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3,017,832

ECHO FIRING DEVICE FOR A DEPTH CHARGE

Filed Dec. 13, 1950

2 Sheets-Sheet 1

FIG. 1.

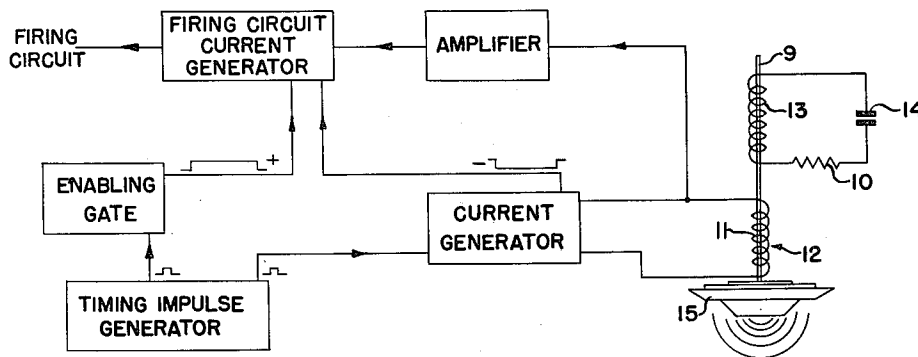
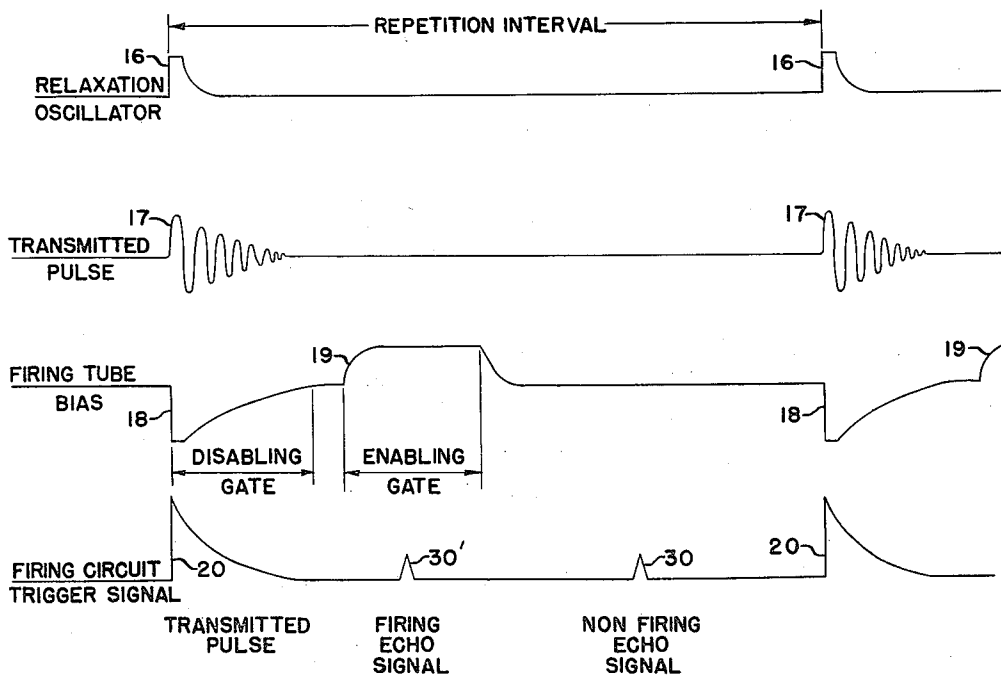


FIG. 2.



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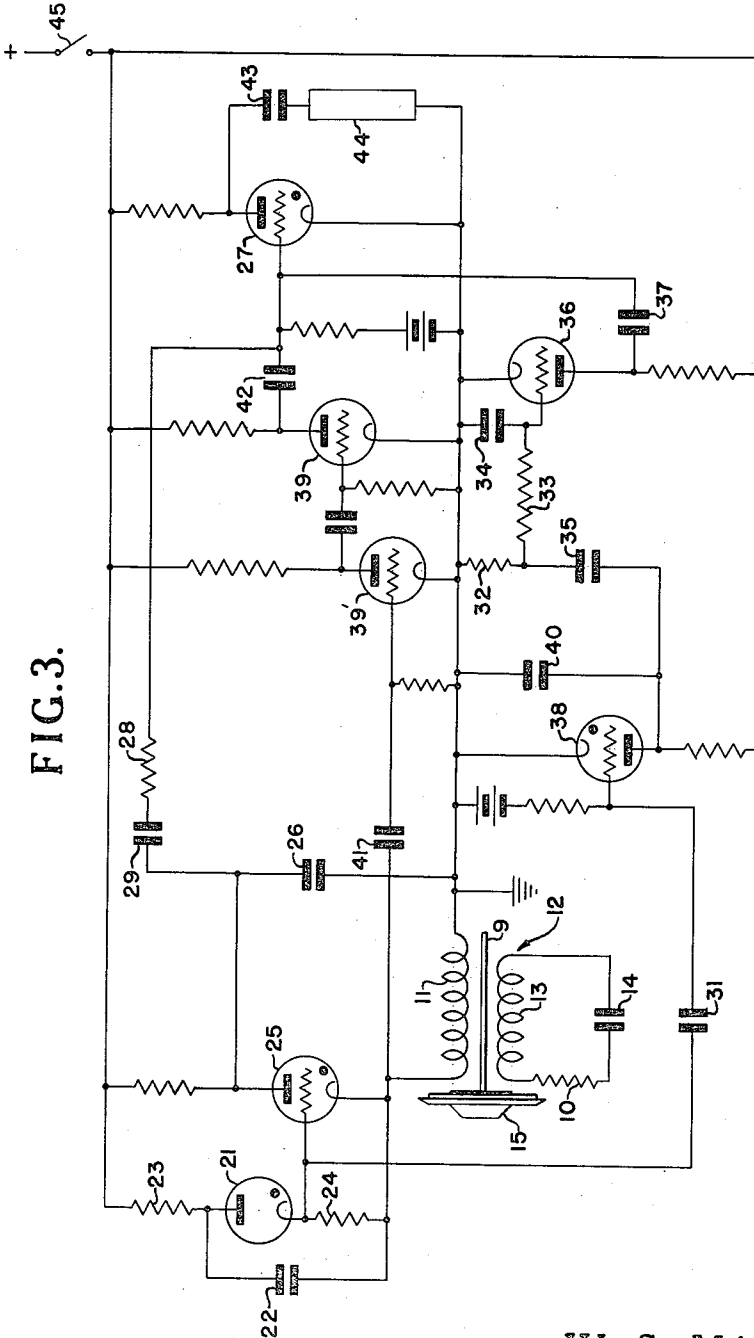
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ECHO FIRING DEVICE FOR A DEPTH CHARGE
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(Granted under Title 35, U.S. Code (1952), sec. 266)

This invention relates generally to an echo-ranging system and more particularly to an elapsed time measuring, echo-ranging system for firing a depth charge, or the like, upon approach of the depth charge within a predetermined range of a reflecting object such as a submarine.

Certain of the prior art depth charges have been limited in their effectiveness due to the inability of the detecting circuits employed therein to sense the approach of the depth charge within a range of the target which is within the destructive range of the explosive charge employed. Such devices have conventionally employed a firing circuit actuated a predetermined time after the charge is launched or upon sinking to a depth where a predetermined water pressure will actuate a firing switch.

The present invention overcomes the disadvantages of such prior art devices by providing an echo-ranging system which transmits wave energy into the water from the falling depth charge and receives reflected echoes from the target submarine. By means of an enabling gate circuit synchronized in predetermined time relation with the transmitted pulse the echoes received from a target are ineffective to fire the firing circuit unless they are received within a predetermined time interval after the transmitted wave energy leaves the depth charge. Such a firing time corresponds to a distance which is within the destructive range of the explosive charge and the time delay is equal to the time taken for the wave energy to travel to the target and return.

It is an object of this invention to provide a new and improved system for firing a depth charge in proximity to a target.

Another object is to provide a new and improved system for firing a depth charge in response to signals reflected from a target.

A further object of this invention is to provide an echo-ranging circuit for operating an electroresponsive circuit upon receiving echo signals corresponding to a predetermined distance to a reflective object.

Another object is to provide a new and improved echo-ranging system in which a predetermined distance as a function of lapsed time between transmitted and reflected signals is measured by means of an enabling gate circuit.

Another object of this invention is to provide a depth charge firing circuit having a high degree of reliability in operation.

Another object of this invention is to provide a depth charge firing circuit which is simple and economical to manufacture and which can be readily adapted to the requirements of the particular depth charge with which it is to be used.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 is a block diagram of the echo-ranging system of the present invention, partly schematic, showing the main functional division among the various parts of the circuit of the system;

FIG. 2 is a timing diagram showing the time relation of various wave forms in the circuit; and

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FIG. 3 is a schematic diagram of the circuit of the invention according to a preferred embodiment thereof.

Referring now to the drawings for a more complete understanding of the invention wherein like characters of reference are used to designate like parts throughout the several views and more particularly to FIG. 1 thereof, there is disclosed the functional operation of the present invention. A timing impulse generator is used to generate pulses to initiate the timing cycle repetitively. A pulse from the timing generator is supplied to a current generator which is triggered thereby to supply a current pulse to a primary winding 11 in a magnetostrictive transducer 12. The energy in the primary is transferred to the secondary winding 13 and is dissipated as a highly damped oscillatory wave in the circuit formed by winding 13, resistor 10 and capacitor 14. A portion of this oscillatory energy is transferred to the magnetic core of coil 13 which is magnetostrictive in nature and in communication with a diaphragm in contact with the surrounding water. A portion of the energy is radiated into the water by virtue of the magnetostrictively induced motion of the diaphragm 15. The flow of current through coil 11 is also effective to provide a disabling pulse to the firing circuit current generator thereby preventing its actuation from signals received during the transmission interval. When not energized by the oscillatory energy in coil 13 the transducer 12 acts as a receiver to respond to wave energy in the water which impinges on diaphragm 15 and will generate magnetostrictively a signal voltage therefrom in coil 11. Such a signal will be generated when an echo of the transmitted wave energy is received after being reflected from a submarine. These signals, in the form of a short impulse similar to the transmitted pulse, are applied to the input of the amplifier and after amplification are applied to trigger the firing circuit current generator. The returning echoes are very much weaker than the transmitted pulse and the amplitude of the echo signal after amplification is still not sufficiently large to trigger the current generator when no additional positive bias is supplied thereto. A positive bias is supplied to the current generator by the enabling gate circuit to enable the amplified echo signals to trigger it. This gate circuit supplies, a positive pulse of fixed magnitude at a predetermined time after the initiating pulse is generated by the timing generator. This gate pulse occurs at a predetermined time after the initiating pulse (and hence after the transmitted wave energy leaves the transducer 15) and the time therebetween corresponds to the time it would take the wave energy to travel to a submarine and back to the receiver transducer, this time being related to the effective destructive range of the depth charge. In this manner it is apparent that only when an echo is received during this predetermined interval which is established by the enabling gate that the amplified echo signal will be effective to trigger the current generator and fire the explosive charge. Such an arrangement insures that detonation will occur only after the depth charge has approached within a range which is equal to or less than the destructive range of the explosive charge employed.

Referring now to FIG. 2 a clearer understanding of the aforementioned sequence can be obtained from the timing diagrams theredisclosed. The repetition interval is determined by the rate of recurrence of the pulses 16 generated by the timing impulse generator and these pulses are used to initiate the successive timing cycles such rate being, for example, 10 pulses per second. As pulse 16 triggers the current generator and induces energy into the oscillatory system the wave form of such oscillations and hence the character of the energy radiated into the water is represented at 17 as a damped oscillatory wave of frequency, for example, of 20,000 cycles per second. The occur-

rence of the current pulse to generate the oscillations 17 also establishes a negative signal 18 at the firing circuit current generator which greatly increases the magnitude of positive signal required to trigger the current generator and thereby prevents the large transmission pulse 20 from triggering the current generator as it passes through the amplifier channel. When the predetermined time interval has elapsed after the transmitted waves 17 occur the enabling gate 19 occurs to enable the amplified echo signals to trigger the firing circuit current generator if received during the occurrence of the enabling gate 19. These echo signals are shown at 30—30', only the signal 30' being within the time duration of the gate 19 and hence able to trigger the firing circuit. The timing process is repeated for each initiating pulse 16 thereby enabling the echo ranging system to continuously sample the surrounding medium for the presence of a target submarine within the destructive range of the explosive charge.

Referring now to FIG. 3 there is shown a schematic wiring diagram of the invention in accordance with a preferred embodiment thereof. The relaxation oscillator comprises a gas diode 21 and its associated circuit of which capacitor 22 and resistor 23 together with the value of the positive supply potential determine the repetition rate at which pulses are generated. This pulse is generated across resistor 24 during the conduction interval of tube 21 and is transmitted directly to the grid of a gas triode 25. This pulse is of sufficient amplitude to initiate conduction in tube 25 and deliver the charge from capacitor 26 to coil 11. The flow of this charge through coil 11 constitutes a current which energizes the coupled magnetic system comprising coils 11 and 13 and the core 9 and initiates the damped oscillations at the resonant frequency of the circuit comprising coil 13 and capacitor 14 as aforesaid. The damped oscillations in the circuit 13, 14 energize the diaphragm 15 by virtue of the magnetostrictive action of the core 9, upon which coils 11 and 13 are wound, as more fully described hereinbefore. The discharge of condenser 26 produces a negative impulse which is transmitted to the grid of gas triode 27 by means of the coupling circuit capacitor 29 and resistor 28 thereby preventing any signal voltage during the transmission interval from initiating conduction in tube 27.

The voltage impulse generated across resistor 24 during the conduction of tube 21 is also supplied to the grid of a gas triode 38 by means of coupling capacitor 31. This voltage impulse initiates conduction in tube 38 and discharges capacitor 40 producing a negative-going voltage which is coupled to the input of a time-delay, wave-shaping filter circuit, comprising resistors 32, 33 and capacitor 34, by means of capacitor 35. The negative voltage on capacitor 34 appearing in time delayed relation to the initiating impulse 16 is applied to the grid of an amplifying discharge device 36 which produces a positive voltage on the plate of this tube. This voltage is coupled to the grid of the firing tube 27 by means of capacitor 37.

Between transmission intervals a sensitive receiving circuit is provided by means of the diaphragm 15 which translates wave energy in the water into motion of the magnetostrictive core 9 which in turn generates electrical impulses in coil 11. These signal voltages are coupled to the input of a two-stage amplifier comprising tubes 39 and 39' and their associated circuits by means of coupling capacitor 41. The output voltage of the amplifier is obtained from the plate of tube 39 and is coupled to the grid of the firing tube 27 via capacitor 42.

The firing circuit comprising gas triode 27 includes an energy storage condenser 43 and an electroresponsive device 44 connected in such a manner that when conduction occurs in tube 27 the charge on capacitor 43 flows through the device 44, producing a large current therein. Electroresponsive device 44 may conveniently be a relay if contacts are used to close a circuit of an electroresponsive detonator or can conveniently be an electroresponsive detonator itself, the current flow being sufficient to detonate

the charge therein. Of course, other utilization means may be employed if desired.

The operation of this device will now be described. Assume, by way of example, that the circuit of FIG. 3 has been incorporated within a depth charge casing which contains an explosive charge and an electroresponsive detonator associated therewith arranged to explode upon the initiation of conduction of tube 27 as hereinbefore described in connection with element 44. When an enemy submarine is suspected to be in the vicinity, a depth charge of this type is launched by conventional means into the water. As the charge sinks in the water a hydrostatic arming device, not shown, closes the switch 45 which energizes the circuit with B+ voltage and a similar switch may be used if desired to energize the filament circuits of the amplifier tubes. The circuit soon becomes stabilized and the relaxation oscillator begins generating periodic pulses 16 of FIG. 2 which cause wave energy to be transmitted into the surrounding water by the transducer 12. These pulses are transmitted through the water and will strike the surface of the enemy submarine and be reflected back toward the depth charge. Upon receipt of this reflected energy transducer 15 induces a voltage in coil 11 which is amplified through the conventional amplifier stages and is supplied to the grid of the firing tube 27 in sufficient magnitude to initiate conduction therein providing the positive bias on the grid of tube 27 has been increased by the magnitude of the enabling gate 19 of FIG. 2. This enabling gate corresponds to a distance between the target submarine and the depth charge which is within the destructive range of the explosive charge employed and is generated in time delayed relation to the initiating impulses 16 such that tube 27 can conduct only when the echo arrives in this predetermined time delayed relation after the transmitted pulse leaves the transducer. During the transmission interval no energy which leaks through the system, or particularly through the amplifier, can initiate connection in tube 27 because of the large negative disabling gate applied to the grid thereof by means of the path coupling the grid of tube 27 to a negative-going voltage associated with tube 25 at the initiation of the transmission. Thus it can be seen as the depth charge falls and comes closer to the target submarine the echoes returned to the transducer 15 will arrive in successively shorter time delayed relation with respect to the transmitted pulse until they fall within the time interval during which the enabling gate exists such as at 30' of FIG. 2. At this moment the depth charge will be within lethal range of the target and the circuit will be in condition to energize electroresponsive device 44 due to the coincidence of a reflected signal and the enabling gate and explode the charge.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. In a depth charge, the combination comprising, an explosive charge, an electroresponsive detonator for said charge, means for generating oscillatory energy in discrete intervals periodically, a transducer for radiating said energy into the surrounding water and responsive to echo signals received at said depth charge, an amplifier for said signals, means selectively responsive to the amplified signals for energizing said detonator, means intercoupled in circuit relation between said generating means and said transducer for applying a disabling potential to said energizing means during said intervals, and means responsive to the output of said generating means apply-

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ing an enabling potential to said energizing means for rendering said energizing means operable in response to amplified signals greater than a predetermined amplitude received during a predetermined period of time after said intervals.

2. In a depth charge, the combination of an explosive charge, an electroresponsive detonator therefor, a circuit comprising a relaxation oscillator for generating repetitive voltage impulses, a first trigger tube adapted to successively conduct in response to said impulses, inductive coil means energized by the flow of current through said tube, a damped oscillatory circuit coupled to said coil means, a magnetostrictive core disposed to carry a substantial portion of the flux generated by said inductive coil means, a water communicating diaphragm mechanically coupled to said core for movement therewith, a second trigger tube adapted to become conductive upon the application thereto of a predetermined effective voltage, means for utilizing conduction in said second tube for energizing said detonator, circuit means coupling said first and second trigger tubes for preventing realization of said effective voltage at the second tube for a predetermined period including the conduction period of the first tube, means including said coil means for detecting signals generated magnetostrictively by compressional wave energy impinging on said diaphragm, an amplifier for said signals having input and output circuits, coupling means between said coil means and said input circuit, coupling means between said output circuit and said second trigger tube for applying the amplified signals thereto, a bias for said second tube insufficient to cause conduction thereof due to said amplified signals, a third trigger tube adapted to successively conduct in response to said impulses, a time-delay wave-shaping circuit for generating a voltage delayed a predetermined time from said impulses and of predetermined duration and having input and output circuits, means for applying to said last named input circuit a voltage generated by conduction in said third trigger tube, and coupling means for applying the delayed voltage at said last named output circuit to said second trigger tube to make sufficient said bias to permit realization of said effective voltage for signals received within the interval of said predetermined duration.

3. In a control circuit of the character disclosed, the combination of a relaxation oscillator for generating repetitive pulses, a gaseous discharge device, a utilization circuit including said device, first biasing means for applying a bias to said device second biasing means responsive to said pulses for applying a potential to said device whereby the bias on said device is decreased to a level insufficient to render the device conducting in response to generated pulses applied thereto, transducer means for deriving reflected signals in response to said pulses, means for deriving a voltage from each of said pulses which reaches a predetermined value in predetermined time delayed relation with respect thereto and persists for a predetermined period at said value, means for applying said voltage to said device in additive relation to the bias thereon thereby to elevate the bias to a level above said reference level and just below the firing potential thereof, and means for applying said signals to said device in additive relation to the elevated bias thereon whereby the tube is fired when one of said signals is applied to the device while the elevated bias is maintained thereon.

4. In a control circuit of the character disclosed, the combination of a signal responsive gaseous discharge device, means applying a fixed bias to said device in additive relation to signals applied thereto, said bias and said

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signals being insufficient additively to render said device conductive, a relaxation oscillator for generating pulses repetitively, means including a vacuum tube for deriving a voltage from each of said pulses which reaches a predetermined level in predetermined time delayed relation thereto and persists at said level for a predetermined period, and means for applying said voltage to said device in additive relation to said bias, said bias, voltage and signals additively exceeding the breakdown potential of the device whereby the device is rendered conducting when one of said signals is applied thereto during said period.

5. In a control circuit of the character disclosed, the combination of a signal responsive gaseous discharge device, power supply means for applying an energizing operating potential to said device, a first bias means for applying a reference bias to said device insufficient to render said device conductive when energized from said power supply means, circuit means for applying signals to said device, a second bias means for applying a negative biasing potential for a predetermined period of time to said device whereby the bias thereon is decreased to provide a bias level effective to render said device non-conductive in response to signals applied thereto during said predetermined period of time, third bias means for applying for a predetermined duration after said predetermined period of time has elapsed a positive voltage to said device to elevate the bias thereon to a level sufficient to render said device conductive in response to signals applied thereto during said predetermined duration, and a timing network associated with said third bias means for determining said predetermined duration whereby the bias on said device is restored to said reference bias after said predetermined duration has elapsed.

6. In a depth charge having an explosive charge with a detonator therefor and an echo-ranging system including a combined sound projector and sound receiver device adapted to project pulses toward a pulse reflecting object and also adapted to be actuated by the echo pulses of said object received in predetermined time delay relation with respect to said projected pulses, a signal responsive gaseous discharge device adaptable to energize said detonator, a reference bias on said device insufficient to render said device conductive in response to echo pulses applied thereto by said receiver device, means for applying a negative bias to said device in synchronization with the projection of said projected pulses to render said device non-conductively responsive to said projected pulses, and a time delay wave shaping network for deriving a predetermined time duration positive voltage impulse from each of said projected pulses and applying said positive voltage at a predetermined interval after the instant of projection of each of said projected pulses to provide a bias level on said device whereby echo pulses applied to said device during said predetermined time duration render said device conductive to ignite said detonator.

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