H. MAXIM.

APPARATUS FOR PRODUCING A MOTOR FLUID.

APPLICATION FILED MAY 12, 1904. RENEWED DEC. 12, 1904.

956,813. **Patented May 3, 1910.**

3 SHEETS—SHEET 1.

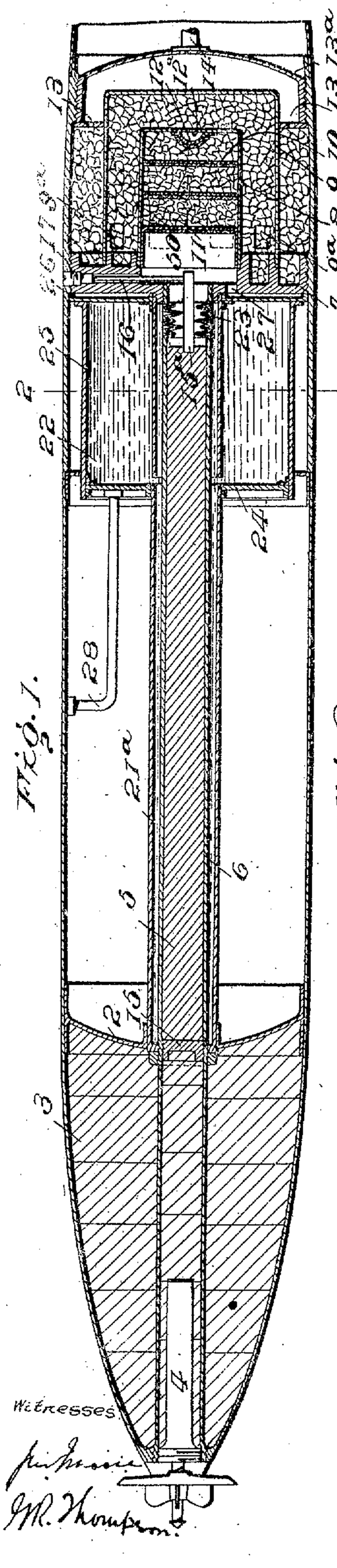

FIG. 1.

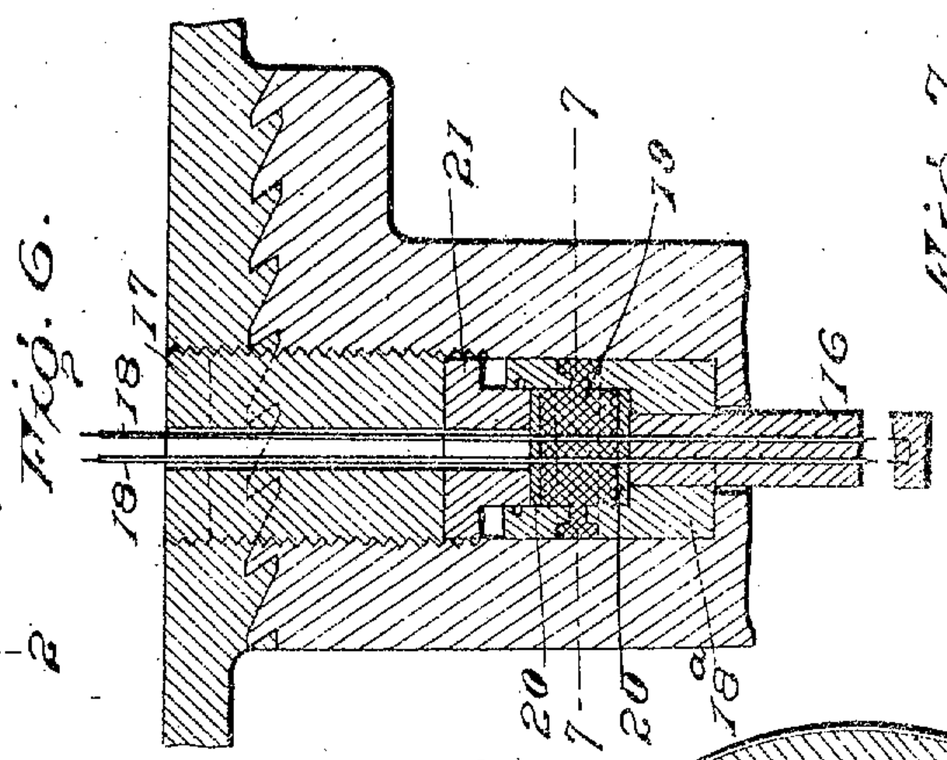

FIG. 6.

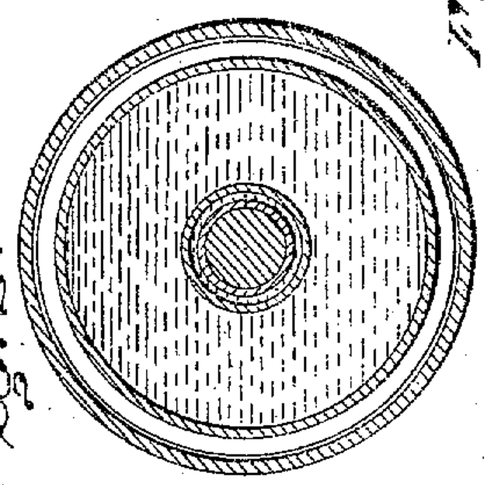

FIG. 2.

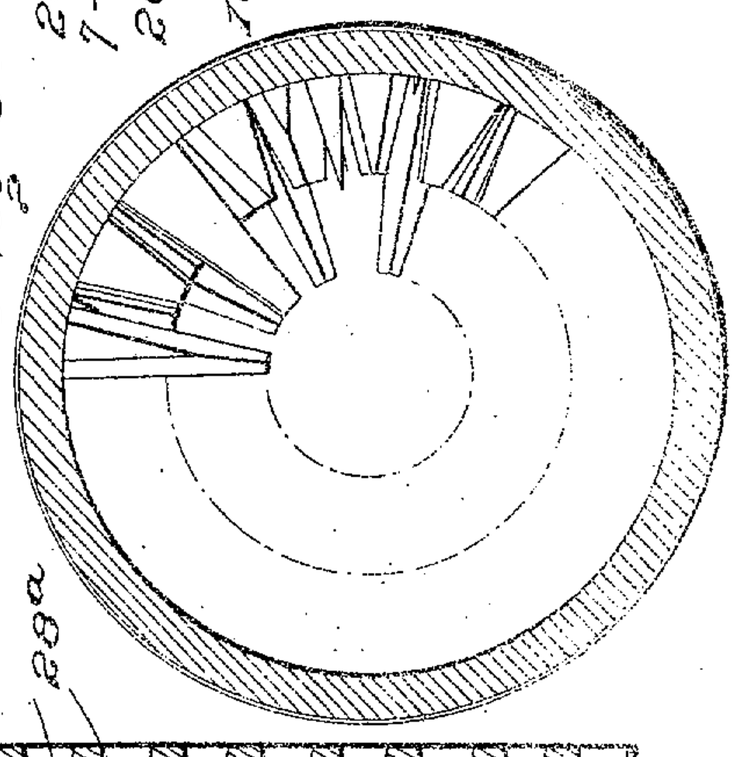

FIG. 5.

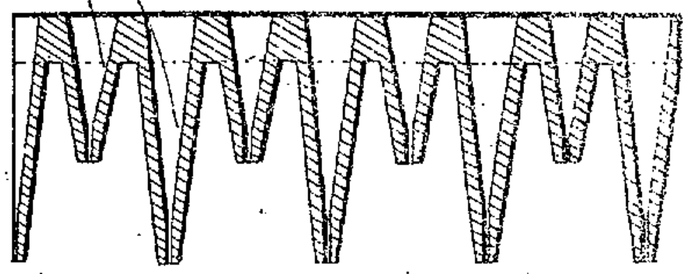

FIG. 4.

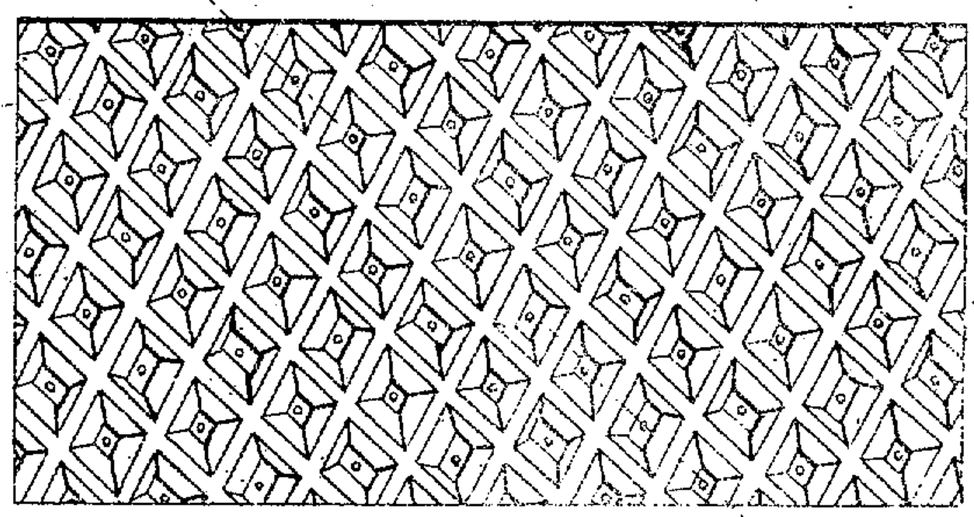

FIG. 3.

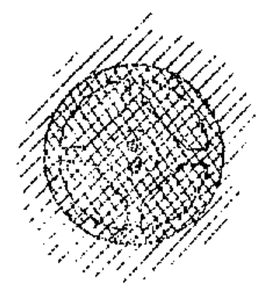

FIG. 7.

Witnesses:

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3 SHEETS—SHEET 2.

Fig. 8.

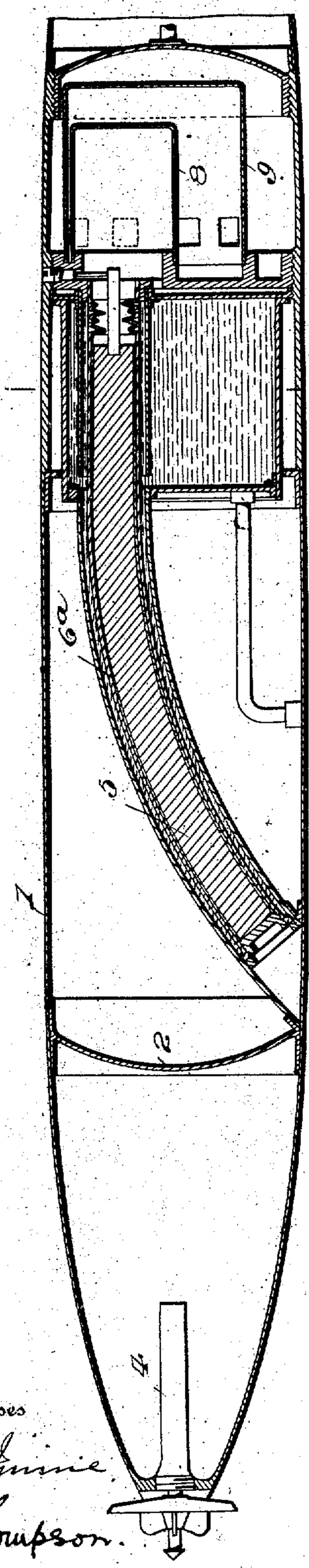


Fig. 11.

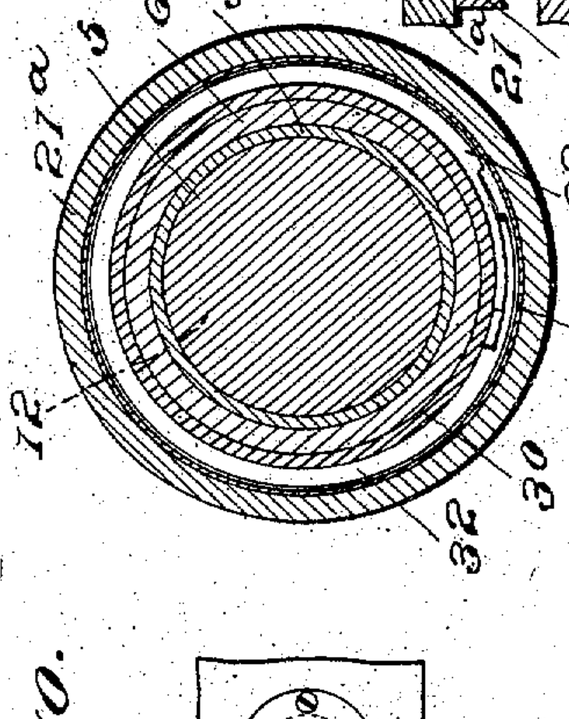


Fig. 12.

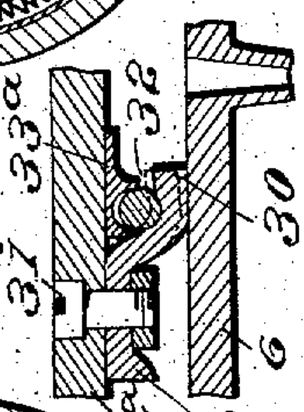


Fig. 10.

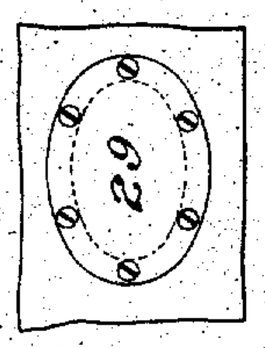
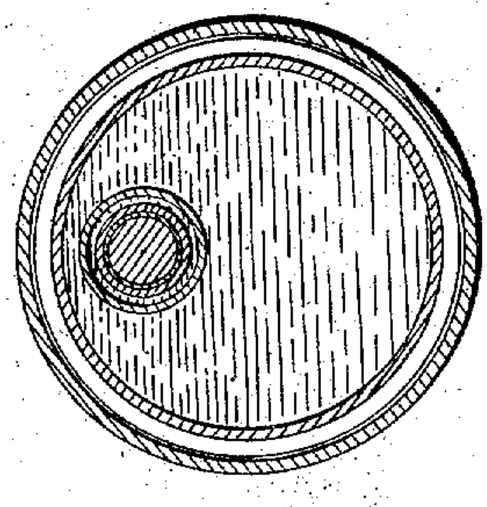


Fig. 9.



Witnesses

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3 SHEETS—SHEET 3.

Fig. 14.

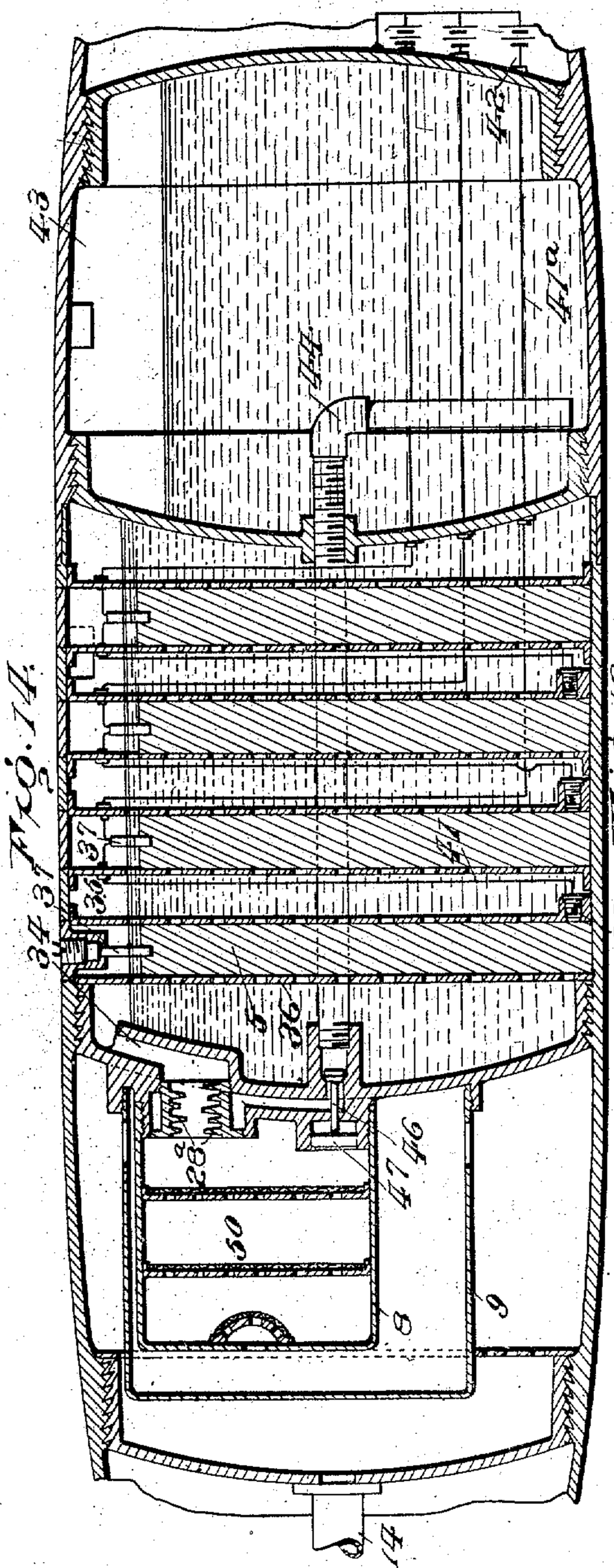
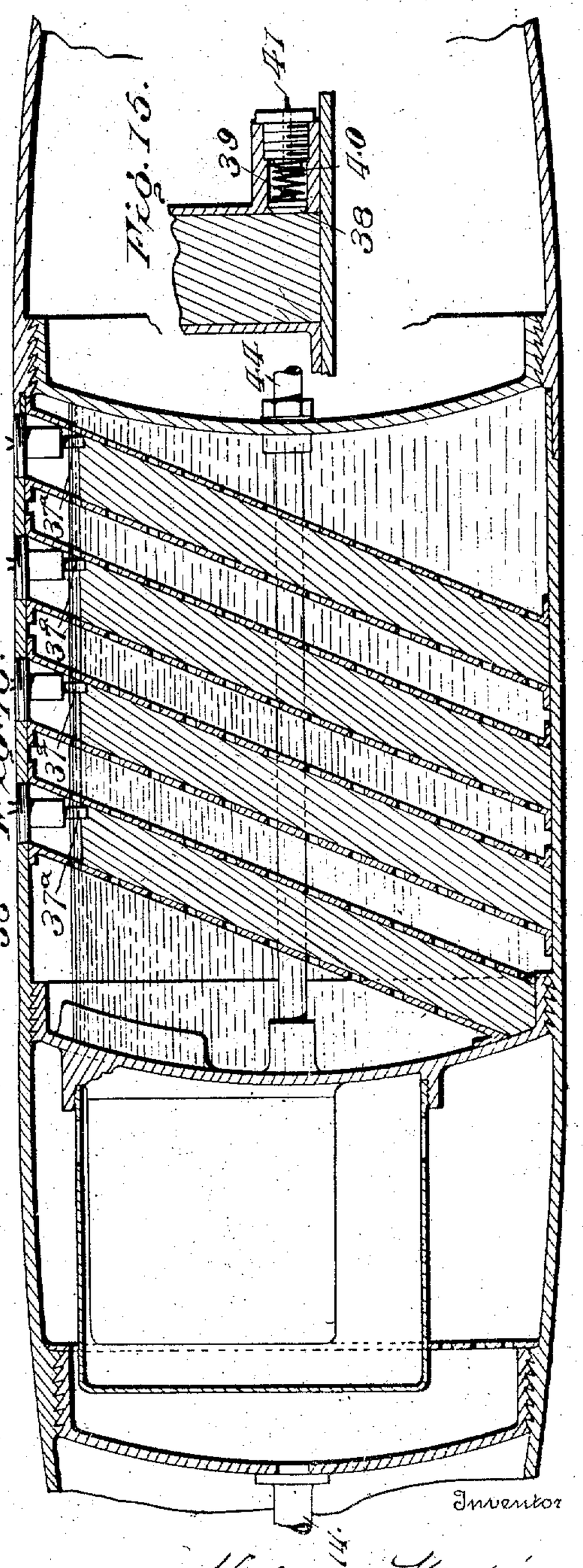


Fig. 15.



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UNITED STATES PATENT OFFICE.

HUDSON MAXIM, OF BROOKLYN, NEW YORK.

APPARATUS FOR PRODUCING A MOTOR FLUID.

956,813. Specification of Letters Patent. Patented May 3, 1910.

Original application filed March 23, 1899, Serial No. 710,192. Divided and this application filed May 12, 1904, Serial No. 207,710. Renewed December 12, 1904. Serial No. 236,584.

To all whom it may concern:

Be it known that I, HUDSON MAXIM, of Brooklyn, New York, have invented a new and useful Improvement in Apparatus for Producing a Motor Fluid, which invention is fully set forth in the following specification.

This application is a division of my application Sr. No. 710,192, filed March 23, 1899, and the invention herein described relates to an improved apparatus for producing motive fluid, for use mainly for the more rapid propulsion than heretofore of self-propelled torpedoes, torpedo boats, and light naval and other launches, but is adapted to other purposes.

The invention has for its object mainly to provide means by which the products of combustion of a nitro-compound capable of supporting its own combustion (hereinafter referred to as a self-combustible body) may be confined, controlled, and utilized for producing motive power, as for actuating a motor or otherwise, as jet propulsion, and by which the heat of the products of combustion is utilized to evaporate a liquid or to heat a gas or vapor for use independently or in connection with the said products of combustion for actuating a motor, or as a propelling means.

The invention also has for its object to provide means for the generation and supply of a largely increased volume of motor fluid, and at a much higher pressure, and without increasing the weight or size of present automobile torpedoes, when the invention is employed for their propulsion, to the end that the motor or propelling means thereof may be driven for a much longer period of time and the torpedo driven to a greater distance and at a much increased speed. The invention also provides that the shell of the torpedo, and especially what has been heretofore employed as the compressed air flask, may be greatly lightened, and the torpedo may therefore carry a much increased charge of high explosives.

The invention further has for its object means for atomizing or spraying the water or other fluid to be evaporated into the path of the products of combustion of the nitro-compound, to be mixed therewith, and means whereby the products of combustion and the watery spray are passed together over heating surfaces, and through an atomizing and mixing device, whereby the heat of the products of combustion is imparted to the surfaces to be again given off and again imparted to the particles of water to more perfectly evaporate the same, and to further facilitate the evaporation of the water particles by the interposition of the said surfaces in the path of the water particles, in such wise that they shall impact upon the evaporizing surfaces to wet them and the evaporated fluid thoroughly mixed with the products of combustion.

The most salient features of the invention consist in means for burning one or more rods or candles of a colloidal nitro-compound, capable of supporting its own combustion, means for igniting the said candle or candles, together with means for protecting from ignition all of the surfaces except one, of the candle, in order that it may be gradually consumed from one end or surface only. The invention also provides means for incasing the said candle in a suitable tube, and also means for cooling the tube exteriorly, whereby the products of combustion passing through the tube shall not overheat the same, and whereby the exterior surface of the candle shall be caused to burn with somewhat less rapidity than the material nearer the center, so that the combustion shall proceed to consume the candle from a concaved or cup-shaped surface, and the material around the periphery of the cup caused, by means of pressure generated by the combustion, to serve as a U-packing to assist in preventing the passage of the gases to the exterior of the candle, and between it and the containing tube. Means are also provided for cooling the atomizing device to prevent the same from being overheated or fused by the products of combustion of the colloidal candle.

The invention further provides means for regulating and controlling the supply of water or other liquids to the atomizer or spraying device, and means for transmitting the pressure of the products of combustion and volatilized liquid to the water or other liquid to be injected, vaporized, or sprayed, and means for augmenting the said pressure per area unit upon the said liquid, whereby the liquid shall be under a greater pressure per area unit than the pressure of the products of combustion and volatilized liquid,

and be, by that excess of pressure, forced through the atomizer into the products of combustion. Means are also provided for circulating a current of cooling liquid around the exterior of the colloidal candle during its combustion.

The invention also provides means for immersing the candles or bars of self-combustible material in a suitable liquid, as water, either vertically or at an angle with the horizontal plane, in such wise that the candle or candles may be ignited at the upper end or ends and consumed downward, while the exterior surface of the candle is cooled or prevented from ignition by the surrounding water, either in direct contact with the surface of the same, or with the receiver or tube containing the same. When a plurality of candles are employed, means are provided for igniting and combusting them, either independently and severally, or altogether, according to the demands of the case. The said candles, when a plurality are employed, may be provided each with an independent atomizing device, or with one, and they all may be in communication with the same evaporation chamber or not, as may be required.

In carrying out the invention, when applied to torpedoes, a rod or candle of the colloidal nitro-compound aforesaid, is inserted into a tube provided for its reception within the torpedo, and which tube may be concentrically situated with relation to the torpedo and adapted to receive the candle through the forward end or nose of the torpedo, by removing the fuse and inserting the same through the fuse tube or chamber, or the candle tube may be situated, arranged and shaped in such wise that the candle may be inserted through the lateral walls of the torpedo. When the candle is to be inserted in the tube, both the tube and the candle are previously coated with a suitable cement or adhesive substance for filling the space between the outer surface of the candle and the walls of the containing tube, in order to effectually prevent the ignition of the same on its outer surface. To effect this end, paraffin may be employed, or a mixture of paraffin and a suitable resin, or the exterior surface of the colloidal candle may be covered with paper or a cotton or other suitable fabric or substance, preferably porous, and which may be wet with water when the candle is inserted into its containing tube, so that the space between the candle and the tube will be filled with water and the wetted material. The water or other liquid chamber is then filled, and when ready for action the candle is ignited at one end, either by an electric spark, a wire heated to incandescence by an electric current, or by other suitable means. The pressure of the products of combustion augmented per area unit upon the water chamber, forces the water in a spray into the path of the products of combustion, and at right angles thereto, and together, the aqueous vapor, watery spray, and products of combustion, are forced onward to the motor or other propelling device through a tortuous path, whereby the complete evaporation of the water is effected.

With this general statement of the leading features of the invention, I have, in order to make the same more clearly understood, shown in the accompanying drawings, means for carrying it into practical effect, without thereby limiting the improvements in their useful applications to the particular construction taken for illustration herein.

In said drawings, Figure 1 is a longitudinal section of a part of a torpedo embodying the improvements; Fig. 2 is a cross-section thereof on the line 2, 2 of Fig. 1; Fig. 3 is a plane projection of the improved spraying device; Fig. 4 is a diagonal cross section of the same on the line 4, 4 of Fig. 3; Fig. 5 is a cross-sectional view of the powder candle-containing tube, showing a part of the spraying device in elevation; Fig. 6 is a longitudinal section of the device for igniting the powder candle with adjacent parts of the torpedo; Fig. 7 is a cross-sectional view of the same on the line 7, 7 of Fig. 6; Fig. 8 is a longitudinal section of a part of a torpedo, showing a modified form of the invention; Fig. 9 is a cross-sectional view on the line 9, 9 of Fig. 8; Fig. 10 is an elevation of a portion of the torpedo shown in Fig. 8, showing the door or plate of the opening for inserting the powder candle; Fig. 11 is an enlarged cross-section of the powder tube and surrounding jacket tube, showing the liquid-controlling valve; Fig. 12 is a radial section of the same on the line 12 of Fig. 11; Fig. 13 is a similar enlarged cross-section of a modified form of valve; Fig. 14 is a longitudinal section of a portion of the torpedo, showing a modified form of the invention; Fig. 15 is an enlarged similar section, illustrating particularly the means for automatically igniting the powder candle; Fig. 16 is a similar view of a different form of the modification shown in Fig. 14.

Referring to the drawings, the torpedo casing 1 can be made so light as to afford only sufficient support for the contained apparatus and may be strengthened at its forward end by a partition 2, forming a chamber containing the explosive charge 3, and the fuse 4. The powder candle 5, is contained in a central longitudinal tube 6, which extends from the front of the torpedo to the atomizing device to be hereinafter described, and which contains at its forward end the fuse 4, and a portion of the explosive charge 3, in front of the plug 15, which closes the candle-containing portion of the tube.

The rear end of the candle tube 6, is in

communication, through a supporting partition 7, with an atomizing and mixing device in a chamber 50, consisting of a series of concentric circular passages formed by the cylinders 8 and 9, and the torpedo casing 1, which are closed at their rear ends, and are attached to the partition 7, and contain atomizing and heat-absorbing material composed of pieces of fire-brick, kaolin, pumice stone or other suitable substance, which material is held in the inner cylinder or combustion chamber 8, between a plurality of transverse perforated metallic partitions 10, covered on their front surfaces with wire gauze or netting 11, for more completely atomizing, disseminating and mixing the liquid spray and products of combustion.

The rear end of the inner cylinder 8 is provided with an opening 12ª into the second cylinder 9, covered with a perforated and gauze-covered plate 12, to prevent the atomizing and heat absorbing material from stopping the opening. The second cylinder 9 is also provided with openings 9ª into the outer cylinder or torpedo casing at its forward end and near the partition 7, so that the gases and vapor upon escaping from the candle tube and spraying device, pass longitudinally through the inner cylinder 8, return through the second cylinder 9 and pass rearward again through the outer casing and the end perforated partition 13, to and through the rear partition 13ª, and by means of the pipe 14, to the motive machinery of the torpedo.

The candle 5 is ignited preferably by means of a small rod of self-combustible material 15ª, inserted and attached into the end of the candle and projecting out of the candle tube toward the cylinder 8, where it is in contact with a similar rod 16, extending radially into the combustion chamber from an externally removable plug 17, see Figs. 1 and 6. The radial rod 16 is ignited by an electric spark or incandescence and is provided for this purpose with two internal insulated wires 18, preferably united at the inner end of the rod by a small filament of platinum or other suitable metal, adapted to be heated to incandescence by the passage of an electric current. The radial rod is inserted into a removable socket 18ª, through which the wires 18 extend and are sealed therein by means of a body of lead 19, held between two plates 20, and adapted to be compressed so as to thoroughly pack around the wires by means of the plunger 21 under the pressure of the screw plug 17, the plunger and plug having a central opening for the passage of the insulated wires to the outside of the torpedo. The socket piece 18ª is provided with an annular recess communicating with the main body of lead so that when the plug is tightly screwed down, the lead prevents any escape of gases from the combustion chamber.

The candle tube 6 is surrounded by a jacket tube 21ª leaving an annular space between the tube and jacket, for a cooling circulating liquid. Preferably such liquid forms a part of that to be sprayed into the products of combustion, and in such case the annular space referred to is in communication with a reservoir 22, containing the liquid, and at its rear end said annular space communicates with a spraying or atomizing device 23 for injecting the liquid into the products of combustion as they pass from the candle tube 6, as will be hereinafter described.

The reservoir 22 is formed by the tube 21ª, and a permanent head 24, attached thereto, and a longitudinally sliding outer wall or cylinder 25, attached to the sliding head or piston 26, which head or piston is extended radially outside of the cylinder 25, preferably to the inside of the casing 1. It will be seen, therefore, that the outer surface of the piston is of greater area than that portion of the inner surface forming a part of the liquid-holding reservoir, and that, should the pressure per unit of area be equal on both surfaces, the piston and cylinder will move forward and force the liquid through the jacket tube and to the spraying device. In order to accomplish this result, the outer surface of the piston 26, is placed in communication with the combustion chamber or evaporating chamber 50 by means of the openings 27, through the partition 7, so that, when the powder is ignited and as pressure is generated, the liquid is forced into the gases of combustion. It will be understood that the pressure on the forward surface of the piston outside the reservoir is practically nothing.

The reservoir is provided with a filling tube or pipe 28, adapted to be opened to the outside of the torpedo, and the colloidal candle 5 is supplied or replaced through the front of the torpedo by removing the fuse 4 and plug 15. The part of torpedo casing about the mixing chambers and liquid reservoir is made of thicker material, in order to stand the pressure of the gases of combustion and evaporated liquid.

The spraying or atomizing device illustrated in Figs. 3 to 5, inclusive, consists of a large number of centrally extending and radial nipples, 28ª, positioned in a zig-zag relation to each other, so that the jets of water or other liquid in emitting from the nipples, may enter every portion of the current of the powder gases. The spraying or atomizing device is preferably formed by tapping the stock or candle tube 6 with threads of comparatively great pitch and of such contour in cross-section as to form threads of different heights (see Fig. 4) while another set of threads are cut from the opposite end of the stock, but of a different pitch, so that

by the intersection of the two threads, nipples are formed not only of different lengths, but also not in a longitudinal line with each other.

Instead of placing the candle tube and the mixing chambers formed by the cylinders 8 and 9 concentric with the torpedo body, as in Fig. 1, these if desired may be arranged as in Fig. 8, in which the candle tube 6^a is shown passing eccentrically through the reservoir and opening int the cylinders 8 and 9, which are not only eccentric to the torpedo body, but are also eccentric to each other. From the reservoir the tube 6^a is curved across the center of the torpedo body to an opening in the side wall, which opening is closed by a removable plate 29, Figs. 8 and 10. The curved form of the candle tube 6^a does not interfere with the placing of the candle in the tube, since the latter is of a plastic or flexible character and readily conforms to the curve of the tube.

In order to prevent the liquid in the reservoir from flowing into the candle tube and combustion chamber, when the candle is not ignited, a spring controlled annular valve 30 (Figs. 11 and 12) of rubber or other suitable material is placed around the candle tube 6, between the communication of the reservoir with the jacket tube 21^a and the spraying or atomizing device 23, and is attached to the jacket tube in any suitable manner as by a ring and screws 31. The valve is held normally seated against the candle tube 6 by a spring 32 of any suitable form, such as a split ring, Fig. 11, or a coiled spring 32^a, Fig. 13, and held in the socket 33^a fixed to the outer tube 21^a. By this means the valve effectually prevents flow of water to the sprayer or atomizer, but is readily forced open by the pressure of the liquid in the reservoir when the candle is ignited.

The candle is preferably covered or coated with a layer 33, of paraffin, Fig. 11, or a mixture of that material and a suitable resin which may be impregnated in a fabric, before or after placing around the rod of powder.

The modified form of apparatus shown in Fig. 14, illustrates a portion of a torpedo with the combustion chamber and mixing device eccentrically situated, and in communication by an opening or conduit 34, with a chamber 35, containing a plurality of rods or candles 5 of self-combustible colloid, extending in a direction substantially transverse to the torpedo, and each in a perforated metallic tube 36. In the modification mentioned, the candles are vertical, and the perforations of the tube are so arranged that the water with which the compartment is nearly filled will cover the top surface of the candles to prevent their premature ignition from the products of combustion of another burning candle. This means of maintaining the outer surface of the candle cool, prevents any possible ignition, except at the top surface purposely ignited.

The rods may be ignited in any suitable manner, in series or in parallel, that is to say, successively or simultaneously. The method illustrated in Fig. 14, however, shows means for igniting one candle externally by electricity, and by means of a small igniter rod 37, which in turn ignites the surface of the first candle. When the candle first ignited is nearly consumed and the zone of fire approaches the bottom of the tube, the pressure of the gases of combustion forces the small contact button 38, at the side of the tube near its bottom outward against the spring 39, Fig. 15, into contact with an insulated metallic button 40, connected by a wire 41, with the small igniter candle or fuse 37 at the top of the next candle. By this means an electric current is made to traverse through the small igniter rod at the top of the succeeding candle, which is ignited, the circuit being completed by the wire 41^a, and the shell of the torpedo, the current being generated by the batteries 42. Each successive candle is ignited in a similar manner, and each ignition device is preferably supplied with a separate battery. In this modification (Fig. 14) I have shown means whereby liquid carbonic acid, or water impregnated with carbonic acid or other liquefiable gas may be injected or sprayed into the path of the products of combustion, by means of the spraying device. For this purpose, the torpedo is provided with the chamber 43, containing the liquid beforementioned, and placed in communication with the spraying device by means of a pipe 44, passing through the combustion chamber 35, and controlled by a valve 46, that is normally kept closed by the great pressure within the liquid chamber 43, but is forced open as soon as pressure is generated in the combustion chamber sufficiently great to counterbalance the pressure of the liquid-holding chamber by means of the large difference in area between the inside of the valve and its outer piston-like surface, 47, in communication with the combustion chamber.

The modification shown in Fig. 16, illustrates a construction similar to that of Fig. 14, but the candles are inclined to the transverse section of the torpedo, and each is provided with a separate igniting device, 37^a, so that they may, if desired, be ignited simultaneously.

What is claimed is:

1. In an apparatus for producing a motor fluid, the combination of a closed combustion chamber containing a self-combustible material, a reservoir containing a fluid, a spraying or atomizing device introduced be-

tween the reservoir and combustion chamber, and means actuated by the products of combustion and forcing the liquid from the reservoir through said spraying or atomizing device into the combustion chamber.

2. In an apparatus for producing a motor fluid, the combination of a closed combustion chamber containing a self-combustible material, a reservoir containing a fluid, a spraying or atomizing device introduced between the reservoir and combustion chamber, and means actuated by the products of combustion exerting a pressure per area unit upon the fluid in the reservoir exceeding the pressure per area unit in the combustion chamber, and thereby forcing the liquid from the reservoir through said spraying device or atomizer into the combustion chamber.

3. In an apparatus for producing a motor fluid, the combination of a closed combustion chamber containing a self-combustible material, a spraying or atomizing device leading into said chamber, a reservoir connected with said device and containing a liquid, and a differential piston element having its greater area exposed to the products of combustion and its lesser area operating on the liquid in the reservoir, whereby the pressure per area unit on the liquid in the reservoir will exceed the pressure per area unit of the products of combustion.

4. In an apparatus for producing a motor fluid, the combination of a closed combustion chamber containing a self-combustible material, a spraying or atomizing device leading into said chamber, a reservoir connected with said device and containing liquid, and a movable wall to said reservoir having a greater area exposed to the products of combustion than is exposed to the liquid in the reservoir.

5. In an apparatus for producing a motor fluid, the combination of a combustion chamber containing a self-combustible material, a cooling fluid surrounding said material, and means mixing said fluid in the form of spray or vapor with the products of combustion of said material.

6. In an apparatus for producing a motor fluid, the combination of a combustion chamber containing a self-combustible material, a cooling fluid surrounding said material, an atomizing or spraying device leading into said chamber, and means forcing said fluid through said device into said chamber.

7. In an apparatus for producing a motor fluid, the combination of a combustion chamber containing a self-combustible material, a cooling fluid surrounding said material, and means actuated by the products of combustion and forcing said liquid into said chamber.

8. In an apparatus for producing a motor fluid, the combination of a combustion chamber containing a self-combustible material, a cooling fluid surrounding said material, an atomizing or spraying device leading into said chamber and means actuated by the products of combustion and forcing said liquid into the combustion chamber.

9. In an apparatus for producing a motor fluid, the combination of a tubular combustion chamber containing a self-combustible material, a tubular jacket surrounding said chamber and leaving an annular space between the two, a reservoir containing a fluid and communicating with said space, a spraying or atomizing device leading from said space to the combustion chamber, and means forcing said fluid through said device into said chamber.

10. In an apparatus for producing a motor fluid, the combination of a tublar combustion chamber containing a self-combustible material, a tubular jacket surrounding said chamber and leaving an annular space between the two, a reservoir containing a fluid and communicating with said space, a spraying or atomizing device leading from said space to the combustion chamber, and means actuated by the products of combustion and forcing the fluid through said device into said chamber.

11. In an apparatus for producing a motor fluid, the combination of a combustion chamber, a fluid reservoir communicating therewith, and means augmenting and transmitting the pressure of the products of combustion to the fluid in the reservoir.

12. In an apparatus for producing a motor fluid, the combination of a combustion chamber, a fluid reservoir communicating therewith, and a differential piston device having its greater area exposed to the products of combustion and its lesser area acting on the fluid in the reservoir.

13. In an apparatus for producing a motor fluid, the combination of a combustion chamber containing a self-combustible material, a fluid reservoir communicating therewith, means spraying the fluid into the products of combustion and a mixing device in the path of the products of combustion.

14. In an apparatus for producing a motor fluid, the combination of a combustion chamber containing a self-combustible material, a heat-absorbing body interposed in the path of the products of combustion, and means actuated by the products of combustion and spraying a liquid into said products, before they reach said body.

15. In an apparatus for producing a motor fluid, the combination of a combustion chamber containing a self-combustible material with only one surface exposed to the flame of ignition, and means for circulating a cooling medium around said material.

16. In an apparatus for producing a motor fluid, the combination of a combustion chamber containing a self-combustible ma-

terial with only one surface exposed to the flame of ignition, and means subjecting said chamber to the action of a cooling medium.

17. In an apparatus for producing a motor fluid, the combination of a combustion chamber containing a self-combustible material with only one surface exposed to the flame of ignition, a reservoir containing a cooling medium, and a conduit leading from said reservoir around and into said combustion chamber.

18. In an apparatus for generating motor fluid, the combination of a combustion chamber containing a fuel capable of supporting its own combustion, a reservoir containing water, and means mixing the products of combustion of the fuel with the water to form the motor fluid.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

HUDSON MAXIM.

Witnesses:
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R. L. SCOTT.