(No Model.)

J. G. POHLE.

PROCESS OF ELEVATING LIQUIDS.

No. 487,639. Patented Dec. 6, 1892.

Fig. 1.

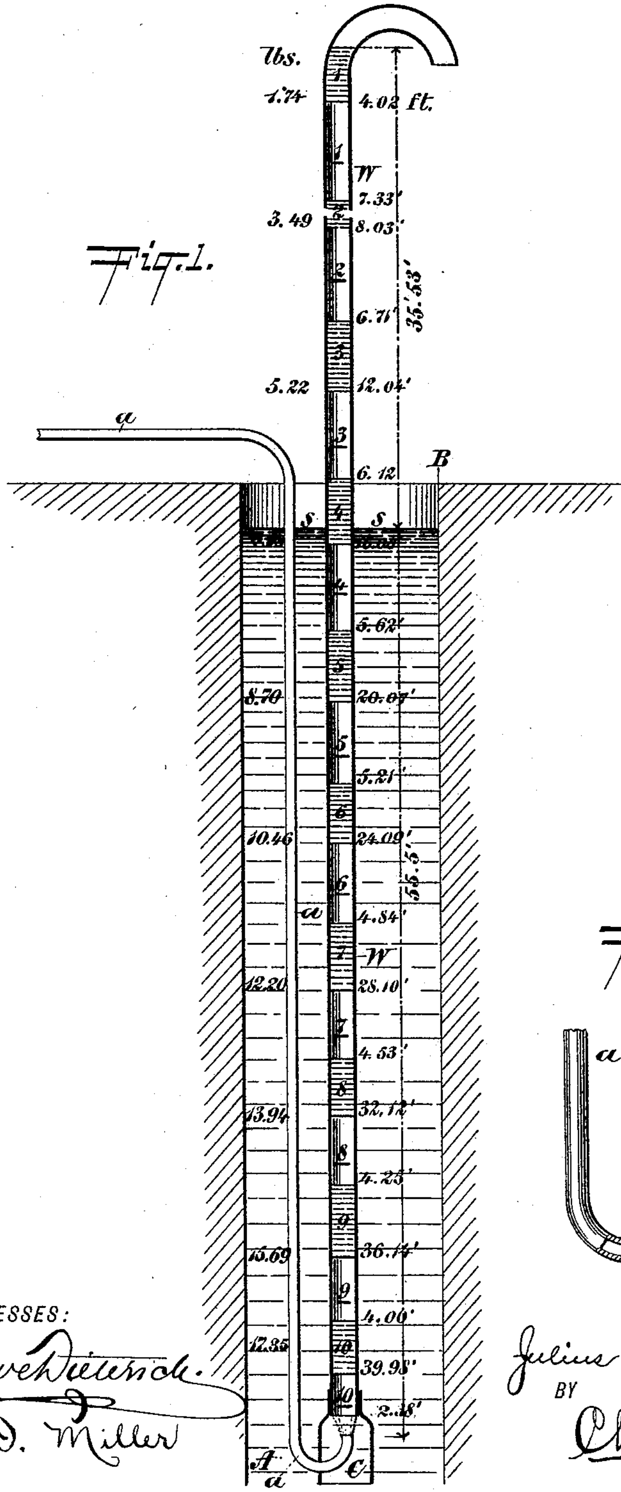
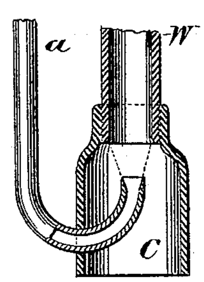


Fig. 2.



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UNITED STATES PATENT OFFICE.

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PROCESS OF ELEVATING LIQUIDS.

SPECIFICATION forming part of Letters Patent No. 487,639, dated December 6, 1892.

Application filed October 24, 1891. Serial No. 409,701. (No model.)

To all whom it may concern:

Be it known that I, JULIUS G. POHLÉ, a citizen of the United States, and a resident of Jersey City, in the county of Hudson and State of New Jersey, have invented a certain new and useful Process of Elevating Liquids, of which the following is a specification.

The invention relates to the art of elevating water by compressed air; and it consists in improved processes and apparatus whereby the compressed air is delivered in bulk into the lower end of the water-eduction pipe and the water and air are caused to ascend through said pipe in distinct alternate layers of definite dimensions.

The object of the invention is to successfully and practically effect the elevation of the water to a much greater height than has heretofore been deemed economic with compressed air and to avoid the results due to an intimate commingling of the air and water, as well as to dispense with all valves, annular spaces, and solid pistons. In accordance with my invention the air is not directed into the water in the form of fine jets or bubbles, which would very readily commingle intimately with the water, but is delivered in mass, and the water and air ascend in well-defined alternate layers through the eduction-pipe.

In the art of raising water by means of ejectors it is essential to use a continuous and rapid current of steam or air, which by its velocity and momentum forms, primarily, a vacuum into which the water flows by suction. From thence it is secondarily drawn along by the induced velocity current of the steam or air thus used. In my process, which I term the "air-lift" process or method, it is not necessary to create a vacuum at all, nor is it necessary to use a velocity current for the purpose of raising water, for its action depends, primarily, upon the gravity force of the liquid into which an eduction-pipe is submerged, and, secondarily, it depends upon the elastic energy stored in compressed air when used in the manner to be described. I have discovered that when air of suitable pressure is allowed to enter in a constant stream and in suitable quantity into an eduction-pipe at or near its lower end when it is submerged in water, while its upper end rises above the water about the same distance that its lower end is submerged, the compressed air thus introduced will at first expel the standing water from the pipe in an unbroken column free from air, and subsequently, by the continued inflowing of the compressed air under a pressure just sufficient to overcome the resistance of the water outside of the eduction-pipe, it will arrange itself in alternate layers with the water, while the latter flows into the lower end of the eduction-pipe by force of gravity until it is discharged at the upper or exit end of the pipe. This alternate interposition of determinate quantities of air between the also determinate quantities of water elongates the entire column of air and water, thus facilitating, without materially adding to the weight of the column, the discharge of the water at a higher level than would be the case were these air sections or layers absent. I have also discovered that under the above-mentioned conditions the compressed air will not escape through the water overlying it, and also that the water overlying the compressed air will not fall back through the underlying air while both are in upward motion, but find that the elasticity stored in the compressed-air layer, pressing alike in all directions, forms a temporary water-tight air-piston, which lifts the water above it to its final discharge without appreciable loss by leakage or so-called "slippage," while this compressed-air piston after having expended its elastic energy in work of lifting water is dispelled with only a practically-unimportant loss of power. To elucidate this process of pumping more clearly, I will refer to the accompanying drawings, in which—

Figure 1 illustrates a central vertical section of an apparatus embodying the invention; and Fig. 2, a like section, on an enlarged scale, of the lower ends of the air and discharge pipes, and in which—

A B designate an Artesian well or its equivalent; S, the surface of the water-level; W, an eduction-pipe submerged therein (being represented as three inches in diameter to correspond with the lengths and weights of the water and air layers) and having at its lower end the enlarged extension C, and *a* indicates the air-conveying pipe, coming from any source of compressed air and terminating with an upturned exit end within the enlargement C several inches below the mouth of the eduction-pipe proper. The exit end of the air-pipe is enlarged by beveling off the inner edge thereof in order to permit the free delivery of the air in mass or bulk, and thus to avoid the formation of air-bubbles. The enlargement C of the pipe W is of sufficient area to compensate for the space occupied by the exit end of air-pipe *a*, and said end of said pipe *a* passes through the vertical side of the enlargement C, as shown, and derives support therefrom.

The drawings represent the apparatus in a state of action pumping water, the shaded sections within the eduction-pipe W representing water-layers and the intervening blank spaces air layers.

At and before the beginning of pumping the level of the water is the same outside and inside of the discharge-pipe W—incidentally, also, in the air-pipe. Hence the vertical pressures per square inch are equal at the submerged end of the discharge-pipe. When, therefore, compressed air is admitted into the air-pipe *a*, it must first expel the incidental standing water before air can enter the eduction-pipe W. When this has been accomplished, the air-pressure is maintained until the water within the eduction-pipe has been forced out, which it will be in one unbroken column, free from air-bubbles. When this has occurred, the pressure of the air is lowered or its bulk diminished and adjusted to a pressure just sufficient to overcome the external water-pressure. It is thus adjusted for the performance of regular and uniform work, which will ensue with the inflowing air and water, which adjust themselves automatically in alternate layers or sections of definite lengths and weights. It will be seen in the drawings that the lengths of the water-columns (shaded) and air (blank spaces) 1 and 1 are entered at the right of the discharge-pipe W; also, that under the pressure of two layers of water 1 and 2 the length of the air column 2 is 6.71 feet long, and so on. The lengths of aggregate water columns and the air columns which they respectively compress are also entered on the right of the water-pipe. On the left of the water-pipe are entered the pressures per square inch of these water columns or layers. Thus the pressure per square inch of column 1 is seen to be 1.74 pounds; that of 2, consisting of two columns or layers 1 and 2, each 4.02 feet long, to be 3.49 pounds, and that of 10, consisting of nine columns or layers of water 1 to 9, inclusive, each 4.02 feet long, and one of 3.80—viz., layer 10—feet in length to be 17.35 pounds, and the aggregate length of the layers of water is 39.98 feet in a total length of ninety-one feet of pipe. It will be noted that the length of pipe below the surface of the water in the well is 55.5 feet, and that the difference between this and the aggregate length of the water layers (39.98) is 15.52 feet—that is, on equal areas the pressure outside of the pipe is greater than the pressure on the inside by the weight due this difference of level, which is 47.65 pounds for the end of the discharge-pipe. It is this difference of 15.52 feet, acting as a head, that supplies the water-pipe, puts the contents of the pipe in motion, and overcomes the resistance in the pipe. In general the water layers are equal each to each, and the pressure upon any layer of air is due to the number of water layers above it. Thus the pressure upon the bottom layer of air 10 in the drawings is due to all the layers of water in the pipe, (17.35 pounds,) and the pressure upon the uppermost layer of air 1 is due to the single layer of water I at the moment of its discharges beginning—viz., 1.74 pounds per square inch. As this discharge progresses this is lessened, until at the completion of the discharge of the water layer the air layer is of the same tension as the normal atmosphere.

The quantitative relations of the air to water are determinable, but vary with the relations of submergence to lift, diameter of pipe, temperature, and atmospheric pressure, and range from 1.5 to more volumes of normal air, compressed to an adequate pressure, for each volume of water raised by this process. The best efficiency is attained when the submersion is three-fifths of the total length of the eduction-pipe. Whatever the submergence or lift may be, in order to secure the desired continuous upward flow of the contents of the eduction-pipe without stoppage or downward dropping of the same it is necessary that the air as introduced into the pipe should be in quantity sufficient to form, immediately upon its issue from the air-pipe bubbles which will expand across to fill the eduction-pipe from side to side and make distinct piston-like layers, entirely separating the portions of the water column between which they enter said pipe. Where the bubbles are smaller than this, they will pass up through the water, and, while necessarily elongating the water column, will not exert the positive elevating power that my pipe-filling air layers, entirely dividing the layers of water from each other, do.

The enlargement at the lower end of the eduction-pipe I have found to be of advantage, not only as compensating for the space taken up by the air-pipe, but, where the mouth of the latter is well below the upper end of the enlargement, as facilitating the formation of bubbles sufficiently large to make the desired pipe-fitting piston-like layers, rapidly and continuously following each other at very short intervals in the flow up the eduction-pipe. When the body of water first standing in the eduction-pipe has been forced up out of the latter by the compressed gaseous fluid used, the fluid pressure is preferably diminished, as indicated hereinbefore. In practice I so reduce the pressure to a point below the weight of the column of liquid which, standing in the eduction-pipe above the point of entrance of the gaseous fluid, has been removed, as stated.

It is evident that the process above described is applicable to all other liquids besides water—such as petroleum-oil, saline solutions, brewers' and tanners liquors, sewage, &c.—and therefore I do not limit the invention to the elevating of water. Neither do I confine the invention to compressed air alone for the purpose of raising liquids by this process, but claim any aeriform body, such as natural gas and steam when used in oily liquids.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. As an improvement in the art of elevating liquid, the process which consists in submerging a portion of an open-ended eduction-pipe in a body of the liquid to be raised and continuously introducing into the liquid within the lower part of the pipe a series of bubbles of compressed gaseous fluid containing enough of the fluid to expand immediately across the pipe and fill the same from side to side, forming pipe-fitting piston-like layers at or just above the point of their entrance into the pipe, whereby the column of liquid rising in the pipe after the forcing out of the liquid first standing in the latter 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 is formed and forced up the pipe, substantially as and for the purpose specified.

2. As an improvement in the art of elevating liquid, the process which consists in submerging in the body of the liquid to be raised a portion of an open-ended eduction-pipe having an enlarged chamber on its lower end and continuously injecting into such enlargement well below its upper end gaseous fluid under pressure to form bubbles in the pipe above the enlargement large enough to extend across from side to side of the pipe proper and form pipe-fitting piston-like layers therein interposed between and entirely separating well-defined layers of liquid in the pipe, substantially as and for the purpose described.

3. As an improvement in the art of elevating water or other liquid, the process which consists in submerging a portion of an open-ended pipe in a body of the liquid to be raised, removing the upper portion of the column of liquid within the pipe and injecting into the latter at a point well below the level of the liquid in which the pipe is submerged gaseous fluid in quantity sufficient to form bubbles, which will expand immediately across the pipe and fill the same from side to side and under pressure less than the weight of a column of liquid in the pipe extending from the point of entrance of the gaseous fluid to the level of the body of liquid surrounding the pipe, so that a continuous upward-moving series of alternate well-defined gaseous fluid and liquid layers will be formed in and forced up the pipe, substantially as and for the purpose described.

Signed at New York, in the county of New York and State of New York, this 23d day of October, A. D. 1891.

JULIUS G. POHLÉ.

Witnesses:
CHAS. C. GILL,
ED. D. MILLER.