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METHOD OF AND APPARATUS FOR ELEVATING FLUIDS BY ELASTIC FLUID PRESSURE.

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1,154,745. Patented Sept. 28, 1915.

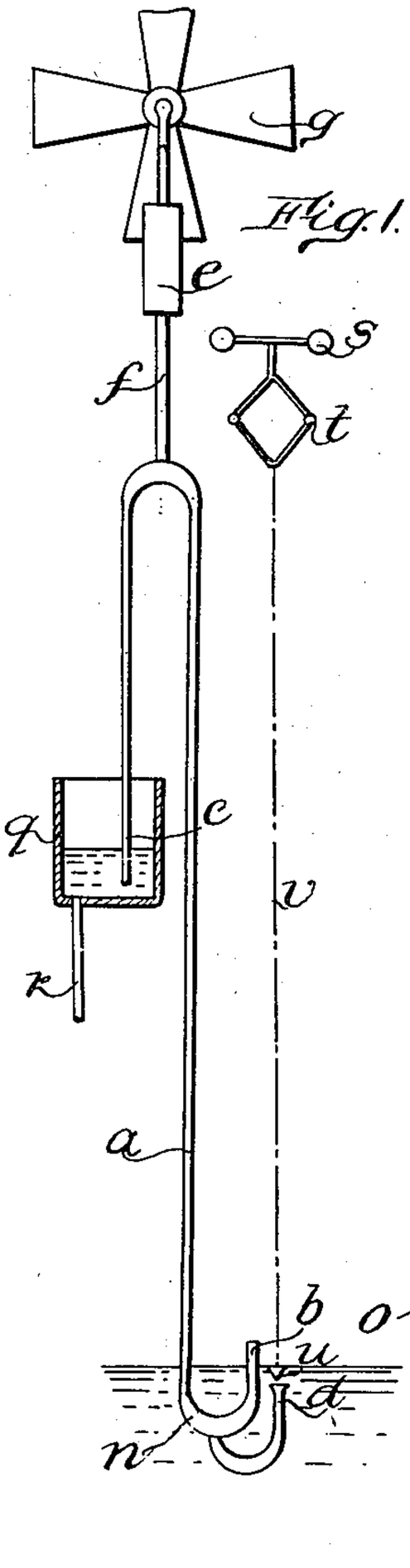


Fig. 1.

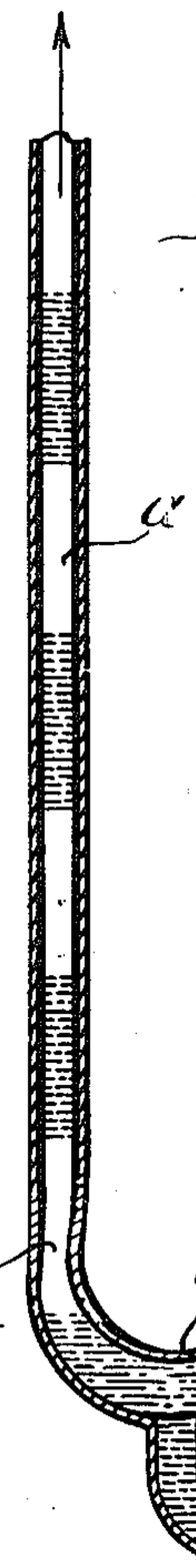


Fig. 2.

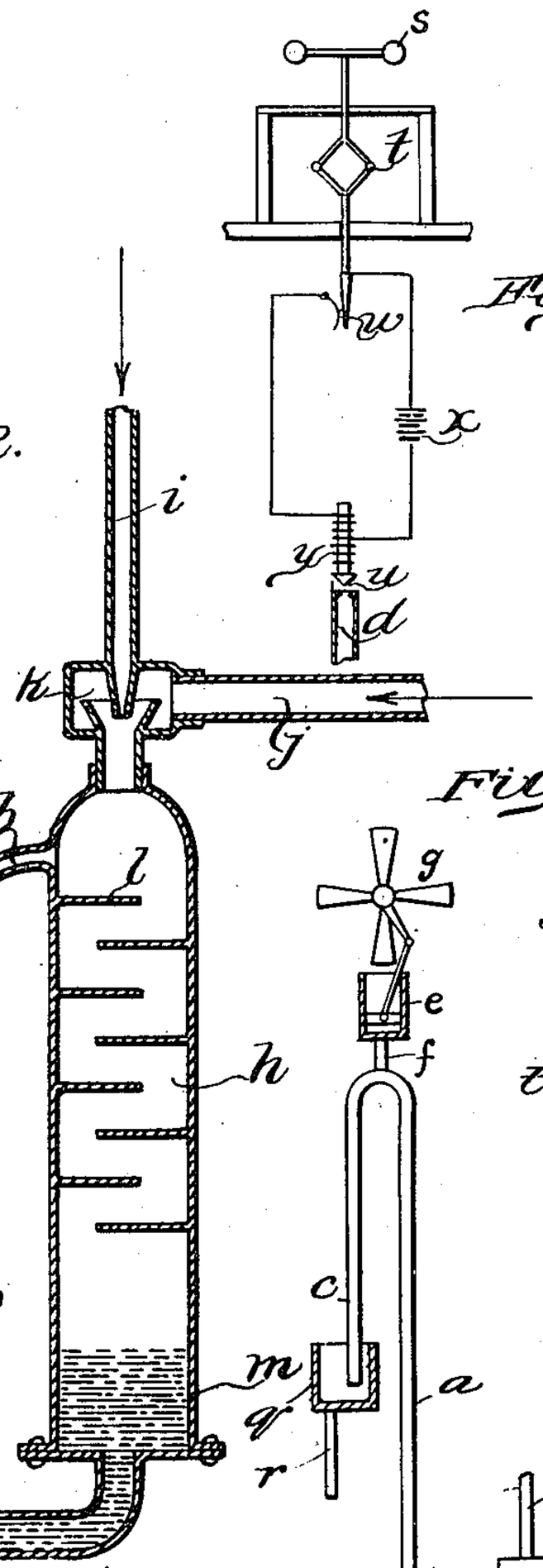
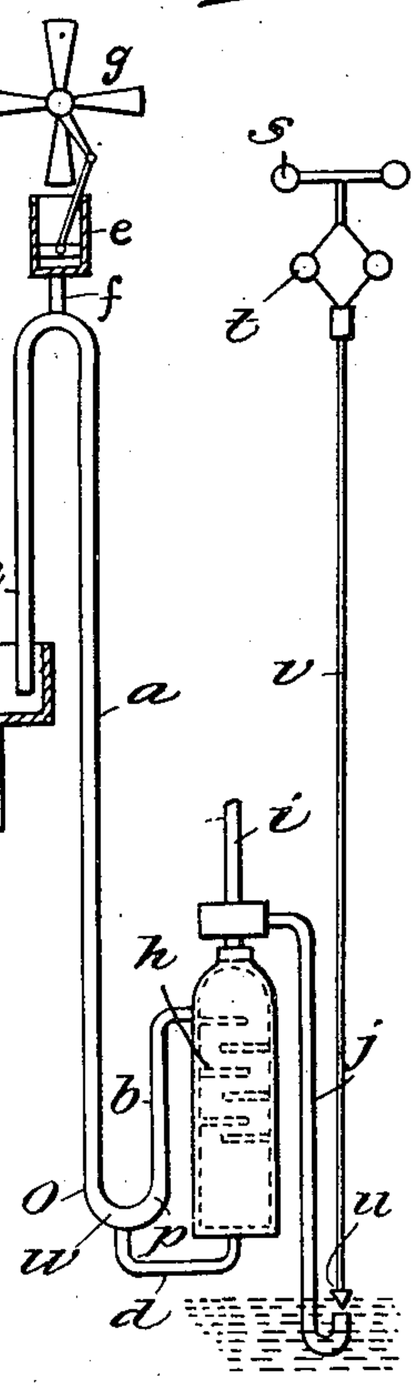


Fig. 3.

Fig. 4.



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UNITED STATES PATENT OFFICE.

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METHOD OF AND APPARATUS FOR ELEVATING FLUIDS BY ELASTIC-FLUID PRESSURE.

1,154,745. Specification of Letters Patent. Patented Sept. 28, 1915.

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To all whom it may concern:

Be it known that I, RALPH C. BROWNE, of Salem, in the county of Essex and State of Massachusetts, have invented certain new and useful Improvements in Methods of and Apparatus for Elevating Fluids by Elastic-Fluid Pressure, of which the following is a specification.

This invention has reference to a method and means by which fluids, usually liquids, may be raised by the direct action of lighter, elastic working fluids, commonly the pressure of the atmosphere or of air working at a higher pressure than atmospheric, and without the operation of mechanical pumping means or the interposition of valves, to heights greatly in excess of that of a continuous column of the fluid operated on sufficiently high to balance the pneumatic pressure of the working fluid.

The object of the invention is to devise a simple method and means of lifting fluids to great heights, preferably by suction, that is, by the atmospheric pressure, but also by pneumatic pressures greater than atmospheric, to heights greatly in excess of the hydrostatic heads equal to the pneumatic working pressure, and not only without mechanical pumping means, but also without the interposition or use in any manner of check valves. One of the uses to which the invention is designed to be put is that of pumping water from mines, and as the depths to which the mine shafts extend are great, the importance of being able to elevate the water to the surface of the earth without cumbersome and expensive pumps and without using an excessive pneumatic pressure is great. Moreover, the water found in such places is frequently impregnated strongly with acid, which has a rapidly destructive effect on the metal parts of pumps and valves, and there is also usually much solid matter carried in suspension by the water, which interferes with the proper action of valves. Accordingly the elimination of valves from the apparatus is an important feature of my invention.

A still further object, and in some aspects the most important one of the invention is to enable water or other liquids to be pumped from wells to elevated tanks for ordinary uses, or to be lifted from service mains to heights greater than that to which the pressure in the mains is capable of lifting the water. A still further object is to provide a means for regulating the rate of flow of the liquid acted upon through the intake so that it will be in proportion to the pneumatic pressure of the working fluid.

In carrying my invention into effect I employ as the main feature of the apparatus embodying the same an uptake pipe through which the working fluid is caused to flow, either by exhausting the fluid from the highest part of the pipe and allowing the fluid to be forced into the lower end thereof by the atmospheric pressure, or by blowing the fluid through the pipe by a pressure greater than that of the atmosphere. At the same time, the water or other liquid or fluid to be elevated is allowed to enter the lowest point of the pipe either by being forced into the same by a pressure greater than atmospheric, or by the suction resulting from the exhaustion of the working fluid from the pipe, and allowing the liquid to collect at the lowest point of the pipe until it effects a sealing thereof against the flow of the working fluid, whereupon the mass of the fluid operated on is bodily displaced and carried through the pipe by the pressure of the working fluid. In connection with the uptake pipe I provide in one embodiment of the invention a suction pump or equivalent apparatus for withdrawing the air or other working fluid from the highest point of the uptake pipe, and in another embodiment of the invention I connect means for supplying working fluid under pressure to the intake end of the pipe. Also associated with the means for inducing a flow of fluids through the pipe is a governing device by which the intake for the fluid to be elevated is closed in greater or less degree so as to govern the rate of inflow of such fluid in proportion to the effective pressure of the working fluid, in order that an apparatus having an uptake pipe of invariable length may be operative with wide variations in the pressure of the working fluid.

Of the accompanying drawings, Figure 1 represents diagrammatically a simple form of apparatus embodying part of my invention, and adapted to carry into effect the method constituting the other part of the

invention. Fig. 2 represents a similar view of the lower part of the apparatus, showing a means by which the invention may be adapted for operation by a working fluid under a pressure greater than atmospheric. Fig. 3 represents diagrammatically a form of governor whereby the rate of inflow of the fluid to be elevated is regulated. Fig. 4 represents a form of the apparatus combining the features shown in Figs. 1 and 2.

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

The apparatus comprises an uptake pipe *a* having an inlet at *b* for the working fluid, and an outlet at *c* for the fluid operated upon. There may be, and preferably is, a second inlet at *d* for the fluid which is to be elevated, which is ordinarily a liquid, and usually is water, although in some instances it is permissible to admit the liquid and working fluid through the same inlet.

For convenience and brevity of description I will hereafter refer in this specification to the working fluid as air, and to the fluid operated upon as water, for in the great majority of instances in which this apparatus is used, air will be the motive power and water the agent acted upon.

The invention is designed to be capable of lifting water by suction to heights greater than thirty-two feet, which is approximately the head of water which balances the atmospheric pressure, and in order to diminish the pressure in the uptake pipe *a*, and thereby cause the air and water to be forced into the lower end of the pipe, I provide an exhausting apparatus such as air pump *e*, which is connected by an intermedate connection *f* with the highest point of the uptake pipe. This pump *e* may be operated by any suitable motor, such as an air motor *g*, or an ordinary wind-mill.

In other instances it is desirable to supply the air for the motive power to the base of the pipe at a pressure higher than that of the atmosphere, and in Fig. 2, I have illustrated an arrangement by which the air and water may be forced into the bottom of the uptake pipe under an equal pressure. In this arrangement the air inlet pipe *b* is connected at the upper end and the water inlet pipe *d* is connected to the base of an auxiliary chamber or cylinder *h* into which air and water are forced. *i* is the inlet pipe for the air, and *j* the intake pipe for the water, both of which are associated with an inspirator or injector *k*. Air under pressure being forced through the pipe *i* draws water through the pipe *j*, and discharges a mingled mass into the cylinder *h*. In the latter are shelves or blades *l* projecting from opposite walls and overlapping so as to retard the descent of the foamy mass and allow the water to separate from the air. The water thus collects at the bottom *m* of the chamber, and the air fills the upper part thereof and flows through the air intake *b* into the uptake pipe *a*.

Between the air inlet and the uptake part of the conduit is a depending loop *n* into which the water intake pipe *d* opens at approximately the lowest point thereof. This loop is of variable diameter, being of a width greater than either the uptake conduit or the air inlet pipe at its middle and lowest portion, and decreasing gradually to the points *o* and *p* where it joins the uptake and intake portions. It is into this loop that the discharge pipe *d* from the chamber *h* opens.

When the air is exhausted from the highest point of the uptake pipe, or when a sufficiently high pressure is applied to force air into the inlet, the air flows downward through the latter, around the loop, and up through the uptake portion of the conduit. At the same time water is caused to flow through the water inlet *d* into the loop. In the case of the suction-operated form of the apparatus, the air and water are caused to flow into the loop by the atmospheric pressure, the loop and water inlet being immersed in the liquid to be pumped to a sufficient depth for the purpose or the air inlet being contracted, in which case immersion of the loop is unnecessary. The water flows into the loop and rises until it either completely seals the air passage through the latter, or so nearly does so as to cause the air entering the inlet *b* to displace the body of water. As soon as any displacement occurs, the volume of water entering the narrower part of the loop and the uptake pipe immediately elongates and fills the pipe from side to side, thereby completely obstructing the flow of air and effecting a seal, having a closed connection with the uptake pipe and the air inlet pipe. Thus the loop constitutes a trap or seal wherein the accumulated body of water periodically obstructs and interrupts the free flow of air through the conduit. Thus a solid mass of water is forced into the uptake pipe and propelled therethrough by the ascending and expanding volume of air beneath it, and these bodies of water follow one another in successions as fast as the water can accumulate sufficiently to effect the sealing of the conduit. Thus a composite column of air and water is formed in the uptake pipe, which is subject to the pneumatic pressure of the air, and as it is considerably lighter than a solid body of water would be, can be impelled by atmospheric pressure to a much greater height than water can be lifted by any form of suction apparatus operating on a continuous column of the water.

The upper end of the conduit is bent over and carried down below the bend a sufficient distance to seal the same so that suction ap-

plied by the pumping apparatus *e* will draw the water through the uptake part of the conduit instead of through the outlet portion thereof. The distance between the bend and the outlet *c* must therefore be as great as the hydraulic head equivalent to the pressure of the atmosphere. The conduit discharges into a tank *q* from which a pipe *r* leads to conduct the water to wherever it is to be used. The outlet dips sufficiently far into the tank to be sealed by the water therein.

When the apparatus is operated on the high-pressure principle, it is necessary to apply pressure to the water in the inlet *d* in order that it may enter the loop or tubular trap *n* against the air pressure. The cylindrical chamber *h* affords a convenient means of supplying the necessary pressure to the water, for as the air under pressure and water are both supplied to the chamber, the water which collects in the bottom is subjected to the same pressure as is the air. Consequently the water is enabled to rise in the loop *n* under the excess of head in the water chamber *m* until it effects the sealing of the conduit as described, when it is displaced and forced upward by the air. Water may be independently forced into the loop from a source separate from that in which the air under pressure is contained, as by being pumped into the loop by a separate pump.

I propose to use in connection with the pump an apparatus by which the rate of inflow of the water may be proportioned to the effective pressure of the air in the conduit. It will be obvious that a diminution in the air pressure employed will leave the pump inoperative to lift the composite column containing as large a proportion of water as when the higher pressure is used, and conversely, an increase in the pressure will enable a column containing a larger proportion of water to be lifted. Accordingly, it is an important part of my invention to provide a governing device which varies the rate of inflow of the water in such manner that the detached masses or pistons of water in the uptake may be spaced greater or less distances apart. This is particularly important in cases where the effective pressure is obtained by a wind-driven pump which exhausts the air from the conduit, for unless the bodies of water are more widely separated when the force of the wind diminishes, the pump will become inoperative except under high-wind conditions. Accordingly, I provide a governor which is also wind-driven and regulates the size of the inlet aperture *d*. Such a governor is shown diagrammatically in Fig. 1, and consists of a motor *s*, a centrifugal governor *t* and a valve *u* which is connected with the governor by a line or rod *v*. It will be evident that as the wind falls and the speed of the motor *s* diminishes, the governor weights will lower and allow the valve to close in part, thereby restricting the opening into the inlet and diminishing the flow of water to the apparatus. Conversely, when the wind rises and the speed of the motor increases, the governor weights lift the valve and allow a more rapid admission of water.

In Fig. 3 is shown an arrangement by which the governor controls the valve through electro-magnetic means. In this figure *s* is the motor, *t* the centrifugal governor, *d* the water inlet, and *u* the valve. The governor operates a variable resistance member or rheostat *w*, which is in circuit with a battery *x* and also an electro-magnet *y*. The variable resistance member is so arranged that as the governor weights rise, the current and magnetic force increase and lift the valve farther.

The pump may be arranged to permit both suction and pressure to be applied, as shown in Fig. 4, where the same reference characters represent the same parts shown in Figs. 1 and 2. In this arrangement the inlet pipe *j* is extended so as to dip beneath the surface of the water.

I desire it to be understood that I do not limit myself in any way to the particular means and apparatus herein set forth, and that any suitable apparatus having the essentials equivalent to the parts *a b c d* and *n* is within the scope of my invention. Also that the invention is not limited to operation upon any particular fluid or class of fluids, or by any particular working fluid, and that any form of governing device operable for the purpose of regulating the water inflow in proportion to the effective air pressure, and controlled by the air pressure or by the means which creates the effective air pressure, is within the scope of my invention.

I claim:—

1. The method of raising fluids by elastic fluid pressure to a height greater than that of a continuous column of the fluid operated on sufficiently high to balance such pressure, which consists in flowing a working fluid through a loop, simultaneously causing the heavier fluid to collect in said loop until the passage therethrough for the working fluid is closed, and immediately displacing the collected fluid by pressure of the working fluid applied downwardly on the upper surface thereof, thereby forming a composite column made up of alternate masses of the fluid operated on and the lighter working fluid.

2. The method of raising fluids by elastic fluid pressure to a height greater than that of a continuous column of the fluid operated on sufficiently high to balance such pressure, which consists in forming a composite column made up of alternate masses of the

fluid operated on and a lighter, more elastic working fluid, by causing the fluid operated on to collect below the admission point of the working fluid and obstruct the working fluid.

3. The method of raising fluids by elastic fluid pressure to a height greater than that of a continuous column of the fluid operated on sufficiently high to balance such pressure, which consists in causing a relatively light elastic working fluid to flow through a conduit, and continuously admitting quantities of the heavier fluid, under approximately equal pressure with the working fluid, into the lowest point of such conduit, until the latter is sealed to the flow of the working fluid to obstruct intermittently the flow of working fluid.

4. The method of elevating fluids by elastic fluid pressure to heights greater than the hydrostatic head of the fluid operated on sufficient to equalize such pressure, which consists in causing a relatively light elastic working fluid to flow downwardly and then upward through a continuous conduit and causing quantities of the heavier fluid to be admitted continuously to the lowest point of such conduit, both such fluids being acted on by an equal impelling force, in such manner that the heavier fluid is entrapped in the lowest part of the conduit until it has accumulated sufficiently to close the conduit, whereupon it is acted upon on its upper surface by the full pressure of the working fluid and is carried by the latter through the conduit in the form of detached masses or plugs.

5. The method of elevating fluids by elastic fluid pressure to heights greater than the hydrostatic head of the fluid operated on sufficient to equalize such pressure, which consists in forcing a relatively light working fluid through a conduit, and forcing the heavier fluid under a pressure equal to that of the working fluid continuously into such conduit at a point thereof lower than the admission point of the working fluid, in such manner that the heavier fluid is entrapped until it close the conduit and is carried by the latter through the conduit in the form of detached masses or plugs.

6. The method of elevating liquids, which consists in exhausting air from the highest point of a conduit and allowing the liquid and air to enter a loop at the lowest point thereof in such manner as to form a composite column of alternate distinct masses of air and the liquid, each entirely filling a limited length of the conduit whereby the liquid may be raised to a height greater than the hydrostatic head thereof corresponding to the atmospheric pressure.

7. An apparatus for raising liquids by elastic fluid pressure to a height greater than that of a continuous column of the liquid sufficient to balance such pressure, comprising a conduit, and means for forcing the liquid and elastic fluid under substantially equal elastic fluid pressure simultaneously into the bottom of said conduit, whereby the apparatus may be kept above the level of the liquid, and means for effecting and maintaining a separation of the fluids into alternate masses, each filling the bore of the conduit.

8. A valveless fluid-operated pump, comprising a chamber containing liquid under pneumatic pressure, an uptake pipe, and permanent connections between the uptake pipe and the liquid and gas spaces of said chamber, whereby the conduit is periodically sealed by the liquid and the pneumatic pressure is enabled to effect an upward movement of the liquid and gas in alternate masses in said uptake pipe, each of such masses filling the bore of the pipe.

9. A valveless fluid-operated pump, comprising provisions for supplying working fluid and liquid to be acted on under equal pneumatic pressure, and an uptake pipe connected to receive the pneumatic pressure, and having a depending loop connected at its lowest point with the liquid supply, whereby the liquid is forced by the pneumatic pressure into said loop until a seal is effected, whereupon the mass of liquid forming the seal is blown from the loop and up through the uptake pipe in a compact lump or plug filling the bore of the pipe and free from admixture with the impelling gas by the pneumatic pressure.

10. A valveless fluid-operated pump comprising an uptake pipe to which a working fluid under pneumatic pressure is admitted, said pipe having a depending loop below the admission point of said working fluid, and a continuously open admission pipe for a heavier, relatively incompressible fluid connected to said loop, through which such heavier fluid is continuously forced, whereby detached masses of the heavier fluid are injected periodically into the uptake pipe, obstructing the flow of the working fluid, and raised by the pneumatic pressure.

11. A valveless fluid-operated pump comprising an uptake pipe to which air is admitted, said pipe having a depending loop below the admission point of the air, and a continuously open admission pipe for a liquid connected to said loop, through which such liquid is caused to flow, whereby quantities of the liquid are allowed to collect in the loop until a seal is effected, obstructing the flow of the air, and are then injected periodically into the uptake pipe, and raised by the pressure of the latter to a height greater than that of a column of the liquid corresponding in hydrostatic pressure to the air pressure employed.

12. A valveless fluid-impelling pump op-

erated by compressed air and operating to lift all of the fluid supplied to it to vertical heights in excess of the height of a column of said fluid, corresponding in hydrostatic pressure to the air pressure employed, and consisting of a tubular water trap or seal having connected thereto air- and water ducts, substantially as shown, through which air and water respectively are continuously admitted, an uptake pipe for conveying away the fluid being pumped to which said seal is directly connected, said uptake pipe being of relatively small diameter compared with said seal, and the latter intermittently discharging into said uptake pipe its entrapped fluid in successive but separated compact masses, said discharge occurring at relatively high velocities due to the restricted cross sectional area of said uptake pipe.

13. In a pump of the character described, an uptake pipe, and independent admission means comprising a chamber containing air and liquid under the same pressure and connections form said chamber opening into different parts of the conduit and arranged to cause the air to act first on the upper surface of the liquid in such means.

14. A valveless fluid-operated pump comprising a conduit through which relatively light and heavy fluids are caused to flow, and having a pocket wherein the difference in specific gravities of the fluids causes collection of the heavier fluid and a periodic sealing of the conduit by the heavier fluid against the flow of the lighter fluid.

15. A valveless fluid-operated pump, comprising a conduit through which relatively light fluid is caused to flow, and into which a relatively heavy fluid is continuously admitted said conduit having a depression in the bottom of which the heavier fluid is caused by its greater specific gravity to collect, and thereby to seal the conduit periodically against flow of the lighter fluid, and thereby cause detached masses of such heavier fluid to be impelled through the conduit by the lighter fluid.

16. A valveless fluid-operated pump, comprising a rising conduit, through which fluids are raised by the pressure of an elastic working fluid, means for exhausting the working fluid from the upper part of said conduit, an inlet for the working fluid and an inlet for a heavier fluid to be raised, at the lower end of the conduit, through which the fluids are caused to enter by the excess of external over internal pressure, and a depressed pocket in which the heavier fluids is allowed to collect to effect a periodic sealing against the flow of the working fluid, and from which it is forced by the full pressure of the working fluid.

17. A valveless fluid-operated pump, comprising a rising conduit, through which fluids are raised by the pressure of an elastic working fluid, inlets for the fluid and for the heavier fluid which is to be raised, at the lower end of the conduit, means producing an excess of external, over internal, pressure acting equally on both fluids to cause the fluids to enter the conduit, and a closed trap at the lowest part of the conduit through which both fluids pass and in which the heavier fluid is caused to collect until it fills said trap and obstructs the flow of the working fluid, whereby detached masses of the heavier fluid are periodically raised in the conduit by the working fluid.

18. A valveless fluid-operated pump, comprising a rising conduit through which relatively heavy fluids are raised by the pressure of an elastic working fluid, means for admitting the fluids to the lower end of said conduit, a trap at the bottom of the conduit in which the heavier fluid is caused to collect until a seal against the flow of the working fluid is effected, and means for separately withdrawing the fluids from the upper portion of the conduit.

19. A valveless fluid-operated pump, comprising a rising conduit through which relatively heavy fluids are raised by the pressure of an elastic working fluid, means for admitting the fluids to the lower end of said conduit, a trap at the bottom of the conduit in which the heavier fluid is caused to collect until a seal against the flow of the working fluid is effected, means for reducing the internal pressure in the conduit at its point of highest elevation, and an independent outlet for the heavier fluid.

20. A valveless fluid-operated pump comprising a rising conduit having a depending loop below its intake end and a rising loop above its outlet end, means for reducing the internal pressure in the conduit at its point of highest elevation, and means for admitting into the dependent loop the fluid which is to be elevated.

21. A valveless fluid-operated pump comprising a rising conduit having inlets for air and water at its lower end, the air inlet being continuous with said conduit and above the lowest point thereof, means for causing the air to enter the inlet and flow through the conduit, and provisions for causing the water to collect in the bottom of the conduit and seal the conduit against the flow of air, whereby masses of water are periodically carried upward through the conduit by the air pressure.

22. A valveless fluid-operated pump comprising a rising conduit having an intake for an elastic working fluid and an uptake portion through which such fluid is caused to flow, a tubular trap between, and lower than, said intake and uptake and in connection therewith at its ends, and means for continuously admitting a heavier fluid to the

trap, said trap being of greater internal diameter than the uptake and diminishing to its junction therewith, whereby such heavier fluid is allowed to collect in sufficient quantity to seal the conduit and is then carried in a compact mass by the pressure of the working fluid through the uptake.

23. A valveless fluid-operated pump comprising a rising conduit having inlets at its lower end for the working fluid and for the heavier fluid operated on, means for causing the pressure of the working fluid external to said conduit to exceed the internal pressure, and a governing device for regulating the rate of inflow of the heavier fluid proportionately to the effective pressure of the working fluid.

24. A valveless fluid-operated pump comprising a rising conduit having inlets at its lower end for the working fluid and for the heavier fluid operated on, means for causing the pressure of the working fluid external to said conduit to exceed the internal pressure, and means for obstructing the inlet for the heavier fluid to a greater or less extent according to the effective pressure of the working fluid.

25. A valveless fluid-operated pump comprising a rising conduit having inlets at its lower end for the working fluid and for the heavier fluid operated on, means for causing the pressure of the working fluid external to said conduit to exceed the internal pressure, and an automatically operative device for governing the rate of inflow of the heavier fluid in proportion to the effective pressure acting upon the working fluid.

26. A valveless fluid-operated pump comprising a rising conduit having inlets at its lower end for the relatively light working fluid and for the heavier fluid to be elevated, a wind-driven pumping device for causing an excess of external pressure in the working fluid over that in the conduit, whereby to induce a flow of the fluid through the conduit, and a wind-driven governing device operative to regulate the inflow of the heavier fluid in proportion to the wind pressure, and therefore to the pressure of the working fluid.

27. A valveless fluid-operated pump; comprising a rising conduit having inlets at its lower end for the working fluid and for a heavier fluid to be raised, means for causing the working fluid to flow through said conduit, thereby carrying separated quantities of the heavier fluid, and a governing device adapted to regulate the proportion of the heavier to the working fluid according to the effective pressure of the latter.

In testimony whereof I have affixed my signature, in presence of two witnesses.

RALPH C. BROWNE.

Witnesses:

A. C. RATIGAN,

P. W. PEZZETTI.