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COMPLETE SPECIFICATION.

[Communicated from abroad by THE ERICSSON COAST DEFENCE COMPANY (INCORPORATED), in the City of New York, United States of America.]

Improvements in Subaquatic Projectiles.

I HENRY EDWARD NEWTON of the Office for Patents, 6 Bream's Buildings, Chancery Lane in the County of Middlesex, Patent Agent, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to that class of projectiles whose path is intended to be either entirely sub-aquatic, or partly aerial and partly sub-aquatic, and which may be fired from guns in fortifications, as well as from ships or other vessels. The objects of the invention are to effect such an automatic steering of the projectile in a vertical plane, after it enters the water, as to insure a true horizontal trajectory at a predetermined and fixed depth, and to obtain as great a subaquatic range as possible for the projectile; and the invention consists in certain means hereinafter described and claimed, whereby these objects are accomplished. For what may be termed purely subaquatic projectiles, which are to be projected from a gun arranged in a vessel below the level of the surface of the water, the automatic steering in a vertical plane is of great importance, as the pitching of the vessel makes it difficult to expel such projectile from the gun at the moment the vessel is level, and any slight inclination of the axis of the gun, either above or below the horizontal, at the time of firing, will seriously affect the depth of submergence of the projectile at the end of its path. For what may be termed aerial-sub-aquatic projectiles, which are projected from guns above water, to strike vessels or bodies under water, the automatic steering in a vertical plane is of as great, if not greater importance, as it enables such projectiles to strike the water and reach the vessel or object aimed at, even if entering the water at a considerable distance from it, thereby increasing the size of its horizontal target manifold.

In the accompanying drawings,

Fig. 1 is a top view of a subaquatic projectile embodying this invention, showing also, in section parts of the wall of a gun from which the projectile is to be fired, and an outside view of a piston through which the charge of the gun acts on the projectile.

Figs. 2 and 3 represent vertical longitudinal sectional views of different portions of the length of the projectile on a larger scale than Fig. 1.

Figs. 4 and 5, represent on a still larger scale than of Figs. 2 and 3, vertical sectional views of portions of the automatic steering apparatus.

Figs. 6, 7, 8, 9, 9*, represent on the same scale as Figs. 4 and 5, transverse sectional views of the projectile taken respectively in the lines *x x*, *y y*, *z z*, ✱ ✱, and 12, 13, of Figs. 2, 3, and 5.

Fig. 10, is a diagram illustrating a modification of what is herein termed the regulator.

Fig. 11 represents an attacking and an attacked vessel, illustrating the operation of the invention.

Similar letters of reference designate corresponding parts in all the figures.

A, A^1, A^2, A^3, A^4, A^5, designate the body of the projectile, which may be constructed in any suitable manner to receive and contain the explosive charge, the automatic steering apparatus, and the rocket charges, to increase the sub-aquatic range, but which projectile is represented as made of six sections, each constituting a portion of its length.

The foremost of these sections, A, contains the explosive charge; the rearmost section, A^5, contains the fuse of what may be called the accelerating charges, and is removable to reach the interior of the next section A^4, which has attached to it the steering rudders or diving blades B B; the second section, A^1, from the front, contains what may be termed the regulator C; the third section A^2 contains what is called the centre-plate D; the fourth section A^3 has upon its exterior, longitudinal fins *f*, two of which are continued on the section A^4.

The several sections may be united in any convenient or suitable manner; for instance, by being secured together as shown at *v* in Fig. 5, or by fitting one into another, and securing them by screws, as shown at v^1 in the same figure, or by connecting bands and screws, as shown at v^2 in Fig. 4.

The example shown has attached to its forward end, what is termed a pilot-shell P, which forms no part of the present invention, and therefore needs no particular description here. The construction of the body will be the same for the purely subaquatic projectile and for the aerial-subaquatic projectile, except that the purely subaquatic projectile will require to be furnished, as in the example shown, with a water-tight packing *e*, to fit the gun from which it is to be discharged. For the aerial-sub-aquatic projectile, such packing would be unnecessary.

The rudders B, which are arranged one on each side of the projectile, are both firmly secured to a pivotal spindle *d*, which passes transversely through the body of the projectile, at right angles to its axis. and is fitted to suitable bearings d^* (Fig. 6), therein. As this spindle requires to be maintained in a horizontal position, that the rudders may always work vertically, the projectile requires to be prevented from turning when it is in the water, and to meet this requirement, I employ the centre plate or weight D, which consists of a substantially flat plate of metal having its central plane parallel with the axis of the projectile, to work through a longitudinal opening d^2 therein, in a plane perpendicular to the axis of the rudder spindle *d*, the axis of the pivot d^1 being parallel with that of the spindle. The lower part of the said plate or weight is made heavier than the rest of it, in order that when it is allowed to drop through the opening d^2, it may bring the centre of gravity of the projectile as low as possible, to maintain the rudder spindle *d* positively horizontal. Stops d^3 are provided on this plate or weight, to prevent it from falling below a proper position, and a watertight casing d^4 is provided in the body, to cover the said plate, and the opening d^2, and prevent the water from entering the body through the said opening. When the projectile is in the gun, this plate or weight is all contained within this casing and within the body of the projectile.

As it is not only absolutely essential that the projectile should have the axis of its rudder spindle horizontal while in the water, but is also desirable that the said axis should be horizontal before the projectile enters the water, an externally projecting stud v^3 (see Fig. 3) is provided on the section A^2, suitably arranged on the circumference of the projectile, to run in a straight groove planed in the bore of the gun, to keep the said axis horizontal.

The regulator hereinbefore mentioned consists mainly of a hydraulic cylinder C, (see Figs. 3, 5, 8 and 9) fitted with two water-tight but freely moving pistons c c^1 of equal diameter (see Figs. 3 and 5). This cylinder is represented as arranged in the lower part of the section A^1 of the body with its axis parallel with that of the projectile. It may be either cast with the section A^1 as represented, or be otherwise permanently attached thereto. The cylinder is fitted, between the pistons c c^1, with a stationary block or bridge C^1, having a central rectangular opening, as shown in Fig. 9, to contain the pinions g g^1 and their supporting spindle g^*, and to permit the passage of four racks h h h^1 h^1, of which h and h are arranged diagonally to each other, as shown in Fig. 9, and are attached to the piston *c*, and h^1 and h^1 are also arranged diagonally to each other, and are attached to the piston c^1.

The spindle g^* is fast in the bridge C^1, and the pinions are loose upon it.

The upper rack *h* of the piston *c*, and the lower rack h^1 of the piston c^1, gear with the pinion *g*, while the upper rack h^1 of the piston c^1, and the lower rack *h* of the piston *c*, gear with the other pinion g^1, so that as either piston moves in one direction, it will tend to pull the other one in the other direction.

The two pistons will be operated upon together by any pressure between them, and being thus geared together, the power exerted upon them is equal to that exerted upon a single piston of double the area, and, what is more important for the purpose of this invention, as will be hereinafter explained, the weight and momentum of one, may be balanced by the weight and momentum of the other.

The racks h h h^1 h^1 being fitted to the quadrangular opening in the block C^1, as shown in Fig. 9, serve to guide the pistons c c^1. The said racks are of such length, that they serve as stops to limit the distance which the pistons are permitted to approach each other. To provide for the insertion of the block C^1 into the cylinder C, the said cylinder is bored of two different diameters, the rearward part being the larger, the smaller diameter of the forward portion corresponding with that of the pistons c c^1. The block is inserted through the larger rearward end of the cylinder up to a shoulder, and is secured in place by a flanged bushing i, which is inserted into the rearward end of the cylinder, and secured by screw bolts i^1. The bore of this bushing corresponds with the smaller forward portion of the cylinder bore, and the diameter of the pistons. Fig. 5 shows the piston c^1 fitted to the smaller bore of the cylinder, and the piston c fitted to the bushing. The piston c is furnished, on its outer side, with a rod or rack c^*, which works through a guide provided in a head j, which is bolted on to the rear end of the cylinder by the same bolts i^1, hereinbefore mentioned, which secure the bushing i. This head j contains the bearings for the shaft k^1 of a toothed sector k, which gears with the said rack c^*.

The cylinder C is provided, between its two pistons c c^1, with openings both in its top and its bottom, for admitting water to it from an annular chamber or reservoir a formed around the exterior of the section A^1 of the projectile, as shown in Figs. 5, 9, and 9*, by constructing a part of the said section with a concave longitudinal profile, as shown in Fig. 5, and covering the said portion with a cylindrical jacket a^1, of flexible water-tight material, as india-rubber. This jacket a^1 is secured in place and protected by an external guard cylinder A* of metal, which is made in two halves, and fastened to the said section A^1 by screws a^4. The said cylinder A* is constructed with numerous openings in its exterior, which may be of an suitable form, as for instance longitudinal slots, which give it the gridiron-like form shown in Fig. 3. The annular chamber or reservoir a, and the space in the cylinder C between the pistons c c^1, are filled with water through an opening at a^2 (see Figs. 5, 9, and 9*), which is then closed by a screw plug a^3. To provide for the escape of air from the cylinder C while filling it with water, a pipe b is provided to form communication between the said cylinder and the chamber a.

When the projectile is in the water, the flexible jacket a^1 is exposed to the pressure of the water surrounding it, and consequently the water in the chamber or reservoir a and cylinder C, are subject to the same pressure. This pressure varies according to the depth of submergence of the projectile, and it is partly by this pressure acting between the pistons c c^1, and partly by the operation of a spring and connections, which will next be described, that the operation of the steering rudders or diving blades B is produced, and the true horizontal trajectory, at a predetermined and fixed depth, is insured.

Firmly secured to the toothed sector k, or to the shaft k^1 thereof, are two grooved sectors l m of different radii, constituting arms of a lever, of which the toothed sector k may be considered as another arm. To the smaller arm m of these sectors, is secured one end of a rope or cord p, preferably a wire rope, which passes partly around a sheave n, fast on the rudder spindle, and the other end of which is secured to the spiral spring t, which is the spring just hereinbefore referred to, the said spring being secured to a screw-threaded rod t^1, which passes freely through a fixed bearing t^2, secured in the section A^4 of the body of the projectile. The screw-thread of this rod is fitted, in front of the said bearing t^2, with a nut t^3, by which the tension of the said spring t may be adjusted. The said rope p is secured to the said sheave by a set screw p^1. The said spring t acts through the lever arm m and the toothed sector k on the piston rod c^*, in such manner as to draw the pistons c c towards each other, in opposition to the tendency to separate them produced by the pressure of the water between the said pistons when the projectile is in the water. The pull of the spring acts to move the rudders downward, and the pressure of the water between the pistons acts to move them upward.

The rudders are fastened on their spindle in such a position that when the pistons are the closest together, the rear ends of the rudders will incline downwards, and the water acting on the under-side of their inclined surface when the projectile is in motion therein, will tend to raise the tail end of the projectile, thereby altering the length of its longitudinal axis in such a manner, that the projectile will descend. As long as the tension of the spring forces the pistons together with a greater power than that exerted by the sea pressure to move them apart, the projectile will continue descending, but as soon as the projectile has reached such a depth that the sea pressure over-powers the tension set on the spring, the two pistons will move apart, thereby reducing the inclination of the rudders, until these have reached a position parallel with the longitudinal axis of the projectile.

If the projectile keeps on descending, the rudders will continue moving until their rear ends incline upward, and force the tail end of the projectile downward. When the projectile has at last found a depth where it will proceed with its longitudinal axis, horizontal, the steering rudders will remain stationary. The tension brought to bear on the spring t by the adjusting nut t^3, will therefore determine the depth at which the projectile will move horizontally in the water. This tension is to be adjusted before placing the projectile in the gun.

In order to compensate for the additional tension of the spring produced by its being extended further and further by the movement of the pistons apart, the sector-shaped lever m is made excentric, as shown in Fig. 5, which makes the said sector in combination with the toothed sector k produce a lever of differential type, the sector k maintaining the same leverage through its movement, and the leverage of the arm or sector m gradually decreasing through its forward movement. The pressure of the water on the pistons is then caused to act more and more powerfully on the rudders as the projectile descends. This increase of the power of the pistons as the projectile descends, tends, in the case of an aerial-subaquatic projectile, to prevent any excessive diving when the projectile enters the water at the end of it aerial flight, as illustrated in Fig. 11, wherein the projectile is represented, at E, as just entering the water, and at E^1 as having assumed its horizontal path.

When the projectile is used on the aerial-subaquatic principle, or on the purely subaquatic principle, it is important that the steering rudders or diving blades should stand parallel with the longitudinal axis of the projectile as this leaves the gun.

In an aerial-subaquatic projectile, any inclination of these rudders might seriously affect its trajectory, or in a purely subaquatic projectile, such inclination would also be dangerous, as it would give the projectile a downward movement before the regulator could be brought to act. In order, therefore, to lock the rudders in a horizontal position against the pull of the spring t, while the projectile is in the gun, and before the regulator can come into operation, there is provided, on the rudder spindle d, a sector shaped projection o, to be engaged by a locking hook or detent o^1, which is pivoted within the body of the projectile, and which is brought into engagement with the said projection o, as shown in Fig. 4, by means of a spring o^2 applied to it. This hook o^1 is also connected by a rope or cord q with the longer one l of the two sectors or lever arms on the shaft of the toothed sector k, so that when the projectile becomes submerged, and the pistons of the regulator are brought into action, the said arm or sector l will act through the cord q to pull the locking hook o^1 out of engagement with the said projection o, and leave the rudders free to the action of the regulator.

Before placing the projectile in the gun, the rudders are pulled up into line with the axis of the projectile, and the hook o^1 then becomes engaged with the projection o, and locks them against the tension of the spring t, which would otherwise give their rear ends a downward inclination. By thus pulling the rudders up, their spindle d is caused to turn, and with it the sheave n; and the wire rope p being fastened to this sheave, and extending therefrom to the lever arm m, must become slack. As this would have the effect of leaving the two pistons free to move, a spring s and a slackening chain or piece r, are inserted into the said rope, the effect being that when the rudders are in their lowest inclined position, the spring s is fully extended, and the chain taut, while when the rudders are pulled up to the horizontal position, as shewn in Fig. 2, the spring contracts, keeping the rope p still taut, besides having sufficient power to keep a good strain on the pistons to draw them towards each other. The chain r hangs down slack in this case. When the projectile gets below the surface of the water, the sea pressure acts through the flexible jacket a^1 on the water in the chamber a, and on that in the cylinder C between the pistons, thus forcing the latter further apart, and the lever l, operated through the rack c^* and toothed sector k, soon moves sufficiently forward for the rope q to pull the detent o^1 out of engagement with the projection o on the rudder spindle, and disengage the said spindle and the rudders, and bring the diving gear into action. As the water forces the pistons further apart, the spring s gives way, and the slack of the chain r is taken up, and the longer lever arm l, acting through the rope q, holds the hook o^1 out of engagement from the rudder spindle.

One of the most important features of this invention, is the regulator having two hydraulic pistons geared together to move in opposite directions. It is well understood that a movable weight in a projectile starting with considerable initial velocity, will tend, by its inertia, to remain stationary while the projectile is moving forward, & the force exerted on such movable body will be equal to its weight multiplied by such velocity. It is therefore paramount that all movable weights in such projectiles should be balanced, and especially those that are intended to govern and regulate.

It will be seen that when the projectile is fired, the piston c will exert a force rearward in proportion to the initial velocity of the projectile, and that the piston c^1 will exert a similar force rearward, if its weight, including that of its racks h^1 h^1, be equal to that of c, including its racks h h, and other movable connections (which are not self-balancing) between the rack c^* and the rudder, but as the rearward motion of the piston c, through the intervention of the racks h and h^1 and pinions g, g^1, which are but substitutes for a lever, will pull the piston c^1 forward, the inertia of each piston balances that of the other, and the strain is brought on the spindle.

In the modification of the hydraulic regulator shewn in Fig. 10, the pistons c c^1, instead of being in the same cylinder, are in separate cylinders C^* C^*, which are arranged one above the other, the piston rods being connected by a lever C^2 working on a fulcrum in such manner as to move in opposite directions. The inner ends of these cylinders are open to the chamber C^3, which constitutes one of the sections of the projectile, and to which water is admitted from the sea through the openings a in the top and bottom. The opening a in the bottom is provided with a valve b^1. The object of this valve b^1 may be explained as follows: As a subaquatic projectile must necessarily be of light construction, so that its weight may not exceed its displacement, it becomes desirable, in an aerial subaquatic projectile, to use a small propelling charge, and fire at a high elevation, to obtain the necessary aerial range. The projectile will consequently enter the water at a considerable angle, and unless the steering rudders or diving blades are brought into immediate action, it will dive too deep. It is therefore advantageous to have the regulator filled with water between its pistons before firing, so that no time will be lost in filling it when the projectile dives.

The regulator constructed in Fig. 10 can be thus preparatorily filled through the upper openings a, and the water will be prevented from escaping through the lower opening by the valve b^1, until the projectile reaches the water, after which the valve b^1 is opened by the external pressure. It is obvious that the piston c^1 being made to properly balance the piston c and the movable parts connected to and moving with it, the inertia of one will balance the inertia of the other. This form of regulator is the equivalent in its action to that first described, but the form first described is preferable, as in that the counterbalancing piston c^1 being in line with the main piston c, can be brought down near the bottom of the projectile, and it is desirable to get the weight as low as possible.

To increase the subaquatic range of the projectile, there are provided in the rear portion of it, a number of rocket charges u. As owing to the occupation of the rear part of the interior of the body by the rudder spindle and its attachments, it would be inconvenient to use such a charge in the central portion of the body, or in the body proper of the projectile, two or more such charges u in sheet iron boxes u^1 are arranged on the exterior of the body in the form of fins, as shown in the Figures 1, 2, and 6. In Fig. 6, two such boxes and rockets charges are represented, the said boxes being represented in line with two of the fins f, and being virtually witened prolongations of said fins, as shown in Fig. 1. The rocket charges u may be of the usual composition, and are represented as contained in cases u^2 of cylindrical form, and having conical bores in their rear ends, for their proper ignition. The cases u^2 are secured in any convenient manner within the boxes u^1, and the boxes have in their rear ends wooden plugs u^3, which are driven out by the explosion of the rocket charges. The charges may be fired by a quick match u^4, inserted through the rear end of the projectile, and having branches leading to each charge. A small hole in the piston employed in the gun for driving out the projectile, will permit the powder charges of the gun to ignite the quick match.

A piston P^1 (Fig. 1) should be applied in rear of the projectile, between the projecting charge & the breech of the gun, the said piston being furnished with any suitable packing to make it fit tightly to the walls W of the gun.

Having now particularly described and ascertained the nature of the said invention and what manner the same is to be performed, as communicated to me from abroad, I declare that what I claim is :—

1. The combination with a subaquatic projectile, of a rudder having its pivot transverse to the axis of the projectile, and a weight suspended in the projectile to move through an opening therein a plane perpendicular to the pivot of the rudder, substantially as herein described, for the purpose of maintaining the rudder pivot horizontal, as herein set forth.

2. The combination with a subaquatic projectile, of a rudder having its pivot transverse to the axis of the projectile, and a weight of plate form, having its central plane parallel with the axis of the projectile, and suspended within the projectile, to move through a longitudinal opening therein in a plane perpendicular to the axis of the rudder, substantially as and for the purpose herein set forth.

3. The combination with a subaquatic projectile and a rudder thereon, for directing it in a horizontal trajectory, of two hydraulic pistons, one of which is connected with said rudder; a cylinder or cylinders for the said pistons, to contain water, exposed to the pressure of the water outside the projectile, and gearing or connections, substantially as herein described, between said pistons, whereby when one is caused to move in one direction, the other will be caused to move in the opposite direction, substantially as and for the purpose herein set forth.

4. The combination with a subaquatic projectile, and a rudder thereon for directing it in a horizontal trajectory, of a cylinder arranged within the projectile, two pistons in said cylinder, one of which is connected with the rudder, and which are geared together substantially as herein described, to be moved simultaneously in opposite directions by water contained in said cylinder between them, substantially as and for the purpose herein set forth.

5. The combination with a subaquatic projectile, a rudder thereon for directing it in a horizontal trajectory, a spindle for said rudder, and a sheave thereon, of a cylinder arranged lengthwise within the projectile, a piston in said cylinder, to be acted upon by the pressure of the water outside of the projectile, a rope or cord connected with said piston, and passing over said sheave, and a spring connected with said sheave, to turn the rudder in the opposite direction to that in which the pressure of the water on said piston acts to turn it, substantially as and for the purpose herein set forth.

6. The combination with the projectile, the rudder, the spring connected with the rudder spindle for turning it in one direction, and the hydraulic regulator for turning it in the other direction, of a lever through which the regulator acts upon the rudder, and which has a differential arm by which the varying tension of said spring is compensated for, substantially as herein described.

7. The combination with the projectile, the rudder, the spring connected with the rudder spindle to turn it in one direction, the hydraulic regulator for turning the said

spindle in the opposite direction, and a detent engaging with said spindle to hold it against the tension of said spring, of a lever engaging with the piston of the said regulator, and having two arms, of which one is connected with the rudder spindle, and the other with said detent, substantially as and for the purpose herein set forth.

8. The combination with the projectile, the rudder, the spring for turning the rudder spindle in one direction, the hydraulic regulator for turning said spindle in the other direction, and the detent for holding the rudder spindle against the tension of said spring, of two ropes or cords forming connections between the regulator and the rudder spindle and said detent respectively, and a spring and chain or slackening piece inserted in the rope or cord which connects the regulator with the rudder spindle, substantially as and for the purpose herein set forth.

9. The combination in a regulator for controlling the action of a rudder for directing a subaquatic projectile in a horizontal trajectory, of a water cylinder and two pistons therein, provided each with two toothed racks arranged in diagonal relation to each other, a stationary bridge arranged within said cylinder between said pistons, and serving as a guide to said racks, and two toothed pinions pivoted within said bridge, and each gearing with one rack of each piston, substantially as herein set forth.

10. The combination with the hydraulic regulator cylinder, of a surrounding annular water chamber or reservoir, the outer wall of which consists of a flexible jacket, substantially as herein described.

11. The combination with the hydraulic regulator cylinder, of a surrounding annular water chamber or reservoir, the outer wall of which consists of a flexible jacket, and an external guard cylinder A*, substantially as herein set forth.

12. The combination with a subaquatic projectile and a rudder therefor, of a piston connected with the said rudder, a water cylinder which is contained within the projectile, and in which said piston works, for controlling the position of the rudder, & to which there are openings from the exterior of the projectile at top & bottom, & of inwardly opening valves for closing said openings at the bottom, to permit the preparatory charging of the cylinder with water, substantially as herein set forth, with reference to Fig. 10.

13. The combination with the body of a projectile, of boxes arranged lengthwise upon the exterior, in the form of fins, for containing rocket charges, substantially as herein described.

Dated this 8th day of July 1890.

NEWTON & SON,
Agents for the Applicant.

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(2 SHEETS)
SHEET 2.

Fig. 6.

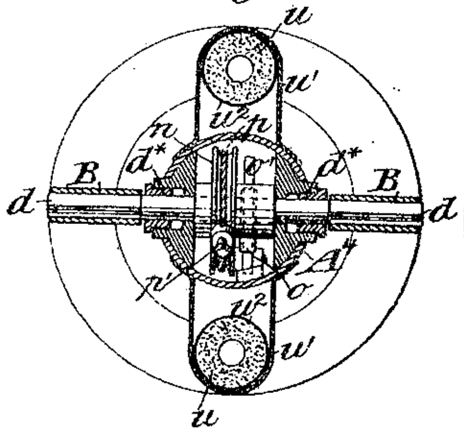


Fig. 7.

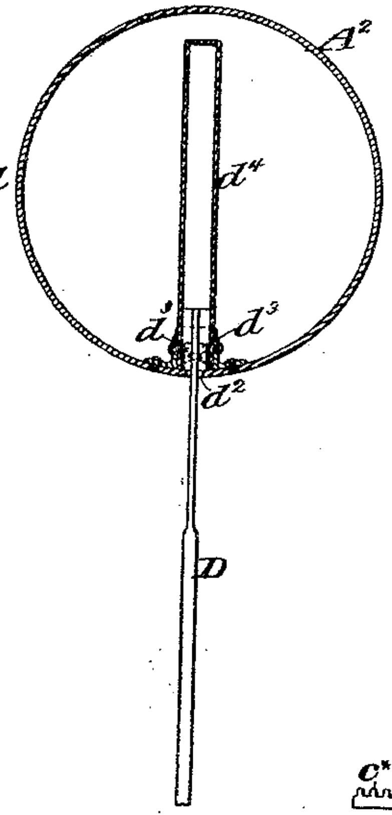


Fig. 8.

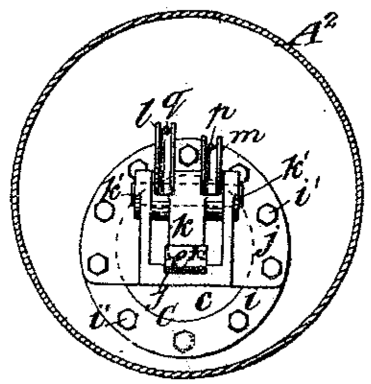


Fig. 9.

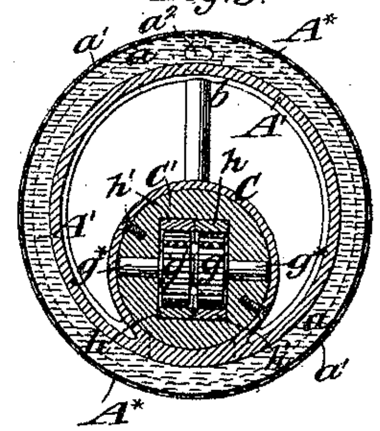


Fig. 9*

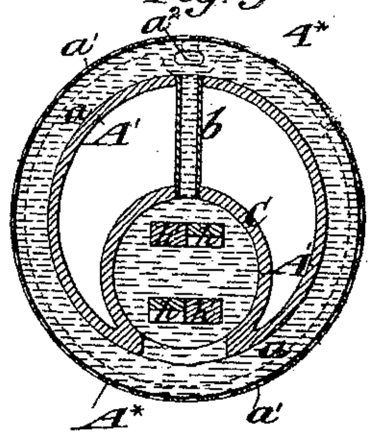


Fig. 10.

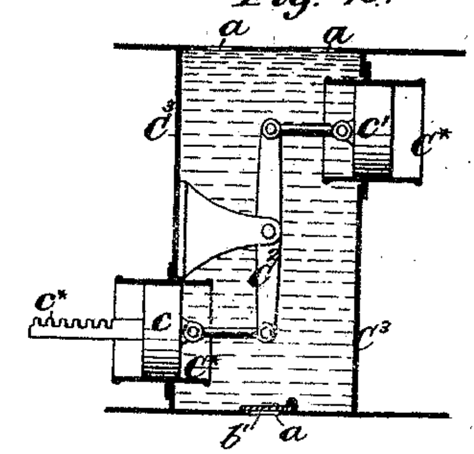
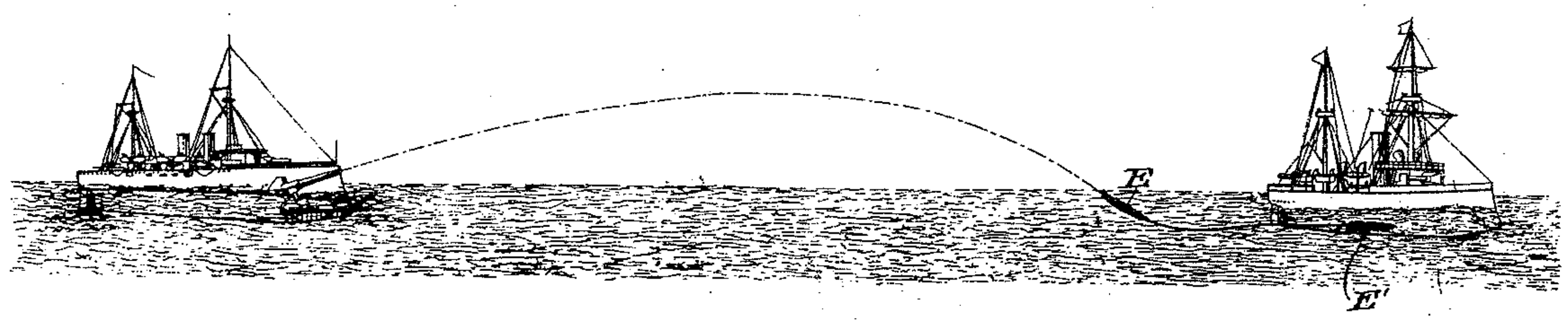


Fig. 11.



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Malby & Sons, Photo-Litho.

Fig. 1.

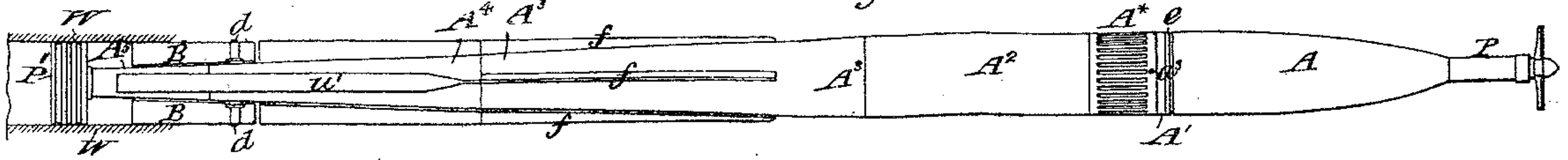


Fig. 2.

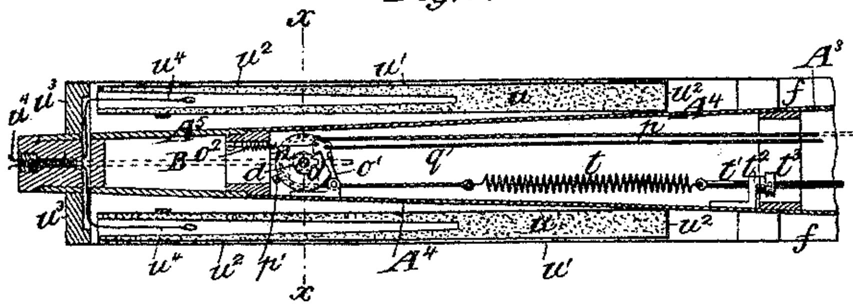


Fig. 3.

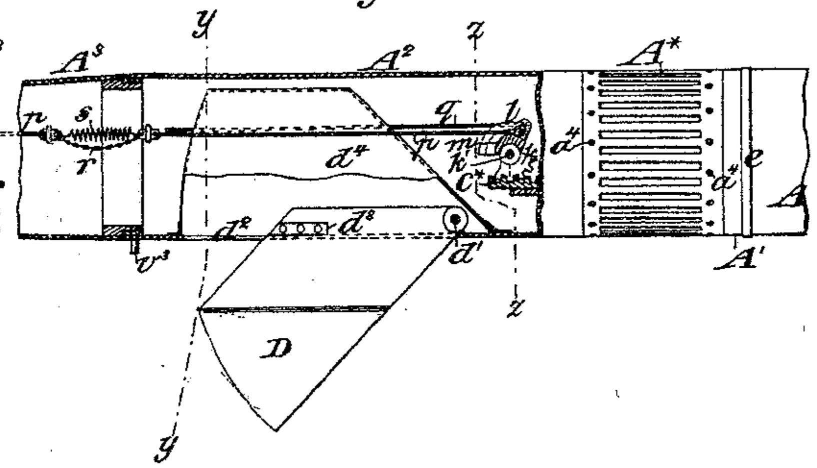


Fig. 4.

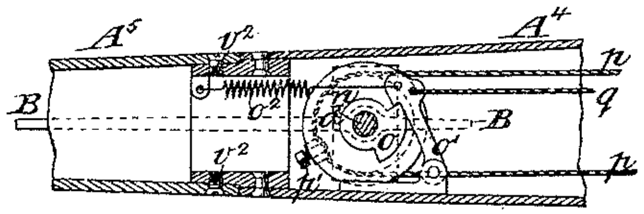
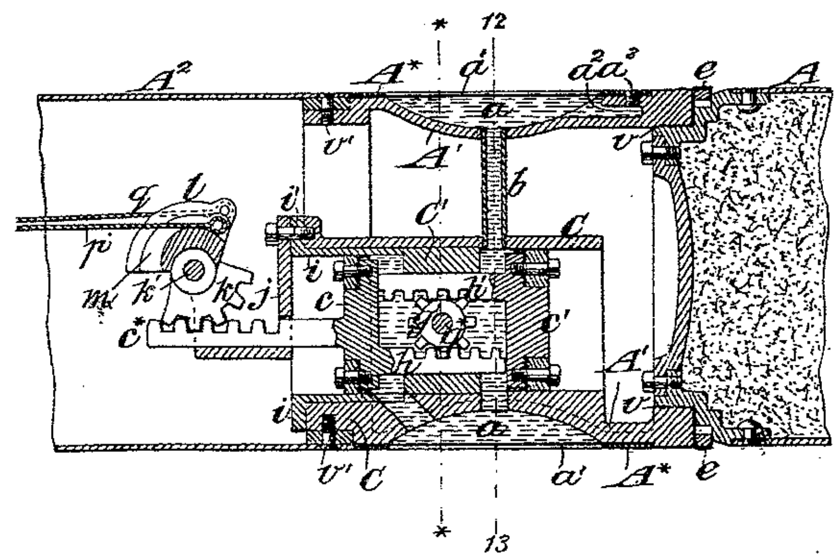


Fig. 5.



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