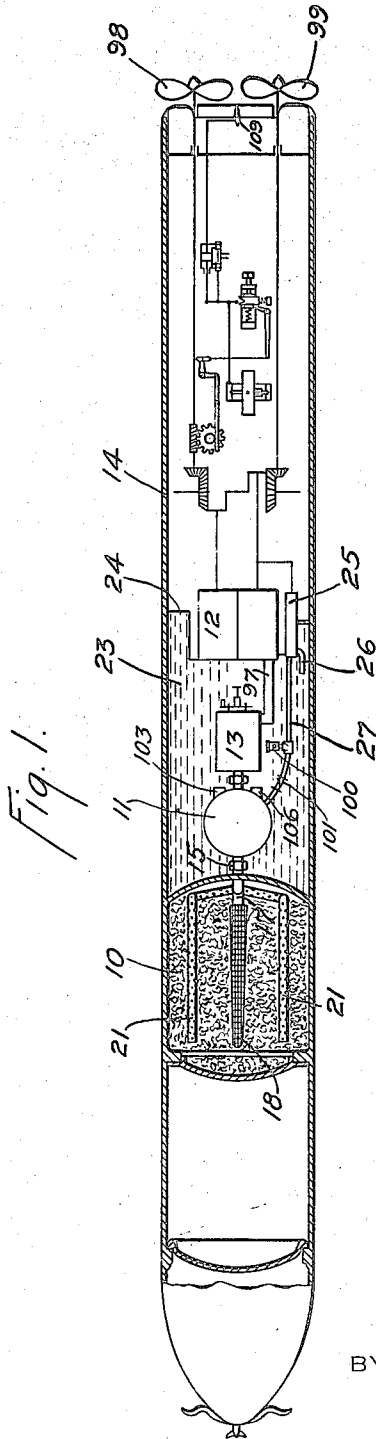


A. T. KASLEY.
 METHOD AND APPARATUS FOR GENERATING POWER.
 APPLICATION FILED AUG. 11, 1916. RENEWED NOV. 4, 1921.

1,419,267.

Patented June 13, 1922.

4 SHEETS—SHEET 1.



INVENTOR.

Alexander T. Kasley

BY *Green & McCariston*

HIS ATTORNEYS IN FACT

A. T. KASLEY.

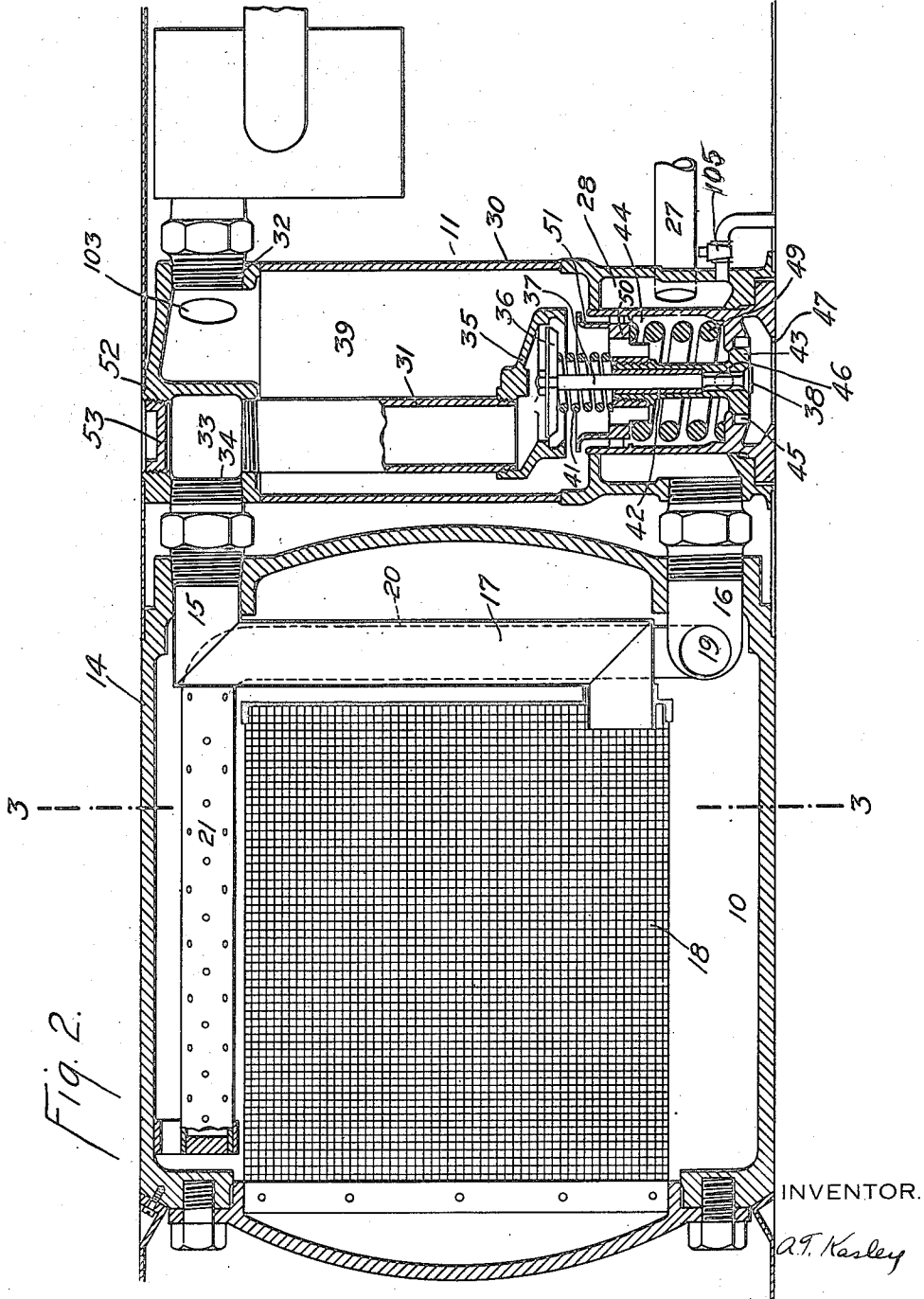
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4 SHEETS—SHEET 2.



BY

Green M. Calliston
HIS ATTORNEY IN FACT

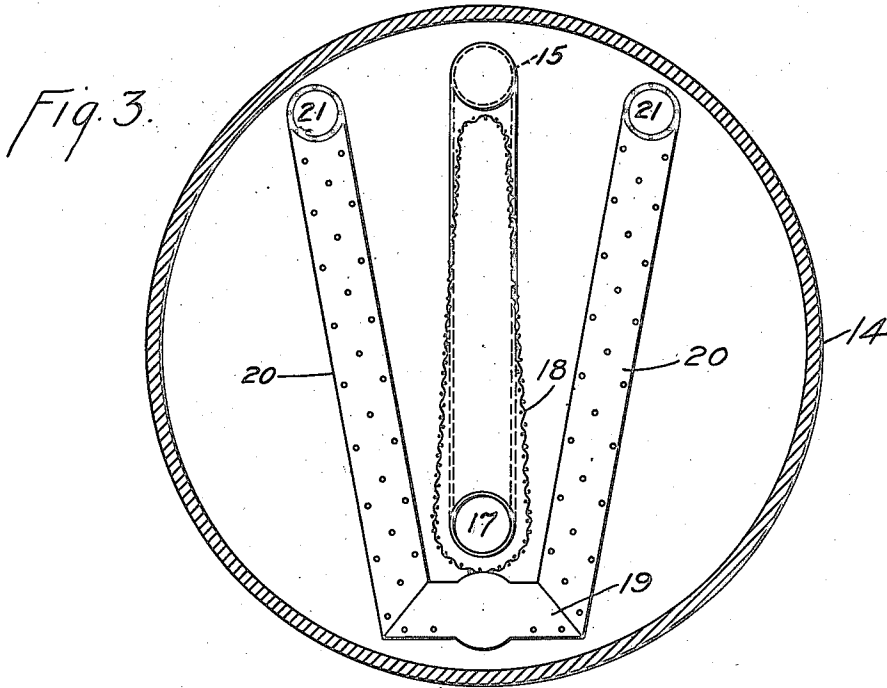
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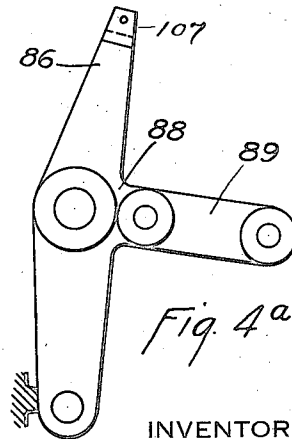
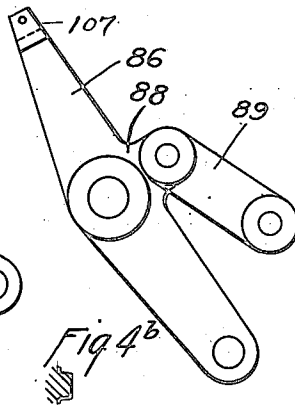
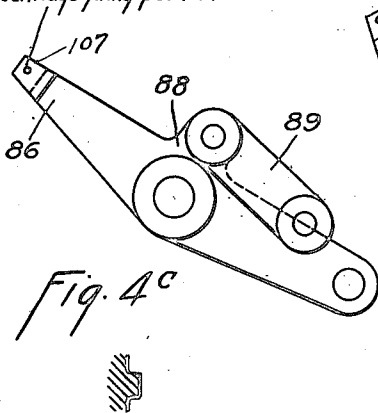
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4 SHEETS—SHEET 3.



Cartridge firing position.



INVENTOR.

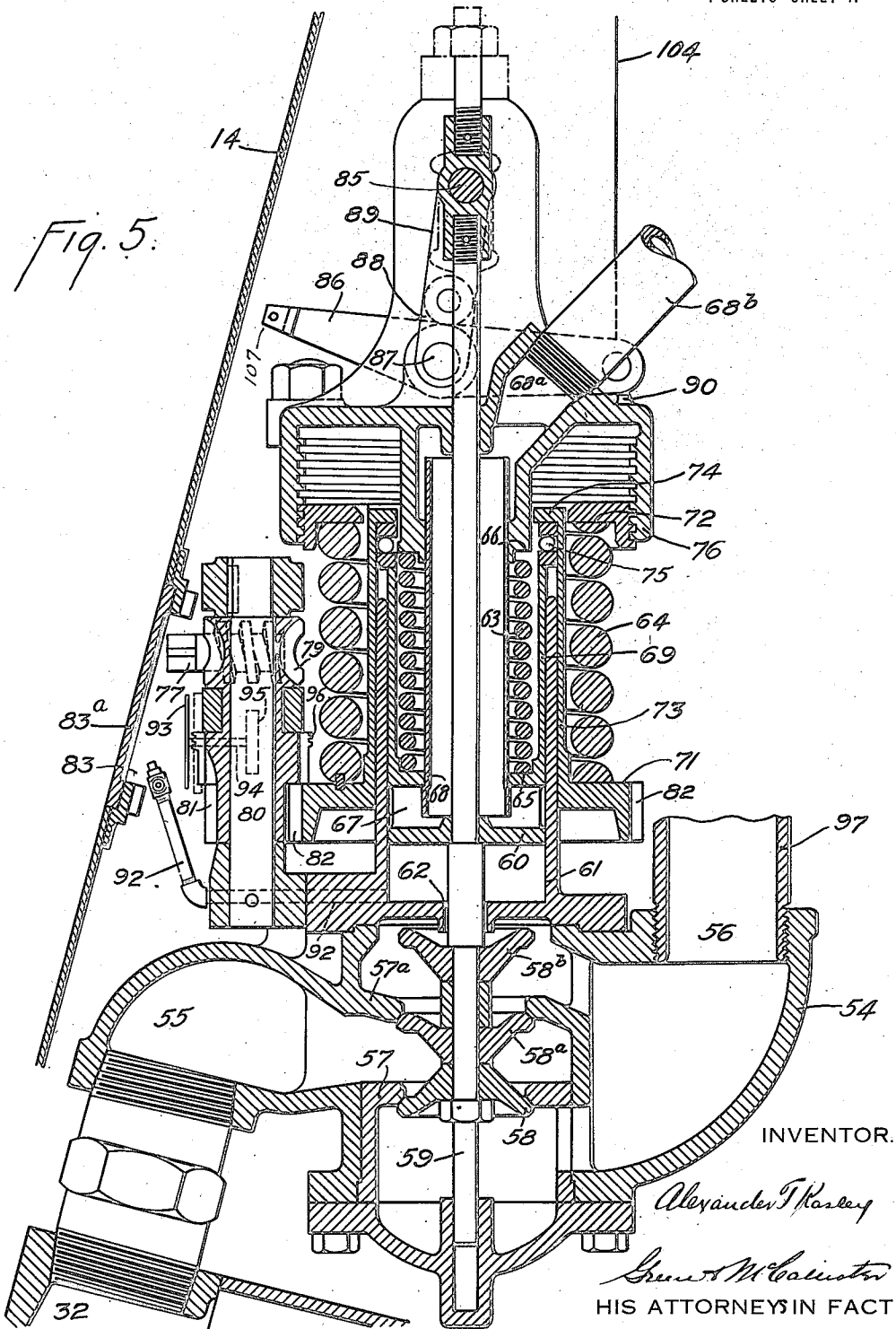
Alexander T. Kasley
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4 SHEETS—SHEET 4.



UNITED STATES PATENT OFFICE.

ALEXANDER T. KASLEY, OF ESSINGTON, PENNSYLVANIA, ASSIGNOR TO WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA.

METHOD AND APPARATUS FOR GENERATING POWER.

1,419,267.

Specification of Letters Patent. Patented June 13, 1922.

Application filed August 11, 1916, Serial No. 114,397. Renewed November 4, 1921. Serial No. 512,941.

To all whom it may concern:

Be it known that I, ALEXANDER T. KASLEY, a citizen of the United States, and a resident of Essington, in the county of Delaware and State of Pennsylvania, have made a new and useful invention in Methods and Apparatus for Generating Power, of which the following is a specification.

This invention relates to a method of generating power and also power generating apparatus for submersible vessels such as automobile torpedoes or submarines.

The so-called automobile torpedoes, now in use, are limited to a speed of about 35 knots and their useful range at approximately 28 knots is about 10,000 yards. Inasmuch as the fighting range of modern battle fleets is approximately 15,000 to 20,000 yards, it is desirable to produce a torpedo having a greater range than those now in use, and this is an object of my present invention.

The torpedoes now in use are usually impelled by compressed air and it is therefore not only necessary for the vessel, equipped with torpedo launching tubes, to be provided with an air compressor, capable of compressing air to exceedingly high pressures, but it is also necessary to charge each torpedo with compressed air, a relatively short time before the torpedo is launched. The process now employed of charging torpedoes with compressed air is troublesome, by reason of the fact that the air within the air chambers of the torpedo is compressed, as additional air is pumped into these chambers, and consequently some means, in addition to the ordinary air coolers employed in connection with the compressor apparatus, must be employed for keeping the torpedoes cool. This is ordinarily accomplished by subjecting the torpedo to the cooling action of a stream of water while it is being charged.

A further object of my invention is to produce a torpedo which may be charged with the power producing agents or elements at any time, which will retain the charge, in an inactive condition, for an indefinite period, which may be charged without the necessity of providing special and complicated apparatus and which will have a longer range of travel.

A further object is to produce a driving mechanism for submersible vessels, such as torpedoes, in which means are employed

within the vessel itself, for generating the operating pressure which drives the propelling apparatus.

A further object is to produce a torpedo which is easily and quickly charged, and which has a longer range of travel than torpedoes now in use or known to me.

A further object is to produce a new and improved method of generating power for propelling submersible vessels, such for example as self-propelled torpedoes.

While I do not wish to limit my invention to torpedoes, as that term is usually employed, and while I desire it to be understood that the broad principle of the invention is applicable to any self-impelled apparatus and particularly to submersible apparatus, I have illustrated the invention in connection with a so-called automobile torpedo and, for the sake of simplicity, I will describe it in connection with such an apparatus.

In the drawings accompanying and forming a part hereof:

Figure 1 is a diagrammatic longitudinal sectional view of a torpedo equipped with apparatus embodying my invention.

Figure 2 is a fragmental longitudinal sectional view on an enlarged scale of a torpedo and illustrates in detail the construction of a pressure generator and a separator, which form parts of the illustrated embodiment of my invention.

Figure 3 is a sectional view along the line 3-3 of Fig. 2.

Figs. 4^a, 4^b, and 4^c illustrate successive positions of a locking or release mechanism which may be employed in connection with a regulating valve which forms a part of the apparatus illustrated.

Fig. 5 is a fragmental longitudinal sectional plan view, on an enlarged scale, of a torpedo, and illustrates a control or reducing valve forming a part of the apparatus illustrated.

In carrying out the process, which is one of the inventions herein described, I employ the principle, that heat is generated concomitantly with certain chemical reactions. I also employ the principle that a gas is evolved, in connection with certain chemical reactions, and particularly when a metal is subjected to the action of a chemical reagent capable of uniting with it to form a chemical compound in which the metal is

included as an element. While I do not desire to limit the invention to the use of any particular chemical agents or reagents, I have found by experiment that when metallic aluminum is subjected to sodium hydroxide solution (NaOH_{aq}), gas is not only evolved, but the reaction is accompanied by the generation of intense heat. This is due to the fact that metallic aluminum has a high affinity for oxygen and, when subjected to the action of water is capable of breaking up the water into its component elements, viz., oxygen and hydrogen. Under ordinary atmospheric conditions, metallic aluminum is protected by a coating of aluminum hydroxide $\text{Al}(\text{OH})_3$ which is insoluble in water but is soluble in caustic soda solution. As soon as the protecting coating of aluminum hydroxide is removed, the aluminum combines with the oxygen of the water, to which it is subjected, and intense heat is generated. I employ the heat so evolved in evaporating a portion of the water or the caustic soda solution, to which the metallic aluminum is subjected.

While I have described the use of aluminum and caustic soda solution in carrying out my improved method of generating power, the following are examples of chemical agents and reagents, which may be employed:

- Metallic sodium plus water;
- Metallic calcium plus water;
- Sodium bicarbonate plus a dilute acid;
- Hot copper oxide plus kerosene and water.

The apparatus herein illustrated, as an embodiment of a part of the invention, includes a pressure generator 10, in which motive fluid under pressure is generated by the heat occasioned by subjecting metallic aluminum to the action of water, or to the action of caustic soda solution. The apparatus also includes a separator 11, which separates the liquid carried over from the generator or generating chamber, from the fluid delivered from that chamber. (In this connection I use the term fluid to designate both the gases and vapors or steam delivered from the generator). In the drawings I have disclosed an engine or pressure operated motor 12, which receives the motive fluid generated in the chamber or generator 10, and I have also illustrated a regulator or controlling valve 13, which is capable of manual adjustment for the purpose of varying the speed of the engine, and consequently the range of travel of the torpedo.

As illustrated, the pressure generator or generating chamber 10 is formed within the shell 14 of the torpedo and is provided with a fluid delivery port 15 and a liquid inlet port 16. As shown, the delivery port is located near the top of the chamber and is provided with a pipe or passage 17,

which extends downwardly and terminates within, and near the bottom of the chamber 10. The inlet end of the pipe 17 is enclosed by wire gauze 18, for the purpose of preventing solid particles of appreciable size from being blown through the delivery port with the motive fluid delivered from the generating chamber. As illustrated, the gauze 18 encloses a screening chamber, which extends upwardly almost to the top of the generating chamber, and therefore provides a large delivery area for the fluid generated within the chamber.

I have found that the best results are obtained by employing metallic aluminum in a sub-divided form and consequently I fill the interior of the chamber 10 with pieces of aluminum, which are preferably of irregular shape. The wire gauze or the screen chamber is therefore surrounded by aluminum particles and is of course of a mesh sufficient to prevent all but the smallest particles of aluminum or of solid material, encountered in the carrying forward of the process, from being discharged through the delivery port with the fluid generated.

In order that the evolution of fluid will not be localized within the chamber, I have provided means for spraying the caustic soda solution into different parts of the chamber 10, so that substantially all of the metallic aluminum will be simultaneously subjected to the action of the soda solution. As shown, the liquid inlet port 16 is located near the bottom of the chamber 10 and is provided with a spray head 19, which is located within the chamber and is provided with two upwardly extending perforated pipes 20, each of which extends into the upper portion of the generating chamber. Each pipe 20 is shown provided with a horizontal extension 21, which extends longitudinally of the shell 14 and adjacent to the top of the chamber 10. The sprayer head, the pipes or passages 20 and the extensions 21, may be formed in one piece, but they are all perforated in such a way that substantially the entire interior of the chamber 10 will be sprayed with the caustic soda solution delivered through the port 16.

As shown in Figure 1, the caustic soda solution is contained within a chamber 23, which is formed within the shell 14 of the torpedo and is located between the generator 10 and a bulk head 24 which extends across the interior of the torpedo and is secured to the shell 14. For the purpose of lightening the torpedo and also of controlling the evolution of fluid within the generator, it may be desirable to fill the chamber 23, or a smaller chamber with a concentrated solution of caustic soda, and to admit sea water in varying amounts through the shell of the torpedo for the purpose of diluting the soda solution more

or less in accordance with the pressure encountered in the generating chamber; or it may be desirable to employ means for admitting sea water in regulable quantities, for the purpose of forming a less concentrated soda solution within a separate chamber of the torpedo, and to then regulate the amount of solution delivered to the generating chamber.

10 In the present embodiment I have shown the chamber 23 filled with caustic soda solution and I have shown a pump 25, driven by the engine 12 and so arranged that its inlet 26 communicates with the chamber 23. The
15 delivery port of the pump communicates through piping 27 with the liquid inlet port 16 of the generating chamber. As shown in Figure 2, the piping 27 does not communicate directly with the port 16, but communi-
20 cates with a chamber 28, which forms a part of the separator 11 and communicates directly with the port 16.

The separator 11, shown in Figure 2 of the drawings, consists of a substantially
25 cylindrical shell 30, which encloses a downwardly projecting fluid delivery pipe 31 through which fluid is delivered from the fluid delivery port 15 of the generator, in such a way that it must reverse its direc-
30 tion of flow before being delivered through the delivery port 32 of the separator. The upper end of the pipe 31 communicates with a chamber 33, formed within the wall of the separator and provided with a port 34,
35 which communicates with the port 15 of the generator. The lower end of the pipe 31 communicates with a casing 35, in which a movable disc 36 is located. The disc 36 is mounted on a stem 37, which performs the
40 double function of guiding the disc and of operating a water discharge valve 38. The disc 36 is so arranged within the casing that it provides a relatively restricted passage through which fluid, issuing from the gen-
45 erator 10, must pass before entering the large chamber 39 of the separator. As illustrated, the disc 36 and the valve 38 are controlled by a coiled spring 41, which surrounds the
50 stem 37 and operates between the disc and an abutment formed by the valve stem 42 of a safety valve 43, it being apparent that the stem 37 extends through the hollow interior of the valve stem 42. The spring 41 is so arranged that it normally holds the
55 valve 38 closed and normally presses the disc in a direction opposite to that of the flow of fluid passing it. The restricted passage, formed by the disc 36 and the casing 35, directs the fluid, traversing it, down-
60 wardly and into a liquid collecting chamber 44. The lower end of this chamber is provided with a port 45, which is normally closed by the safety valve 43, and a pas-
65 sage 46 is formed, within the safety valve and its stem, 42, for discharging liquid

which may collect in the chamber 44, through a port 47 formed in the shell 14 of the torpedo, and directly communicating with the port 45. The passage 46 is controlled by the valve 38 and is closed, under
70 normal conditions of fluid flow, since the fluid pressure on opposite sides of the disc 36 will be substantially balanced and the slight preponderance of pressure above the disc will not be sufficient to force the disc
75 downwardly in opposition to the pressure of the spring 41. If, however, appreciable quantities of liquid are delivered with the fluid, the restricted passage, between the disc 36 and the casing 35, will be further
80 restricted, or momentarily sealed, and the disc will move downwardly in response to the unbalanced fluid pressure occasioned by the sealing or choking of the normally restricted passage and the valve 38 will
85 open. The liquid contained within the collecting chamber, will then be blown out through the port 47 by the pressure existing within the separator.

The safety valve 43, like the valve 38, is
90 an outwardly opening valve and is normally held closed by a coiled spring 49, which surrounds the stem 42 and is located between an end wall of the chamber 44 and an ad-
95 justable nut or collar 50 mounted on the stem. As illustrated, the collar 50 is provided with passages for the purpose of delivering the liquid, extracted from the fluid issuing from the pipe 31, into the bottom of the collecting
100 chamber. The collar is also provided with an upwardly projecting flange 51, which serves as a directing or collecting apron, in that the flow of motive fluid is reversed within the confines of the flange and the flange
105 cooperates with the casing 35 in forming a somewhat circuitous passage for the fluid after it has been discharged past the disc 36. In case the pressure in the generator, and consequently in the separator, exceeds a de-
110 termined pressure, the valve 43 opens, in opposition to the pressure of the spring 49, and thereby vents the system through the port 47.

The wall of the chamber 44 forms one wall of the annular liquid delivery chamber 28, to which I have previously referred, and
115 consequently all the liquid entering the generator 10 is first subjected to the heating action of the liquid collected in the chamber 44.

The upper end of the separator 11 is provided with a charging port 52, which is
120 normally closed by a screw plug 53, and communicates with the chamber 33. The port 52 is, in effect, formed in the shell 14 of the torpedo and is employed for introducing the primary charge of caustic soda into the fluid
125 generating system, as will be hereinafter more fully described.

In the apparatus illustrated, the delivery of fluid to the engine 12 is controlled by the valve 13, which performs the functions of a
130

pressure regulator and is also adapted to cut off communication between the generator 19 and the engine 12, until after the generator is in operation. The valve is also adapted to cut off communication between the generator and the engine, after the pressure in the generator falls below a determined pressure, due to the fact that the charge of one or both chemical agents or reagents is exhausted.

As illustrated, the valve 13 includes a casing 54, which is provided with an inlet port 55, adapted to communicate with the delivery port 32 of the separator, and a discharge port 56, adapted to communicate with the fluid admission piping of the engine. Two ported diaphragms 57 and 57^a are located within the casing 54 between the ports 55 and 56. As illustrated, three valve discs 58, 58^a and 58^b cooperate with the diaphragms, in controlling the delivery of fluid through the valve. The three discs are mounted on a single valve stem 59, which is provided within the casing 54, with a pressure responsive piston 60 capable of controlling the operation of the valve in response to variations in the pressure of the fluid delivered by the valve to the engine 12.

As illustrated, the piston 60 is located within a cylinder 61 formed within the valve casing and adapted to communicate with the delivery side, or the delivery port of the valve, through an annular passage 62, located around the valve stem 59. As illustrated, the piston 60 is controlled by the combined action of two coiled springs 63 and 64, the latter of which is adjustable. The former spring operates between a spring seat 65, shown secured to the piston 60, and a stationary seat 66, which forms a part of the valve casing 54. As illustrated the spring seat 65 is separated from the piston 60 by radial webs 67 and surrounds a tubular member 68, which may be rigidly secured to the piston 60 and may cooperate with the valve stem 59 in guiding the valve discs during their motion. The spring seat 65 is provided with an annular flange 69, which is concentric with the valve stem 59 and the tubular member 68 and, extending away from the piston 60, engages the inner cylindrical face of the cylinder 61. This flange 69 provides an operative connection between the adjustable spring 64 and the piston, and also acts as a packing in that it prevents leakage of fluid past the seat 65, as will hereinafter be described.

The spring 64 surrounds the cylinder 61 and operates between a movable spring seat 71 and an adjustable spring seat 72. The spring seat 71 is formed integrally with a sleeve 73, which has a sliding fit with the outer face of the cylinder 61. The end of the sleeve, farthest removed from the spring seat 65, is provided with an inwardly projecting

annular flange 74 which, through the agency of a ball bearing connection 75, is adapted to engage the adjacent end of the flange 69 and, in this way, impart the pressure of the spring 64 to the piston 60 or to the valve stem 59. The tension of the spring 64 is adjusted by turning the spring seat 71 to different positions, about the cylinder 61, and by thereby turning the spring seat 72, through the agency of the spring 64 itself. The outer peripheral face of the spring seat 72 is provided with screw threads which cooperate with an internally threaded sleeve 76, shown as mounted on the valve casing 54. In order that the spring seat 72 will turn with the spring seat 71 it is desirable that the ends of the spring 64 shall be doweled to the spring seats 71 and 72.

As illustrated, the spring seat 71 is turned by means of a key ended worm 77, a worm wheel 79, and a gear 81, which meshes with the gear teeth 82 provided on the peripheral face of the seat 71. The worm wheel 79 and gear 81 are shown formed in one piece and are rotatively mounted on a suitably located shaft 80. The key end of the worm 77 is located in an accessible position, with relation to the hand hole 83 formed in the shell 14 and provided with a cover plate 83^a. With this arrangement the tension of the spring 64 may be adjusted and consequently the pressure of the fluid delivered by the valve 13 may be varied.

In order that the valve will remain closed, until the torpedo is launched and the generating chamber 10 is capable of delivering fluid under pressure, I have provided means for locking it closed, in opposition to the pressure of the springs 63 and 64. As illustrated in Figure 5 and as clearly shown in Figures 4^a, 4^b and 4^c, this closing or locking means consists of toggle linkage, which is located between the sleeve 76 and a pin 85 carried by the valve stem 59. One link of the toggle consists of a lever 86, which is fulcrumed on a pin 87 carried by a lug formed on the sleeve 76 and which is provided with a laterally projecting arm 88. The arm 88 is, in effect, one link of the toggle and is pivotally connected to the other link 89. The opposite end of the link 89 is pivotally mounted on the pin 85, carried by the valve stem. The toggle joint is so mounted between the sleeve 76 and the valve stem that one end of the lever 86 engages a lug 90 formed on the sleeve when the links are approximately in the straight line position. The lug 90 is preferably so located, with relation to the line of the thrust imparted to the link 89 by the valve stem 59, that the toggle will remain in the valve closing position until it is tripped by moving the end of the lever 86 out of engagement with the lug 90. The tripping of the toggle may be accomplished at the launch-

ing of the torpedo by any suitable means, and in order that the springs 63 and 64 will not immediately close the valve by moving the valve disc 58^a against the diaphragm 57 and the valve disc 58^b against the diaphragm 57^a, I provide a passage 92 for partly filling the cylinder 61 with oil, after the toggle has been set in the valve closing position. The passage 92 is preferably located in such a position that it is accessible through the hand hole 83, and it is also provided with a valve for closing it after the oil has been introduced into the cylinder 61. It will be apparent that the cylinder cannot be filled more than half full of oil, since additional oil will run out of the fluid passage 62 provided around the valve stem. This, however, is not objectionable, since the oil confined in the cylinder will check the piston 60 after it has moved through approximately one-half of its stroke and, in this way, it will check the closing movement of the valve discs 58^a and 58^b and will hold the valve open for an appreciable time or until fluid, delivered from the generator 10 is capable of exerting a pressure on the piston 60 in opposition to the pressure of the springs 63 and 64. As soon as the piston 60 moves, in response to the fluid pressure delivered through the valve, the operation of governing the amount of fluid pressure delivered by the valve is imposed upon the valve discs 58 and 58^a, which in themselves form a balanced valve and will move toward their seats to close off the flow of fluid as the pressure of the fluid, delivered through the port 62 and acting on the piston 60 exceeds the pressure for which the combined springs 63 and 64 are adjusted. In this way the valve, operating as an ordinary reducing valve, will maintain the pressure delivered to the engine substantially constant as long as the generator is capable of delivering fluid at a pressure in excess of that for which the valve is adjusted.

In this connection, attention is called to the fact that the adjusting mechanism of the spring 64 may be provided with an indicating pointer 93, which moves across a dial for the purpose of indicating the adjustment of the spring 64. As shown, the pointer 93 is mounted on the standard 94, which carries a worm wheel 95, and the worm wheel engages a worm 96 mounted on the gear 81.

The valve casing 54 may also be provided with a leakage delivery port 68^a, through which fluid, leaking past the piston 60, will be discharged. The port 68^a may and preferably will communicate with a port, formed in the shell of the torpedo, through piping 68^b. As illustrated, the port 68^a communicates with the space between the spring seat 65 and the piston 60, through the tubular member 68. With this arrangement, the

fluid leaking past the piston will pass out through the port 68^a since the flange 69, on the spring seat 65, will present a greater resistance to leakage flow than the comparatively free passage through the port 68^a. It will, of course, be apparent that the piping 68^b may be provided with a check valve to prevent water entering the port 68^a.

The fluid delivered by the reducing or control valve 13, passes to the engine through a supply pipe or passage 97. In Figure 1, I have diagrammatically illustrated the engine as consisting of two cylinders and as provided with two piston rods which operate, in connection with a double crank, in driving two propellers 98 and 99 by means of beveled gears, so arranged that the propellers are driven in opposite directions. The engine of course exhausts through the shell 14.

The engine 12 is preferably so designed that it will be capable of operating on relatively wet fluid, or on fluid containing some liquid. This is accomplished by making its valve areas ample; and this in turn renders the engine capable of taking care of any small particles of solid material which may be carried over from the generator and are not retained in the separator. It will be apparent to those skilled in the art, that the engine 12 may be replaced by a turbine and that such a substitution will, to some extent, simplify the apparatus, since solid particles and liquid carried by the motive fluid will have little, if any, detrimental effect on the turbine.

The engine 12 drives the pump 25 which delivers liquid reagent or caustic soda solution to the generator 10. In Figure 1, I have shown a relief valve 100, which may be employed in the delivery piping of the pump. This relief valve operates as a safety valve and is set for the desirable pressure within the generator. As soon as the pressure within the generator exceeds this pressure, the pump 25, instead of delivering additional soda solution to the generator, opens the valve 100 and pumps the solution back into the chamber 23, from which it is drawn. In this way, the delivery of caustic soda solution to the generator 10 is controlled by the pressure within the generator. In Figure 1, I have diagrammatically shown a check valve 101, which may be located in the pipe 27 on the generator side of the valve 100 and which will prevent caustic soda solution from being blown out of the generator, when the valve 100 is opened.

The operation of the apparatus, as applied to a torpedo, is as follows: Assuming that the generating chamber is charged with metallic aluminum, which may be pure aluminum or aluminum carrying some impurities, since I have found that aluminum containing some sodium and silicon is not

objectionable, and assuming also that the chamber 23 is filled with an adequate supply of caustic soda solution, it is then necessary to provide some means for generating pressure for starting the engine 12, or to be more concise, it is necessary to provide some means for starting the pump 25, which delivers caustic soda solution into the generator. This may be accomplished by introducing a preliminary charge of caustic soda solution into the separator 11, and thereby providing some means for subjecting the separator to pressure. In the drawings I have shown the separator provided with a cartridge chamber 103, which is adapted to receive a blank cartridge capable of being fired into the separator for the purpose of increasing the pressure within the separator chamber 39. Before launching the torpedo, the discharging mechanism of the cartridge is set, and the chamber 39 is filled with caustic soda solution to some point well above the disc 36. This may be accomplished by removing the plug 53 and by filling the chamber 39 directly through the pipe 31. The plug 53 is then replaced and the torpedo is ready to be launched. The mechanism for starting the gyroscope, which is usually tripped at the time the torpedo is discharged from the torpedo tube, may also be employed for firing the cartridge in the chamber 103. The increased pressure, occasioned by firing the cartridge, forces the caustic soda solution, through the pipe 31, the fluid delivery port 15 and the pipe 17 into the interior of the generator and consequently into contact with the aluminum contained within the generator. Inasmuch as the chemical reaction resulting from subjecting aluminum to caustic soda solution is rapid and the heat evolved is intense, the generator operates somewhat like a flash boiler and fluid pressure is generated within the chamber 10 almost immediately. By the time the locking toggle of the valve 13 is tripped, the generator is not only capable of delivering sufficient fluid to start the engine, but to drive it at high speed.

It will be apparent that the preliminary charge of caustic soda solution may be omitted from the separator chamber and that the engine may be started by the pressure developed by firing the cartridge into the chamber. If this method of procedure is employed, the cartridge will preferably be charged with a charge of slow burning smokeless powder, which will be adequate to produce the desired pressure within the generator. This will be advantageous in that the aluminum, within the generator, will be preheated, which will aid in the generation of steam when the pump 25 delivers solution to the generator.

In Figure 5, I have shown means which may be employed for tripping the toggle

after the torpedo has left the tube, in case it is desirable to delay the tripping for that length of time. As shown, I provide a cable 104, one end of which is secured to the end of the lever 86 adjacent to the lug 90. This cable may extend through suitable protecting tubes within the shell 14, and is preferably so designed that it will break at some point within the protecting tubes when subjected to excessive strain. The outer end of this cable may be attached to a second cable, carried on a spring wound reel within the launching tube. During the operation of launching of the torpedo, the reel allows the second cable to unwind, until the torpedo is free of the launching tube or projecting spoon, at which time the cable 104 is stretched tight so that it first breaks the toggle joint, and then is severed within its protecting tube.

As soon as the engine 12 is in operation, the pump 25 begins to deliver caustic soda solution to all parts of the generator, and the evolution of gas and of steam continues until the charge of aluminum is exhausted.

When a large cartridge is employed for starting the engine, and the preliminary charge of soda solution is omitted from the separator, the cartridge may be fired by the cable 104, and the toggle closing mechanism of the valve 13 may be replaced by a spring retracted latch, adapted to engage the stem 59 of the valve 13 and to hold the valve open, in opposition to the closing springs. As soon as the pressure delivered through the valve is sufficient to move the piston 60, in opposition to the springs 63 and 64, the latch will be retracted by its actuating spring and the valve will then be free to operate in response to the pressure of the fluid delivered by it.

The fluid pressure delivered by the valve 13 decreases as soon as the charge of aluminum is exhausted, and this permits the spring 63 to move the valve disc 58^a against the diaphragm 57, and the valve disc 58^b against the diaphragm 57^a. It will be apparent that after the valve is closed, it cannot be opened by an increase in pressure within the generator, since the discs 58^a and 58^b cooperate to form a balance valve.

In order that the torpedo may be recovered in practice firing, I have provided means for discharging all of the caustic soda solution, contained within the generator, from the torpedo at the time the discs 58^a and 58^b operate to close the valve 13. The means illustrated consists of a trigger actuated drain cock 105, (shown in Figure 2) which may communicate with the lowest part of the generating chamber, or as illustrated, may communicate with the liquid delivery chamber 28. It may also be necessary to subject the generating chamber to additional pressure for the purpose of forcing liquid

out of it through the drain cock, and this may be accomplished by firing a second cartridge into the generator, or into the fluid passages communicating with it. In Figure

the fluid evolved by the chemical reaction and by evaporation occasioned by the heat accompanying the chemical reaction, from the chamber, in separating the liquid from the gases and expanding the mixed gases, so discharged, in doing useful work.

3. A power developing apparatus for submerged vessels, comprising a fluid pressure generator in which pressure is generated by a chemical reaction, a separator receiving the fluid delivered by the generator, a reducing valve receiving the fluid issuing from the separator, a fluid driven engine receiving the fluid delivered by the valve, and means for forcing a chemical reagent into said generator.

4. A power developing apparatus for submersible vessels, comprising a pressure generator, charged with a chemical reagent, a fluid actuated engine adapted to receive fluid pressure delivered from said generator, means driven by the engine for delivering a chemical solution to said generator, and means for initially subjecting said generator to fluid pressure for the purpose of starting said engine and said chemical solution delivering means.

5. A power developing apparatus for submersible vessels, comprising a pressure generator, charged with a chemical agent, a fluid actuated engine adapted to receive fluid pressure delivered from said generator, a pump driven by the engine, for delivering a chemical solution to said generator, and means for initially delivering fluid pressure to the engine for the purpose of starting the delivery of solution to the generator.

6. A power developing apparatus for submersible torpedoes, comprising a generator located in the torpedo shell and in which fluid pressure is developed by chemical reaction and by the heat evolved by the reaction, an engine for receiving fluid under pressure from said generator, adjustable means for controlling the delivery of fluid from the generator to the engine and for maintaining substantially constant a determined fluid pressure at the inlet to the engine, independently of increases in pressure within the generator, means for delivering a chemical reagent to said generator, and means for creating an initial pressure within the generator for the purpose of initially starting the delivery of chemical reagent to said generator.

7. A power developing apparatus for submersible torpedoes, comprising a generator located within the torpedo shell and in which fluid pressure is developed by chemical reaction, an engine for receiving fluid delivered from the generator, and an adjustable controlling valve for controlling the delivery of fluid to the engine, and for maintaining the fluid pressure at the inlet to the engine below a determined pressure independent-

1, I have diagrammatically illustrated a cartridge chamber 106, which is so arranged that a cartridge located in it will discharge into the separator chamber 39, thereby increasing the pressure within the generator.

The firing mechanism of this cartridge and also the operating mechanism of the drain cock 105 are not illustrated in the drawings, since they may be of the ordinary type of trigger actuated mechanism usually employed in torpedo construction. I, however, contemplate actuating both the firing mechanism and the drain cock operating mechanism by means of the lever 86, which forms a part of the toggle mechanism. This may be accomplished by providing a trigger mechanism of the ordinary form, which is actuated by means of mechanism operatively connected to the end 107 of the lever 86. It will be apparent from the disclosures of Figs. 4^a, 4^b, and 4^c, that this lever occupies three different positions throughout the cycle of operation of the torpedo propelling mechanism. It is first locked in the position shown in Figure 4^a, in which position the regulator valve 13 is held closed. As soon as the toggle joint is broken the lever 86 assumes a position substantially as illustrated in Figure 4^b, in which the regulator valve is fully open. The decreasing pressure within the generator 10, after the charge of aluminum has been exhausted, causes the lever to move to the position shown in Figure 4^c. In this position, the lever will release the cartridge firing, and the drain cock actuating mechanism, and thereby drain the generator chamber.

While I have described but one embodiment of my invention, I desire it to be understood that various changes, modifications, substitutions, omissions and additions may be made in the apparatus illustrated without departing from the spirit and scope of my invention.

What I claim is:

1. A method of generating power, which consists in subjecting a chemical agent to the action of a liquid chemical reagent in a closed receptacle, employing the heat generated by the chemical reaction in evaporating liquid contained within the receptacle, mixing the fluids evolved by the chemical action and by the evaporation, discharging the mixed fluids from the receptacle, separating the liquid from the gases and expanding the gases outside the receptacle in doing useful work.

2. A method of generating power, which consists in subjecting metallic aluminum to the action of a liquid solution of caustic soda in a closed receptacle, in discharging

ently of increases in pressure within the generator, means controlled by the pressure within a generator for delivering regulable amounts of chemical reagent to the generator, and means for subjecting the generator to initial pressure and to initial heating.

8. A power developing apparatus for submersible vessels, comprising a generator in which fluid pressure is developed by chemical reaction and by the heat developed by the reaction, means for expanding the fluid generated in the generator in doing useful work, means for delivering a chemical reagent into said generator, and means for creating an initial pressure within the generator and for initially heating the contents of the generator.

9. A power developing apparatus for submersible vessels, comprising a generator in which fluid pressure is developed by chemical reaction and by the heat developed by the reaction, an engine driven by fluid delivered from the generator, a pump driven by the engine for delivering a chemical reagent to said generator, and means for initially heating the contents of the generator and for creating initial fluid pressure within the generator prior to the delivery of reagent by said pump.

10. In combination with a submersible torpedo, a fluid pressure generator, located within the torpedo shell, a chamber located within the shell adapted to contain a liquid solution of chemical reagent, means for delivering solution from the chamber to the generator, propelling means receiving fluid under pressure from said generator, means for separating liquid from the fluid before it is delivered to the propeller means, and means for discharging the liquid from the shell.

11. A method of generating power which consists in subjecting a chemical agent to the action of a reagent within a closed receptacle, in delivering the fluid evolved at a uniform pressure from the receptacle, in expanding the fluids exterior of the receptacle in doing useful work, in utilizing the expansion of the fluid in forcing reagent into the

receptacle and in controlling the delivery of reagent so that it is reduced by an increase of pressure within the receptacle.

12. A method of generating power which consists in subjecting metallic aluminum to the action of a solution of caustic soda in a closed receptacle, in discharging the fluid evolved by the chemical reaction and by evaporation occasioned by the heat accompanying the chemical reaction from the chamber at a uniform pressure, in expanding the fluids exterior of the receptacle in doing useful work, in utilizing the expansion of the fluid in forcing reagent into the receptacle and in controlling the delivery of reagent so that it is reduced by an increase of pressure within the receptacle.

13. A power developing apparatus for submersible vessels comprising a generator, charged with a chemical agent, an engine receiving fluid under pressure issuing from the said generator, a regulating valve between the generator and the engine for maintaining the pressure of the fluid delivered to the engine substantially constant independently of increases in the pressure within the generator, means actuated by the engine for delivering a chemical reagent to the generator, and means responsive to the pressure within the generator for controlling the delivery of reagent to the generator.

14. A power developing apparatus for submersible vessels comprising a generator charged with metallic aluminum, an engine receiving fluid under pressure issuing from the said generator, a regulating valve between the generator and the engine for maintaining the pressure of the fluid delivered to the engine substantially constant independently of increases in the pressure within the generator, means actuated by the engine for delivering liquid bearing caustic soda to the generator, and means responsive to the pressure within the generator for controlling the delivery of the reagent to the generator.

In testimony whereof, I have hereunto subscribed my name this 8th day of August, 1916.

ALEXANDER T. KASLEY.