

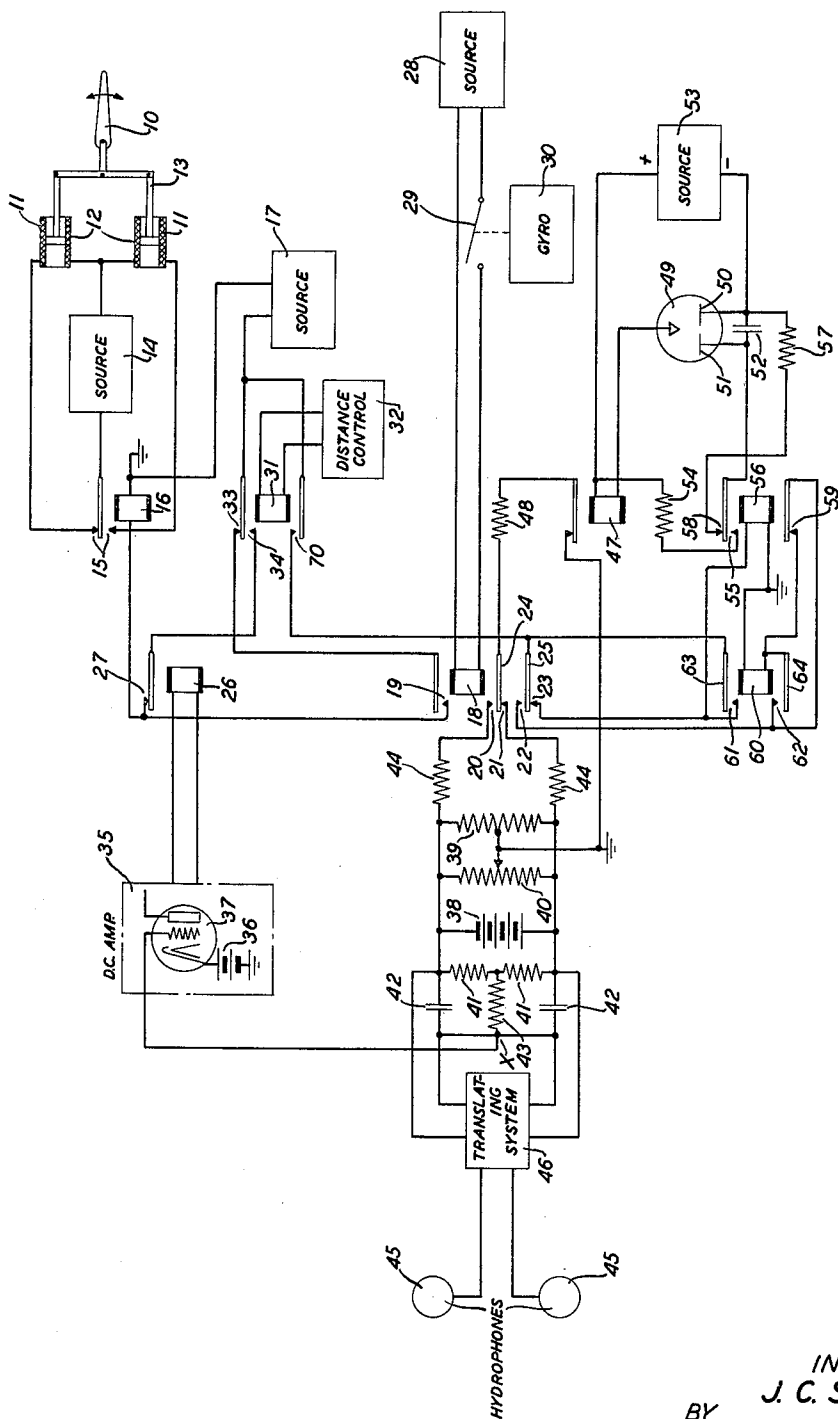
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TORPEDO CONTROL CIRCUIT

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TORPEDO CONTROL CIRCUIT

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This invention relates to control circuits and more particularly to torpedo steering systems of the type, such as disclosed in the application Serial No. 600,905, filed June 22, 1945, of Charles F. Wiebusch, and now U.S. Patent No. 3,003,449, wherein the rudder is gyroscope controlled for a period following launching of the torpedo and subsequently is controlled in accordance with signals emanating from a target to guide the torpedo to the target.

In such steering systems, it is eminently desirable from the standpoint of accuracy of attack and effective range, that the transfer of the rudder from gyroscope to target signal control be accomplished automatically when the torpedo approaches within the effective signal field of the target, that is to say when the torpedo reaches such position relative to the target that the target signal responsive portion of the steering system is capable of effecting accurate steering in accordance with signals, such as propeller and ship noises, emanating from the target.

One general object of this invention is to improve steering systems of the type above mentioned. More particularly, one object of this invention is to increase the range at which target signal control can be initiated and specifically to enable automatic transfer of the rudder from gyroscope to target signal control in a torpedo steering system of this type, when the torpedo is at the maximum distance from the target at which steering in accordance with target signals can be accomplished.

In one illustrative embodiment of this invention, a torpedo steering system comprises a rudder, actuating means therefor, a control element for the actuating means, gyroscope controlled means for producing a first control signal of polarity determined by the direction of departure of the torpedo from a preset course, a system responsive to under-water signals for producing a second control signal of amplitude and polarity determined by the bearing of the source of under-water signals received thereby, relative to the torpedo, and a resolving network for converting the first and second control signals into a resultant signal in accordance with which the control element, and hence the rudder, is controlled.

In accordance with one feature of this invention, a gate element is provided for effectively disabling the gyroscope controlled means whenever the torpedo reaches such position relative to the target that the first signal above noted remains of one polarity for a time of greater than preassigned duration, specifically significantly greater than one-half the hunting period of the torpedo under gyroscope control. The first control signal will remain of one polarity for such time only when the second control signal above noted reaches a minimum value sufficient to overcome the gyroscope signal so that transfer will be effected only when the torpedo is within the effective signal field of the target and headed at least a minimum angle with respect to the target.

In accordance with another feature of this invention, the gyroscope control signal is made of fixed amplitude just sufficient to overcome the component of the second control signal above noted due to the torpedo self-noise, whereby transfer of the rudder from gyroscope to target signal control can occur at substantially the maximum effective target signal control range of the under-water signal responsive portion of the steering system.

The invention and the above-noted and other features thereof will be understood more clearly and fully from

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the following detailed description with reference to the accompanying drawing in which the single figure is a circuit schematic, partly in functional block form, of a torpedo steering system illustrative of one embodiment of this invention.

The steering system illustrated comprises a rudder 10 deflectable in opposite directions to steer the torpedo in the horizontal dimension, the rudder being actuated by a pair of differentially operated solenoids 11 to the armatures 12 of which it is coupled by a suitable linkage 13. The solenoids 11 are arranged to be energized individually from a source 14 over a circuit including the respective contact 15 of a steering relay 16, so that the direction of deflection of the rudder is determined by the condition of the relay 16.

The energizing circuit for the relay 16 includes a source 17 and is arranged to be controlled by a gyroscope relay 18 having a contact 19 and a pair of transfer contacts 20, 21 and 22, 23 with associated armatures 24 and 25 respectively, and by a control relay 26 having a contact 27. The relay 18 is energizable from a source 28 over a circuit including a switch 29 which is operated by a gyroscope 30 to open or close the energizing circuit for the relay 18 depending upon the direction of departure of the torpedo from the horizontal course for which the gyroscope is set, specifically upon turning of the torpedo to port or starboard.

Associated with the relays 18 and 26 is an enabler relay 31 which is controlled by a distance control 32 and is provided with transfer contacts 33 and 34 and an auxiliary contact 70. Normally, the relay 31 is deenergized so that its contact 33 is closed; when, after launching, the torpedo has receded from the launching vessel a prescribed distance, measured for example by revolutions of the propeller shaft of the torpedo, sufficient to place it beyond the effective signal field of the launching vessel, the distance control 32 operates to effect operation of the relay 31 whereby the contact 33 is opened and the contacts 34 and 70 are closed.

The relay 26 is included in the output circuit of a direct current amplifier 35 biased at cut-off, as by a battery 36 included in the input circuit of the first stage tube 37 of the amplifier as indicated in the drawing, whereby normally the relay 26 is deenergized and its contact 27 is closed. The input circuit aforementioned includes a differential or resolving network which functions to convert several control signals applied thereto into a resultant potential of polarity and amplitude determined by the algebraic sum of the control signals, impressed upon the input circuit. This network comprises a direct current source 38 which is bridged by a resistance 39, a potentiometer resistance 40, the contact arm of which is connected to the mid-point of the resistance 39 and is grounded as shown, and by a pair of equal resistances 41. Each of the resistances 41 is bridged by the respective one of a pair of equal condensers 42 by way of a common resistor 43. The resistance 39 has its ends connected to the transfer contacts 20 and 21 of the gyroscope relay 18 over equal resistances 44. One end of the resistor 43 is connected to the control grid of the tube 37 as shown so that, as will be apparent, the control potential upon this grid at any time will be determined by the bias due to the source 36 and the potential of the point X in the network.

Applied to the resolving network are potentials determined by the bearing of the target toward which the torpedo is launched, with respect to the torpedo. A suitable system for producing these potentials is described in detail in the application, Serial No. 491,795, filed June 22, 1943, of Donald D. Robertson and, therefore, detailed description thereof here is deemed unnecessary. It may be noted, however, that this system comprises, generally, a pair of similar hydrophones 45 mounted on the torpedo

body on opposite sides, i.e. port and starboard, of the longitudinal axis of the body so that the outputs of the hydrophones in response to under-water signals are of relative amplitudes determined by the horizontal angle between the source of the signals and the axis noted. The hydrophone outputs are converted in a translating system 46 into two direct current potentials each of amplitude determined by the output of a respective hydrophone and these potentials are impressed across the condensers 42 in such polarity relation that the resultant potential appearing across the resistance 43 is of amplitude proportional to and polarity determined by the magnitude and sign respectively of the horizontal angle mentioned. Thus, signals, such as propeller and ship noises, emanating from a target are converted into a control potential across the resistance 43, which is a measure of the bearing of the target relative to the torpedo.

Also applied to the resolving network, under conditions which will be pointed out hereinafter, is a second control signal of preassigned amplitude and of polarity determined by the direction of departure of the torpedo from the gyroscope course. Specifically, the armature 24 of the gyroscope relay 18 is connected to ground over the armature and contact of a normally deenergized gate relay 47 and a suitable resistance 43. As is apparent, when the relay 18 operates or releases and while the relay 47 is deenergized, one or the other of the transfer contacts 20 and 21 is connected to ground, whereby a voltage component of positive or negative polarity is introduced in the resolving network. Thus, while the relay 47 is deenergized, the potential of the point X will be determined by the condition of the relay 18 and the control signal, if any, obtained from the translating system 46.

The polarities of the several control signals are made such that each alone tends to place the relay 26 in the condition requisite to effect deflection of the rudder to bring the torpedo on the course, gyroscope or target as the case may be, called for by the respective signal. The resistances 39, 44 and 48 are made such that the control signal due to operation of the relay 18 is of fixed amplitude set as pointed out hereinafter.

The general operation of the steering system as thus far described is as follows: At the time the torpedo is launched, the several relays are in the condition shown in the drawing. The torpedo proceeds at its prescribed running depth, being maintained at this depth in ways known in the art, and is maintained upon the gyroscope course by operation of the gyroscope relay 18, the control of the steering relay 16 being effected over the circuit traced from the ungrounded side of the source 17, over contacts 33 and 19, thence to the relay 16 and back to the source 17. Until the enabler relay 31 operates, the relay 26 cannot exercise any control over the steering relay because the contact 34 is open. When the torpedo has receded from the launching vessel a distance sufficient to place it beyond the effective signal field of the launching vessel so that it will not be subject to control in accordance with signals emanating from this vessel, the distance control 32 operates to energize the relay 31, whereby the contact 33 is opened and the contact 34 is closed. Hence, the steering relay 16 is placed under control of the relay 26 over the circuit traced from the ungrounded side of the source 17, over contacts 34 and 27, thence to the relay 16 and back to the source 17.

At this time, the torpedo may be at such position that the target signals are of insufficient intensity to effect control of the amplifier 35 and, hence, the condition of the relay 26. The gyroscope relay, then, controls the relay 26 by determining the polarity of the potential of the point X in the resolving network in accordance with the position of the armature 24, i.e. in accordance with the engagement of this armature with one or the other

of the contacts 20 or 21, whereby the torpedo is maintained on the gyroscope course.

When, however, the target signals received by the hydrophones are of sufficient intensity to effect control of the amplifier 35, which may be at the time of operation of the enabler relay 31 or subsequent thereto, the potential of the point X and, therefore, the condition of the relay 26 will be determined by the resultant of the gyroscope control potential and the target signal control potential.

It is desirable that the steering of the torpedo throughout the final portion of its run toward the target be controlled in accordance with the target signals alone, and further, that steering in accordance with the target signals alone be initiated at the maximum range, i.e. distance between target and torpedo, at which the target signal responsive system comprising the hydrophones 45 and translating system 46 is capable of effecting accurate steering. This maximum range is determined by the torpedo self-noise, as set forth in the application, Serial No. 545,835, July 20, 1944, of Alton C. Dickieson, now U.S. Patent No. 3,004,508. Moreover, as set forth for example, in the application Serial No. 564,340, filed November 20, 1944, to Harold C. Montgomery and John C. Steinberg and now U.S. Patent No. 2,996,028, it is advantageous that in a steering system of the type here under discussion, initiation of control of steering in accordance with target signals alone be determined by the target difference signal, i.e. the difference in the outputs of the two hydrophones, rather than by the absolute level of the target signals. In addition, it is obviously desirable that such initiation of control be prevented by transient signals such as may be produced, for example, by countermining operations.

In accordance with one feature of this invention, both the desiderata of commitment of the steering to target signal control on a target difference signal basis and prevention of such commitment by transient signals are realized.

As is apparent from the drawing, after the circuit is conditioned, by operation of the enabler relay 31, so that the steering relay 16 is placed under control of the relay 26, the gyroscope control of the relay 26 may be disabled by operation of the gate relay 47. The gate relay is included in the anode circuit of a gaseous discharge device 49 having a cathode 50 and control electrode 51 bridged by a condenser 52. The anode circuit includes also a source 53 which applies between the cathode and anode a potential below the breakdown value but at least as great as the sustaining value of the anode-cathode gap of the device 49. When the potential of the control electrode 51 relative to the cathode 50 is below a prescribed value, the device 49 is non-conducting and, therefore, the relay 47 is released and its contact is closed; when, however, the control electrode potential once reaches this value, the device is rendered conductive and remains conducting, whereby the relay 47 is energized and its contact is opened permanently.

The condenser 52 is arranged to be charged over an obvious circuit including a resistor 54 and the contact 55 of a relay 56 and is arranged to discharge through the resistor 57 over an obvious circuit including the contact 58 of the relay 56. If the relay 56 remains operated for a period of preassigned duration, the condenser 52 becomes charged to a potential sufficient to cause breakdown of the control electrode-cathode gap of the device 49, whereby this device is rendered conductive. For reasons which will appear presently, the length of the period noted is made substantially greater than one-half the normal hunting period of the torpedo.

The relay 56 is provided also with an auxiliary, normally closed contact 59 which is included in an energizing circuit for an auxiliary or lock-up relay 60 having normally open contacts 61 and 62 and associated armatures 63 and 64 respectively. As shown in the drawing, the

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contact 62 and associated armature 64 are connected across the contact 59 and associated armature in transposed relation, the contact 62 is connected to the contact 22 of the gyroscope relay 18, and the contact 61 and associated armature 63 are connected to the contact 23 and armature 25 respectively of the gyroscope relay. Also, the relays 56 and 60 have one terminal in common grounded.

The relay 56 is energized when either of the contacts 22 or 23 of the gyroscope relay is closed. Specifically, when the contact 23 is closed, the relay 56 is energized over a circuit traced from the grounded side of the source 17, through this source, over contact 70 to armature 25, over contact 23 to the relay 56 and thence to ground. When the contact 22 is closed, the relay 60 is energized over the circuit traced from the grounded side of the source 17, through the source, over contact 70 to armature 25, over contacts 22 and 59 to the relay 60 and thence to ground. When the relay 60 is operated, the relay 56 operates, the energizing circuit for the latter relay being traced from the grounded side of the source 17, through the source, over contact 70 to the armature 63, over contact 61 to the relay 56 and thence to ground. When the relay 56 operates in response to operation of the relay 60, the previously traced energizing circuit for the relay 60 is broken at the contact 59; however, operation of the relay 60 closes an obvious lock-in circuit at the contact 62 and armature 64 so that the relay 60 remains operated as long as the contact 22 of the gyroscope relay 18 is closed.

Thus, when either of the contacts 22 or 23 of the gyroscope relay is closed, the relay 56 is operated. Consequently, for departure of the torpedo in either direction from the gyroscope course, the charging circuit for the condenser 52 is closed and an increasing potential is applied to the control electrode 51.

When the torpedo is proceeding under gyroscope control alone either before operation of the enabler relay 31 or after operation of the enabler relay 31 and before the torpedo has reached a position such that the target signal responsive circuit can effect steering control, the torpedo hunts about the gyroscope course, that is, it oscillates about this course at a frequency which is fixed by the physical parameters of the torpedo and the time constants of the gyroscope control system. For any torpedo, the hunting period is readily determinable. Thus, for the conditions noted, it is obvious that the relay 56 will operate and release at the hunting frequency and the condenser 52 will be charged to a certain value during each period that the relay 56 is operated and will discharge quickly when this relay releases.

When the torpedo reaches a point such that the target difference signal in the differential network is sufficient to overcome the gyroscope control potential introduced in this network, the armature 25 of the gyroscope relay 18 will remain in engagement with one or the other of the contacts 22 and 23 for a time significantly greater than the half period corresponding to the hunting frequency while the torpedo is under gyroscope control alone and, therefore, when the torpedo reaches such point, the condenser 52 will be charged to a potential greater than that to which it is charged while the torpedo is under gyroscope control alone.

The relative lengths of time that the gyroscope relay 18 is operated or released before and after the torpedo enters the effective signal field of the target affords a basis for distinction upon which control of the device 49 can be predicted. Specifically, the time constant of the condenser charging circuit is made such that the condenser can be charged to a potential sufficient to effect breakdown of the control gap of the device 49 only if the armature 25 of the gyroscope relay remains in engagement with either contact 22 or 23 for a period significantly greater than one-half the hunting period of the torpedo under gyroscope control. In a particular torpedo having such

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a hunting period of 2.0 seconds, a condenser charging circuit having such constants that the condenser potential reaches the control gap breakdown value in 4.0 seconds after operation of the relay 56 has been found to be satisfactory. Thus, it will be appreciated that the gate relay 47 will be operated and the gyroscope control disabled when the torpedo has reached a position relative to the target such that the target difference signal is sufficient to overcome the gyroscope control signal introduced into the differential network but will not operate to effect disabling of the gyroscope control either while the torpedo is under gyroscope control alone or in response to transient under-water signals such as are produced by depth charges in countermining operations.

The exact point in the torpedo course at which steering will be committed to target signal control alone will be determined by the magnitude of the control potential introduced in the differential network by the gyroscope control. The minimum magnitude of this potential which can be utilized is dependent upon the torpedo self-noise, specifically upon the magnitude of the signal difference potential established in the differential network by the self-noise. The gyroscope control potential is made of such fixed amplitude that it is slightly greater than the difference potential in the differential network due to self-noise. Consequently, as will be appreciated, in a steering system of the construction illustrated, the steering may be committed to control in accordance with the target signals alone at the maximum range consistent with the torpedo self-noise.

Although a specific embodiment of the invention has been shown and described, it will be understood, of course, 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 steering system for a moving body, comprising a steering member, means for effecting deflection of said steering member in one or the opposite direction in accordance with the polarity of a signal applied to said means, means for producing a first control signal of polarity determined by the direction of departure of the body from a preset course, means responsive to signals emanating from a source for producing a second control signal of polarity and amplitude determined by the apparent bearing of said source relative to the body, means for resolving said first and second control signals into a resultant signal applied to said deflection effecting means, and means for disabling said first control signal producing means when the body departs from said preset course for a period of greater than a preassigned duration.

2. A steering system in accordance with claim 1 wherein said disabling means comprises a gate element effective when operated to disable said first control signal producing means, control means for causing operation of said gate element only when a potential of at least a certain magnitude is applied thereto, and means for producing a potential applied to said control means increasing proportionally to the duration of departure of the body in one or the opposite direction from said preset course.

3. A steering system for a moving body, comprising a steering member, means for effecting deflection of said steering member in one or the opposite direction in accordance with the polarity of a signal applied to said means, gyroscope-controlled means for producing a first control signal of polarity determined by the direction of departure of the body from a preset course, means responsive to signals emanating from a source for producing a second control signal of polarity and amplitude determined by the apparent bearing of said source relative to the body, means for resolving said first and second control signals into a resultant signal applied to said deflection effecting means, and means for disabling said first control signal producing means when the body departs from

said preset course for a period of duration significantly greater than one-half the normal hunting period of the body when said second control signal is of less than a prescribed magnitude.

4. A steering system for a moving body, comprising a steering member, means for effecting deflection of said steering member in one or the opposite direction in accordance with the polarity of a signal applied to said means, gyroscope-controlled relay means for producing a first control signal of polarity determined by the direction of departure of the body from a preset course, means responsive to signals emanating from a source for producing a second control signal of polarity and amplitude determined by the apparent bearing of said source relative to the body, means for resolving said first and second control signals into a resultant signal applied to said deflection means, and means for disabling said first control signal producing means when the body departs from said preset course for a period of greater than a preassigned duration, said disabling means comprising a gate element effective when operated to disable said first control signal producing means, a condenser, means controlled in accordance with the potential appearing across said condenser for causing operation of said gate element only when the potential appearing across said condenser is of at least a preassigned value, a charging circuit for said condenser, and means controlled by said relay means for closing said charging circuit for a period proportional to the length of departure of the body in either direction from said preset course.

5. A steering system for a moving body, comprising a steering member, means for effecting deflection of said steering member in one or the opposite direction in accordance with the polarity of a signal applied to said means, gyroscope-controlled relay means for producing a first control signal of polarity determined by the direction of departure of the body from a preset course, means responsive to signals emanating from a source for producing a second control signal of polarity and amplitude determined by the apparent bearing of said source relative to the body, means for resolving said first and second control signals into a resultant signal applied to said deflection effecting means, and means for disabling said first control signal producing means, said disabling means comprising a gaseous discharge device having output and input circuits, a relay included in the output circuit of said device and effective when operated to disable said first control signal producing means, a condenser included in the input circuit of said device, a charging circuit for said condenser, and means for closing said charging circuit for periods of duration proportional to the time said relay means is in either its operated or released condition.

6. A steering system for a moving body, comprising a steering member, means for effecting deflection of said member in one or the opposite direction, means responsive to signals emanating from a target for producing a first control signal of amplitude proportional to and polarity determined by the bearing of the target relative to the body, means for producing a second control signal of fixed amplitude and of polarity determined by the direction of departure of the body from a preset course, means controlled in accordance with the algebraic resultant of said first and second control signals for controlling said first means to effect deflection of said member in one or the opposite direction in accordance with the polarity of said resultant, and means for disabling said second control signal producing means when said first control signal is of at least a preassigned amplitude.

7. A steering system for a moving body, comprising a steering member, means including a relay for effecting deflection of said member in one or the opposite direction in accordance with the condition of said relay, control means for determining the condition of said relay in accordance with the polarity of the potential applied to said control means, means including a second relay for pro-

ducing a first control signal of fixed amplitude and of polarity determined by the direction of departure of the body from a preset course, the condition of said second relay being determined by the direction of departure of the body from said preset course, means responsive to signals emanating from a target for producing a second control signal of amplitude proportional to and polarity determined by the bearing of the target relative to the body, a resolving network for converting said first and second control signals in algebraic additive relation into a resultant potential applied to said control means, and means controlled by said first control signal producing means for disabling said first control signal producing means when said second relay remains in one condition for a period of greater than preassigned duration.

8. A steering system for a torpedo, comprising a rudder, control means for effecting deflection of said rudder in one direction or the other in accordance with the polarity of a signal applied to said control means, gyroscope-controlled means for producing a first control signal of polarity determined by the direction of departure of the torpedo from a preset course, means responsive to under-water signals for producing a second control signal of amplitude and polarity determined by the bearing of the source of signals received thereby relative to the torpedo, means for resolving said first and second control signals into a resultant signal applied to said control means, and means for disabling said gyroscope means when said first control signal remains of one polarity for a time significantly greater than one-half the hunting period of the torpedo under control of said gyroscope control means alone.

9. A steering system in accordance with claim 8 wherein said first control signal is of constant preassigned amplitude greater than the component of said second control signal due to the self-noise of the torpedo.

10. A steering system for a torpedo, comprising a rudder, control means for effecting deflection of said rudder in one direction or the other in accordance with the polarity of the potential applied to said control means, submarine signal responsive means for producing a first control signal of amplitude proportional to and polarity corresponding to the horizontal angle between the source of signals received thereby and the longitudinal axis of the torpedo, means for producing a second control signal of fixed amplitude slightly greater than that of the component of said first control signal due to self-noise of the torpedo and of polarity determined by the direction of departure of the torpedo from a preset course, said second control signal producing means comprising a relay the condition of which determines the polarity of said second control signal and gyroscope means for determining the condition of said relay, means for resolving said first and second control signals in algebraic additive relation into a resultant potential applied to said control means, and means for disabling said second control signal producing means when said relay remains in one condition for greater than a preassigned time.

11. A steering system in accordance with claim 10 wherein said disabling means comprises a normally non-conducting gaseous discharge device having input and output circuits, a gate relay included in said output circuit to operate when said device is conducting and effective when operated to disable said second control signal producing means, a condenser included in said input circuit and arranged to render said device conducting when the potential across the condenser is of a certain value and a charging circuit for said condenser controlled by said first relay to be closed for periods proportional to the time said first relay is in either operated or released condition, the time constant of said charging circuit being such that said condenser will be charged to a potential of said certain value only if said first relay remains in one condition for a period significantly longer than one-half the hunting period of the torpedo under control of said second control signal producing means alone.

12. A control circuit comprising an operating member, control means for actuating said operating member in accordance with the polarity of a potential applied to the control means, a pair of signal translating devices, means for producing a first control signal of amplitude and polarity determined by the difference of the outputs of said devices, means for producing a second control signal of polarity tending, when applied to said control

means, to maintain said operating member at a preassigned position, means for resolving said first and second control signals in algebraic additive relation into a resultant potential applied to said control means, and means for disabling said second control signal producing means when said first control signal becomes of amplitude greater than that of said second control signal.

No references cited.