause a sudden decrease of speed and shock in the engine. I provide a simple construction by which the pressure of the accumulator and compensating cylinders is drawn from and depends upon the force main, and at the same time all difficulty in respect to sudden changes is avoided, by providing a valve controlling the pressure in the compensating cylinders and controlled by the pressures in the compensating cylinders or connections and the force main, so as to be opened to relieve the pressure in the compensating cylinders on a sudden fall of pressure in the force main, and by providing a small constant connection between the force main and compensating cylinders, so that the pressure in the compensating cylinders will rise or fall gradually with the pressure in the force main, but a sudden increase in the force pressure will not be transmitted to the compensating cylinders. I preferably employ an air chamber through which the force pressure is transmitted to the compensating cylinders, and employ a valve constructed to relieve the pressure in the air chamber when opened, and controlled by the pressures in the air chamber and force main, so as to be closed while the pressure in the force main is equal to or greater than that in the air chamber, but to be opened on a sudden decrease in the force pressure below that in the air chamber and relieve the pressure in the air chamber, a small constant connection between the force main and air chamber being provided through which water may pass gradually. By this construction any increase of force pressure is not transmitted to the compensating cylinders except by the gradual passage of water from the force main to the air chamber, so that any sudden rise of the force pressure produces no shock on the compensating cylinders, while the pressure in the compensating cylinder, or the accumulator when the latter is used, is normally that of the force main, as any continued rise of the pressure is transmitted by the passage of water through the small connection and the pressure in the air chamber gradually increased to that in the force main. Upon a sudden fall of the force pressure, the valve controlling the pressure in the air chamber is opened by the excess of pressure in the air chamber, and the pressure in the air chamber and consequently in the compensating cylinders is relieved by the escape of the air, or the water by which the air is held under compression, the construction being preferably so arranged that the air is allowed to escape im-

mediately on the opening of the valve or on the return of a small amount of water from the air chamber to the force main.

It is evident that this invention may be embodied in constructions differing widely and that, when the preferred construction, employing an air chamber is used, the air chamber may be mounted on the force main or connection between the force main and air chamber be made in any suitable manner, and that the air chamber also may form a part of the accumulator commonly employed in such constructions, or be connected thereto in the usual manner. It is preferable, however, that the air chamber be connected with the force main in such a manner that the water may be allowed to rise in the air chamber as the pressure of the air decreases, so as to preserve the pressure in the air chamber, and that the valve controlling the pressure in the air chamber be normally covered with water to prevent leakage of the air, while at the same time but a small body of water need be discharged before air is allowed to escape, so that the pressure in the air chamber may be quickly relieved, and I have devised a construction fulfilling these conditions which I preferably use and which in itself forms a part of my invention.

For a full understanding of my invention a detailed description of a construction embodying my invention in its preferred form, and certain modifications thereof will now be given, reference being had to the accompanying drawings in which I have shown my invention as applied to a duplex pumping engine with compensating cylinders, of substantially the general form and arrangement shown in many Letters Patent heretofore granted to me, of which special reference is made to Nos. 292,525, 332,857, 341,534, 422,680, 445,917 and 455,935. It will be understood, however, that the invention is applicable generally to pumping engines employing compensating cylinders.

In said drawings:—Figure 1 is a longitudinal section of a duplex engine embodying my invention, the section being taken between the pump cylinders. Fig. 2 is a detail vertical section of the parts embodying my invention. Fig. 3 is a section on the line 3 of Fig. 2 looking downward. Fig. 4 is a section on the line 4 of Fig. 2 looking upward. Figs. 5 to 8 show modifications.

Referring to said drawings it will be understood that A are the steam cylinders and B the water cylinders of the pump, and C, D, respectively the usual suction and force mains, E the accumulator of the usual construction from which pressure is transmitted through the pipe F to compensating cylinders G connected to the cross head H of the extended piston rod I, all these parts being constructed and operating as is common in this class of engine and substantially as shown and described in the patents above referred to.

Referring now to the parts embodying my invention, as shown in Figs. 1 to 4, K is a casting mounted on the force main in the position of the usual air chamber and forming the air chamber from which the pressure in the accumulator is drawn by a pipe L communicating therewith near the top. This pipe L may pass outside the chamber K but is preferably extended downward through the chamber and force main D and thence to the accumulator E between the cylinders on opposite sides of the pump. A pipe M enters the upper part of the chamber K and forms the air supply pipe through which air is forced to the pressure desired by an air compressor X shown in diagram. Between the air chamber K and the force main D is a plate N which forms the base of the chamber K, and in this plate N is secured a pipe O preferably of a considerable size, as shown, and extending nearly to the top of the chamber, this pipe being provided near its lower end with small openings 1 through which water may pass. The air chamber K communicates with the force main directly and constantly through small openings 2 in the plate N so that the pressure in the chamber and force main are maintained normally the same. The pipe O communicates with the force main D through a check valve 3 opening toward the force main and spring pressed by a spring 4 resting against a cap 5 which is carried by a rod 6 screw-threaded in a bracket 7, so as to be adjustable therein to vary the tension of the spring 4, this rod 6 being extended through the wall of the force main and provided with a handle 8 outside the force main for the purpose of adjustment. By this construction the valve 3 is kept normally closed by the pressure of spring 4, the pressure in the force main and air chamber being the same, and the pressure of the spring may be adjusted so as to regulate as desired the decrease of pressure allowed in the force main before the valve will be opened by the excess of pressure in the air chamber.

The operation of the construction will be understood from a brief description. The pressure in the force main D and air chamber K are normally the same, the water passing from the force main D through the small openings 2 in plate N and rising in the air chamber as the pressure of the air in the upper part of the chamber decreases, so as to preserve a uniform pressure, the check valve 3 being closed by the pressure of spring 4 while the pressure in the force main and chamber is substantially the same, or the pressure in the former the greater, any permanent increase of pressure in the force main therefore being transmitted gradually to the air chamber K by the water passing slowly from the force main into the air chamber through the openings 2 and compressing the air therein, while the air chamber does not respond quickly to such increase, so that a sudden rise of the force pressure is not felt in the compensating cylinders and no shock is produced

thereon. The pressure of spring 4 is preferably so adjusted that the valve 3 does not open upon a slight fall in the pressure of the force main, and the pressure is equalized again only by the passage of the water from the air chamber to the force main through the openings 2, but if the force pressure fall substantially and below the point for which the spring is adjusted, the check valve 3 is opened against the pressure of spring 4 by the excess of pressure in the air chamber, and the small amount of water in the pipe O flows out at once, and immediately upon the emptying of the pipe O some of the air in the cylinder K escapes through the pipe O, the water from the lower part of the air chamber passing through the openings 1 into the pipe O so slowly as not to interfere with the escape of air. The pressure in the air chamber is thus relieved and the effect of the compensating cylinders reduced almost instantaneously in accordance with the fall of pressure in the force main. Upon the reduction of the pressure in the air chamber to substantially that in the force main the check valve 3 closes.

While the construction thus far described embodies my invention in its preferred form, it is evident that this construction may be varied and that other constructions embodying my invention may be readily devised. Thus the openings 1 in the pipe O may be omitted so that the air escapes immediately upon the opening of the valve, and it may be found that the water will still seal the valve sufficiently to prevent the leakage of air, but the sealing is assured by the use of the holes, while the relief of the pressure in the air chamber is not substantially delayed. The valve construction may be used without the pipe O, and all the water in the air chamber pass out before the air, and this construction is efficient if the water be kept at a low level in the air chamber so as to secure a quick relief, but this requires constant or frequent supply of air to the air chamber.

In Fig. 5 I have shown a very simple construction in which the arrangement of the air chamber K on the force main and of the pipes L, M is substantially the same as that described, except that the pipe L is led to the accumulator outside the air chamber. In this figure, however, I show in place of the plate N and parts carried thereby for controlling the pressure in the air chamber, a simple disk valve 8 which is carried by a rod 9 mounted to rock in the base of the air chamber and provided outside the latter with a crank arm 10 carrying an adjustable weight 11 by which the valve is held normally closed when the pressure in the force main and air chamber are substantially the same, this weight 11 corresponding to the spring 4 in the construction previously described. The valve 8 is placed upon the rod 9 in such a manner as to open against the pressure of the weight 11 on a fall of pressure in the force main D, and is made to fit loosely when closed, so as to allow the gradual passage of water between the air chamber and force main, as in the case of openings 2 in the construction previously described. The operation of this construction is identical with that previously described, except that the pressure in the air chamber is relieved by the escape of the air only after all the water in the air chamber has passed out, the water being kept preferably at a low level in the air chamber as shown so as to secure a quick relief. With this construction, also, in which the opening of the valve affords space for the free escape of the water it will be found practicable to connect the pipe L with the chamber K below the normal level of the water in the air chamber, so that the pressure is transmitted from the air chamber to the accumulator or compensating cylinder through a column of water, and the pressure is relieved only by the escape of the water from the air chamber, the air being retained within the air chamber but allowed to expand by the escape of water. It is evident however, that the constructions in which the air is allowed to escape are much preferable, as a quicker relief may be given and moreover, upon the closing of the valve the pressure is more quickly equalized by the return of water through the passages 2, the amount to be returned being less. It is not necessary that the pressure in the air chamber should be relieved by the escape of water or air from the air chamber to the force main, but means may be provided by which the air is allowed to escape to the atmosphere independently of the level of the water in the air chamber, and in place of using a check valve between the air chamber and force main, the valve controlling the pressure in the air chamber may be controlled by a weighted or spring pressed piston subjected on opposite sides to the pressures in the air chamber and force main, so as to hold the valve closed when the pressure in the force main is equal to or greater than that in the air chamber, but to be actuated to open the valve on a fall of pressure in the force main. In Fig. 6 I have shown such a construction in which the base plate of the air chamber K has mounted therein a short cylinder 12 open at opposite ends to the force main and air chamber and in which moves a piston 13 subjected on opposite sides to the pressure in the force main and air chamber. This piston is connected by a rod 14 extending upward through the air chamber to a piston valve 15 constructed to allow the escape of air when the valve is moved downward to a certain point, but to prevent the escape of air when the valve is above this point. The spring 4, cap 5, rod 6, bracket 7, and hand wheel 8 of the construction shown in Figs. 1 to 4 are used, the spring pressing against the lower side of the piston 13 so as to keep the valve 15 normally closed to prevent the escape of air, and the base plate is provided with the small openings 2 to permit the gradual passage of water between the air chamber

and force main. In the operation of this construction, the piston 13 is normally held in position by the spring 4 so that the valve 15 is always closed to prevent the escape of air from the air chamber K when the pressure in the force main D is equal to or greater than that in the air chamber, the piston 13 being moved by slight variations of pressure but not so as to open the valve. Upon a sudden fall of pressure in the force main D below the point for which the spring 4 is adjusted, however, the piston 13 is moved downward by the excess of pressure in the air chamber so as to open the valve 15 and allow the escape of air from the air chamber to relieve the pressure therein. It will be seen that by this construction an immediate relief in the air chamber is secured, this being independent of the amount of water in the air chamber. The constructions previously described however, will generally be found preferable, as the leakage of air is prevented by the water seal.

In Fig. 7, I have shown a construction in which the air chamber Q is connected to the force main D by a pipe R having thereon a spring pressed check valve 16 opening toward the force main and corresponding to the valve 3 of the construction shown in Figs. 1 to 4, a by-pass 17 being provided for the gradual passage of water between the force main and air chamber, and this by-pass being controlled by throttle 18 so as to be adjustable at will. A valve 19 to permit the escape of air from the air chamber to the atmosphere is used, this valve being controlled by a float 20, so that the valve is always closed when the pressure in the force main is equal to or greater than that in the air chamber and the water in the latter held at or above a certain level, while upon the fall of the water and float below that level consequent upon a fall of pressure in the force main, the valve is opened and the pressure relieved by the escape of air from the air chamber. A common gage 21 is preferably provided to enable the height of the water in the air chamber to be constantly seen, so that the water may be kept at the proper level by the supply of air through pipe M.

In all the constructions thus far described the pressure from the air chamber may be transmitted directly to the compensating cylinders instead of through an accumulator, as shown in Figs. 1 to 4. It is evident moreover that where an accumulator is employed, the air chamber may be in the accumulator and the force main connected directly with the latter. In Fig. 8 I have shown such a construction in which the upper part of the accumulator E forms the air chamber and is provided with the pipe M through which air may be forced into the accumulator as in the case of the air chamber K in the construction previously described, and the force main connects with the accumulator above the piston 22 in the same manner as shown in Fig. 7, by the pipe R, check valve 16 and by pass 17 controlled by throttle 18. The operation of this construction will be understood without further description, it being evident that the pressure in the accumulator is relieved by the escape of water through the pipe R when the check valve 16 is opened by the excess of pressure in the air chamber, and by the escape of the air after the water has reached the level of the pipe R. The pressure may be relieved enough by the escape of the water alone and consequent expansion of the air as previously described in connection with Fig. 5.

While I have described air as the elastic fluid and used the term air chamber to designate the part through which the force pressure is transmitted to the compensating cylinders, it will be understood that any other elastic fluid may be used for this purpose, and by the term air chamber I intend to cover a chamber for applying elastic fluid pressure in the manner described, independently of the character of the fluid.

While I have shown only the preferred construction embodying my invention and certain modifications thereof, it will be understood that other modifications may readily be made by those skilled in the art without departing from my invention and I am not to be limited to any of the specific constructions shown.

What I claim is—

1. The combination with the force main of a pumping engine and a compensating cylinder or cylinders deriving pressure from the force main and having a constant connection with the force main to permit the gradual transfer of pressure between the force main and compensating cylinder or cylinders of a valve controlled by the pressure on opposite sides of said constant connection and normally closed when said pressures are the same, the pressure on the force main side tending to close the valve, said valve being constructed and arranged to relieve the pressure in the compensating cylinder or cylinders when opened, substantially as described.

2. The combination with the force main of a pumping engine and a compensating cylinder or cylinders deriving pressure from the force main, of an air chamber between the force main and compensating cylinders having a constant connection with the force main to permit the gradual passage of water between the air chamber and force main, and a normally closed valve constructed and arranged to relieve the pressure in the air chamber when opened and controlled by the pressures in the force main and air chamber, the pressure in the force main tending to open the valve, substantially as described.

3. The combination with the force main of a pumping engine and a compensating cylinder or cylinders deriving pressure from the

force main, of an air chamber between the force main and compensating cylinders having a constant connection with the force main to permit the gradual passage of water between the air chamber and force main, and a normally closed valve permitting the escape of fluid from the air chamber when opened and controlled by the pressures in the force main and air chamber, the pressure in the force main tending to close the valve, substantially as described.

4. The combination with the force main of a pumping engine and a compensating cylinder or cylinders deriving pressure from the force main, of an air chamber between the force main and compensating cylinders having a constant connection with the force main to permit the gradual passage of water between the air chamber and force main, a valve permitting the escape of fluid from the air chamber when opened and controlled by the pressures in the force main and air chamber, the pressure in the force main tending to close the valve, and pressure devices tending to close the valve, substantially as described.

5. The combination with the force main of a pumping engine and a compensating cylinder or cylinders deriving pressure from the force main, of an air chamber between the force main and compensating cylinders having a constant connection with the force main to permit the gradual passage of water between the air chamber and force main, a valve permitting the escape of fluid from the air chamber when opened and controlled by the pressures in the force main and air chamber, the pressure in the force main tending to close the valve, and adjustable pressure devices tending to close the valve, substantially as described.

6. The combination with the force main of a pumping engine and a compensating cylinder or cylinders deriving pressure from the force main, of an air chamber between the force main and compensating cylinders having a constant connection with the force main to permit the gradual passage of water between the air chamber and force main, and a check valve between the force main and air chamber opening toward the force main and normally closed when the pressures in the force main and air chamber are the same, substantially as described.

7. The combination with the force main of a pumping engine and a compensating cylinder or cylinders deriving pressure from the force main, of an air chamber between the force main and compensating cylinders having a constant connection with the force main to permit the gradual passage of water between the air chamber and force main, a check valve between the force main and air chamber opening toward the force main, and pressure devices tending to close the valve, substantially as described.

8. The combination with the force main of a pumping engine and a compensating cylinder or cylinders deriving pressure from the force main, of an air chamber between the force main and compensating cylinders having a constant connection with the force main to permit the gradual passage of water between the air chamber and force main, a check valve between the force main and air chamber opening toward the force main, and adjustable pressure devices tending to close the valve, substantially as described.

9. The combination with the force main of a pumping engine, of an air chamber having a constant connection with said main to allow the gradual passage of water, and a check valve controlling a larger connection between the main and air chamber and opening toward the main, substantially as described.

10. The combination with the force main of a pumping engine, of an air chamber on said main having an escape for the air independent of the escape of all the water in the air chamber, and a valve controlling said escape and closed by the pressure in the force main against an opposing pressure, whereby the escape is opened upon a fall of pressure in the force main, substantially as described.

11. The combination with force main D, of an air chamber having a constant connection with said main to allow the gradual passage of water, pipe O extending into the air chamber from the main, and normally closed check valve 3 closing said pipe and opening toward the main, substantially as described.

12. The combination with force main D, of an air chamber having a constant connection with said main to allow the gradual passage of water, pipe O extending into the air chamber from the force main and having openings 1 inside the air chamber, and normally closed check valve 3 closing said pipe and opening toward the main, substantially as described.

13. The combination with force main D, of an air chamber having a constant connection with said main to allow the gradual passage of water, pipe O extending into the air chamber from the force main and having openings 1 inside the air chamber, normally closed check valve 3 closing said pipe and opening toward the main, and means for adjusting the closing tension upon said valve, substantially as described.

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

CHARLES C. WORTHINGTON.

Witnesses:
LOUIS R. ALBERGER,
H. W. TILLINGHAST.

Correction in Letters Patent No. 504,644.

It is hereby certified that in Letters Patent No. 504,644, granted September 5, 1893, upon the application of Charles C. Worthington, of Irvington, New York, for an improvement in "Direct-Acting Pumping-Engines," an error appears in the printed specification requiring the following correction, viz: In line 46, page 1, the word "decrease" should read *increase;* and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed, countersigned, and sealed this 16th day of January A. D. 1894.

[SEAL.]

JNO. M. REYNOLDS,
Assistant Secretary of the Interior.

Countersigned:

JOHN S. SEYMOUR,
Commissioner of Patents.