Aug. 8, 1961 R. C. JONES 2,995,102

TORPEDO STEERING SYSTEM

Filed Nov. 20, 1944

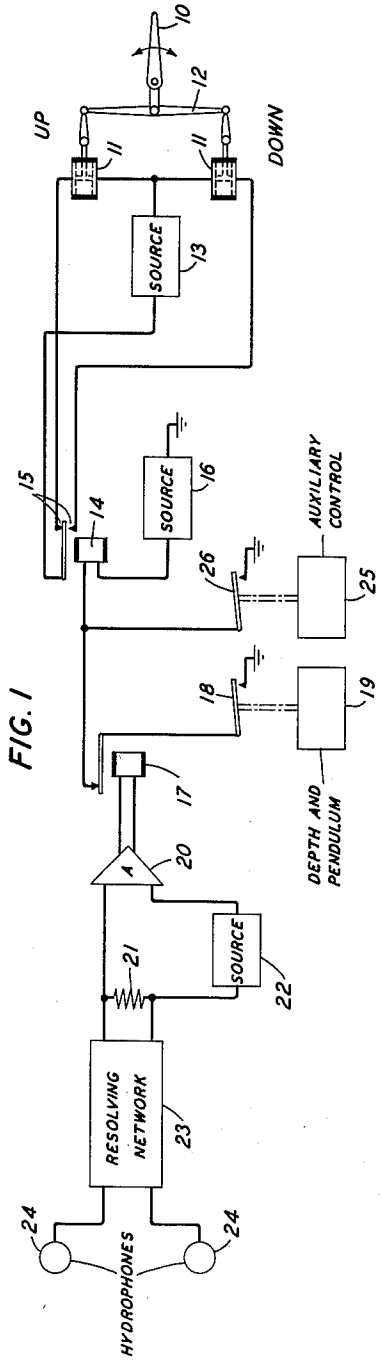

FIG. 1

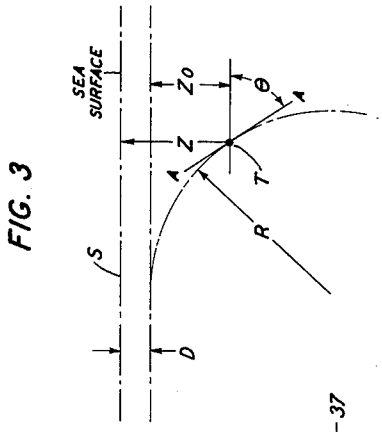

FIG. 3

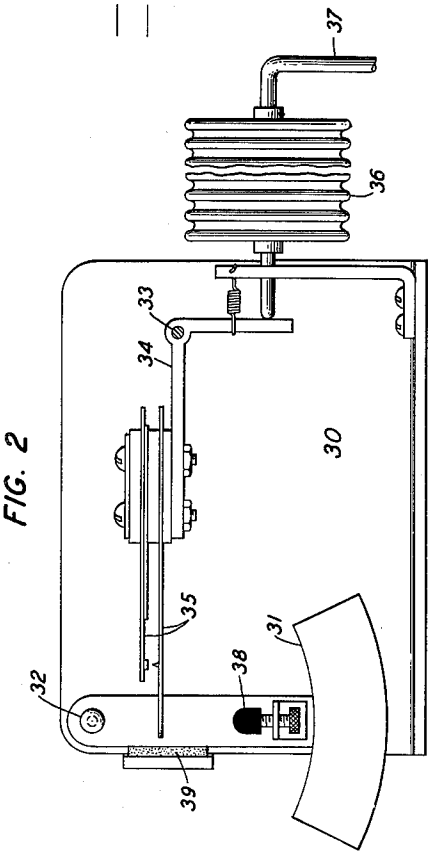

FIG. 2

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TORPEDO STEERING SYSTEM

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7 Claims. (Cl. 114—25)

This invention relates to control circuits and more particularly to circuits of the type disclosed in the applications Serial No. 555,523, filed September 23, 1944, of John C. Steinbergg and Serial No. 564,360 filed November 20, 1944 of Robert C. Jones, for controlling the elevator of torpedoes having target signal responsive steering systems.

In such torpedoes, the elevator is subject to control in accordance with signals emanating from a target to steer the torpedo in the vertical dimension and guide it to the target. The latter may be a surface vessel, and, for such case, as pointed out in the application of John C. Steinberg above-identified, the possibility exists that the torpedo may broach. Such action, of course, is undesirable. In some cases, further, it is desirable that the torpedo remain below a preassigned depth or ceiling.

One general object of this invention is to prevent a torpedo from rising above a prescribed depth or ceiling. More specifically, one object of this invention is to prevent a torpedo having a target signal responsive steering system from broaching.

In accordance with one feature of this invention, means are provided in the elevator control system of a torpedo for preventing the latter from reaching such position, considering both depth and tilt, that the torpedo would be incapable, under control of the elevator, of following a path in the vertical dimension which would not pass through the prescribed ceiling.

More specifically, in accordance with one feature of this invention, means are provided in the elevator control system for producing down elevator whenever the torpedo is so oriented, i.e., at such depth and so tilted, relative to the ceiling prescribed, that it could not, turning at its minimum turning radius, follow an arcuate path in the vertical dimension passing below, or in the extreme tangent to, the ceiling.

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 schematic, mainly in functional block form, of an elevator control system for sonically guided torpedoes, illustrative of one embodiment of this invention;

FIG. 2 is an elevational view of a control unit, included in the system illustrated in FIG. 1, for preventing rising of a torpedo above a prescribed ceiling; and

FIG. 3 is a diagram which will be referred to hereinafter in the discussion of certain principles involved in this invention.

Referring now to the drawing, the steering system illustrated in FIG. 1 is of the general configuration disclosed in the application of Robert C. Jones, identified hereinabove, and comprises an elevator **10** which is deflected in one direction or the other under control of a pair of solenoids **11** to the armatures of which it is coupled by a suitable linkage **12**, to steer the torpedo in the vertical dimension. The direction of deflection of the elevator **10** is determined by which of the solenoids **11** is energized from the source **13** and this is determined in turn by the condition of a control relay **14**, the contacts **15** of which are associated with the solenoid energizing circuits as shown. For reasons which will appear presently, in a particular system when the relay **14** is energized, i.e., when its armature engages the lower contact **15** in FIG. 1, the elevator is deflected to steer the torpedo downwardly and when the relay **14** releases, up elevator is produced.

The energizing circuit for the relay **14** includes a source **16**, the armature and contact of a relay **17** and a switch **18** which is controlled by a depth and pendulum unit **19** in such manner as to tend to control the relay **14** to maintain the torpedo level and at a preassigned running depth. The relay **17** is included in the output circuit of a direct current amplifier **20**, the input circuit for which includes an impedance **21** and a biasing source **22**. The impedance **21** is associated with the output side of a resolving network **23** which may be of the construction disclosed in the application, Serial No. 491,795, filed June 22, 1943 of Donald D. Robertson and serves to convert the outputs of a pair of hydrophones **24**, mounted above and below the longitudinal axis of the torpedo, into a potential across the impedance **21** of polarity related to an magnitude proportional to the sign and amplitude respectively of the vertical angle between the torpedo and the source, i.e., target, of the signals received by the hydrophones **24**. The network **23**, amplifier **20** and relay **17** are so constructed and arranged that when the torpedo is headed below the target the potential across the impedance **21** is such as to tend to cause energization of the relay **17**. The bias due to the source **22** is of such polarity as to tend to result in deenergization of the relay **17** and is of such amplitude that this relay cannot be energized unless the vertical angle between target and torpedo is of at least a prescribed magnitude.

The operation of the system as thus far described is set forth in detail in the application of Robert C. Jones, identified above. However, it may be noted briefly that initially after launching thereof the torpedo proceeds with the elevator **10** under control of the depth and pendulum unit **19** and is maintained level at a preassigned depth until the vertical angle between it and the target is sufficient to result in a target signal potential across the impedance **21** greater than the bias due to the source **22**. Thereupon, the relay **17** is energized to open the energizing circuit for the relay **14** whereby up elevator is produced. Thereafter the relay **14** is subject to control by the relay **17** on the one hand and the depth of pendulum unit on the other in such manner that the torpedo is aimed at a substantially constant average angle, in the vertical dimension, relative to the target.

As has been noted heretofore, there is the possibility that the torpedo may pass through a prescribed ceiling or broach and in accordance with one feature of this invention means are provided for preventing such action. In FIG. 1, this means is indicated as an auxiliary control **25** for a switch **26** associated with the energizing circuit for the relay **14**. As is apparent from the drawing, when the switch **26** is closed, the relay **14** will be energized and down elevator will result irrespective of the condition of the relay **17** or switch **18**. The function and performance of the auxiliary control **25** will be understood from the following consideration with particular reference to FIG. 3.

Assume that the torpedo is at a point T below the seat surface S, is headed upwardly and at an angle θ to horizontal. Assume further that it is desired that in no event shall the torpedo rise above a prescribed ceiling a distance D below the sea surface. The torpedo, then, is at a distance Z_0 below the prescribed ceiling and at a depth of Z. D may be selected at any value and may be zero in which case Z would be equal to Z_0. In order that the torpedo cannot rise above the ceiling set, it is apparent that it must be capable in the extreme of fol-

lowing an arc of radius R which is tangent to the heading A—A of the torpedo and to the ceiling. The minimum value of R which can be obtained is equal to the minimum turning radius of the torpedo. Thus, in order that the torpedo cannot pass through the prescribed ceiling it is necessary that it be controlled in such manner that at any position it is capable of following an arc of radius no smaller than the minimum turning radius of the torpedo and, in the extreme, tangent to the ceiling. It can be shown readily that this objective can be realized if the torpedo is so controlled that for any depth and heading thereof the distance Z_o is equal to or greater than the quantity $R_m(1-\cos\theta)$, where R_m is the minimum turning radius of the torpedo and θ is the heading angle as indicated in FIG. 3. Practically, this means that the elevator should be controlled to produce down elevator whenever the angle θ exceeds a certain angle dependent upon the depth of the torpedo.

An illustrative construction of auxiliary control for effecting actuation of the elevator in the manner requisite to prevent the torpedo from passing through a prescribed ceiling is shown in FIG. 2 and comprises a frame or support **30** upon which a pendulum **31** is pivotally mounted as indicated at **32**. Also pivotally mounted upon the frame or support **30**, as indicated at **33**, is a bell-crank **34** one arm of which carries a pair of normally open contacts **35**. The other arm of the bell-crank is coupled to a bellows **36**, the interior of which is coupled to the sea by a pipe or conduit **37** terminating at a port in the torpedo body. Mounted upon the pendulum **31** is a push-button **38** arranged to engage the lower contact **35** and thus to cause it to engage the upper contact. The two contacts constitute the normally open switch **26** illustrated in FIG. 1.

The frame or support **30** is mounted on the torpedo so that when the torpedo is level the pendulum is vertical and when the torpedo tilts upwardly the pendulum swings relative to the support or frame **30** to move the button toward the contact springs **35**. A stop **39** is provided to prevent motion of the pendulum in the opposite direction.

The bellows **36**, crank arm **34** and push-button **38** are so constructed and arranged that when the torpedo is level and at a distance below the prescribed ceiling substantially equal to the minimum turning radius of the torpedo, swinging of the pendulum through substantially 90 degrees would be required for the push-button **38** to actuate the contacts **35**. Thus, the vertical component of displacement of the push-button for 90-degree rotation of the pendulum corresponds to a movement of the bellows for a change in torpedo depth equal to the minimum turning radius.

If the torpedo sinks to a distance below the prescribed ceiling greater than the minimum turning radius, the bellows **36** expands and rocks the crank **34**, in the clockwise direction in FIG. 2, whereby the contact springs **35** are raised. Hence, for such distance, the torpedo can tilt substantially vertically upwardly without causing closure of the contacts **35** and consequent production of down elevator. However, when the torpedo rises, the bellows contracts and the crank is rocked, in the counter-clockwise direction in FIG. 2, so that, as will be apparent, the angle through which the pendulum **31** must swing to effect closure of the contacts **35** decreases. Thus as the torpedo rises, the angle of upward tilt thereof which will result in closure of the contacts **35** and down elevator decreases. The displacement of the contact springs with rocking of crank **34** is proportional to the distance Z and the swing of the pendulum **31** is proportional to the angle θ so that the component of the motion of the button **38** relative to the axis of the torpedo in the direction normal to this axis is proportional to $(1-\cos\theta)$. Hence, the contacts **35** will be closed and down elevator will result whenever the torpedo is at such position, i.e., at such depth and so tilted, that Z_o is less than the quantity $R_m(1-\cos\theta)$. Consequently, the torpedo is so controlled that it cannot reach such position that turning in the vertical dimension at its minimum turning radius it would rise above the preassigned ceiling.

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 torpedo steering system comprising an elevator, means for actuating said elevator, signal responsive means for controlling said actuating means to guide the torpedo in the vertical dimension, and means for preventing the torpedo from rising above a prescribed ceiling, said last-mentioned means comprising auxiliary means for controlling said actuating means to produce down elevator whenever the torpedo is so oriented relative to said ceiling that it could not follow an arc of prescribed radius in the vertical dimension tangent to or passing below said ceiling.

2. A torpedo steering system comprising an elevator, means for actuating said elevator, signal responsive means for controlling said actuating means to guide the torpedo in the vertical dimension, and auxiliary means for controlling said actuating means to produce down elevator whenever the torpedo is so oriented that the distance thereof from a prescribed ceiling is less than the quantity $R_m(1-\cos\theta)$, where R_m is the minimum turning radius of the torpedo and θ is the angle of tilt of the torpedo.

3. In a torpedo steering system, an elevator and a control circuit therefor, said control circuit comprising means for actuating said elevator, energizing means for said actuating means, relay means for controlling said energizing means to produce up or down elevator in accordance with the condition of said relay means, and auxiliary means for controlling said relay means to place it in the condition corresponding to down elevator whenever the torpedo is tilted upwardly at an angle of greater than a prescribed magnitude dependent upon the depth of the torpedo and decreasing as said depth decreases.

4. In a torpedo steering system, an elevator and a control circuit therefor, said control circuit comprising means for actuating said elevator, operating means for controlling said actuating means to produce up or down elevator in accordance with the condition of said operating means, signal responsive means for controlling said operating means, and auxiliary means for controlling said operating means to place it in the condition corresponding to down elevator whenever the torpedo is so oriented that its angle of tilt departs in one direction from a prescribed relation with respect to the torpedo depth.

5. In a steering system for a moving body, an elevator, actuating means therefor, a control system for said actuating means, said control system comprising operating means for controlling said actuating means to produce up or down elevator in accordance with the condition of said operating means, signal responsive means for controlling said operating means, and auxiliary means for controlling said operating means, said auxiliary means comprising a control member which when operated places said operating means in the condition corresponding to down elevator, an actuating member for said control member and spaced therefrom, means for varying the distance of travel of said actuating member requisite to effect operation of said control member thereby proportionately to the distance in the vertical dimension between the body and a prescribed horizontal plane, and means for varying said distance of travel proportionately to the angle of tilt of said body.

6. In a torpedo steering system, an elevator, actuating means therefor and a control circuit for said actuating means, said control circuit comprising operating means for controlling said actuating means to produce up or down elevator in accordance with the condition of said operating means, signal responsive means for controlling

said operating means, and auxiliary means for controlling said operating means, said auxiliary means comprising a control member effective when operated to place said operating means in the condition corresponding to down elevator, an actuating member for said control member and spaced therefrom, means for varying the distance between said control and actuating member proportionately to variations in depth of the torpedo and increasing as said depth increases, and means for decreasing said distance proportionately to the angle of upward tilt of the torpedo.

7. In a torpedo steering system, an elevator, actuating means therefor and a control circuit for said actuating means, said control circuit comprising relay means for controlling said actuating means to produce up or down elevator in accordance with the condition of said relay

means, an energizing circuit for said relay means including contact means which when operated result in placing said relay means in the condition corresponding to down elevator, a crank member mounting said contact means, an actuating member for said contact means, a pendulum mounting said actuating member, and bellows means for rocking said crank through an arc proportional to variations in depth of the torpedo, said bellows means and pendulum being constructed and arranged so that when the torpedo is at a distance below a prescribed ceiling substantially equal to the minimum turning radius of the torpedo, the upward tilt of the torpedo requisite to result in operation of said contact means by said actuating member is substantially 90 degrees.

No references cited.