

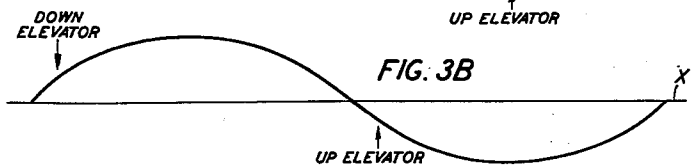
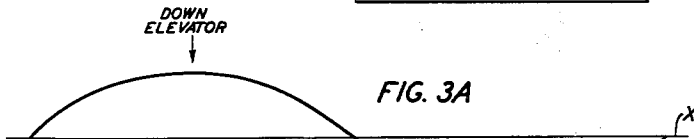
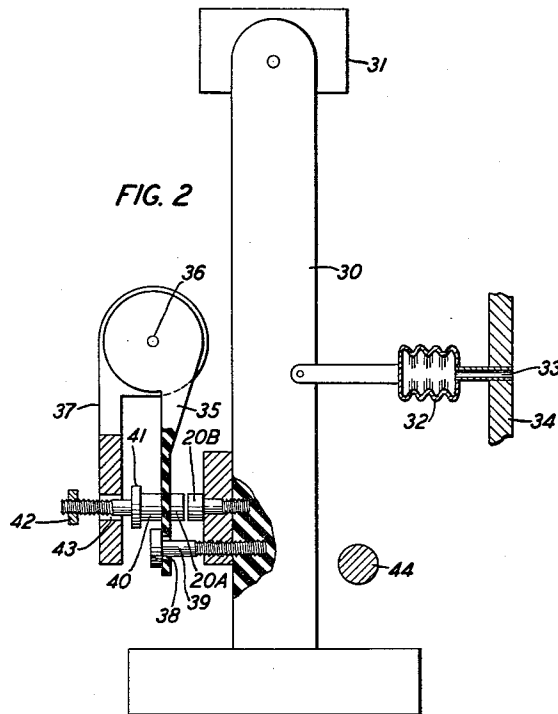
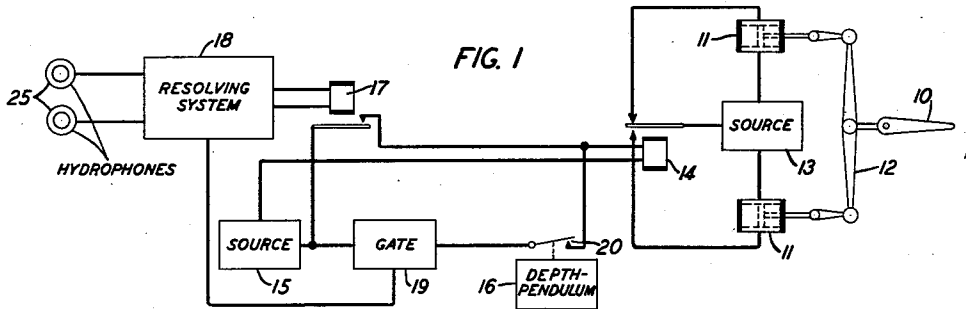
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3,002,482

CONTROL UNIT

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CONTROL UNIT

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This invention relates to control units and more particularly to depth-pendulum units for controlling the elevator in sonically guided torpedoes such as disclosed, for example, in the application Serial No. 564,340, filed November 20, 1944 of Harold C. Montgomery and John C. Steinberg.

Such units comprise, in general, a pendulum, contacts controlled thereby, and a bellows or similar element coupled to the pendulum and actuated in accordance with the hydrostatic pressure upon or at the torpedo. The contacts are included in a control circuit for the elevator and the pendulum, bellows and contacts are cooperatively associated to control the elevator in such manner as to tend to maintain the torpedo level and at a preassigned running depth, the control being effected by closing or opening of the contacts.

When proceeding under depth and pendulum control, the torpedo follows a substantially sinusoidal path in the vertical dimension, i.e. it oscillates about the preassigned running depth. Such oscillatory motion represents an increase in the length of path followed by the torpedo and, hence, a loss in the range.

One object of this invention is to reduce the oscillatory motion of the torpedo and more particularly to reduce both the amplitude and period of the oscillation, whereby the departure of the torpedo from the preassigned running depth path is decreased.

In accordance with one feature of this invention, the depth-pendulum control unit is constructed to effect an advance in the application of elevator correction thereby during each half of the oscillating cycle. More specifically, in accordance with one feature of this invention, the unit is constructed to introduce a leading phase shift, relative to the time when the pendulum tilt angle passes through zero, of or approaching 90 degrees in the operation of the pendulum controlled contacts whereby application of elevator correction is advanced correspondingly and both the amplitude and period of oscillating motion of the torpedo are substantially reduced.

The invention and the above-noted and other features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing in which:

FIG. 1 is a circuit diagram, mainly in block form, of an elevator control system illustrative of one embodiment of this invention;

FIG. 2 is an elevational view, partly in section, of a depth-pendulum control unit constructed in accordance with this invention; and,

FIGS. 3A and 3B are diagrams which will be referred to hereinafter in explaining the operation of the control unit illustrated in FIG. 2.

Referring now to the drawing, the control system illustrated in FIG. 1 comprises an elevator 10 which is deflectable in opposite directions, i.e. up or down, by solenoids 11 to the cores of which it is coupled by a linkage 12, the direction of deflection being determined by which of the solenoids is energized by the source 13. The energizing circuit for each of the solenoids is obvious and is traced from the source 13 over the armature and one or the other of the transfer contacts of a relay 14.

The relay 14 is energized from a source 15 over either of two circuits, one of which is controlled by a depth pendulum unit 16 and the other of which is controlled by

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an auxiliary relay 17. The relay 17 is controlled, in turn, by a resolving system 18 which is energized by hydrophones 25 mounted one above and the other below the longitudinal axis of the torpedo so that the relative output of the two hydrophones is determined by the direction relative to the torpedo of the source, such as a target vessel, from which underwater signals received by the hydrophones emanate. The system 18 converts signals received by the hydrophones 25 into a control signal effective to cause operation or release of the relay 17 depending upon whether the torpedo is headed above or below the target vessel.

The circuit controlled by the depth-pendulum unit 16 includes a gate 19 which is operated from the system 18 to open this circuit when the signals received by the hydrophones 25 are of a prescribed character. The gate may be, for example, of the amplitude type which operates when the underwater signals received by the hydrophones reach a preassigned level. Alternatively, it may be of the differential type, such as disclosed in the application Serial No. 564,340, filed November 20, 1944 of Harold C. Montgomery and John C. Steinberg, which operates when the difference between the outputs of the two hydrophones reaches a preassigned magnitude. The depth pendulum unit 16 controls the relay 14 by opening or closing contacts 20 in accordance with the direction of departure of the torpedo from level position at a prescribed running depth whereby the elevator 10 is deflected accordingly to tend to maintain the torpedo level at this depth.

The general operation of the system as thus far described is as follows: Immediately after launching, the torpedo proceeds with the relay 14 and, hence, the elevator 10 under control of the depth-pendulum unit 16. When the signals received by the hydrophones from the target vessel are such that the gate 19 operates, the depth-pendulum unit is dissociated from the relay 14 and the latter, thus, is placed under control of the relay 17 so that the elevator is controlled thereafter in accordance with target signals to steer the torpedo, in the vertical dimension, to the target.

When the torpedo is proceeding with the elevator under control of the depth pendulum unit 16, it oscillates substantially sinusoidally about the prescribed running depth. The general form of the torpedo path in the vertical dimension is illustrated by the curves in FIGS. 3A and 3B, the prescribed running depth being indicated in the figures by the line X. It is eminently desirable, of course, that both the amplitude and period of oscillation be small. In accordance with one feature of this invention, a very small amplitude and period of oscillation are realized by constructing the depth-pendulum unit so that, in effect, the unit hastens the application of elevator correction.

In one construction illustrative of this invention and shown in FIG. 2, the depth-pendulum unit comprises a pendulum 30 pivotally mounted upon a fixed support 31 in the torpedo so that the pendulum is vertical when the torpedo is level. Coupled to the pendulum 16 is a bellows 32 the interior of which is in communication with the sea by way of a port 33 in the wall of the torpedo, a portion of the wall being shown at 34. The bellows is so constructed that when the torpedo is at a prescribed running depth, the bellows exerts no force tending to tilt the pendulum from vertical position.

An arm 35 is pivotally mounted, as indicated at 36, from a second fixed support 37, the pivot mounting being such as to provide just sufficient friction so that the arm will remain at any position to which it is deflected or swung. The arm is provided with an aperture 38 through which the shank of a coupler 39, such as a screw threaded into the pendulum 30, extends. Mounted upon the arm 35 is a contact 20A and a stud 40 having a pair of

collars 41 and 42 threaded thereon, the stud extending through an oversized aperture 43 in the fixed support 37.

A second contact 20B is mounted upon the pendulum 30 in juxtaposition to the contact 20A.

Motion of the pendulum in one direction is limited by a stop 44 and in the other direction is limited by engagement of the collar 41 with the support 37. Motion of the arm 35 is limited by engagement of one or the other of the collars 41 and 42 with the support 37.

It will be noted that when the pendulum 30 swings to the left in FIG. 2, the contact 20B is forced against the contact 20A and the arm 35 is moved to the left. Then when the pendulum begins to swing to the right, the contact 20B is immediately disengaged from the contact 20A. The arm 35 remains in the position to which it had been moved until the head of the coupler 39 engages the arm 35, whereupon the arm is moved to the right as a result of the swing of the pendulum in this direction. Consequently, both the contacts 20A and 20B move to the right. If, then, the pendulum again swings to the left the contact 20B almost immediately engages the contact 20A.

The effect of the arm 35 and its detachable coupling associated with the pendulum 30 is to introduce a leading phase, of or approaching 90 degrees, in the operation of the contacts 20. This will be seen from the following considerations. Assume that the contact 20A were fixed at the mid-position of the pendulum swing, that engagement of the contact 20A with contact 20B results in up elevator and disengagement of these contacts from one another results in down elevator. For these conditions, the opening or closing of the contacts would occur as the tilt angle of the torpedo went through zero as shown in FIG. 3A. That is to say, the contacts would remain disengaged for the time that the pendulum swung from vertical, to the right and back to vertical and would remain engaged for the balance of each cycle.

In the construction illustrated in FIG. 2, however, as has been pointed out hereinabove, immediately after the pendulum has swung to the left and begun to return to vertical, the contacts 20 become disengaged. Similarly, immediately after the pendulum has swung to the right and begun to return to vertical, the contacts engage. Thus, in both cases, the control of the elevator as a result of engagement or disengagement of the contacts occurs at substantially the beginning of the swing of the pendulum to the left or to the right as the case may be. Thus, in effect, a 90 degree leading phase shift in the operation of the contacts is produced as shown in FIG. 3B. As a result, both the amplitude and period of the oscillations of the torpedo about the prescribed running depth, while the elevator is under control of the depth pendulum unit, are substantially reduced.

In any construction, certain design criteria should be observed. The stops for limiting the motion of the pendulum should be adjusted so that the pendulum is free to swing through angles corresponding to oscillations of the torpedo without the introduced phase shift, so that the pendulum may reverse its direction of swing as soon as the torpedo changes its direction of tilt. Also, the spacing of the contacts 20A and 20B should be small compared to the swing of the pendulum in order to prevent substantial delay in closing of the contacts when the pendulum moves away from its extreme position (its extreme right position in FIG. 2). Also, this spacing should be sufficiently great to prevent accidental engagement of the two contacts by jars to which the torpedo may be subjected during operation.

In a typical construction of unit for a twenty-one foot

torpedo, stops positioned to allow a maximum pendulum motion in either direction corresponding to a tilt angle of 4 degrees or a depth change of 8 feet and a spacing of approximately 0.005 inch between the contacts 20A and 20B have been found satisfactory.

Although a specific embodiment of the invention has been shown and described, it will be understood that it is but illustrative and that various modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. A depth-pendulum control unit comprising a pendulum, depth control means coupled to said pendulum, an electrical contact mounted by said pendulum, an arm having an aperture therein, means pivotally supporting said arm for motion in the directions of swing of said pendulum, said arm being pivotally supported separate from said pendulum, said supporting means being constructed to hold said arm frictionally in any position to which it is deflected, an electrical contact mounted by said arm in position to be engaged by said first contact when said pendulum swings in the direction toward said arm, and a coupler carried by said pendulum and extending through said aperture, said coupler having a portion for engaging said arm only when said pendulum swings in the direction away from said arm and said contacts have separated a preassigned distance.

2. A depth-pendulum control unit in accordance with claim 1 comprising a first stop for limiting the swing of said pendulum in the direction away from said arm, and a second stop for limiting the deflection of said arm in the direction away from said pendulum.

3. An elevator control system for torpedoes, comprising an elevator, actuating means for said elevator, a control circuit for said actuating means and including a pair of contacts, said circuit being effective to cause deflection of said elevator in one or the opposite direction in accordance with the opening or closing of said contacts, and a depth-pendulum unit for controlling said contacts, said unit comprises a pendulum, depth control means coupled to said pendulum for applying a deflection force thereto in one or the opposite direction in accordance with the direction of departure of the torpedo from a prescribed depth, means mounting one of said contacts from said pendulum, an arm having an aperture therein, means pivotally supporting said arm separate from said pendulum for motion in the direction of swing of said pendulum, said supporting means being constructed to hold said arm frictionally in any position to which it is deflected, said arm mounting the other of said contacts in position to be engaged by said one contact when said pendulum swings in one direction to deflect said arm in said one direction of pendulum swing, and means comprising a coupler carried by said pendulum and extending through said aperture for coupling said support to said pendulum whenever the pendulum swings in the opposite direction through an arc sufficient to separate said contacts a preassigned distance.

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