

Aug. 29, 1961

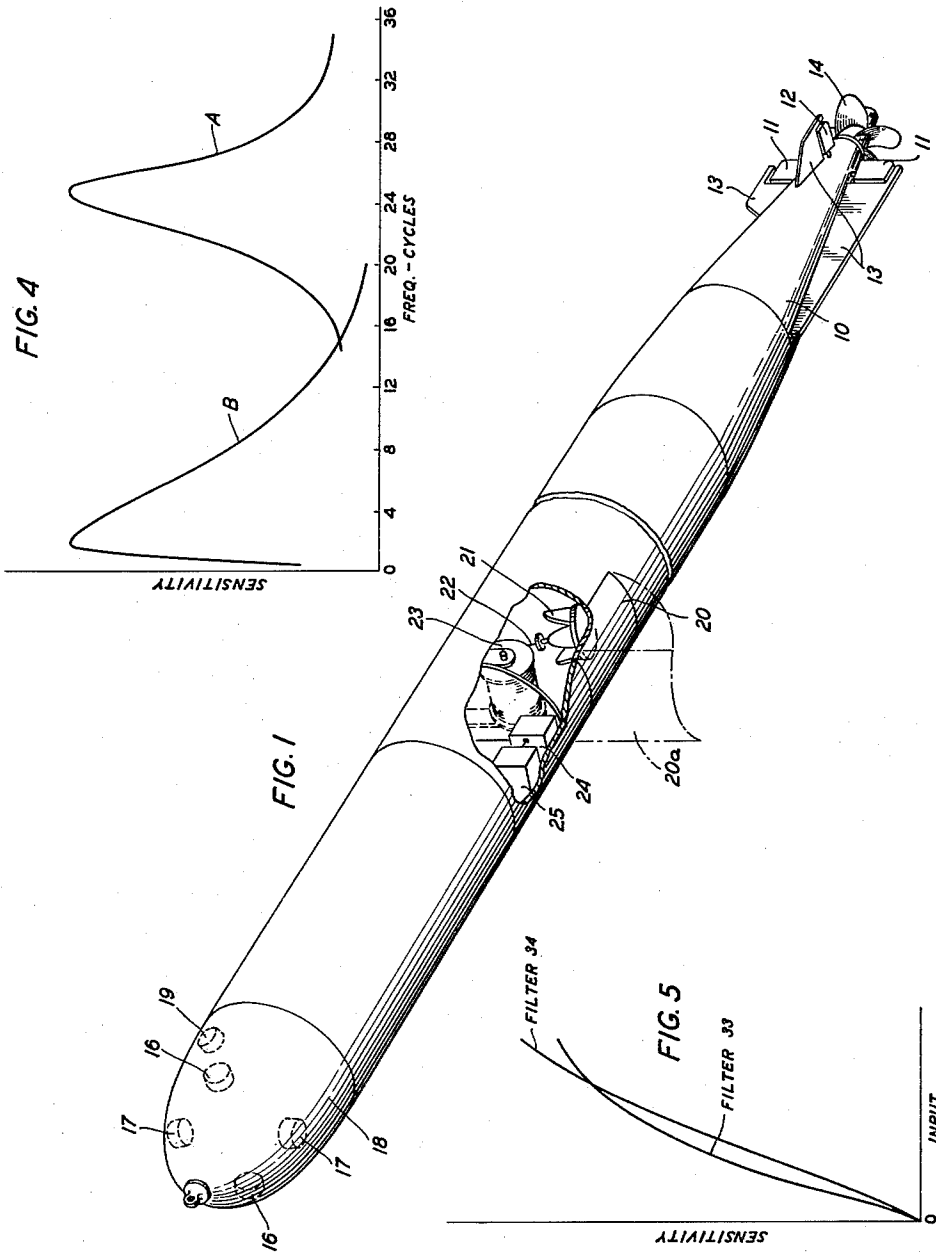
A. C. DICKIESON

2,997,970

CONTROL SYSTEM FOR TORPEDO STEERING

Filed June 2, 1944

2 Sheets-Sheet 1



INVENTOR
A. C. DICKIESON
BY
Charles C. Kiesel
ATTORNEY

Aug. 29, 1961

A. C. DICKIESON

2,997,970

CONTROL SYSTEM FOR TORPEDO STEERING

Filed June 2, 1944

2 Sheets-Sheet 2

FIG. 2

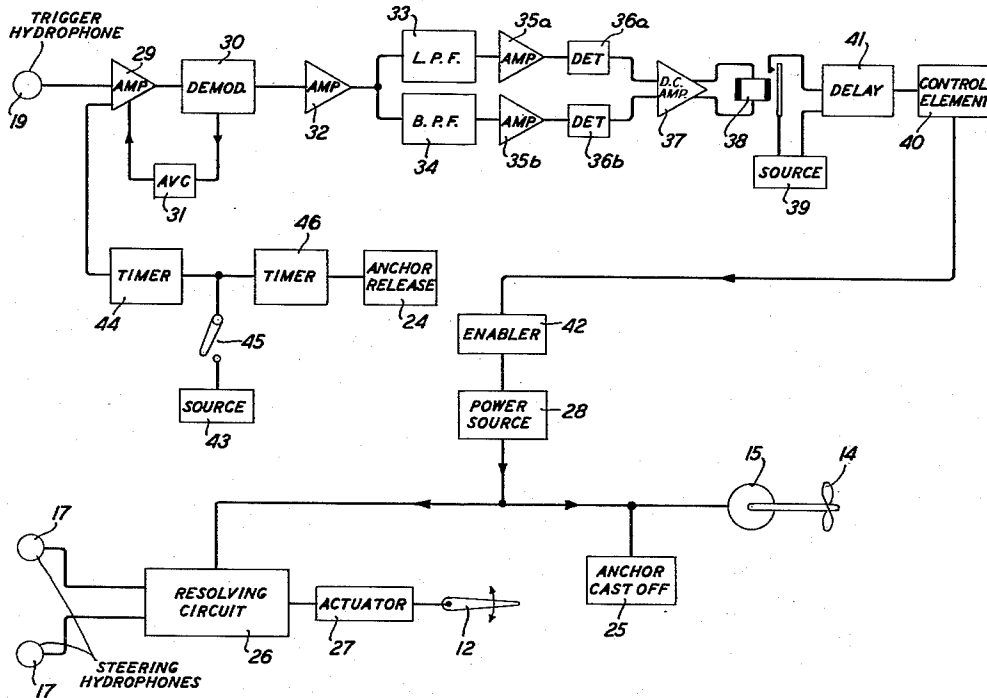
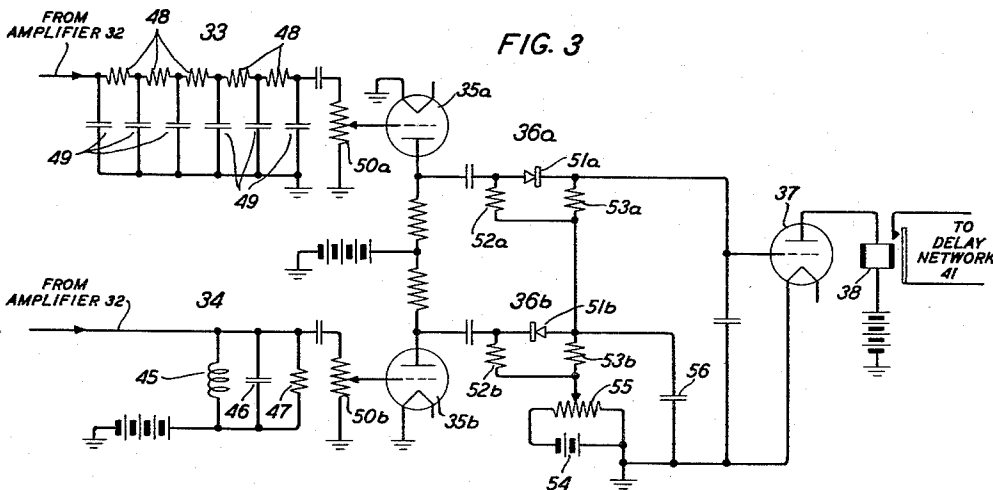


FIG. 3



INVENTOR
A. C. DICKIESON

BY

Walter E. Kiesel

ATTORNEY

1

2,997,970

CONTROL SYSTEM FOR TORPEDO STEERING

Alton C. Dickieson, Mountain Lakes, N.J., assignor to Bell Telephone Laboratories, Incorporated, New York, N.Y., a corporation of New York

Filed June 2, 1944, Ser. No. 538,435

9 Claims. (Cl. 114-23)

This invention relates to control systems and more particularly to signal responsive control systems for torpedoes having target signal actuated steering systems such as disclosed, for example, in the application Serial No. 491,795, filed June 22, 1943 of Donald D. Robertson.

One object of this invention is to enable use of a self-propelling signal guided torpedo as a mine which can be launched in waters frequented or traversed by enemy ships, will lie quiescent after launching and will be set into operation to attack such a ship by signals emanating from a ship that approaches within range of the torpedo.

Another object of the invention is to prevent false actuation of such a torpedo used as a mine, as by random submarine signals or signals emanating from ships beyond the effective range of the torpedo or having speeds such that they could not be reached or overtaken by the torpedo.

In one illustrative embodiment of this invention, a torpedo of the self-propelling type and having positive buoyancy comprises means for anchoring it at a pre-assigned depth after it is launched, as from a submarine or surface vessel, and normally disabled rudder and elevator control systems for guiding the torpedo toward and against a ship in response to supersonic signals emanating from the ship.

In accordance with one feature of this invention, a trigger or control system is provided for casting off the anchoring means and enabling the steering systems and the propelling mechanism for the torpedo when a ship to be attacked comes into the area where the torpedo has been launched. In one particular construction, the control system comprises a hydrophone, mounted on the torpedo, for detecting noises originating at the ship to be attacked, a resolving circuit for converting the hydrophone output into an operating signal and a control element responsive to the operating signal for effecting enabling of the propelling mechanism, the steering systems and the anchor cast off.

In accordance with another feature of this invention, means are provided for preventing operation of the control system except in response to reception by the hydrophone of noises emanating from ships within the effective range of the torpedo. In one particular construction, the resolving circuit included in the control system is constructed and arranged to discriminate between on the one hand characteristic noises emanating from ships having speeds within a preassigned range and on the other hand random or background noises and characteristic noises emanating from ships having speeds above the pre-assigned range, whereby the torpedo is set into operation only in response to signals emanating from such ships as it can reach or overtake.

Background submarine noise is random in character and the level throughout various frequency bands over a substantial range of low frequencies is fairly uniform. The noise emanating from a ship in motion also is random in character but is modulated to a substantial extent

2

at the propeller frequency. The propeller frequency, of course, has a relation to the speed of the ship and, in general, for a given number of propeller blades, a linear relation obtains between ship's speed and propeller frequency. Thus, the envelope of ship's noise may be utilized to discriminate sonically between ships having speeds within a preassigned range and ships having greater speeds.

The discriminating action of the resolving circuit in the particular construction aforementioned makes use of this characteristic of the envelope of ship's noise. In one specific form, this circuit includes two filters which are supplied in parallel with energy corresponding to low frequency demodulation products of the submarine signals within a prescribed band of frequencies received by the hydrophone. The outputs of the two filters are combined in difference relation. One of the filters is of the low-pass type constructed to pass frequencies corresponding to the propeller frequency of ships having such speeds that the torpedo can overtake them. For example, this filter may have an upper cut-off frequency of the order of eight cycles so that it passes frequencies corresponding to the propeller frequencies of ships having speeds below of the order of twenty knots, and having four propeller blades. The other filter may be of the band-pass type, for example having a pass band of substantially twenty-one to twenty-eight cycles. The two filters are designed to have similar load characteristics and the pass-bands thereof are such that for random noise the outputs of the two are substantially equal.

The filters are associated with the control element so that this element will operate only when the output of the low-pass filter exceeds that of the other filter to a prescribed minimum degree. Thus, for random or background noise or the envelope of ship's noise for ships having speeds above the preassigned range, received by the hydrophone, and for the envelope of ship's noise of ships having speeds within the prescribed range but beyond the effective range of the torpedo, the control element remains inoperative.

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 perspective view of a torpedo including a control system illustrative of one embodiment of this invention, a portion of the body of the torpedo being broken away to show the anchor and the operating mechanism associated therewith;

FIG. 2 is a functional schematic of a steering control and trigger system illustrative of one embodiment of this invention;

FIG. 3 is a circuit diagram of the trigger system; and

FIGS. 4 and 5 are graphs illustrating the characteristics of the filters included in a typical trigger system of the configuration shown in FIG. 3.

Referring now to the drawing, the torpedo illustrated in FIG. 1 comprises an elongated body having a tail section 10 in which a two-part rudder 11 and a two-part elevator 12 and associated vanes 13 are mounted, the two parts of each of the rudder and elevator being coupled mechanically to deflect in unison. Extending from the tail section is a shaft carrying a propeller 14, the propeller being driven by a suitable motor 15, illustrated in FIG. 2.

The rudder and elevator are controlled in accordance with sonic signals emanating from a target, such as a ship, by way of a signal actuating steering system, such as disclosed, for example, in the above-identified application of Donald D. Robertson, in accordance with such signals received by two pairs of hydrophones 16 and 17, respectively, mounted in the nose section 18, to steer the torpedo toward and against the target. Also mounted in the nose section of the torpedo is a fifth hydrophone 19, the function of which will be pointed out hereinafter.

The torpedo is provided with a compartment having a door 20 and in which there is mounted an anchor 21 attached to a cable 22 normally wound on a reel 23. Associated with the reel 23 is a release mechanism 24 for allowing, when actuated, revolution of the reel to pay out a prescribed length of the cable 22, and a cast-off mechanism 25 which, when actuated, severs or releases the cable to uncouple the anchor from the torpedo. The open position of the door is indicated in broken outline at 20a.

The control system for the torpedo, illustrated in FIG. 2, comprises a steering system including a resolving circuit 26 and actuator 27 associated with the hydrophones 17 and elevator 12 and a similar resolving circuit and actuator, not shown, associated with the hydrophones 16 and rudder 11, the correlation of the elements and the operation of which are described in detail in the aforementioned application of D. D. Robertson. The steering system is energized from a suitable power source 28, such as a battery, which, as pointed out in detail hereinafter, is normally disabled so that the steering system also is disabled. The anchor cast-off mechanism 25 and the motor 15 also are energized from the source 28.

The control system includes also a trigger circuit for enabling the steering control system in response to receipt by the hydrophone 19 of submarine signals of a prescribed character. The hydrophone 19 which may be, for example, of the piezoelectric crystal type, is constructed to be particularly sensitive to signals within a prescribed band of frequencies, for example a 2,500-cycle band with a mid-frequency of 5 kilocycles, and the output thereof is supplied to an amplifier 29, for example, of several RC coupled stages, broadly tuned to be efficiently operable over the prescribed band of frequencies. The amplifier output is supplied to a demodulator 30, for example, of the copper-oxide disc type, to which automatic gain control 31 for the amplifier is connected, and the low frequency demodulation frequencies obtained are amplified by a low frequency amplifier 32.

The output of amplifier 32 is supplied to both a low-pass filter 33 and a band-pass filter 34, the two filters having balanced load characteristics, having substantially equal effective band widths for random noise and the filter 34 having a pass-band somewhat above the upper cut-off frequency of the low-pass filter 33 as described in detail hereinafter. Each filter has associated therewith a respective amplifier 35 followed by a detector 36. The direct current output voltages of the two detectors are combined in opposing relation and the resultant is impressed upon the input circuit of a direct current amplifier 37, normally desensitized as by biasing of the input grid thereof beyond cut-off. The two filters and associated amplifiers and detectors are so constructed and associated with the direct current amplifier 37 that when the outputs of the two filters are equal or that of the filter 34 exceeds that of the filter 33, the direct current amplifier 37 remains desensitized whereas if the output of the low-pass filter 33 is greater, to at least a prescribed minimum extent, than that of the filter 34 the normal bias upon the input grid of the amplifier 37 is overcome to enable passage of sufficient current to the relay 38 to cause operation thereof.

Included in the output circuit of the amplifier 37 is a relay 38 which, when operated, closes the energizing cir-

cuit from a source 39 to a control element 40 through a delay network 41 such as disclosed in the application Serial No. 538,525 filed June 2, 1944, of Paul G. Edwards. The control element 40, when energized, operates an enabler 42 for the power source 28 to render the steering control system operative.

In a specific construction, the power source 28 may be a battery the electrolyte for which is contained initially in a vial or vials mounted above the cells of the battery. The enabler includes a small detonating cap or a series of such caps which are fired in response to operation of the control element 40 to shatter the vial or vials and thus allow flow of the electrolyte into the battery cells, whereby the battery is rendered operative.

The trigger circuit is energized by a source 43 by way of a timer 44 which delays enabling of the trigger circuit for a predetermined interval after closure of the starting switch 45. The anchor release 24 also is energized from the source 43 by way of a timer 46 which delays operation of the anchor release for a second predetermined interval, of less duration than that provided by the timer 44, after closure of the starting switch 45.

The general operation of the control system is as follows: Before the torpedo is launched, both the steering and trigger systems are disabled. When the torpedo is launched, the starting switch 45 is closed and the torpedo coasts for a period, the duration of which is determined by the timer 46, whereupon the anchor release 24 operates and the anchor falls from the compartment through the door 20 to moor the torpedo at a preassigned depth. At the end of a longer period, the duration of which is determined by the timer 44, the trigger circuit is connected operatively to the source 43 and thus enabled.

In the absence of a ship within the effective range of the trigger circuit, the direct current amplifier 37 remains desensitized so that the steering system remains disabled. Random or background submarine noises received by the hydrophone 19 result in substantially equal outputs from the filters 33 and 34 and, therefore, have no effect upon the direct current amplifier. Similarly, signals or noises within the effective band of the filter 33 but below a prescribed intensity level have no effect upon this amplifier, being insufficient to overcome the blocking bias upon the input grid thereof. Signals or noises within the pass-band of the filter 34, irrespective of their intensity, cannot render the amplifier 37 effective inasmuch as, as noted heretofore, the effect of the rectified output of this filter as applied to the input of this amplifier is to increase the blocking bias upon the input grid thereof.

When a ship having such speed that its noise envelope is of the character that the energy supplied to the filter 33 exceeds that supplied to the filter 34 by a preassigned amount, comes within the effective range of the torpedo, the voltage obtained from the detector 36a associated with the filter 33 is sufficient to overcome the normal bias on the input grid of the amplifier 37 together with the rectified output voltage of the filter 34, whereby the relay 38 operates to effect energization of the control element and operation thereof after an interval determined by the delay network 41. Operation of the control element results in operation of the enabler 42 so that the power source 28 is enabled. The source, when thus enabled, causes operation of the anchor cut-off, energizes the motor 15 and supplies power to the steering system. The torpedo then attacks the ship, being guided thereto by the steering system in accordance with signals, such as noises of a preassigned frequency, emanating from the ship and received by the hydrophones 16 and 17.

Because of the character of the filters 33 and 34 and their manner of association with the amplifier 37, false operation of the trigger circuit by random or background submarine noises and operation of the trigger circuit to enable the steering system in response to the envelope of noise of ships having speeds such that the torpedo could

not overtake them are prevented. Thus, the trigger system discriminates between signals emanating from ships having speeds within a preassigned range on the one hand, and random or background noises and signals emanating from ships having speeds outside the preassigned range on the other hand, so that the torpedo will be rendered operative only in response to the envelope of ship's noise of such ships as it is capable of reaching or overtaking.

A typical construction of filters and associated elements is illustrated in FIG. 3. The band-pass filter 34 may be a tuned circuit comprising an inductance 45, condenser 46 and resistance 47, the sensitivity characteristic thereof being as illustrated by the curve A in FIG. 4. The low-pass filter 33 may be of the resistance-condenser type comprising a plurality of substantially identical series resistors 48 and substantially identical shunt capacitances 49, the sensitivity characteristic thereof being as illustrated by the curve B in FIG. 4. The parameters of the filters are made such that the load characteristics for the two are substantially the same, as illustrated in FIG. 5, and the effective band width for random noise is substantially the same for the two filters so that for random or background noise received by the hydrophone 19 the outputs of the two filters are substantially equal.

The outputs of the two filters 33 and 34 are impressed upon the control grids of the amplifiers 35a and 35b by way of potentiometers 50a and 50b respectively. The output circuit of each amplifier includes a copper-oxide rectifier 51 bridged by resistors 52 and 53 in series, the rectifiers and resistors being identified in the drawing by the reference numeral followed by the letter, a or b, of the respective amplifier. As shown, the two rectifiers are oppositely poled and the two resistors 53 are connected in series with the biasing source 54 by way of the potentiometer 55. A condenser 56 serves as a common alternating current return in the plate circuits of the two amplifiers 35.

As is apparent, the voltages appearing across each of the resistors 53 at any instant are proportional to the output of the respective amplifiers. The potentiometers 50 are so adjusted that for background noises, these two voltages are substantially equal. Also, as is apparent, the voltage across the resistance 53b opposes that across the resistance 53a and aids that due to the source 54, in the input circuit for the amplifier 37. The potentiometer 55 is set initially so that normally, i.e., for no input to the filters, the grid of the amplifier is biased beyond cut-off. Hence, the amplifier 37 will be rendered conductive to effect operation of the relay 38 only when the output of the filter 33 exceeds that of the filter 34 to a preassigned extent.

Of course, the sensitivity of the trigger circuit should be correlated with that of the steering system so that the latter will not be enabled when the ship producing operation of the trigger circuit is beyond the effective range of the steering system. Such correlation may be realized conveniently by a potentiometer in the circuit of the amplifier 29, for example in the input circuit to the second stage thereof. Such potentiometer may be utilized also to set the minimum threshold of signals to which the trigger system will be responsive.

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 control system for a torpedo comprising a normally disabled steering system, means responsive to submarine signals within a range of frequencies, and means controlled by said first means for enabling said steering system only when the energy content of signals within a preassigned band within said range, received by said first means exceeds that of signals within said range and outside of said band.

2. A control system for a torpedo comprising a normally disabled steering system, means responsive to submarine signals within a preassigned range for enabling said steering system, and means responsive to submarine signals outside of said range for preventing operation of said enabling means in response to background submarine noise of frequencies within said range.

3. A control system for a torpedo comprising a normally disabled steering system, and means for enabling said steering system, said means comprising a hydrophone, a pair of signal channels energized in accordance with the output of said hydrophone, substantially balanced for background submarine noise and sensitive to different bands of frequencies, one of said channels being sensitive only to frequencies characteristic of the noise envelope of ships having speeds within a preassigned range, means for combining the outputs of said channels in difference relation, and operating means controlled in accordance with the resultant of the combined outputs of said channels to enable said steering system when the output of said one channel exceeds that of the other.

4. A control system in accordance with claim 3 wherein each of said channels comprises a filter, the two filters having similar load characteristics and different pass-bands and the pass-band of the filter in said one channel being below that in the other channel and including said characteristic frequencies.

5. A control system in accordance with claim 3 wherein each of said channels includes a rectifier at its output end and said combining means comprises a direct current amplifier normally biased beyond cut-off and to the input circuit of which the rectifier outputs are supplied in opposing relation.

6. A control system comprising a submarine signal receiver, a pair of filters having different pass-bands, said filters having similar load characteristics and being substantially balanced for random submarine noise, means for supplying both said filters with energy corresponding to signals received by said receiver, means for combining the outputs of said filters in difference relation, operating means, and means controlled in accordance with the resultant of the combined outputs of said filters for actuating said operating means.

7. A control system comprising a submarine signal receiver, means for demodulating the output of said receiver, a low-pass filter, a second filter having a pass-band above that of the low-pass filter, said filters having similar load characteristics and being substantially balanced for random submarine noise, means connecting said filters in common to the output of said demodulating means, means for combining the outputs of said filters in opposing relation, and means controlled in accordance with the resultant of the combined filter outputs to operate only when the output of said low-pass filter exceeds that of said second filter.

8. A control system comprising a hydrophone, an amplifier having its input connected to said hydrophone, a demodulator connected to the output of said amplifier, a pair of filters having their inputs connected in common to the output of said demodulator, said filters being substantially balanced for random submarine noise, one of said filters being adapted to pass a restricted band of low frequencies and the other being adapted to pass a higher band of low frequencies, means for rectifying the outputs of said filters, and a direct current amplifier normally biased beyond cut-off and having an input circuit in which the outputs of said rectifiers are combined in opposing relation, the rectified output of said one filter being of the polarity to oppose the normal bias of said amplifier.

9. A control system for a torpedo comprising a rudder, normally disabled means for controlling said rudder to steer the torpedo toward a ship, and means responsive to noise emanating from a ship for enabling said controlling means, said enabling means comprising means for de-

tecting submarine noise, means for demodulating the
 output of said detecting means, a first filter capable of
 passing a prescribed band of low frequencies, a second
 filter capable of passing a second and higher prescribed
 band of low frequencies, said filters being energized in
 parallel by said demodulating means and being substan-
 tially balanced for random noise components in the bands
 passed thereby, means for converting the outputs of said
 filters into respective direct current potentials, means for
 combining said potentials in difference relation, and
 means controlled by the resultant of the differentially
 combined potentials for rendering said controlling means

5

10

operative only when the output of said first filter exceeds
 the output of said second filter by a predetermined
 amount.

References Cited in the file of this patent

UNITED STATES PATENTS

1,312,510	Baker	Aug. 12, 1919
1,344,352	Parmelet al.	June 22, 1920

FOREIGN PATENTS

216,905	Great Britain	June 10, 1924
---------	---------------	---------------