T. M. CHANCE.

METHOD OF PUMPING LIQUIDS.

APPLICATION FILED AUG. 5, 1910.

1,021,038.

Patented Mar. 26, 1912.

3 SHEETS—SHEET 1.

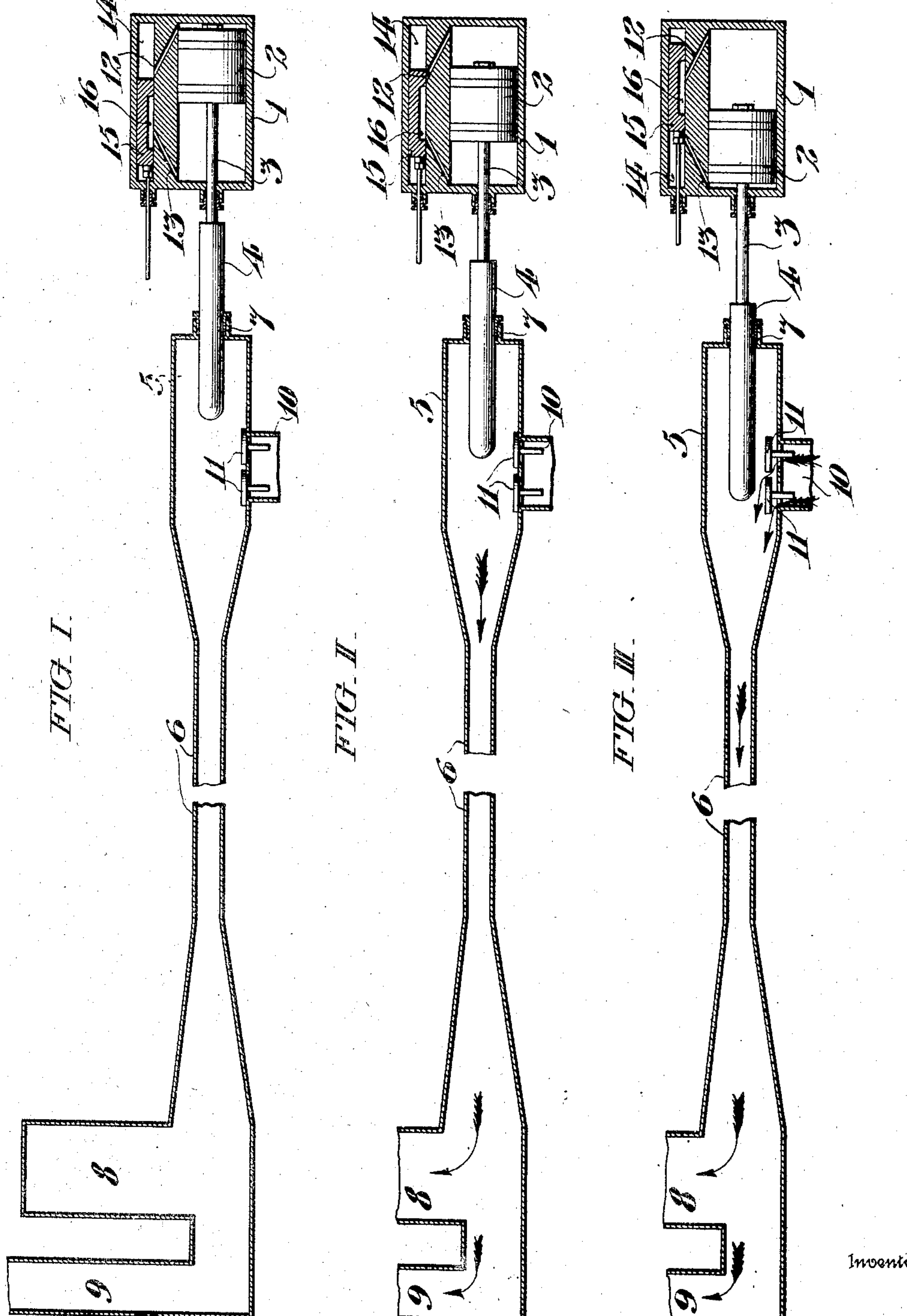

FIG. I.

FIG. II.

FIG. III.

Witnesses

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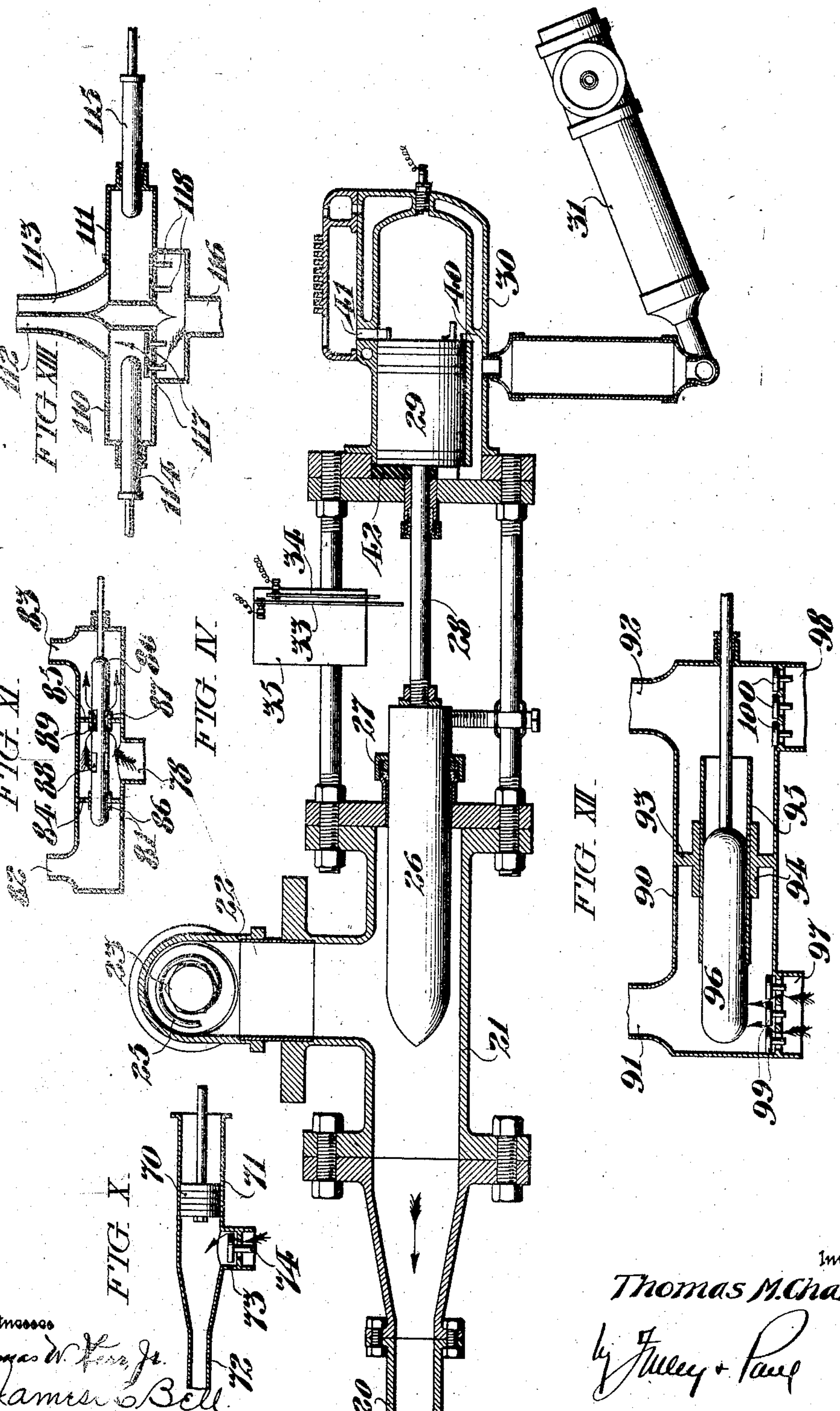

FIG. XIII.

FIG. XI.

FIG. IV.

FIG. X.

FIG. XII.

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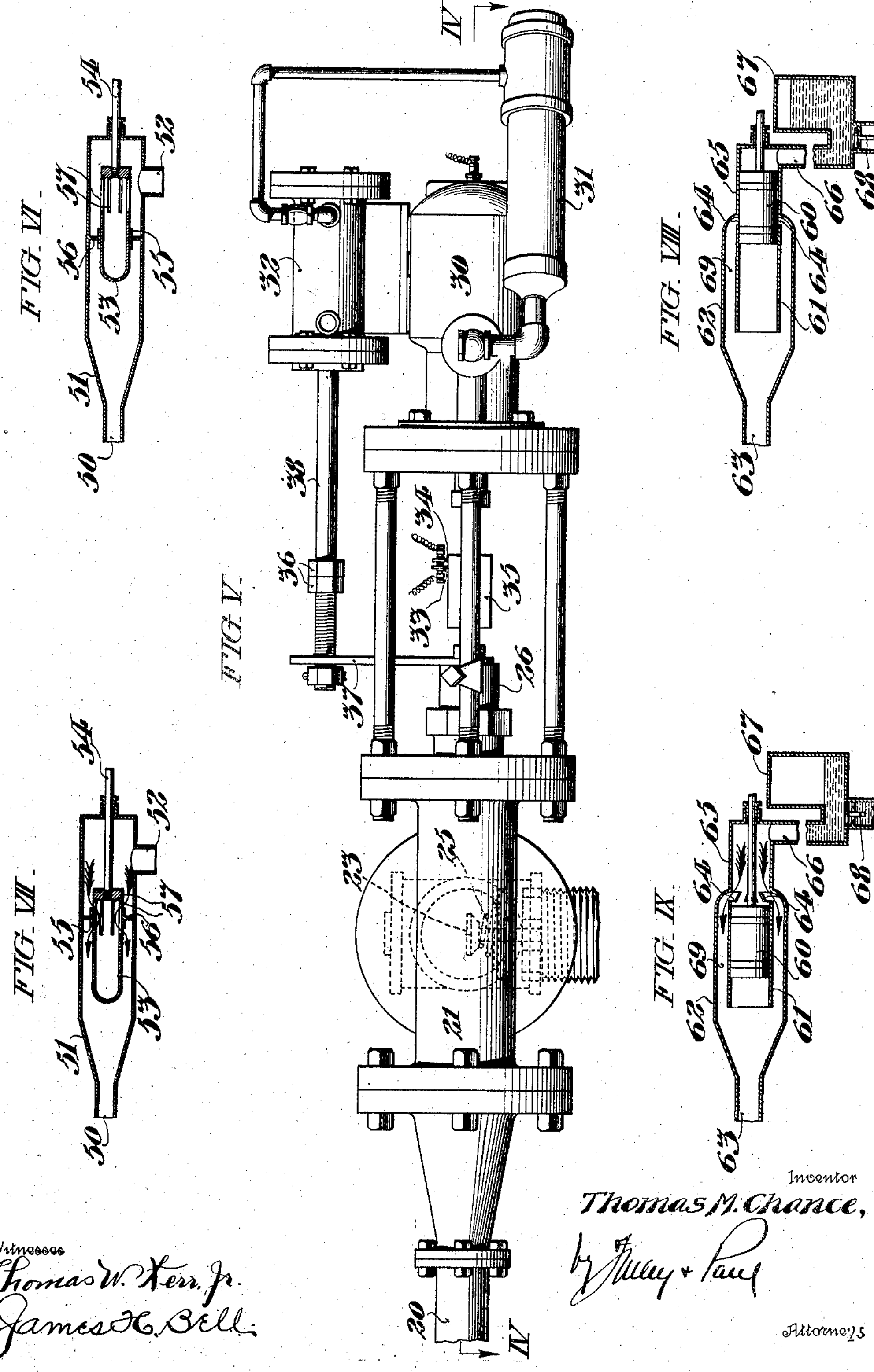

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UNITED STATES PATENT OFFICE.

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METHOD OF PUMPING LIQUIDS.

1,021,038. Specification of Letters Patent. Patented Mar. 26, 1912.

Application filed August 5, 1910. Serial No. 575,669.

To all whom it may concern:

Be it known that I, THOMAS M. CHANCE, of Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented a certain new and useful Method of Pumping Liquids, whereof the following is a specification, reference being had to the accompanying drawings.

I use the term "liquid" as comprehending not merely single liquids, but also mixtures of two or more liquids, mixtures of liquids and solids, and mixtures of liquids and gases, whenever such substances are capable of being pumped.

The objects of my invention are to utilize the momentum of a confined body of liquid, which has been set in motion by means of a mechanical actuator positively driven by a primary medium having high initial pressure and subsequent expansive force, to effect the discharge of liquid and to draw in a new accretion of liquid at the intake end of the system after the cessation or retardation of movement of the actuator, thus permitting the supply of the primary medium to be so controlled as to realize its expansive force to the fullest extent, and further to utilize the momentum and resultant pressure of the said body of liquid in the reverse direction, after the completion of its initial movement, in such manner as to re-act upon the actuator, and thereby permit it to assist in developing the desired conditions of that portion of the elastic medium which is to effect the next power stroke.

Figuratively speaking, the confined body of liquid may be considered as a liquid piston in so far as it tends to force liquids toward the delivery end of the system and to draw in liquid at the intake end of the system, and since said body of liquid has relatively large inertia, it may be likened to an oscillating fly wheel in so far as it tends to store up the energy transmitted from the actuator, and, after employing a part of such stored up energy for the primary work of effecting motion of translation of the liquid, to then employ another part of such energy in a reverse direction for reaction upon the actuator. This capacity for storing up energy and transmitting parts of it first in one direction and then in the other permits the expansive force of the medium of the prime mover to be most advantageously utilized during the power stroke, and is also efficient for compressing the next succeeding charge of said medium or portion of such charge in preparation for the next succeeding power stroke.

My method contemplates the use of a reciprocating actuator which is positively driven in only one direction, although it may be positively driven in both directions, and while it is of special value in connection with internal combustion engines, it is also available for engines which employ the expansive force of steam.

In the accompanying drawings, Figures I, II, and III, represent diagrammatically, in vertical longitudinal section, a typical system of apparatus adapted for the employment of my method, showing, as the prime mover, a conventional representation of a steam cylinder, and its immediate adjuncts. Said three views indicate the steam piston and its valve in three critical positions, which will be hereinafter described. Fig. IV, represents a sectional plan view of a preferred actuator mechanism, adapted to be employed in my method, the prime mover being represented as a gas engine acting on the two stroke auto cycle. Fig. V, is a side elevation of the devices represented in Fig. IV, certain parts being shown in dotted lines. Figs. VI to XIII, inclusive, are sectional diagrammatic views, showing various typical forms of actuator mechanism which can be employed in carrying out my method; Figs. VI and VII, show one form of actuator in two characteristic positions; Figs. VIII and IX, show another form in two characteristic positions, while the remaining figures respectively show other forms in only a single position.

Referring now to the diagrammatic views of Figs. I, II, and III, 1, indicates a steam cylinder having a piston 2, and piston rod 3, which latter is operatively connected to a plunger 4, which enters the enlarged end 5, of an inclosed conduit 6. As indicated by the packing represented at 7, said plunger is of the type termed "outside packed."

The conduit 6, which may be termed the liquid piston conduit, is preferably horizontal and straight, though not necessarily so, and is prolonged for a considerable distance, so as to inclose a relatively extended body of liquid, such as water. Said conduit is, in this instance, provided with an inclosed air chamber 8, adjacent to the delivery main 9.

An inlet pipe 10, for water, communicates with the interior of the chamber 5, in the region adjacent to the plunger 4, the opening of said inlet pipe being controlled by one or more valves 11.

Returning now to the power cylinder 1, the ports are represented at 12, and 13, respectively, the valve chest at 14, and the valve at 15, it being understood, of course, that the interior of the valve chamber 14, is in communication with a source of steam at suitable pressure, and that the internal chamber 16, of the valve, communicates with the exhaust.

In Fig. I, the parts are represented in the position which they occupy just at the commencement of the power stroke. If now, steam under pressure be admitted in rear of the piston 2, through the port 12, the piston 2, and plunger 4, will be actuated with relatively high velocity, this movement of the plunger imparting movements of substantially similar velocity to the body of water within the liquid piston conduit 6. At a predetermined position of the steam piston 2, as shown in Fig. II, the valve 15, is shifted so as to cut off the steam, and the remaining forward movement of said piston is effected by the expansion of the steam theretofore admitted. The liquid piston having been set in motion at the relatively high velocity which characterizes the initial portion movement of the steam piston 2, under full initial pressure, the momentum of the liquid permits the utilization to the highest extent of the expansive force of the steam in rear of the piston 2 and the movement thereof continues until the position shown in Fig. III, is reached, where the piston 2, is close to the end of its forward stroke. At this point, the valve 15, is shifted, so as to momentarily open communication between the front end of the cylinder and the interior of the valve chest through the port 13, and a cushion of steam is thus admitted in front of the piston 2, so as to decelerate and arrest the movement thereof without shock. The movement of the plunger 4, is similarly decelerated and ultimately arrested, without, however, affecting the movement of the liquid piston within the conduit 6, and the momentum of said liquid piston causes an area of low pressure in the region of the plunger 4, so that the valves 11, open, admitting water into the interior of the chamber 5, as indicated by the arrows in Fig. III. The position of the steam valve 15, shown in Fig. III, is only momentary, and it is again shifted, so as to cut off the admission of steam in front of the piston, while still maintaining communication between the exhaust and the portion of the cylinder in rear of the piston. The momentum of the liquid piston in the conduit 6, is gradually checked by the combined effect of the resistance at the delivery end of the system, and the suction which is being exerted at the intake end. Thereupon, a surge of reversed pressure in the liquid piston takes place, forcing the plunger 4, and piston 2, rearwardly. This return movement is advantageously attended at the proper moment by a position of the slide valve, which momentarily admits steam in the rear of the piston just before the completion of the return movement thereof, so that the steam is compressed behind the piston and the clearance spaces are thus filled, the exhaust being in communication with that portion of the cylinder which is in front of the piston. The cycle of operations then recurs. The forward movement of the liquid piston, which has been described, delivers the water through the discharge main 9, which, it will be observed, need not be provided with any delivery valve. Where, as indicated in Figs. I, II, and III, an air chamber is employed, such device acts in the ordinary manner. The use of an air chamber, as an adjunct to the system, though desirable, is, however, not essential when the column of water which is to be pumped is relatively short, as this column of liquid may then perform the functions of the air chamber 8, which latter is intended to be typical of any form of accumulator, or device capable of absorbing and giving out energy.

The movements of the steam piston should, of course, be timed in proper relation to the movement, or rate of oscillation, of the liquid piston, which last mentioned factor will depend upon the dimensions of said liquid piston, and the pressure against which the pumping action takes place.

Furthermore, one characteristic of my method, is found in the fact that the energy developed by the return stroke of the body of liquid, is utilized in the direction of performing a useful work, as distinguished from merely moving what may be considered as idle parts.

Since in any given case the actuating force of the prime medium is fixed, the pressure against which the body of liquid is to be outwardly propelled is fixed, and the energy which can be utilized in useful work on the prime medium upon the return stroke is also fixed, an important factor in the securing of the maximum of efficiency and economy resides in the relation between the dimensions of that portion of the actuator which directly acts upon the body of liquid and is re-acted upon by it, and the dimensions of that portion of the actuator upon which the prime medium acts and which re-acts upon the prime medium.

In the diagrams just referred to, it will be noted that the cross sectional area of the actuator, 4, is very considerably less than the cross sectional area of the piston 2, and by properly proportioning the respective cross sectional areas of said parts, the active effect of the plunger upon the column of liquid upon the out-stroke and the re-active effect upon the prime medium on the return stroke can be so controlled as to yield the desired results.

Another factor in determining the economy of operation depends upon whether the actuator is moved throughout the whole of its return stroke by the re-action of the body of liquid alone, or is driven through a portion of its return stroke by other means and is assisted by the re-action of said body of liquid. Hence in carrying out my method, while control of the quantity of the prime medium may be used to compensate for minor variations in the pressure against which the actuator makes its out-stroke, and while efficiency may be aided by thus varying the application of power, the dimensions of the actuator must be proportioned to the pressure against which it is to work. For example, if the mean effective pressure of the prime medium, be one hundred pounds per square inch, and the pressure against which the body of liquid is to be outwardly propelled be eighty pounds per square inch, and if the energy which can be utilized on the return stroke in useful work upon the prime medium be equal to a mean effective pressure applied to said prime medium of twenty pounds per square inch, then the cross sectional area of that part of the actuator which acts upon the body of liquid should be made about one-fourth of the cross sectional area of that part of the actuator upon which the prime medium acts. With the parts so proportioned (and disregarding friction), twenty per cent. of the energy of the prime medium will be stored for utilization during the return stroke in useful work on the prime medium, and eighty per cent. of said energy will be utilized directly in the discharge and drawing in of liquid.

Such being a typical outline of the general principle of operation, I will now proceed to describe a system adapted to carry out my method in connection with a gas engine, as the prime mover, such an embodiment being shown in Figs. IV and V. In said Figs. IV and V, 20 represents the end of the liquid piston conduit adjacent to the actuator mechanism, only the latter being shown in said drawings. Said conduit 20, is provided with an enlarged chamber 21, having a horizontal offset 22, in which the inlet valve 23, is located. Said valve opens upward and is preferably provided with a spring 25, exerting downward pressure, as indicated in the dotted lines of Fig. V. The plunger 26, is externally packed, as shown at 27, and is connected by means of the rod 28, with the power piston 29. The cylinder 30, is of the usual construction characteristic of this type of gas engines, having inlet and outlet ports 40, and 41, respectively, a mixing chamber 31, which is divided into two subdivisions by an automatic inlet check valve, (the portion adjacent to the power cylinder thus becoming a compression chamber), and gas pumping device 32. Said cylinder may advantageously be provided with a buffer device 42, of rubber, to assist in cushioning the piston. The contact devices 33, and 34, of the igniting circuit, are mounted upon an adjustable block 35, in proper relation to the wiping element, carried by the piston rod, so that the spark can be timed at any desired point of the stroke.

Other adjunctive devices are the tappet arm 37, mounted upon the piston rod 28, and adapted to actuate the piston rod 38, of the gas pump 32, at suitable intervals, by contact with the adjustable nuts 36. These devices may be of any character ordinarily employed and need not be further particularized.

The cycle of operations, when this pump mechanism and prime mover are employed for carrying out my method, is preferably as follows: Starting with the piston 29, and plunger 26, at the commencement of the power stroke, the highly compressed mixture of air and gas contained in the clearance of the cylinder 30, is ignited. Rapid combustion, or explosion, follows, and the piston 29, and the plunger 26, are driven forward at relatively high velocity, imparting similar movement to the water in the liquid piston conduit 20. As the piston 29, approaches the end of its stroke, the tappet arm 37, actuates the rod 38, of the gas pump to draw in a fresh supply of gas, and just before the said piston 29, reaches the end of its stroke, it uncovers the exhaust port 41, and the burned gases escape to atmospheric pressure. Communication is also afforded at the proper time, through the inlet port 40, to permit the initial entrance into the cylinder, of the partly compressed charge of gas and air in that portion of the mixer adjacent to the power cylinder. The stroke of the piston 29, is decelerated and arrested, by the back pressure produced within the mixer, and ultimately by the buffer 42. This part of the cycle of movement of the gas engine has been attended by the forward actuation of the liquid piston in the conduit 20, derived from the movement of the plunger 26. Said liquid piston delivers a certain quantity of water at the discharge end, during its forward movement, and upon the deceleration and arresting of the plunger 26, draws in a new accretion of water through the valve 23. When the forward movement of the liquid piston within the conduit 20, is arrested, and the return surge of pressure commences, the valve 23, closes, and the re-action of the liquid piston upon the plunger 26, drives the latter rearwardly, thus forcing the power piston 29, to its initial position and compressing the mingled charge of air and gas behind it while drawing a fresh charge of gas and air into the mixer, in preparation for the succeeding stroke. It will thus be seen that the liquid piston, in this embodiment of the system, attains a result generally similar to that which is performed by the fly wheel ordinarily used in connection with such an internal combustion engine, such action of the liquid piston being in addition to its direct conveyance of a portion of its own contents to the delivery end of the system and its action in drawing in a further accretion to its own contents at the intake end of said system.

Referring now to the remaining views, which indicate various alternate forms of actuator mechanism, Figs. VI and VII, show such pumping mechanism respectively at the beginning and end of the power stroke. In these figures, 50, indicates the end of the liquid piston conduit, which is adjacent to the pumping mechanism, 51, being the enlarged chamber of said conduit, and 52, the water inlet pipe. The plunger 53, is hollow and is actuated by means of the piston rod 54. Said plunger fits snugly within a ring 55, carried by the annular diaphragm 56, which divides the chamber 51. A plurality of slots 57, of greater length than the surface of said ring 55, are formed near the rear end of the plunger, said slots being so positioned with reference to the stroke thereof, that at the commencement of the forward stroke, they are in the rear of said ring but at or near the conclusion of said stroke, they straddle said ring and thus afford channels for the passage of water from the inlet pipe 52, to the front end of the chamber 51. In this device the valves, before described, for controlling the water inlet pipe 52, are dispensed with.

Figs. VIII and IX, show another form of device respectively at the beginning and end of the power stroke. In this instance, a piston 60, is used instead of a plunger, said piston fitting within an internal cylinder 61, contained within the enlarged chamber 62, of the liquid conduit 63. The cylinder 61, projects rearwardly as shown, beyond the extremity of the chamber 62, and is provided with a plurality of openings 64, which afford communication between the interior of the cylinder 61, and the annular space 69, between it and the wall of the chamber 62. The inlet pipe 66, for water communicates with the rear end of the cylinder 65, and may be advantageously provided with an air chamber 67, located above the valve 68. The longitudinal dimensions of the piston 60, are such that during a large portion of the stroke, it covers the openings 64, and only exposes them when it is approaching the end of its forward stroke. At this period the deceleration and arresting of the piston stroke and the continuance of the forward movement of the liquid within the conduit, produce an area of low pressure in the region behind the piston 60, and water is drawn in through the openings 64. The air chamber 67, forms a useful adjunct of this device, the air therein being compressed upon the return movement of the piston 60.

In Fig. X, the pumping mechanism comprises a piston 70, which fits snugly within the enlarged chamber 71, of the conduit 72. The inlet pipe 73, for water is arranged at a point in front of the extreme forward position of the piston 70, and is provided with a valve 74, which opens when the movement of the piston 70, is decelerated and arrested, so as to permit the entrance of water.

In Fig. XI, a double acting plunger 80, is shown, said plunger being arranged within an elongated chamber 81, communicating with two liquid conduits 82, and 83, respectively, at its opposite ends. Said chamber is divided into three compartments, by annular diaphragms 84, and 85, whose rings 86, and 87, fit snugly upon the plunger 80. The plunger is hollow, and is provided with two sets of slots respectively represented at 88, and 89, the dimensions and positions of said slots with relation to the diaphragm rings 86, and 87, being such that as the plunger reciprocates, communication shall be alternately established between the middle compartment and the compartments at the respective ends of the chamber 81. The inlet pipe 78, leads into the middle compartment, and hence the pumping action takes place in one conduit upon the forward stroke of the piston, and within the other conduit upon its rearward stroke.

In Fig. XII, the enlarged chamber 90, is connected at its respective ends with liquid piston conduits 91, and 92, said chamber being centrally divided by means of the diaphragm 93, and ring 94, which latter may advantageously be provided with an elongated bushing cylinder 95, fitting snugly upon the plunger 96. At the respective ends of the chamber 90, are inlet pipes 97 and 98, respectively, provided respectively with valves 99, and 100. In this form of device the pumping action is effected in one conduit by the forward movement of the piston stroke and in the other conduit by the return movement thereof.

In Fig. XIII, two enlarged chambers 110, and 111, are shown, these chambers being separated from one another and communicating with separate conduits 112, and 113, respectively, which may unite at a common point of delivery. The chamber 110, is provided with a plunger 114, and the chamber 111, with a similar plunger 115. The inlet pipe 116, for water communicates through valved openings 117, with the chamber 110, and through similar valved openings 118, to the chamber 111. The plungers 114, and 115, are actuated in opposition, so that the pumping action takes place alternately in the respective conduits 112, and 113, the proper relative action of the plungers being attained by connecting them through a yoke, or in any other convenient manner.

It will be observed that with all these various forms of actuator mechanism, the underlying principle of my invention remains the same, and I have shown and described them not with a view of limiting the scope of my invention, but in order to indicate to some extent the unity of the method itself, notwithstanding the variety of actuators and their adjuncts which may be employed to carry it out.

From the foregoing description, those familiar with the art will be able to use any type of internal combustion engine in carrying out this method of pumping, such as two four-stroke Otto cycle cylinders coupled as a unit to give a two-stroke cycle effect, or cylinders operated on the Diesel, or other cycle, and to combine a plurality of such power cylinders with or without a plurality of pump pistons or plungers.

It is also obvious that any kind of fuel applicable to the operation of internal combustion engines may be used in operating such cylinders.

I am aware that it is not broadly new to utilize the momentum of a column of water for storing up and transmitting energy, or for drawing in water at the intake end of the system and expelling water at the delivery end after the cessation of movement of an actuating plunger. So far as I am aware, however, I believe myself to be the first to utilize the momentum of a body of liquid under the conditions described, in such manner as to make available the expensive force of the driving medium during the power stroke, and to store energy to effect a return stroke of said body of liquid and utilize said stored energy in performing useful work upon the prime medium.

I do not herein claim the apparatus shown by the drawings and described in this specification, as this has been made the subject of an application filed by me January 10th, 1912, Serial No. 670,413.

Having thus described my invention, I claim:

1. The hereinbefore described method of pumping liquid, which consists in transmitting pressure to a confined body of liquid of greater length than diameter, by means of an actuator driven directly by a primary medium having high initial pressure and subsequent expansive force, whereby a power stroke of relatively high velocity is imparted to said body of liquid while the pressure of said medium is relatively high; controlling the quantity of said medium to permit the expansion thereof down to relatively low pressure at the end of the power stroke, while permitting the body of liquid to maintain relatively high velocity during said stroke; permitting the body of liquid to continue in motion after the actuator has come to rest and thereby creating a region of low pressure in the vicinity of the actuator; discharging a portion of said body of liquid; and drawing in at said region of low pressure a new increment of liquid, substantially as set forth.

2. The hereinbefore described method of pumping liquid, which consists in transmitting pressure to a confined body of liquid of greater length than diameter, by means of an actuator driven directly by a primary medium having high initial pressure and subsequent expansive force, whereby a power stroke of relatively high velocity is imparted to said body of liquid while the pressure of said medium is relatively high; controlling the quantity of said medium to permit the expansion thereof down to relatively low pressure at the end of the power stroke, while permitting the body of liquid to maintain relatively high velocity, during said stroke; permitting the body of liquid to continue in motion after the actuator has come to rest and thereby creating a region of low pressure in the vicinity of the actuator; discharging a portion of said body of liquid; drawing in at said region of low pressure a new increment of liquid; causing the power stored up by said body of liquid during the power stroke to re-act upon the actuator and to compress a succeeding new increment of the primary medium in preparation for the next stroke thereof, substantially as set forth.

3. The hereinbefore described method of pumping liquid, which consists in imparting motion of relatively high velocity to a body of liquid interposed between an actuator and an accumulator, said actuator being driven by means of a prime medium having high initial pressure and subsequent expansive force; controlling the quantity of said medium to permit the expansion thereof to relatively low pressure during the outstroke of said actuator; causing the outstroke and continued travel of said body of liquid to discharge liquid and to store energy in said accumulator; permitting the body of liquid to continue in motion after the end of the power stroke of said actuator and thereby creating a region of low pressure in the vicinity of said actuator; drawing in a new increment of liquid at said region of low pressure; causing the energy stored in said accumulator to react upon said actuator

and upon the prime medium in preparation for the next power stroke of said actuator; and controlling the quantity of energy transmitted by the return stroke of said actuator in correspondence with the amount of power required for performing useful work upon said prime medium.

In testimony whereof, I have hereunto signed my name at Philadelphia, Pennsylvania.

THOMAS M. CHANCE.

Witnesses:

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