No. 681,216. Patented Aug. 27, 1901.

# E. GRAY.

## PNEUMATIC LIQUID RAISING APPARATUS.

(Application filed Mar. 23, 1900.)

(No Model.)

Fig. 1.

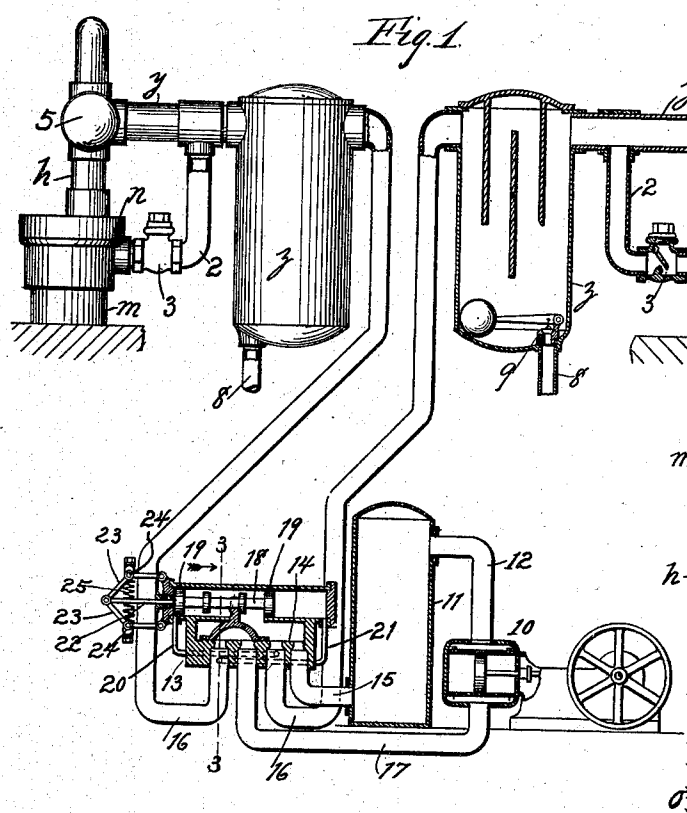


Fig. 4.

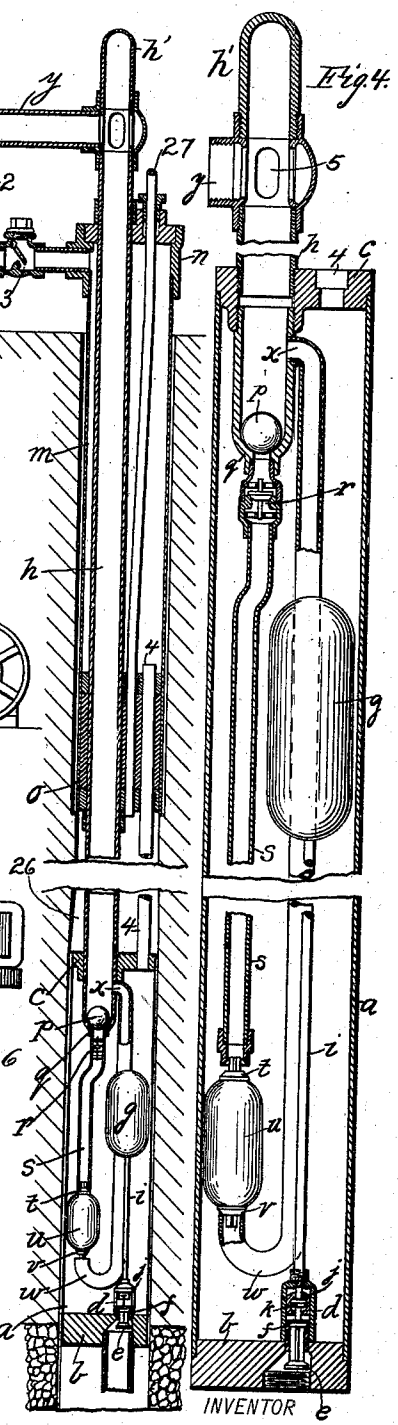


Fig. 2.

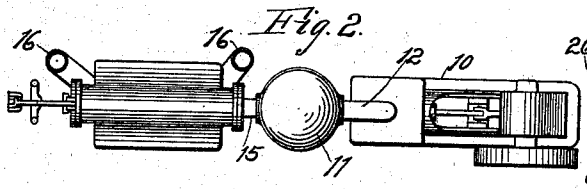


Fig. 5.

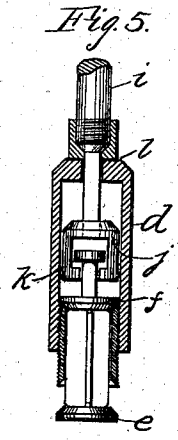


Fig. 6.

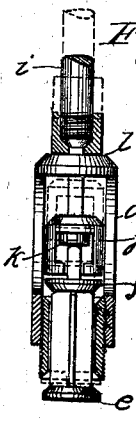
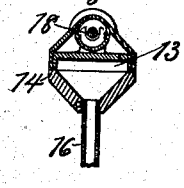


Fig. 3.



WITNESSES

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C. Dodgwick

INVENTOR

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# UNITED STATES PATENT OFFICE.

EDWARD GRAY, OF BRADFORD, PENNSYLVANIA, ASSIGNOR OF ONE-HALF TO PHILO C. BLAISDELL, OF SAME PLACE.

## PNEUMATIC LIQUID-RAISING APPARATUS.

SPECIFICATION forming part of Letters Patent No. 681,216, dated August 27, 1901.

Application filed March 23, 1900. Serial No. 9,884. (No model.)

*To all whom it may concern:*

Be it known that I, EDWARD GRAY, a citizen of the United States of America, and a resident of Bradford, county of McKean, and State of Pennsylvania, have invented certain new and useful Improvements in Pneumatic Liquid-Raising Apparatus, of which the following is a specification.

My invention relates to means for raising liquid from subterraneous sources, as oil, brine, and Artesian wells, by means of compressed air or gas applied so as to utilize the direct lifting action of the air in periodical impulses alternating with periodic inductions of measures of liquid to be raised into the receiving-chamber located in the well below the normal level of the liquid therein.

The essential feature distinguishing my invention from various other contrivances of compressed-air liquid-raising apparatus is a follower in the eduction-pipe that automatically intervenes between the liquid column to be raised and the ejecting column of air in a way to utilize direct action of the air with much less waste of energy of the air by largely preventing escape of air through the liquid on account of the difference in densities.

The invention also comprises apparatus for effecting such intervention of the follower, also apparatus whereby a considerable economy of power may be effected by recovery of the partially-spent air in the compressor, and also apparatus whereby a plurality of wells located in proximity may be operated by a single air compressing and distributing plant, all as hereinafter described, reference being made to the accompanying drawings, in which—

Figure 1 is a vertical section of one well and the apparatus for working it in accordance with my invention and a side elevation of part of the apparatus of another well, both of which are connected with the one compressing and distributing plant. Fig. 2 is a plan view of the compressing and distributing plant. Fig. 3 is a detail in transverse section of the distributing apparatus of Fig. 1. Fig. 4 is a vertical section of the receiving-chamber and its adjuncts at the bottom of the well, the same as in Fig. 1, but on a larger scale for greater clearness. Fig. 5 is a sectional elevation of the foot-valve in the bottom of the receiving-chamber, detached and enlarged for greater clearness, and showing the position when the process of raising a charge of liquid is in operation. Fig. 6 is another section of said foot-valve, showing the position when the liquid is entering the receiving-chamber, with dotted lines indicating the position of the valve when inlet to the receiving-chamber is closed.

The receiving-chamber for the bottom or lower portion of the well-bore comprises the tube *a*, having heads *b* and *c*, said tube being of such size relatively to the bore of the well as to permit it to be placed at the bottom or in the lower portion of the well, and being of any suitable height, according to the quantity of the charge of liquid to be raised by one operation, it is hereinafter designated as "receiving-chamber *a*." A double-acting foot-valve is represented at *d* in the lower head of said chamber to control the inlet-passage for the liquid, said valve comprising the disk *e* to shut off the inlet and the disk *f* to prevent backflow of the liquid, to which is attached a float *g*, the purpose of which is to close disk *e* and prevent overflooding the receiver and the eduction-pipe *h* under conditions and for reasons that will appear farther on. The float *g* is connected to the upper end of the rod *i*, which is coupled to the valve *e f* by the yoke *j* and head *k* of the valve-stem by a slack joint, which when rod *i* rests on the top *l* of the valve-case leaves the valve free to be lifted by the inflowing liquid, as represented in Fig. 6, for charging the receiver, and also to be closed to prevent backflow of the liquid when pressure is applied to the liquid in the receiver for ejecting it. When the liquid rises in the receiver so as to lift the float, it closes disk *e* and stops further inlet.

The upper part of the well-bore is cased by a tube *m* from the top downward a suitable distance, the top of the case is closed by a cap *n*, and the lower end is also closed by a suitable packing *o*. This is hereinafter referred to as chamber *m*. The eduction-pipe *h* enters through cap *n* and extends through packing *o* and head *c* into a receiving-cham-

ber *a*. It contains the follower, which is in this example represented as a ball *p*, but may be of any other approved form and must be of sufficient density to sink in the liquid. A little below the head *c* of the receiver the eduction-pipe *h* is contracted at *q* to form a seat for the follower, and it has an extension *s* downward therefrom, of smaller size, which is open at the lower end and provided with a valve *t* on the upper end of a float *u* for closing it when the float is buoyed up by the liquid in the receiver. A check-valve *r* is also provided in this extension to retain air or fluid for the follower to cushion on when it descends. The lower end of said float has another valve *v*, that closes the upturned end of a small pipe *w*, whose other end is connected into the eduction-pipe at *x* above the follower *p* when on its seat.

The upper end of the eduction-pipe is connected through a branch *y* with a receiver *z* for the ejected liquid and the impelling air. The chamber *m* is also connected with this receiver through branch *y* by a branch 2 of said branch *y*, in which is a check-valve 3, admitting air to said casing freely, but preventing its return. The chamber *m* is connected with the receiving-chamber *a* by a pipe 4, extending through packing *o* and head *c*. It is to be noted that the connection of eduction-pipe *h* with branch *y* is by a lantern-coupling 5, which distributes the escaping flow of liquid and air equally in opposite directions, and thus prevents pressing the follower against the outlet and choking it, as would be the case with a single outlet into branch *y*. An extension *h'* of the eduction-pipe *h* above the branch *y* forms a cushion to the follower in its upward range.

Compressed air for operating the apparatus is supplied and exhausted through the receiver *z*, into which the liquid is discharged along with the ejecting air and from which the liquid is trapped off through pipe 8, controlled by a ball-cock 9, which closes and prevents escape of air when the liquid has escaped. For supplying the compressed air any suitable compressor 10 may be employed with an accumulator 11, into which the compressed air is delivered through a pipe 12.

The apparatus may be used to advantage for operating a well singly; but as there is generally a plurality of wells in convenient proximity for operating them with the one compressing plant and there is considerable energy in the air escaping from the eduction-pipe it is preferable for economy to so operate them, and I have found it advantageous to operate them in pairs through the instrumentality of a controlling-valve in which a D-slide 13, inclosed in a suitable case, works on a port-face 14, to which the inlet-pipe 15 from the accumulator is always open and from which pipes 16 lead to the receivers *z* of a pair of wells, respectively, and the exhaust-pipe 17 leads to the suction side of the compressor. The D-slide is connected to the rod 18 of the double-ended piston 19 for being operated. From the right-hand pipe 16 there is communication through pipe 20 behind the left-hand end of piston 19, and from the left-hand pipe 16 there is communication through pipe 21 behind the right-hand end of said piston.

The operation is as follows: As represented in Fig. 1, the receiver *a* of the right-hand well is supposed to contain a charge of liquid to be ejected, and receiver *z*, the eduction-pipe *h*, chamber *m*, and receiver *a* are open to receive compressed air from the accumulator, disk *f* of the foot-valve being closed, when a slight waste back through the valve allows float *g* to permit said disk to close by the effect of the air-pressure on the liquid in receiver *a*. Meantime the corresponding parts of the other well are open to the suction side of the compressor and being exhausted for reception of another charge of liquid to be expelled. Maximum pressure now being obtained in the right-hand well, back pressure through pipe 20 on the left-hand end of the piston shifts the piston, which opens receiver *z* and stand-pipe *h* to the suction side of the accumulator. The first effect of the air-pressure in chamber *m* and receiver *a* after pressure in the stand-pipe is thus relieved in the charged well is to expel liquid from receiver *a* into the eduction-pipe *h* above the follower *p* through pipe *w*, which is open at the lower end, float *u* being raised by the liquid in which it is submerged and the lower end of extension *s* being closed. When the level of the liquid in said receiver *a* that is being emptied falls, so that float *u* falls, valve *v* closes the lower end of pipe *w* and valve *t* opens extension-pipe *s*, and the air rushes in under the follower, lifting it, driving the liquid above it out of the eduction-pipe into the receiver *z*, said follower acting as a piston and preventing escape of air through the liquid. Water that may leak past the piston serves as water-packing to prevent escape of air to any material extent upward past the piston. When after admission of the air to the several parts of the well the pressure rises to a predetermined maximum, which is governed by the pressure requisite for promptly ejecting the charge, the end of the piston 19 then opens to pressure, receives an impulse which thrusts it forward and reverses the valve to supply the other well with air, and opens the first well to the exhaust side of the compressor. When this takes place, the check-valve 3 closes, preventing escape of air from chamber *m* to utilize the expansive effect of the air therein for effecting the expulsion of the charge of liquid after the supply from the accumulator is cut off, and in like manner when the pressure rises in the other well the other end of the piston receives an impulse through pipe 21 to shift it back again, and so on. To prevent the shifting of the piston before the proper degree of pressure is attained in the well and reacts on the pis-

ton, the stem 22 of the piston is connected to the toggle-arms 23, which have fulcrums 24, movable toward and from each other and connected by a contracting spring 25, the resistance of which opposes the movement of the piston until the pressure rises to the requisite amount of force for effecting the intended action.

It is not desirable in practice to have to work under conditions requiring very high compression of air, as would be necessary if in working deep wells it were attempted to raise the liquid in columns of such height as to demand high pressure, because of the more expensive plant that would be required and greater percentage of waste power. Hence the receiving-chamber *a* and the foot-valve and its controlling-float are contrived to limit the charges admitted to a measure, making a liquid column in the ejecting-pipe of less height than said pipe and such that a moderate pressure of air—say about a hundred pounds pressure to the inch—will be competent to expel, thus adapting the apparatus for working under such pressure alike for wells of any depth.

It will be seen that the chamber *m* constitutes a reservoir of compressed air which, by its expansive action, ejects the liquid economically when pressure in the stand-pipe is relieved, the maximum pressure being sufficient to raise the top of the water column to the discharge-spout and the expanded air being sufficient for the decreasing weight of the discharging column, and by turning the exhaust into the suction side of the compressor considerable economies of power are effected. Any greater number of wells can be worked with one controlling-valve by branches of the pipes 16 or one of them, and they can all discharge into one receiver *z* or each well may have its own receiver.

Between the receiving-chamber *a* and the expansion-chamber *m* is an uncased section 26, in which gas may accumulate in some wells in sufficient column and pressure for various useful purposes, wherefore I have provided the pipe 27, inserted through the cap *n* and packing *o* to supply the compressing plant with fuel, also for light, and in some cases there is sufficient pressure and volume to operate the ejecting apparatus in lieu of the compressed air, except that after a charge of gas has done its work it would be exhausted into the atmosphere or into a low-pressure line and then be used for light and power.

The chamber *m* is not necessarily located in the well, but can be on the surface and may be of any approved form.

I am aware of the British patent to Clark *et al.*, No. 11,077, dated February 11, 1846, in which a partial vacuum above the liquid column and atmospheric pressure below said column are made available for the application of ejecting force to the extent of ten pounds, or thereabout, to the square inch; but my invention is distinguished from that in the employment of means for expelling the liquid charges by compressed air, and the difference is that such means enables the application of unlimited pressure, whereby an eduction-tube of small size, such as it is practicable to provide in deep wells of correspondingly small bore, may be made available for raising unlimited quantities, whereas to raise large quantities by the atmospheric process would demand the provision of wells of impracticable size and cost.

What I claim as my invention is—

1. In a fluid-raising apparatus, the combination of a receiver for limited charges of the liquid to be raised, means for automatically controlling the supply of said charges, an eduction-pipe, means for successively expelling the liquid charges therethrough by compressed air acting under the liquid in said eduction-pipe, and a follower in said pipe between the air column and the liquid column.

2. In a fluid-raising apparatus, the combination of a receiver for the liquid to be raised, means for supplying the liquid thereto in limited charges, means for automatically controlling the supply of said charges, an eduction-pipe, means for successively expelling the liquid charges therethrough by compressed air acting under the liquid in said eduction-pipe, and a follower in said pipe between the air column and the liquid column.

3. In fluid-raising apparatus, the combination of a receiver for the liquid to be raised, means for supplying the liquid thereto in limited charges, an eduction-pipe for the liquid, a follower therein, means for transferring the liquid from the receiver into the eduction-pipe above the follower by pneumatic pressure, and means for applying pneumatic ejecting force under the follower to the liquid column in the eduction-pipe.

4. In fluid-raising apparatus, the combination of a receiver for the liquid to be raised, means for supplying the liquid thereto in limited quantities, an eduction-pipe, means for successively expelling the liquid charges therethrough by pneumatic pressure applied under the liquid column, part of which means comprises a pneumatic chamber in connection with the service of compressed air and affording ejecting force by expansive action of its contents after the supply is shut off, and a follower in said eduction-pipe between the air column and the liquid column.

5. In fluid-raising apparatus, the combination of a receiver for limited charges of the liquid to be raised, means for supplying the liquid thereto in limited quantities, an eduction-pipe, means for successively expelling the liquid charges therethrough by pneumatic pressure applied under the liquid column, part of which means comprises a pneumatic chamber in connection with the main source of compressed air and affording ejecting force by expansive action of its contents after the supply of air is shut off, a compressor for supplying the pneumatic pressure, means for au-

tomatically connecting the eduction-exhaust with the suction side of the compressor when the supply is shut off, and the follower between the air column and the liquid column in the ejector-pipe.

6. In fluid-raising apparatus, the combination in each of a plurality of wells or other sources of the liquid to be raised, of a receiver for limited charges of the liquid to be raised, an eduction-pipe, means for successively expelling the liquid charges therethrough by pneumatic pressure acting under the liquid in said pipes to be ejected, a part of which means comprises a pneumatic chamber in connection with the main source of supply of compressed air and affording the ejecting force by expansive action of its contents after the supply of air is shut off, a follower between the air column and the liquid column in the eduction-pipe, a compressor supplying pneumatic pressure, alike to the plurality of wells or sources, and a controlling-valve for the apparatus of said wells, automatically actuated by air of the charging-supply when maximum pressure is reached to shut off such supply, and open the exhaust of the supplied well or wells and admit the supply and close the exhaust of the other well or wells alternately.

7. In fluid-raising apparatus, the combination of a receiver for the liquid to be raised, means for supplying the liquid thereto in limited charges, an eduction-pipe for the liquid, a follower therein, means for transferring the liquid into the eduction-pipe above the follower by pneumatic pressure, means for applying pneumatic ejecting force under the follower to the liquid column in the eduction-pipe, said means consisting of a compressor, an expansion-chamber, a connection between said compressor and expansion-chamber, with a receiving and separating chamber in said connection, and with a check-valve in the connection between the receiving and separating chamber and the expansion-chamber.

8. In fluid-raising apparatus, the combination of a receiver for the liquid to be raised, means for supplying the liquid thereto in limited charges, an eduction-pipe for the liquid, a follower therein, and means for transferring the liquid into the eduction-pipe above the follower and for applying pneumatic ejecting force under the follower to the liquid column in the eduction-pipe, said means consisting of the pipe in the receiving-chamber connected into the eduction-pipe above the follower and having the upturned lower end, the extension of the eduction-pipe below the follower and the duplex float-valve intermediate of the open ends of the said extension and pipe, said receiver being subject to pneumatic compression and suction alternately.

9. The combination with the eduction-pipe, the follower in said pipe, seat for the follower, and the extension of the pipe below the seat, of the check-valve under the seat to retain a cushion for the follower above the seat.

Signed by me at Bradford this 14th day of March, 1900.

EDWARD GRAY.

Witnesses:
GEORGE PATON,
PHILO C. BLAISDELL.