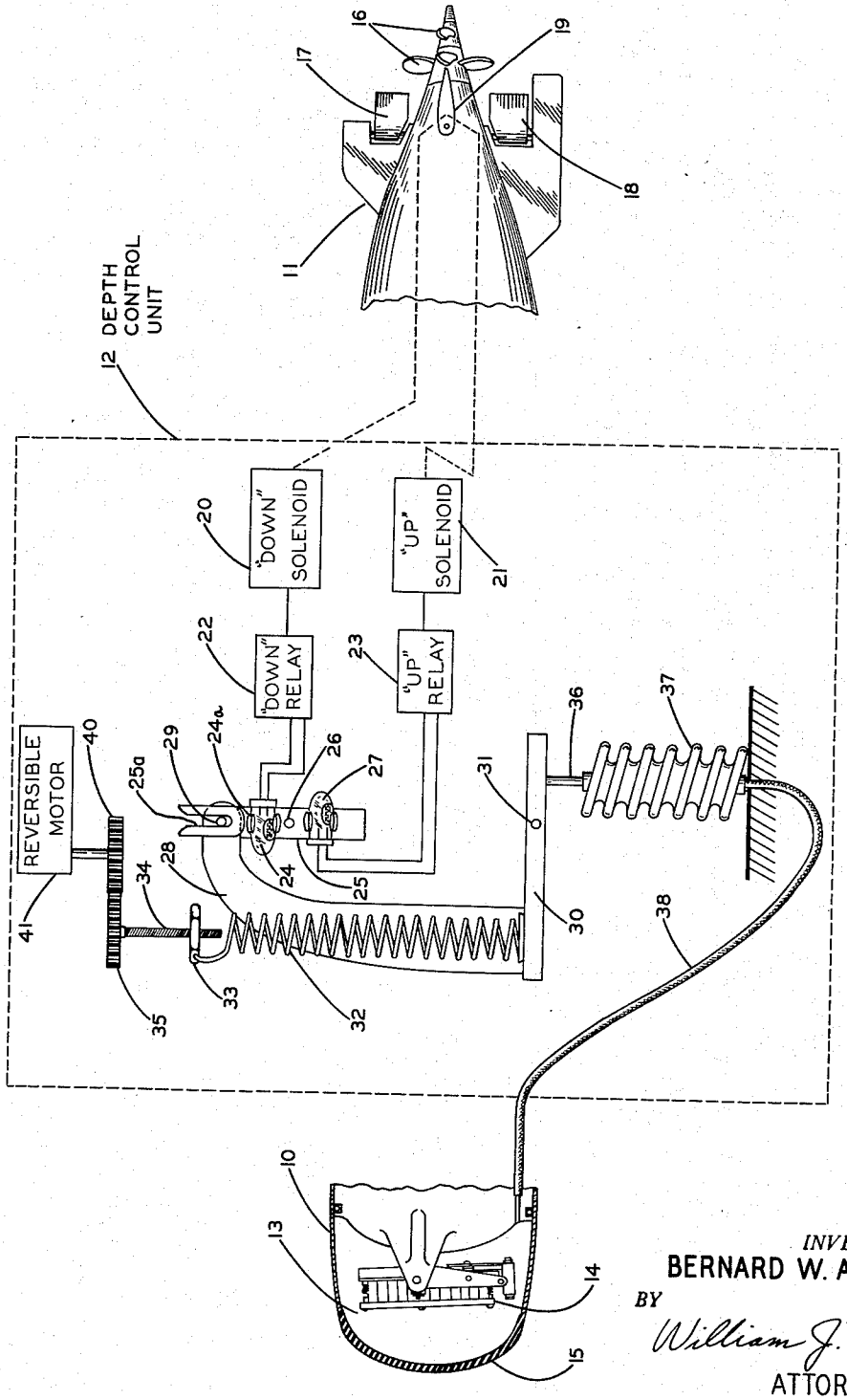
Aug. 29, 1961 B. W. ABRAMS 2,997,972

DEPTH CONTROL ARRANGEMENT FOR TORPEDO

Filed Aug. 26, 1955



INVENTOR.
BERNARD W. ABRAMS
BY
William J. Flynn
ATTORNEY

United States Patent Office 2,997,972 Patented Aug. 29, 1961

2,997,972

DEPTH CONTROL ARRANGEMENT FOR TORPEDO

Bernard W. Abrams, South Euclid, Ohio, assignor to Clevite Corporation, Cleveland, Ohio, a corporation of Ohio

Filed Aug. 26, 1955, Ser. No. 530,755
2 Claims. (Cl. 114—25)

This invention relates to an arrangement for maintaining a search torpedo operating at a desired depth in the water.

Prior to this invention, acoustic torpedos have been designed for search operation between predetermined upper and lower depth limits in the water while the torpedo is operating to detect acoustically any submarine or other target within its range. In the previous depth control arrangements on such torpedos, sea water enters through a small passage in the torpedo hull into a depth control bellows which operates suitable means for controlling the elevators on the torpedo. The pressure exerted by the sea water is a function of the depth at which the torpedo is then operating. Hence, the operation of the elevators in response to the sea pressure on the depth control bellows gives an accurate control over the depth at which it is desired to have the torpedo operate. However, the operation of such depth control arrangements has been unsatisfactory in extremely cold ocean regions because of the icing over of the passage leading to the depth control bellows and the associated tubing, which rendered the bellows no longer responsive to the sea pressure.

The present invention is directed to a novel depth control arrangement for a torpedo which avoids this difficulty, and thereby adapts the torpedo for successful operation under extremely cold conditions.

Accordingly, it is an object of this invention to provide a novel and improved depth control arrangement for a torpedo.

It is also an object of this invention to provide a novel depth control arrangement for a torpedo which operates in response to sea pressure, but which is not susceptible to being rendered inoperative at low temperatures by the formation of ice.

The foregoing objectives are accomplished in the preferred embodiment of the present invention by operating the depth control bellows from the liquid filling the chamber in the torpedo nose in which the electroacoustic transducer is mounted. The flexible diaphragm which extends across the front of this chamber causes this liquid to equalize the sea pressure, so that the pressure exerted by this liquid on the depth control bellows accurately reflects the actual sea pressure at the depth at which the torpedo is then operating. Since this pressure system for the depth control bellows does not involve the entry of the sea water itself into the bellows, it continues to operate even under icing conditions which would render the previous depth control systems inoperative.

Other and further objects and advantages of the present invention will be apparent from the following description of a preferred embodiment thereof, which is illustrated schematically in the accompanying drawing.

Referring to the drawing, the torpedo has an elongated generally cylindrical hull having a nose section 10 at its forward end, a tail section 11 at its rear end, and a control section between its ends which includes the depth control unit 12.

In the nose section 10 is formed a chamber 13 in which is mounted an electroacoustic transducer 14. A flexible resilient diaphragm 15 of rubber, neoprene or the like extends across the front of chamber 13 and is exposed to the sea pressure at its outer face. Suitable acoustic

energy-transmitting liquid, such as a mixture of silicone fluids, fills the chamber 13 and serves to pass acoustic energy to and from the transducer 14.

At the tail section 11 are located the propellors 16 for propelling the torpedo through the water, upper and lower rudders 17 and 18 for controlling the azimuth steering of the torpedo, and, at either side, a pivoted elevator 19 for controlling the depth movement of the torpedo. Each of the elevators 19 is suitably coupled to a "down" solenoid 20 and an "up" solenoid 21, which in turn are controlled by corresponding relays 22 and 23, respectively. Relay 22 is connected across a first mercury switch 24 mounted, by means of a spring clip 24*a*, on a rocker arm 25 which pivots about point 26. Relay 23 is connected across a second mercury switch 27 similarly mounted on rocker arm 25 at the opposite side of the pivot 26.

In their normal, horizontal positions both mercury switches 24 and 27 are open, which keeps relays 22 and 23 deenergized. When the rocker arm 25 is pivoted sufficiently clockwise from the position shown in the drawing, the globule of mercury in switch 24 moves down (to the right in the drawing) to bridge the fixed electrodes in this switch, thereby electrically closing switch 24. At this time switch 27 remains open because its electrodes are at the upper end of the switch envelope in this position of the rocker arm and hence are not bridged by the mercury globule in this switch. Conversely, when the rocker arm is pivoted a sufficient amount counterclockwise from its position in the drawing, switch 27 closes and switch 24 is open.

The position of the rocker arm 25, on which the mercury switches 24, 27 are mounted, is controlled by a generally L-shaped actuator 28 which carries a transverse pin 29 slidably received in an elongated slot 25*a* in the upper end of the rocker arm 25. At its other end the actuator 28 is secured to a plate 30, which is pivoted about point 31.

At one side of this pivot point a tension coil spring 32 is secured at one of its ends to the unit consisting of plate 30 and actuator 28. The opposite end of this spring is attached to a nut 33 threadedly mounted on a screw 34, which may be turned through a gear 35 attached to its opposite end. By turning the screw, the position of the nut 33, and hence the tension on spring 32, is adjusted to exert the desired clockwise bias on plate 30 and actuator 28. Gear 35 is mounted to be driven through gear 40 from a reversible motor 41 for changing the tension on spring 32.

At the opposite side of the pivot 31 for the plate 30 and actuator 28 is attached a rod 36, which is connected at its other end to the movable end of a corrugated metal bellows 37. The opposite end of this bellows is fixedly positioned. At this latter end the interior of the bellows is connected through a hose 38 to the chamber 13 in the nose section of the torpedo. Accordingly, the interior of the bellows 37 receives the transducer liquid at the same pressure as prevails in chamber 13. This liquid pressure in bellows 37 causes the bellows to exert on the unit consisting of plate 30 and actuator 28 a counterclockwise push which is opposed by the pull exerted by tension spring 32.

In operation, the motor 41 is intermittently energized in one direction to turn screw 34 intermittently in the corresponding direction for causing the torpedo to ascend gradually as it circles about searching for a target. When the torpedo reaches a predetermined search ceiling, the motor 41 is intermittently energized in the reverse direction to intermittently turn screw 34 correspondingly to cause the torpedo to descend gradually as it circles about.

The depth control unit operates on the principle of

causing the torpedo to assume an upward or downward path to maintain both mercury switches open. It will be understood that the operation of motor 41 may be controlled by any suitable means such as a programming device (not shown) which determines the duration of periods of its operation, the initial direction of turning, the time of reversal, etc. In the following description, it will be assumed that the motor 41 is operating continuously at a selected speed in a direction to cause the torpedo to ascend. Thus, at the start of the torpedo's ascent the motor 41 turns screw 34 in a direction to reduce the tension exerted by spring 32. When this happens, the force exerted by spring 32 becomes appreciably less than the opposing torque exerted by bellows 37, due to the sea pressure acting through the transducer liquid in chamber 13 and bellows 37. Therefore, plate 30 and actuator 28 tilt counterclockwise from the position shown in the drawing and, through the pin and slot connection 29, 30 to the rocker arm 25, this causes the mercury switches 24 and 27 to tilt with respect to the torpedo (counterclockwise from the position shown in the drawing). Mercury switch 27 closes, energizing relay 23 which actuates the "up" solenoid 21 to operate the elevators to cause the torpedo to head upward. The torpedo heads upward at an angle opposite to the tilt of the mercury switches with respect to the torpedo, tending to restore these switches to their horizontal position, at which both switches are open. Upon continued driving of screw 34 in the same direction, the tension exerted by spring 32 is lessened progressively and the torpedo continues to head upward so as to have this spring torque equalized by the torque exerted by the bellows in response to the sea pressure, which lessens as the torpedo continues to climb. Thus it will be seen that spring 32 exerts a control force (constantly diminishing due to continued operation of motor 41) and an opposing or counter-force, proportional to pressure on diaphragm 15, is exerted by bellows 37. Consequently, the inclination of the torpedo is controlled by and is a joint function of both forces. At the normal rate of ascent, the water pressure decreases at the same rate as the force exerted by spring 32. Under such conditions rocker arm 25 remains vertical with respect to the force of gravity and both switches 24, 27 are open. Should anything cause the torpedo to deviate from its set inclination, resulting in a greater or smaller rate of ascent, the water pressure acting on diaphragm becomes higher or lower than it should be at the particular instantaneous setting of the force of spring 32. The resulting unbalance between the control force and the counter-force then acts to correct the deviation and return the rate of ascent to the proper value.

It is to be noted that if the counter-force supplying means (viz., 36, 37, 38 etc.) were eliminated from the system, the continued operation of motor 41 would result in a monotonically increasing rather than constant inclination and rate of ascent.

Under the control of the programming device, motor 41 may be operated intermittently in the same direction. In this case, the screw would be turned a preselected amount and then would stop. Assuming the direction of turning to be such as to cause ascent, this would give the torpedo an upward heading in the same manner as already described.

The torpedo maintains the upward heading until the water pressure and, therefore, the pressure in chamber 13 decreases sufficiently to cause bellows 37 to contract. This results in rotating plate 30 and rocker arm 25 in a clockwise direction as viewed in the drawings causing the mercury in switch 24 to complete the circuit to "down" relay 22 and "down" solenoid 20. Consequently, elevators 19 are depressed, terminating the ascent of the torpedo and causing it to level off until both mercury switches are open. When the motor is again actuated by the programming means the same procedure is repeated to cause the torpedo to ascend to a new (shallower) depth. Thus it will be seen that, by intermittent operation of motor 41, the torpedo can be made to ascend (or descend) in a series of steps.

When the torpedo reaches the desired ceiling in depth the motor 41 is reversed, turning screw 34 in a direction to progressively increase the tension on spring 32. When the control force exerted by this spring on the plate 30 and actuator 28 appreciably exceeds the opposing force exerted bellows 37, rocker arm 25 is pivoted clockwise from the position shown in the drawing a sufficient amount to close mercury switch 24, the other mercury switch 27 being open at this time. This energizes relay 22 which actuates the "down" solenoid 20 to operate the elevators 19 on the torpedo to cause the torpedo to begin to descend. The torpedo heads downward at an angle opposite to the tilting of the mercury switches relative to the torpedo, tending to restore these switches to their horizontal position, at which both are open. With continued turning of screw 34 in this direction, the tension exerted by spring 32 continues to increase and the torpedo continues to descend in order to have the spring torque equalized by the bellows torque due to increasing sea pressure at lower depths.

As explained for the ascent travel of the torpedo, gradual descent also can be accomplished by intermittent operation of motor 41. It will also be understood that the motor may be kept inoperative throughout the run in which case the control force exerted by spring 32 will be constant and the torpedo will seek and remain at a constant depth as determined by the setting of the spring.

Thus, in both ascent and descent the present pressure control arrangement for bellows 37 operates to cause the torpedo to assume the depth called for by the tension exerted by spring 32, as determined by motor 41.

From the foregoing it will be apparent that the depth control arrangement of the present invention is particularly advantageous in that it provides a closed pressure system for operating the depth control bellows which is not susceptible to being rendered inoperative by the formation of ice.

While there has been described herein and illustrated schematically in the accompanying drawing a particular preferred embodiment of the present invention, it is to be understood that various modifications, omissions and refinements which depart from the disclosed embodiment may be adopted without departing from the spirit and scope of the present invention. For example, the present depth control may be operated from a diaphragm located elsewhere on the torpedo body than at the nose, with suitable liquid acting between such diaphragm and the depth control bellows to apply to the bellows a pressure equal to the sea pressure acting against the outside of the diaphragm.

What is claimed is:

1. In a torpedo comprising a body having a nose section with a chamber therein, an electroacoustic transducer in said chamber, acoustic energy-transmitting liquid filling said chamber, and a flexible diaphragm extending across the front of said chamber and exposed to the sea pressure to apply sea pressure to the liquid in said chamber, the improvement which comprises pressure responsive depth control means for controlling the depth at which the torpedo is operating, and a coupling from said chamber to said depth control means for operating the depth control means in response to the pressure of the liquid in said chamber.

2. In a torpedo comprising a body having a nose section with a chamber therein, an electroacoustic transducer in said chamber, a flexible resilient diaphragm extending across the front of said chamber and exposed to the sea pressure outside the torpedo, acoustic energy-transmitting liquid filling said chamber and responsive to

the pressure exerted from outside the torpedo to exert a corresponding pressure within said chamber, and elevators controlling the direction of the torpedo in depth, the improvement which comprises depth control means controlling the position of said elevators and including a pressure responsive member, and conduit means connected between said chamber and said pressure responsive member for applying said liquid to said pressure responsive member to control the elevators in response to the pressure of said liquid.

References Cited in the file of this patent

UNITED STATES PATENTS

1,022,706	Shonnard	Apr. 9, 1912
1,145,355	Dieter	July 6, 1915
2,060,202	Hammond	Nov. 10, 1936
2,404,785	Bostwick	July 30, 1946
2,420,676	Peterson	May 20, 1947
2,561,368	Hayes	July 24, 1951
2,810,033	Supernaw	Oct. 15, 1957