No. 746,488. PATENTED DEC. 8, 1903.

J. C. FRALEY.

APPARATUS FOR DEVELOPING AND UTILIZING FLUID PRESSURE.

APPLICATION FILED OCT. 5, 1903.

NO MODEL. 3 SHEETS—SHEET 1.

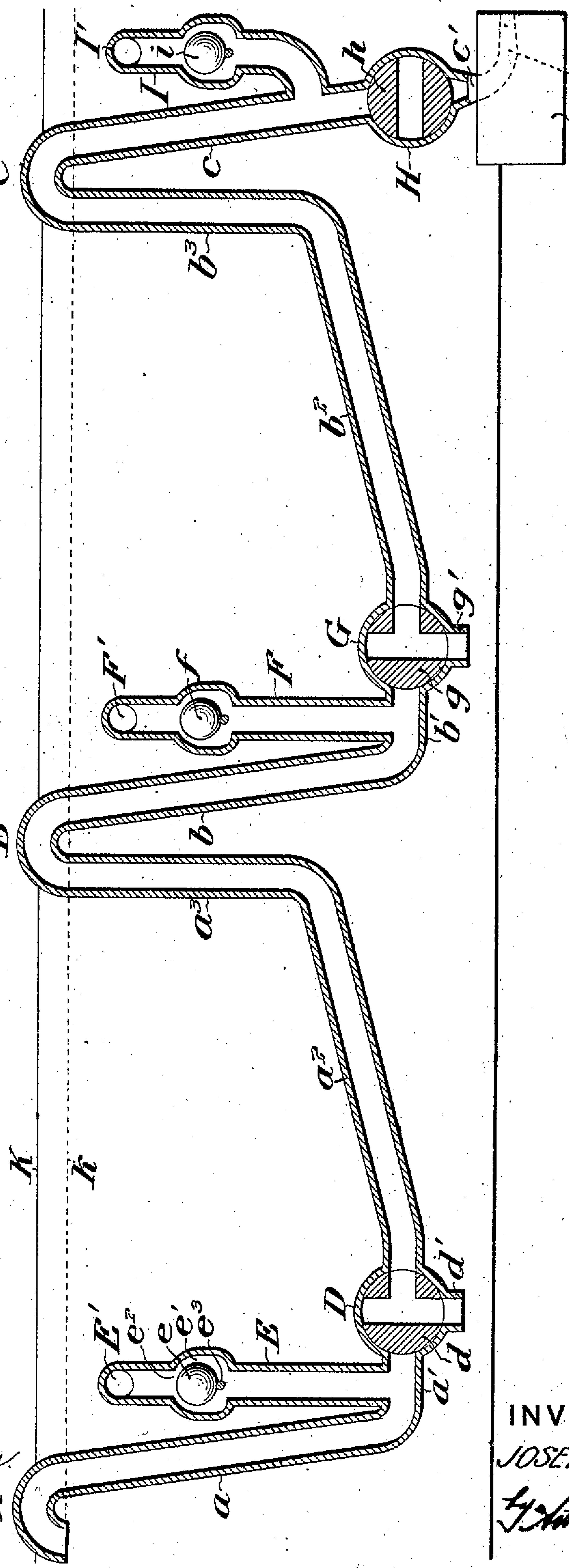

FIG. 1.

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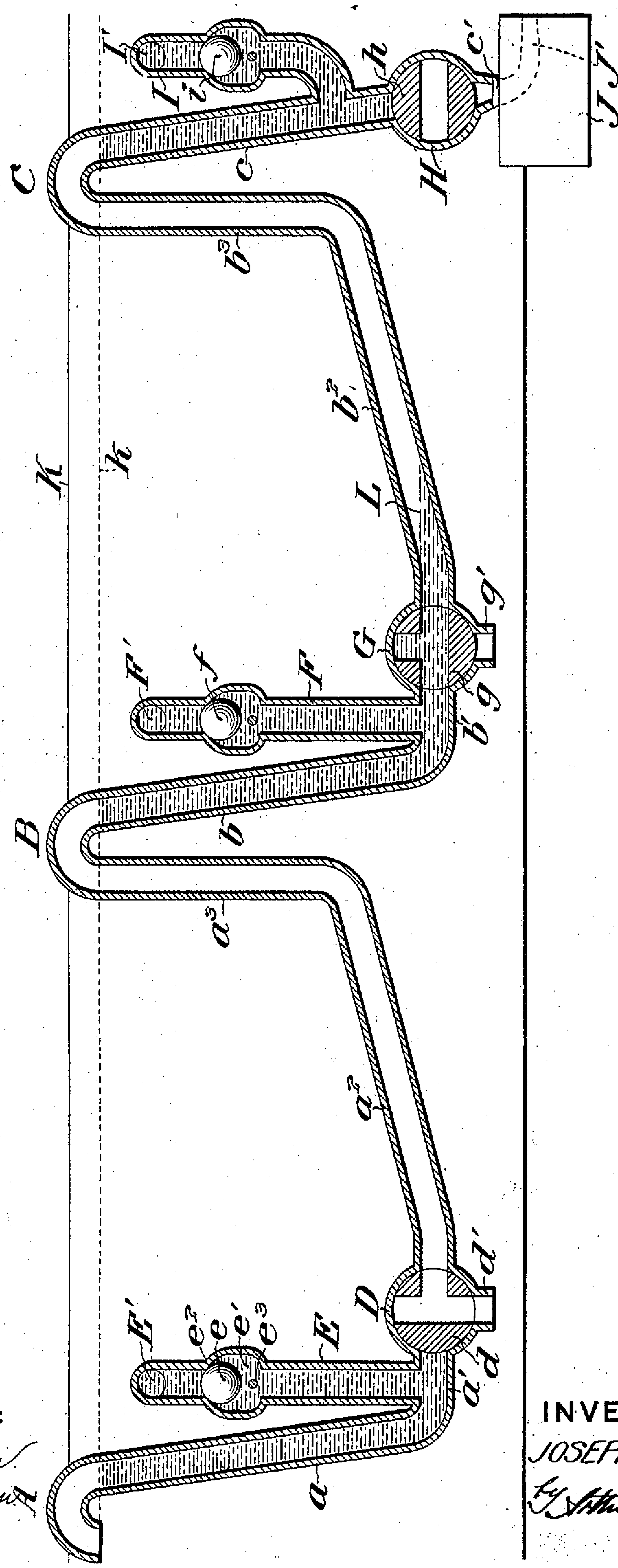
NO MODEL. 3 SHEETS—SHEET 2.

FIG. 2.



WITNESSES:

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NO MODEL.

3 SHEETS—SHEET 3.

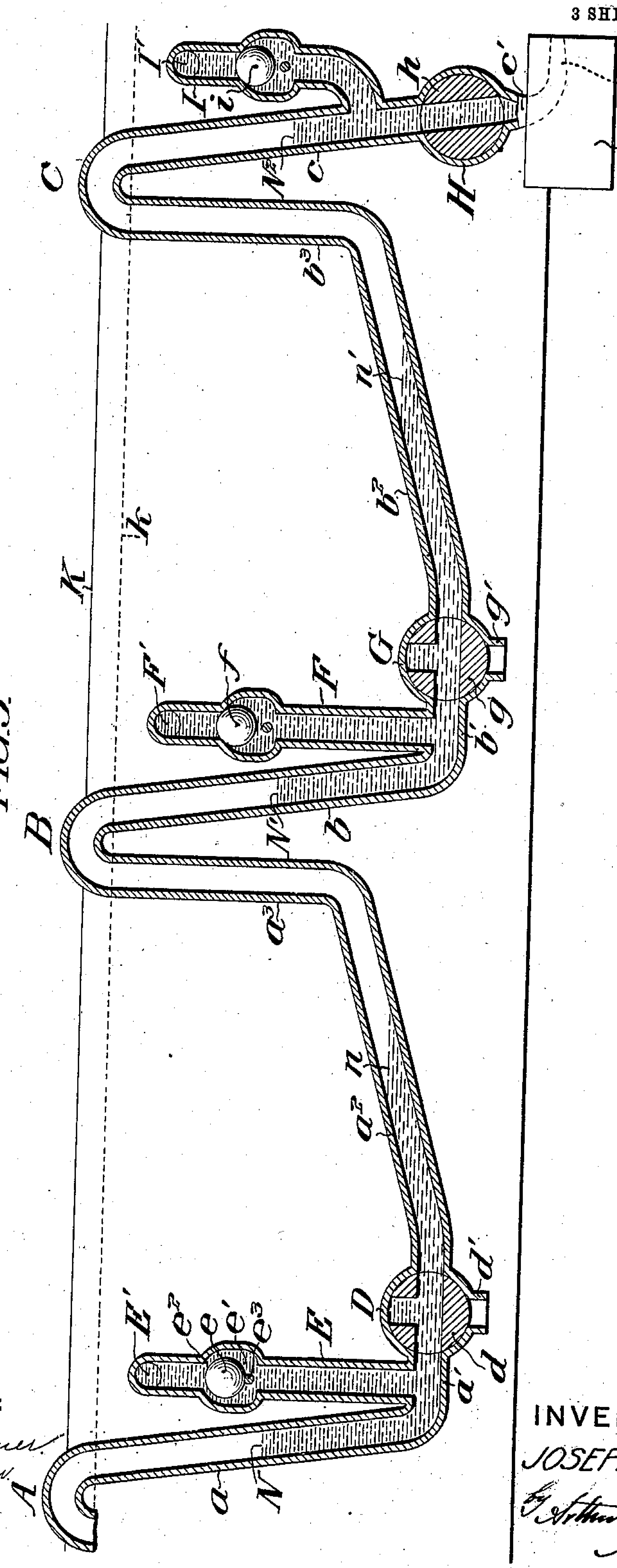

FIG. 3.

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No. 746,488. Patented December 8, 1903.

UNITED STATES PATENT OFFICE.

JOSEPH C. FRALEY, OF PHILADELPHIA, PENNSYLVANIA.

APPARATUS FOR DEVELOPING AND UTILIZING FLUID-PRESSURE.

SPECIFICATION forming part of Letters Patent No. 746,488, dated December 8, 1903.

Application filed October 5, 1903. Serial No. 175,761. (No model.)

To all whom it may concern:

Be it known that I, JOSEPH C. FRALEY, of Philadelphia, in the State of Pennsylvania, have invented certain new and useful Improvements in Apparatus for Developing and Utilizing Fluid-Pressure, whereof the following is a specification, reference being had to the accompanying drawings.

This application comprises claims for apparatus of the character set forth in my application, Serial No. 141,252, filed January 31, 1903, for Letters Patent of the United States for improvements in the art of developing and utilizing fluid-pressure, which was allowed under date of May 14, 1903, comprising claims for a method in which such apparatus may be conveniently employed. It may also be noted that my application, Serial No. 141,251, filed January 31, 1903, for Letters Patent of the United States for improvements in the art of developing and utilizing fluid-pressure, which was allowed under date of May 13, 1903, comprises claims for a method of developing pressure, which, broadly speaking, involves similar conditions to those existing in the apparatus herein set forth.

My invention relates to the development and utilization of fluid-pressure by what may appropriately be termed the "cumulative" transformation thereof.

The primary object of the invention is to convert a relatively low pressure, such as that obtainable by the discharge of fluid under a head of limited height, into higher pressure, dynamically available as such and corresponding in degree to that obtained from a much greater head.

The underlying principle of operation is based upon my discovery that when several pressure-producing fluid columns are so combined in series as to establish communication between the base of each column and the top of the next in series by means of confined bodies of lighter fluid the pressure at the base of the ultimate column will be substantially equal to that which would exist at the base of a single column whose height is represented by the sum of the heights of the individual columns. In application Serial No. 141,252 I have set forth and broadly claimed the method of thus developing cumulative pressure irrespective of the mode by which the columns of fluid are established. Employing this principle of the cumulative transmission of pressure in the case of a waterfall of limited head, for instance, I have further discovered that the several columns of heavier fluid (in this instance water) can be individually established to a height corresponding with the head or fall by the mere inflow of water into proper receptacles, that thereafter the columns can be so thrown into communication with each other as to transform the plurality of low pressures into a much higher pressure at the end of the series, and that a portion of the fluid can be discharged under such high pressure to develop energy in any appropriate form. Such discharge is attended by an approach toward equilibrium throughout the series; but by individual discharges in the regions of the respective columns the latter can be again individually restored to a height corresponding to the actual head or fall and again combined in series to cumulatively transform and transmit the total pressure to the region of operative discharge. Thus a succession of impulses, each corresponding to a relatively high pressure exhibited in a given discharge of fluid can be obtained although the initial pressure of the fluid be relatively small. The development of energy by this method is of course attended by a total expenditure of fluid which is correspondingly large in quantity. In many cases, however, where a water-power of large volume but low head is sought to be utilized the amount of water expended is not economically important, provided the requisite pressure can be conveniently attained, and it is under these conditions that I believe my invention will prove especially valuable.

In the accompanying drawings I have illustrated the application of the invention by means of an elementary or typical apparatus; but it must be understood that its scope is in no way limited to such an embodiment.

In each of said drawings the apparatus is represented in similar vertical longitudinal section, Figure 1 showing certain controlling elements in what may be considered as the first operative position for the separate establishment of the individual columns. Fig. 2 shows said elements in a position which they may, if desired, occupy at an intermediate stage of operation or where the pressure is undergoing cumulative transformation, and Fig. 3 shows said elements in the ultimate position corresponding to the operative discharge of that portion of the fluid which is subjected to the total cumulative pressure.

The apparatus consists of a continuous elongated conduit—as, for instance, iron piping—comprising a series of similar undulations, in this instance three in number, (indicated at A, B, and C.) Commencing at the left-hand end of the figure the leg *a* (whose vertical height is slightly in excess of the height of the water-fall) is continued at its lower extremity a short distance horizontally, as shown at *a'*, and leads to the chamber D of a three-way valve *d*, which has a discharge-orifice *d'*. From the said chamber D the piping continues, preferably as shown, with a slight incline a^2 to the region of the next undulation, where it rises vertically, as shown at a^3, and leads by a return-bend at the top to the next vertical leg *b*. At a point between the leg *a* and the chamber D an inlet-pipe E is connected, said inlet-pipe being provided with a floating check-valve *e*, so arranged in the valve-chamber *e'* as to permit the downflow of water through the pipe E, but prevent any upward flow therein by closing against a seat at e^2. A transverse pin or stop e^3 prevents the check-valve *e* from closing the outlet at bottom of the chamber *e'*. Above the check-valve *e* the pipe E communicates at E' with the source of water-supply—as, for instance, a forebay, whose wall is shown at K, the normal level of the water being indicated by the dotted line *k*.

The undulation at B is constructed and arranged in a manner exactly similar to that just described in the case of the undulation at A, the corresponding parts being indicated by the small letters *b* with numerals like those employed in connection with the small letters *a*. It is also provided with a water-inlet pipe F, controlled by the check-valve *f* and connected at F' with the source of supply in the forebay K. A three-way valve *g*, arranged in chamber G, is interposed in the same relative position as the valve *d*. The next undulation at C has a vertical leg *c*, which terminates in a nozzle *c'*, controlled by a simple discharge-valve *h* in the chamber H. The leg *c* is provided with an inlet-pipe I, controlled by a check-valve *i* and connected at I' with the source of water-supply. The nozzle *c'* is represented in full lines as leading to an inclosure at J, which may be considered as conventionally indicating any suitable motor device adapted to be actuated by water or air under pressure, or, as illustrated by the dotted lines at J', the system may terminate in a mere jet.

It is to be understood that the apparatus described is merely a typical embodiment of certain elements necessary or convenient for converting the energy of the discharge into mechanical movement, and I therefore have merely indicated the locality where the energy is displayed without attempting to set forth further details.

Assuming that the working parts are in the positions shown in Fig. 1 and that no water has yet entered, the action is as follows: The water flows down the three inlet-pipes E, F, and I and rises in the legs *a*, *b*, and *c* to the level of the dotted line *k*, but does not overflow into the legs a^3 or b^3, as the return-bends at the top of the undulations are above the actual water-level. The three-way valves *d* and *g* are in a position to afford outlet from the pipe portions a^2 and b^2 to the atmosphere, so that the rise of water in the vertical legs *a*, *b*, and *c* is not impeded by the compression of air in the adjacent portions of the conduit. When the legs are thus filled, the valve *g* may be turned, as shown in Fig. 2, so as to close the outlet *g'* and establish communication between the leg *b* and the slightly-inclined pipe portion b^2, whereupon the column of water in the leg *b* will momentarily fall by reason of the fact that a portion will flow through the valve *g* into the incline b^2, compressing the air ahead of it and thereby reducing somewhat the bulk of the confined body of air between the surface of the water at L in said incline and the top of the water column in the leg *c*. This fall in the leg *b* is, however, immediately compensated, because the check-valve *f* will open and permit the water to flow in until it rises in the leg *b* to the original level *k*. During this operation the water in the leg *c* becomes subjected to the pressure of the column in the leg *b*, transmitted by means of the confined body of air in the incline b^2 and upright b^3. The pressure at the discharge-valve *h* is therefore substantially twice that due to the natural head. The check-valve at *i* prevents the water in the leg *c* and pipe I from backing into the forebay under this increased pressure, and hence the full head is maintained in said leg *c*. The positions of the working parts in the leg *b* and the water-levels therein after this action has occurred are shown in Fig. 2, where it will be observed that the column in the leg *a* is still in its initial condition of establishment. When the column in the leg *b* has been thus finally established, the valve *d* is turned so as to connect the leg *a* with the incline a^2, whereupon a similar initial fall of the column in the leg *a* will occur, compressing the air in the incline a^2 and upright a^3, but the column in the leg *a* will be immediately restored by the entry of more water through the pipe E. This action will also cause a slight permanent fall in the column in the leg *b* by reason of the fact that the increment of pressure thus transmitted to its upper surface occasions a further compression of the air in the incline b^2 and upright b^3, thereby reducing the bulk of the confined body of air. When the entire series of legs has been thus thrown into communication, the conduit will contain a series of water columns corresponding in number with the undulations, and the base of each column (excepting the ultimate one) will be connected to the top of the next by an interposed confined body of air, so that the sum of the individual pressures of the several columns will be cumulatively transmitted to the ultimate column. If then the discharge-valve *h* be opened, as shown in Fig. 3, the water will be forced out at the nozzle *c'* with a pressure which initially will be equal to the sum of the total pressures thus cumulatively transformed, but which will of course fall in an increasing ratio as the several columns descend together. It may therefore not be expedient to permit the entire discharge of the water from the leg *c*, but to arrest it when the water has descended in the vertical legs *a*, *b*, and *c* and flowed into the inclines a^2 and b^2, attaining, for instance, the levels indicated at N, N', N^2, *n*, and *n'*, respectively, but not yet coming to a state of equilibrium.

To recharge the system, the three valves *d*, *g*, and *h* are turned into the positions shown in Fig. 1, when the water will flow out from the inclines a^2 and b^2 through the outlets *d'* and *g'*, and a new supply will flow into the legs *a*, *b*, and *c* through the inlets E, F, and I until the three columns have been reëstablished, when the series of operations just described may be repeated. Thus a succession of impulses due to the operative discharge of a body of fluid under the total available pressure can be obtained at the nozzle *c'* or other terminal of the series, and it can readily be seen that by the employment of several such systems discharging alternately at a common point the method lends itself to a practically continuous action.

It may be noted that although I have described the operation as comprising, so to speak, an intermediate stage between the establishment of the several columns and their ultimate discharge and have represented the corresponding conditions in Fig. 2 such order of procedure is not in any way essential. Instead of successively turning the three-way valves *g* and *d* to permit the primary compression of the air and the reëstablishment of the column after their momentary slight fall the entire set of valves *g*, *d*, and *h* may be simultaneously opened to the positions shown in Fig. 3, whereupon the cumulative action will occur as before, but the momentum of the several columns descending together to the full limit modifies the apparent dynamic result to some extent, and under some conditions this variation of detail in the operation may be considered preferable to the order of operating the valves first described. It is apparent, however, that the identity of the invention is in no way affected by such modifications of procedure as these or others which are consistent with the underlying principle herein set forth.

In the drawings I have shown a structure providing for three columns, but obviously a series would comprehend the use of merely two such columns or any greater number which is consistent with practical conditions.

In the type of apparatus above set forth water and air are the two fluids employed, and the operative element is described as being a water-discharge. I do not, however, limit my claims to the use of any particular kind of fluids, provided they be of different specific gravity, nor do I mean to imply that the dynamic result must be exhibited as a discharge of the heavier fluid, for it is obvious that the ultimate pressure may be exerted upon a confined body of air, for instance, and that an air-discharge under these conditions would be entirely within the principle and scope of the invention.

I claim—

1. In apparatus for developing and utilizing fluid-pressure, the combination with casings for a plurality of fluid columns; of casings for interposed confined bodies of lighter fluid leading from the base of one column to the top of the next; and, means arranged to permit the operative discharge of fluid under the cumulative pressure thus attained, substantially as set forth.

2. In apparatus for developing and utilizing fluid-pressure, the combination with casings for a plurality of fluid columns; of casings for interposed confined bodies of lighter fluid leading from the base of one column to the top of the next; and, rotary valves arranged to permit the operative discharge of fluid under the cumulative pressure thus attained, substantially as set forth.

3. In apparatus for developing and utilizing fluid-pressure, the combination with casings for a plurality of fluid columns; of inlets connecting said columns with a supply of fluid; means arranged to control the flow of fluid through said inlets; casings connecting said columns in series, arranged to confine bodies of lighter fluid leading from the base of one column to the top of the next; and, means arranged to permit the operative discharge of fluid under the cumulative pressure thus attained, substantially as set forth.

4. In apparatus for developing and utilizing fluid-pressure, the combination with casings for a plurality of fluid columns; of inlets connecting said columns with a supply of fluid; valves arranged to automatically control the flow of fluid through said inlets; casings connecting said columns in series, arranged to confine bodies of lighter fluid leading from the base of one column to the top of the next; and, rotary valves arranged to permit the operative discharge of fluid under the cumulative pressure thus attained, substantially as set forth.

In testimony whereof I have hereunto signed my name, at Philadelphia, Pennsylvania, this 2d day of October, 1903.

JOSEPH C. FRALEY.

Witnesses:
ARTHUR E. PAIGE,
E. L. FULLERTON.