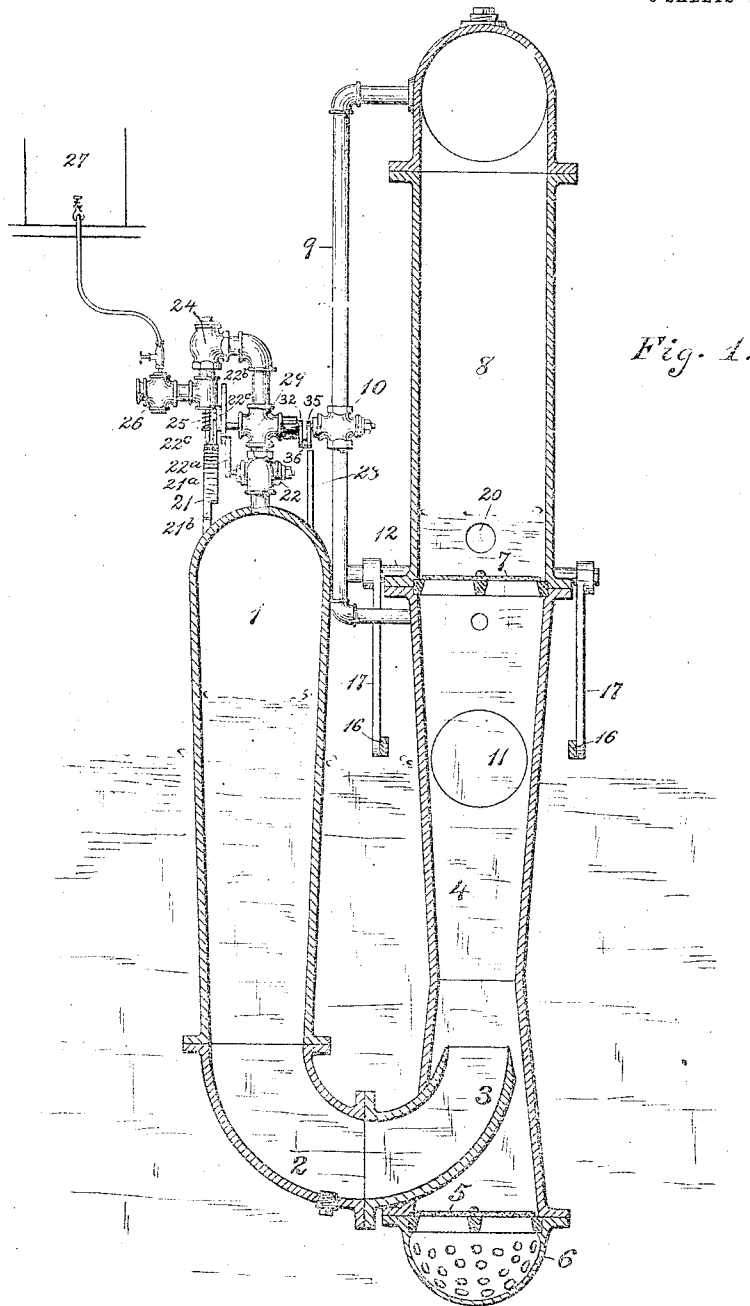


W. H. SMYTH.
UTILIZING HEAT ENERGY.
APPLICATION FILED FEB. 5, 1900.

1,037,071.

Patented Aug. 27, 1912.

8 SHEETS—SHEET 1.



Witnesses:
H. W. Kren
A. B. Powers.

Inventor:
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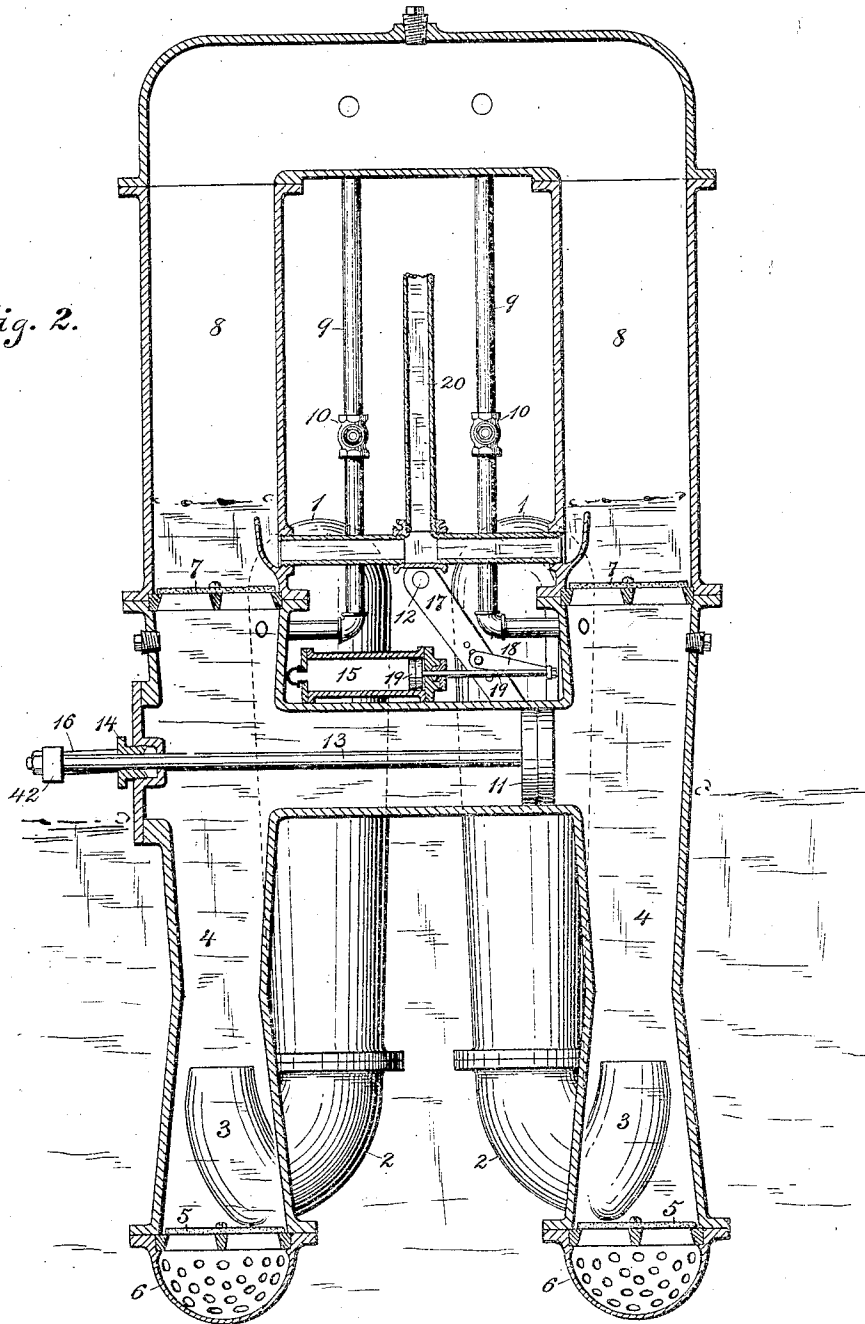
W. H. SMYTH.
UTILIZING HEAT ENERGY.
APPLICATION FILED FEB. 5, 1900.

1,037,071.

Patented Aug. 27, 1912.

8 SHEETS—SHEET 2.

Fig. 2.



Witnesses:
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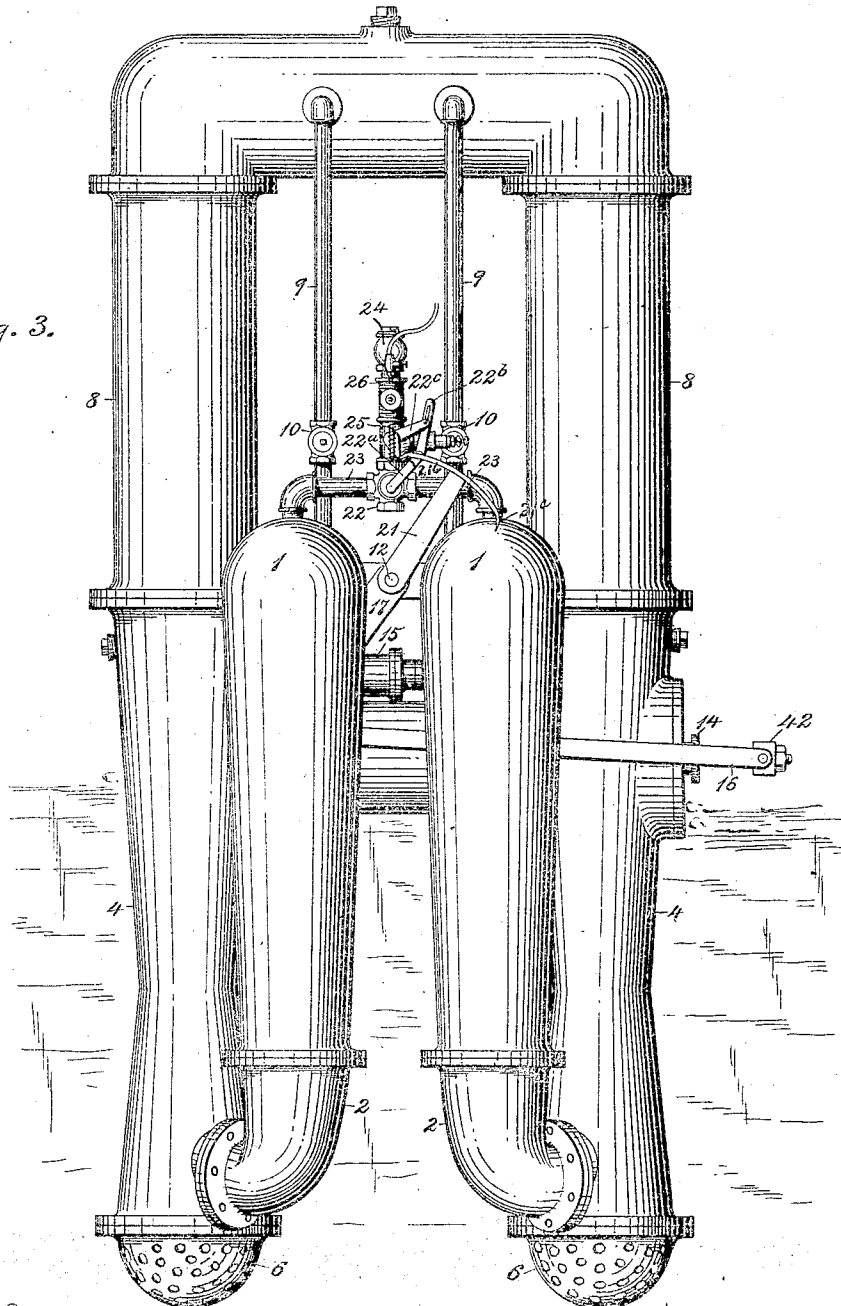
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 UTILIZING HEAT ENERGY.
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1,037,071.

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8 SHEETS—SHEET 3.

Fig. 3.



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8 SHEETS—SHEET 4.

Fig. 4.

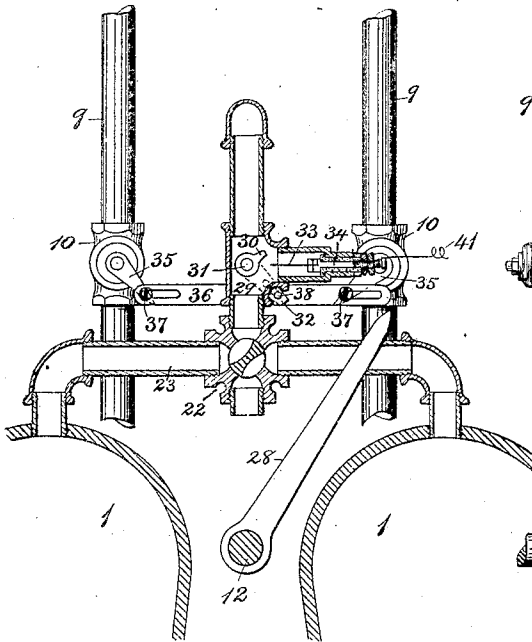


Fig. 5.

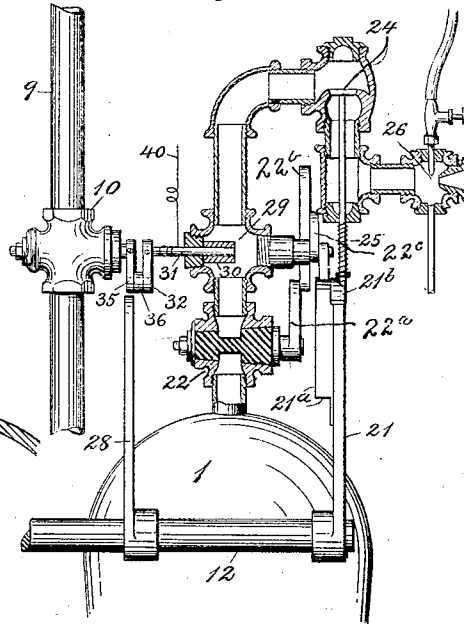
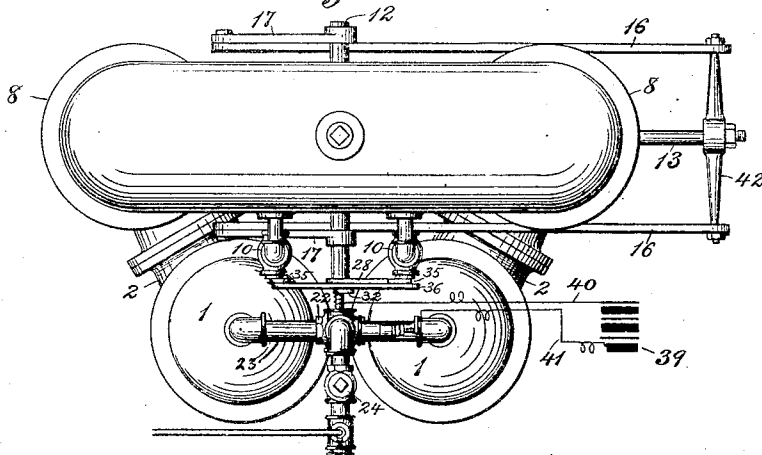


Fig. 6.



Witnesses:
 W. W. Kornee
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Inventor:
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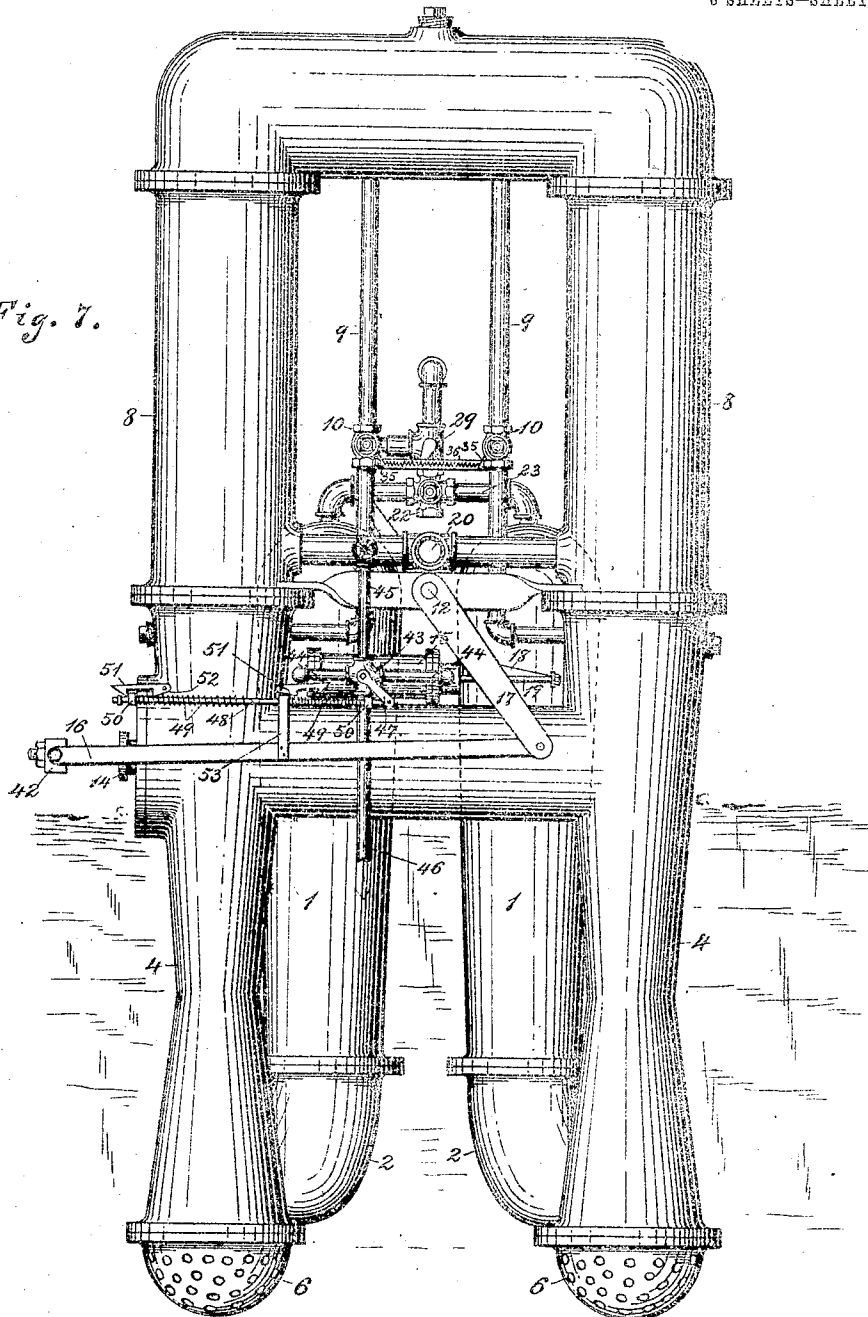
W. H. SMYTH.
 UTILIZING HEAT ENERGY.
 APPLICATION FILED FEB. 5, 1900.

1,037,071.

Patented Aug. 27, 1912.

3 SHEETS—SHEET 5.

Fig. 7.



Witnesses:
 W. A. McVee
 J. H. Miller

Inventor:
 William H. Smyth

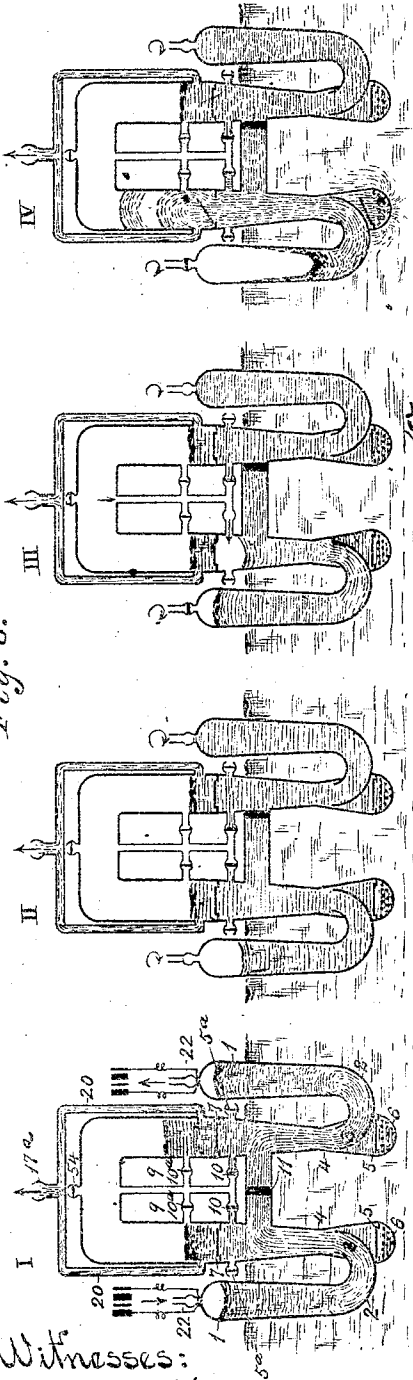
W. H. SMYTH.
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1,037,071.

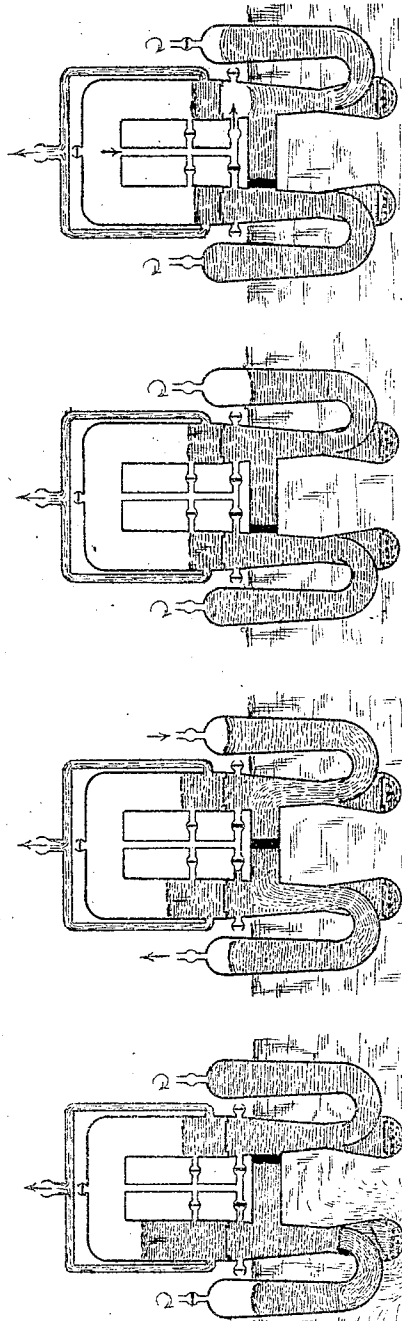
Patented Aug. 27, 1912.

8 SHEETS—SHEET 6.

Fig. 8.



Witnesses:
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 A. B. Bowers.



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 UTILIZING HEAT ENERGY.
 APPLICATION FILED FEB. 5, 1900.

1,087,071.

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8 SHEETS—SHEET 7.

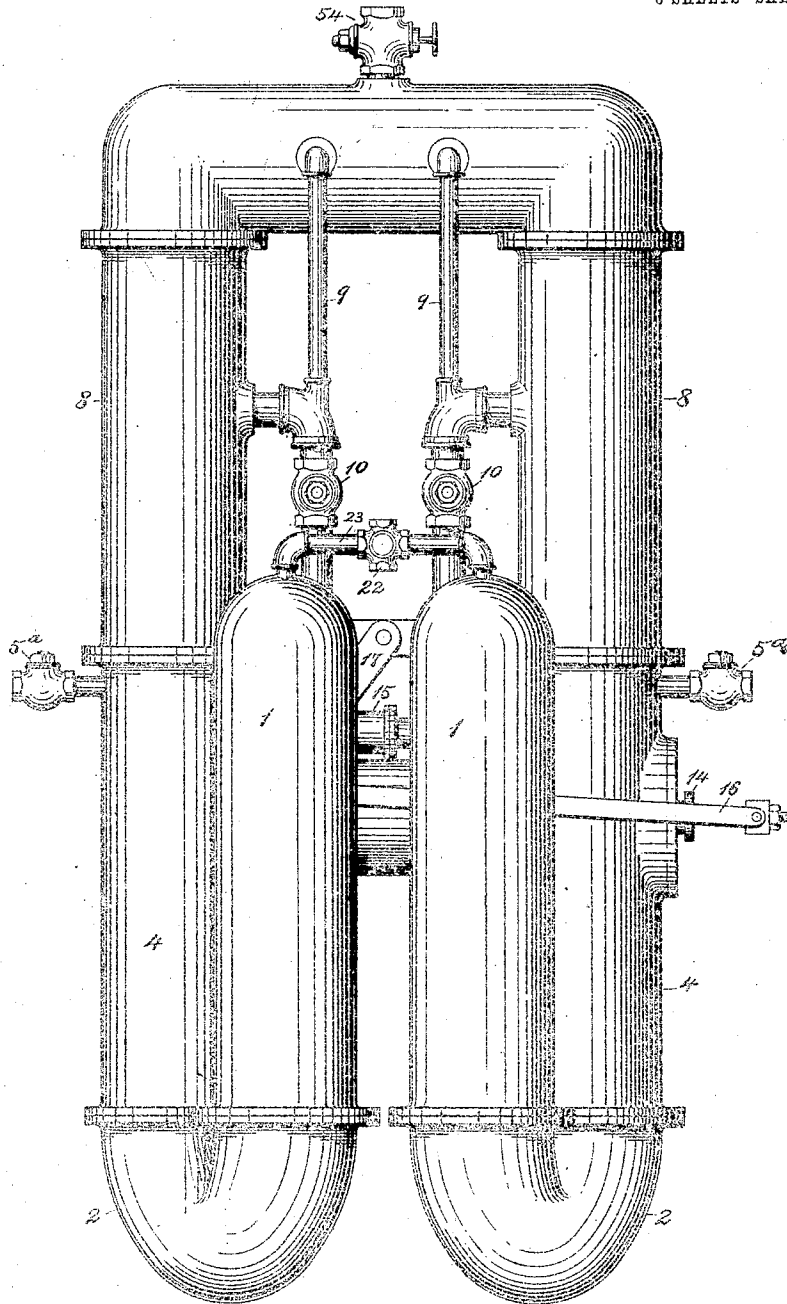


Fig. 2.

Witnesses:
 W. H. Home
 C. B. Bowers.

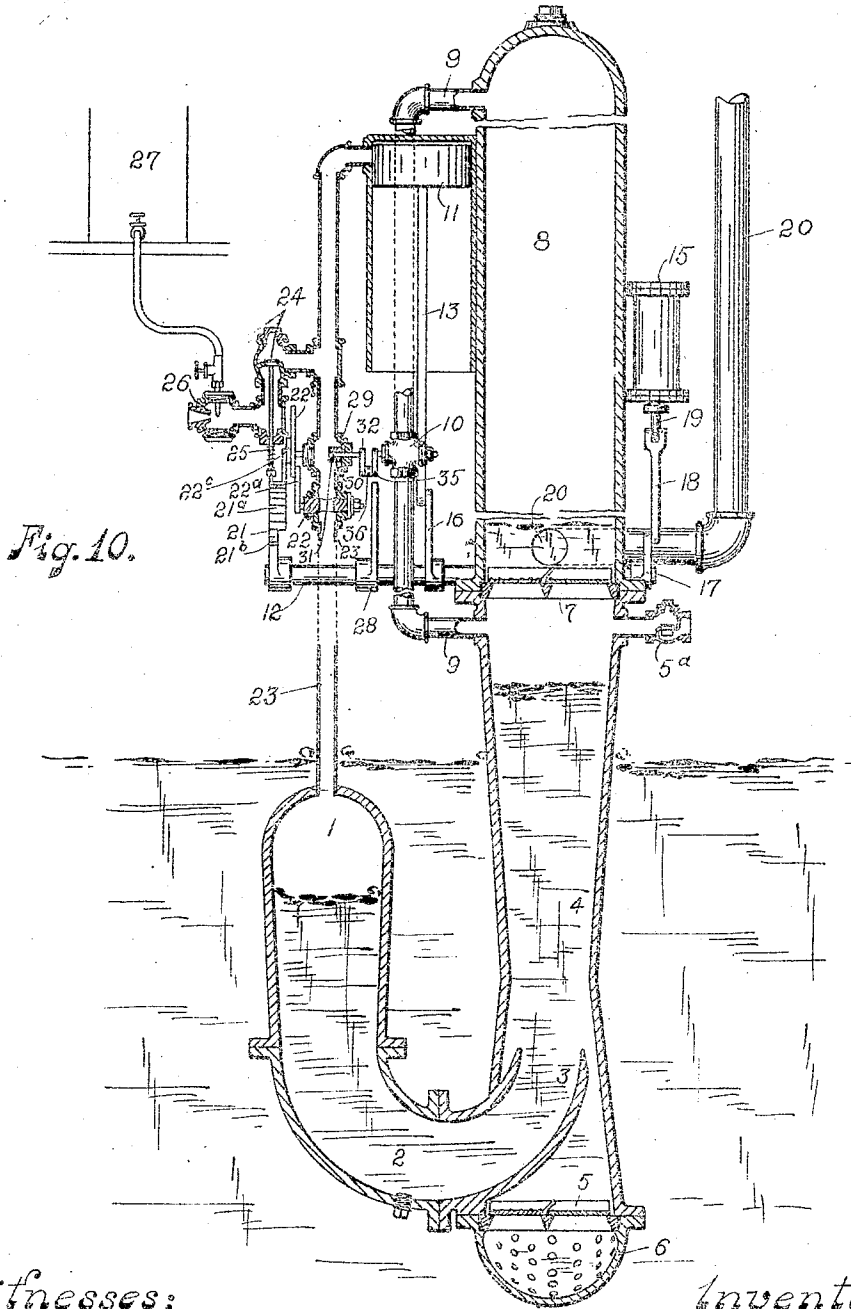
Inventor:
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APPLICATION FILED FEB. 5, 1900.

1,037,071.

Patented Aug. 27, 1912.

8 SHEETS—SHEET 8.



Witnesses:

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Jno. St. Miller

Inventor:

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UNITED STATES PATENT OFFICE.

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UTILIZING HEAT ENERGY.

1,037,071.

Specification of Letters Patent.

Patented Aug. 27, 1912.

Application filed February 5, 1900. Serial No. 4,123.

To all whom it may concern:

Be it known that I, WILLIAM H. SMYTH, mechanical engineer, citizen of the United States, residing at Berkeley, in the county of Alameda and State of California, have invented certain new and useful Improvements in Utilizing Heat Energy; and I do hereby declare the following to be a full, clear, and exact description of the same.

This invention relates to improved means for utilizing the expansive force of heat.

It also involves improvements in dynamics as embodied in heat motors; pneumatics as in air compressors and other gas apparatus; hydraulics as in pumps and other water devices.

In the devices and methods adopted heretofore, in utilizing heat as a source of power, an exceedingly large proportion of the heat value of fuels has been wastefully dissipated.

The present invention is a radical departure from the accepted practice having for its object the utilization of much of this heretofore wasted heat energy.

In general terms the objects of the invention are to effect high initial and especially low terminal temperatures of an inflamed charge, and to transform this wide range into an equivalent of useful work.

It aims to utilize a larger percentage of the fuel heat value, by providing conditions in harmony with the requirements for harnessing heat energy as displayed in explosive action.

Incidental to the main object of the invention and more fully stated, some of the objects are to provide conditions in the utilization of explosive energy to effect:— high initial temperature and pressure; low terminal temperature and pressure; expansion below atmosphere; high piston speed; immediate conversion of the fugitive energy of explosion into a stable form of practically available pressure; compression of charge prior to ignition; prior compression of charge in proportion to the resistance to be met by its expansion during flaming; compression automatically produced, regulated and controlled by the resistance to be overcome; expansion commensurate with varying initial temperatures and pressures; extreme mobility and responsiveness of piston to initial pressure; transmitting association between piston and power storing

or utilizing means providing for the resistance being applied with increasing intensity; complete scavenging of spent or used gases.

The present invention comprises means and apparatus whereby may be effected the art or process described and claimed in my copending application having Serial No. 4127 filed Feb. 5, 1900.

Referring to the accompanying drawings illustrating by way of example such means Figure 1 is a vertical section of a unit member. Fig. 2 is a vertical section at right angles to Fig. 1. Fig. 3 is a front elevation of a two cylinder or duplex apparatus. Fig. 4 is a detail on larger scale of the ignition and charge chamber. Fig. 5 is substantially the same as Fig. 4 at right angles thereto. Fig. 6 is a plan of Fig. 3. Fig. 7 is a rear elevation of Fig. 3. Fig. 8 is a series of diagrams illustrating cycle of device, Fig. 9, is a front view of modification of Fig. 3 to pump air. Fig. 10 same as Fig. 1, showing complete single cylinder apparatus.

Referring to the drawings, 1 is a cylinder (using this term conventionally) of any suitable form, which constitutes a charge, explosion or expansion or heat generating chamber. This cylinder is shown as prolonged into an easy curve 2, and the whole cylinder and bend is tapered to a nozzle outlet 3 directed upward. The nozzle 3 projects into and is surrounded by a casing or uptake 4 tapering in the opposite direction, from the neighborhood of the nozzle, to form an injector on a large scale. The lower part of chamber 1, the curve 2 and casing 4, also constitute a play pipe. At the lower end of casing 4 I have placed a suitable check valve 5 and strainer 6, and at the upper end of the casing another check valve 7. An air inlet valve 5^a is provided, opening into the explosion and expansion chamber or its extension. The structure thus described from its commencement, around the curve to the valve 7 comprises the charge and expansion chamber. Above the check valve 7 is placed an air-chamber 8. A pipe 9 connects the air chamber 8 with the casing 4 below the valve 7. A valve 10 is provided on the pipe 9 to control the flow of air or water from the chamber 8 into the casing 4. A suitable independent freely movable piston is located in chamber

1 and the play pipe extending therefrom. In the form of the device illustrated in Figs. 3 and 10, when in position and operation this piston may consist of a volume of fluid, preferably water. Means may be provided for changing or regulating the position of the surface of this piston in chamber 1. In the present instance as illustrated in Figs. 2 and 10, it is shown as piston 11, movable in a cylinder in communication with the chamber 1, so that the fluid piston, though entirely independent and free to move in response to heat pressure impulse, is also under control as to its position. Power connections are represented by a rock-shaft 12, with levers to operate piston 11 and the various valves for controlling the charges and effecting the ignition.

As illustrated in Fig. 2 the piston 11 is provided with a rod 13 which extends through a stuffing-box 14 in the side of the device. The rod 13 in this form is connected to a motor cylinder 15 by suitable connections such as links 16, levers 17, rock-shaft 12, link 18 and the piston rod 19 as illustrated in the forms either Fig. 10 or Fig. 7. A pipe 20 forms an outlet for the chamber or chambers 8. The chambers 8, if more than one, may be connected so as to form one air chamber of large size compared with the volume of the water-piston. In other words the piston should always be of relatively small size as compared with the resilient cushion of the air chamber. To operate in proper sequence the other working or controlling devices, I have provided the following described mechanism. A cam lever and tappet 21 is attached securely on shaft 12 having cam surfaces 21^a and 21^b. A plug valve 22 is common to and controls the flow of gases to or from the two explosion chambers. It is shown connected to the explosion chamber in Figs. 3, 4, 6 and 10, by pipe 23. A check valve 24, controlling the admission of the explosive charge, is provided with a spring actuated valve stem 25, as shown in Fig. 5. The operating lever or handle 22^a is secured to the plug or stem of the valve 22. A slotted link 22^b is loosely connected to 22^a and engages with one arm of a loosely pivoted bell-crank tappet lever 22^c. The other arm of the lever 22^c constitutes a tappet which engages with the part 21^a of the cam ended lever 21 to be operated thereby at each arc reciprocation of the cam end of the lever. This cam end serves the double function of reversing the four-way valve 22 and raising and keeping the valve 24 open, by engagement of the cam surfaces 21^a and 21^b with the stem connections of valves 22 and 24 respectively. This is shown in Figs. 5 and 10. A vaporizer or fuel mixer 26 is connected to a fuel reservoir 27 by a suitable valve controlled pipe, Figs. 1 and 10.

tappet arm 28 is secured to shaft 12 and is adapted to engage, and actuate tappet lever 35.

29 is an ignition chamber connected to the explosion chamber 1 by pipe 23 but separable therefrom by valve 22. A sparking device consisting of a metallic rocking wiper 30 is provided in the ignition chamber and in the path of the ingoing explosive gas, but removed from the path or splash of the water. This rocking wiper 30 is secured on shaft 31, which extends through the side of the ignition chamber and is provided with an operating lever 32, on its outer end. The other element of the sparking device consists of a flat spring 33 attached to an insulated rod 34 passing to the outside of the ignition chamber.

35 is a tappet lever secured upon the spindle of each of the valves 10.

36 is a link slotted at each end for the reception of the pin 37 on the tappet levers 35. The link 36 is provided with a pin 38 approximately midway of its length, which engages with the lever 32 of the spark wiper, Figs. 4 and 5. A battery or other suitable source of electrical energy is represented by 39.

40 and 41 are wires leading to the wiper and spring respectively. A yoke 42 is secured upon the piston-rod 13 and its ends are pivotally connected to the rods 16, Figs. 6 and 7.

A plug valve 43 is placed in a pipe 44 which connects the opposite ends of cylinder 15, see Fig. 7, and a pipe 45 connects the valve and the cylinder ends with a source of pressure through pipe 20. An exhaust pipe for the four-way valve 43 is shown at 46 which permits each end of cylinder 15 to exhaust alternately. An operating lever 47 is provided for valve 43, which is connected to a sliding tappet rod 48 having springs 49, and tappets 50. Levers 51, hinged at one end and each provided, at or near that end with a cam surface 52, are provided. The opposite end of each lever is provided with a wedge-shaped latch, to engage with tappets 50. A tappet 53 is secured upon one of the rods 16, to engage with and release the latch levers 51 alternately. All of which is clearly shown in Fig. 7.

In Fig. 10 is shown a complete operative unit or single cylinder device. All the working parts are in operative association. Thus, from this view, being partly in section, the construction of the device and the manner of operation will be clearly understood. The course of the explosive charge and the water can also clearly be followed from their sources to their outflow. In this view the main body of the explosion chamber 1 is shown entirely submerged, its small extension or ignition tube 23 alone appears

above water. In this view also, the charging cylinder is shown connected directly with the explosion or combustion chamber

1. The discharge pipe 20 leads from the air chamber 8 near the bottom thereof but sufficiently above the valve 7 to provide a water seal thereto. The air chamber 8 and the various pipes are shown broken to indicate that these pipes may be made longer or shorter to meet the requirements of the conditions under which the device is to be operated, and whether it is to be operated purely as a force pump or as partly "suction" and partly force.

The cycle of operation and the steps of the process as exemplified in the two-cylinder apparatus are illustrated in the diagrammatic series Fig. 8, in which for simplicity and clearness, the details of mechanical construction have been omitted. These diagrams will assist in making clear the operation of the described apparatus and a ready comprehension of the arrangement purpose and functions of the various mechanical details hereinbefore set out.

I. Shows the device taking an explosive charge in the left hand cylinder and discharging the spent gases from the other cylinder, the piston 11 being midway of its stroke, traveling to the right.

II. Shows the left hand cylinder with a fresh charge therein, and the right hand cylinder completely occupied by the water piston, the spent gases of the previous explosion having been driven out by the water.

III. Shows the charge in the left hand cylinder compressed to less than half of its original bulk by the admission of air pressure between the water piston and the check valve 7.

IV. Shows the expansion of the charge due to explosion and the travel of the water into the air chamber, preceded by the volume of air from beneath the valve 7. This diagram also shows the inrush of water through the lower check valve 5 induced by the injector form of the uptake pipe, gravity and atmospheric pressure.

V. Shows the left hand cylinder almost filled with water.

VI. Shows a condition similar to that of I, but reversed as to the direction of the flow of gases and the movement of the water piston.

VII. Shows a charge in the right hand cylinder. The left hand cylinder in this case being completely scavenged of spent gases of the previous explosion.

VIII. Shows the explosive charge in the right hand cylinder ready to be ignited, thus completing the cycle.

When operated as an air compressor the valves 5 and 7 are closed. The valves 10 are operated together alternately on their appropriate sides. The valves 5^a are operated at

suitable times to satisfy the vacuum resulting from the explosion of the charge taking the place of, and performing the functions for the inlet of air which the valves 5 do for water.

In the foregoing brief description of the diagrams of Fig. 8, emphasis has not been laid on the operation and function of valve 5^a in the cycle and process, as the extent of its use is a matter, largely within the discretion and judgment of the operator and dependent on the nature of the work to be done in relation to the head to which the water is to be forced. It should in practically all cases be used to insure best economy. Its use enables atmospheric pressure to be employed to displace the water in the air chamber to the level of the discharge opening; and thereafter supply air absorbed by the water under pressure in the air chamber, and, in addition thereto, it permits the excess of atmospheric pressure over that required to force water into chamber 1 to be employed in lightening the column and so reducing the resistance to be overcome by the explosive charge.

With the foregoing description of the mechanical construction of the apparatus and its cycle, its mechanical operation and the steps of the process carried into effect thereby, will be simple and apparent to those skilled in kindred arts. The following brief description therefore will suffice.

Motion is imparted to the piston 11 by the operation of the small engine 15 and by the described or other suitable mechanism, the various valves and other moving parts are worked in proper sequence. The action of the piston 11 causes the fluid piston to move in the chamber 1 and make room for the charge in this chamber. The valve 22 being properly disposed, the action of piston 11 and the travel of the water piston causes successive inflow of explosive charges and expulsion or scavenging of the spent gases. Assuming as is shown in Figs. 1 and 10, the explosive charge to be in chamber 1, the water piston will extend nearly to valve 7, separated from the water and pressure in the air chamber 8 by the valve 7 and by whatever air has been permitted access through valve 5^a. At this point valve 10 (or valves 10 and 10^a of diagram 1 Fig. 8) is opened by engagement of tappet arm 28 with the tappet lever 35 and the compressed air, or water under pressure (or air and water) from the air chamber consequently flows beneath the valve 7. Thus the water piston is forced back against the charge, compressing it to the pressure of the air chamber, which is, of course, that of the head. The charge is prevented from escaping by the closing of valve 24. Thus the water piston while free to respond to the explosive impulse, is under control and moves

able at will. As the air pressure increases in the air chamber by reason of the increased resistance of the work of forcing the water column or other resistance against which air is applied, so also does the compression of the charge increase and consequently the initial temperature and pressure of explosion of the compressed charge and also the relative and absolute expansion of the exploding charge.

The charge in the combustion chamber 1 and the air chamber 8 are now under like pressure, which is as has been shown, that due and corresponding to the head to which the liquid is being forced. It may be noticed also that the ignition chamber 29 with its sparkler is in free communication with the explosion chamber. Ignition now takes place by the engagement of the tappet pin 37 with the end of the slot in the link 36 thus rocking the wiper 30 past the spring 33 by the connection of the link 36 to wiper arm 32, see Figs. 4 and 5. The slot in 36 permits the valve 10 to close immediately the wiper arm 32 passes out of engagement with the spring 33. By the explosive expansion of the gases, in cylinder 1, the water piston is driven with great energy and speed through the nozzle 3. The entire water piston may be driven out of the expansion chamber through valve 7. The size of the expansion chamber is a matter within the discretion of the builder, having in mind the circumstances under which the apparatus is to work. It may be so proportioned to the discharge, that the expansion may extend so far as to not only drive out the water piston completely, but to permit a portion of the expanded charge to pass into the air chamber during expansion, together with air admitted through the valve 5^a.

The spaces vacated in chamber 1 and extension 4 are filled instantly (practically simultaneously with the expansion) by air through valve 5^a, if this is desired and the valve properly proportioned, or with any desired proportion of air and water. That portion of the air admixed with the spent gases in the part 4 of the expansion chamber will be cut off and separated from that in the charge chamber 1 by the incoming water through valve 5. The portion of air and gas in the extension 4 is thus trapped beneath valve 7, ready to be driven into the air chamber at the next operation of the water piston. That portion of the spent gases and air in chamber 1 will pass out as exhaust. The lengths of the charge chamber 1 and its extension 4 may be so proportioned to each other that, as shown in Fig. 1, the extension may facilitate the scavenging of the spent gases and also the introduction of air beneath valve 7 by the gravity of the water piston.

Owing to the poised or balanced condition

and the small mass of the water piston, the mobility and responsiveness is extremely great. It offers practically inappreciable resistance to being started into motion and high velocity. It is practically a liquid projectile. Its inertia due to weight and speed causes it to travel, under practical conditions, a distance comparable to the expansion of the same compressed explosive charge exploding and expanding freely in the atmosphere. Thus the terminal pressure in the expansion chamber after the drive of the piston, always runs in practice below that of atmosphere. A good vacuum is produced and the economic results accruing thereto. Vacuum, however, in whole or part, is not essential to its operation. When used as illustrated in the various figures, with the normal level of the water piston in the explosion chamber 1 at or below the outside level of the water, vacuum may be dispensed with entirely, (though this is seldom advisable) the gravity of the water supplies the energy required of the atmospheric pressure of vacuum. But even under these circumstances the benefits and economies of vacuum are available with this apparatus. When the device is operated under conditions where gravity can supply the water to the working level in the charge chamber, vacuum is utilized to carry and force atmospheric air into the expansion chamber and so beneath the submergence head. In fact vacuum is in a sense provided as atmospheric air and pressure is permitted free and unrestricted entrance to the expansion chamber during the time that the expansion pressure runs below atmospheric pressure. Vacuum is applicable in low lifts; this is controllable through valve 5^a more or less in accordance with the lift.

The means and method employed for compressing the charge, bring about a somewhat paradoxical condition, viz, that the initial pressure of explosion is exerted against a minimum resistance. This action is due partly to the lowering of the pressure in the air chamber, immediately prior to explosion, below the static pressure of the liquid column and partly to employing the head to compress the charge before ignition.

The necessary conditions to ideal economy in explosive engines are thus presented in the invention herein set forth, and in a peculiarly complete manner. The piston speed is mechanically unrestrained. The range of expansion is also unhampered, and is proportional to the resistance. The explosive expansion acts against a minimum initial pressure and with prior compression of the resilient charge equal to the pressure to be met by the exceedingly enhanced pressure due to igniting.

As earlier stated, the invention is broader

in scope than its application to raising or moving water; it is equally applicable to raising or moving or overcoming any other form of mechanical resistance. The apparatus described is equally available for handling or compressing gaseous fluids as for moving liquid fluids.

The whole device may be located at a point distant from that at which the work is being utilized. The compressed air, water or impulse may be carried by pipes to suitable devices at the bottom of a shaft or other distant location.

The displacement of the spent gases by liquid piston or induction of fresh charges thereby, is not of the essence of the invention; these functions may be performed in many other ways. One such is illustrated in Fig. 10.

The injector form of construction may not always be desirable nor is it essential. The U or curved shape of connection between the cylinder and uptake is only one convenient form. The uptake may concentrically or otherwise surround the cylinder, or be entirely omitted. The means shown for controlling the fluid piston is not essential, in practice the gravity of the water piston has been used to charge and exhaust the gases, though the means shown have been found positive and reliable.

The work required of the engine is so insignificant that, in many instances, it will be found advantageous to operate a number of explosion chambers, with an engine and valve mechanism common to all, as shown in the various views in which the engine serves for two explosion chambers. In some instances where a source of small power is available in any of the ordinary forms, it may be used with economy to operate the charging and valve admission in a plant of considerable proportions. A wind mill or even hand-power may be made available to supply explosive fuel, and pump large volumes of water rapidly. These supplementary motor devices serve only to supply the explosive mixture at atmospheric pressure, which function, of course, requires but little power.

The apparatus for effecting my said invention may be stationary or portable; it may be employed for locomotion or propulsion in any of its various adaptabilities and under its dynamic, pneumatic, or hydraulic categories.

An illustration of another embodiment of the invention involved in the present disclosure, differing in appearance and construction and details, is presented in a companion application for improvement in utilizing heat energy filed Feb. 5, 1900, Serial No. 4129.

As the invention herein described is a complete departure in the arts referred to, I

claim it broadly, unrestricted to the particular forms shown, the particular proportion or arrangement of parts or details of construction.

What I claim is:—

1. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing therinto successive volumes of fluid fuel and air and commingling them to form a succession of explosive charges, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of an unconnected body interposed between the charges and the air.

2. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing therinto successive charges of fuel material, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of a fluid body interposed between the charges and the air.

3. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing therinto successive charges of fuel material, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of a fluid body interposed between the charges and the air, and means adapted to move the body through a stroke of definite length simultaneously with the introduction of the charges.

4. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing therinto successive charges of fuel material, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of a fluid body interposed between the charges and the air and means adapted to regulate the position of the body.

5. In an apparatus of the named type, the combination with a chamber, of means for introducing therinto successive charges of fuel material, an igniter, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of a fluid body interposed between the charges and the air and means adapted to compress the charges prior to ignition.

6. In an apparatus of the named type, the combination with two chambers having an igniter, of means adapted to introduce there-

into successive charges of fuel material, an air chamber suitably arranged and communicating with the first mentioned chambers in such manner that the air therein opposes the expansion of the ignited charges through the intervention of a fluid body interposed between the charges and the air.

7. In an apparatus of the named type, the combination with two chambers having an igniter, of means for introducing thereto successive charges of fuel material, an air chamber suitably arranged and communicating with the first mentioned chambers in such manner that the air therein opposes the expansion of the ignited charges through the intervention of a fluid body interposed between the charges and the air and means adapted to compress the charges prior to ignition.

8. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing thereto successive volumes of fluid fuel and air and commingling them to form a succession of explosive charges, an air chamber suitably arranged and communicating with the first mentioned chamber, means between these two chambers for permitting and directing the discharge of the expanding gases against the air in the air chamber whereby the air opposes the expansion and stores up the energy of successive explosions through the intervention of an unconnected body interposed between the charges and the air.

9. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing thereto successive charges of fuel material, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of a fluid body interposed between the charges and the air, and means adapted to permit and direct the flow of fluid from the air chamber to the first mentioned chamber.

10. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing thereto successive charges of fuel material, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of a fluid body interposed between the charges and the air, a foot or entrance valve for liquid, and a discharge pipe.

11. An apparatus of the named type comprising a chamber having an igniter, means for introducing thereto successive charges of fuel material, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the

air therein opposes the expansion of the ignited charges through the intervention of a fluid body interposed between the charges and the air and means adapted to permit and direct flow of fluid from the air chamber to the first mentioned chamber and also to the exterior of the apparatus.

12. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing thereto successive charges of fuel material, a valved passage and an air chamber suitably arranged and communicating with the first mentioned chamber by the valved passage whereby the air therein opposes the expansion of the ignited charges through the intervention of a fluid body interposed between the charges and the air.

13. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing thereto successive charges of fuel material, a valved passage, an air chamber suitably arranged and communicating with the first mentioned chamber by the valved passage whereby the air therein opposes the expansion of the ignited charges through the intervention of a fluid body interposed between the charges and the air, and a passby or passage adapted to permit and direct flow of fluid from the air chamber to the first mentioned chamber.

14. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing thereto successive charges of fuel material, a valved passage, an air chamber suitably arranged and communicating with the first mentioned chamber by the valved passage whereby the air therein opposes the expansion of the ignited charges through the intervention of a fluid body interposed between the charges and the air, and pipes or passages adapted to permit and direct the flow of fluid from the air chamber to the first mentioned chamber and also to the exterior.

15. In an apparatus of the named type, the combination with a chamber having an igniter and a check valve opening freely inward to permit the inflow of atmospheric air, of means for introducing into the chamber successive volumes of fluid fuel and commingling it with the air therein to form a succession of explosive charges, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of an unconnected body interposed between the charges and the air.

16. In an apparatus of the named type, the combination with a chamber having an igniter and check valve opening freely inward to permit the inflow of atmospheric air, of means for introducing into the chamber successive charges of fuel material, an

air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of a fluid body interposed between the charges and the air.

17. In an apparatus of the named type, the combination with a chamber having an igniter and a check valve opening freely inward to permit the inflow of atmospheric air, of means for introducing into the chamber successive volumes of fluid fuel and commingling it with the air therein to form a succession of explosive charges, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of an unconnected body interposed between the charge and the air prior to ignition.

18. In an apparatus of the named type, the combination with a chamber having an igniter and a check valve opening freely inward to permit the inflow of atmospheric air, of means for introducing into the chamber successive charges of fuel material, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of a fluid body interposed between the charges and the air and means adapted to compress the charges prior to ignition.

19. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing thereinto successive charges of fuel material, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of a fluid body interposed between the charges and the air, a foot valve for liquid in the first mentioned chamber, a discharge pipe, and means adapted to compress the charges prior to ignition.

20. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing thereinto successive charges of fuel material, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of a fluid body interposed between the charges and the air, valves in the first mentioned chamber for the entrance and exit of liquid, and means adapted to compress the charges prior to ignition.

21. In an apparatus of the named type, the combination with a chamber having an igniter, means for introducing thereinto successive charges of fuel material, an air

chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of a fluid body interposed between the charges and the air, valves in the first mentioned chamber for the entrance and exit of liquid, means adapted to compress the charges prior to ignition, and a check valve suitably placed to admit atmospheric air into the first mentioned chamber.

22. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing thereinto successive charges of fuel material, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of a fluid body interposed between the charges and air, valves in the first mentioned chamber for the entrance and exit of liquid, and means adapted to compress the charges, prior to ignition, by the pressure in the air chamber.

23. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing thereinto successive charges of fuel material, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of a fluid body interposed between the charges and air, valves in the first mentioned chamber for the entrance and exit of liquid, a discharge pipe communicating with the air chamber, and means adapted to compress the charges, prior to ignition, by the pressure in the discharge pipe.

24. An apparatus of the named type, comprising two chambers and means for admitting air thereinto, pumping means adapted to introduce fluid fuel into said chambers and commingle it with the air therein to form a succession of explosive charges, means to ignite the same, means to compress the charges prior to ignition, an air chamber connected and communicating with the first mentioned chambers in such manner that the air therein opposes the expansion of the ignited charges through the intervention of an unconnected body interposed between the charges and the air, and a valve controlled exit for fluid.

25. An apparatus of the named type, comprising two chambers, means for admitting air thereinto, means adapted to introduce fluid fuel into said chambers alternately and commingle it with the air therein to form a succession of explosive charges, means to ignite the same, means to compress the charges prior to ignition, an air chamber

connected and communicating with the first mentioned chambers in such manner that the air therein opposes the expansion of the ignited charges through the intervention of a fluid body interposed between the charges and the air, and valve controlled openings for the entrance and exit of liquid.

26. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing successive volumes of fluid fuel to form therein a succession of explosive charges, an elastic cushion suitably arranged and adapted to resist and store up the energy of successive operations, through the intervention of an unconnected piston introduced between the cushion and charges.

27. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing successive volumes of fluid fuel to form therein a succession of explosive charges, an air chamber suitably arranged and adapted to resist and store up the energy of successive operations through the intervention of an unconnected piston introduced between the air chamber and charges.

28. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing successive volumes of fluid fuel to form therein a succession of explosive charges, an air chamber connected with the first mentioned chamber by a passage and adapted to resist the expansion of the charges through a fluid body interposed between the charges and air chamber, and means adapted to move the fluid body through a stroke of definite length simultaneously with the introduction of the charges.

29. In an apparatus of the named type, the combination with a multiplicity of chambers having igniters, of means for introducing successive volumes of fluid fuel to form a succession of explosive charges in each chamber, an air chamber connected with the first mentioned chambers by passages and arranged and adapted to resist the expansion of the charges through a fluid body interposed between the charges and air chamber, and means adapted to regulate the position of the fluid body.

30. In an apparatus of the named type, the combination with two chambers each provided with an igniter, of means for introducing successive volumes of fluid fuel to form a succession of explosive charges in each chamber, an air chamber connected with the first mentioned chambers by passages and means for introducing fluid into the passages between the air chamber and the first mentioned chambers and means adapted to compress the charges in each of the first mentioned chambers alternately through the intervention of the fluid in the passages.

31. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing successive volumes of fluid fuel to form a succession of explosive charges, an elastic cushion suitably arranged and adapted to resist and store up the energy of successive operations through the intervention of an unconnected piston introduced between the cushion and charge, and means adapted to compress the charges prior to ignition.

32. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing fluid fuel to form an explosive charge, an air chamber suitably arranged and adapted to resist the expansion of the charge through the intervention of an unconnected piston introduced between the air chamber and charge and a valve to control the flow of air from the air chamber to the first mentioned chamber.

33. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing fluid fuel to form an explosive charge, an air chamber suitably arranged and adapted to resist the expansion of the charge through the intervention of an unconnected piston introduced between the air chamber and charge, and suitable valves to control the flow of fluid from the air chamber to the first mentioned chamber and also to the exterior.

34. In an apparatus of the named type, the combination with a heat generating chamber, of a valved passage, an air chamber communicating with the first chamber by the valved passage, a free piston introduced between the chambers, a passby passage connecting the heat generating chamber and the air chamber and a valve to control the passby.

35. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing successive volumes of fluid fuel to form a succession of explosive charges, an unconnected piston in the chamber and means adapted to move the piston through a stroke of definite length simultaneously with the introduction of the charges.

36. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing successive volumes of fluid fuel to form a succession of explosive charges, a fluid piston introduced in advance of the charges and an inwardly opening check valve to the chamber for the admission of air.

37. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing successive volumes of fluid fuel to form a succession of explosive charges therein, a fluid piston introduced in advance of the charges, and means to regulate the position of the fluid

piston and means to compress the charges prior to ignition.

38. In an apparatus of the named type, the combination with a chamber having an igniter, of means to control the inlet of successive volumes of fuel and air and commingle them and effect a succession of explosive charges, a valve for the outflow of spent gases, an extension of the chamber with a non-return valve, a check valve opening inwardly into said chamber and extension for the admission of fluid and means to compress the charges prior to ignition.

39. In an apparatus of the named type, the combination with a chamber having an igniter, of means to control the inlet of successive volumes of fuel and air and commingle them and effect a succession of explosive charges, a valve for the outflow of spent gases, an extension to the chamber provided with a non-return valve and means to introduce a body of liquid in advance of each explosive charge and means to compress the charges prior to ignition.

40. In an apparatus of the named type, the combination with a chamber having an igniter, of means to control the inlet of successive volumes of fuel and air and commingle them and effect a succession of explosive charges and a valve for the outflow of spent gases, an extension to the chamber provided with a non-return valve, an inlet to introduce liquid in advance of each explosive charge and a check valve opening freely inward to atmospheric pressure for the admission of air into the chamber.

41. In an apparatus of the type named, the combination with a chamber having an igniter, of means to control the inlet of successive volumes of fuel and air and commingle them and effect a succession of explosive charges, a valve for the outflow of spent gases, an air chamber connected with the first mentioned chamber by an extension provided with a non-return valve, an inlet valve to introduce a body of liquid in advance of each explosive impulse and means to compress the charge prior to ignition.

42. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing fluid fuel to form an explosive charge, an extension to the chamber provided with a non-return valve, means to introduce liquid in advance of the explosive charge, another substantial similar apparatus and connecting devices between said apparatuses to control them whereby they coact and operate alternately.

43. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing fluid fuel to form an explosive charge, an extension to the chamber provided with a non-return valve, an inlet valve to introduce liquid in advance of each explosive charge, an air in-

let valve opening freely to atmospheric pressure for the admission of air into the chamber; another substantially similar apparatus and connecting devices between said apparatuses to control them whereby they coact and operate alternately.

44. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing fluid fuel to form an explosive charge, an air chamber connected with the first mentioned chamber by an extension forming an uptake provided with a non-return valve, an inlet valve to introduce a body of liquid in advance of the explosive charge; another substantially similar apparatus and connecting devices between said apparatuses to control them whereby they coact and operate alternately, and means to compress the charges prior to ignition.

45. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing fuel to form an explosive charge, an air chamber connected with the first mentioned chamber by an extension provided with a non-return valve and an inlet valve to introduce liquid in advance of the explosive charge, a check valve opening freely inward to atmospheric pressure for the admission of air into the first mentioned chamber; another substantially similar apparatus, connecting devices between said apparatuses to control them whereby they coact and operate alternately and means to compress the charges prior to ignition.

46. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing successive volumes of fluid fuel to form a succession of explosive charges, an air chamber connected with the first mentioned chamber and adapted to resist and store up the energy of successive operations through the intervention of a body of liquid interposed between the charge and air in the air chamber and means adapted to compress the charge by the pressure of air in the air chamber.

47. In an apparatus of the named type, the combination with a chamber having an igniter, of means for introducing successive volumes of fluid fuel to form a succession of explosive charges, an air chamber connected with the first mentioned chamber and adapted to resist and store up the energy of successive operations through the intervention of a body of liquid interposed between the charge and air in the air chamber, a check valve opening freely inward to atmospheric pressure for the admission of air into the first mentioned chamber and means adapted to compress the charges by the pressure of air in the air chamber.

48. An apparatus of the named type, 130

comprising a chamber having an igniter, means for introducing fuel to form an explosive charge therein, an air chamber with a discharge and connected with the first mentioned chamber and provided with a non-return valve between the chambers, a valve opening to the first mentioned chamber to introduce liquid, the air chamber suitably arranged and adapted to oppose and store up the energy of successive operations through the intervention of the introduced liquid, a passby passage between the two chambers suitably arranged to effect the compression of the charge prior to ignition by the pressure in the air chamber.

49. An apparatus of the named type, comprising a chamber having an igniter, means for introducing fuel to form an explosive charge therein, an air chamber with a discharge and connected with the first mentioned chamber by a pipe provided with a non-return valve, a valve opening to the first mentioned chamber to introduce liquid, the air chamber suitably arranged and adapted to oppose and store up the energy of successive operations through the intervention of the introduced liquid, a valve controlled passby passage between the two chambers suitably arranged to effect the compression of the charge prior to ignition by pressure in the air chamber.

50. An apparatus of the named type, comprising a chamber having an igniter, means for introducing fuel to form an explosive charge therein, an air chamber with a discharge and connected with the first mentioned chamber and provided with a non-return valve between the chambers, a valve opening to the first mentioned chamber to introduce liquid, the air chamber suitably arranged and adapted to oppose and store up the energy of successive operations through the intervention of the introduced liquid, a check-valve opening freely inward to atmospheric pressure for the admission of air into the first mentioned chamber, a passby passage between the two chambers suitably arranged to effect the compression of the charge prior to ignition by pressure in the air chamber.

51. An apparatus of the named type, comprising a chamber having an igniter, means for introducing fuel to form an explosive charge therein, an air chamber with a discharge and connected with the first mentioned chamber and provided with a non-return valve between the chambers, a valve opening to the first mentioned chamber to introduce liquid, the air chamber suitably arranged and adapted to oppose and store up the energy of successive operations through the intervention of the introduced liquid, a check-valve opening freely inward to atmospheric pressure for the admission of air into the first mentioned cham-

ber, a valve controlled passby passage between the two chambers suitably arranged to effect the compression of the charge prior to ignition by pressure in the air chamber.

52. In an apparatus of the named type, a chamber having an igniter, means for introducing fuel to form an explosive charge, an air chamber connected with the first mentioned chamber and adapted to resist and store up the energy of successive operations through the intervention of liquid interposed between the charge and air chamber, means adapted to compress the charge by the pressure of air in the air chamber, another substantially similar apparatus combined with connecting devices between said apparatuses to control them whereby they coact and operate alternately.

53. In an apparatus of the named type, a chamber having an igniter, means for introducing fuel to form an explosive charge, an air chamber connected with the first mentioned chamber and adapted to resist and store up the energy of successive operations through the intervention of liquid interposed between the charge and air in the air chamber, a check valve opening freely inward to atmospheric pressure for the admission of air into the first mentioned chamber, means adapted to compress the charge by the pressure of air in the air chamber, and another substantially similar apparatus combined with connecting devices between said apparatuses to control them whereby they coact and operate alternately.

54. An apparatus of the named type, comprising a chamber having an igniter, means for introducing fuel to form an explosive charge therein, an air chamber with a discharge and connected with the first mentioned chamber and provided with a non-return valve between the chambers, a valve opening to the first mentioned chamber to introduce liquid, the air chamber suitably arranged and adapted to oppose and store up the energy of successive operations through the intervention of the introduced liquid, a passby passage between the two chambers suitably arranged to effect the compression of the charge prior to ignition by pressure in the air chamber, another substantially similar apparatus, connecting devices between said apparatuses to control them whereby they coact and operate alternately.

55. An apparatus of the named type, comprising a chamber having an igniter, means for introducing fuel to form an explosive charge therein, an air chamber with a discharge and connected with the first mentioned chamber and provided with a non-return valve between the chambers, a valve opening to the first mentioned chamber to introduce liquid, the air chamber suitably arranged and adapted to oppose and store up the en-

ergy of successive operations through the intervention of the introduced liquid, a valve controlled passby between the two chambers suitably arranged to effect the compression of the charge prior to ignition by the pressure in the air chamber, another substantially similar apparatus and connecting devices between said apparatuses to control them whereby they coact and operate alternately.

56. An apparatus of the named type, comprising a chamber having an igniter, means for introducing fuel to form an explosive charge therein, an air chamber with a discharge and connected with the first mentioned chamber and provided with a non-return valve between the chambers, a valve opening to the first mentioned chamber to introduce liquid, the air chamber suitably arranged and adapted to oppose and store up the energy of successive operations through the intervention of the introduced liquid, a check valve opening freely inward to atmospheric pressure for the admission of air into the first mentioned chamber, a passby passage between the two chambers suitably arranged to effect the compression of the charge, prior to ignition, by pressure in the air chamber, another substantially similar apparatus and connecting devices between said apparatuses to control them whereby they coact and operate alternately.

57. An apparatus of the named type, comprising a chamber having an igniter, means for introducing fuel to form an explosive charge therein, an air chamber with a discharge and connected with the first mentioned chamber and provided with a non-return valve between the chambers, a valve opening to the first mentioned chamber to introduce liquid, the air chamber suitably arranged and adapted to oppose and store up the energy of successive operations through the intervention of the introduced liquid, a check valve opening freely inward to atmospheric pressure for the admission of air into the first mentioned chamber, a valve controlled passby passage between the two chambers suitably arranged to effect the compression of the charge prior to ignition by pressure in the air chamber, another substantially similar apparatus and connecting devices between said apparatuses to control them whereby they coact and operate alternately.

58. In an apparatus of the named type, a combustion chamber explosive charge forming and regulating devices connected therewith, an air chamber and connections whereby a body of liquid is moved against the resistance of air in the air chamber by the direct pressure of inflaming gases, a valve controlled passage to the air chamber from the first mentioned chamber, and a valve

controlled passage from the air chamber to the first mentioned chamber.

59. In an apparatus of the named type, a combustion chamber, explosive charge forming and regulating devices connected therewith, an air chamber and connections whereby a body of liquid is moved against the resistance of air in the air chamber by the direct pressure of inflaming gases, means adapted to compress the charge prior to ignition by the pressure of air in the air chamber.

60. In an apparatus of the named type means for moving a disconnected body of material by the direct pressure of inflaming gaseous fuel to store energy, and means for effecting the compression of the gaseous fuel prior to ignition.

61. In an apparatus of the named type means for moving a body of liquid against the resistance of a resilient cushion by the direct pressure of inflaming gases, and means for effecting the compression of the gases prior to ignition.

62. Means comprising an expansion chamber, a play pipe, an inlet and a discharge, whereby liquid is moved in one direction by the expansion of a compressed expansible charge, and in the other direction to cause the compression of a fresh charge.

63. In an apparatus of the named type means, comprising an expansion chamber whereby a body of liquid is moved against the resistance of a resilient cushion by the direct pressure of inflaming gases, and a pump to introduce successive charges into the chamber.

64. In an apparatus of the named type means, comprising an expansion chamber whereby a body of liquid is moved by the direct pressure of inflaming gases, means for introducing atmospheric air into the chamber during the movement of the liquid and means adapted to effect the compression of the gases prior to ignition.

65. In an apparatus of the named type means, comprising an expansion chamber and an air chamber, whereby a body of liquid is moved against the resistance of air pressure in the air chamber by the direct pressure of ignited gases in the expansion chamber, the apparatus being provided with a discharge pipe for liquid connected with the air chamber in such manner that liquid in the discharge pipe is sustained by air in the air chamber, and means to reduce the air pressure in the air chamber below the pressure due to the liquid in the discharge pipe immediately preceding the ignition of the charge.

66. In an apparatus for storing energy of the named type, the combination of an expansion chamber, means for introducing therinto a gaseous charge and igniting the

same; means for introducing in advance of the charge, a body of liquid, and a discharge pipe for liquid communicating with the charge containing chamber in such manner that the pressure of the liquid in the discharge pipe is resisted by the charge, whereby the charge is compressed prior to ignition.

67. In an apparatus of the named type means, comprising an expansion chamber for ignited charges and an air chamber, whereby a body of liquid is moved against the resistance of air pressure in the air chamber, by direct pressure of ignited gases in the expansion chamber, the apparatus being provided with a discharge pipe for liquid connected with the air chamber in such manner that liquid in the discharge pipe is sustained by the air in the air chamber, means to reduce the air pressure in the air chamber below the pressure due to the liquid in the discharge pipe immediately preceding the ignition of the charge, and means adapted to effect the compression of the charge by pressure in the air chamber prior to ignition.

68. In an apparatus of the named type means, comprising an expansion chamber for ignited charges and an air chamber, whereby a succession of liquid bodies are moved against the resistance of air pressure in the air chamber by direct pressure of a succession of ignited charges in the expansion chamber, the apparatus being provided with a variable pressure device connected with the air chamber in such manner that the pressure therein is sustained by air in the air chamber; and means adapted to effect varying compression of successive charges by the variable pressure in the air chamber prior to ignition.

69. In an apparatus of the named type means, comprising an expansion chamber and an air chamber, whereby liquid is moved against the resistance of air pressure in the air chamber by direct pressure of a succession of ignited charges in the expansion chamber, and means for introducing air into the air chamber simultaneously with the liquid.

70. In an apparatus of the named type means, comprising an expansion chamber, and a discharge pipe whereby liquid is moved against the resistance of liquid in the discharge pipe by direct pressure of a succession of ignited charges in the expansion chamber, and means for introducing atmospheric air into the discharge pipe simultaneously with the liquid.

71. In an apparatus of the named type means, comprising an expansion chamber and an air chamber, whereby a body of liquid is moved against the resistance of air pressure in the air chamber by direct pres-

sure of ignited charges in the expansion chamber, a casing connected with the expansion chamber and a piston operating therein, whereby the position of the liquid in the expansion chamber is controlled.

72. In apparatus of the named type means, comprising an expansion chamber and an air chamber, whereby a body of liquid is moved against the resistance of air pressure in the air chamber through a valve controlled passage by the direct pressure of ignited charges in the expansion chamber, a casing connected with the expansion chamber and a piston therein, whereby the position of the liquid in the expansion chamber is controlled, another substantially similar apparatus, and connecting devices between said apparatus whereby they coact and operate alternately.

73. In an apparatus of the named type, the combination of an expansion chamber, an air chamber, a valve controlled passage therebetween explosive charge forming and regulating devices, and an igniter connected with the expansion chamber, whereby a body of liquid is moved against the resistance of air in the air chamber through the valve controlled passage by the direct pressure of inflaming gases; a casing connected with the expansion chamber and a piston therein, whereby the position of the liquid in the expansion chamber is controlled, and automatic means adapted to control the operation of the igniter, the charge regulating devices and the movement of the piston.

74. In an apparatus of the named type, the combination of an expansion chamber, an air chamber, a valve controlled passage therebetween, explosive charge forming and regulating devices and an igniter connected with the expansion chamber, whereby a body of liquid is moved against the resistance of air in the air chamber, through the valve controlled passage, by the direct pressure of inflaming gases; a casing connected with the expansion chamber and a piston therein, whereby the position of the liquid in the expansion chamber is controlled, another substantially similar apparatus and connecting devices between said apparatus to control them, whereby they coact and operate alternately, and automatic means common to both apparatus adapted to control the operation of the igniter, charge regulating devices and the movement of the piston.

75. Means comprising an expansion chamber, a play pipe, an inlet and a discharge, whereby liquid is moved in one direction by the expansion of a compressed expandible charge, and in the other direction by energy derived from previous expansions.

76. In an apparatus of the named type, the combination of an expansion chamber,

an air chamber, a valve controlled passage therebetween, explosive charge forming and regulating devices and an igniter connected with the expansion chamber, whereby a
 5 body of liquid is moved against the resistance of air in the air chamber through the valve controlled passage by the direct pressure of inflaming gases, a check valve opening freely inward to atmospheric pressure
 10 for the admission of air into the expansion chamber, a casing connected with the expansion chamber and a piston therein, whereby the position of the liquid in the expansion chamber is controlled; another
 15 substantially similar apparatus, connecting devices between said apparatus to control them whereby they coact and operate alternately, automatic means common to both apparatuses adapted for controlling the operations of the igniters, charge regulating
 20 devices and the movement of the piston, and means for compressing the charges prior to ignition.

77. In an apparatus of the named type
 25 for storing energy the combination of an expansion chamber with an igniter; means for introducing a succession of charges of elastic fluid of uniform volume, and means adapted to effect the compression of the
 30 charges prior to ignition in proportion to the resistance to be overcome by each of said charges after ignition.

78. In an apparatus of the named type, the combination of an air chamber and an
 35 expansion chamber in which a body of liquid is moved against a varying resistance of air pressure in the air chamber by direct pressure of a succession of ignited charges in the expansion chamber, and means to
 40 compress the charges prior to ignition in proportion to the varying pressure in the air chamber.

79. In an apparatus of the named type, the combination of an air chamber, and an
 45 expansion chamber in which a body of liquid is moved against a varying resistance of air pressure in the air chamber by direct pressure of a succession of ignited charges in the expansion chamber; and means adapted
 50 to increase the compression of the charges prior to ignition in proportion to the increased pressure in the air chamber.

80. In an apparatus of the named type, the combination of a pipe and an expansion
 55 chamber in which a body of liquid is moved against the varying resistance of a column of liquid in the pipe by the direct pressure of a succession of ignited charges in the expansion chamber, and means adapted to
 60 compress the charges prior to ignition in proportion to the varying resistance of the column of liquid.

81. In an apparatus of the named type, the combination of an air chamber and an
 65 expansion chamber in which a body of liquid

is moved against the resistance of air pressure in the air chamber by direct pressure of ignited gases in the expansion chamber, the apparatus being provided with a
 70 pipe for liquid connected with the air chamber in such manner that liquid in the pipe is sustained by air in the air chamber, and means adapted to compress the charges prior to ignition in proportion to the varying pressure of air in the air chamber.

82. In an apparatus of the named type for storing energy, the combination of an expansion chamber with an igniter, means for introducing a succession of charges of elastic fluid and means adapted to effect the
 80 compression of each charge prior to ignition, irrespective of its volume, in proportion to the resistance to be overcome by each of the charges after ignition.

83. In an apparatus of the named type, the combination of an expansion chamber in which a variable load is moved by the direct pressure of inflaming gases, and means for applying the load to be moved to the gases prior to ignition whereby the gases
 90 are compressed variably in proportion to the load.

84. In an apparatus of the named type, the combination of an air chamber and an expansion chamber in which a body of liquid is moved against the resistance of air
 95 pressure in the air chamber by direct pressure of a succession of explosive impulses of ignited gases; means for introducing a succession of fuel charges, an electric spark igniter, a cylinder, a pressure actuated piston therein, and controlling mechanism connected with said piston and with the fuel
 100 introducing and igniting devices whereby the operative functions of the devices are automatically controlled.

85. In an apparatus of the named type, the combination of an expansion chamber in which a disconnected body of material is moved by the direct pressure of a succession
 110 of ignited charges in the expansion chamber, means adapted to compress each charge prior to ignition by a comprehensive movement of the body of material in proportion to the resistance to be overcome after ignition, and means to effect the comprehensive movement of the body of material.

86. In an apparatus of the named type, the combination of an expansion chamber in which a body of liquid is moved by the direct pressure of a succession of ignited charges in the expansion chamber, means adapted to compress each charge prior to ignition by a comprehensive movement of
 120 the body of liquid in proportion to the resistance to be overcome after ignition, and means adapted to effect the comprehensive movement of the body of liquid.

87. In an apparatus of the named type, 125

the combination of an expansion chamber in which a body of liquid is moved by the direct pressure of a succession of ignited charges in the expansion chamber, means adapted to compress each charge prior to ignition by a comprehensive movement of the body of liquid in proportion to the resistance to be overcome after ignition, and automatic means to effect the comprehensive movement of the body of liquid.

88. Means comprising an expansion chamber, a play pipe, an inlet and a discharge, whereby liquid is moved in one direction by the expansion of a compressed expansible charge, and in the other direction by energy derived from previous expansions, and whereby the inertia of the moving liquid causes a tendency to vacuum to the rear thereof.

89. Means comprising an expansion chamber, a play pipe, an inlet and a discharge, whereby liquid is moved in one direction by the expansion of a compressed expansible charge, and in the other direction by energy derived from previous expansions, and whereby the inertia of the moving liquid causes the charge to expand to below atmospheric pressure.

90. In an apparatus of the named type means, comprising an expansion chamber whereby liquid is moved by the direct pressure of a succession of ignited charges, means for introducing resilient fluid whereby a portion of the liquid is separated from the remainder to form a piston of relatively small mass and means adapted to compress the charges prior to ignition.

91. In an apparatus of the named type means, comprising an air chamber and an expansion chamber whereby liquid is moved against the resistance of air pressure in the air chamber by direct pressure of a succession of ignited charges in the expansion chamber, means for introducing liquid and means for introducing resilient fluid whereby a portion of the liquid is separated from the remainder to form a piston of relatively small mass against which the explosive energy is directed and means adapted to compress the charges prior to ignition.

92. Means comprising an expansion chamber, a play pipe, an inlet and a discharge, whereby liquid is moved in one direction by the expansion of a compressed expansible charge, and in the other direction by energy derived from previous expansions and whereby the inertia of the moving liquid facilitates the expansion of the charge.

93. In an apparatus of the named type, the combination of an air chamber and an explosion and expansion chamber in which liquid is moved against the resistance of air pressure in the air chamber by direct pressure of a succession of ignited charges in

the expansion chamber, means for introducing liquid, means adapted to permit and direct air from the air chamber to the liquid whereby a portion of the liquid is separated from the remainder to form a piston of relatively small mass against which the explosive energy is directed, and means adapted to compress the charges prior to ignition.

94. In an apparatus of the named type, the combination of explosion and expansion chamber, a pipe and means to introduce liquid thereinto, and an injector nozzle in said pipe to permit and direct fluid, ejected from the expansion chamber, into the liquid in the pipe, whereby the motion of the liquid is accelerated.

95. In an apparatus of the named type, the combination of an explosion and expansion chamber, a pipe provided with a valve controlled inlet for liquid, and an injector nozzle in said pipe to permit and direct fluid ejected from the expansion chamber into the liquid in the pipe whereby the motion of the liquid is accelerated.

96. In an apparatus of the named type, the combination of an explosion chamber, a pipe provided with a valve controlled outlet for liquid, and an injector nozzle in said pipe to permit and direct fluid ejected from the explosion chamber into the liquid in the pipe whereby the motion of the liquid is accelerated.

97. In an apparatus of the named type, the combination of an explosion and expansion chamber, a pipe and an air chamber connected therewith, means to introduce liquid into the pipe, and an injector nozzle in said pipe to permit and direct fluid ejected from the expansion chamber into the liquid in the pipe whereby the motion of the liquid is accelerated.

98. In an apparatus of the named type, the combination of an explosion and expansion chamber, a pipe and an air chamber connected therewith, the pipe being provided with a valve controlled inlet for liquid, and an injector nozzle in said pipe to permit and direct fluid ejected from the expansion chamber into the liquid in the pipe whereby the motion of the liquid is accelerated.

99. In apparatus of the named type, the combination of an expansion chamber, a pipe and an air chamber connected therewith, the pipe being provided with a valve controlled inlet for liquid and a valve controlled outlet into the air chamber, and an injector nozzle in said pipe to permit and direct fluid, ejected from the expansion chamber, into the liquid in the pipe, whereby the motion of the liquid is accelerated.

100. In an apparatus of the named type, the combination of an explosion and expansion chamber in which a body of liquid is moved by the direct pressure of a succession

of compressed ignited charges; an igniter, a piston pump adapted to introduce into the chamber successive charges of fuel, and means adapted to effect the operative motion of the pump.

101. In an apparatus of the named type, an air chamber, an explosion and expansion chamber in which liquid is moved against the resistance of air pressure in the air chamber by direct pressure of a succession of compressed ignited charges in the expansion chamber, an igniter, a piston pump adapted to introduce into the expansion chamber successive charges of fuel and means to effect the operative motion of the pump.

102. In an apparatus of the named type, the combination of an explosion and expansion chamber in which a body of liquid is moved by the direct pressure of a succession of compressed ignited charges, and means adapted to separate a portion of the body of liquid to form a liquid piston of relatively small mass against which the explosive energy is directed.

103. In an apparatus of the named type, the combination of an explosion and expansion chamber in which a body of liquid is moved by the direct pressure of a succession of ignited charges, means adapted to separate a portion of the body of liquid to form a liquid piston of relatively small mass against which the explosive energy is directed and means for renewing the liquid piston from the exterior.

104. In an apparatus of the named type, the combination of an explosion and expansion chamber in which liquid is moved by the direct pressure of a succession of ignited charges, means adapted to separate a portion of the liquid to form a piston of relatively small mass against which the explosive energy is directed, and means for renewing the liquid piston from the exterior after each explosive impulse.

105. In an apparatus of the named type, the combination of an air chamber and an explosion and expansion chamber in which liquid is moved against the resistance of air in the air chamber by the direct pressure of a succession of ignited charges, and means adapted to separate a portion of the liquid to form a piston of relatively small mass against which the explosive energy is directed.

106. In an apparatus of the named type, the combination of an air chamber and an explosion and expansion chamber in which liquid is moved against the resistance of air in the air chamber by the direct pressure of a succession of ignited charges, means adapted to separate a portion of the liquid to form a piston of relatively small mass, against which the explosive energy is directed, and

means for renewing the piston from the exterior.

107. In an apparatus of the named type, the combination of an air chamber and an explosion and expansion chamber in which liquid is moved against the resistance of air in the air chamber by the direct pressure of a succession of ignited charges, means adapted to separate a portion of the liquid to form a piston of relatively small mass, against which the explosive energy is directed, and means for renewing the piston from the exterior after each explosive impulse.

108. In an apparatus of the named type, the combination of an explosion and expansion chamber in which liquid is moved by the direct pressure of a succession of ignited charges, means adapted to separate a portion of the liquid to form a piston of relatively small mass, against which the explosive energy is directed and means adapted to compress the charges prior to ignition.

109. In an apparatus of the named type, the combination of an explosion and expansion chamber in which liquid is moved by direct pressure of a succession of ignited charges, means adapted to separate a portion of the liquid to form a piston of relatively small mass, against which the explosive energy is directed, means for renewing the piston from the exterior, and means adapted to compress the charges prior to ignition.

110. In an apparatus of the named type, the combination of an explosion and expansion chamber in which liquid is moved by the direct pressure of a succession of ignited charges, means adapted to separate a portion of the liquid to form a piston of relatively small mass against which the explosive energy is directed and means for renewing the piston from the exterior after each explosive impulse, and means adapted to compress the charges prior to ignition.

111. In an apparatus of the named type, the combination of an air chamber and an explosion and expansion chamber in which liquid is moved against the resistance of air in the air chamber by the direct pressure of a succession of ignited charges, means adapted to separate a portion of the liquid to form a piston of relatively small mass, against which the explosive energy is directed, and means adapted to compress the charges prior to ignition.

112. In an apparatus of the named type, the combination of an air chamber and an explosion and expansion chamber in which liquid is moved against the resistance of air in the air chamber by the direct pressure of a succession of ignited charges, means adapted to separate a portion of the liquid to form a piston of relatively small mass against

which the explosive energy is directed, and means for renewing the piston from the exterior, and means adapted to compress the charges prior to ignition.

113. In an apparatus of the named type, the combination of an air chamber and an explosion and expansion chamber in which liquid is moved against the resistance of air in the air chamber by the direct pressure of a succession of ignited charges, means adapted to separate a portion of the liquid to form a piston of relatively small mass, against which the explosive energy is directed, means for renewing the piston from the exterior after each explosive impulse, and means adapted to compress the charges prior to ignition.

114. In an apparatus of the named type, the combination of an air chamber and an explosion and expansion chamber in which liquid is moved against the resistance of air in the air chamber by the direct pressure of a succession of ignited charges, means adapted to separate a portion of the liquid to form a liquid piston of relatively small mass, against which the explosive energy is directed, and means adapted to compress the charges prior to ignition by the pressure of the air in the air chamber.

115. In an apparatus of the named type, the combination of an air chamber and an explosion and expansion chamber in which liquid is moved against the resistance of air in the air chamber by the direct pressure of a succession of ignited charges, means adapted to separate a portion of the liquid to form a piston of relatively small mass, against which the explosive energy is directed, means for renewing the piston from the exterior, and means adapted to compress the charges prior to ignition by the pressure of the air in the air chamber.

116. In an apparatus of the named type, the combination of an air chamber and an explosion and expansion chamber in which liquid is moved against the resistance of air in the air chamber by the direct pressure of a succession of ignited charges, means adapted to separate a portion of the liquid to form a piston of relatively small mass against which the explosive energy is directed, means for renewing the liquid piston from the exterior after each explosive impulse, and means adapted to compress the charges prior to ignition by the pressure of the air in the air chamber.

117. An apparatus of the named type comprising a chamber having an igniter, means for introducing therein fuel and air to form a succession of explosive charges, an air chamber with a discharge and suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the

ignited charges through the intervention of liquid, and means to separate a portion of the liquid to form a piston of relatively small mass against which the explosive energy is directed.

118. An apparatus of the named type comprising a chamber having an igniter, means for introducing therein fuel and air to form a succession of explosive charges, an air chamber with a discharge and suitably arranged and communicating with the first mentioned chamber in such a manner that the air therein opposes the expansion of the ignited charges through the intervention of liquid, means to separate a portion of the liquid to form a piston of relatively small mass against which the explosive energy is directed and means adapted to compress the charges prior to ignition.

119. An apparatus of the named type comprising a chamber having an igniter, means for introducing therein fuel and air to form a succession of explosive charges, an air chamber with a discharge and suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of liquid, means to separate a portion of the liquid to form a piston of relatively small mass against which the explosive energy is directed and means adapted to compress the charges prior to ignition by the pressure of air in the air chamber.

120. Means, comprising an expansion chamber, a play pipe, a piston, an inlet and a discharge, whereby the piston is actuated by the expansion of an expansible charge to move the liquid in one direction and means whereby the piston is actuated in the opposite direction by the head or pressure resulting from previous expansions.

121. An apparatus of the named type comprising a chamber having an igniter, means for introducing therein fuel and air to form a succession of explosive charges, an air chamber with a discharge and suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of liquid, means for introducing resilient fluid whereby a portion of the liquid is separated from the remainder to form a piston of relatively small mass against which the explosive energy is directed and means adapted to compress the charges prior to ignition.

122. An apparatus of the named type comprising a chamber having an igniter, means for introducing therein fuel and air to form a succession of explosive charges, an air chamber with a discharge and suitably arranged and communicating with the first mentioned chamber in such manner

that the air therein opposes the expansion of the ignited charges through the intervention of liquid, means for introducing resilient fluid whereby a portion of the liquid is separated from the remainder to form a liquid piston of relatively small mass against which the explosive energy is directed and means adapted to compress the charges prior to ignition by the pressure of air in the air chamber.

123. An apparatus of the named type comprising a chamber having an igniter, means for introducing therein fuel and air to form a succession of explosive charges, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of liquid, a discharge pipe communicating with the air chamber, means to separate a portion of the liquid to form a piston of relatively small mass against which the explosive energy is directed, and means adapted to permit the flow of fluid from the first mentioned chamber to the air chamber and discharge pipe.

124. An apparatus of the named type comprising a chamber having an igniter, means for introducing therein fuel and air to form a succession of explosive charges, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of liquid, a discharge pipe communicating with the air chamber, means to separate a portion of the liquid to form a piston of relatively small mass against which the explosive energy is directed, means adapted to permit the flow of fluid from the first mentioned chamber to the air chamber and discharge pipe, and means adapted to compress the charges prior to ignition.

125. An apparatus of the named type comprising a chamber having an igniter, means for introducing therein fuel and air to form a succession of explosive charges, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of liquid, a discharge pipe, means to separate a portion of the liquid from the remainder to form a piston of relatively small mass, against which the explosive energy is directed, means adapted to permit and direct the flow of fluid from the first mentioned chamber to the air chamber and discharge pipe, and means adapted to compress the charges prior to ignition by the pressure of air in the air chamber.

126. Means, comprising an expansion chamber, a play pipe, a piston, an inlet and

a discharge, whereby the piston is actuated by the expansion of an expansible charge to move the liquid in one direction and means whereby the piston is actuated in the opposite direction by the head or pressure resulting from previous expansions, and whereby the inertia of the moving liquid is utilized.

127. An apparatus of the named type comprising a chamber having an igniter, means for introducing therein fuel and air to form a succession of explosive charges, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of liquid, a discharge pipe, means for introducing resilient fluid, whereby a portion of the liquid is separated from the remainder to form a liquid piston of relatively small mass, against which the explosive energy is directed, means adapted to permit and direct the flow of fluid from the first mentioned chamber to the air chamber and discharge pipe, and means adapted to compress the charges prior to ignition.

128. An apparatus of the named type comprising a chamber having an igniter, means for introducing therein fuel and air to form a succession of explosive charges, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of liquid, a discharge pipe, means for introducing resilient fluid whereby a portion of the liquid is separated from the remainder to form a piston of relatively small mass, against which the explosive energy is directed, means adapted to permit and direct the flow of fluid from the first mentioned chamber to the air chamber, and discharge pipe, and means adapted to compress the charges prior to ignition by the pressure of air in the air chamber.

129. An apparatus of the named type comprising a chamber having an igniter, means for introducing therein fuel and air to form a succession of explosive charges, the chamber being provided with a valve controlled inlet for liquid, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of liquid, means to separate a portion of the liquid to form a piston of relatively small mass, against which the explosive energy is directed, and a valve controlled passage to permit the flow of fluid from the first mentioned chamber to the air chamber and to the exterior.

130. An apparatus of the named type comprising a chamber having an igniter,

means for introducing thereto fuel and air to form a succession of explosive charges, the chamber being provided with a valve controlled inlet for liquid, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of liquid, means to separate a portion of the liquid to form a piston of relatively small mass, against which the explosive energy is directed, a valve controlled passage to permit the flow of fluid from the first mentioned chamber to the air chamber and to the exterior, and means adapted to compress the charges prior to ignition.

131. An apparatus of the named type comprising a chamber having an igniter, means for introducing thereto fuel and air to form a succession of explosive charges, the chamber being provided with a valve controlled inlet for liquid, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of liquid, means to separate a portion of the liquid to form a piston of relatively small mass, against which the explosive energy is directed, a valve controlled passage to permit the flow of fluid from the first mentioned chamber to the air chamber and to the exterior, and means adapted to compress the charges prior to ignition by the pressure of air in the air chamber.

132. Means, comprising an expansion chamber, a play pipe, a piston, an inlet and a discharge, whereby the piston is actuated by the expansion of an expansible charge to move the liquid in one direction and means whereby the piston is actuated in the opposite direction, to compress a fresh charge.

133. An apparatus of the named type comprising a chamber having an igniter, means for introducing thereto fuel and air to form a succession of explosive charges, the chamber being provided with a valve controlled inlet for liquid, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of liquid, means for introducing resilient fluid whereby a portion of the liquid is separated from the remainder to form a liquid piston of relatively small mass, against which the explosive energy is directed, a valve controlled passage to permit the flow of fluid from the first mentioned chamber to the air chamber and to the exterior, and means adapted to compress the charges prior to ignition.

134. An apparatus of the named type comprising a chamber having an igniter, means for introducing thereto fuel and air to form a succession of explosive charges, the chamber being provided with a valve controlled inlet for liquid, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges through the intervention of liquid, means for introducing resilient fluid, whereby a portion of the liquid is separated from the remainder to form a piston of relatively small mass, against which the explosive energy is directed, a valve controlled passage to permit the flow of fluid from the first mentioned chamber to the air chamber and to the exterior, and means adapted to compress the charges prior to ignition by the pressure of air in the air chamber.

135. Means, comprising an expansion chamber, a play pipe, a piston, an inlet and a discharge, whereby the piston is actuated by the expansion of an expansible charge to move the liquid in one direction, and means for moving the piston in opposite directions, whereby fresh charges are introduced and compressed.

136. An apparatus of the named type comprising a chamber having an igniter, means for introducing thereto fuel and air to form a succession of explosive charges, the chamber being provided with a valve controlled inlet for liquid, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges, through the intervention of liquid, a discharge pipe communicating with the air chamber, means to separate a portion of the liquid to form a piston of relatively small mass, against which the explosive energy is directed, a valve controlled passage to permit the flow of fluid from the first mentioned chamber to the air chamber and discharge pipe, and means adapted to compress the charges prior to ignition.

137. An apparatus of the named type comprising a chamber having an igniter, means for introducing thereto fuel and air to form a succession of explosive charges, the chamber being provided with a valve controlled inlet for liquid, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges, through the intervention of liquid, a discharge pipe communicating with the air chamber, means to separate a portion of the liquid to form a piston of relatively small mass, against which the explosive energy is directed, a valve controlled passage

to permit the flow of fluid from the first mentioned chamber to the air chamber and discharge pipe, and means adapted to compress the charges prior to ignition by the pressure of air in the air chamber.

138. An apparatus of the named type comprising a chamber having an igniter, means for introducing thereto fuel and air to form a succession of explosive charges, the chamber being provided with a valve controlled inlet for liquid, an air chamber suitably arranged and communicating with the first mentioned chamber in such manner that the air therein opposes the expansion of the ignited charges, through the intervention of liquid, a discharge pipe communicating with the air chamber, means for introducing resilient fluid whereby a portion of the liquid is separated from the remainder to form a liquid piston of relatively small mass, against which the explosive energy is directed, and a valve controlled passage to permit the flow of fluid from the first mentioned chamber to the air chamber and discharge pipe.

139. In an apparatus of the named type, the combination with a combustion chamber, of means for admitting an explosive mixture thereto, an igniter, means for admitting liquid into said chamber, a discharge pipe for liquid from said chamber, air cushioning means between the combustion chamber and the discharge pipe and means for compressing the explosive mixture prior to ignition.

140. In an apparatus of the named type, the combination with a combustion chamber, of means for forming and introducing an explosive mixture thereto, an igniter, means for admitting liquid into said chamber, a discharge pipe for liquid from said chamber, air cushioning means between the combustion chamber and the discharge pipe, and means for compressing the explosive mixture prior to ignition.

141. In an apparatus of the named type, the combination with a combustion chamber, of means for admitting an explosive mixture thereto, an igniter, a non-return valve for admitting liquid into said chamber, a discharge pipe from said chamber provided with a non-return valve air cushioning means between the combustion chamber and the discharge pipe, and means for compressing the explosive mixture prior to ignition.

142. In an apparatus of the named type, the combination with a combustion chamber, of means for forming and introducing an explosive mixture thereto, an igniter, a non-return valve for admitting liquid into said chamber, a discharge pipe from said chamber provided with a non-return valve, air cushioning means between the combustion chamber and the discharge pipe and means for compressing the explosive mixture prior to ignition.

tion chamber and the discharge pipe and means for compressing the explosive mixture prior to ignition.

143. Means, comprising an expansion chamber, a play pipe, a piston, an inlet and a discharge, whereby the piston is actuated by the expansion of an expansible charge to move the liquid in one direction, and means for moving the piston in opposite directions, whereby burnt products are expelled and fresh charges are introduced and compressed.

144. In an apparatus of the named type, the combination with a combustion chamber, a pipe for admitting an explosive mixture thereto forming an ignition chamber, an igniter in the pipe in the path of the ingoing mixture, means for admitting liquid into the combustion chamber, a discharge pipe for liquid from said chamber, air cushioning means between the combustion chamber and the discharge pipe and means for compressing the explosive mixture prior to ignition.

145. Means, comprising an expansion chamber, a play pipe, a piston, an inlet and a discharge, whereby the piston is actuated by the expansion of an expansible charge to move the liquid in one direction to compress an elastic cushion, and means whereby the piston is actuated in the opposite direction by the elastic cushion.

146. In an apparatus of the named type, the combination with a combustion chamber, a pipe for admitting an explosive mixture thereto forming an ignition chamber, an igniter in the pipe in the path of the ingoing mixture, a non-return valve for admitting liquid into the combustion chamber, a discharge pipe from said chamber provided with a non-return valve, air cushioning means between the combustion chamber and the discharge pipe, and means for compressing the explosive mixture prior to ignition.

147. In an apparatus of the named type, the combination with a submerged combustion chamber, of means for admitting an explosive mixture thereto, an igniter, means for admitting liquid into said chamber, a discharge pipe for liquid from said chamber, and air cushioning means between the combustion chamber and the discharge pipe.

148. In an apparatus of the named type, the combination with a submerged combustion chamber, of means for forming and introducing an explosive mixture thereto, means for compressing the explosive mixture in the combustion chamber, an igniter, means for admitting liquid into said chamber, a discharge pipe for liquid from said chamber and air cushioning means between the combustion chamber and the discharge pipe.

149. In an apparatus of the named type, the combination with a submerged combustion chamber, of means for admitting an explosive mixture therein, an igniter, means for admitting liquid into said chamber, a discharge pipe for liquid from said chamber, air cushioning means between the combustion chamber and the discharge pipe, and means for compressing the explosive mixture prior to ignition. 70
150. In an apparatus of the named type, the combination with a submerged combustion chamber, of means for forming and introducing an explosive mixture therein, an igniter, means for admitting liquid into said chamber, a discharge pipe for liquid from said chamber, air cushioning means between the combustion chamber and the discharge pipe, and means for compressing the explosive mixture prior to ignition. 75
151. Means, comprising an expansion chamber, a play pipe, a piston, an inlet and a discharge, whereby the piston is actuated by the expansion of an expansible charge to move the liquid in one direction to compress an elastic cushion, and whereby the piston is actuated in the opposite direction by the elastic cushion to compress a fresh charge. 80
152. Means, comprising an expansion chamber, a play pipe, an air chamber connected therewith, an inlet and a discharge, whereby liquid is moved in the play pipe against an elastic cushion in the air chamber, by the expansion of a compressed combustible charge, and whereby the elastic cushion causes a reverse movement of liquid to compress a fresh charge. 85
153. In an apparatus of the named type, the combination with a submerged combustion chamber, of means for admitting an explosive mixture therein, an igniter, a non-return valve for admitting liquid into said chamber, a discharge pipe from said chamber provided with a non-return valve, air cushioning means between the combustion chamber and the discharge pipe, and means for compressing the explosive mixture prior to ignition. 90
154. In an apparatus of the named type, the combination with a submerged combustion chamber, of means for forming and introducing an explosive mixture therein, an igniter, a non-return valve for admitting liquid into said chamber, a discharge pipe from said chamber provided with a non-return valve, air cushioning means between the combustion chamber and the discharge pipe, and means for compressing the explosive mixture prior to ignition. 95
155. In an apparatus of the named type, the combination with a submerged combustion chamber, a pipe for admitting an explosive mixture thereto forming an ignition chamber, an igniter in the pipe in the path of the ingoing mixture, means for admitting liquid into the combustion chamber, a discharge pipe for liquid from said chamber, and air cushioning means between the combustion chamber and the discharge pipe. 100
156. In an apparatus of the named type, the combination with a submerged combustion chamber, a pipe for admitting an explosive mixture therein forming an ignition chamber, an igniter in the pipe in the path of the ingoing mixture, means for admitting liquid into the combustion chamber, a discharge pipe for liquid from said chamber, air cushioning means between the combustion chamber and the discharge pipe, and means for compressing the explosive mixture prior to ignition. 105
157. In an apparatus of the named type, the combination with a submerged combustion chamber, a pipe for admitting an explosive mixture therein forming an ignition chamber, an igniter in the path of the ingoing mixture, a non-return valve for admitting liquid into the combustion chamber, a discharge pipe from said chamber provided with a non-return valve, and air cushioning means between the combustion chamber and the discharge pipe. 110
158. In an apparatus of the named type, the combination with a submerged combustion chamber, a pipe for admitting an explosive mixture therein forming an ignition chamber, an igniter in the pipe in the path of the ingoing mixture, a non-return valve for admitting liquid into the combustion chamber, a discharge pipe from said chamber provided with a non-return valve, air cushioning means between the combustion chamber and the discharge pipe, and means for compressing the explosive mixture prior to ignition. 115
159. Means, comprising an expansion chamber, a play pipe, an inlet and a discharge, whereby liquid is moved to a greater head or pressure, and means for utilizing the head or pressure to cause a return movement of liquid to compress a fresh charge. 120
160. In an apparatus of the named type, the combination with a combustion chamber, of a pump for introducing an explosive charge therein, an igniter, means for admitting liquid into said chamber, a discharge pipe for liquid from said chamber, air cushioning means between the combustion chamber and the discharge pipe, and means for compressing the explosive charge prior to ignition. 125
161. Means, comprising an expansion chamber, a play pipe, an inlet and a discharge, whereby liquid is moved to a greater head or pressure and to compress an elastic cushion, and means for utilizing the head or pressure to cause a return movement of liquid to compress a fresh charge. 130
162. In an apparatus of the named type, 130

the combination with a combustion chamber, of a pump for introducing an explosive charge therein, an igniter, a non-return valve for admitting liquid into said chamber, a discharge pipe from said chamber provided with a non-return valve, air cushioning means between the combustion chamber and the discharge pipe, and means for compressing the explosive charge prior to ignition.

163. Means, comprising an expansion chamber, a play pipe, an inlet and a discharge, whereby liquid is moved to a greater head or pressure and to compress an elastic cushion, and means for utilizing the head or pressure, through the interposed elastic cushion, to cause a return movement of liquid to compress a fresh charge.

164. In an apparatus of the named type, the combination with a submerged combustion chamber, of a pipe connected therewith forming an ignition chamber, a pump for introducing an explosive charge therein, an igniter in the pipe in the path of the incoming charge, means for admitting liquid into the combustion chamber, a discharge pipe for liquid from the combustion chamber, air cushioning means between the combustion chamber and the discharge pipe, and means for compressing the explosive charge prior to ignition.

165. Means, comprising an expansion chamber, a play pipe, a piston, an inlet and a discharge, whereby a compressed combustible charge is expanded to actuate the piston to move liquid, and whereby the return movement of the liquid causes compression of a fresh charge.

166. In an apparatus of the named type, the combination with a combustion chamber, of a pump for introducing an explosive charge therein, an igniter, means for admitting liquid into said chamber, a discharge pipe for liquid from said chamber, air cushioning means between the combustion chamber and the discharge pipe, means for compressing the explosive charge prior to ignition, and a motor for operating said pump.

167. Means, comprising an expansion chamber, a play pipe, a piston, an inlet and a discharge, whereby a compressed combustible charge is expanded to actuate the piston to move liquid, and whereby the inertia of the moving liquid facilitates the expansion of the charge.

168. In an apparatus of the named type, the combination with a combustion chamber, of a pump for introducing an explosive charge therein, an igniter, a non-return valve for admitting liquid into said chamber, a discharge pipe from said chamber provided with a non-return valve, air cushioning means between the combustion chamber

and the discharge pipe, means for compressing the explosive charge prior to ignition, and a motor for operating said pump.

169. Means, comprising an expansion chamber, a play pipe, a piston, an inlet and a discharge, whereby a compressed combustible charge is expanded to actuate the piston to move liquid, and means for storing energy due to the inertia of the moving liquid.

170. In an apparatus of the named type, the combination with a submerged combustion chamber, of a pipe connected therewith forming an ignition chamber, a pump for introducing an explosive charge therein, an igniter in the pipe in the path of the incoming charge, means for admitting liquid into the combustion chamber, a discharge pipe for liquid from the combustion chamber, air cushioning means between the combustion chamber and the discharge pipe, means for compressing the explosive charge prior to ignition, and a motor for operating said pump.

171. Means, comprising an expansion chamber, a play pipe, a piston, an inlet and a discharge, whereby a compressed combustible charge is expanded to actuate the piston to move liquid, and whereby the inertia of the moving liquid causes a tendency to vacuum to the rear thereof.

172. In an apparatus of the named type, the combination with a combustion chamber, of a pump for introducing an explosive charge therein, an igniter, means for admitting liquid from the exterior, a discharge pipe for liquid from said chamber, air cushioning means between the combustion chamber and the discharge pipe, means for compressing the explosive charge prior to ignition, and a motor to operate the pump and igniter.

173. In an apparatus of the named type, the combination with a combustion chamber, of means for admitting an explosive mixture therein, an igniter, means for admitting liquid into said chamber, a discharge pipe for liquid from said chamber, air cushioning means between the combustion chamber and the discharge pipe, and a valve for admitting air into the combustion chamber.

174. In an apparatus of the named type, the combination with a combustion chamber, of means for forming and introducing an explosive mixture therein, an igniter, means for admitting liquid into said chamber, a discharge pipe for liquid from said chamber, air cushioning means between the combustion chamber and the discharge pipe, and a valve for admitting air into the combustion chamber.

175. In an apparatus of the named type, the combination with a combustion chamber, of means for admitting an explosive mixture therein, an igniter, means for admitting

liquid into said chamber, a discharge pipe for liquid from said chamber, air cushioning means between the combustion chamber and the discharge pipe, means for compressing the explosive mixture prior to ignition and a valve for admitting air into the combustion chamber.

176. In an apparatus of the named type, the combination with a combustion chamber, of means for forming and introducing an explosive mixture therein, an igniter, means for admitting liquid into said chamber, a discharge pipe for liquid from said chamber, air cushioning means between the combustion chamber and the discharge pipe, means for compressing the explosive mixture prior to ignition, and a valve for admitting air into the combustion chamber.

177. Means, comprising an expansion chamber, a play pipe, a piston, an inlet, an air chamber and a discharge, whereby a compressed combustible charge is expanded to actuate the piston to move liquid, and means whereby the inertia of the moving liquid is utilized in compressing an elastic cushion in the air chamber.

178. Means, comprising an expansion chamber, a play pipe, a piston, an inlet, an air chamber and a discharge, whereby a compressed combustible charge is expanded to actuate the piston to move liquid, and means whereby the inertia of the moving liquid is utilized in compressing an elastic cushion in the air chamber, and whereby the expansion of the elastic cushion causes a return movement of liquid to compress a fresh charge.

179. In an apparatus of the named type, the combination with a combustion chamber, of means for admitting an explosive mixture therein, an igniter, a non-return valve for admitting liquid into said chamber, a discharge pipe from said chamber provided with a non-return valve, air cushioning means between the combustion chamber and the discharge pipe, means for compressing the explosive charge prior to ignition, and a valve for admitting air into the combustion chamber.

180. In an apparatus of the named type, the combination with a combustion chamber, of means for forming and introducing an explosive mixture therein, an igniter, means having a non-return valve for admitting liquid into said chamber, a discharge pipe from said chamber provided with a non-return valve, air cushioning means between the combustion chamber and discharge pipe, means for compressing the explosive mixture prior to ignition and a valve for admitting air into the combustion chamber.

181. In an apparatus of the named type, the combination with a combustion cham-

ber, of means for admitting an explosive mixture therein, an igniter, means for admitting liquid into said chamber, an uptake pipe, an outlet from the combustion chamber of less diameter than the uptake pipe entering the uptake pipe, a discharge pipe for liquid from the uptake pipe, and air cushioning means between the combustion chamber and the discharge pipe.

182. In an apparatus of the named type, the combination with a combustion chamber, of means for admitting an explosive mixture therein, an igniter, means for admitting liquid into said chamber, an uptake pipe, an outlet from the combustion chamber of less diameter than the uptake pipe entering the uptake pipe, a discharge for liquid from the uptake pipe, air cushioning means between the combustion chamber and the discharge pipe, and means for compressing the explosive mixture before ignition.

183. Means comprising an expansion chamber, a play pipe, an inlet and a discharge to a higher point, whereby liquid is moved in the play pipe toward the discharge by the expansion of an ignited compressed expansible charge in the expansion chamber.

184. Means comprising an expansion chamber, a play pipe, an inlet and a discharge whereby liquid is moved in the play pipe by the expansion of a compressed expansible charge in the expansion chamber, and means for utilizing energy derived therefrom for compressing subsequent expansible charges.

185. Means comprising an expansion chamber, a play pipe, an inlet and a discharge, whereby liquid is moved in the play pipe by the expansion of a compressed expansible charge in the expansion chamber, and means whereby the inertia of the moving liquid causes the expansible charge to expand to below atmospheric pressure.

186. Means comprising an expansion chamber, a play pipe, an inlet and a discharge, whereby liquid is moved in the play pipe by the expansion of a compressed expansible charge in the expansion chamber, and means whereby the inertia of the moving liquid causes the liquid to travel a sufficient distance to reduce the expansible charge to below atmospheric pressure.

187. Means comprising an expansion chamber, a play pipe, an inlet and a discharge, whereby liquid is moved in the play pipe by the expansion of a compressed expansible charge in the expansion chamber, and means whereby the inertia of the moving liquid causes a tendency toward vacuum to the rear thereof.

188. Means comprising an expansion chamber, a play pipe, an inlet and a discharge, whereby liquid is moved in the play

pipe by the expansion of a compressed expansible charge in the expansion chamber, and means for utilizing energy derived therefrom for introducing and compressing subsequent expansible charges.

189. Means comprising an expansion chamber, a play pipe, an inlet and a discharge, and an igniter, whereby liquid is moved in the play pipe by the expansion of an ignited expansible charge in the expansion chamber and means for utilizing energy derived therefrom for introducing and igniting subsequent expansible charges.

190. Means comprising an expansion chamber, a play pipe, an inlet and a discharge, and an igniter, whereby liquid is moved in the play pipe by the expansion of an ignited compressed expansible charge in the expansion chamber and means for utilizing energy derived thereby for introducing, compressing and igniting subsequent expansible charges.

191. Means comprising an expansion chamber, a play pipe, an inlet and a discharge to a higher point whereby liquid is moved in the play pipe by the expansion of a compressed expansible charge in the expansion chamber, and means for utilizing energy derived therefrom for introducing fresh liquid into the play pipe.

192. Means comprising an expansion chamber, a play pipe, an inlet and a discharge to a higher point whereby liquid is moved in the play pipe by the expansion of a compressed expansible charge in the expansion chamber, and means for utilizing energy derived therefrom for expelling burnt products from the expansion chamber.

193. Means comprising an expansion cham-

ber, a play pipe, an inlet and a discharge to a higher point whereby liquid is moved in the play pipe by the expansion of a compressed expansible charge in the expansion chamber, and means for utilizing energy derived therefrom for introducing fresh liquid into the play pipe and expelling burnt products from the expansion chamber.

194. Means comprising an expansion chamber, a play pipe, an air chamber connected therewith, an inlet and a discharge, and means for introducing into the expansion chamber a compressed expansible charge whereby liquid is moved in the play pipe against the elastic cushion in the air chamber by the expansion of said compressed expansible charge in the expansion chamber.

195. Means comprising an expansion chamber, a play pipe, an air chamber, an inlet and a discharge, and means for introducing into the expansion chamber a compressed expansible charge whereby liquid is moved in the play pipe by the expansion of said compressed expansible charge in the expansion chamber to compress air in the air chamber.

196. Means comprising an expansion chamber, a play pipe, an air chamber, an inlet and a discharge, whereby liquid is moved in the play pipe by the expansion of a compressed expansible charge in the expansion chamber to compress air in the air chamber, and means for utilizing energy stored in the air chamber for compressing fresh expansible charges in the expansion chamber.

WILLIAM H. SMYTH.

Witnesses:

A. B. BOWERS,

J. H. MILLER.