Oct. 8, 1946. C. C. WHITTAKER 2,409,169

CONTROL SYSTEM FOR EXHAUSTING BALLAST FROM TORPEDOES

Filed May 9, 1945 3 Sheets-Sheet 1

Fig. 1

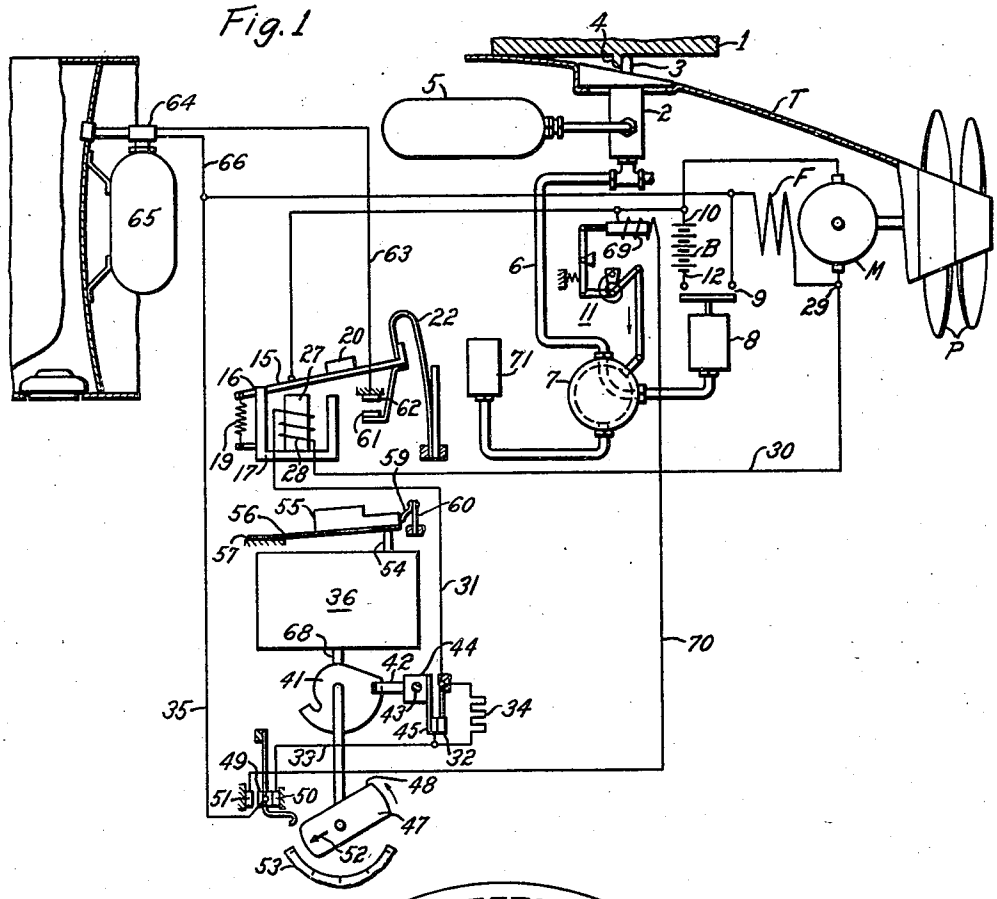
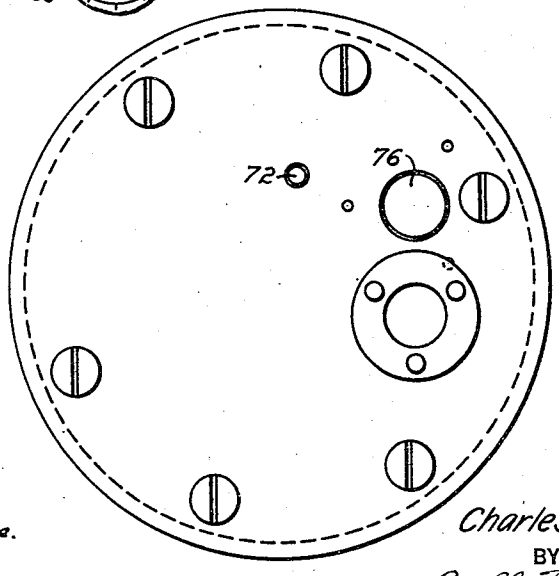


Fig. 2.



WITNESSES:
Wm. B. Sellers.

INVENTOR
Charles C. Whittaker.
BY
Paul E. Friedemann
ATTORNEY

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Filed May 9, 1945 3 Sheets-Sheet 2

Fig. 3.

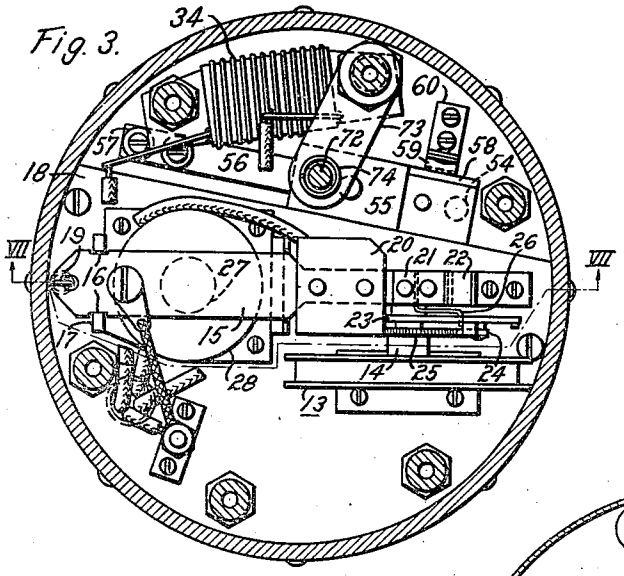


Fig. 4.

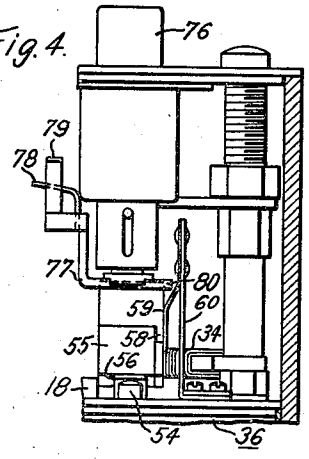


Fig. 5.

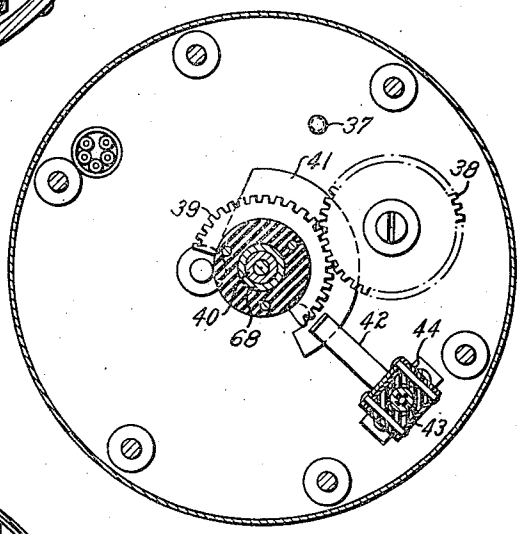
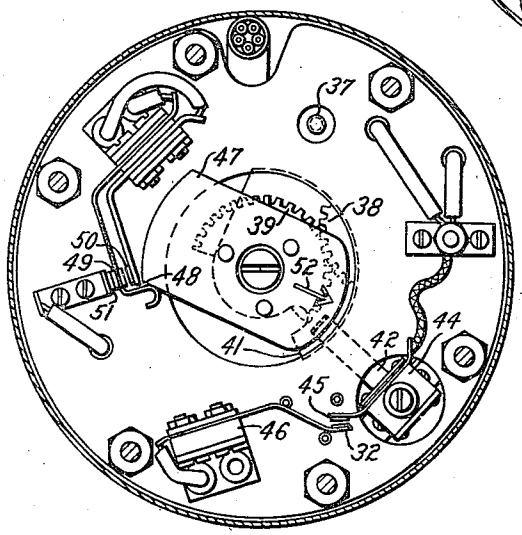


Fig. 6.



INVENTOR
Charles C. Whittaker.
BY
Paul E. Friedemann
ATTORNEY

Oct. 8, 1946. C. C. WHITTAKER 2,409,169

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Filed May 9, 1945 3 Sheets-Sheet 3

Fig. 7.

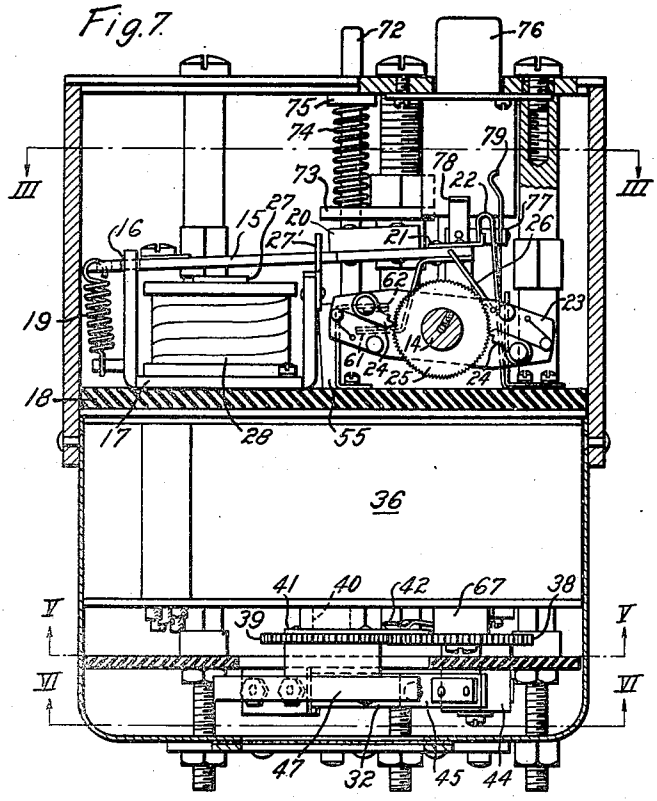
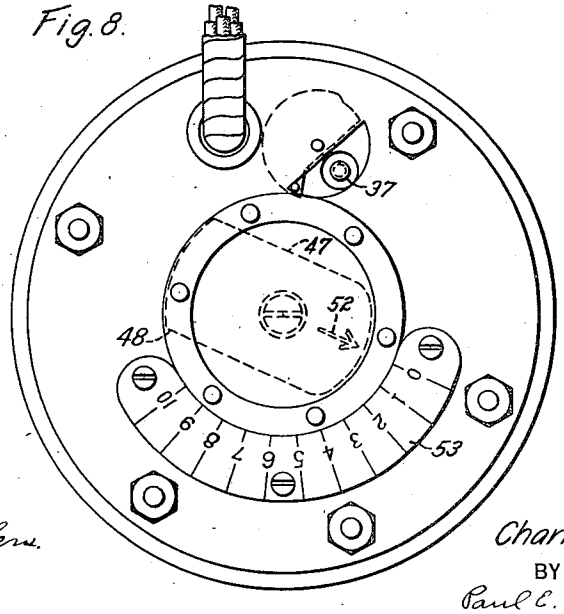


Fig. 8.



WITNESSES:

Wm. B. Sellers.

INVENTOR

Charles C. Whittaker.

BY

Paul C. Dietemann

ATTORNEY

Patented Oct. 8, 1946 2,409,169

UNITED STATES PATENT OFFICE

2,409,169

CONTROL SYSTEM FOR EXHAUSTING BALLAST FROM TORPEDOES

Charles C. Whittaker, Pittsburgh, Pa., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Application May 9, 1945, Serial No. 592,803

8 Claims. (Cl. 114—20)

1

My invention relates to control devices for torpedoes and, more particularly, to devices for controlling the buoyancy of torpedoes.

The Government of the United States has been granted a certain royalty-free license for governmental purposes with respect to the invention herein described.

It is extremely important that a torpedo does not sink and thus make recovery difficult or impossible during exercise runs of a torpedo.

During exercise runs of a torpedo, the exercise head—corresponding to the war head for battle shots—is filled with ballast water, or some other cheap liquid, which must be expelled, that is, blown from the exercise head to make the torpedo buoyant. For reasons well known, a torpedo is normally so loaded that it has a negative buoyancy. To effect surfacing of a torpedo at a desired time, the ballast liquid is expelled from the exercise head to cause surfacing of the torpedo. The most desirable time for effecting such surfacing is just prior to the end of the exercise run, but if for any cause whatsoever the torpedo does not complete its normal exercise run, it is essential to cause surfacing of the torpedo while it is still in motion.

With the electrically propelled torpedo now generally used, the "blowing" of the exercise head is usually effected by admitting carbon dioxide gas into the exercise head from a high-pressure CO_2 flask.

One object of my invention is to effect surfacing of a torpedo at the desired time.

Another object of my invention is to effect "blowing" of the ballast liquid from the exercise head of a torpedo when the operating conditions are such that the torpedo should surface to facilitate recovery of the torpedo.

A more specific object of my invention is the provision of timing means so devised that the ballast liquid is expelled from the exercise head of a torpedo just prior to the end of the exercise run, or prior to the expiration of such time if the operating conditions are such as to make surfacing of the torpedo desirable.

Another not so specific object of my invention is to effect surfacing of a torpedo a definite time after firing of the torpedo, or prior to the expiration of such definite time period should the torpedo speed decrease to a given speed or some other operating condition of the torpedo make surfacing desirable.

Other objects and advantages of my invention will become more apparent from a study of the

2

following specification and the accompanying drawings, in which:

Figure 1 diagrammatically shows so much of the circuits of an electrically propelled torpedo as are necessary to illustrate some features of my invention;

Fig. 2 is a top plan view of my special timers with the cover in place;

Fig. 3 is a sectional top plan view of my timer on section line III—III of Fig. 7;

Fig. 4 is a fragmentary sectional view of the top portion of the timer mechanism and illustrating one of the reset buttons, or stems, mounted in the top cover;

Fig. 5 is a sectional view on lines V—V of Fig. 7;

Fig. 6 is a sectional view on line VI—VI of Fig. 7;

Fig. 7 is a vertical sectional view of parts of my invention taken on line VII—VII of Fig. 3; and

Fig. 8 is a bottom plan view of my timer with the cover in place.

The clearest concept of my contribution to the art can probably be had from a study of the operating sequence of the subject matter shown in Fig. 1. The details of the timing mechanisms will be described below after the discussion of Fig. 1.

When the torpedo T is fired from the firing tube 1, the trigger valve 2, through the operation of lever 3 by the dog 4 on the firing tube 1, is operated to connect the gas pressure flask 5 to the conduit 6. This conduit is connected to the valve 7 which is latched to the open position by the latch mechanism 11.

With valve 7 in the position shown, gas pressure is admitted to the pneumatically operable switch 8. This switch, with a time delay of about three-fourths of a second, closes the contacts 9, whereupon a circuit is established from the positive terminal 10 of the battery B through the motor armature of motor M, the field windings F, and contacts 9 to the negative terminal 12 of the battery.

The pneumatically operable switch is of the type disclosed and claimed in the pending joint application of myself and Ruel C. Jones, Serial No. 559,077, filed October 17, 1944, and entitled Controls.

Per se the switch 8 forms no part of my present invention, but in the combination herein disclosed this switch 8 functions to close contacts 9 with a sufficient time delay to assure that the torpedo is well clear of the louvers at the front

of the torpedo tube. Rotation of the propellers P is thus delayed just sufficiently to prevent rotating contact of the propellers with the louvers. A time delay of a half to one second is usually selected. This time is ample for the torpedo to clear the tube.

In the equipment with which my invention has actually been used, the time constant of switch 8 has been so adjusted that the contacts 9 close after a delay of three-fourths of a second after the firing of the torpedo.

Since the firing of the torpedo produces an acceleration of approximately 11G, I make use of this accelerating force to set my timing mechanisms in operation. My timer mechanisms include two distinct clock mechanisms one, namely 13, for producing a short time delay, and a second, namely 36, for producing a longer time delay.

The timer 13 per se is of well known design and includes an inertia gear train. When a torque is applied to its actuating shaft 14, (see Figs. 3 and 7), this timer 13 through the inertia elements of its gear train, permits rotation of shaft 14 at a constant speed for as long as a torque is applied to this shaft 14. The time of operation of shaft 14 is selected at about two to three seconds.

Torque is applied to this shaft by the armature 15 pivoted at 16 on the U-shaped bracket 17 rigidly secured to the insulating plate 18 fixed on the timer mechanism frame. The armature 15 is biased for counterclockwise rotation by the tension spring 19 hooked to the back end of the armature and the frame, as shown most clearly in Fig. 7. The armature carries a weight 20. The timer mechanism is mounted on the torpedo so that the bottom thereof is directed aft of the torpedo. Acceleration of the torpedo through the inertia of weight 20 thus causes the armature 15 to move clockwise about its pivot 16.

The right-hand end of the armature is provided with a clip 21 having at its extreme right end an upwardly directed hook engaging the left-hand leg of the U-shaped upper end of the leaf spring 22. This leaf spring at its base is secured to the frame and is biased to move toward the right once released by the hook on the clip 21.

The right-hand end of the armature is, by means of link 26, operatively connected to the bar 23 loosely mounted on the shaft 14. The bar 23 carries a pair of spring biased pawls 24 disposed to engage the ratchet wheel 25 rigidly connected to the shaft 14.

The instant torpedo is fired, the weight 20 causes the armature to move clockwise till it engages the horizontal base on the brass guide plate 27'. The horizontal base is accurately machined so as to have a proper space relation to the top of core 27 of the actuating coil 28 for the armature 15. A proper air gap is thus provided to prevent sticking of the armature. In so doing, the spring 22 is released, and the bar 23 is rotated clockwise on the shaft 14. The instant the torpedo acceleration ceases, spring 19 starts the armature rotating counterclockwise about pivot 16, but such rotation is retarded because the pawls 24 engage wheel 25 fixed on shaft 14. A torque is thus applied to shaft 14, but its counterclockwise rotation is slowed to a constant speed by the inertia elements of the clock mechanism 13.

The actuating coil 28 is connected across the field windings F of the motor. A short time after the closing of the contacts 9, the voltage drop across the field F is built up sufficiently to energize coil 28. The circuit for coil 28 may be traced from junction 29 through conductor 30, coil 28, conductor 31, contacts 32 and 45, conductor 33, contacts 49 and 50, conductor 35, and contacts 9 to the negative terminal 12 of the battery B. The full energization of coil 28 thus occurs a moment after acceleration of the torpedo ceases and while the armature 15 is in its initial stages of its counterclockwise movement. The armature is thus again, but now electromagnetically, moved clockwise and will remain in contact with the horizontal surface of guide 27' as long as coil 28 remains energized.

The second timing device or clock mechanism 36 I utilize is also in itself in part of well known design and includes a clock spring for driving its timing elements. The spring of this timing device is wound by a suitable key attached to the shaft 37. Another shaft 67, operable by the clock spring, not shown, I provide with a gear 38 meshing with a gear sector 39 fixed on a sleeve shaft 68 which is rotatably disposed on shaft 40.

To the gear sector 39 I rigidly secure a friction sector 41. A leaf spring 42 is pivotally mounted at 43 and is so biased that it frictionally engages the friction sector 41 by an axially directed force. Any clockwise movement of the friction sector 41, as seen in Figs. 5 and 6, causes counterclockwise movement of the leaf spring 42.

The pivot block 44 for the leaf spring 42 is of insulating material carrying the leaf-spring contact 45. Any relatively small angular movement of the leaf spring in a counterclockwise direction will thus cause contact 45 to engage resilient contact 32 disposed on a suitable block of insulation 46 mounted on the frame on the timing device. It will thus be apparent that setting of timing device 36 presently to be discussed and involving clockwise movement of friction sector 41 will cause engagement of contacts 32 and 45. These two contacts are connected in parallel to the current limiting resistor 34. During the energization of coil 28, maximum voltage is thus applied to this coil 28.

To the gear sector 39 I also rigidly secure the cam 47. This cam 47, when the timer is in its full zero position, as shown in Fig. 8 and Fig. 6, is in such a position that the cam surface 48 moves the resilient contact 49 so that it is out of contact with contact 50 but is in engagement with contact 51.

When the exercise run is to be made by the torpedo, the shaft 68 is turned thus actuating friction sector 41 and this operation carries leaf spring 42 counterclockwise to thus cause engagement of contacts 32 and 45. The shaft is turned till the index 52 on cam 47 is opposite the number selected on the adjacent dial 53.

It will be noted that the graduated sector or dial 53 carries numerals running from 0 to 10. This simply means that by suitable manipulation of the key on shaft 37, the index 52 may be brought adjacent any one of the numbers on the dial 53. The number selected indicates, for normal operation, the time in minutes after firing of the torpedo that the ballast liquid is to be expelled from the exercise head.

If the index is moved opposite number 8 on the dial 53, then the cam region is well out of the way of the actuating end of the resilient contact 49, and contacts 49 and 50 are in engagement.

The second timing device or clock mechanism 36 is set in operation by depressing the button 54. A weight 55 is mounted directly above this button 54 and is biased away from the button by the leaf spring 56 fixed to the frame at 57. The leaf spring 56 carries the weight 55. The weight 55 is provided with a notch 58 coacting with the downwardly directed leaf spring 59. (See Figs. 3 and 4.) The spring 59 is fixed at its upper end to the relatively rigid bracket 60 secured to the frame.

Upon firing of the torpedo, the weight lags the movement of the torpedo and thus actuates the button 54. The leaf spring immediately moves into the notch 58 and the weight 55 and thus the button 54 remains in the actuated position. The timing device is thus set in operation and continues to operate until a short time after the index moves opposite the zero reading on the dial 53.

An instant after the torpedo is on its way, the timing device 36 starts the movement of elements 39, 41 and 47 in a counterclockwise direction. (See Figs. 5 and 6.) A relatively short time—a half minute or somewhat less—the leaf spring 42 is moved clockwise an amount sufficient to open the contacts 32 and 45. The current limiting resistor is thus inserted in the circuit of coil 28. The armature 15 is, however, not released since this coil 28 is normally energized sufficiently even though the resistor 46 is inserted in the coil circuit. By the use of the resistor 34 the drop-out voltage is made nearly equal to pull-in voltage. The coil is thus made more sensitive to voltage changes after firing of the torpedo.

The right-hand end of the armature is provided with a contact 61 disposed to engage contact 62 in the event coil 28 is for any cause deenergized.

If the operation of all the elements is normal, namely as expected, then after the lapse of eight minutes of torpedo movement through the water, the cam portion 48 engages the actuating end of the resilient contact 49, thus causing a break between contacts 49 and 50. Disengagement of these contacts interrupts the energizing circuit for coil 28 at these contacts.

The armature 15 is thus released, and the spring 19 moves the armature counterclockwise. The speed of movement is, however, retarded by the timing device 13 since the pawls 24 engage wheel 25 to rotate the gear train for actuating the verge escapement of this timing device or clock mechanism 13.

After the lapse of four or five seconds at the most, contacts 61 and 62 are brought into engagement. As soon as these contacts engage each other, a circuit is established from the positive terminal of the battery through contacts 61 and 62 to conductor 63, the squib 64 of the CO_2 flask 65, conductor 66, and contacts 9 to the negative terminal of the battery B.

The CO_2 flask gas pressure is thus admitted to the exercise head and the ballast liquid is expelled from the exercise head. It will be noted that the expulsion of the ballast liquid takes place—or at least is well underway—while the torpedo is still in motion.

Some ten to twenty seconds after the contacts 49 and 50 move out of engagement, the resilient contact 49 engages contact 51 whereupon a circuit is established for the latch release coil for the valve. The circuit is from the positive terminal 10 through coil 69, conductor 70, contacts 51 and 49, conductors 35 and 66, and contacts 9 to the negative terminal of the battery.

This valve thus moves through 90° with a snap action. The pneumatic switch is now connected to the timing leak device 71. This device is described in considerable detail in the hereinbefore mentioned pending application.

It suffices to state in this application that the timing leak device 71 permits the gas pressure acting on the pneumatic switch 8 to leak away at a selected speed. When the pressure acting on pneumatic switch 8 decreases to a selected value, contacts 9 are opened with a snap action and the motor is thus disconnected from the battery. The torpedo is thus stopped and may be readily recovered since normally by this time it is also buoyant.

My device is, however, not limited to the normal functioning of all elements. If for any reason, when the torpedo is fired, power fails to be applied to the driving motor, the coil 28 is deenergized and as a consequence the contacts 61 and 62 are closed. The ballast liquid is thus immediately expelled even though the cam 47 has by no means moved to its zero position.

If, after the torpedo starts in a normal manner, some difficulty develops during the run so that power to the driving motor is interrupted, coil 28 becomes deenergized and the device functions to expel the ballast liquid.

Also, if, after the torpedo starts in a normal manner and the power supply gradually fails, the device functions to cause the torpedo to surface before it has lost sufficient speed such that it would start to sink.

Since the clock mechanisms must be useful for repeated exercise runs it is very desirable to provide simple resetting means and means for effecting operation of the clock mechanism 36 independent of firing of the torpedo.

For independent starting of the clock mechanism I utilize the actuating stem 72. This stem projects through the top cover and has a lower end projecting through a guide opening in the bracket 73. A biasing spring 74 is disposed on the stem 72 and is disposed between the bracket 73 and a shoulder 75 fixed on the stem 72. The spring 74 thus biases the stem upwardly so that its lower end, which terminates directly above weight 55, is out of contact with weight 55. By depressing stem 72 the weight 55 and stem 54 is actuated in the same manner as if the inertia of weight 55 were to actuate stem 54.

If both clock mechanisms have completed their cycle of operation the leaf spring 22 is out of engagement with the clip 21 and spring 59 is disposed in notch 58. Button 76 constitutes the reset button for both weights 20 and 55, this button is spring biased upwardly to a given position. The inner, or lower, end is provided with a bracket 77 having actuating arms 78 and 79 and a heel portion 80 for actuating armature 15 and leaf springs 22 and 59 respectively. When button 76 is depressed arm 78 engages clip 21 to thus move the armature 15 down sufficiently so that the upper U-shaped end of spring 22 can be moved over the hook on clip 21. At the same arm 79 engages the right-hand surface of spring 22 placing the spring 22 in the position shown in Fig. 7. The heel portion 80 engages spring 59 to move it toward the right to thus release the weight 55 so that the spring 56 carrying this weight moves the weight to the position shown in Fig. 4. When the button is released it moves to the position shown in Figs.

4 and 7 but the armature 15 and weight 55 remain in the position shown in Figs. 4 and 7.

While I have shown but one embodiment of my invention, I do not wish to be limited to the specific showing made but wish to be limited only by the scope of the claims hereto appended.

I claim as my invention:

1. In an electro-mechanical control system for controlling the buoyancy of an underwater craft normally having a negative buoyancy, in combination, a chamber containing a ballast liquid, a flask containing gas under pressure mounted on the craft for connection to the chamber containing the ballast liquid, means for establishing fluid communication between the chamber and flask, a pair of electric terminals normally energized at a substantially constant potential, means responsive to predetermined drop of said potential for operating said means for establishing fluid communication between the chamber and the flask to thus admit gas from the flask into the chamber containing the ballast liquid.

2. In an electromechanical control system for controlling the buoyancy of an underwater device normally having a negative buoyancy, in combination, a chamber in the device containing a ballast liquid, a flask containing gas under pressure mounted on the device for connection to the chamber containing the ballast liquid, electric means for establishing fluid communication between the chamber and flask, a pair of electric terminals normally energized at a substantially constant potential, electromagnetic means, responsive to the potential of said terminals, for energizing said electric means upon a selected decrease in the potential across said terminals, and timing means set in operation when the device is placed under water for automatically decreasing the potential across said terminals sufficiently, after the lapse of a selected time interval, to effect deenergization of said electromagnetic means to thereby effect the energization of said electric means.

3. In an electromechanical control system for controlling the buoyancy of a torpedo normally having a negative buoyancy and normally being launched with acceleration over a relatively short time interval, in combination, a chamber in said torpedo containing a ballast liquid, a flask containing gas under pressure mounted in the torpedo and disposed to be connected to said chamber to expel the ballast liquid therefrom, electric means for establishing fluid communication between the flask and chamber, a pair of electric terminals normally energized at a constant potential, electromagnetic means connected to said terminals and operable on a selected decrease of the potential of said terminals to energize said electric means, timing means, inertia responsive means operable by the acceleration of the torpedo during launching for setting said timing means in operation, said timing means including means operable a selected time interval after the timing means is set in operation for decreasing the potential across said terminals sufficiently to deenergize said electromagnetic means to thus effect energization of said electric means.

4. In an electromechanical control system for controlling the buoyancy of a torpedo normally having a negative buoyancy and normally being launched with acceleration over a relatively short time interval, in combination, a chamber in said torpedo containing a ballast liquid, a flask containing gas under pressure mounted in the torpedo and disposed to be connected to said chamber to expel the ballast liquid therefrom,, electric means for establishing fluid communication between the flask and chamber, a pair of electric terminals normally energized at a constant potential, electromagnetic switching means, a torpedo propulsion motor, trigger means operated during the initial stages of torpedo acceleration for connecting said electromagnetic switching means to said terminals, said electromagnetic switching means having a time limit just sufficient so as to connect said propulsion motor to said terminals at the end of the accelerating period of the torpedo, a short-time timing device, a long-time timing device, inertia responsive means for setting said short-time timing device during launching of the torpedo, electromagnetic means, energized by the switching means, for holding said short-time timing device in set position, inertia responsive means for setting said long-time timing device during launching of the torpedo, said short-time timing device being operable, when released by the electromagnetic device, to energize said electric means to thus effect connection of the flask to the chamber, and means operable by said long-time timing device for deenergizing said electromagnetic means in a given interval of time and deenergizing said electromagnetic switching means in a longer interval of time.

5. In an electromechanical control system for controlling the buoyancy of a torpedo normally having negative buoyancy by the inclusion of a ballast liquid, normally being fired from a firing tube with considerable acceleration, and normally including means for expelling the ballast liquid from the torpedo when it is to be made buoyant, in combination, a source of electric potential, a timing device, means responsive to inertia and thus normally operable during acceleration to set said timing device, said timing device including means for effecting the operation of said means for expelling the ballast liquid of a selected time interval after the timing device is set.

6. In an electromechanical control system for controlling the buoyancy of a torpedo normally having negative buoyancy by reason of the inclusion within the torpedo of a ballast liquid, normally being fired from a firing tube with considerable acceleration, normally including propulsion equipment set in operation the instant the torpedo clears the firing tube and normally including means for expelling the ballast liquid when the torpedo is to be made buoyant, in combination, a source of electric potential normally of constant value, means responsive to a predetermined drop in potential of said source of electric potential, regardless of the cause of such drop, for effecting the operation of the means for expelling the ballast liquid from the torpedo, a timing device, means responsive to inertia and thus normally operable during the accelerating period of the torpedo for setting said timing device, said timing device including means for effecting the operation of said means for expelling the ballast liquid a selected time interval after the timing device is set and including means for deenergizing the propulsion equipment a greater time interval after the timing device is set.

7. In an electromechanical control system for controlling the buoyancy of a torpedo normally having negative buoyancy by reason of the inclusion within the torpedo of a ballast liquid, normally being fired from a firing tube with considerable acceleration, normally including propulsion equipment set in operation the instant

the torpedo clears the firing tube, and normally including means for expelling the ballast liquid when the torpedo is to be made buoyant, in combination, a source of electric potential normally of constant value, a timing device, means responsive to inertia and thus normally operable during the accelerating period of the torpedo for setting said timing device, said timing device including means for effecting the operation of said means for expelling the ballast liquid a selected time interval after the timing device is set and including means for deenergizing the propulsion equipment a greater time interval after the timing device is set.

8. In an electromechanical control system for controlling the buoyancy of a torpedo normally having negative buoyancy by reason of the inclusion within the torpedo of a ballast liquid, normally being fired from a firing tube with considerable acceleration, normally including propulsion equipment set in operation the instant the torpedo clears the firing tube, and normally including means for expelling the ballast liquid when the torpedo is to be made buoyant, in combination, a source of electric potential normally of constant value, means responsive to a predetermined drop in potential of said source of electric potential, regardless of the cause of such drop, for effecting the operation of the means for expelling the ballast liquid, a timing device, means responsive to inertia and thus normally operable during the accelerating period of the torpedo for setting said timing device, said timing device including means for effecting the operation of said means for expelling the ballast liquid a selected time interval after the timing device is set.

CHARLES C. WHITTAKER.