May 15, 1928.

H. B. PRATT

1,670,078

SUBMARINE MINE

Filed June 28, 1926

3 Sheets-Sheet 1

Fig. 1.

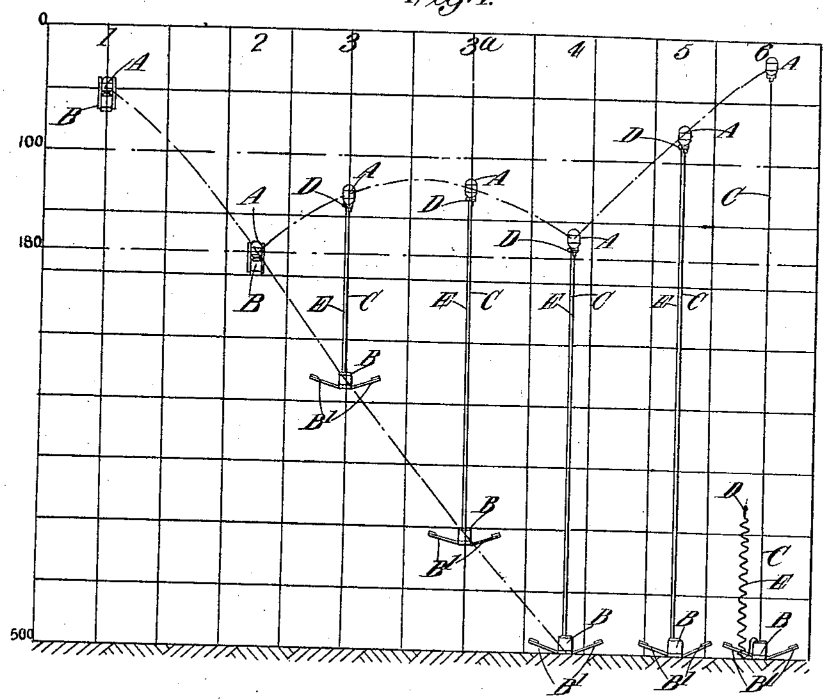

Fig. 5

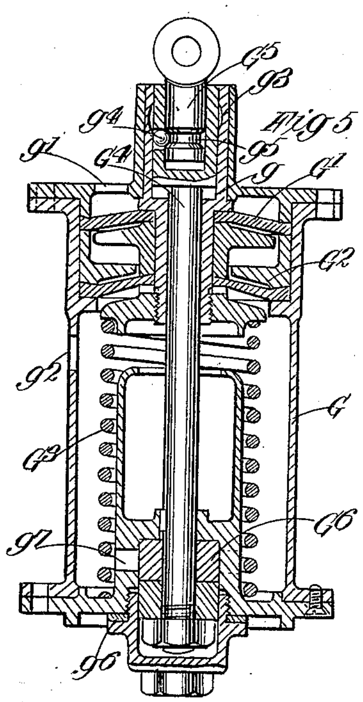

Fig. 4.

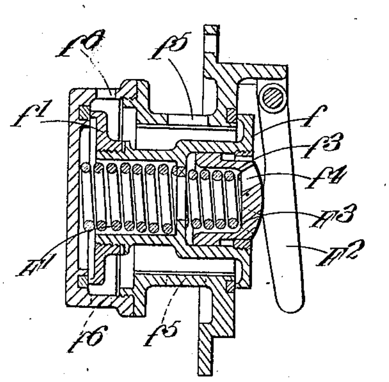

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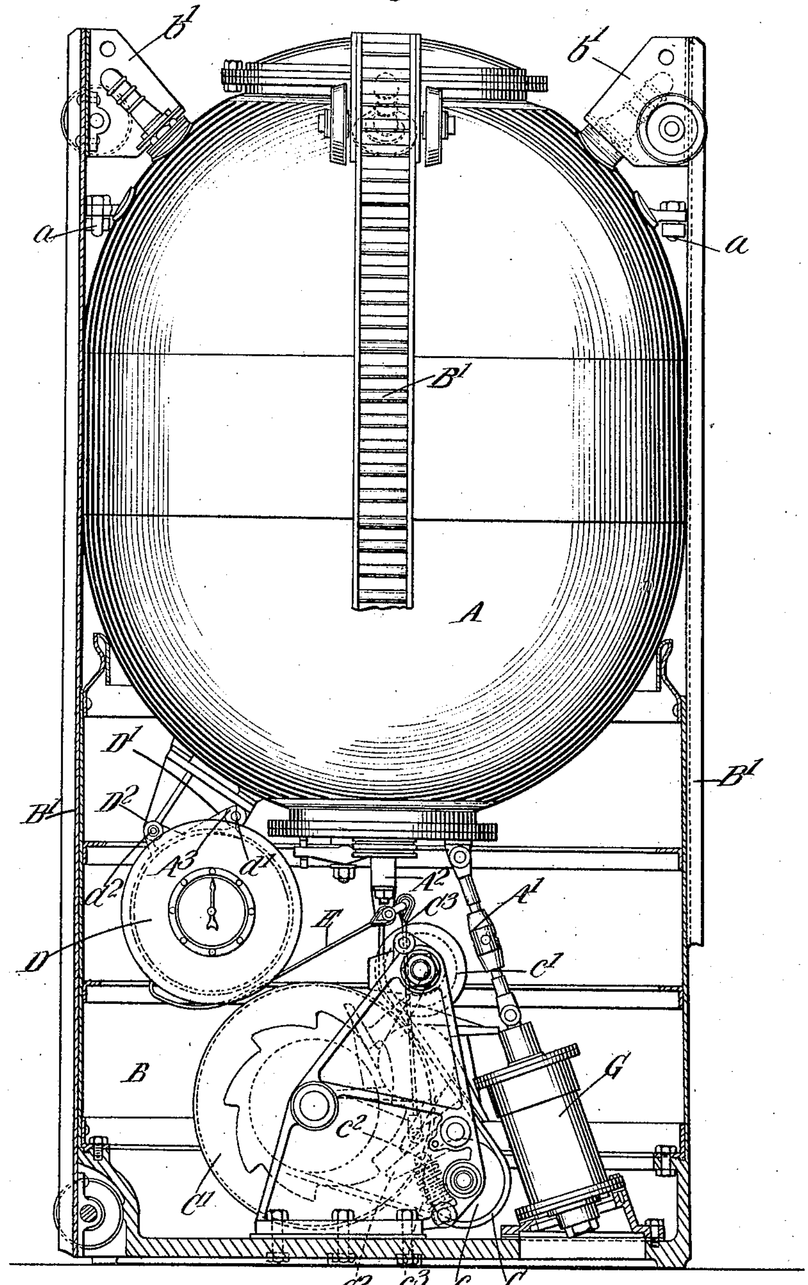
Fig. 2.



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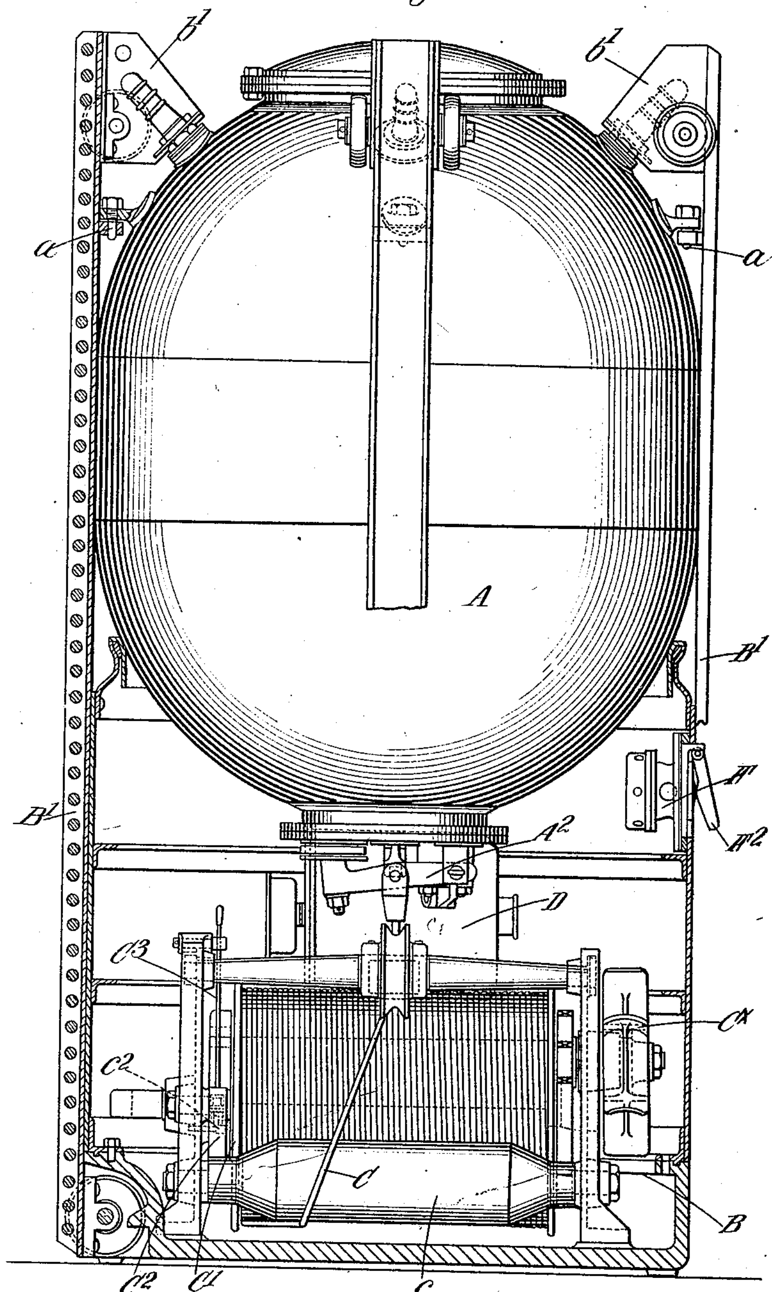
3 Sheets-Sheet 3

Fig. 3.



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Patented May 15, 1928. **1,670,078**

UNITED STATES PATENT OFFICE.

HARTLEY BLYTH PRATT, OF BARROW-IN-FURNESS, ENGLAND, ASSIGNOR TO VICKERS LIMITED, OF WESTMINSTER, ENGLAND, A BRITISH COMPANY.

SUBMARINE MINE.

Application filed June 28, 1926, Serial No. 119,044, and in Great Britain November 27, 1925.

This invention relates to submarine mines of the kind in which the flotation chamber or mine proper and the anchor are launched as a connected unit and become separated from each other by a hydrostatic release device when the said unit reaches a predetermined depth less than the depth at which the external hydrostatic pressure would be greater than the flotation chamber could safely resist, these depths being herein termed the releasing depth and the safe depth respectively; in such mines it has been proposed when the separation takes place to vary the rate of paying out of the mooring cable in such a manner that the flotation chamber remains substantially stationary at approximately the said releasing depth until the anchor reaches the sea bed, whereupon the flotation chamber rises until it reaches the final depth (herein termed the set depth) at which it is to be submerged, and then a depth setting hydrostatic device on the flotation chamber comes into operation to stop the paying out of the mooring cable. It has also been proposed to vary the rate of paying out of the mooring cable in such a manner that the flotation chamber remains at approximately the set depth during the descent of the anchor as described in United States Patent No. 1,515,195, the paying out of the mooring cable being stopped when the anchor reaches the sea bed. It has further been proposed in United States Patent No. 1,505,997 to provide a submarine mine of the kind referred to above with an auxiliary line or cord which is released from the flotation chamber or from the upper end of the mooring cable by means of the depth setting hydrostatic device to cause the paying out of the mooring cable to be stopped, the said line or cord being then no longer supported by the flotation chamber.

According to the present invention the hydrostatic device for releasing the flotation chamber from the anchor is arranged to come into operation at a depth substantially greater than the maximum set depth of the flotation chamber, and the retarding device for the drum of the mooring cable is such that during the subsequent descent of the anchor to the sea bed the flotation chamber will not rise above the set depth nor descend below the safe depth, and the depth setting hydrostatic device is detachably carried by the flotation chamber in such a manner that when it comes into operation and has caused the paying out of the mooring cable to stop it becomes detached from the flotation chamber and descends to the sea bed. The said depth setting hydrostatic device is preferably of the known kind having a drum which carries an auxiliary wire connected to the locking pawl of the mooring cable drum in the anchor and which is prevented from rotating to pay out the auxiliary wire when the set depth is reached, the pull on the auxiliary wire which then occurs severing a shearing pin by which the pawl is normally held in its operative position; in the present invention the further pull on the auxiliary wire that occurs upon engagement of the pawl, severs a shearing pin by which the casing of the hydrostatic depth setting device is connected to the flotation chamber, thereby disconnecting said device from the flotation chamber and enabling it to fall to the sea bed together with the auxiliary wire. The present invention has no reference to the type of mine in which the separation of the flotation chamber from the anchor is intended to take place only after the unit has reached the sea bed (i. e. the type of mine in which a hydrostatic releasing device is not provided) in one known form of which it has been proposed to cause a depth setting hydrostatic device to become detached from the flotation chamber as the latter ascends to the set depth, although a length of cable appertaining to the releasing contrivance for the said device remains connected to the mooring cable near the flotation chamber.

The mine unit when in the launching tube preferably has neutral buoyancy (i. e., it is of approximately the same specific gravity as the sea water) and the anchor has a buoyancy chamber provided with a flooding valve (preferably having two seatings of different effective areas) which is released when the unit leaves the launching tube and opens to admit the sea water to the said buoyancy chamber so that the unit then possesses substantial negative buoyancy and descends to the releasing depth. The releasing hydrostatic device is carried by the anchor and preferably comprises two diaphragms of different effective areas secured to a releasing member whose movement under the influence of the differential hydrostatic pressure is opposed by a spring of the required strength to enable the releasing member to move and thereby liberate the flotation chamber from the anchor when the predetermined releasing depth has been reached. The liberation of the flotation chamber may be effected by the well known ball and groove arrangement in which the balls normally hold a member connected to the flotation chamber in engagement with a part connected to the anchor. This part may be constituted by a rod between which and a portion of the spring casing a soluble plug is arranged. This soluble plug is provided for the purpose of liberating the flotation chamber from the anchor after the lapse of a predetermined interval of time, in the event of the depth of sea being less than the aforesaid releasing depth, and enables the said rod to be moved upwards by the upward pull of the flotation chamber to bring the aforesaid balls opposite the aforesaid groove which is formed in the releasing member and thereby effect the release of the flotation chamber independently of the movement of the said releasing member.

In order that the said invention may be clearly understood and readily carried into effect the same will be more fully described with reference to the accompanying drawings, in which:—

Figure 1 is a diagrammatic view shewing the sequence of operations of the main parts of the mine from the time of launching to the moment when the flotation chamber is finally anchored at the set depth.

Figures 2 and 3 are sectional side elevations viewed at right angles to one another shewing a mine constructed in accordance with this invention, the parts being shewn in the position they occupy prior to launching.

Figure 4 is a section shewing the aforesaid flooding valve, and

Figure 5 is a section shewing the aforesaid hydrostatic releasing device.

A is the flotation chamber or mine proper, B is the anchor, C is the mooring cable, C^1 is the mooring cable drum, D is the hydrostatic depth setting device, E is the auxiliary wire appertaining to this device, F is the flooding valve and G is the hydrostatic releasing device.

Referring to Figures 2 and 3, the flotation chamber or mine proper is shewn, by way of example, as of the well known horned electric type and may be provided with the switch operating and primer releasing mechanism forming the subject matter of my copending application Serial No. 119,046, filed June 28, 1926. This flotation chamber is made sufficiently strong to withstand the hydrostatic pressure at the desired safe depth which may for example be 200 metres. The said flotation chamber is seated in a water-tight manner at the upper part of the anchor the interior of which constitutes a buoyancy chamber, and the flotation chamber is held in place by a turn-buckle arrangement A^1 interposed between the lower part of the flotation chamber and the hydrostatic releasing device G. To the lower part of the anchor are pivoted four launching arms B^1 on the pivots of which rollers are arranged, rollers being also carried by these arms near their upper ends. The said upper ends are provided with hoods b^1 to protect the horns from damage and the arms are held in place by pins a which are carried by brackets on the flotation chamber and engage freely in holes in lugs on the said arms so that when the flotation chamber becomes liberated from the anchor and rises slowly the said pins are withdrawn from the holes and the arms can then fall outwardly about their pivots.

The mooring cable C passes from the drum C^1 over a roller c and a pulley c^1 and thence to a spring controlled lever A^2 on the flotation chamber, this lever operating in the manner described in the specification of my aforesaid concurrent patent application Serial No. 119,046. The locking pawl C^2 for engaging with ratchet teeth on the drum C^1 is normally held in the disengaging position by a shearing pin c^2 and is placed under the influence of a spring c^3 serving, when the pin c^2 is sheared, to move the pawl C^2 into engagement with the ratchet teeth. The said pawl is connected to a wire C^3 which in turn is coupled to the end of the aforesaid auxiliary wire E appertaining to the hydrostatic depth setting device D. This device comprises a drum on which the said auxiliary wire is wound and a locking bolt which, when the set depth is reached, is moved into a position to stop the rotation of the drum. The said depth setting device is preferably constructed in the manner described in the specification of my copending patent application Serial No. 119,045, filed June 28, 1926. The casing of the device has a half boss D^1 which receives a bolt d^1 also engaging with a half boss A^3 on a bracket attached to the flotation chamber A; the said casing also has a boss D^2 through which and a hole in the said bracket a shearing pin d^2 passes. The arrangement is such that when a pull is exerted on the auxiliary wire E, when the set depth is reached, owing to the stoppage of the rotation of the drum on which this wire is wound, not only is the shearing pin c^2 of the pawl C^2 severed to allow the latter to stop the rotation of the mooring cable drum C^1, but the shearing pin d^2 is severed by the further pull exerted upon the wire owing to the engagement of the pawl with the teeth of the drum and the depth setting device D can then fall from the flotation chamber owing to the provision of the half bosses D^1, A^3 as above described. The stated order of shearing of the pins c^2 and d^2 is ensured by making the pin d^2 stronger than the pin c^2.

The necessary resistance to the rotation of the mooring cable drum C^1 is obtained by a paddle brake C^x (Figure 3) which is driven by toothed gearing at an increased speed from the said drum. This brake is of such character that it will impose a resistance to the rotation of the drum in unwinding the mooring cable such that during the descent of the anchor from the releasing depth to the sea bed, the flotation chamber will not be drawn below the safe depth and will not rise above the maximum set depth which may for example be 100 metres, that is to say at such times the flotation chamber will always occupy some position between the maximum set depth of, say, 100 metres and the safe depth of, say, 200 metres.

The braking torque due to the rotation in water of a paddle brake varies as the square of the rotational velocity. As the mooring cable pays out from the drum, its radius from the axis decreases.

Let R—Revolution speed of the brake;

Let T—Brake torque;

Let P—Pull in mooring cable due to the brake;

Let r—Radius of mooring cable about the drum axis at any stage;

Let V—Velocity of paying out of mooring cable;

—Relative velocity between flotation chamber and the anchor.

Now T varies as R^2, P varies as $\frac{T}{r}$, V varies as Rxr

From which it follows that $P=\frac{V^2}{r^3}\times$ a constant which is the characteristic of the paddle brake system.

The resultant force acting on the flotation chamber at any moment is the algrebraic sum of the following forces:

(1) The buoyancy of the flotation chamber which is constant and acts upwards.

(2) The pull in the mooring cable due to the brake which is variable and acts downwards.

(3) The weight in water of the length of mooring cable between the flotation chamber and the anchor which acts downwards and increases.

The reaction of this resultant force is the dynamic force due to the resistance of the water corresponding to the velocity of the flotation chamber up or down.

The resultant forces acting on the anchor at any moment are the algebraic sum of the following:

(1) The weight in water of the anchor with the amount of mooring cable still on the drum which decreases and acts downwards.

(2) The pull in the mooring cable due to the brake effect, which is variable and acts upwards.

The reaction to this resultant force is the dynamic force due to the resistance of the water corresponding to the velocity of the anchor.

With the known water resistance characteristics of the flotation chamber and the anchor, and with the relative weights etc. suitably adjusted, it is found that by using a paddle brake which has the characteristic that $P=\frac{V^2}{r^3}\times$ constant as explained above, it is possible by calculating a suitable size of brake to obtain the following results.

(1) The flotation chamber when first released from the anchor rises, with decreasing velocity, until the downward forces on it equal its buoyancy.

(2) It then descends at increasing velocity until the anchor reaches the sea bottom.

With the paddle type of brake, the characteristics result in the amplitude of the motion of the flotation chamber being less than for a type of brake in which the resistance is not a function of the square of the rotational speed. The essential feature of the brake is that the braking force is a function of the square of the rotational velocity. The actual size of brake required and its speed of rotation relative to the mooring cable drum is determined by an analysis of the motions of the flotation chamber and the anchor when all their characteristics are known.

Referring to Figure 4 which shews the aforesaid flooding valve F in detail, this valve has two seating portions f, f^1, of different effective areas, open to the sea water and is normally held in its closed position against the action of a spring F^1 by a pivoted arm F^2 which is retained in the position shewn in Figures 3 and 4 by the wall of the launching tube. This arm bears against a sliding piece F^3 between which and a shoulder in the valve F is placed a spring f^3 which is stiffer than the spring F^1 so that the pressure of the arm F^2 on the sliding piece F^3 is transmitted to the valve F through the spring f^3. The said sliding piece is formed with a hole f^4 to enable sea water to pass through the central bore of the valve F and act on the inner face of the seating portion f^1. The effective area of the portion f^1 is slightly less than the effective area of the portion f so that when the mine unit is launched the spring F^1 in opening the valve F has only to overcome a hydrostatic pressure dependent at any depth upon the difference in the said effective areas. When the valve is opened the sea water enters the buoyancy chamber of the anchor through holes f^5, f^6 in the valve casing and thereby gives the mine unit substantial negative buoyancy as aforesaid.

Referring to Figure 5 which shews in detail the aforesaid hydrostatic releasing device which is interposed between the anchor and the flotation chamber, the casing G which is attached in a watertight manner over a hole in the anchor as shewn in Figure 2 has clamped therein the outer portions of two flexible diaphragms G^1, G^2 the inner parts of which are clamped to a sliding sleeve g. The upper diaphragm G^1 has a larger effective area than the lower diaphragm G^2 and between them is a space containing air at atmospheric pressure. The sea water has access to the upper surface of the diaphragm G^1 and to the lower surface of the diaphragm G^2 (when the aforesaid flooding valve F is open) through holes g^1, g^2, so that there is then a resultant downward hydrostatic pressure at any depth of immersion dependent upon the difference in the effective areas of the diaphragms. The downward movement of the sleeve g is resisted by a spring G^3 interposed between the sleeve and a part attached to the casing, the strength of this spring being such that the sleeve g will move downwards when the aforesaid releasing depth of, say, 180 metres is reached. The said downward movement of the sleeve g brings a groove g^3 with inclined walls opposite balls g^4 which are mounted in the wall of the hollow end of a rod G^4 and normally engage in a groove g^5 with inclined walls in an eye G^5 connected to the flotation chamber through the aforesaid turn-buckle arrangement A^1 (Figure 2). When the groove g^3 comes opposite the balls g^4 as stated, the upward pull on the eye G^5 due to the buoyancy of the flotation chamber causes the inclined walls of the groove g^5 to press the balls outwards into the groove g^3 and the eye G^5 is thereby liberated from the rod G^4 thus enabling the flotation chamber to separate from the anchor. For liberating the flotation chamber from the anchor when the depth of the sea is less than the aforesaid liberating depth, a soluble plug G^6 is provided between part of the casing and a collar g^6 on the lower end of the rod G^4. When this soluble plug has dissolved after the lapse of a suitable interval of time (water having access thereto through a hole g^7) the pull on the eye G^5 and the rod G^4 moves these parts upwards and brings the balls g^4 opposite the groove g^3 whereupon the eye is liberated from the rod in the manner described above.

The sequence of operations in laying a mine in accordance with this invention is shewn diagrammatically in Figure 1 in which the depth of the sea bed is assumed to be 500 metres, the releasing depth 180 metres and the maximum required set depth 100 metres. The mine unit when in the launching tube has neutral buoyancy as aforesaid and sinks when the flooding valve in the anchor is opened in the manner above described. Position 1 in Figure 1 represents the mine unit sinking after the flooding valve has been opened. When the mine unit reaches the predetermined releasing depth of 180 metres (position 2) the aforesaid hydrostatic releasing device comes into operation in the manner hereinbefore described to liberate the flotation chamber A from the anchor B. As the flotation chamber and the anchor separate the aforesaid pivoted arms B^1 carried by the anchor B are liberated in the manner hereinbefore described and fall down to a horizontal position. The anchor then descends and the flotation chamber ascends as shewn in the positions 3 and 3^a. The speed of ascent of the flotation chamber is determined by the resultant effect of the force of the flotation chamber buoyancy acting upwards and the resistance of the aforesaid paddle brake on the mooring cable drum plus the weight of the mooring cable paid out acting downwards. The effect of the brake is such that the motion of the flotation chamber is at first upwards and finally downwards, the total movement being well within the limits of the maximum set depth and the safe depth. This is due to the following conditions:—The downward pull on the flotation chamber due to the mooring cable is equal to the weight in water of the length of this cable hanging from the flotation chamber between it and the anchor plus the pull at the bottom end of this cable due to the mooring cable drum brake. The virtual downward pull on the flotation chamber due to the auxiliary wire E is equal to the pull of the brake of the drum appertaining to the hydrostatic depth-setting device D less the weight in water of wire between the flotation chamber and the anchor. This is because the tension of this wire at the flotation chamber end is always equal to the brake pull on this wire, but the buoyancy of the flotation chamber is increased by the amount of the wire paid out. The remaining active force on the flotation chamber is its buoyancy acting upwards. The resultant effect of all these forces on the flotation chamber causes it to first move upwards and then, as the increased weight of mooring cable makes itself felt, downwards, so that its final position when the anchor touches the sea bottom is not very far above its position when released from the anchor, and the highest point attained is below the maximum set depth of the flotation chamber as will be seen from positions 3, 3^a and 4 of Figure 1. The speed of descent of the anchor is determined by the force of the anchor weight in water acting downwards less the weight of the mooring cable paid out and the brake pull acting upwards. When the anchor reaches the sea bed (position 4) the flotation chamber will as above described be at some depth between the safe depth and the maximum set depth depending on the depth of the sea bed. When the anchor reaches the sea bed the flotation chamber proceeds to ascend with a velocity determined by the resultant effect of the upward force of its buoyancy upwards and the weight in water of the mooring cable paid out plus the brake pull acting downwards (position 5). When the flotation chamber reaches its set depth (position 6) the hydrostatic depth setting device D on the flotation chamber operates and stops the paying out of the auxiliary wire E. The upward pull on the auxiliary wire E is transmitted to the pawl of the mooring cable drum where it shears the aforesaid shearing pin and allows the spring of this pawl to push the latter into engagement with the teeth on the said drum and thus locks the latter and stops the paying out of the mooring cable. The pawl is held in engagement by the spring. The further shock on the auxiliary wire E at the moment of pawling effects the release of the hydrostatic device from the flotation chamber as aforesaid. The said device and the auxiliary wire then fall freely to the sea bottom leaving the flotation chamber moored only by the mooring cable.

What I claim and desire to secure by Letters Patent of the United States is:—

1. A submarine mine, comprising in combination a flotation chamber, an anchor, a hydrostatic device normally connecting said chamber and anchor together and arranged to release said chamber from the anchor when the unit composed of these parts has sunk to a depth substantially exceeding the maximum set depth at which it is ever desired to anchor the flotation chamber beneath the surface of the water, a drum in the anchor, a mooring cable wound on said drum and connected to said chamber, a retarding device for said drum, said device, during the descent of the anchor to the sea bed after separation from the flotation chamber, ensuring that the latter will not rise above the said set depth nor descend below a predetermined lower depth, a depth setting hydrostatic device carried by said flotation chamber, means whereby, when a predetermined depth has been reached during the ascent of the flotation chamber after separation from the anchor, said depth setting hydrostatic device will stop the paying out of the mooring cable from the drum in the anchor, and means whereby when this paying out ceases said depth setting hydrostatic device is automatically detached from the flotation chamber and falls to the sea bed.

2. A submarine mine, comprising in combination a flotation chamber, an anchor, a hydrostatic device normally connecting said chamber and anchor together and arranged to release said chamber from the anchor when the unit composed of these parts has sunk to a depth substantially exceeding the maximum set depth at which it is ever desired to anchor the flotation chamber beneath the surface of the water, a drum in the anchor, a mooring cable wound on said drum and connected to said chamber, a retarding device for said drum, said device, during the descent of the anchor to the sea bed after separation from the flotation chamber, ensuring that the latter will not rise above the said set depth nor descend below a predetermined lower depth, a depth setting hydrostatic device, a casing of the latter device, a shearing pin connecting said casing to the flotation chamber, a drum within said casing, a wire on said drum, a locking pawl for co-operating with the mooring cable drum in the anchor, and a shearing pin normally holding said pawl in the inoperative position, the latter pin being sheared and the pawl brought into its engaging position when the paying out of said wire is stopped by the depth setting hydrostatic device upon a predetermined depth being attained and the first-mentioned pin being thereupon sheared by the pull in said wire caused by the pawl coming into its engaging position, the shearing of the latter pin separating the depth setting hydrostatic device from the flotation chamber.

3. A submarine mine, comprising in combination a flotation chamber, an anchor, a hydrostatic device normally connecting said chamber and anchor together and arranged to release said chamber from the anchor when the unit composed of these parts has sunk to a predetermined depth, said unit normally (i. e. prior to launching) possessing neutral buoyancy, a buoyancy chamber forming part of said anchor, and a flooding valve controlling a passage leading to the interior of said buoyancy chamber, said valve opening, after the mine unit has been launched, to admit sea water to said buoyancy chamber so as to give said unit substantial negative buoyancy.

4. A submarine mine, comprising in combination, a flotation chamber, an anchor, a hydrostatic device normally connecting said chamber and anchor together and arranged to release said chamber from the anchor when the unit composed of these parts has sunk to a predetermined depth, said unit normally (i. e. prior to launching) possessing neutral buoyancy, a buoyancy chamber forming part of said anchor, and a flooding valve controlling a passage leading to the interior of said buoyancy chamber, said valve having two portions of nearly equal effective area exposed to the sea water when

the mine unit is in the sea so that the water pressure opens the valve to admit sea water to said buoyancy chamber so as to give said unit substantial negative buoyancy.

5. In a submarine mine, the combination of the elements claimed in claim 3, of a member co-acting with the flooding valve to keep the latter closed when the mine is in the launching tube.

6. In a submarine mine, the combination of the elements claimed in claim 4, of a member co-acting with the the flooding valve to keep the latter closed when the mine is in the launching tube.

7. A submarine mine, comprising in combination a flotation chamber, an anchor, a member connected to the flotation chamber, a member connected to the anchor, a releasing member normally serving to hold the other two members together, two diaphragms of different effective areas connected to said releasing member, both said diaphragms being exposed to the pressure of the sea water and the pressures on the diaphragms acting in opposition to one another, and a spring acting in opposition to the movement of the releasing member under increase in the pressure of the sea water on the diaphragms, said spring being of such strength that when a predetermined depth of immersion has been reached the releasing member will assume its position releasing the first two members from one another.

8. A submarine mine, comprising in combination a flotation chamber, an anchor, a member connected to the flotation chamber, a member connected to the anchor, elements carried by one member and engaging with the other, a releasing member normally serving to hold said elements in their engaging positions and having a groove which, when the releasing member occupies the releasing position, serves to permit said elements to move to their disengaging positions, two diaphragms of different effective areas connected to said releasing member, both said diaphragms being exposed to the pressure of the sea water and the pressures on the diaphragms acting in opposition to one another, and a spring acting in opposition to the movement of the releasing member under increase in the pressure of the sea water on the diaphragms, said spring being of such strength that when a predetermined depth of immersion has been reached the releasing member will assume its position with the groove therein opposite said elements so as to release the first two members from one another.

9. In a submarine mine, the combination with the elements claimed in claim 7, of a soluble plug normally acting on the member connected to the anchor so as to permit said member to move upwards relatively to the releasing member and effect the release of the member connected to the anchor from the member connected to the flotation chamber after the lapse of a predetermined interval of time in the event of the depth of the sea being less than the depth at which said releasing device would be brought into action by the diaphragms under the action of the pressure of the sea water.

10. In a submarine mine, the combination with the elements claimed in claim 8, of a soluble plug normally acting on the member connected to the anchor so as to permit said member to move upwards relatively to the releasing member and effect the release of the member connected to the anchor from the member connected to the flotation chamber after the lapse of a predetermined interval of time in the event of the depth of the sea being less than the depth at which said releasing device would be brought into action by the diaphragms under the action of the pressure of the sea water.

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