(No Model.) 2 Sheets—Sheet 1.

J. G. POHLÉ.

PROCESS OF AND APPARATUS FOR ELEVATING LIQUIDS.

No. 532,699. Patented Jan. 15, 1895.

Fig. 1.

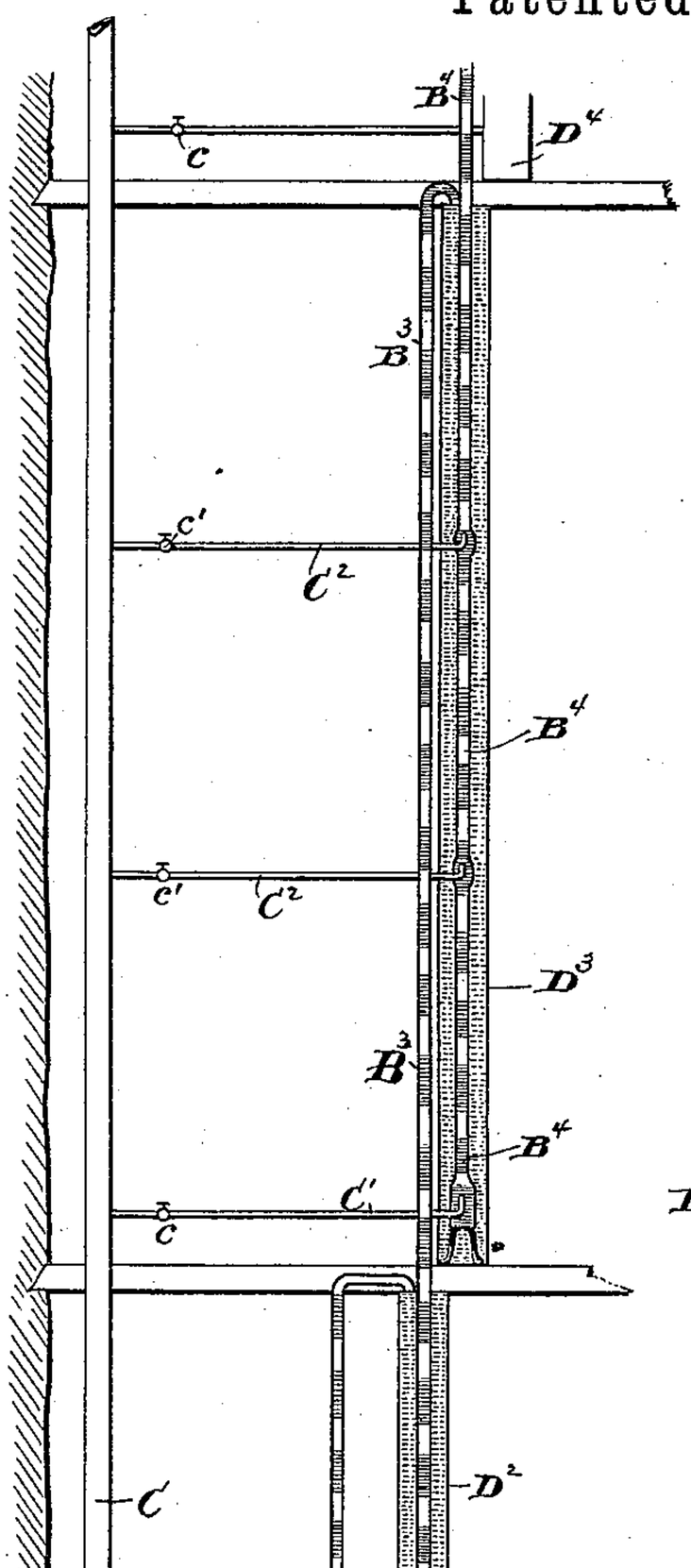
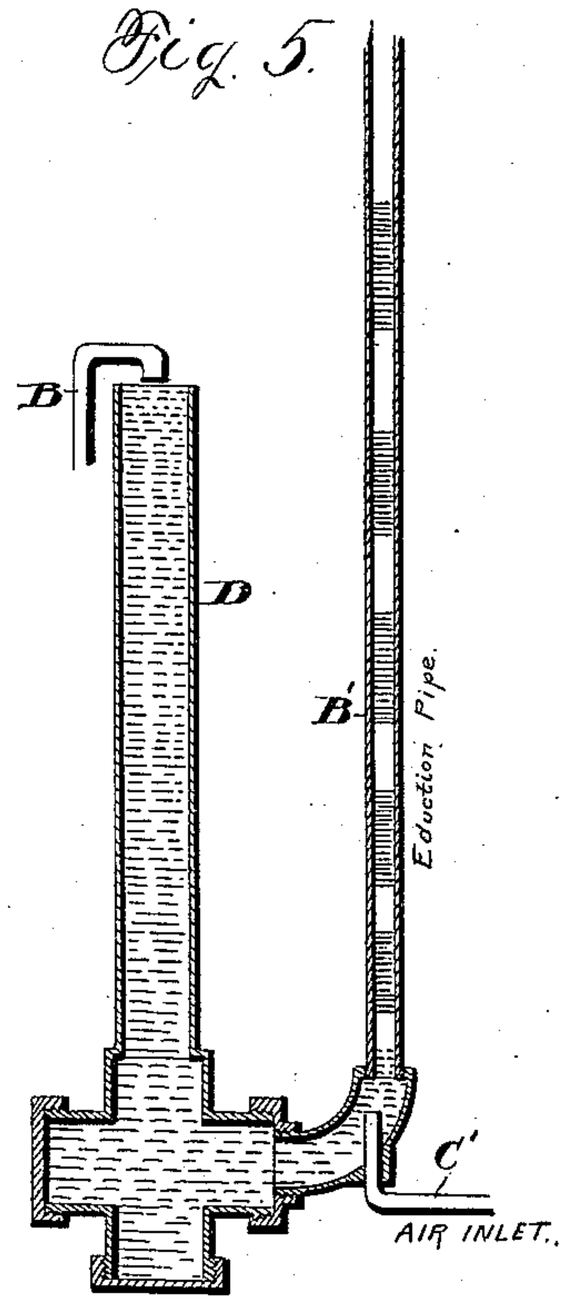


Fig. 5.



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(No Model.) 2 Sheets—Sheet 2.

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PROCESS OF AND APPARATUS FOR ELEVATING LIQUIDS.

No. 532,699. Patented Jan. 15, 1895.

Fig. 2.

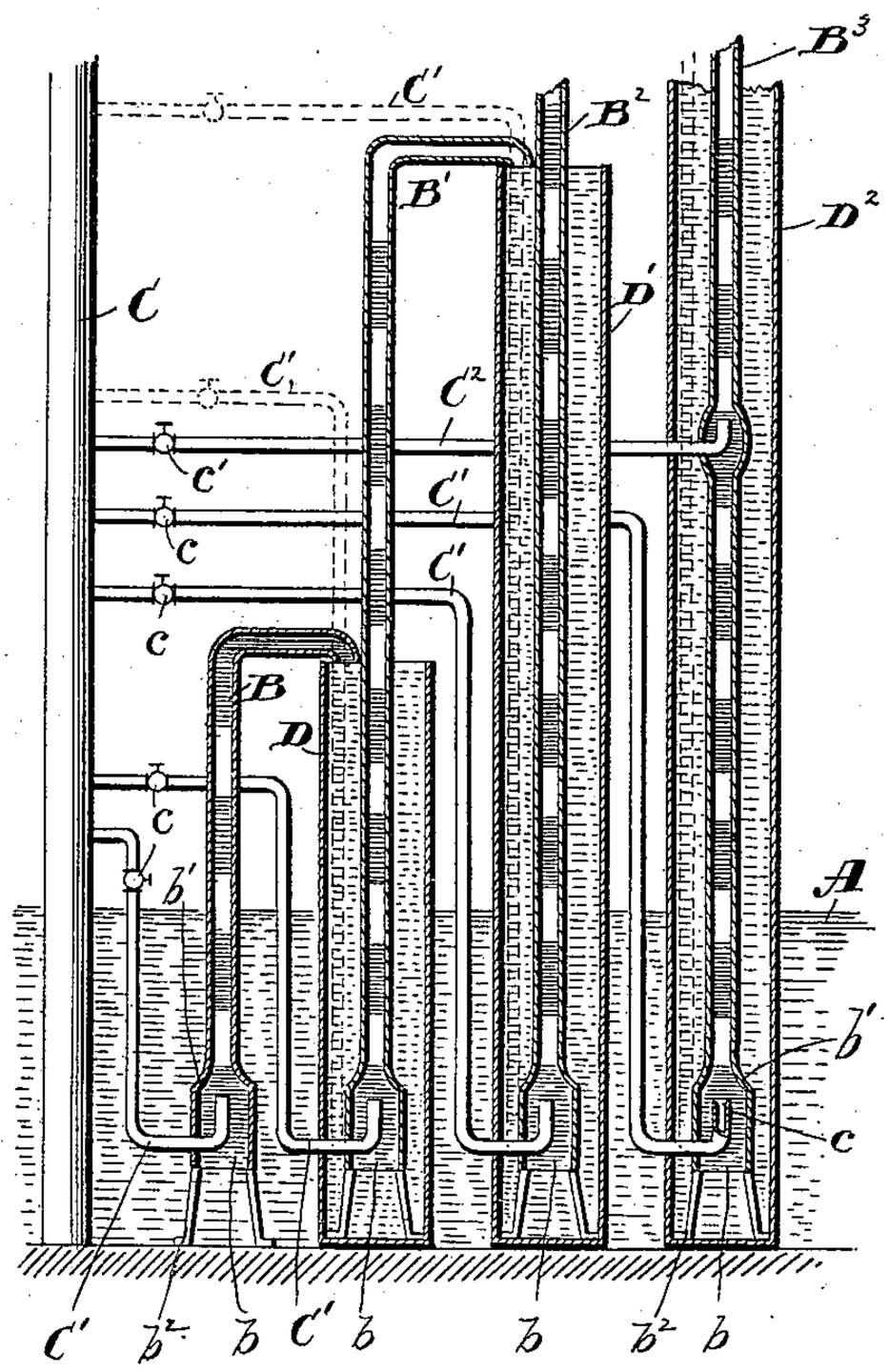


Fig. 3.

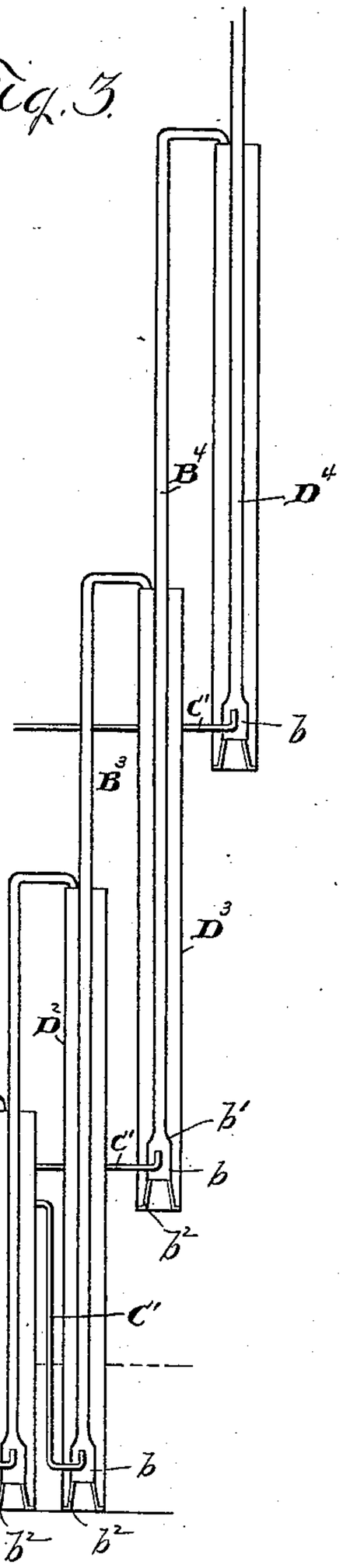
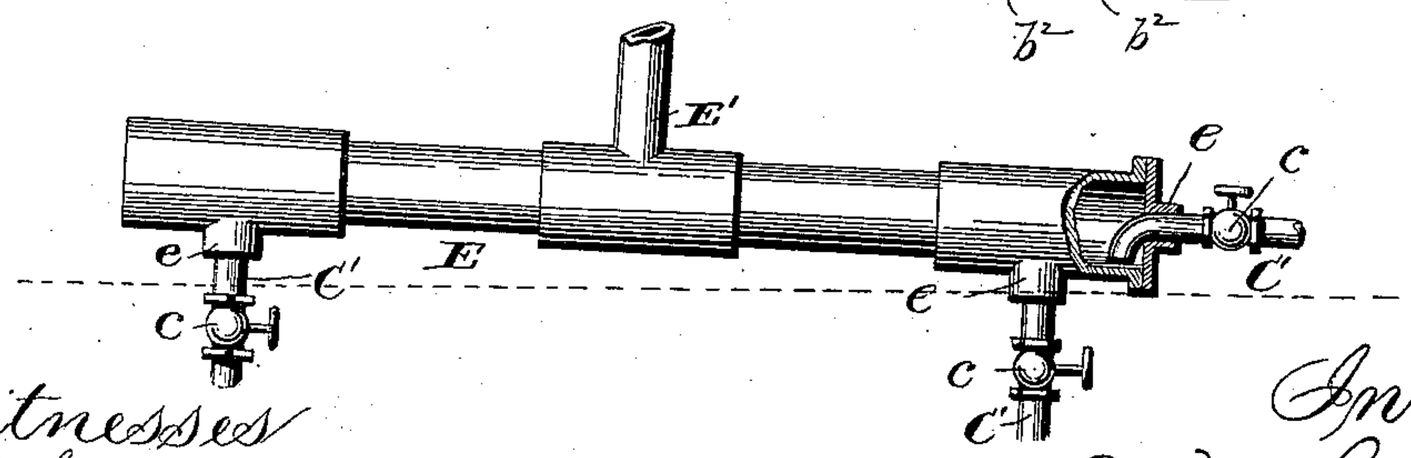


Fig. 4.



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UNITED STATES PATENT OFFICE.

JULIUS G. POHLÉ, OF NEW YORK, N. Y.

PROCESS OF AND APPARATUS FOR ELEVATING LIQUIDS.

SPECIFICATION forming part of Letters Patent No. 532,699, dated January 15, 1895.

Application filed June 10, 1893. Serial No. 477,240. (No model.)

To all whom it may concern:

Be it known that I, JULIUS G. POHLÉ, a citizen of the United States, residing at New York city, in the county of New York, and in the State of New York, have invented certain new and useful Improvements in Processes of and Apparatus for Elevating Liquids; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, in which—

Figure 1 shows a view of my apparatus partly in vertical section, and partly in elevation; Fig. 2, a view on an enlarged scale of a longitudinal vertical section of the lower part of the apparatus, shown in Fig. 1; Fig. 3, a view of a modified arrangement of the tanks or stand-pipes of the upper part of the apparatus; Fig. 4, a detail view on an enlarged scale, showing the air distributing reservoir, with the casing of its lower end partially broken away, and Fig. 5, a detail view showing an eduction pipe running up outside of the respective stand pipe.

Letters of like name and kind refer to like parts in each of the figures.

In the United States patent granted to me, December 6, 1892, No. 487,639, there is shown, described and claimed, a process of elevating liquids, in the carrying out of which an open ended eduction-pipe is partially submerged in a body of the liquid to be raised, and compressed gaseous fluid, preferably air, is continuously introduced into the lower part of the eduction-pipe, in such manner, as to form, in the pipe, a series of bubbles of the compressed gaseous fluid, containing enough of the latter to expand across the pipe, and form pipe-fitting piston-like layers in the column of liquid within the pipe; so that the column of liquid rising in the pipe, because of the pressure of the external liquid, after that portion which originally stood in the pipe has been forced out, is subdivided by the gaseous fluid into small portions before it reaches the level of the liquid outside of the pipe; and a continuously upward flowing series of well defined alternate layers of gaseous fluid and short layers of liquid are formed and forced up the pipe. The result is, that, after the process is once started, the liquid will be continuously elevated in the eduction-pipe and discharged from the mouth thereof, even where the latter is situated far above the level of the body of liquid surrounding the submerged part of the pipe. As fully described in my said patent, with the submergence of the pipe equal to about three fifths of its entire length, a rapid and substantially continuous flow of liquid from the upper end of the pipe can be secured, with the gaseous fluid at a pressure less, than that of the weight of a column of the liquid extending up in the pipe, from the point of entry of the fluid, to the level of the surrounding liquid. The manner and principle of the working of my said process are fully set forth in my said patent, and need not be explained at length in the present case.

As described, the process and apparatus are well adapted for the economical raising of the liquid to a height, above the body, in which the eduction-pipe is submerged, equal to or two thirds of the extent of the submergence. The possible height of elevation of liquid, above said body, depends upon the submergence. With this fact in view, it has been the special purpose of my present invention, set forth in and covered by this application, to make my process applicable where, as is often the case in mines, the water or other liquid is to be raised to a considerable height, and the depth of the body of liquid to be acted upon, is not sufficient to enable the required submergence to be obtained by sinking the eduction-pipe directly in it; and to make it possible to secure any extent of submergence needed for the raising of liquid to the height desired for any one direct lift through a single eduction-pipe, and to this end my invention consists in the process, and in the apparatus and parts thereof, as hereinafter specified.

In the drawings A designates a mine-sump or other receptacle, from which the water is to be elevated many times the depth of the liquid contents thereof. As indicated, such depth is six feet, but it can be more or less, without interfering with the successful operation of my process, if the parts of the apparatus used are varied accordingly, in the manner to be suggested hereinafter. Par-

tially submerged in the body of water in said sump or receptacle, is the upright eduction-pipe B, shaped like the corresponding part shown in my said patent; that is, having the enlargement or chamber *b*, at its lower end, connected with the main part of the pipe by a taper or conical part *b'*. Such enlargement, while desirable, can be dispensed with, without departure from my process, as covered herein. For support of the pipe, so as to leave its lower end open, to allow free flow of the water, from the sump, up through it, I show legs or standards b^2, b^2, resting on the sump-bottom; but do not confine myself to such construction. Any other form of support can be used instead.

A pipe C, connected with any suitable source of supply of gaseous fluid, for ordinary purposes, preferably, air, has a part C' running down into the lower end of the eduction-pipe, or the enlargement *b* therein, and its end turned upward, so as to discharge substantially in line with the main part of pipe B. Its mouth *c* is, as shown and described, in my patent referred to, preferably made upwardly flaring, so as to cause the air issuing from it to spread out and form bubbles as large as possible.

The eduction-pipe B extends up above the level of the water in the sump or receptacle A, a distance about equal to the length of the submerged portion of the pipe, that is, about six feet, and there discharges into the upper end of a stand-pipe or deep tank D, which can be conveniently made in the form of a pipe, as it need not have a diameter much larger than the second eduction-pipe B', which extends down within it, to or nearly to its bottom, and can be supported in the same way as pipe B. With stand-pipe D filled from the latter pipe, as indicated, I secure about twelve feet submergence of eduction-pipe B'. Where the final lift, from the lower level, is to be to a point one hundred feet above the bottom of the sump, I prefer to make the depth of stand-pipe D a little greater than twelve feet, so as to secure about twelve and a half feet submergence of pipe B'. A branch C' from pipe C, enters the lower end of pipe B', being there turned and shaped the same as the corresponding portion C' of pipe C, already described.

The eduction-pipe B' runs up above the level of the liquid in stand-pipe or tank D about twelve and a half feet, so that its discharge mouth is about twenty five feet from the bottom of the sump. Here it discharges into a second stand-pipe D' which is twenty five feet deep, and in which is submerged the third eduction-pipe B^2 fifty feet in length, constructed like the others already described, and also having a correspondingly arranged and shaped inlet pipe C', for introducing compressed air or other gaseous fluid into its lower portion. This pipe B^2, in turn, discharges into the fifty foot stand-pipe D^2, in which is half submerged the eduction-pipe B^3, one hundred feet long, made like the others already described, and having the same kind and arrangement of air or fluid introducing device C'.

With the compressed air or other gaseous fluid introduced into the lower part of eduction-pipe B^3, through the respective pipe C', in the manner described in my said patent, the water will be elevated up through and discharged from the upper end of the eduction-pipe, at a height of one hundred feet above the bottom of the sump or receptacle A. If, for any reason, it is desired that the extent of elevation be one hundred feet above the level of the water in the sump, such end can be easily attained by making one or more of the eduction-pipes, and the respective stand-pipes, a little longer.

While I have found one hundred feet to be the most convenient extent for one lift, as the pressure of the air used to secure it by my process, need not be more than forty five pounds, I, of course, do not limit myself to such a lift. If desired, the described arrangement can be continued, so as to bring into use longer stand and eduction pipes, and increase the length of lift, to any required extent, the only limit being the strength of the pipes and the amount of air or gaseous fluid pressure available. It will, of course, be understood, that, where the depth of the body of water to be acted upon is greater than that mentioned above, and indicated in the drawings, the length of the first eduction-pipe and the depth of the first stand-pipe into which such pipe discharges, can be made correspondingly greater, so that the desired length of lift of eighty or one hundred feet might be secured with fewer stand and eduction-pipes, or a longer lift might be obtained with the number and arrangement of such pipes shown and described.

Since, as indicated hereinbefore, it is not necessary that the submergence-tanks D, D', D^2, should be much larger than the respective eduction pipes B', B^2, B^3, they can be made in the form of pipes and arranged close together in the bottom of the mine, so as to take up but very little room. I can, then, secure any desired length of submergence of the last one of the series of eduction-pipes, however shallow the sump may be, without obstructing, to any objectionable extent, the mine or other shaft up which the water is to be elevated. This can be done, also, without any objectionable complication of apparatus, and at but very slight expense, since it necessarily involves only an increase in the number of pipes used. Having secured the desired length of lift, in the manner shown and described, if the distance to which the water or other liquid is to be raised is greater than such length, I have the last eduction-pipe B^3 discharge into an elevated stand-pipe or submergence tank D^3, which is supported, in any

desired manner, with its bottom above that of stand-pipe D^2, and, preferably, at or near the top of the latter. As shown in Fig. 1, such pipe D^3 stands with its bottom at the level of the top of stand-pipe D^2, and has a height equal to the length of the eduction pipe B^3 above the liquid, in which the latter is submerged. From this elevated stand-pipe D^3 another eduction-pipe B^4 takes the liquid and discharges it into a higher stand-pipe or submergence-tank D^4, arranged, with reference to stand-pipe D^3, just as the latter is with relation to D^2.

A branch pipe C′ from air pipe C enters the lower end of pipe B^4, and discharges compressed air or other gaseous fluid into the same, in the same manner as do the other branch air pipes, into their respective eduction pipes already described. This arrangement is continued with a series of successively higher and higher stand-pipes, of similar length or depth, and the eduction-pipe in each lower stand-pipe, discharging into the next higher one, until the point to which the liquid is to be raised, is finally reached by the discharge mouth of the highest eduction-pipe.

In the apparatus, as shown in Fig. 1, the successively higher stand-pipes are shown of the same length, as the unsubmerged portions of the respective eduction-pipes discharging into them. With this construction, I, of course, get only about one half submergence of the eduction-pipes. If it is desired to increase this submergence, for instance, to three fifths, which, as I have found by practice, insures the very best result in the elevation of the water in an eduction-pipe by my process set forth in my patent referred to, the bottoms of the successive stand-pipes can be set below the tops of the preceding ones, in the manner indicated in Fig. 3.

With the construction and arrangement described, the air or other gaseous fluid under pressure, may be supplied by the main pipe C, acting as a distributing reservoir connected with the various eduction pipes, by pipes or branches extending directly from such pipe in through the respective stand-pipes, to the proper points within the eduction-pipes, as shown in full lines in Fig. 1, or, running down into the respective stand-pipes, as indicated in dotted lines in Fig. 2. In either case the branch pipes should all be provided with valves or cocks *c*, whereby the flow of compressed air or fluid to the respective mouths within the lower parts of the eduction pipes, may be adjusted, so that just enough air or fluid may be introduced into the columns of liquid in the various ones of such latter pipes. While, it is sufficient, for the purpose of regulating the supply of air to the needs of the various elevating devices of which my present apparatus is made up, that the valves *c*, *c*, should be ordinary ones, to be operated by hand, I contemplate where desired, employing, instead, any of the well known forms of reducing valves, capable of being set to maintain the required pressure of air in the parts of branch pipes C′, entering the respective eduction pipes, without reference to the pressure in pipe C.

In order to enable the elevation of the liquid in the longer eduction-pipes to be started most easily, without the necessity of using a high pressure of air or gaseous fluid, to lift bodily out of each pipe the column of liquid first standing therein, I use one or more supplementary air introducing pipes C^2, C^2, which, being connected with the air supply main or pipe C, and provided with suitable stop-cocks *c′*, *c′*, enter the long eduction-pipe at different points above the place where the branch pipe C′ is to deliver its air. When the elevation is to be commenced, the upper one of these supplementary pipes, where there are more than one, is opened first, so that the compressed air can flow into the eduction-pipe, and force that part of the column of liquid, which is above such supplemental pipe, up and out of the eduction pipe. This reduces the weight of liquid to be raised bodily by the air entering through the discharge end of pipe C. If the column of water is very long, it can be further divided and partially removed by air admitted through the second or lower supplementary air introducing pipe C^2, C^2. With this preliminary removal of part of the column of water, a comparatively low pressure of air can be used, both in the supplementary pipes, and in the branch pipe C′ in the lower end of the eduction-pipe, to secure the removal of the column of water standing in the eduction-pipe, even when the latter is very long, so as to leave the way clear for the rush of water up in the lower part of the eduction-pipe in such manner, as to secure the continuous formation and upward movement of the alternate layers of air and liquid, in accordance with my process described in my said patent.

In Fig. 4 I show an air distributing reservoir E, which I have used to advantage where several air pipes running to different eduction pipes are used. It consists of a casing, preferably, but not necessarily, cylindrical in general shape, having the pipe E′ through which the compressed air or other gaseous fluid is supplied to it from any desired compressing apparatus, and suitable couplings *e*, *e*, *e*, for the various air pipes C′, C′, C′, which are valved at *c*, *c*, *c*, in order that the flow of air through them may be regulated, as required for the work to be done by the air from the respective pipes.

In order that no moisture may collect in the reservoir to freeze there, or vary the capacity of the latter, I place the casing at a slight angle, so that any moisture will run down to one end thereof, and then continue the inner end of one of the air pipes inward, so that its inner end will be close to the casing bottom at the lowest portion thereof, in

position to draw off, at once, any moisture which may collect in the reservoir. With this arrangement and the reservoir of sufficient size, it is possible to insure a regular supply of air through the several air pipes without any variation, so that, when the valves *c*, *c*, *c*, are once adjusted, the flow of air will be constant and invariable.

While I have shown the eduction-pipes as simple straight open-ended ones, thrust down within the respective stand-pipes or submergence-tanks, I do not limit myself to such construction, but contemplate using instead, where it is desired, eduction-pipes which, running outside of the stand-pipes, are connected, at their lower ends, with the lower portions thereof, as shown in Fig. 5.

The manner of carrying out my improved process, by means of the apparatus shown and described, which will be fully understood from the foregoing description and the drawings, is briefly as follows:—

With the eduction-pipes empty, air is first turned on, so as to flow, through the lower end or branch of pipe C, into the lower part of the first eduction-pipe B, so as to elevate the water from the sump, in accordance with my said patented process, and cause it to be discharged into the first stand-pipe or submergence-tank D. When this is filled, air is admitted into the second eduction-pipe B′ through the pipe C′ and the water is elevated, through the eduction-pipe, from the tank or stand-pipe D, into the second stand-pipe D′. Air is then turned on through the pipe C′ leading to the third eduction pipe B^2, so as to raise the water therethrough into tank or stand-pipe D^2.

As less pressure of air is needed to elevate the water through the shorter eduction pipes, the respective valves *c*, *c*, are, after the regular flow of water is established, adjusted, so as to regulate the flow of air to the requirements of the different parts of the apparatus.

With the water being discharged, from the eduction pipe B^2, into stand-pipe D^2, from which the long lift is to be made, the supplementary air-pipe branches C^2, C^2, can first be opened to remove from stand-pipe B^3 a portion of the column of liquid standing therein, above the air admitting branch pipe C′, and the air is then turned on through the latter, so as to establish and continue the elevation of the liquid from tank or stand-pipe D^2 up through and from said eduction-pipe. The supplementary air pipes C^2, C^2, can then be closed, and water will be taken continuously from the sump or receptacle A, and delivered from the upper end of eduction-pipe B^3. Here it enters the first of the series of stand-pipes or submergence-tanks which are arranged at different heights in the manner described and shown in the drawings. As the lower one of said stand pipes is filled from the eduction pipe B^3, so that the water rises up in the eduction pipe B^4, the compressed air or other fluid is turned on, so as to enter said pipe and raise the water therein, in the same way as it does in the other eduction pipes.

Where the lift is a long one, supplementary air introducing pipes C^2, C^2, are used for removing some of the column of water above the air inlet pipe C′, just as they were in the case of eduction pipe B^3, already described. The successively higher and higher stand pipes with their respective eduction pipes, and air introducing devices, are manipulated in the same way, so that the water, being continuously taken from the shallow sump or receptacle A, is lifted to and delivered at any desired elevation, in a substantially continuous current.

By my process, as described, water can be most successfully elevated to very great heights, even where the depth of submergence of eduction-pipe in the sump or receptacle, from which the water is to be taken, is but slight; and such elevation can be secured without the use of great air or gaseous fluid pressure, or the presence of long columns of water, such as might require great strength of piping for safety.

The apparatus is, obviously, most simple and cheap in construction, and has no parts which can get out of order, or valves which may be injured or clogged by the liquid acted upon, or anything carried in suspension therein.

The air or gaseous fluid compressor can, of course, be placed anywhere, where it can be conveniently worked and watched, and need not be in the mine shaft, or where it may be liable to injury.

Having thus described my invention, what I claim is—

1. As an improvement in the art of elevating liquids, the process which consists in connecting the lower end of an eduction-pipe with the body of liquid to be raised so that such liquid will rise to a certain extent within the pipe, introducing compressed gaseous fluid into the latter, below the level of the liquid therein, so as to elevate the liquid and cause it to flow from the upper end of the pipe, receiving the outflow in a suitable tank connecting with the liquid in the tank—a second eduction pipe, having its lower end farther below the level of the liquid with which it is connected, than the first eduction pipe, and introducing compressed gaseous fluid into the second eduction pipe, at a point below that to which the water from the tank would rise by the action of gravity, substantially as and for the purpose specified.

2. As an improvement in the art of elevating liquids, the process which consists in submerging a portion of an open-ended eduction-pipe in the body of liquid to be raised, introducing compressed gaseous fluid into such pipe below the level of the surrounding liquid, so as to raise the liquid within the pipe up and out of the same, receiving the outflow

from the pipe in a suitable tank, submerging a portion of a second longer eduction-pipe in the tank more deeply than the first pipe is submerged, and introducing compressed gaseous fluid into the second pipe, at a point below the level of the liquid in the tank, substantially as and for the purpose set forth.

3. As an improvement in the art of elevating liquids, the process which consists in submerging a portion of an open-ended eduction-pipe in the body of liquid to be raised, introducing compressed gaseous fluid into such pipe at a point below the level of the surrounding liquid, so as to raise the liquid up in and from the pipe, receiving the outflow from the latter in a tank deeper than the body of liquid to be raised, submerging a second open-ended eduction-pipe more deeply in the tank than the other pipe is submerged, and introducing compressed gaseous fluid into the lower portion of the second pipe, so as to raise the liquid up in and from the same, substantially as and for the purpose described.

4. As an improvement in the art of elevating water, the process which consists in submerging a portion of an open-ended eduction-pipe in the liquid to be raised, introducing gaseous fluid into such pipe, below the level of the liquid, and above the lower end of the pipe to first expel the water above the point of introduction, and then introducing compressed gaseous fluid into the lower portion of the pipe near its lower end, substantially as and for the purpose shown.

5. As an improvement in the art of elevating liquids the process which consists in arranging a series of successively longer open-ended eduction-pipes, and successively longer and longer stand-pipes or tanks, respectively, so that each successive eduction-pipe is submerged more deeply in its respective stand-pipe or tank than the preceding one, causing each eduction pipe to discharge into the tank or stand pipe of the next longest eduction pipe, introducing compressed gaseous fluid into the lower portions of the several eduction-pipes, and in the longest eduction-pipe, between the level of the liquid in which it is submerged and above the point at which compressed gaseous fluid is admitted to the lower part thereof, substantially as and for the purpose set forth.

6. In an apparatus for elevating water in combination with an open-ended eduction-pipe connected with the body of liquid to be raised, so that such liquid will tend to rise up in the pipe, means for introducing compressed gaseous fluid into the lower part of the pipe below the point to which the liquid rises from the source of supply, a tank or stand-pipe receiving the liquid from the upper end of the eduction-pipe, a second longer open-ended eduction-pipe connected with the liquid in the tank, so that such liquid tends to stand higher in it than it does in the first eduction pipe, and means for introducing compressed gaseous fluid into the lower part of the second eduction pipe, substantially as and for the purpose described.

7. In an apparatus for elevating water in combination with an open-ended eduction-pipe, partially submerged in the body of liquid to be raised, means for introducing compressed gaseous fluid into the lower part of such pipe, to raise the liquid up in and from the pipe, a tank into which such pipe discharges, a second longer open-ended eduction-pipe submerged more deeply in the liquid in the tank, than the first pipe is in its body of liquid, and means for introducing compressed gaseous fluid into the lower part of the second pipe, to raise the liquid up in and from the same, substantially as and for the purpose specified.

8. In an apparatus for elevating liquid, in combination with a series of tanks or stand-pipes made successively longer and longer, a series of open-ended eduction pipes made successively longer and longer, and the shortest one connected with the body of liquid to be raised, so that such liquid tends normally to rise to some distance in the same, and the others connected with the respective tanks or stand-pipes, so that each successive one is connected with its respective tank or pipe at a point farther below the upper end thereof, than the preceding eduction pipe is, suitable connections whereby each shorter eduction-pipe discharges into the stand-pipe or tank of the next longer one, and means for introducing compressed gaseous fluid into the lower parts of the several eduction-pipes, to raise the liquid up in and from the pipes, substantially as and for the purpose shown.

9. In an apparatus for elevating liquid, in combination with a series of tanks or stand-pipes of successively greater and greater depths, a series of open-ended eduction-pipes of successively greater and greater lengths, the shortest one partially submerged in the body of liquid to be raised, and the others partially submerged in the respective tanks or stand-pipes, so that each successive one is submerged to a greater depth in its respective tank, than the preceding one, suitable connections whereby each shorter eduction-pipe discharges into the stand-pipe of the next longer one, and means for introducing compressed gaseous fluid into the lower portion of the respective eduction-pipes to raise the liquid up in and from such pipes, substantially as and for the purpose set forth.

10. In an apparatus for elevating liquids, in combination with a suitable tank or receptacle for the liquid to be raised, an open-ended eduction-pipe connected therewith, so that the liquid will normally rise therein from the tank or receptacle, means for introducing compressed gaseous fluid into the lower part of such pipe, an elevated tank or stand-pipe receiving the liquid discharged from the up-

per end of such eduction-pipe, a second longer open-ended eduction-pipe having its lower end connected with the lower part of such stand-pipe and its discharge end at a higher level than that of the other eduction pipe, means for introducing compressed gaseous fluid into said eduction pipe between its ends and means for introducing compressed gaseous fluid into the lower portion of the second eduction-pipe, substantially as and for the purpose described.

In testimony that I claim the foregoing I have hereunto set my hand this 25th day of April, 1893.

JULIUS G. POHLÉ.

Witnesses:
JAS. E. HUTCHINSON,
CHAS. J. WILLIAMSON.