E. M. ROGERS.

AIR LIFT APPARATUS.

APPLICATION FILED JUNE 28, 1918.

1,319,797.

Patented Oct. 28, 1919.

7 SHEETS—SHEET 1.

FIG. 1.

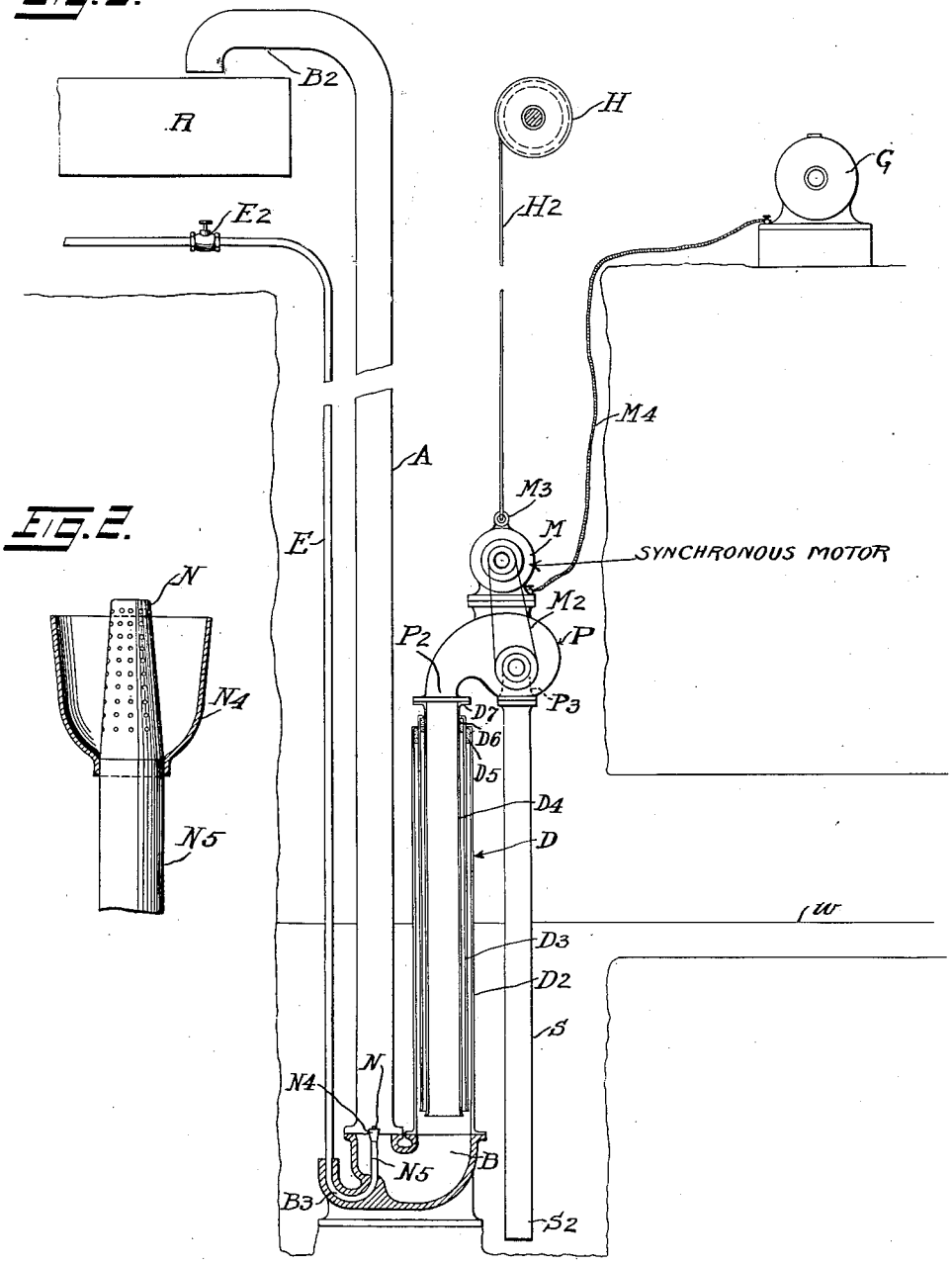



FIG. 2.




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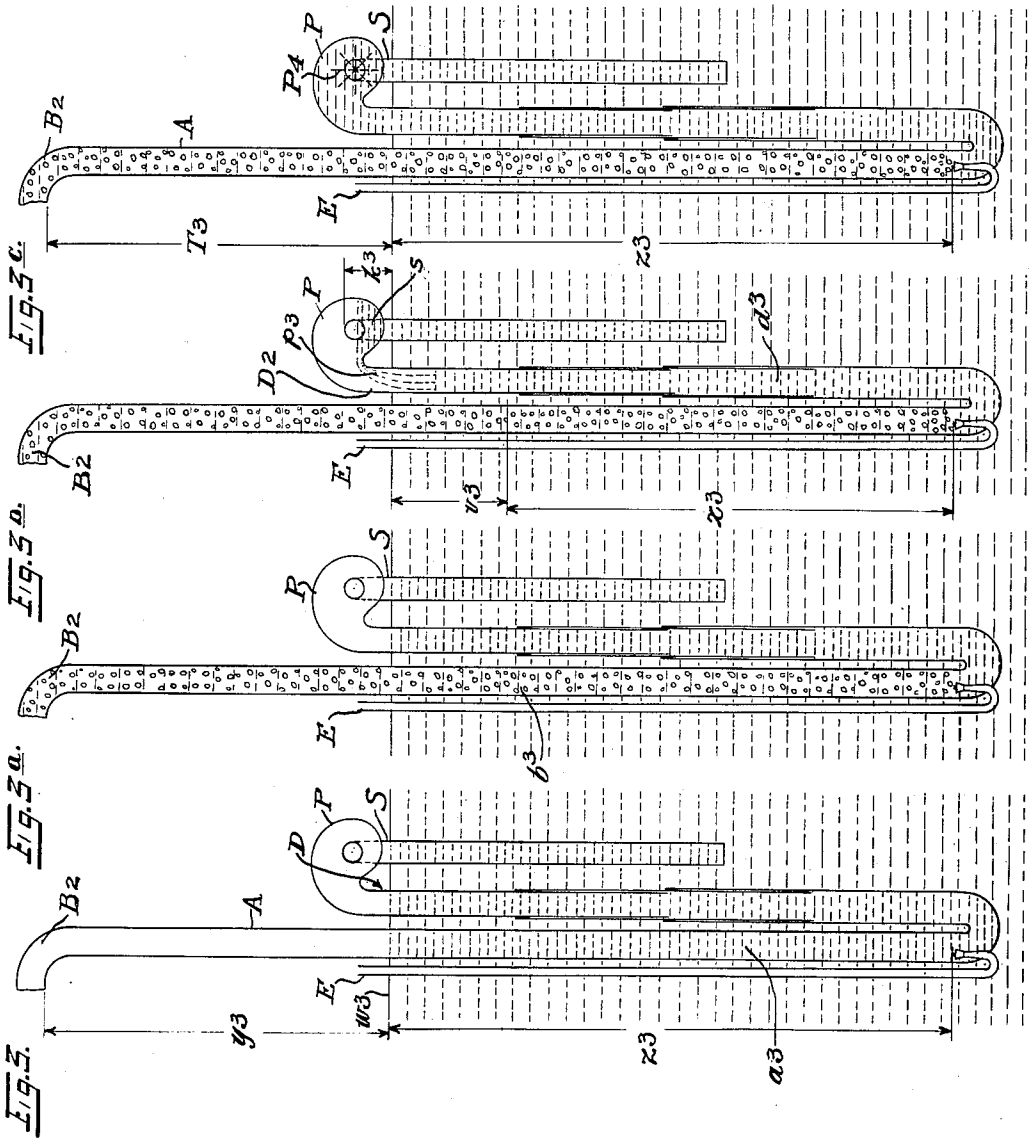
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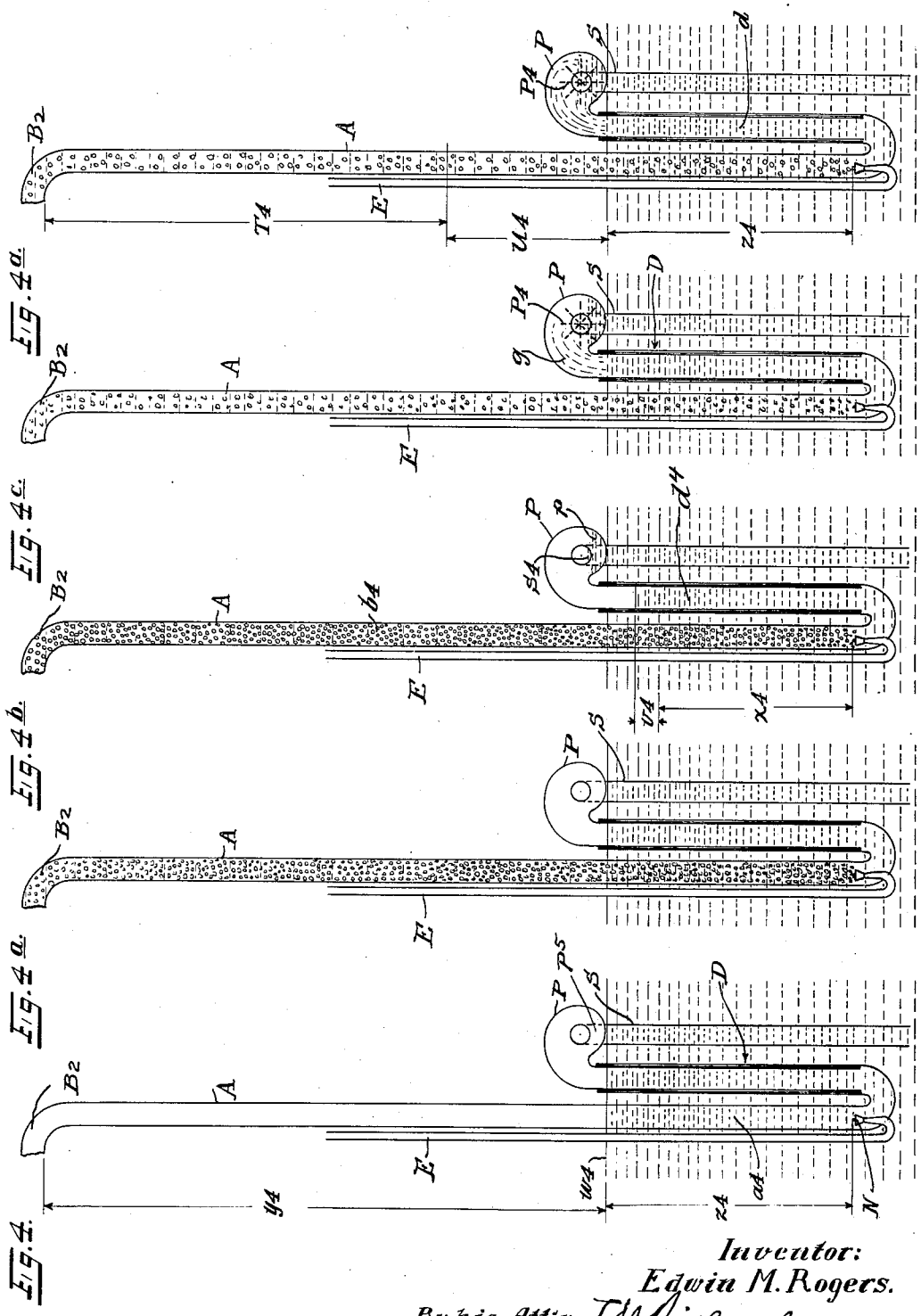
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7 SHEETS—SHEET 3.




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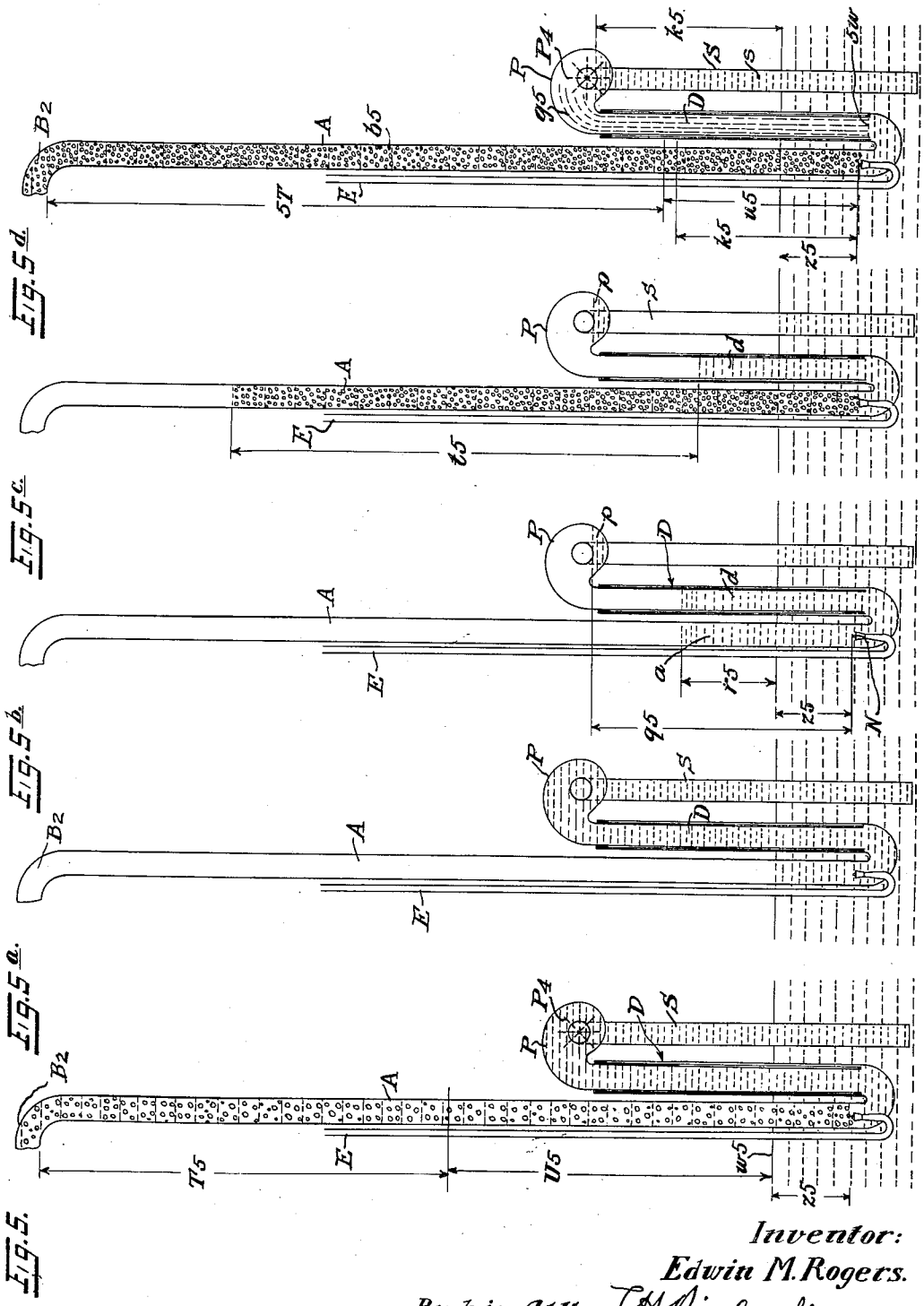
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7 SHEETS—SHEET 4.




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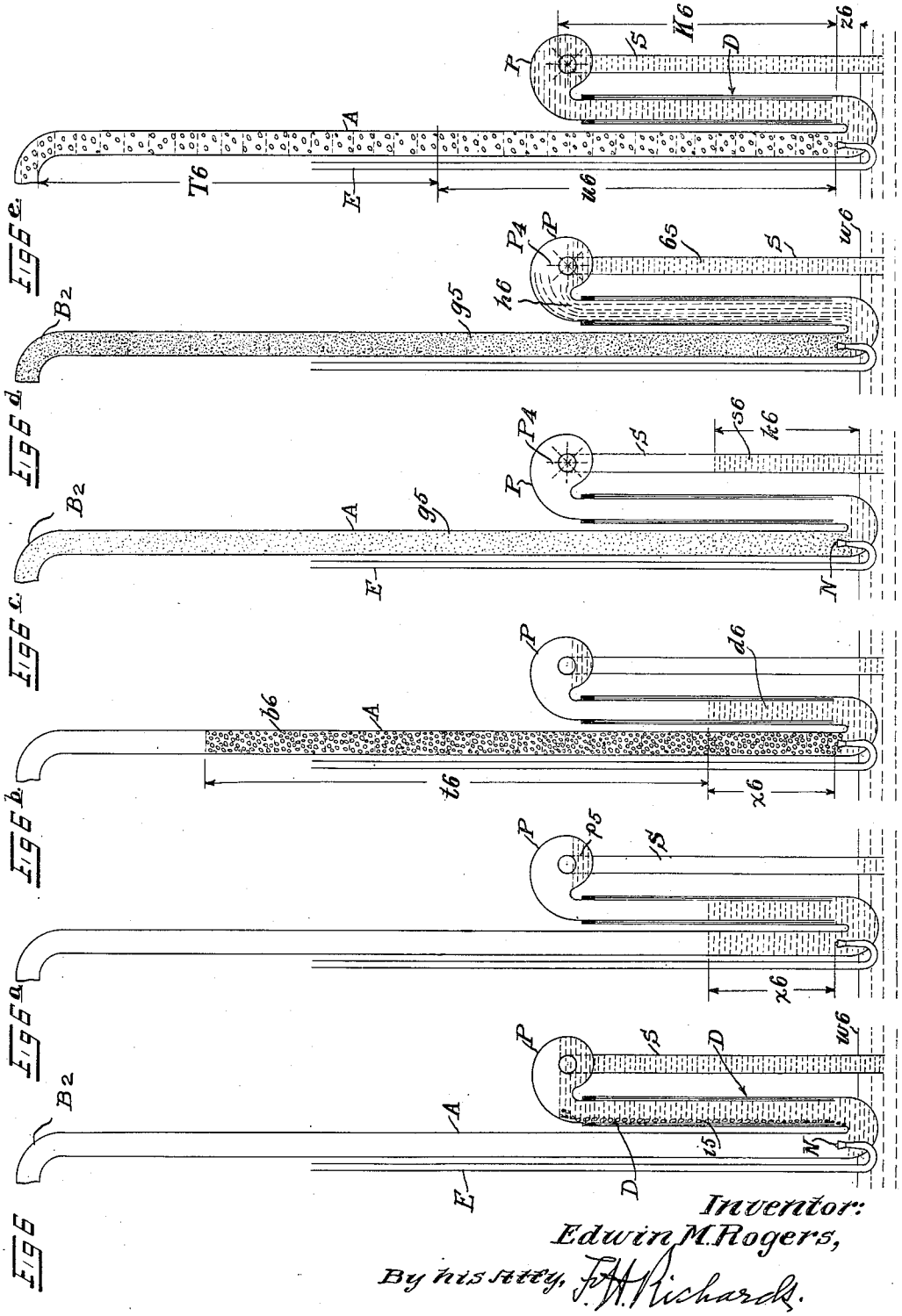
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7 SHEETS—SHEET 5.




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7 SHEETS—SHEET 6.

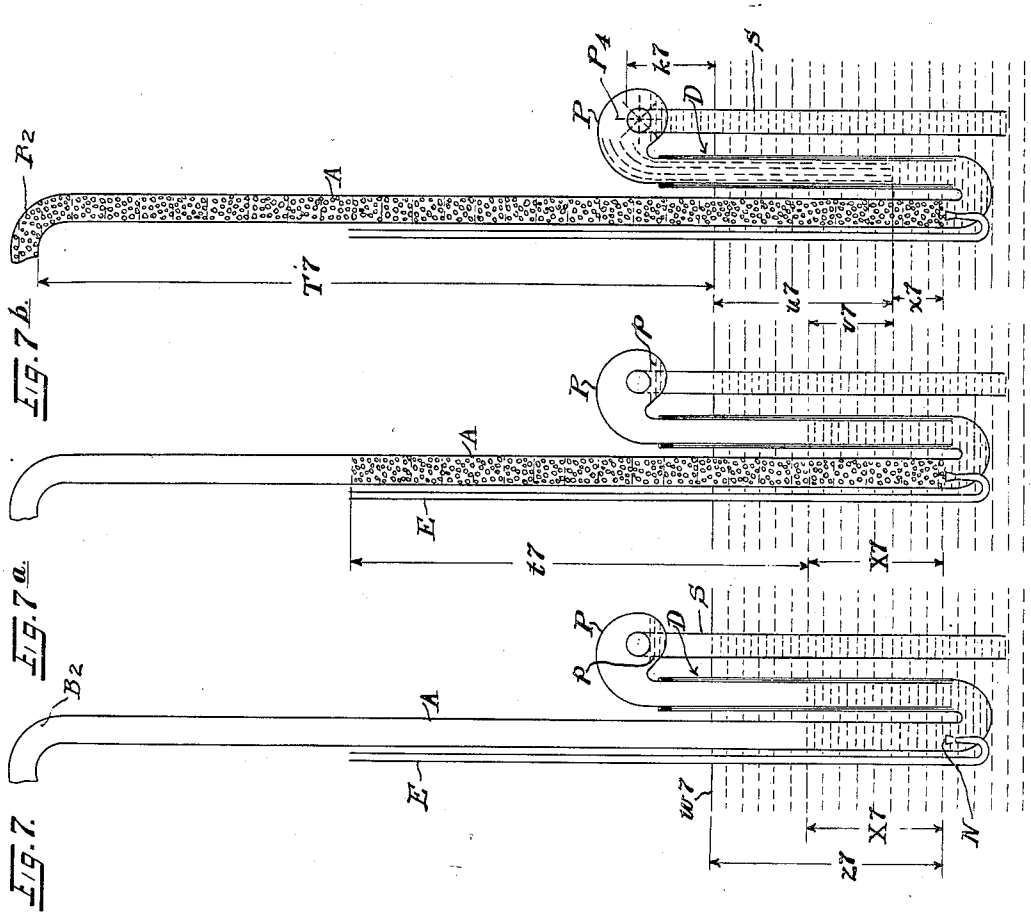



Fig. 7b.

Fig. 7a.

Fig. 7.

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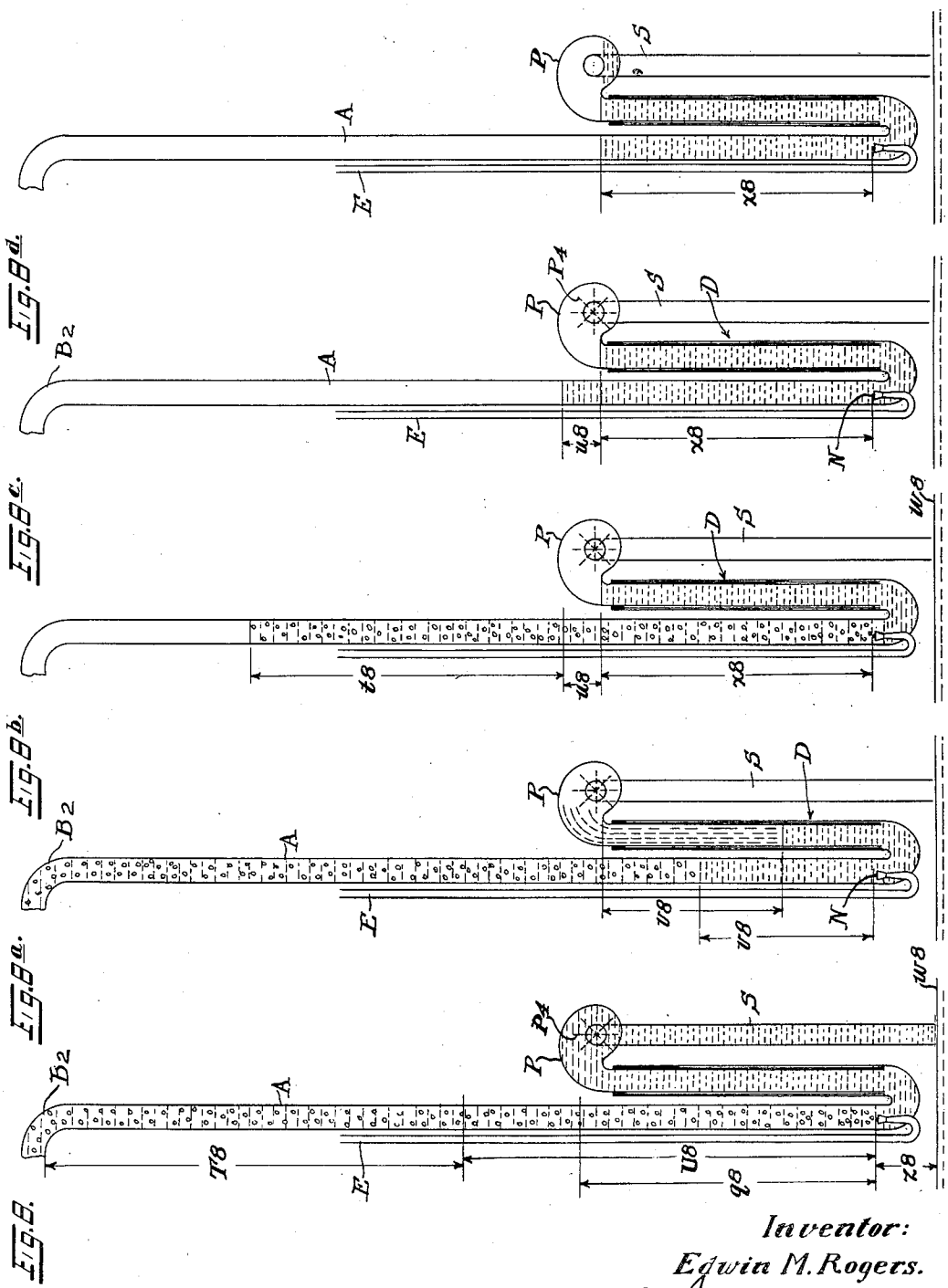
AIR LIFT APPARATUS.

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**1,319,797.**

Patented Oct. 28, 1919.

7 SHEETS—SHEET 7.




*Inventor:*

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# UNITED STATES PATENT OFFICE.

EDWIN M. ROGERS, OF NEW YORK, N. Y.

## AIR-LIFT APPARATUS.

1,319,797. Specification of Letters Patent. Patented Oct. 28, 1919.

Application filed June 28, 1918. Serial No. 242,363.

*To all whom it may concern:*

Be it known that I, EDWIN M. ROGERS, a citizen of the United States, residing in New York city, in the county of New York and State of New York, have invented certain new and useful Improvements in Air-Lift Apparatus, of which the following is a specification.

This invention relates to that class of air lift apparatus in which the column of water raised is aerated, and thereby lightened, to facilitate the raising thereof.

The object of the invention is to improve the construction and mode of action of such apparatus, and to provide efficient water-elevating apparatus of this kind which will be reliable and economical in operation under many and varied conditions of use, and which may be readily installed, operated and cared for by relatively unskilled labor.

In the accompanying drawing, Figure 1 is a somewhat diagrammatic side elevation illustrating the essential features of my invention, in a form and arrangement thereof especially adapted for use in draining and "un-watering" mines.

Fig. 2 is a fragmental vertical sectional view showing the aerating nozzle, in a well-known and preferable form thereof.

Figs. 3 to 8[a] are a series of six groups of diagrammatic side elevations illustrating phases of the operation of the apparatus.

Similar characters designate like parts in all the views.

In the form and arrangement thereof shown in Fig. 1, the aeration column pipe A, has its lower end connected to a base member, B, through which communication is established between the aeration pipe A and the submergence column pipe D. If preferred, the member B may be omitted, and the pipes A and D directly connected through an ordinary bend, as shown, for instance at the lower end of Fig. 3.

In order to provide for extension and shortening, whenever this shall be required, the column pipe D is herein shown, in Fig. 1, as comprising a lower section $D^2$, connected to the base member B, and an intermediate section $D^3$ telescopically received in the lower section, and an upper section $D^4$ telescopically received in the intermediate section. Suitable stuffing glands, as $D^5$ and $D^6$ appurtenant to the sections $D^2$ and $D^3$, respectively, provide sufficiently water-tight and air-tight slip joints between the intermediate section $D^3$ and the sections $D^2$ and $D^4$. It is of course understood that, in practice, the section $D^3$ may not be required, and that even the provision of any telescoping sections may sometimes not be necessary.

The upper end of the section $D^4$ is shown connected by some suitable means, as for instance the usual bolted flanges $D^7$ with the discharge pipe $P^2$ of the pump P, which in the present instance is shown of any well-known centrifugal kind. The intake pipe $P^3$ of the pump P is connected to the upper end of the suction pipe S, the lower end $S^2$ of which extends to the lowest point from which water is to be pumped, for instance as shown in Fig. 1 just below the base member B, but not more than operative suction distance below the top of the pump P.

As the various elements of the apparatus as above described are connected together in a water tight manner, these elements together form a laterally closed system having its extremities adapted for the ingress and egress of the water.

The pump P constitutes a fluid moving means, and it is preferably operated by an electric motor M; this may be mounted directly upon the pump and operably connected to the impeller of the pump by a suitable means, as for instance the belt $M^2$. The pump, the motor, the upper section $D^4$ and the suction pipe thus form a system relatively movable with respect to the aeration pipe, the base B and the lower section $D^2$, so that this system is adapted to be raised and lowered as a whole by some form of hoisting apparatus,—as for instance a winch at H,—from which said system may be suspended by means of a cable or the like, $H^2$, connected to an eye $M^3$ at the top of the motor. By this or analogous means, the pump may be lowered from time to time, and thus "follow down" the lowering water level during the un-watering of a pit or mine shaft.

Operating current is supplied to the motor through the electric cable $M^4$ connected to a generator G or other suitable source of current. The compressed air for aerating the aeration column is introduced into the lower part of the aeration column and this is preferably effected by means of an upwardly directed nozzle, N, having its extreme upper end closed and provided with

perforated sides surrounded by an upwardly flaring bell $N^4$ secured to the nozzle. The lower part of the nozzle is herein shown extended downwardly in the form of a pipe, $N^5$, and this may be screwed into the inner end of a U-shaped passage $B^3$ formed in the base member B. In the outer end of the passage *b* is screwed the lower end of the usual air pipe E and this is shown provided at its upper part with an air-admission valve, $E^2$, leading from the air compressor (not shown).

In normal operation, water passes through the suction pipe into the pump and thence into the submergence-column pipe D whence it passes into the aeration column pipe A. Air is admitted through the nozzle N under sufficient pressure to overcome the pressure of the water of the aeration column and to supply the desired amount of aeration, usually about fifty per cent., for reducing the weight of the water in the aeration column so that it may be overcome by the weight of water in the submergence column and if necessary or desirable, by additional pressure supplied from the pump itself. The aerated water passes out through the discharge-end, as $B^2$, of the aeration pipe and may be discharged into a trough or reservoir, as at R, and thence carried off, or pumped to a higher level, as occasion may require.

The pump P is, or may be, of any suitable character and preferably is a through-way pump or a centrifugal pump of the kind commonly used in mines. By "through-way" pump is meant that kind of pump through which whether operating or not, the water may have a continuous flow; this pump is also preferably of the kind, which, when not running, furnishes a free and unobstructed passage for water or air in either direction. This is true of the ordinary centrifugal pump.

The discharge pipe $P^2$ of the pump and the intake pipe $P^3$ thereof, are both shown in communication with the interior chamber of the pump at a point or level considerably above the lowest point of same chamber, and thereby a containing space as $P^5$, (Fig. 4) is provided for holding the priming water *p*, (Fig. $4^b$).

The motor M is preferably a synchronous motor or any other motor such that in normal operation an increase in load thereon correspondingly increases automatically the power output of the motor, so that the pump will at all times take care of any varying or increased load caused by any decrease in the lifting effect of the aeration, or by the increased suction resistance in the suction pipe S due to lowering of the level *w* of the water to be pumped.

The air-lift system when organized and arranged as herein described, provides space in the base B and the lower part of the pipes A and D in which the water contained therein forms a water seal to assist in starting the system, I have found in practice, even when constructed in very large dimensions, to have the important advantage of being self starting under all ordinary conditions, merely by supplying air in suitable quantity and pressure, and if necessary properly inaugurating and maintaining the operation of the pump, or the impeller. Also the means for operating the pump automatically varies in its operating effect in accordance with the varying lifting power, and substantially inversely as the lifting power of the aeration column varies.

Beginning with the apparatus at rest, and until it is in full operation, it is evident that during this period, the forces and resistances involved act, react and mutually coact in a variable and complex manner, which, as I now apprehend, may not as yet, or in all respects, be fully understood. However, from my investigations as regards the performance of my present improvements in practical operation, it appears that the more important phenomena occurring during said period of starting, accelerating and bringing it to full operation, may be sufficiently explained as follows:

First will be considered the conditions and operation of starting the apparatus when it is first let down into the water, the water being at a very high level, $w^3$ (Fig. 3), in which case the upper section is raised to keep the pump and motor out of the water.

The aeration pipe A, and the lower section $D^2$ are gradually lowered into the water, the pipe A usually being constructed,—or, the lengths or sections,—thereof assembled, during the lowering operation. The pipes A and D may be very economically constructed of relatively thin material, and water is or may be poured into these as they are let down in order to prevent water pressure from the outside from collapsing their thin sides, thus keeping the inside level substantially the same as the outside level $w^3$. After the pipes A and $D^2$ are let down, the sections $D^3$ and $D^4$ are slipped into place. The distance $z^3$ from the nozzle N to the level $w^3$ may be for instance, 35 feet, and the water having been permitted to rise in the suction pipe S will be of substantially the same level. In this condition, equilibrium is reached, the water $a^3$ in the pipe A balancing that in the pipe D, and the water in the suction pipe S being balanced by the water on the outside.

If now the valve $E^2$ be opened, and compressed air supplied in sufficient quantity to aerate the water in the pipe A until the aerated mixture consists only of about 50 per cent. water, the water and air mixture

$b^3$ will tend to rise until its height in A becomes 70 feet or twice its previous height. But since the distance $z^3$ plus $y^3$ is only 56 feet, the aerated mixture will pass rapidly out at $b^2$ and will continue to do so until all the water in pipe A is aerated. When this condition is reached the mixture in the whole 56 feet of the pipe A will weigh only as much as 28 feet of unaerated water and in order to establish equilibrium water will pass from the pipe D into the pipe A. The lowering of the water in the pipe D causes, through suction, a corresponding raising of water in the suction pipe S, and this lowering will continue until the water $d^3$ in the column D is balanced by the combined action of the mixture $b^3$ in the column pipe A and the water $s$ that is raised above the level $w^3$ in the pipe S. In the present assumed instance the distance $x^3$ or 28 feet of water in the pipe D would be required for balancing the mixture in the pipe A, while one half of the distance $z^3$—$x^3$, or $v^3$ (Fig. 3$^b$), in the present instance 3½ feet would be more than is necessary to draw the water the distance $k^3$; this raising of the water $s$, however, would carry the water above the inlet to the pump and cause the same to overflow into the discharge pipe $D^2$ as indicated at $p^3$ in Fig. 3$^b$. As the aerated mixture continues to flow out at $B^2$, the water would be drawn in at $p^3$ and continue to feed the submergence column, which action would continue until the water gradually absorbed and carried away all of the air in the pump, in which case the system would continue to operate efficiently on 50% aeration without the impeller $P^4$ (Fig. 3$^c$) being operated at all.

During this operation and since the intake and discharge waters of the pump having the same height balance each other, the balancing or submergence effect of the water in the submergence pipe is equal to the distance $z^3$ which is sufficient to balance a column aerated 50%, a distance of 35 feet in addition to the distance $z^3$ which is much more than the distance $T^3$ (Fig. 3$^c$) which in the present instance is only 21 feet.

Since the pump here described is a through-way pump, and hence acts as a passage or space when the impeller is not running, this condition of the impeller is diagrammatically indicated by omitting the impeller when it is not operated, the figures showing the impeller indicating thereby that the impeller is running. However, it would be desirable to start up the impeller before the level $w^3$ is reduced to, for instance, one half the distance $z^3$ plus $T^3$, since if the natural submergence effect supplied by the level $w^3$ should become less than that required to raise water aerated 50% to $B^2$, it would be necessary to supply some of the submergence effect by means of the impeller $P^4$ as will be more fully explained hereinafter.

Should both sections $D^3$ and $D^4$ be fully raised, the principle of operation of the apparatus would be the same as above described, and in either case it would be possible to operate the apparatus by either aeration or the pump alone or by both.

Now will be considered the conditions of starting the apparatus when it is first let down into the water, the water being at an intermediate level $w^4$ (Fig. 4), and with the sections $D^3$ and $D^4$ fully let down upon the lower section. The system, comprising the parts shown in Fig. 4, are let down as previously explained, water is poured in (when required) to prevent collapsing, thus keeping the water level therein substantially the same as the outside level $w^4$. The distance from the nozzle N to the level $w^4$ may be for instance 17 feet.

In this condition, the water in pipe A balances that in pipe D, and the water in S is balanced by the water on the outside. If now the valve $E^2$ be opened and air supplied in sufficient quantity to aerate the water $a^4$ in the pipe A until the aerated mixture consists of only about 25 per cent. water, the mixture $b$ will tend to rise until the height in the pipe A becomes 68 feet or four times its previous height. But since in the apparatus indicated the distance $z^4$ plus $y^4$ is only 56 feet, the aerated mixture will pass out at $B^2$ and continue to do so until all of the water in the pipe A is aerated. When this condition is reached, the mixture in the whole 56 feet of the pipe A will weigh only as much as would 14 feet of unaerated water in the pipe A, and in order to establish equilibrium water will have passed from the pipe D into the pipe A. The lowering of the water in the pipe D causes through suction a corresponding raising of the water in the suction pipe S, and this lowering will continue until the water $d^4$ (Fig. 4$^b$) in the column D is balanced by the combined action of the aerated water $b^4$ water in the pipe A and the water $s^4$ that is raised above the level $w^4$ in the pipe S. In the present assumed instance 14 feet of water in D would be required for balancing the mixture $b^4$ in the pipe A, while 1½ feet would be required to balance an equal amount of water raised in the suction pipe S if the suction pipe were the same diameter. This raising of the water in the pipe S however, would throw some water into the pump P thus priming the pump as indicated at $p$ in Fig. 4$^b$; but because of the irregular diameter of the intake of the pump and the pump chamber itself, there would be a slight variation from the distances stated above and the distances $x^4$ and $v^4$ (Fig. 4$^b$) would be only approximately 14 feet and 1½ feet respectively.

After the pump is thus primed, the im-

peller $P^4$ thereof is started and throws a spray $g$ (Fig. $4^a$) into the submergence pipe until the air therein is carried with the water from the submergence pipe into the aeration pipe to pass off with the aerated mixture. After this has been done the air supply through the nozzle N may be reduced until the aeration is most efficient, say 50 per cent., and the apparatus allowed to operate normally.

During this normal operation, since the intake and discharge waters of the pump balance each other as to their height, the balancing or submergence effect of the water $d$ in the pipe D is the distance $z^4$, and sufficient power is supplied to exert an unaerated water lifting-effect equal to somewhat more than the distance $u^4$ (Fig. $4^a$), making a total unaerated-water lifting effect of, in the present instance, more than 28 feet. Since the 50 per cent. aerated water weighs only half as much as the unaerated water,—neglecting the slight weight of the contained air,—the lifting effect of the aerated water is more than twice $u^4$ plus $z^4$, or $u^4$ plus $z^4$ plus $t^4$, or sufficient to carry the aerated water out at $B^2$.

It is noted that in the operation described in Figs. 3 to $3^c$ and 4 to $4^d$, the priming of the pump is incidental to the necessary operation of the system as a whole, and it is perfectly obvious that enough water may be poured into the aeration pipe A as the system is let down into the water to cause overflow of water from the pipe D into the pump for priming the latter before the air is admitted through the nozzle N. If the level $w$ of the water were less than is indicated in Figs. 3 and 4 when the pump is first let down, sufficient water could in this case also be poured in at the aeration pipe to cause the priming of the pump before starting the aeration, as just stated. But often the system has been in normal operation and is then stopped, the restarting thereof presents conditions different from those described above. In one of these conditions (Fig. 5) it will be considered that the water level $w^5$ has become so low that the distance $z^5$ (Fig. 5) is for instance, only about 6 feet. Under these conditions the natural submergence effect in the pipe D is only the distance $z^5$. At this time the water in the pipe D above the level $w^5$ is balanced by the same height of the water in the suction pipe S, therefore, in order to furnish sufficient submergence effect to discharge the water at $B^2$ at 50% aeration, it is necessary for the pump to furnish an additional submergence effect equal to the distance $U^5$, or for instance, 22 feet. When the impeller stops and the valve $E^2$ is closed, and aeration ceases, the water in the pipe A settles down until it stands at the height $z^5$, and the height $z^5$ in the pipe A is counterbalanced by the same height of water in pipe D, while the water in the pipe D above the level $w^5$ is counterbalanced by the water in the pipe S above said level, (Fig. $5^a$). After this condition takes place there will, in time, be a leakage of air through the bearings of the pump into the pump, which will permit the water to sink in the pipe S down to the level $w^5$. At the same time the water which is contained in the pipe D passes into the pipe A until the two columns of water $a$ and $d$ are balanced at a height $z^5$ plus $r^5$ which may be in the present instance 12 feet, since the length of the submergence pipe as indicated in Fig. $5^b$, is from the level of the nozzle N to the lower part of the discharge opening of the pump the distance $q^5$ for instance, about 18 feet. Since the suction pipe S extends below the level $w^5$, the evaporation of the priming water $p$ which was left in the pump is prevented, therefore, when the apparatus is again started up, the water disposed in the pipe $d$ furnishes a natural submergence for the distance $z^5$ plus $r^5$ (Fig. $5^b$) and when the water in the aeration pipe is aerated to 25% of water to 75% of air the 12 feet of water $d$ in the pipe D will balance aerated mixture in the pipe to the additional distance $t^5$, and thus the water is held four times as high in the column A as it is in the column D.

When the pump $p$ is started after being previously primed as stated, it immediately draws water up through the suction pipe S a distance for instance of $K^5$, at the same time forcing the air down the same distance in the submergence pipe D. This distance in the present instance will be just about sufficient to force the level $w^5$ in the pipe D to the bottom of said pipe. In doing this the pump exerts a lifting force of $k^5$ and another lifting force equal to $u^5$ necessary for holding the level of the water in the pipe D to $w^5$ and against the weight of the mixture $b^5$ (Fig. $5^d$), the 25% aeration of which adds the additional height of $5^T$. During this time additional water is poured as indicated at $g^5$ into the pipe D in turn to be supplied to the pipe A and aerated, and this action will continue to take place until all of the air is carried by the spray $g^5$ from the pipe D into the pipe A, and when the aeration is reduced to 50% the apparatus will continue the normal operation as indicated in Fig. 5.

If when the pump ceases operation the level $w^6$ (Fig. 6) in the pit is below the nozzle N, then when the supplied air to the aeration column is stopped, the mixture in the pipe A will gradually settle down and as it settles, the water in the pipe A will be siphoned out from the pipe D, the pump $p$ and the pipe S until the siphon breaks. Air bubbles $i^5$ will bubble up through the pipe D and permit all of the water to run out of the pipe S (Fig. $6^a$). At the same time the

water which was contained in the pipe D will rush back until it stands at equal heights $x^6$ in the pipes A and D.

If, as in Fig. 6, the level $w^6$ should be below the lower end of the pipe A, when the water passed out through the suction pipe S as stated of Fig. $5^a$, this action would continue until the water in the pipe A would be drawn to the lower end of the pipe A because the heights $x^6$ in pipes D and S would balance each other while there would be nothing to balance the height $z^6$ of the pips S. Therefore the air bubbles 5 would pass into the pump and permit all of the water in the pipe S to pass out by gravity, leaving the priming water $p$ in the pump, and the water balanced in the pipes A and D at the height $x^6$.

If now the water in the pipe A be aerated to 75%, and only 25% water, the aerated water $b^6$ will stand four times its previous height, having the additional height of $t^6$ due to the aeration. If at this time, the impeller, (which has been already primed, as stated), be started, water, $s^6$ in the pipe S will be drawn up distance $k^6$ (Fig. $6^c$) somewhat greater than the distance $x^6$ (Fig. $6^b$) and at the same time the water $d^6$ in the pipe D will be forced down an equal amount and the air from the impeller will be blown into the pipe A and coact with the air blast from the nozzle to blow out the aerated water in the form of a spray, $g^5$, thus lightening the load on the pump so that the pump will immediately draw up water $6^s$ in the suction pipe S (Fig. $6^d$) and throw the same over in the form of a spray $h^6$ into the pipe D. In time this spray will carry away with it the air from the pipe D, after which the aerations may be reduced to 50%, in which case, the height $K^6$ (Fig. $6^e$) in the pipes D and S, will balance each other and the impeller will have to furnish (will be drawn upon for) a lifting effect equal to $u^6$ plus $z^6$ in order that the additional lifting effect $T^6$ due to the aeration may cause the water to be carried out at $B^2$.

If after the water in the pipes A and D has come to equilibrium at the height $X^7$ (Fig. 7) in the manner indicated in Figs. 6 and $6^a$, and the level $w^7$ of the water should rise to the height $z^7$ above nozzle N, aeration to 25% of the water in the pipe A would cause the aerated water to raise the additional height $t^7$. When the impeller is started up, the water in the pipe D is drawn up to the pump the distance $k^7$ and depressed a corresponding distance $v^7$ in the pipe D. At this time, the impeller exerts a lifting effect of $k^7$ and a submergence effect equal to $u^7$, the aeration effect thereof being equal to $T^7$, and this continued operation of the impeller causes the carrying away of all of the air from the pipe D and when the aeration is reduced to 50% the pump will operate normally approximately as indicated in Fig. $4^d$.

In practice it will sometimes happen that pumping continues to take place until the level $w^8$ (Fig. 8) falls below the lower end of the suction pipe S. Just at the instant before this takes place, the water in the pipes D and S, measured by the distance $q^8$, balance each other, while the impeller $P^4$ must exert a lifting effect in the pipe S equal to the distance $z^8$ and must also furnish an artificial submergence effect equal to the distance $U^8$, which is half the distance $U^8+T^8$ so that the additional lifting effect due to normal 50% aeration may raise the water through the additional distance $T^8$.

As soon as the lower part of the pipe S, clears the water, the water in said pipe will drop out, except that which is thrown over into the submergence pipe in the form of a water and air spray. This will lower or push down the level of the water in the pipe D at the most, probably as far as the distance $V^8$, the water being thrown up in the pipe A a similar distance $V^8$. This will cause aerated water to be thrown out at $B^2$, until equilibrium is reached. After the water has been entirely driven out from the pump, the air-pressure effect of the pump is greatly reduced, say to about two feet, and the water and water mixture in the pipe A will balance the water in the submergence pipe D and the pressure of the pump. This is indicated in Fig. $8^b$ where the distance $x^8$ represents the submergence effect of the water and $u^8$ represents the pressure submergence effect of the pump P, which effects together balance the aerated mixture in pipe at the additional equal height $t^8$. This is indicated in Fig. $8^b$, where the aerated water having a height approximating $t^8$ plus $u^8$ plus $x^8$, is counterbalanced by the submergence water having a height of $x^8$ and the pump having a pressure effect of $u^8$.

If, therefore, the air be permitted to pass off through $B^2$, the water in the pipe A will settle down to the height $u^8$ plus $x^8$ (Fig. $8^c$), with the impeller still running; but when the impeller is stopped, the pressure effect, which holds the water in the pipe A the additional height $u^8$, will be lost, and the water in the pipes A and D will tend to become of the same height $X^8$, and water will be forced back into the pump. Thus the pump will be left primed and the pipe D left filled for a time in readiness for a subsequent operation.

During the practical normal operation of the apparatus, it is impossible to prevent variations in the supply of operating current to the motor. This causes fluctuations in the lifting power applied by the pump. When these fluctuations take place, the inertia and weight of the water in the submergence column D furnish a steadying effect to

the operation as a whole, not only because of the inertia of the water, but because the weight of the water in the submergence column balances a large portion of the aerated water.

I claim:—

1. An apparatus of the character described comprising an aeration column; a submergence column having its upper end higher than the lower part of the aeration column and having its lower part in communication with the aeration column; and a pump positioned and connected to force water into the submergence column and to add its pressure effect to the submergence effect of the submergence column so that the total submergence effect is greater than the submergence effect of the submergence column.

2. An apparatus of the character described comprising an aeration column; a submergence column having its upper end higher than the lower part of the aeration column and having its lower part in communication with the aeration column; and a pump positioned and connected to force water into the upper part of said submergence column, said columns and pump together forming a substantially laterally closed, laterally air-tight system.

3. An apparatus of the character described comprising an aeration column; a submergence column having its upper end higher than the lower part of the aeration column and having its lower part in communication with the aeration column; and a pump positioned and connected to force water into the upper part of said submergence column and to add its pressure effect to the submergence effect of the submergence column so that the total submergence effect is greater than the submergence effect of the submergence column alone to permit the varying of the total submergence effect by varying the pressure effect of the pump, said columns and pump together forming a substantially laterally air-tight system.

4. An apparatus of the character described comprising an aeration column; a submergence column having its upper end higher than the lower part of the aeration column and having its lower part in communication with the aeration column; a throughway centrifugal pump disposed above said submergence column and positioned and connected to force water into the upper part of said submergence column and to add its pressure effect to the submergence effect of the submergence column thereby to increase the maximum submergence effect of the submergence column and to permit the varying of the total submergence effect in excess of said maximum by varying the pressure effect of the pump, said columns and pump together forming a substantially laterally air-tight system; and means operable independently of the pump for supplying air to the aeration column.

5. An apparatus of the character described adapted to convey water from a lower to a higher level, said apparatus comprising an up-take aeration column; a submergence column having its upper end higher than the lower part of the aeration column and having its lower part in communication with the aeration column and lower than said lower level; and a pump disposed above said submergence column and above said lower level and positioned and connected to force water into the upper part of said submergence column to increase the submergence effect of the submergence column by the pressure effect of the pump, said columns and pump together forming a substantially laterally closed, laterally air-tight system.

6. An apparatus of the character described adapted to convey water from a lower to a higher level, said apparatus comprising an up-take aeration column; a submergence column having its upper end higher than the lower part of the up-take column and having its lower part in communication with the up-take column; a pump disposed above said submergence column and above said lower level and positioned and connected to force water downwardly into the upper part of said submergence column to increase the submergence effect thereof; and a suction pipe for said pump having its lower end near the lower end of the submergence column, said columns, pipe and pump together forming a substantially laterally closed, laterally air-tight system.

7. An apparatus of the character described adapted to convey water from a lower to a higher level, said apparatus comprising an up-take aeration column; a submergence column having its upper end higher than the lower part of the up-take column and having its lower part in communication with the up-take column; and a pump disposed above said submergence column and above said lower level and adapted to hold its own priming water and positioned and connected to force water into the upper part of said submergence column to increase the submergence effect thereof, said columns and pump together forming a substantially laterally closed, laterally air-tight system.

8. An apparatus of the character described comprising an up-take column; a submergence column having its upper end higher than the lower part of the up-take column and having its lower part in communication with the up-take column; and a pump disposed above said submergence col-

umn and adapted to hold its own priming water, and positioned and connected to force water into the upper part of said submergence column, said columns and pump together forming a substantially laterally air-tight system.

9. An apparatus of the character described comprising an up-take aeration column; a submergence column having its upper end higher than the lower part of the up-take column and having its lower part in communication with the up-take column; a throughway pump positioned and connected to force water into the upper part of said submergence column to increase the submergence effect thereof, said columns and pump together forming a substantially laterally closed, laterally air-tight system; a motor for said pump; and means operable independently of the pump for supplying air to the up-take column for aerating the water in the up-take column for permitting the submergence column to balance a portion of the aerated water and furnish by its weight and inertia a steadying effect to the pressure effect of the pump during variations in the power supplied by the motor to the pump.

10. An apparatus of the character described comprising an up-take aeration column; a submergence column having its upper end higher than the lower part of the aeration column and having its lower part in communication with the aeration column; a throughway centrifugal pump disposed above said submergence column and adapted to force water into the upper part of said submergence column, said columns and pump together forming a substantially laterally closed, laterally air-tight system; a motor for said pump; and means operable independently of the pump for supplying air to the aeration column for aerating the water in the aeration column to permit the submergence column to balance a portion of the aerated water and furnish by its weight and inertia a steadying effect to the pressure effect of the pump and to the air-lift effect during variations of air or power supply.

11. An apparatus of the character described adapted to convey water from a lower to a higher level, said apparatus comprising an aeration column; a submergence column having its upper end higher than the lower part of the aeration column and having its lower part in communication with the aeration column; a throughway centrifugal pump disposed above said submergence column and above said lower level and adapted to force water into the upper part of said submergence column and to add its pressure effect to the submergence effect of the submergence column thereby to increase the submergence effect to the extent of the pressure effect furnished by the pump and to permit the varying of the total submergence effect by varying of the pressure effect of the pump; a suction pipe for said pump having its lower end near and lower than the lower end of the submergence column, said columns, pipe and pump together forming a substantially laterally closed, laterally air-tight system; a motor for said pump; and means operable independently of the pump for supplying air to the aeration column for aerating and thereby lightening the water in aeration column to permit the submergence column to balance a portion of the aerated water and furnish by its weight and inertia a steadying effect to the pressure effect of the pump if the power supplied by the motor should vary.

12. In an apparatus of the character described, the combination of an aeration column; a longitudinally adjustable submergence pipe communicating with said column; and means for discharging water into the submergence pipe.

13. In an apparatus of the character described, the combination of an aeration column; a longitudinally adjustable submergence pipe communicating with said column; a suction pipe; means for drawing water from the suction pipe and discharging it into the submergence pipe; and means for adjusting the length of the submergence pipe and the depth of the inlet of the suction pipe.

14. In an apparatus of the character described, the combination of an aeration column; a submergence pipe communicating with said column and comprising telescoping upper and lower sections; means for supplying air to the aeration column and means for discharging water into the submergence pipe.

15. In an apparatus of the character described, the combination of a pair of fluid moving means adapted to add their fluid effects, one of which means is adapted to automatically vary its moving effect inversely as the moving effect of the other means varies.

16. In an apparatus of the character described, the combination of an aeration column; and means adapted to force water into the aeration column and to automatically vary its forcing effect inversely as the lifting effect of the column varies.

17. In an apparatus of the character described, the combination of an aeration column; a submergence column communicating with the lower part of the aeration column; a centrifugal pump adapted to force water into the submergence column; and an electric motor for operating the pump and automatically varying its lifting

power substantially inversely as the lifting power of the aeration column varies.

18. In an apparatus of the character described, the combination of an aeration column; and a pump connected in series; and means for operating said pump and automatically varying its power output so that when the lifting effect of the aeration column varies, the power output of the motor and the lifting power of the pump vary substantially inversely to the lifting effect of said column.

19. In an apparatus of the character described, the combination of an aeration column; a submergence pipe comprising an upper section and a lower section, the latter communicating with the aeration column; a suction pipe; a pump communicating with said upper section and suction pipe; a motor for the pump; and means for raising said motor, pump, suction pipe and upper section relative to the lower section.

20. In an apparatus of the character described, the combination of an aeration column; a submergence pipe comprising relatively movable upper, intermediate, and lower sections, the lower section communicating with the aeration column; a suction pipe; a pump secured to and communicating with said upper section and said suction pipe; a motor secured on said pump for operating the same; and means for raising or lowering said motor, pump, suction pipe and upper section in unison.

21. In an apparatus of the character described, the combination of an aeration column means for forcing the water into the aeration column; and means for raising or raising or lowering said first named means relative to the aeration column.

22. In an apparatus of the character described, the combination of an aeration column; a suction pipe; means for drawing water from the suction pipe and forcing the water into the aeration column; and means for raising or lowering said first named means and said suction pipe relative to the aeration column.

23. In an apparatus of the character described, the combination of an aeration column; a submergence pipe comprising an upper section, an intermediate section and a lower section, the one telescoping into the other, the lower section communicating with the aeration column; a suction pipe; a centrifugal pump having its intake secured to and communicating with the suction pipe and its discharge secured to and communicating with said upper section; a motor secured on said pump and operatively connected thereto; and a suspending means attached to said motor for lowering and raising the motor, the pump, the suction pipe and said upper section together.

EDWIN M. ROGERS.

Witnesses:
H. M. KILPATRICK,
H. D. PENNEY.