H. A. HUMPHREY & A. CERASOLI.

METHOD OF RAISING OR FORCING LIQUID.

APPLICATION FILED AUG. 16, 1907.

1,037,009.

Patented Aug. 27, 1912.

2 SHEETS—SHEET 1.

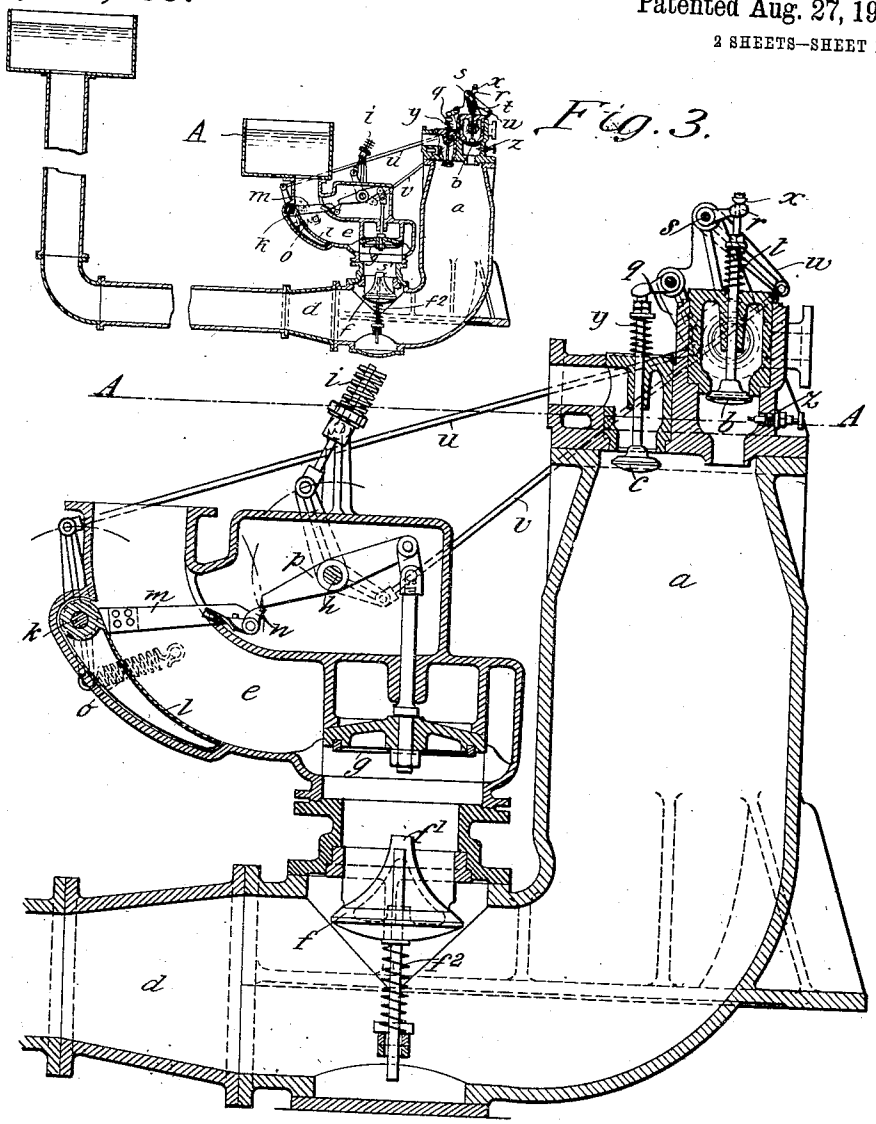

Fig. 3.

Fig. 1.

Witnesses:

Robt. Everett

by

Inventors:

Herbert A. Humphrey

Alberto Cerasoli

James L. Norris.

Atty

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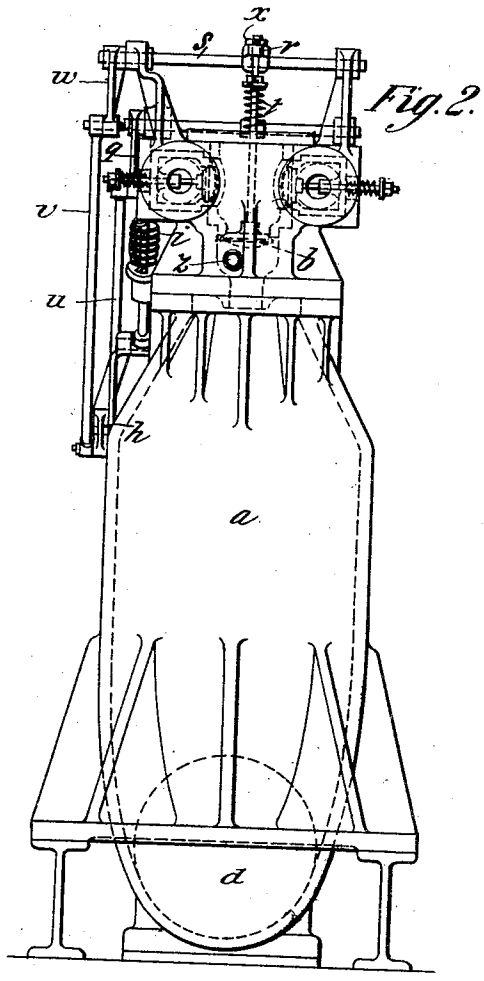

Fig. 2.

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UNITED STATES PATENT OFFICE.

HERBERT A. HUMPHREY AND ALBERTO CERASOLI, OF LONDON, ENGLAND, ASSIGNORS TO HUMPHREY GAS PUMP COMPANY, A CORPORATION OF NEW YORK.

METHOD OF RAISING OR FORCING LIQUID.

1,037,009. Specification of Letters Patent. Patented Aug. 27, 1912.

Application filed August 16, 1907. Serial No. 388,902.

To all whom it may concern:

Be it known that we, HERBERT ALFRED HUMPHREY, consulting engineer, and ALBERTO CERASOLI, engineer, both subjects of the King of Great Britain, residing, respectively, at 38 Victoria street, Westminster, in the county of London, England, and 18 Avenue road, Regents Park, in the county of London, England, have invented a certain new and useful Improved Method of Raising or Forcing Liquid, of which the following is a specification.

Our invention relates to improved method of raising or forcing liquid, in which the liquid acts as a freely reciprocating piston and performs the functions of a fly wheel and the momentum thereof is utilized.

It is known that advantage can be taken of the momentum of a moving mass of liquid to cause a pump to pass a larger volume of liquid than that calculated from the capacity and speed of the pump. The moving mass of liquid draws more liquid through the inlet valve than would be taken in by the mere operation of the pump.

The process of raising or forcing a liquid according to this invention consists in imparting a suitable momentum to a mass of the liquid by a propelling force, such as the combustion and consequent expansion of a compressed combustible mixture, and causing the kinetic energy, represented by this momentum, to introduce into the path of travel of the moving liquid, or to the rear of the liquid being propelled forward, more liquid, and into the combustion space a fresh supply of combustible mixture or the constituents of such a mixture. A portion of the liquid drawn is utilized in expelling the products of combustion from the combustion space, and, the momentum of the liquid returning toward the combustion space, under the pressure head to which it has been forced, may be utilized in compressing the combustible charge before it is ignited. The advantage of this process is that there need be no piston, other than the liquid piston, and that no valve is required between the combustion space and the column of liquid which is being forced.

Referring to the drawings which illustrate, merely by way of example, suitable means for effecting our invention—Figure 1 is a longitudinal section of the expansion chamber end of such means. Fig. 2 is an end elevation of same. Fig. 3 is a longitudinal vertical section, on a reduced scale, showing the apparatus with high and low level reservoirs, the play pipe being broken for considerations of space.

Similar letters refer to similar parts throughout the several views.

The combustion or expansion chamber *a* is provided with an inlet valve *b* for admission of combustible mixture, and an exhaust valve *c* for exit of burnt products. The lower part of the chamber communicates directly with the liquid conducting pipe *d* leading, for example, to a reservoir at a higher lever than that of the pump. It will be understood that this play pipe *d* must be of sufficient length to insure the acquisition by the liquid of the necessary momentum; the length will depend, of course, upon the dimensions of the apparatus, and speed of operation. It is assumed in this case, that the liquid level in the low level reservoir, from which the liquid is to be lifted, is approximately at A—A; it is then possible, as will presently be explained, to cause part of the liquid which enters the apparatus to expel the products of combustion from the chamber *a*.

At a part of the pipe *d* near the chamber *a* is an intake branch *e*, normally cut off from the pipe by an intake valve *f* above which is a second intake valve *g*. These valves may be opened and closed in any suitable manner, the devices shown in the drawings, and presently to be described, being only a specific example and not essential to the invention. Whatever mode of operation of the valve is adopted, however, it must be such as to allow the following working process:—Assuming the first intake valve *f* to be closed, and a charge of combustible mixture to be contained in chamber *a*, under the pressure produced by the pressure head and the momentum of the returning liquid, as aforesaid, this charge is ignited by any known ignition device, such as the spark plug *z*; explosion occurs, and the liquid is forced down the chamber *a* and along pipe *d*.

When the liquid has attained a certain velocity, and the combustion products have expanded to a certain volume, the pressure of the liquid from the low level reservoir on the intake valve *f* exceeds that of the water within the pipe *d* and the gases in chamber

a. The intake valve now opens and liquid flows into the pipe *d* to pass along with the liquid moving therein, and also into the combustion chamber to expel the combustion products through the exhaust valve *c*, which is opened in any suitable manner for the purpose.

The intake valve is shut again in any suitable manner, such as that presently to be described, while the liquid in pipe *d* still has sufficient momentum to cause some of the liquid, which has flowed into the combustion chamber, to follow it into the pipe *d*. The valve *b* at the same time opens and a fresh combustible charge is drawn into chamber *a*.

When the liquid in the pipe *d* comes to rest, it returns under the pressure head, acquiring momentum, and compresses the fresh charge in the chamber *a*, whereupon ignition occurs again and the cycle is repeated.

The mechanism shown in the drawings for operating the valves may now be described.

There are two liquid-intake valves *f* and *g* in the intake, which are both shown, in the drawings, in the open position, this representing the position of the parts when liquid is flowing into the apparatus. The stem of valve *g* is linked to an arm on a rocking shaft *h* which can remain in only one of two positions, under influence of any known device such as a spring rod *i* operating on an arm on the shaft. A shaft *k* turns in suitably packed bearings in the walls of a recess in the intake *e*, and to that portion of this shaft which is within the intake, is keyed a curved plate *l* and an arm *m* carrying at its end a spring pawl *n*. The illustrated position of these parts is maintained by the velocity of the liquid flowing through the intake *e* and past the valve *f*, into pipe *d*. When this velocity falls below a certain value, consequent upon the fall of velocity of the liquid in pipe *d*, the pressure on the plate *l* becomes less than the tension of spring *o*, attached at one end to a fixed point and at the other to an arm on the portion of the shaft *k* which extends outside the intake casing. Plate *l* is therefore drawn inward and pawl *n* trips arm *p* on the shaft *h*, thus turning the latter sufficiently to allow the spring rod *i* to complete the movement and close valve *g*.

Valve *f* remains open, because in that position, its stem *f'* is in contact with valve *g* and spring rod *i* is stronger than spring f^2. When the liquid returns in pipe *d* and the pressure in chamber *a* has risen above a certain value, valve *g* is opened by this pressure, thus allowing spring f^2 immediately to close valve *f*. After expansion of the combustible charge, when the pressure in the pipe *d* has fallen below that in the intake, valve *f* is opened and the pressure of the inflowing water deflects the plate *l* until pawl *n* slips past the end of arm *p*, and engages therewith, ready for closing the valve *g*, in the manner already described.

Since the exhaust valve *c* requires to be opened when liquid is flowing into pipe *d*, we have provided the lever *q*, linked by link rod *u* to an arm on the shaft *k*, so that the deflection of plate *l* by the flow of liquid through the intake causes the opening of the exhaust valve by depressing the valve stem against the tension of spring *y*. The return of the plate *l* to its spring-actuated position, due to the interruption of such flow, actuates lever *q* to permit the return of valve *c* to the closed position in response to the pressure of spring *y*.

The admission valve *b* is prevented from opening when the valve *g* is open, by the engagement of a collar *r* with the head *x* of the valve stem. This collar *r* is carried by an arm on the shaft *s* which is rocked by a link rod *v* connecting the second arm *w* on shaft *s*, with an arm on shaft *h*. When the valve *g* is shut, collar *r* is lowered, and the suction in the chamber *a* has only to overcome the light spring *t*, in taking in a charge.

What we claim is:—

1. The method which consists in reciprocating liquid, one movement of said reciprocation being due to an expansive force, and utilizing the momentum of the liquid, in each direction of its reciprocation whereby liquid is forced to a greater head or pressure, fresh liquid is introduced, burnt products are expelled, and fresh expansible charges are introduced and compressed.

2. The method which consists in causing the reciprocation of a body of liquid by an expansive force, utilizing its momentum to entrain fresh liquid whereby burnt products are displaced, to entrain a fresh expansible charge and compress said charge, and utilizing the direction of flow of liquid to control exit for burnt products and inlet for combustible charge.

3. The method which consists in causing the movement of a suitable body of liquid by an expansive force, permitting a return movement of liquid due to head or pressure to which it has been forced in the first movement and utilizing the momentum of the liquid to entrain and compress a fresh expansible charge.

4. The method which consists in causing the movement of a suitable body of liquid in one direction by an expansive force, permitting a return movement due to head or pressure after the first movement utilizing the momentum of said body to produce a diminution of pressure to the rear of said body and thereby entrain a fresh expansible charge and utilizing the momentum of a return stroke to compress the charge.

5. The method which consists in causing the movement of a suitable body of liquid by an expansive force and utilizing its momentum to produce a diminution of pressure to the rear of said body whereby fresh liquid is caused to enter the path of travel of said body, some of which expels the burnt products, and then, following the moving body, due to the continuing momentum of its first impulse, entrains a fresh combustible charge, then utilizing the momentum of the return movement of said body to compress the charge.

6. The method which consists in causing the movement of a suitable body of liquid by an expansive force and utilizing its momentum to produce a diminution of pressure to the rear of said body, whereby fresh liquid is caused to enter the path of travel of said body, some of which expels the burnt products and then following the moving body due to the continuing momentum of its first impulse entrains a fresh combustible charge, then utilizing the momentum of the return movement of said body together with its head or pressure to compress the charge.

7. The method which consists in reciprocating a body of liquid through a path of travel of required extent, the initial movement of said reciprocation being due to an expansive force, utilizing part of the momentum due to the first impulse to entrain more liquid, utilizing a movement in direction opposite that of first impulse to expel burnt products, and the momentum of a movement in the direction of the first impulse to entrain fresh combustible charge.

8. The method which consists in reciprocating a body of liquid through a path of travel of required extent, the initial movement of said reciprocation being due to an expansive force, utilizing part of the momentum due to the first impulse to entrain more liquid, utilizing a movement in direction opposite to that of first impulse to expel burnt products, a movement in the direction of the first impulse to entrain fresh combustible charge, and the momentum of a return movement to compress the charge.

9. The method which consists in reciprocating a body of liquid through a path of travel of required extent, the initial movement of said reciprocation being due to an expansive force, utilizing part of the momentum due to the first impulse to entrain more liquid, utilizing a movement in direction opposite that of first impulse to expel products of combustion, a movement in the direction of the first impulse to entrain fresh combustible charge, and the momentum of a return movement plus the head of said body of liquid to compress the charge.

10. The method which consists in reciprocating a continuous body of liquid of required volume and path of travel, the outstroke movement due to an expansive force, the instroke movement due to head or pressure when the momentum of the outstroke is spent, utilizing the momentum of the outstroke to permit inflow of fresh liquid to discharge burnt products, and to entrain a fresh combustible charge.

11. The method which consists in reciprocating a continuous body of liquid of required volume and path of travel, an outstroke movement being due to an expansive force, and an instroke movement due to head or pressure when the momentum of the outstroke is spent, and utilizing the momentum of the liquid whereby fresh liquid is introduced, burnt products are displaced and a fresh combustible charge is entrained and compressed.

12. The art of utilizing the expansive force of a combustible charge, which consists in compressing the charge by the pressure of a body of liquid, expanding the charge against said body to cause an outstroke, utilizing the momentum of the outstroke, which produces a diminution of pressure to the rear of the body, to cause fresh liquid to flow into the path of travel of said body and also to displace burnt products, utilizing the momentum of the liquid to entrain a fresh combustible charge and utilizing momentum of the instroke due to head, after momentum of outstroke is spent, to compress the fresh charge.

13. The art of utilizing the expansive force of a combustible charge, which consists in reciprocating a body of liquid through a path of sufficient length to insure the acquisition by the body of necessary momentum, said body being continuous and said path being unobstructed and unconstricted, utilizing the momentum of the liquid to entrain a fresh combustible charge.

14. The art of utilizing the expansive force of a combustible charge, which consists in reciprocating a body of liquid through a path of sufficient length to insure the acquisition by the body of useful momentum, said body being continuous and said path being unobstructed and unconstricted, utilizing the momentum of the liquid to entrain and compress a fresh combustible charge.

15. The art of utilizing the expansive force of a combustible charge, which consists in reciprocating a continuous body of liquid of required volume and path of travel, a movement in one direction due to said expansive force, a movement in opposite direction due to the head or pressure of the body when the momentum in the first direction is spent, utilizing the momentum of the liquid to cause a diminution of pressure behind the moving body whereby fresh liquid is entrained, part following the mov-

ing body and part displacing the burnt products, utilizing the direction of flow of the liquid to control the exit for burnt products and the inlet for fresh combustible charge.

16. The art of utilizing an expansive force, which consists in causing the free reciprocation of a body of liquid, a movement in one direction of said reciprocation being due to said expansive force, utilizing the momentum of said movements of the liquid in both directions whereby liquid is delivered to a greater head, fresh liquid is entrained, burnt products are expelled and a fresh expansible charge is entrained and compressed.

17. The art of utilizing an expansive force, which consists in causing the free reciprocation of a body of liquid, a movement in one direction of said reciprocation being due to said expansive force, utilizing the momentum of said movements of the liquid in both directions whereby energy is stored. fresh liquid is entrained, burnt products are expelled and a fresh expansible charge is entrained and compressed.

18. The art of utilizing an expansive force which consists in causing the free reciprocation of a body of liquid, a movement in one direction of said reciprocation being due to said expansive force, a return movement being automatically due to said head or pressure when the liquid comes to rest at the end of the first movement, utilizing the momentum of said movements whereby energy is stored, fresh liquid is entrained. burnt products are expelled and a fresh expansible charge is entrained and compressed, and controlling the exit for burnt products and the inlet for expansible charge relatively to the direction of flow of the body of liquid.

19. The art of utilizing the expansive force of an ignited combustible charge under pressure, which consists in the free reciprocation of a body of liquid, a movement in one direction of said reciprocation being due to said expansive force, utilizing the momentum of said movements of the liquid in both directions whereby energy is stored, fresh liquid is entrained, burnt products are expelled and fresh combustible charges are entrained and compressed, and automatically controlling the exit for burnt products and the inlet for combustible charge in order to secure the steps above enumerated.

20. The art of utilizing the expansive force of a compressed combustible charge in the movement of liquid, which consists in forcing the liquid to greater head or pressure by said expansive force, utilizing the momentum of said movement to introduce a fresh combustible charge, permitting some of the liquid to return under said head or pressure and utilizing the momentum thereof to compress the fresh charge.

21. The art of utilizing the expansive force of a compressed combustible charge in the movement of liquid, which consists in forcing the liquid to greater head or pressure by said expansive force, utilizing the momentum of said movement to introduce fresh liquid and a fresh combustible charge, permitting some of the liquid to return under said head or pressure and utilizing the momentum thereof to compress the fresh charge.

22. The art of utilizing the expansive force of a compressed combustible charge in the movement of liquid, which consists in forcing the liquid to greater head or pressure by said expansive force, utilizing the momentum of said movement to introduce fresh liquid and a fresh combustible charge, permitting some of the liquid to return under said head or pressure, utilizing the momentum thereof to compress the fresh charge, and utilizing the inflowing fresh liquid to discharge burnt products.

23. The method of raising or forcing liquid by the energy of expansion of an ignited combustible mixture, which consists in allowing the energy of expansion to act upon one end of a column of liquid so as to impart momentum to the said column of liquid and force it to a greater head or pressure, allowing the momentum of the moving column of liquid to produce a diminution of pressure in the rear of the column and thus entrain fresh combustible mixture, allowing the column of liquid to return under action of its head or pressure, and utilizing the momentum acquired by the returning column to compress the fresh combustible mixture.

24. The method of raising or forcing liquid by the energy of expansion of an ignited combustible mixture, which consists in allowing the energy of expansion to act upon one end of the column of liquid so as to impart momentum to the column of liquid and force it to a greater head or pressure, allowing the momentum of the column of liquid to produce a diminution of pressure in the rear of the column and thus entrain fresh liquid and fresh combustible mixture, allowing the column of liquid to return under action of its head or pressure, and utilizing the momentum acquired by the returning column to compress the fresh combustible mixture.

25. The method of raising or forcing liquid by the energy of expansion of an ignited combustible mixture, which consists in allowing the energy of expansion to act upon one end of a column of liquid so as to impart momentum to the column of liquid and force it to a greater head or pressure, allowing the momentum of the co- lum

of liquid to produce a diminution of pressure in the rear of the column and thus entrain both fresh liquid, some of which displaces products of combustion, and fresh combustible mixture, allowing the column of liquid to return under action of its head or pressure, and utilizing the momentum acquired by the returning column to compress the fresh combustible mixture.

26. The method of raising or forcing liquid comprising the following cycle:—(1) ignition of a compressed combustible charge, (2) combustion and expansion of said charge and outward movement of a column of liquid, (3) admission of fresh liquid under the reduced pressure caused by the moving column, (4) expulsion of the products of combustion by a part of the liquid admitted, (5) cutting off the supply of fresh liquid and admitting a fresh combustible charge under the suction caused by the moving column, (6) compression of the fresh charge by the inward movement of the column.

In testimony whereof we have signed our names to this specification in the presence of two subscribing witnesses.

H. A. HUMPHREY.
A. CERASOLI.

Witnesses:
OLIVER IMRAY,
OLIVER J. IMRAY.