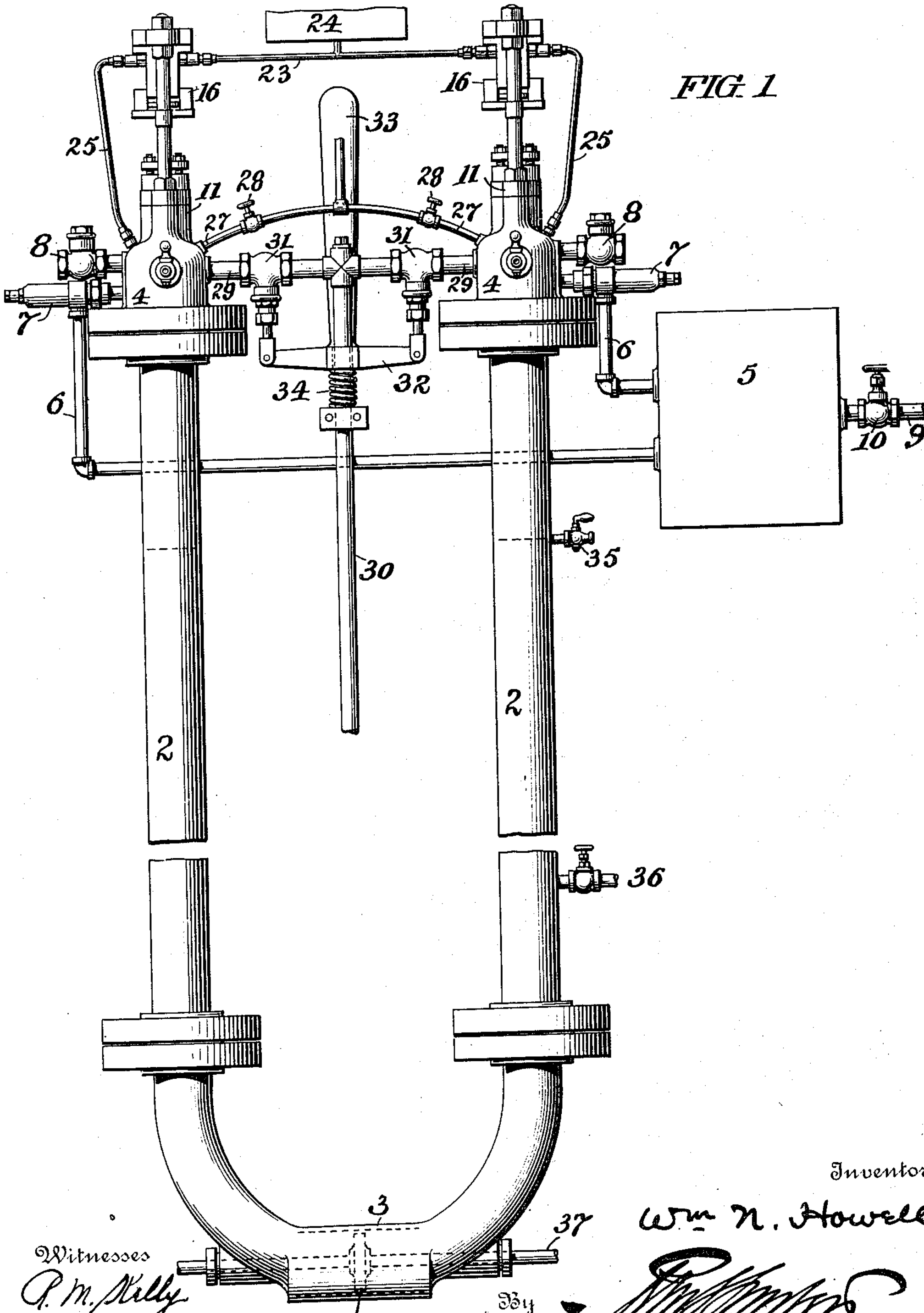
W. N. HOWELL.
EXPLOSIVE GENERATOR.
APPLICATION FILED MAY 4, 1910.

1,000,410.

Patented Aug. 15, 1911.
3 SHEETS—SHEET 1.

FIG. 1



Witnesses
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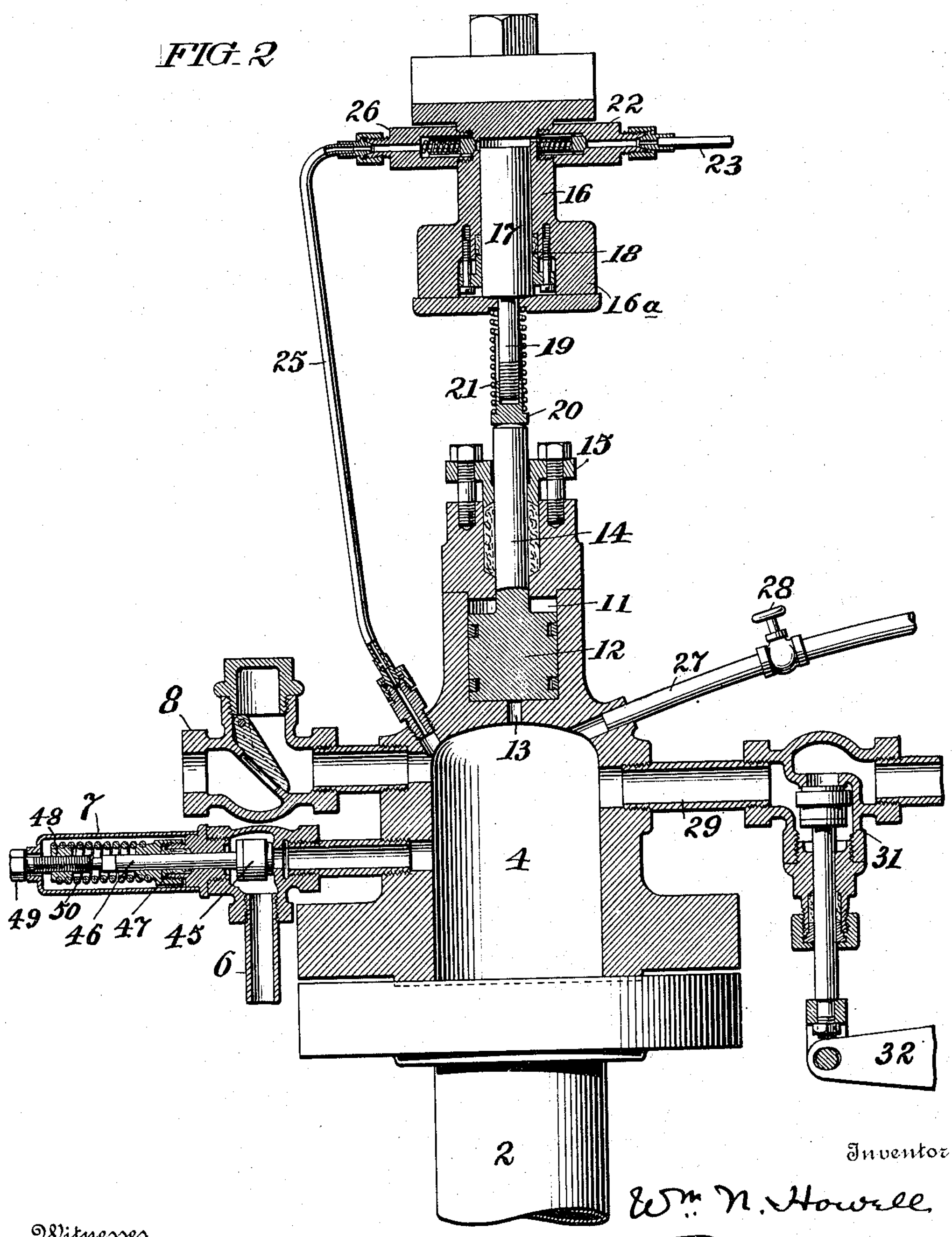
3 SHEETS—SHEET 2.

FIG. 2



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3 SHEETS—SHEET 3.

FIG. 8

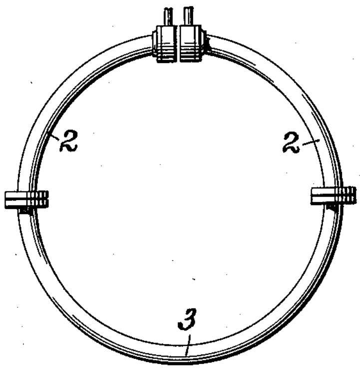


FIG. 7

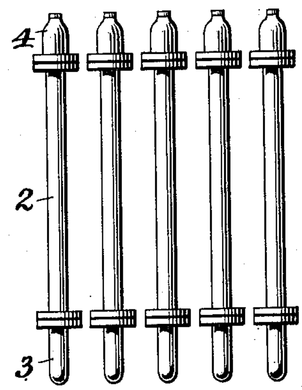


FIG. 6

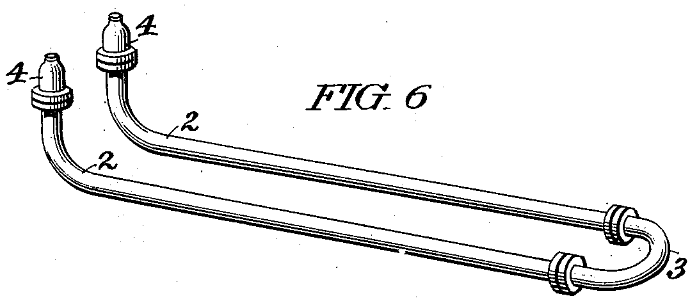


FIG. 4

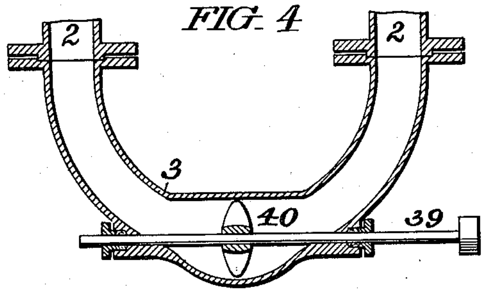


FIG. 5

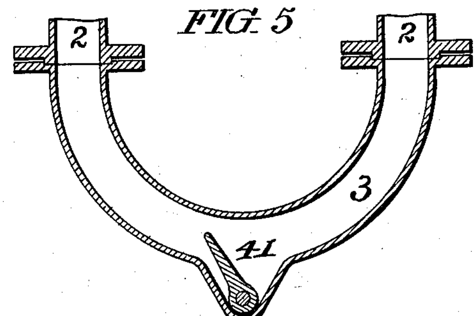
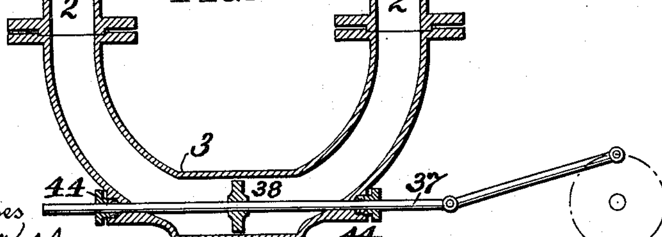


FIG. 3



Witnesses

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UNITED STATES PATENT OFFICE.

WILLIAM N. HOWELL, OF BRIDGEPORT, CONNECTICUT.

EXPLOSIVE-GENERATOR.

1,000,410. Specification of Letters Patent. Patented Aug. 15, 1911.

Application filed May 4, 1910. Serial No. 559,304.

To all whom it may concern:

Be it known that I, WILLIAM N. HOWELL, a citizen of the United States, and a resident of Bridgeport, county of Fairfield, State of Connecticut, have invented an Improvement in Explosive-Generators, of which the following is a specification.

My invention has reference to explosive generators for producing power and consists of certain improvements which are fully set forth in the following specification and shown in the accompanying drawing which forms a part thereof.

The object of my invention is to provide a generator of energy which shall be simple, compact and capable of producing power under widely variable conditions to suit the particular uses for which the energy is to be employed; and more particularly, my invention is intended to utilize the explosive energy due to the combustion of air and carbon or hydrocarbon mixtures under high compression, said utilization, however, being accomplished in a secondary manner by transmitting the energy produced in the generator to the machine or apparatus to be operated and which may be otherwise independent of the generator itself.

My object is also to provide an apparatus and method which will enable the production of energy from combustion of fuel under pressure conditions which shall be very economical as to consumption of the fuel employed per given horse power.

When my invention is utilized for the purpose of operating engines similar to steam engines which vary their power and speed under throttling or variations in degree of expansion, I generate, in an automatic manner, high tension gases by internal combustion of air and fuel under high compression and utilize the gases so generated to perform the dual function of maintaining the generator in operation and providing the high tension compressed gases which may be utilized in the engine in the same manner that steam might be employed therein. When my invention is otherwise utilized for the purpose of producing mechanical power, the operation of the generator causes a fluid body to be set into motion and the inertia of the said fluid body is directly caused to operate mechanical devices for the purpose of transmitting the power so generated.

My object is, further, to provide a simple and inexpensive generator of power by means of internal combustion which may be operated without the requirement of ignition devices other than that due to the compression of the air within the generator itself; and finally, my object is to provide a form of apparatus for generating energy from the explosive force of air and fuel which may produce energy under various conditions of pressure by its own internal action and by proper adjustment to suit the requirements for which the power is utilized.

My invention consists of means for utilizing the momentum of a body of fluid to produce the compression and also regulate the admixture of air and fuel to be burned, and further to produce the heat necessary by the compression of the gases to insure ignition thereof in the act of exploding them and these improvements comprehend the various features of constructions hereinafter more fully described and more particularly defined in the claims.

In that form of my apparatus in which the body of fluid, whose momentum is the means of producing compression, is water, the said water is brought into contact with the heated surfaces of the metal in the combustion chambers and thereby keeps the apparatus from excessive heating; and moreover, a small portion of the water is vaporized at the moment of highest compression and explosion and is thereby utilized to augment the gases produced and forced into the receiver for subsequent use by expansion.

Referring to the drawings, Figure 1 is an elevation of an explosive generator embodying my improvements; Fig. 2 is a sectional elevation of a portion of the same on a larger scale; Fig. 3 is a sectional elevation of the lower part of Fig. 1; Figs. 4 and 5 are similar sectional elevations to Fig. 3 illustrating modified constructions and Fig. 6 is a perspective view illustrating the generator fluid containing tubes bent into a horizontal position, and Figs. 7 and 8 are elevations of modified arrangements of the fluid containing tubes.

2, 3, 2 represents a U-shaped tubular chamber which is normally filled with water up to the dotted line on a level with the petcock 35. This tube may be properly filled with water by means of a valved water pipe 36 connecting with its lower portion. The lower or return part 3 of the U-shaped tubular chamber may be plain tube or it may be provided with power devices which may be actuated by the flow of the water from one tube 2 to the other through the said return bend 3, and vice versa. Secured to the top of each of the upright tubes 2 is a head 4.

5 is a receiver into which the gases from the heads 4 may be delivered through pipe 6, the escape of the gases from the heads being caused to take place through relief valves 7 with which the pipes 6 connect. These relief valves 7 are in the form of spring actuated check valves and are capable of adjustment so as to open under a predetermined pressure. While these relief valves 7 may be made in any suitable manner desired, the particular construction preferred is clearly illustrated in Fig. 2 and will be described further on in the specification. The gases which are delivered from the heads 4 into the receiver 5 may be employed to operate an engine of any suitable construction by conveying to said engine the said gases under the initial pressure of the said receiver by means of a supply pipe 9 having a control valve 10. As the gases are delivered to the receiver 5 under high pressure and exhaust in the said receiver in a continuous manner, they may be supplied to an engine very much the same as steam is supplied thereto for operating it by means of expansion. Each of the heads 4 is further provided with an automatic check valve or inlet 8 by which atmospheric air may be drawn into the chamber to form a mixture with the hydrocarbon vapors produced therein from the hydrocarbon fluid delivered through the pipe 25.

24 is a source of hydrocarbon fluid which is delivered by a pipe 23 to each of the pumps 16 of the respective heads 4. The oil is drawn into the cylinder of pump 16 through check valve 22 when the piston 17 descends. When the piston 17 is forced upward, the charge of hydrocarbon contained within the cylinder 16 is forced through the check valve 26 and into the pipe 25, by which it is delivered into the head 4. The piston 17 of the oil pump 16 works through packing 18 on the pump cylinder and has a very small movement; namely, just sufficient to insure the proper charge of oil being delivered to the head to produce therein, with the air passing through the valve inlet 8, the right admixture to produce an automatic explosion when the said gases are compressed. The lower end of the piston 17 is provided with a piston rod 19, upon the bottom of which is adjustably screwed a cap 20. Arranged about the cap 20 and resting upon an annular collar thereon is a coil spring 21, the upper end of which presses against a cap plate 16^a upon the cylinder 16, the said cap plate performing the function of sustaining the spring and also limiting the downward movement of the piston. The pump thus described is arranged exactly over the head 4 and is operated by a piston 12 arranged within a cylinder 11 formed in the upper part of the body of the head 4. A port 13 communicates with the interior of the cylinder 11 below the piston 12, and opens into the interior chamber of the head 4. The piston 12 is provided with a piston rod which extends upward through a stuffing box 15 and abuts against the bottom of the cap 20 on the pump plunger. By examining Fig. 2, it is evident that any pressure applied to the bottom of the piston 12 will necessarily force the plunger 17 of the oil pump 16 upward and cause a discharge of the oil into the pipe 25 at the moment of the existence of the required pressure within the head 4 which creates the pressure upon the bottom of the piston 12. The pressure to overcome the spring 21 should approximate the maximum pressure of the compression of the air in the compression chamber before admission of the fuel.

It is preferable in the construction last above described that the piston rod 14 shall not have a positive connection with the pump plunger 17 because the pump plunger should be capable of operating under the action of the spring 21 to suck the oil from the pipe 23 into the cylinder 16 at a rate which is commensurable with the size of the pipe and this action may continue to be performed long after the piston 12 has returned to its normal position in the bottom of its cylinder 11. The piston 12 and the piston rod 14, therefore, act to produce a positive thrust upon the pump plunger to force the oil into the head 4 against the pressure therein, but permit the plunger to return to its lowest position independently of the descent of the piston 12 within its cylinder. Furthermore, by adjusting the cap 20 upon the rod 19 of the plunger 17, it is evident that the plunger 17 may be made to assume different normal positions within the pump cylinder, and thereby vary the amount of oil which will be forced into the pipe 25 with each upward stroke of the plunger and the operating piston 12. With the adjustment of the devices shown, a maximum oil delivery is produced, and while ordinarily the machine should be carefully designed so that just the right amount of oil is delivered into the head of the chamber 4 to produce the desired explosive mixture, the provision of means for adjustment would be desirable as such adjustment would be required according to the chemical composition of the hydrocarbon fluid which might be employed.

27 is a pipe leading from a source of air pressure and is provided with a valve 28, by which air or gas may be delivered into the head 4 when desired, as in starting the operation of the apparatus. As shown, there

is a pipe 27 and valve 28 for each of the heads. In fact all of the mechanism which has been described is employed in connection with each of the two heads 4 and it will, therefore, not be necessary to repeat the description in connection with each of the said heads. Each of the heads 4 is further provided with a relief pipe 29 communicating with an exhaust pipe 30, and each of these relief pipes 29 is provided with a positively closing valve 31. These valves are so constructed that the pressure within the head 4 will cause the valves to tightly fit their seats and prevent the escape of the gases from the heads into the exhaust pipe. The two valves 31 corresponding to the respective heads are connected by a rocking lever having a handle 33, the said rocking lever 32 being loosely sleeved upon the exhaust pipe 30 and spring pressed upward by a coil spring 34, which normally keeps both valves tight upon their seats. This construction is such that if the handle 33 is rocked to the right (Fig. 1) the valve to the right hand head will be opened to relieve the said head of pressure and permit it to exhaust through the exhaust pipe 30, while the valve to the left hand head will be held tight to its seat. The reverse operation will take place if the handle is moved to the left.

Referring to the relief valve 7, the preferred construction thereof consists of the following mechanism: 45 is the valve piece which seats upon the outer face of the valve seat so that the pressure from the chamber of the head 4 will tend to force the valve piece away from its seat when the gases are escaping into the pipe 6. The valve piece 45 is provided with a stem 46 which extends through a stuffing box 47.

48 is a nut through which an adjusting screw 49 extends, the inner end of said adjusting screw abutting upon the end of the stem 46. A coil spring 50 surrounds the screw and stem and is secured at one end to the nut 48 and at the other end to the cap of the stuffing box 47. It will now be seen that when the valve piece 45 is forced away from its valve seat, it will move the screw 49 and the nut 48 backward or away from the stuffing box cap and hence put the spring 50 under tension. By adjusting the screw 49, the amount of pressure required to overcome the tension of the spring 50 may be regulated. Furthermore, by this construction the spring is not reached by the hot gases which are passing from the head 4 into the pipe 6 and consequently the temper of the spring is not affected as would be the case if the spring were arranged within the valve body. An outer case may be employed about the spring as indicated in Fig. 2, but this is immaterial and may be omitted if so desired. While this particular character of relief valve is excellently adapted for the duties of my improved apparatus, any other form of valve may be used if so desired.

While I have shown the U-shaped pipes 2, 3, 2 in Fig. 1 as arranged in a vertical plane, I do not restrict myself to this arrangement, as these pipes may be arranged horizontally as indicated in Fig. 6, or in any other suitable manner desired. Furthermore, while the heads 4 are directed upward, this is not necessary, although it is preferable. For instance, Fig. 1 may be considered as a plan view instead of an elevation and the apparatus would embody my invention and would work in the same manner as if arranged vertically. It is also evident that the bend 3 might be straightened out so that these pipes 2, 2 may lie in the same straight line. I prefer, however, to employ the bend 3 so as to bring the heads 4 reasonably close together to make the operative mechanism more compact.

In the modification shown in Fig. 8, I have shown the pipes 2, 3, 2 as arranged in a perfect circle, the only advantage of this, however, is that the resistance to the flow of the water is at all times uniform as no abrupt bends or straight parts are provided through which the water is required to change its general form during its flow. In Fig. 7 I have illustrated what is intended to represent a battery of generators each embodying my improvements, but which taken together will multiply the volume of gas generated to suit the requirements of larger engines.

As hereinbefore stated, I may provide the bend 3 with a power transmitting mechanism and such devices are shown in Figs. 1, 3, 4 and 5. In Figs. 1 and 3 the part 3 is made in the form of a cylinder, each end of which is in constant communication with the pipes 2. Piston rod 37 extends through stuffing boxes 44 and may be connected by the usual connecting rod with a crank or arranged for transmitting power in any other suitable way. The piston rod 37 is provided with a piston 38 working in the cylinder and forming therein a very loose fitting so that the water while driving the piston forward may freely escape around the said piston. Each reversal of the flow of the water through the bend and its cylinder 3, will cause a reciprocation of the piston 38 and its piston rod 37 with the result of transferring the energy of the moving body of water into rotary or other motion.

In Fig. 4, the reciprocating piston rod and piston have been replaced by a propeller 40 upon a rotary shaft 39. The rush of water alternately in opposite directions past the propeller will cause it to rotate first in one direction and then in the other. This reverse rotary motion may be utilized in any manner desired and may be modified into continuous motion by any of the well-known mechanical movements in use by engineers.

In Fig. 5 I have shown a pivoted flapper 41 arranged in the path of the water flowing through the bend 3. This flapper is rocked first in one direction and then in the other and the rocking shaft thereby operated may transmit its motion by any suitable mechanical movement as desired. It is evident that the operation of the devices shown in Figs. 3, 4 and 5 may be employed for any useful purpose in conjunction or separate from the use of the gases delivered into the receiver 5, the particular uses of the power generated by this apparatus being immaterial to my invention.

The operation of my generator will now be understood and may be described as follows: Compressed air is admitted by valve 28 into the right-hand head 4, with the result that the liquid within the pipe 2 communicating with said head is forced downward, whereas the level of the liquid in the other pipe 2 is forced upward toward the other or left-hand head 4 communicating therewith. This produces a considerable difference in level of the liquid in the two pipes 2. The valve 28 may then be closed. The hand lever 33 is then rocked to the right which action opens the valve 31 between the exhaust pipe 30 and the right hand head 4 and relieves the pressure therein. This same action positively holds the other valve 31 communicating with the left hand head 4 tightly upon its seat. This condition is maintained for a moment and then the pressure is unbalanced in this manner, the weight of the column of liquid in the left hand pipe 2, supplemented by the compression of the air in its head 4, causes the liquid to rush down the left hand pipe and rise up in the right-hand pipe toward the right-hand head 4, producing therein a compression of the air, because before this compression takes place fully the valve 31 has been closed. This action may be accelerated by admitting a charge of compressed air by the pipe 27 into the left-hand head 4. As in each case, where a pressure is produced in the heads 4, the piston 12 operating upon the oil plunger 17 causes a discharge of hydrocarbon into the chamber of the head and, while this mixture would not produce ignition from a gradual production of the said pressure, it will ignite when the production of such pressure is accomplished rapidly with the attendant generation of heat due to such rapid compression. It will, therefore, be seen that when the column of liquid is caused to rush up the right-hand pipe 2 and produce a compression of the said gases in the right-hand head 4, said gases, if of the proper admixture and if sufficient heat is generated, will explode. If the valve 31 has been closed, the said explosion of the gases will expend the power produced thereby in two ways; namely, by forcing the liquid downward in the right leg or pipe 2 and upward in the left leg or pipe 2 to compress and heat the explosive charge in the left head 4, and secondly to discharge the surplus gas under its high pressure due to the explosion through the relief valve 7 and pipe 6 into the receiver 5. If the ignition has taken place, the apparatus will now continue to operate automatically by producing mixtures and exploding them alternately in the two heads 4, 4. In making these admixtures the supply of air will be automatically drawn in through the check valves 8 and at this time the valves 28 in the compressed air pipes 27 will be permanently closed. By regulating the supply of oil, the explosive mixture produced in the heads will be very accurate to insure the maximum energy from a given amount of fuel.

In the operation of this device the compression which takes place in the heads 4 may reach a thousand pounds to the square inch and this would overcome the spring 21 of the pump and cause the piston 12 and the pump plunger 17 to operate to force the fuel into the chamber of the head 4 only when the air therein had been compressed to this high pressure and brought to a highly heated state by the said compression. When the fuel is thus injected, it is instantly vaporized and burned with the air contained within the head, and the pressure within the said head is instantly raised to a considerably higher pressure before the inertia of the column of moving water or liquid can be reversed in direction, and consequently this excess pressure is relieved by forcing the burned gases through the relief valve 7 and pipe 6 into the receiver 5. The main part of the gases produced by burning the fuel in this manner are discharged through the relief valve and only a relatively small portion of the high pressure gases remains in the clearance or compression space in the head to accelerate the water column in the opposite direction when said gases expand down to atmospheric pressure. The expansion of these gases below atmospheric pressure is due to the moving column of water which has been put into motion by the gases when existing above atmospheric pressure, and when said pressure below the atmosphere is reached, the atmospheric air is sucked through the check valve 8 into the head for the purpose of providing the air portion of the charge for the next compression and explosion when the reverse operation of the water takes place under a similar action to that above described performed in the other head.

The surging of the water back and forth

in the tubes 2 and 3 brings the same in contact with the heated heads 4 and tends to keep them from excessive heating. Furthermore, at the moment of highest compression, a small part of the water which enters the heads is vaporized and the high tension vapor so produced augments and passes with the products of combustion into the receiver 5.

In stating the above operation of the apparatus, I have assumed that the explosion takes place upon the first compression and vibration of the hand lever 33; but it is evident that if it fails to produce the desired result on the first throw of the lever 33, the operation may be repeated in the reverse direction, namely, by throwing the lever 33 to the left, so as to relieve the pressure in the left-hand head at the right time. It is also evident that, while the charging valves 28 for compressed air are shown as ordinary hand valves, they may, by simple mechanical connections, be made to automatically operate by the same lever 33, but this is immaterial to my invention because, in any event, they are only utilized in producing the initial movement of the column of liquid. My invention is more particularly directed to the means of generating the burned gases under pressure and the maintaining the column of liquid in reciprocating motion, than to the device for first starting it in motion, as this latter may be modified in various ways without departing from the essential characteristics of my invention.

The moving column of water or other fluid through the bend 3 alternately in opposite directions may be utilized as before stated to produce mechanical power by its action upon a piston, a propeller, a flapper, or in fact, upon any other mechanism which may be affected by the moving fluid.

I have described my invention with reference to ordinary water for use in the U-shaped fluid chamber or pipes, but it is evident that mercury or any other fluid may be employed in place of or in combination with water.

The advantage of my improved method of generating power resides in the utilization of the momentum of a column of water or other fluid to secure a much higher compression of the explosive mixture than it is practicable to secure with the ordinary type of construction of explosive engines, the effect of this high compression being to produce a very high initial temperature in the exploded gases, so high in fact, that when the fuel is introduced into this heated space it is vaporized and burned under the most favorable conditions for producing mechanical results. Moreover, my improved apparatus embodies simplicity of construction and lightness in weight as compared with an explosive engine of the same power, and also dispenses with the necessity of elaborately packed pistons, flywheels, gearing and heavy foundations. I, furthermore, secure the capacity in my improved generator of generating gaseous products of combustion under pressure which may be used either in the ordinary reciprocating steam engine or in a steam turbine, or as before explained, the moving column of liquid may be directly employed for positively operating a mechanical power transmitting device.

While I have described my invention in the form which I consider excellently adapted for general purposes for which it is designed, I desire it to be understood that I do not limit or restrict myself as to details of construction, as these may be modified or varied in many ways without departing from the principles of the invention.

Having now described my invention, what I claim as new and desire to secure by Letters Patent, is:—

1. In a device of the character described, the combination of a tubular passage terminating at each end in a compression chamber, a fluid in the tubular passage and free to flow toward and from each compression chamber alternately, means for admitting fuel to the compression chambers alternately, means for admitting air into the compression chambers alternately, relief devices for permitting the escape of the products from the burned air and fuel from the compression chambers when under high pressure, and timing devices for insuring the admission of the fuel to the compression chambers at a time when the air therein is under high compression.

2. In a device of the character described, the combination of a tubular passage terminating at each end in a compression chamber, a fluid in the tubular passage and free to flow toward and from each compression chamber alternately, means for admitting fuel to the compression chambers alternately said means consisting of a pump for each compression chamber to pump the fuel into the compression chamber, a cylinder and a piston for operating the pump actuated by the compressed air in the compression chamber, and means to resist the action of the piston until the compressed air has reached a high condition of compression for insuring the admission of the fuel to the compression chambers at a time when the air therein is under high compression, means for admitting air into the compression chambers alternately wherein it is compressed by the action of the fluid, and relief devices for permitting the escape of the products from the burned air and fuel from the compression chambers when under high pressure.

3. In a device of the character described,

the combination of a tubular passage terminating at each end in a compression chamber, a fluid in the tubular passage and free to flow toward and from each compression chamber alternately, ducts for admitting fuel to the compression chambers alternately, means for admitting air into the compression chambers alternately wherein it is compressed by the action of the fluid, relief devices for permitting the escape of the products from the burned air and fuel from the compression chambers and when under high pressure, and timing devices for insuring the admission of the fuel to the compression chambers at a time when the air therein is under high compression said devices being provided with adjustable means for varying the amount of the fuel which is delivered to the compression chamber at each charge thereof.

4. In a device of the character described, the combination of a tubular passage terminating at each end in a compression chamber, a fluid in the tubular passage and free to flow toward and from each compression chamber alternately, pipes for admitting fuel to the compression chambers alternately, means for admitting air into the compression chambers alternately wherein it is compressed by the action of the fluid, relief devices for permitting the escape of the products from the burned air and fuel from the compression chambers and when under high pressure consisting of spring actuated check valves, relief pipes from the relief check valves terminating in a common reservoir, devices for insuring the admission of the fuel to the compression chambers at a time when the air therein is under high compression, a pipe for delivering gas from the reservoir to the place of use, and a means for controlling the flow of gas through the said pipe.

5. In a device of the character described, the combination of a tubular passage terminating at each end in a compression chamber, a fluid in the tubular passage and free to flow toward and from each compression chamber alternately, pipes for admitting fuel to the compression chambers alternately, means for admitting air into the compression chambers alternately wherein it is compressed by the action of the fluid, relief devices for permitting the escape of the products from the burned air and fuel from the compression chambers and when under high pressure, devices for insuring the admission of the fuel to the compression chambers at a time when the air therein is under high compression and having adjustable means to regulate the quantity of fuel to be delivered to the compression chambers before explosion of the mixtures therein.

6. In a device of the character described, the combination of a tubular passage terminating at each end in a compression chamber, a fluid in the tubular passage and free to flow toward and from each compression chamber alternately, pipes for admitting fuel to the compression chambers alternately, means for admitting air into the compression chambers alternately wherein it is compressed by the action of the fluid, relief devices for permitting the escape of the products from the burned air and fuel from the compression chambers and when under high pressure, devices for insuring the admission of the fuel to the compression chambers at a time when the air therein is under high compression, and power transmitting devices arranged in the tubular passage intermediate of the compression chambers adapted to be operated by the reciprocating movement of the fluid within the said tubular passage under the action of the explosive forces generated in the compression chambers.

7. In a device of the character described, the combination of a tubular passage terminating at each end in a compression chamber, said tubular passage consisting of two upright portions supporting heads at the top in which the compression chambers are formed and connected at the bottom to form a substantially U-shaped passage, a fluid in the tubular passage and free to flow toward and from each compression chamber alternately, ducts for admitting fuel to the compression chambers alternately wherein it is compressed by the action of the fluid, means for admitting air into the compression chambers alternately, relief devices for permitting the escape of the products from the burned air and fuel from the compression chambers when under high pressure, and devices for insuring the admission of the fuel to the compression chambers at a time when the air therein is under high compression.

8. In a device of the character described, the combination of a tubular passage terminating at each end in a compression chamber, a fluid in the tubular passage and free to flow toward and from each compression chamber alternately, means for admitting fuel to the compression chambers alternately, ducts for admitting air into the compression chambers alternately wherein it is compressed by the action of the fluid, relief devices for permitting the escape of the products from the burned air and fuel from the compression chambers and when under high pressure, devices for insuring the admission of the fuel to the compression chambers at a time when the air therein is under high compression, and hand controlled means for admitting a charge of compressed air or gas to one of the compression chambers and relieving excessive compression in

the other compression chamber, said means being employed when starting the reciprocation of fluid.

9. In a device of the character described, the combination of a tubular passage terminating at each end in a compression chamber, a fluid in the tubular passage and free to flow toward and from each compression chamber alternately, ducts for admitting fuel to the compression chambers alternately, means for admitting air into the compression chambers alternately wherein it is compressed by the action of the fluid, relief devices for permitting the escape of the products from the burned air and fuel from the compression chambers and when under high pressure, devices for insuring the admission of the fuel to the compression chambers at a time when the air therein is under high compression, means for admitting a charge of compressed air or gas to each of the compression chambers as may be required in starting the reciprocation of the fluid between the compression chambers, and hand controlled devices for relieving the compression in each of the compression chambers according to the requirements when starting the apparatus as aforesaid.

10. In a device of the character described, the combination of a tubular passage terminating at each end in a compression chamber, a fluid in the tubular passage and free to flow toward and from each compression chamber alternately, ducts for admitting fuel to the compression chambers alternately, means for admitting air into the compression chambers alternately wherein it is compressed by the action of the fluid, relief devices for permitting the escape of the products from the burned air and fuel from the compression chambers and when under high pressure, devices for insuring the admission of the fuel to the compression chambers at a time when the air therein is under high compression, means for admitting a charge of compressed air or gas to each of the compression chambers as may be required in starting the reciprocating of the fluid between the compression chambers, and hand controlled devices for relieving the compression in each of the compression chambers according to the requirements when starting the apparatus as aforesaid, said hand controlled devices consisting of an exhaust pipe having communication with each of the compression chambers, exhaust valves arranged between the compression chambers and the pipe, devices common to both of the valves for holding them normally closed and hand operated means for separately opening either of said exhaust valves.

11. In a device for securing power from explosive mixtures, the combination of a chamber in which the explosive mixture is burned, means for supplying an explosive mixture to said chamber, and a relief valve for the products produced by the explosion consisting of a valve casing opening from the chamber, a valve piece seating upon the case against the pressure of the chamber and having a stem extending through the case, a stuffing box around the stem, and a coiled spring outside of the case entirely clear of the passage of the hot products of combustion and normally held in a stretched condition, said spring having one end connected with the case and the other end acting upon the valve stem to force the valve piece upon its seat.

12. In a device for securing power from explosive mixtures, the combination of a chamber in which the explosive mixture is burned, means for supplying an explosive mixture to said chamber, and a relief valve for the products produced by the explosion consisting of a valve casing opening from the chamber, a valve piece seating upon the case against the pressure of the chamber and having a stem extending through the case, a stuffing box around the stem, and a coiled spring outside of the case entirely clear of the passage of the hot products of combustion and normally held in a stretched condition, said spring having one end connected with the case and the other end acting upon the valve stem to force the valve piece upon its seat, and means to adjust the tension of the spring by varying its stretched condition.

13. The herein described method of generating power which consists in putting a confined body of fluid into rapid reciprocation between two compression chambers, alternately supplying air to the compression chambers when the liquid is moving away from said compression chambers, alternately supplying fuel to the compression chambers when the liquid is approaching the said compression chambers respectively, exploding the mixture of air and fuel when under high compression, relieving the compression chamber of the gases produced by the explosion simultaneously with the action of the said expanding gases to propel the fluid away from the compression chamber in which the explosion is taking place and toward the other compression chamber, repeating the said operation alternately in each compression chamber, and utilizing the power of the exploded mixture.

14. The herein described method of generating power which consists in putting a confined body of fluid into rapid reciprocation between two compression chambers, alternately supplying air to the compression chambers when the liquid is moving away from said compression chambers, alternately supplying fuel to the compression chambers when the liquid is approaching the said compression chambers respectively, explod-

ing the mixture of air and fuel when under high compression, relieving the compression chamber of the gases produced by the explosion simultaneously with the action of the said expanding gases to propel the fluid away from the compression chamber in which the explosion is taking place and toward the other compression chamber, repeating the said operation alternately in each compression chamber, receiving the gases produced by the explosion in a receiver, and utilizing the said gases in a continuous manner under throttling control.

15. The herein described method of generating power which consists in putting a confined body of fluid into rapid reciprocation between two compression chambers, alternately supplying air to the compression chambers when the liquid is moving away from said compression chambers, alternately supplying fuel to the compression chambers when the liquid is approaching the said compression chambers respectively, exploding the mixture of air and fuel when under high compression, relieving the compression chamber of the gases produced by the explosion simultaneously with the action of the said expanding gases to propel the fluid away from the compression chamber in which the explosion is taking place and toward the other compression chamber, repeating the said operation alternately in each compression chamber, and utilizing the power of the inertia of the reciprocating body of liquid by causing said liquid to operate upon mechanical power transmitting devices.

In testimony of which invention, I hereunto set my hand.

WILLIAM N. HOWELL.

Witnesses:
DENIS F. KELLER,
G. HOWARD SCRIBNER.