April 5, 1960 W. B. H. LORD ET AL 2,931,300

RADIANT-ENERGY PROJECTILE DETONATING SYSTEM

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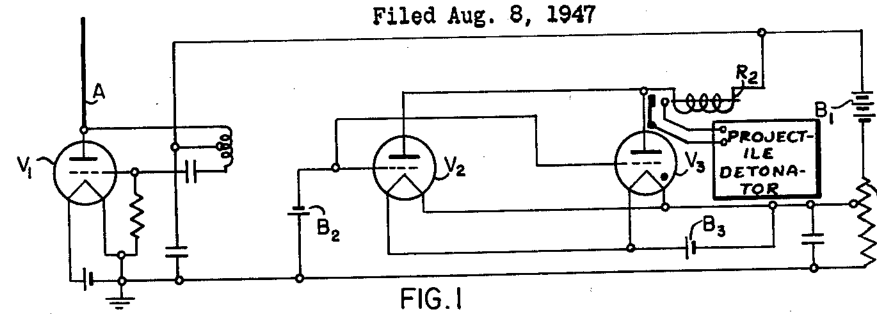

FIG.1

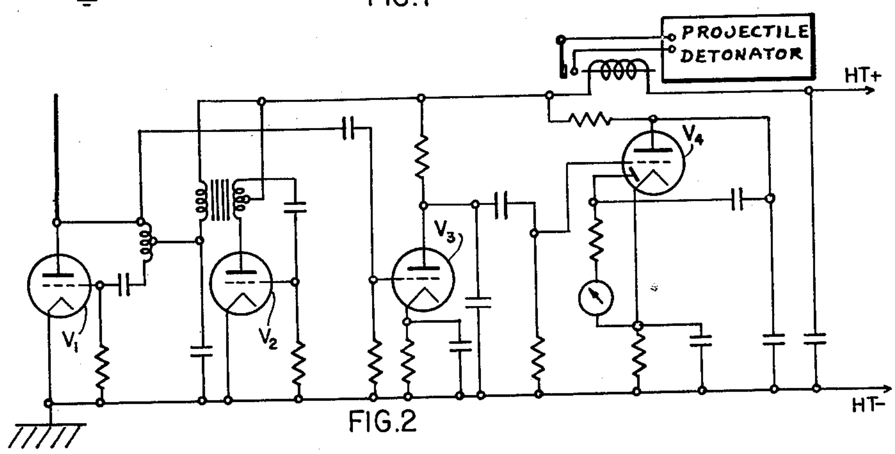

FIG.2

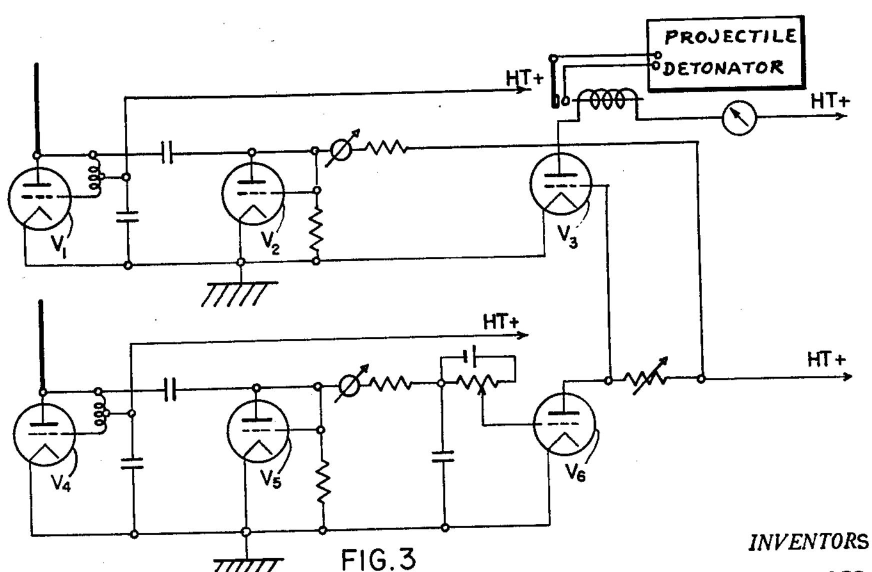

FIG.3

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RADIANT-ENERGY PROJECTILE DETONATING SYSTEM

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This invention is concerned with improvements in or relating to electric relay and controlling systems of the kind in which the approach of (or to) a body, to (or of) a part of the controlling system, influences the said system. The invention is particularly directed toward the provision of means for controlling the detonation and/or release of a projectile, for example an aerial bomb, a shell, rocket, torpedo, or the like.

Thus one object of the invention is to provide an anti-aircraft shell or rocket, the detonation of which is effected upon the approach of the shell or rocket to a target, so that a so-called "proximity burst" is achieved.

A second object of the invention is to provide a fusing means for an aerial bomb, torpedo, mortar shell or the like whereby the bomb, shell or the like is arranged to burst prior to impact with a target to achieve a maximum blast and/or fragmentation effect in the target area.

It is know that when the position of a radiating aerial alters with respect to the earth or other reflecting system, a change of effective impedance of the said aerial takes place when the distance of the said aerial from the said surface is a multiple or submultiple of the half wave length of the radiation from the aerial.

An explanation of this phenomenon is that the signal radiated from the aerial, which is preferably a half wave aerial, is reflected back on to the aerial from a body of sufficient electrical conductivity (when the distance between the aerial and the body is half or multiples of a half wave length of the emitted radiation), approximately 180° out of phase. The emitted signal and the received phase-displaced signal cause two-of-phase currents to build up on the aerial. Accordingly when the distance between the aerial and the reflecting body is a half wave length or a multiple of a half wave length, the effective aerial impedance rises rapidly to a peak as in a resonance circuit, the vector sum of the current flowing in the aerial being reduced or in extreme cases being zero. It has been proposed to make use of this phenomenon for measurement purposes.

As previously mentioned, the degree of reflection and the actual phase angle of the reflected signal will depend on the electrical conductivity and the area of the reflecting object compared with the wave length of the signal. For instance, if the area of the reflecting body is bounded by one wave length or more than one wave length, then reflection will depend more upon the electrical conductivity of the reflector and to a lesser extent on the other physical characteristics of the reflector.

An object of the present invention is to utilize the phenomenon of the change of effective impedance for controlling purposes for projectiles.

According to the present invention, means for controlling the detonation and/or release of a projectile comprise in combination an aerial system adapted to radiate a signal from a suitable oscillator and means responsive to change of effective impedance of said aerial system

due to receipt of reflected radiation thereon, adapted to exert the desired control.

It will be appreciated that since the strength of a received signal obeys the inverse square law, that is to say decreases as the square of the distance from the transmitting aerial, then the effective change of impedance of the aerial due to the presence of a reflecting body, will be correspondingly reduced with increase in distance in half wave lengths between aerial and reflector.

Accordingly, in a preferred arrangement in accordance with the invention, the means responsive to change of effective aerial impedance are made variably critical in response in such manner that the control effected thereby is dependent on a critical distance between the aerial and the reflecting body.

In a further embodiment of the invention means for controlling detonation and/or release of a projectile comprise in combination an aerial system adapted to radiate a modulated signal from a suitable oscillator and demodulating and amplifying means, responsive to change of effective aerial impedance due to receipt of modulated reflected radiation thereon, adapted to exert or effect the desired control.

In yet another embodiment of the invention, means for controlling the detonation and/or release of a projectile comprise in combination at least two aerial systems each adapted to radiate signals from separate oscillators and to receive radiation reflected by a distant reflector, the wave length of the radiation from said oscillators being different submultiples of a predetermined value, amplifying circuits connected to said oscillators to amplify changes of effective aerial impedance due to receipt of reflected radiation on the respective aerial systems, the circuits being so interconnected that a control may be effected only at specific distances between the aerial systems and the reflector.

Referring now to the drawing, Fig. 1 is a schematic circuit diagram of a radiant-energy projectile detonating system embodying the present invention in a particular form, and Figs. 2 and 3 are schematic circuit diagrams representing modified forms of the invention.

In the arrangement shown in Fig. 1 of the drawing, the valve V_1 is connected in a Hartley oscillator circuit, which may oscillate at any frequency between 10 and 600 megacycles and a half or quarter wave aerial A is tightly coupled to the oscillating circuit so that substantially maximum power is dissipated therefrom.

The valve V_1 is supplied from a 60 volt high-tension battery B_1, the cathode of the valve V_1 being connected to the battery B_1 through a resistance R_1. The valves V_2 and V_3 constitute a D.C. amplifier the grids of which are connected through a bias battery B_2 to the cathode of the valve V_1 and the anodes of which are connected through the winding of a relay R_2, the energization of which effects a desired control such as the arming of a projectile by any of various well-understood procedures, for example by actuating a solenoid operated detonating plunger. The cathodes of the valves V_2 and V_3 are supplied from an individual battery B_3 and are directly connected at one end to a tapping of the resistance R_1.

If now the aerial approaches or is approached by a reflector, as the distance between the reflector and the aerial becomes a multiple of the half wave length of the transmitted signal then as mentioned above, the effective impedance of the aerial rises rapidly, consequently the oscillator anode current also increases rapidly. Accordingly the voltage drop across the resistance R_1 increases; the filaments of the valves V_2 and V_3 then assume an increased negative potential with respect to the grids, of these valves causing a large increase of current through these valves. The effect is enhanced in that the increase of anode current through the valves

V_2 and V_3 and that part of the resistance R_1 between the tap and the negative end of the battery B_1 increases the voltage drop over the said part of the resistance R_1. Consequently, an initial relatively small change in the anode current of the valve V_1 will cause a relatively large change in the anode current of the valves V_2, V_3. The relay having the winding R_2 in series with the anodes of the valves V_2 and V_3 can be made to close at any suitable current value to effect the desired control.

As previously mentioned, the effective change of impedance of the aerial is reduced with increase of the distance between aerial and reflector; accordingly the relay can be made critical in operation at any predetermined distance in half wave lengths between aerial and reflecting body by an adjustment of the battery B_2. Alternatively, the wave length of the signal can be made relatively so long that the relay operates when the distance between aerial and reflector is one-half wave length.

In a modification of the arrangement described above the valve V_3 may be replaced by a gas or vapour filled relay device.

From the foregoing description of the Fig. 1 arrangement, it will be apparent that when the wave length of the radiated wave-signal energy is small with relation to the distance between the aerial and the reflector, continuous relative movement of the reflector and aerial toward or away from one another produces cyclic changes of the aerial impedance between maximum and minimum values. It will further be apparent that the period of this cyclic change of the aerial impedance varies with the velocity at which the aerial and reflector approach toward or recede from one another. Thus if the valves V_2, V_3 are biased to provide amplification of the cyclic potential derived across the resistor R_1 consequent upon a cyclic change of aerial impedance, the device R_2 in the anode circuit of the valves may be of a type adapted to indicate the frequency of the amplified potential and may be calibrated in terms of the velocity of relative movement between the aerial and reflector.

In the arrangement shown in Fig. 2 of the accompanying drawing, which shows a circuit capable of giving greater amplification than that previously described, V_1 is an oscillator valve oscillating at a frequency such that the wave length is a multiple or submultiple of the distance or distances at which control is to be effected or some fraction such as half, twice, etc. of the distance. V_2 is a low-frequency oscillator valve oscillating at some audio frequency such as 1,000 cycles per second. The signal from the valve V_2 is caused to modulate the high-frequency oscillator V_1, the system shown being Heising modulation although any other type can be employed. The valve V_3 is an anode bend rectifier connected so as to measure the high-frequency voltage between the aerial and the earth. The valve V_4 is a low-frequency amplifying valve which can be either a triode or multi-electrode valve connected so as to amplify the signal from the valve V_3.

In operation, the reflected signal from the earth or other object, proximity to which is to cause the desired control, causes a change in high-frequency voltage on the aerial and this change causes a change in voltage applied to the grid of the valve V_3. The valve V_3 rectifies the high-frequency voltage and produces a low-frequency signal as the result of the rectification in the anode circuit. A change in voltage from the original voltage impressed on the valve V_3 is amplified by the valve V_4 and the desired control may be effected by relay means connected in the anode circuit of the valve V_4. The fact that the control is excited by means utilizing an audio-frequency signal ensures that the amplification used may be quite as high as is necessary, and gains of 20,000 are easily possible.

In practice, it is necessary to "back off" the large standing high-frequency voltage from the aerial on the grid of the valve V_3 otherwise the entire system is overloaded, and in practice this is done by applying a large negative voltage to the grid or the valve V_3. In actual tests utilizing a six meter oscillator for the valve V_1 over sea water gave very large indications up to the eleventh half wave length using an audio amplification of 30.

In practice, it may be necessary to rectify the low-frequency output signal and apply the D.C. current so obtained through the relay, and since the amplitude of the received signal reduces as the distance away from the earth (or other reflecting object proximity to which is to initiate the desired control) is increased it is possible to close the relay on any particular half wave length. Using this system, accurate control at heights as great as 150 feet has been effected with a small aerial of one-eighth wave length at a frequency of 20 megacycles.

The improved arrangement shown in Fig. 3 of the accompanying drawing, which will now be described, is one in which control may be effected at desired half wave lengths while no control is effected at other half wave lengths.

In this arrangement, V_1 is an oscillator valve oscillating at such a frequency that the half wave length is some fraction of the distance at which control is to be effected. V_2 is a triode rectifying valve with a meter in the anode circuit whereby a measure of the high-frequency voltage developed between the aerial and the chassis may be obtained for test purposes, V_3 is a low-frequency amplifying valve connected as a D.C. amplifier.

V_4 is a further oscillator valve oscillating at such a frequency that the half wave length is some fraction of the distance at which control is to be effected, this fraction being different from that applying to V_1.

V_5 is a triode valve connected similarly to the triode V_2 and the valve V_6 is a further low-frequency amplifying valve connected as a D.C. amplifier. The voltage developed across the anode load of the valve V_6 is applied as bias to the grid of the valve V_3. In operation the reflected signals from the object cause changes in high-frequency voltages on the aerials connected to the valve V_1 and V_4. This causes changes in the D.C. voltage applied to the grid of the valve V_3 and corresponding variations in the anode current of this valve. These variations in anode current are used to initiate the desired control through relay means. Thus it can be arranged that undesired half wave indications do not change the anode current of the valve V_3 because the bias due to the anode load of the valve V_6 is rendering the valve V_3 inoperative. On the desired half wave length, however, the desired control is effected because the bias due to the valve V_6 causes the valve V_3 to operate at the same time as the valve V_3 receives a change in grid voltage due to the valve V_1.

In practice, say the valve V_1 oscillates at a frequency giving a half wave of 10 feet, and the valve V_4 oscillates at a frequency giving a half wave length of 15 feet, control can only be initiated on the coincidence of multiples of these two half wave lengths, i.e. at 30 feet, 60 feet, 90 feet, etc., that is on the third, sixth, ninth, half waves of V_1, and second, fourth and sixth half waves of V_4.

Arrangements as described above in which a control is exerted upon relative movement between an apparatus embodying the invention and a reflecting object, as will be appreciated, may have many general applications. Thus, in one arrangement a controlling unit in accordance with the invention is incorporated in a shell or rocket to ensure detonation of the shell or rocket in the proximity of a target. It will be appreciated that the said target may be airborne, seaborne or on the ground. The invention is, however, particularly applicable as a means for controlling the detonation of an antiaircraft shell or rocket in the proximity of an airborne target.

In those cases in which the invention is applied to an aerial bomb or torpedo, the unit may be arranged in the bomb or torpedo in place of the normal impact detonator in such a manner that the bomb will be exploded prior to impact with a target and consequently the effect of fragmentation and/or blast or, in the case of a gas bomb, dissemination, will be a maximum. In such arrangements the controlling device in accordance with the invention can be housed in the finned tail casing of the bomb. The aerial system may then be constituted by short rods arranged for transport between opposite fins of the bomb tail adapted, after release of the bomb to be moved, for example by spinner means, into operative positions at right angles to the bomb. Alternatively the body and/or the tail unit and/or the nose assembly of the bomb, shell, rocket or the like may constitute the aerial system.

In a further arrangement apparatus in accordance with the invention may be employed for control of the release and/or detonation of a torpedo from a torpedo-carrying aircraft. Thus, assuming that a device in accordance with the invention is provided in a torpedo-carrying aircraft to control the release of a torpedo, the arrangement is such that the pilot of the aircraft having preset the height above the sea at which the torpedo is to be launched has then only to bring his aircraft in the correct attitude toward the sea and, at the critical distance, the torpedo is released.

While there has been described what is at present considered to be the preferred embodiment of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A radiant-energy projectile detonating system comprising, means including a radiant-signal translator for generating wave-signal energy and for radiating said energy to a remote object which returns to said translator radiant energy having a frequency approximately equal to that of said first-mentioned radiant energy, said translator and said object having during operation of said system relative movement effecting a change of phase between the wave-signal energy radiated and received by said translator whereby the impedance of said translator varies with said movement, means effectively responsive to variations of impedance of said translator for deriving a control effect, and a projectile detonating arrangement responsive to said control effect for detonating a projectile.

2. A radiant-energy projectile detonating system comprising, an oscillator for generating wave-signal energy, an antenna relatively tightly coupled to said oscillator for radiating said energy therefrom to a remote object which returns to said antenna radiant energy having a frequency approximately equal to that of said first-mentioned radiant energy, said antenna and said object having during operation of said system relative movement effecting a change of phase between the wave-signal energy radiated and received by said antenna whereby the impedance of said antenna varies with said movement, means effectively responsive to variations of impedance of said antenna for deriving a control effect, and a projectile detonating arrangement responsive to said control effect for detonating a projectile.

3. A radiant-energy projectile detonating system comprising, a vacuum-tube oscillator for generating wave-signal energy, an antenna relatively tightly coupled to said oscillator for radiating said energy therefrom to a remote object which returns to said antenna radiant energy having a frequency approximately equal to that of said first-mentioned radiant energy, said antenna and said object having during operation of said system relative movement effecting a change of phase between the wave-signal energy radiated and received by said antenna whereby the impedance of said antenna and thereby the space current of said oscillator vary with said movement, a resistor included in the space-current energising circuit of said oscillator to derive from the space current thereof a control voltage, and a projectile detonating arrangement including a relay device responsive to said control voltage for detonating a projectile.

4. A radiant-energy projectile detonating system comprising, means including a radiant-signal translator for generating wave-signal energy and for radiating said energy to a remote object which returns to said translator radiant energy having a frequency approximately equal to that of said first-mentioned radiant energy, said translator and said object having during operation of said system relative movement toward one another to effect a change of phase between the wave-signal energy radiated and received by said translator whereby the impedance of said translator varies with said movement, means effectively responsive to variations of impedance of said translator for deriving a control effect having a magnitude increasing with said movement, and a projectile detonating arrangement responsive to a predetermined value of the increasing magnitude of said control effect for detonating a projectile.

5. A radiant-energy projectile detonating system comprising, a source of modulation signals, means including a radiant-signel translator for generating wave-signal energy modulated by the signal of said source and for radiating said energy to a remote object which returns to said translator correspondingly modulated radiant energy having a frequency approximately equal to that of said first-mentioned radiant energy, said translator and said object having during operation of said system relative movement effecting a change of phase between the wave-signal energy radiated and received by said translator whereby the impedance of said translator and the intensity of energy radiated thereby vary with said movement, means for deriving the modulation components of the wave-signal energy applied to said translator to derive a control effect, and a projectile detonating arrangement responsive to said control effect for detonating a projectile.

6. A radiant-energy projectile detonating system comprising, means including a radiant-energy translator for generating wave-signal energy and for radiating said energy to a remote object which returns to said translator radiant energy having a frequency approximately equal to that of said first-mentioned radiant energy, said translator and said object having during operation of said system relative movement toward one another to effect a change of phase between the wave-signal energy radiated and received by said translator whereby the impedance of said translator varies with said movement, means effectively responsive to variations of impedance of said translator for deriving a control effect having a magnitude increasing with said movement, and a projectile detonating arrangement having a critical response to said control effect for effecting at a critical distance between said translator and said object a control which detonates a projectile.

7. A radiant-energy projectile detonating system comprising: a pair of wave-signal oscillators having individual antennas coupled thereto for generating and radiating individual wave-signal energies, of individual different frequencies, to a remote object which returns to said antennas radiant energy having frequencies approximately equal to those of said first-mentioned wave-signal energies; the wave lengths of said first-mentioned wave signals being different submultiples of a predetermined value and said antennas and said object having during operation of said system relative movement effecting a change of phase between the wave-signal energy radiated and received by each of said antennas whereby the impedance of said each antenna varies with said movement; means effectively responsive to variations of impedance of each of said antennas for deriving individual controls effects; and a projectile detonating arrangement responsive jointly to said control effects for effecting at predetermined dis-

tances between said antennas and said object detonation of a projectile.

8. A radiant-energy projectile detonating system comprising, a source of modulation of signals of relatively low frequency, means including a radiant-signal translator for generating higher frequency wave-signal energy modulated by the signal of said source and for radiating said modulated energy to a remote object which returns to said translator radiant energy having a frequency approximately equal to that of said first-mentioned radiant energy, said higher frequency wave-signal energy having a wave length which is a multiple or submultiple of a distance between said radiant-signal translator and said object and said translator and object having during operation of said system relative movement effecting a change of phase between the wave-signal energy radiated and received by said translator whereby the impedance of said translator varies with said movement, means coupled to said first-mentioned means for deriving the modulation components of the wave-signal energy applied to said translator to derive a control effect, and a projectile detonating arrangement including amplifying means responsive to said control effect for detonating a projectile.

9. A radiant-energy projectile detonating system in accordance with claim 8 in which said control effect deriving means comprises a vacuum tube which includes a control electrode and is biased to provide anode-circuit rectification and in which there is applied to said control electrode of said vacuum tube a relatively large negative bias potential.

10. A radiant-energy projectile detonating system comprising, means including a radiant-signal translator for generating wave-signal energy and for radiating said energy to a remote object which returns to said translator radiant energy having a frequency approximately equal to that of said first-mentioned radiant energy, said translator and said object having during operation of said system relative movement toward one another effecting a change of phase between the wave-signal energy radiated and received by said translator whereby the impedance of said translator varies with said movement, means effectively responsive to variations in impedance of said translator for deriving a control potential, and a projectile detonating arrangement including a gas-filled electron-discharge device responsive to a critical value of said control potential corresponding to a critical distance between said translator and said object for providing an abrupt control to effect the detonation of a projectile.

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