Aug. 8, 1961 P. G. EDWARDS 2,995,100

CONTROL SYSTEM FOR TORPEDO STEERING

Filed June 2, 1944

FIG. 1

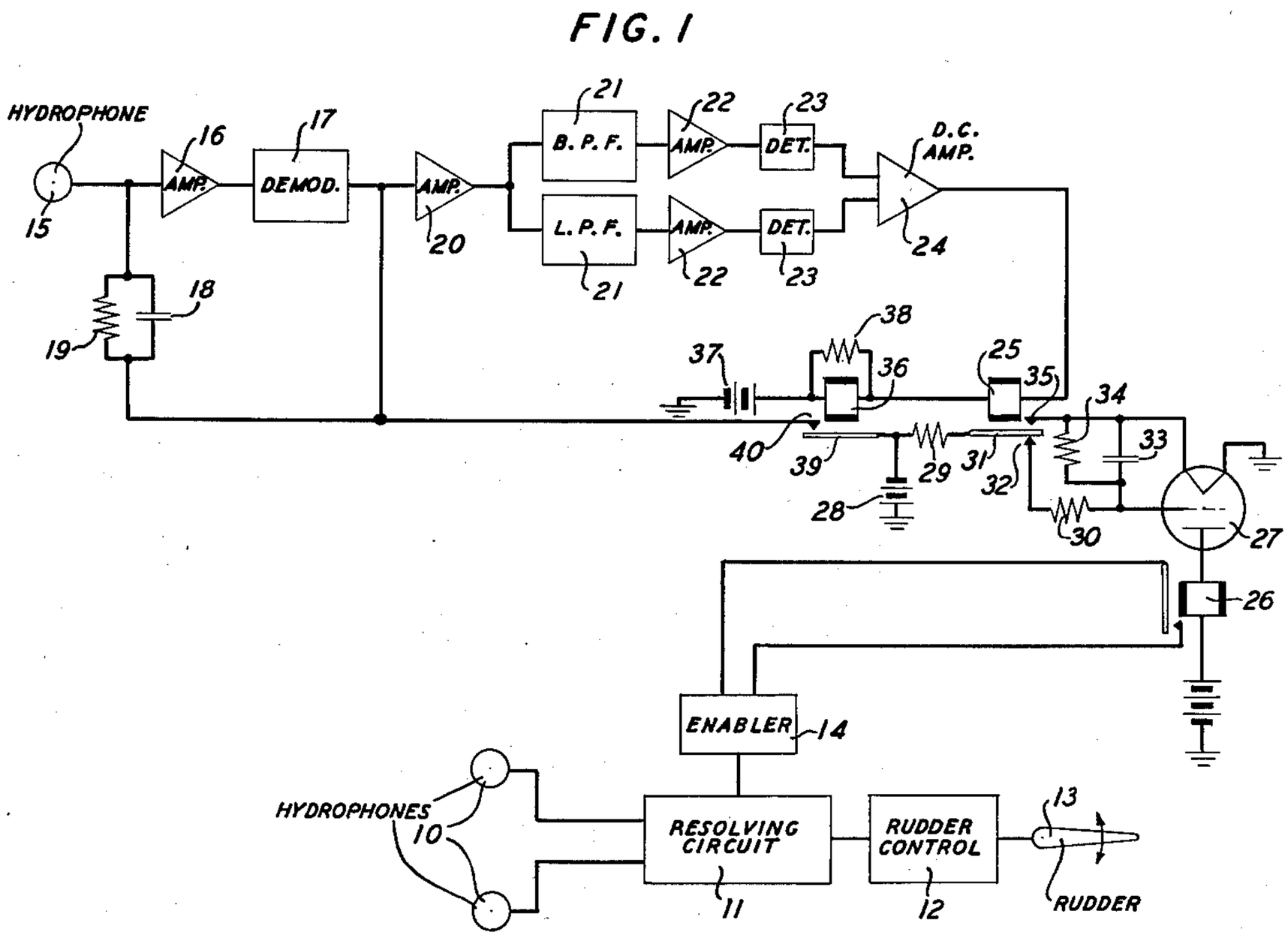
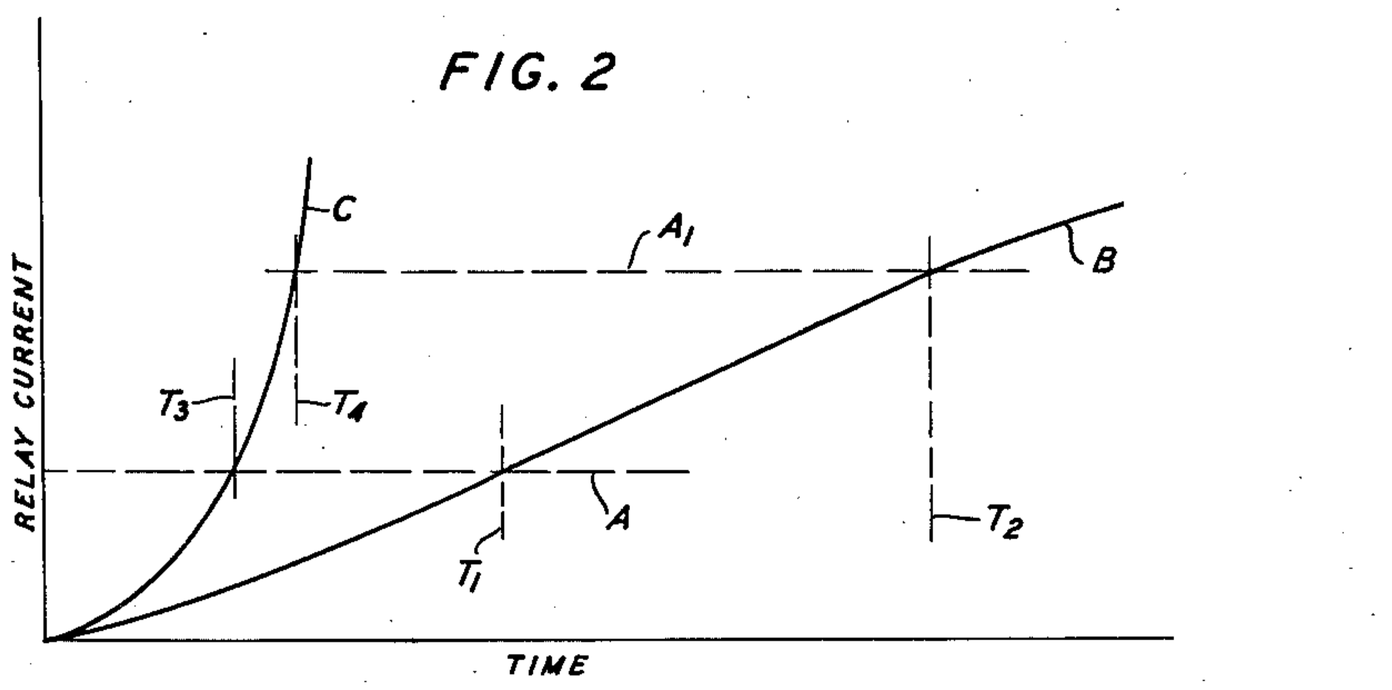


FIG. 2



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CONTROL SYSTEM FOR TORPEDO STEERING

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11 Claims. (Cl. 114—23)

This invention relates to control systems and more particularly to anti-countermining protective systems for torpedoes having control circuits of the type disclosed in the application Serial No. 538,435 filed June 2, 1944, of Alton C. Dickieson.

A torpedo having a control circuit of the form disclosed in the application above identified comprises, in general, a normally disabled steering system for guiding the torpedo to a target, such as a ship, in accordance with signals emanating from the target, and a trigger circuit for enabling the steering system when a ship comes within the effective range of the torpedo after the latter is launched. The trigger circuit operates in response to sonic signals received at a hydrophone constituting the input element of the circuit and is so constructed and arranged as to discriminate against background submarine noises and target signals of other than a prescribed character, whereby it functions to enable the steering system only in response to receipt at the hydrophone of signals characteristic of ships having such speeds that the torpedo can overtake them. In a specific circuit, the discrimination is effected on the basis of propeller frequencies, the propeller frequency of a ship being a measure of the ship's speed, and the enabling of the steering system is brought about by operation of a control relay in the output circuit of an amplifier energized in accordance with a potential derived from the output of the hydrophone, the relay, when operated, serving to cause energization of a control element for an enabler associated with the steering system.

One object of this invention is to prevent false enabling of a torpedo steering system of the signal controlled, sonically triggered type. More specifically, one object of this invention is to prevent operation of a submarine signal responsive control circuit by explosion waves, such as are produced by mines in countermining operations.

In one illustrative embodiment of this invention, a control circuit of the general form and organization described above comprises a delay element for allowing operation of the control element only after elapse of a prescribed interval after operation of the control relay and a second relay is provided energized in series with the control relay, the second relay being less sensitive than the control relay and effective when operated to cause disabling of the trigger control circuit. The two relays are constructed and arranged so that when the amplifier input is in accordance with ships signals received by the hydrophone the interval between operation of the two relays is greater than the delay interval aforenoted whereby the control relay is effective to cause enabling of the steering system, but when the amplifier input is in accordance with explosion waves received by the hydrophone, the interval between operation of the two relays is less than the delay interval aforenoted, whereby the second relay is effective to disable the trigger circuit before the steering system can be enabled as a result of operation of the control relay.

The invention and the various 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, partly in functional schematic form, of a control system for a torpedo illustrative of one embodiment of this invention, and

FIG. 2 is a graph illustrating the relation between relay currents and time for both ship signal and explosion waves received by the hydrophone in the trigger circuit shown in FIG. 1.

Referring now to the drawing, the control system in FIG. 1 comprises a steering system, which may be of the construction disclosed in the application Serial No. 491,795, filed June 22, 1943 of Donald D. Robertson, including hydrophones **10** for receiving signals emanating from a target, e.g. ship, a resolving circuit **11** for converting the hydrophone outputs into a potential related in amplitude and polarity to the angle and direction of the target with respect to the torpedo, and a control element **12** actuated in accordance with this potential for deflecting the rudder **13** to guide the torpedo to the target. The resolving circuit normally is inoperative and has associated therewith an enabler **14** controlled by a trigger control circuit.

The trigger control circuit, which may be of the general form described in detail in the application of Alton C. Dickieson identified hereinabove, comprises a hydrophone **15** the output of which is fed to an amplifier **16** and then demodulated by a demodulator **17**, for example of the copper oxide disc type. The amplifier **16** is provided with an automatic volume control including a condenser **18** and a resistance **19**. The low frequency demodulation components are amplified by a suitable low frequency amplifier **20** and supplied to two channels each of which includes a filter **21** followed by an amplifier **22** and a detector **23**. The two channels are blanced for background or random submarine noise and one of the filters is of the low-pass type and the other of the band-pass type as indicated in FIG. 1. The direct current output voltages of the detectors **23** are combined in opposing relation and applied to the input circuit of a direct current amplifier **24** which normally is biased beyond cut-off. The output circuit of the amplifier includes a relay **25** which when operated effects actuation of the enabler **14** in a manner described in detail hereinafter.

In brief, the general operation of the system is as follows: After the torpedo is launched, an anchor therein is released automatically to moor the torpedo at a preassigned depth. At this time, the steering and propelling systems for the torpedo are disabled. The trigger circuit also is disabled but is rendered operative automatically at a preassigned interval after the launching of the torpedo. After this interval, when a ship having an envelope of noise of prescribed character comes within the effective range of the torpedo, the trigger circuit operates to energize the enabler and the latter causes the anchor to be cast off and renders the steering and propelling systems operative whereby the torpedo is guided to the ship. The details of operation are set forth fully in the aforementioned applications. It may be pointed out, however, that the filters serve to prevent operation of the trigger circuit by background submarine noise and by ships the propeller frequencies of which correspond to ship speeds so great that the torpedo could not overtake the ship. More particularly, the pass-band of the low-pass filter embraces only those frequencies characteristic of the propeller frequencies of ships that the torpedo can overtake and the two signal channels are so constructed and arranged that the direct current amplifier **24** will have sufficient output current to cause operation of the relay **25** only when the direct current voltage of the channel including the low-pass filter exceeds that of the other channel to a preassigned extent.

The control or actuating system for the enabler **14** compriss a relay **26** which is connected in the output circuit of an electron discharge device **27**. The grid of this device normally is biased beyond cut-off by a suitable source **28**, such as a battery, over the circuit including a pair of resistances **29** and **30** and the armature **31** and

contact 32 of the relay 25. The grid circuit of the device 27 includes also a condenser 33 bridged by a resistance 34.

Normally, that is when the relay 25 is not energized, the device 27 is blocked and the condenser 33 is charged through the resistances 29 and 30. When the relay 25 is energized, the armature 31 engages the other contact 35 and the condenser 33 discharges through the resistance 34 at a rate determined by the constants of this resistance and the condenser. After an interval, determined by these constants, the bias upon the grid of the device 27 decreases sufficiently to render the device conductive and cause operation of relay 26 to energize the enabler 14.

If, after the relay 25 operates and during the interval noted, the signals received by the hydrophone 15 are such as to render the amplifier 24 non-conducting, the armature 31 transfers from contact 35 to contact 32 and the condenser begins to charge at a rate determined by the resistances 29 and 30, and the bias on the grid of the device 27 is increased accordingly. It will be seen then, that in order that the relay 26 may operate, it is necessary that the armature 31 be disengaged from the contact 32 for a certain fraction, determined of course by the constants of the charging and discharging circuits for the condenser 33, of a preassigned period. In a typical system these constants may be such that the armature be disengaged from the contact 32 at least four-fifths of the time during a five second period in order that the device 27 may cause operation of the relay 26, substantially five seconds after the relay 25 is first energized. Specifically, the voltage of source 28 may be 10.5 volts, the condenser 33 of 2 microfarad capacity and the resistances 30, 34 and 29 of 1.5 megohms, 2.7 megohms and 130 ohms, respectively, for a device 27 of the 3Q4 type operated with a plate voltage of 67.5 volts. Thus, as will be apparent, operation of the enabler 14 by transient signals even of such character as to render the amplifier 24 conductive momentarily, and false operation of the system by such signals are prevented.

It will be noted that when the relay 25 is in its non-operated state, the cathode or heater for the device 27 is extinguished so that the power drain is small. When the relay operates, the cathode heater circuit is closed directly through the resistance 29.

It will be appreciated that because of the character of the trigger control circuit, principally its operation in response to low frequency signals, the circuit as thus far described might be operated falsely by explosion signal waves such as are produced during countermining operations, although some measure of protection against such waves is provided by the delay system, above described, associated with the device 27. To protect the system further against false operation by such waves, means are provided, in accordance with a feature of this invention, for disabling the trigger circuit when explosion signals are received by the hydrophone 15.

As shown in FIG. 1, a second relay 36 is provided in series with the relay 25 and the anode supply source 37 for the direct current amplifier 24, the relay 36 being desensitized as by a shunt resistor 38. When the amplifier 24 is rendered conductive, the current through the relay 36 will increase at a lesser rate than that through the relay 25 and, the two relays being otherwise similar, the relay 25 will operate some time before the relay 36. The relay 36 has its armature 39 and contact 40 in circuit with the source 28 and the AVC for the amplifier 16 so that when the relay 36 operates the amplifier 16 is paralyzed and the trigger circuit is thus disabled.

The rate of current increase in the two relays is dependent upon the character of the input to the hydrophone 15 and, in general, is substantially slower for signals due to a ship approaching within range of the torpedo than for signals due to explosions in the vicinity

of the torpedo. The general relation between time and relay current is illustrated in FIG. 2. In this figure, the operating currents for the relays 25 and 36 are indicated by the lines A and A′ respectively; the relation between relay currents and time for current due to ship signals received by the hydrophone 15 is indicated by the line B; and the current-time relation for relay currents due to explosion signals received by the hydrophone 15 is indicated by the curve C.

The relay 36 is so desensitized, as by the shunt resistor 38, that the interval between the operate times, T_1 and T_2, for the two relays in response to ship signals is greater than the delay interval, for example 5 seconds in the specific case given above, provided by the delay element 33, 34. The interval between the operate times, T_3 and T_4, for the two relays in response to explosion waves is less than the delay interval, for example 5 seconds, provided by the delay element.

When the two relays are operated in response to ship signals, the relay 25 operates first and after the delay interval the enabler 14 is operated and the steering system is enabled. Once enabled, the steering system remains enabled, so that subsequent operation of the relay 36, that is after the elapse of a period greater than the delay interval following operation of the relay 25, has no effect upon the steering system. However, if the relays are actuated in response to explosion waves received by the hydrophone 15, the interval between operation of the relay 25 and subsequent operation of the relay 36 is so short that the amplifier 16 is paralyzed before the elapse of the delay interval between operation of the relay 25 and functioning of the device 27 requisite for energization of the enabler. Hence, false enabling of the steering system by explosion waves is prevented. Specifically, in such case, the relays 25 and 36 release when the amplifier 16 is paralyzed so that the condenser 33 is charged and the delay element is reset. The charge placed upon the condenser 18 by operation of the relay 36 leaks off gradually when this relay releases following disabling of the amplifier 16 so that the trigger circuit is reset after a preassignable interval following receipt of explosion waves by the hydrophone.

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 by the appended claims.

What is claimed is:

1. A control system for a torpedo having normally disabled steering means, said system comprising a hydrophone, a trigger circuit for which the hydrophone constitutes the input element, responsive to noise emanating from a ship for enabling said steering means, and means for disabling said circuit when explosion noise is received by said hydrophone.

2. A control system for a torpedo having normally disabled steering means, said system comprising a submarine signal detector, an operating means for enabling said steering means, an energizing circuit for said operating means for which said detector constitutes the input element, and means for disabling said circuit when explosion submarine signals are received by said detector.

3. A control system for a torpedo having normally disabled steering means, said system comprising a hydrophone, a trigger circuit for which said hydrophone constitutes the input element and including relay means, operating means responsive to operation of said relay means for enabling said steering means, means for delaying operation of said operating means for a preassigned interval after operation of said relay means, and means for disabling said circuit during said interval when explosion signals are received by said hydrophone.

4. A control system for a torpedo having normally disabled steering means, said system comprising an enabler for said steering means, means for actuating said enabler,

control means for said actuating means, an energizing circuit for said control means, a hydrophone constituting the input element for said circuit, a delay element associating said actuating and control means for delaying operation of said actuating means for a prescribed interval after energization of said control means, and means for disabling said energizing circuit in response to receipt by said hydrophone of signals increasing in intensity at greater than a preassigned rate.

5. A control system comprising normally disabled operating means, means for enabling said operating means, actuating means for said enabling means, a hydrophone, a first relay, a second relay less sensitive than said first relay, means for energizing said first and second relays in common in accordance with the output of said hydrophone, means for energizing said actuating means in response to operation of said first relay, and means for disabling said relay energizing means in response to operation of said second relay.

6. A control system comprising a hydrophone, a first relay, a second relay less sensitive than said first relay, an energizing circuit for which said hydrophone constitutes the input element and in which said relays are serially connected, an operating means, means including a delay network for energizing said operating means at a preassigned interval after operation of said first relay, and means for disabling said energizing circuit in response to operation of said second relay, the operating levels of said first and second relays being such that for a maximum prescribed rate of increase in output of said hydrophone the time between operation of said first and second relays is greater than said preassigned interval.

7. A control system comprising an operating element, a hydrophone, and means for enabling said operating element only in response to submarine signals received by said hydrophone increasing in intensity at less than a preassigned rate, said means comprising a first relay, a second relay, means for energizing said operating element in response to operation of said first relay at a prescribed interval after operation of said first relay, means for energizing said relays in common in accordance with the output of said hydrophone, means responsive to operation of said second relay for disabling said relay energizing means, and means for desensitizing said second relay so that the interval between operation of said first and second relays in response to signals received by said hydrophone and increasing in intensity at less than said preassigned rate is greater than said prescribed interval.

8. A control system for a torpedo having normally disabled steering means, said system comprising a hydrophone, an amplifier, said hydrophone constituting the input element for said amplifier, a relay in the output circuit of said amplifier, means for enabling said steering means, an energizing circuit for said enabling means, means for closing said energizing circuit in response to and at a preassigned interval after operation of said relay, and means for disabling said amplifier within said interval when explosion noises are received by said hydrophone.

9. A control system in accordance with claim 8 wherein said disabling means comprises a second relay energized in series with and less sensitive than said first relay such that for outputs of said hydrophone due to noise emanating from ships the interval between operation of said first and second relays is greater than said preassigned interval.

10. A control system comprising an operating element, a signal detecting device, an amplifier for which said device constitutes the input element, a relay connected to the output of said amplifier, a control circuit for said operating element including an electron discharge device having a control grid and cathode, a source for normally biasing said control grid beyond cut-off, and means for rendering said device conducting in response to operation of said relay only when said relay remains operated for a certain portion of a prescribed interval after initial operation of said relay, said last means comprising a condenser connected between said cathode and said control grid, a charging circuit for said condenser including said source and a first resistance and a discharging circuit for said condenser including a second resistance separate from said charging circuit, said relay being arranged to open said charging circuit when operated.

11. A control system in accordance with claim 10 comprising means for disabling said amplifier when signals of a certain character are received by said detecting device, said disabling means comprising a second relay energized in series with said first relay and of less sensitivity than said first relay such that for signals of said character the interval between operation of said first and second relays is less than said prescribed interval.

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