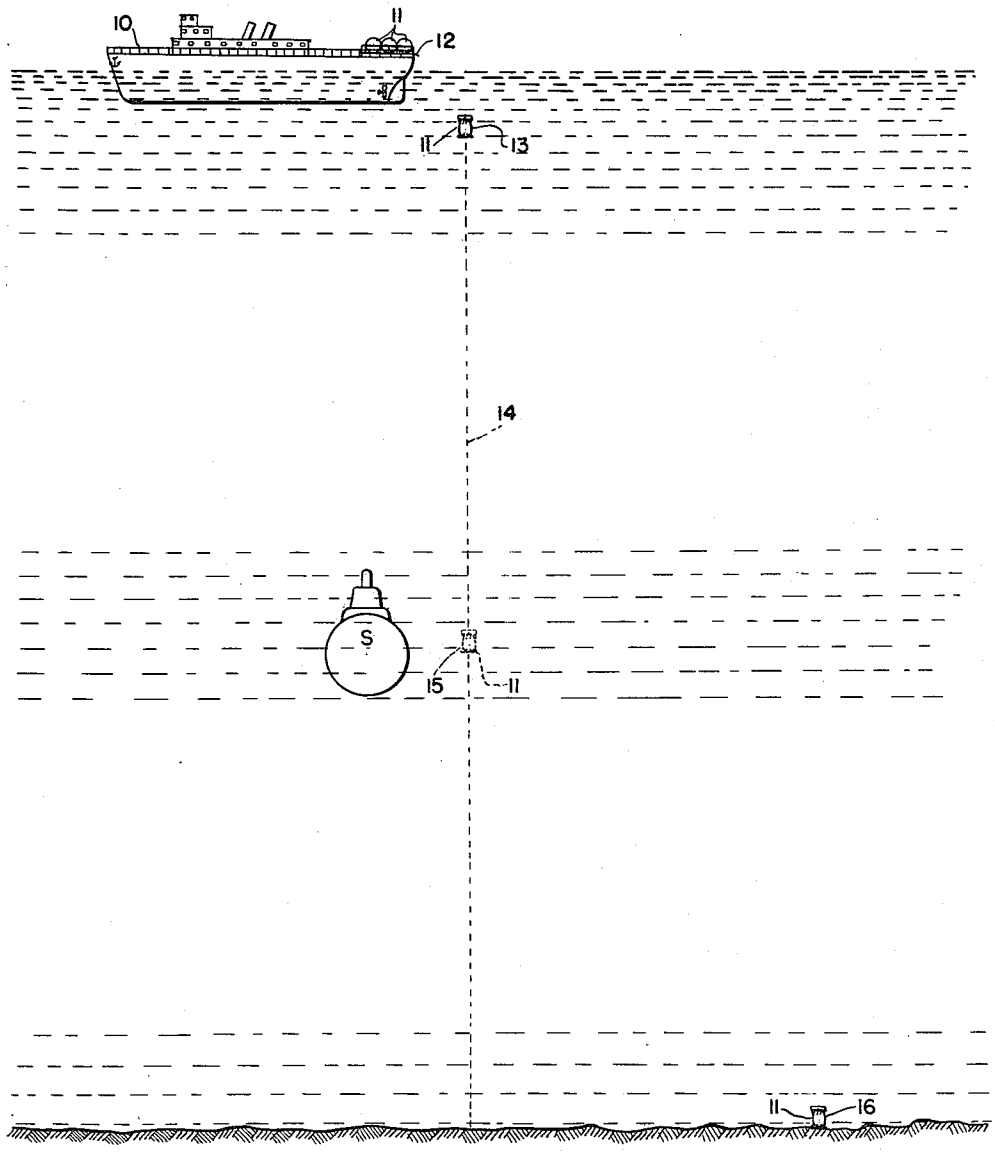
Dec. 31, 1963 H. H. HALL ETAL 3,115,833

ACOUSTICAL DOPPLER FIRING DEVICE

Filed Jan. 28, 1944 5 Sheets-Sheet 1

FIG. 1.



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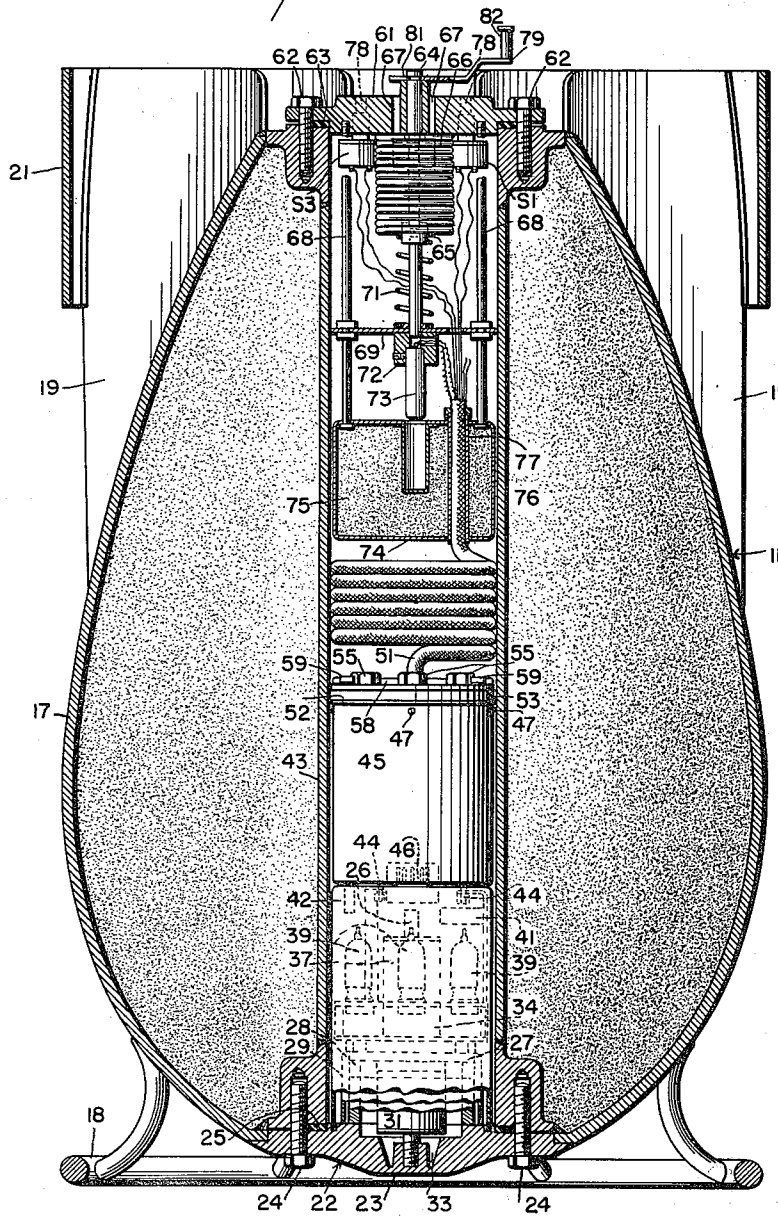
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ACOUSTICAL DOPPLER FIRING DEVICE

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Fig. 2.



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ACOUSTICAL DOPPLER FIRING DEVICE

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Fig. 3.

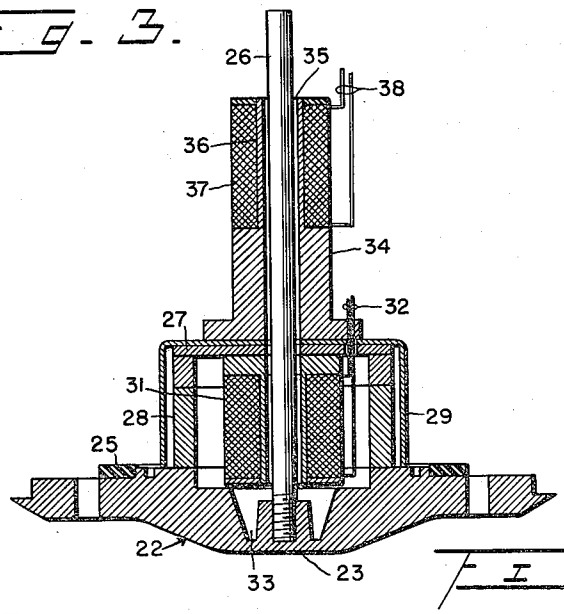


Fig. 5.

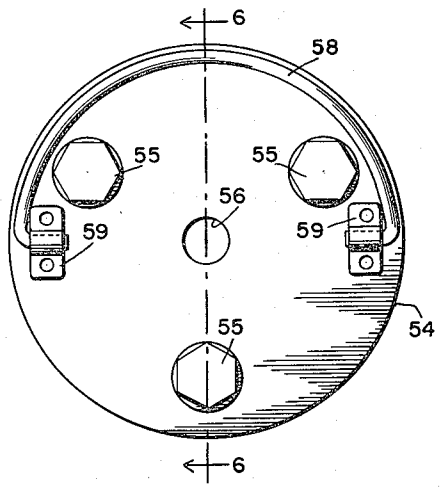
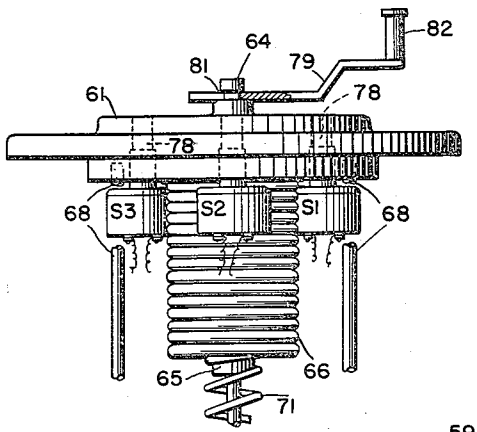


Fig. 4.



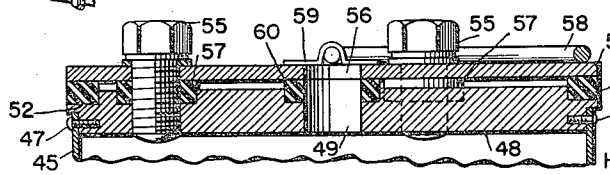


Fig. 6.

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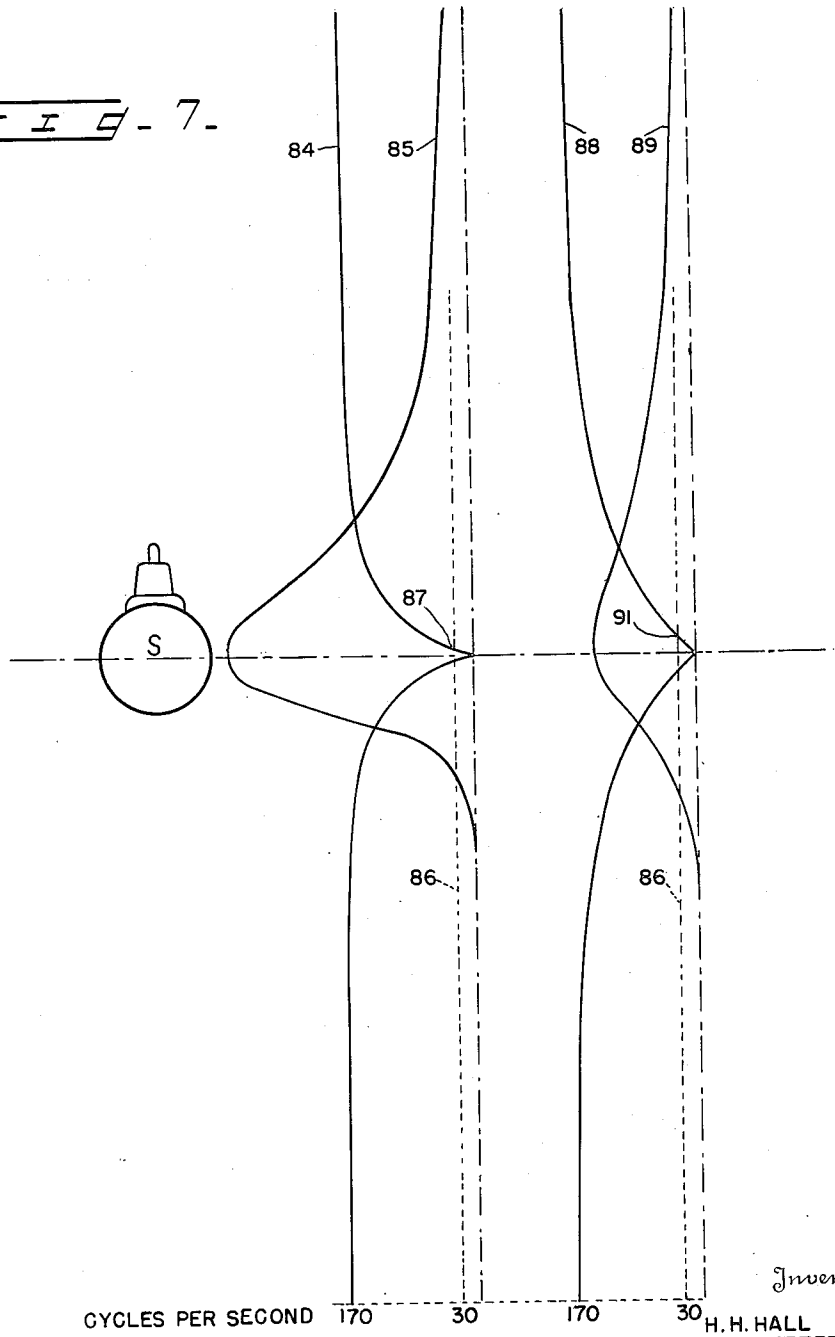
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ACOUSTICAL DOPPLER FIRING DEVICE

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Fig. 7.



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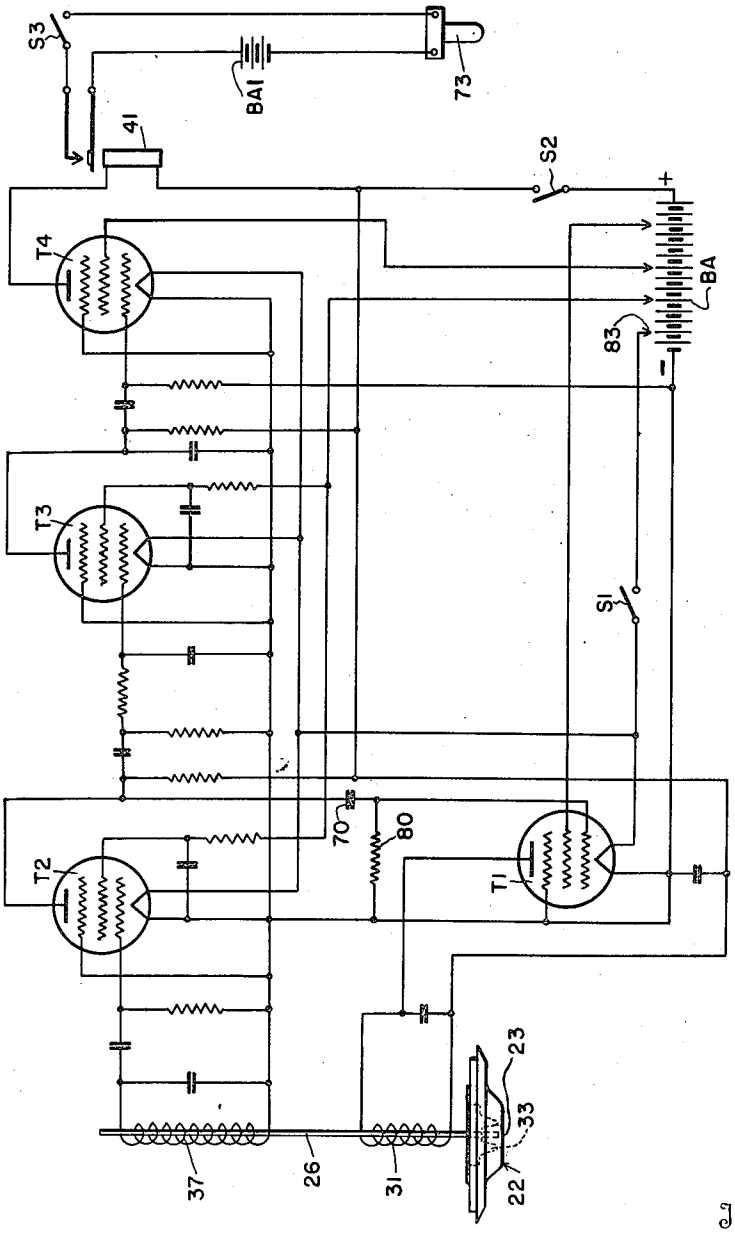
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ACOUSTICAL DOPPLER FIRING DEVICE

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FIG. 5.



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United States Patent Office 3,115,833 Patented Dec. 31, 1963

3,115,833
ACOUSTICAL DOPPLER FIRING DEVICE

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Filed Jan. 28, 1944, Ser. No. 520,074
29 Claims. (Cl. 102—18)
(Granted under Title 35, U.S. Code (1952), sec. 266)

This invention relates to means for firing an explosive charge in proximate relation to a target by signals transmitted through a fluid medium from a transmitting source moving relative to the target when the signals reflected from the target bear a predetermined relation to the signals emanating from the transmitting source and more particularly to a mechanism for firing an explosive charge by reflected signals in which the principle known in the art as the Doppler effect is employed to fire the charge under control of the frequency of the heterodyne beat of the reflected signals with the signals emanating from the transmitting source when the frequency of the beat signals has been reduced to a predetermined value corresponding to substantially the closest point of approach of the charge with respect to the target.

The present invention is particularly adapted for use with underwater ordnance such, for example, as depth charges, marine mines and the like, but it is obviously not so limited, as it may be employed for controlling the firing of projectiles, bombs and the like by signals reflected from the target when the beat frequency of the reflected signals has been reduced to a predetermined frequency during relative movement between the weapon and the target. When employed to control the firing of a depth charge, for example, the depth charge is fired only in proximate relation to the submarine regardless of the depth of submersion of the submarine within the water and in the event that the submarine is not disposed within the effective zone of damage or destruction of the explosive charge, the charge is not fired and the submarine, therefore, does not receive a warning that it is under attack.

It has been the usual practice in devices heretofore proposed for firing a depth charge to control the firing of the charge by the pressure of the water adjacent thereto or to fire the charge when a predetermined period of time has elapsed after the charge has been launched. Such devices have been found to be not altogether satisfactory in service for the reason that the depth charge may fire at a depth sufficiently different from the depth of submersion of the submarine to prevent damage or injury thereto as a result of the underwater explosion. Furthermore, modern submarines are constructed to withstand greater depths of submersion than earlier types of submarines heretofore employed in naval warfare and with the development of the submarine art, the submarine of the future will be designed to withstand still greater depths of submersion without damage or injury thereto as the result of the normal pressure of the surrounding water. The efficiency and usefulness of depth charges fired by water pressure at a predetermined depth of submersion or by timing devices will, therefore, be reduced inversely in proportion to the depth in which the submarine is adapted to submerge.

According to the present invention, the firing of the explosive charge is under control of the Doppler effect and the firing of the charge takes place when the submarine is substantially opposite the depth charge during the downward movement of the depth charge within the water and thus the maximum destructive effect of the explosion of the depth charge is obtained regardless of the depth of submersion of the submarine. The firing control mechanism, according to the preferred embodiment of the invention, comprises a transducer adapted to emit a continual signal comprising a series of impulses of predetermined high frequency during the downward travel of the depth charge within the water, and means for receiving the heterodyne signals reflected from the submarine in accordance with the well known Doppler effect. These reflected signals decrease in frequency as the depth charge approaches the submarine and are reduced to zero as the depth charge is directly opposite the submarine. When the frequency of the received heterodyne signals has been reduced to a relatively low value corresponding to a position of the depth charge within the water substantially opposite the submarine, an electroresponsive device responsive to this predetermined frequency is caused to operate and fire the depth charge, as will more clearly appear as the description proceeds.

One of the objects of the present invention is to provide new and improved means for controlling the firing of a depth charge by signals reflected from the target whereby the charge is fired at the closest point of approach to the target.

Another of the objects is to fire an explosive charge under control of reflected signals in accordance with the Doppler effect.

Another object is the provision of a depth charge firing mechanism adapted to transmit signals continually during the travel of the depth charge within the water, in which the depth charge is fired when the frequency of the detected signals caused by the interaction of the signals reflected from a target with the transmitted signals has decreased to a predetermined value.

Another of the objects is the provision of a new and improved depth charge and means for firing the depth charge at the closest point of approach thereof to a target regardless of the depth of submersion of the target.

Still other objects, advantages and improvements will be apparent from the following detailed description taken in connection with the accompanying drawings of which:

FIG. 1 is a diagrammatic view illustrating the device according to a preferred embodiment thereof as employed for destroying a submarine;

FIG. 2 is an enlarged view partially in section of the device of FIG. 1;

FIG. 3 is a sectional view of the transducer employed with the device of FIG. 2;

FIG. 4 is a fragmentary view of the arming mechanism and safety device employed with the device of FIG. 2;

FIG. 5 is a plan view of the battery case;

FIG. 6 is a fragmentary view in section taken along the line 6—6 of FIG. 5;

FIG. 7 illustrates diagrammatically the variations in the beat or heterodyne frequency of the signals detected by the transducer during the approach and recession of a pair of depth charges with respect to a submarine; and,

FIG. 8 illustrates in diagrammatic form a complete system suitable for use with the present invention.

Referring now to the drawings on which like numerals are employed to designate like parts throughout the several views and more particularly to FIG. 1 thereof there is shown thereon a vessel 10 and a plurality of depth charges 11 thereon adapted to be launched in succession from the launching rail 12 and a depth charge 11 within the water at 13 above the submarine S, the path of travel of the depth charge within the water being indicated by the dashed line 14. The depth charge is also shown in dashed outline in a position at 15 along the path of travel thereof at which the frequency of the heterodyne signals reflected from the submarine has been reduced to the predetermined value at which firing of the depth charge occurs. There is also shown at 16 another depth charge resting on the bed of the body of water, the

depth charge having been previously dropped by the vessel 10 at a sufficient distance from the submarine to prevent firing of the depth charge as the depth charge moves past the depth of submersion in the water at which the submarine is disposed.

The depth charge comprises a streamlined casing 17 such, for example, as the streamlined casing disclosed in the co-pending application for Streamline Depth Charge of Robert H. Park et al., Serial No. 456,048, filed August 25, 1942, now Patent No. 2,641,184, and having an annular member 18 secured to the lower portion of the casing and a plurality of fins 19 secured to the upper portion of the casing respectively, a second annular member 21 being disposed about and supported by the fins. The fins may be arranged parallel to the casing or, if desired, at an angle with respect thereto. Secured to the lower portion of the casing in coaxial relation with respect to the axis thereof is a transducer indicated generally by the numeral 22 comprising a movable diaphragm 23 secured to the casing as by the bolts 24, a suitable gasket 25 being provided to prevent the seepage or leakage of water therebetween. The outer surface of the diaphragm is arranged to conform with the outline of the casing 17 and present a smooth unbroken front to the opposing water during the downward movement of the depth charge therein in which there is no possibility of the formation of air bubbles or other condition of cavity within the water adjacent the diaphragm sufficient to impair or interfere with the operation of the transducer. The diaphragm 22 is preferably composed of magnetic material thereby to complete a magnetic circuit between a magnetostrictive rod 26 secured to the central portion of the diaphragm and projecting upwardly and inwardly within the casing of the depth charge and a yoke comprising the magnetic plate 27 and a permanent magnet 28 disposed about the rod 26. There is also provided a metallic shield 29 arranged above the permanent magnet and adapted to shield the device from the magnetic effects set up by an alternating current within a driving coil 31 arranged about the rod 26 within which the rod 26 is adapted to move in an axial direction. The coil 31 is energized by current impulses applied to the pair of conductors 32 connected thereto.

From the foregoing, it will be apparent that an alternating current applied to the coil 31 causes axial movement of the magnetostrictive rod 26 and a vibratory or oscillatory movement of the diaphragm 23, the movement of the diaphragm being facilitated by the recessed portion 33 thereof within which one end of the rod 26 is secured in any suitable manner as by threading the parts together. There is also provided a support 34 secured to the plate 27 in any suitable manner and having an aperture 35 therein within which the rod 26 is adapted to move. The support 34 is preferably provided with a recessed portion 36 within which is arranged a winding or receiving coil 37 and coaxially arranged with respect to the rod 26, the coil being provided with a pair of conductors 38 thereby to establish an external circuit connection to the coil. The manner in which the driving coil 31 is employed to actuate the flexible diaphragm 23 during the travel of the depth charge within the water to send out a signal of predetermined frequency and the manner in which the receiving coil 37 is employed to detect the signal reflected from the surface of a target in acordance with the principle known as the Doppler principle will become more apparent as the description proceeds.

Secured to the diaphragm 23 in any suitable manner is a plurality of vacuum tubes indicated generally at 39 including a detector tube for generating the alternating current impulses applied to the coil 31 and for receiving and amplifying the heterodyne or beat signals generated by the detector due to the interaction of the transmitted or primary signals and the reflected or secondary signals induced in the receiving coil 37.

The magnetostrictive rod 26 is of such length and the driving currents are of such frequency that the rod is induced to vibrate longitudinally in its second mode of vibration including two nodes of displacement, one of the nodes being approximately ¼ of a wave length from the free end of the rod, the other near the end of the rod to which the diaphragm is secured. The driving coil 31 is arranged at the node nearer the diaphragm and the receiving coil is arranged at the node nearer the free end of the rod. A tuned relay 41 is connected to the output of the amplifier circuit and adapted to be controlled by the heterodyne signals amplified therein and adapted to close a firing circuit when the frequency of the heterodyne signals has been reduced to a predetermined relatively low value. Secured in any suitable manner to the diaphragm member 23 is a container 42 adapted to be arranged within the tubular member 43 and having secured thereto in any suitable manner as by the bolts 44 a casing 45 within which is disposed a battery, hereinafter referred to as BA, the connections between the battery and the firing control mechanism being established by the plug and jack arrangement 46. Secured to the casing 45 in any suitable manner as by the screws 47 is a circular plate or cover 48 having an aperture 49 centrally arranged therein in which is disposed one end of the cable 51. The cover is provided with an annular recessed portion 52 arranged circumferentially thereon in which is disposed a washer or gasket 53 adapted to be clamped by the plate 54 as the bolts 55 are tightened thereby to expand the gasket and secure the casing 45 to the tubular member 43. The plate 54 is also provided with an aperture 56 in substantial alinement with the aperture 49 of the cover 48 thereby to receive the aforesaid cable 51, a suitable gasket 60 being preferably provided about the cable in registered engagement with the plate 48 thereby to seal the plate to the cover as the bolts 55 are tightened. In like manner, a seal is established between the bolts 55 and the cover 48 by the gasket 57. The plate 54 is preferably provided with a bale or handle 58 pivotally secured thereto as at 59 thereby to facilitate handling of the device during the assembly and testing thereof.

The upper portion of the tubular member 43 supports a plate or cover 61 secured thereto and in watertight relation therewith as by the bolts 62 and gasket 63. Slidably arranged within the plate 61 is a plunger or rod 64 secured at 65 to an expansible bellows 66 sealed in any suitable manner at the upper portion thereof to the lower portion of the plate 61. Communication between the interior of the bellows and the surrounding water is established by a plurality of apertures 67 within the plate 61. Secured to the plate in any suitable manner as by the rods 68 is a bearing support 69 within which the lower end of the plunger 64 is slidably arranged, a spring 71 being provided between the bearing support in engagement with the rod 64 at 65 thereby to maintain the rod 64 in a safe retracted position until the pressure of the water within the expansible bellows has increased sufficiently to overcome the spring and move the arm to an extended or armed position. Secured to the inner end of the rod 64 in any suitable manner as by the holder 72 is an electroresponsive detonator 73 adapted to be fired by the relay 41 when the heterodyne signals are reduced in frequency to a predetermined value.

There is also secured to the rods 68 a container 74 within which is disposed an explosive booster charge 75 adapted to be fired by the detonator 73 when the detonator has been moved into an armed position in operative relation therewith by the pressure of the water within the expansible bellows 66. The explosion of the booster charge causes the main explosive charge 76 to be fired as is well-known in the art of underwater ordnance. The container 74 is preferably provided with a tubular member 77 within which the upper end of the cable 51 is disposed.

There is also secured to the lower portion of the plate 61 a plurality of hydrostatically controlled switches S1, S2, and S3 of any well known construction and having

the hydrostat elements thereof in communication with the surrounding water by reason of the provision of a plurality of apertures 78 within the plate 61 respectively associated with each of the hydrostat elements, the hydrostat elements are preferably adjusted to close the switches in a predetermined order of sequence as the depth charge sinks within the water, the switches S1 and S2 closing at a relatively small depth of submersion in the order named such, for example, as 6 and 8 feet respectively and the switch S3 closing at a somewhat greater depth of submersion within the water such, for example, as 10 feet. The plunger 64 is preferably provided with a safety fork or bar 79 detachably secured in registered engagement with the outer portion of the rod 64 at 81 and having a projecting portion 82 thereon adapted to be engaged by a complementary fixed member disposed within the path of travel of the projecting portion 82 of the fork and thereby detach the fork from the plunger 64 during the movement of the depth charge along the launching rails of the vessel.

The operation of the device will now be described. Let it be assumed, by way of example, that the depth charge 11 has been launched from the deck of the vessel 10 above the submarine S and that the depth charge moves downwardly within the water along a path of travel indicated by the dashed line 14, FIG. 1. The launching of the depth charge from the vessel 10 caused the safety fork 79 to be detached from the plunger 64 whereby the plunger is adapted to be moved inwardly by the pressure of water within the expansible bellows 66. The switches S1 and S2 are closed and switch S3 is subsequently closed when the depth charge has reached the depths of submersion respectively corresponding to the pressures at which the respective switch hydrostat elements are adapted to operate and the detonator 73 is moved by the pressure of the water within the bellows 66 into the armed position with respect to the booster charge 75.

The operation of the system in response to the closing of switches S1, S2, and S3 will best be understood by consideration of FIG. 8 on which is shown the complete electrical system of the depth charge. As switch S1 moves to closed position, a circuit is closed from terminal 83 of battery BA to the filaments of tubes T1, T2, T3, and T4 thereby heating and activating the tubes. As switch S2 closes its contact, battery potential is applied to the plates of tubes T1 to T4, the plate circuit of the tube T4 including the winding of the tuned relay 41 and the plate circuit of the tube T1 including the coil 31. For the purpose of description, the tube T1 may be regarded as an oscillator or power amplifier, the tube T2 as a detector amplifier, and the tubes T3 and T4 as amplifying tubes adapted to amplify the heterodyne signals generated by the detector T2. The coupling between the detector and oscillator introduced by the magnetostrictive rod 26 and the network comprising the condenser 70 and resistance element 80 provides a regenerative path for the signals received by the detector and causes these signals to be amplified, and the heterodyne signals to be relatively strong. The frequency of the heterodyne signals, it will be understood, is continuously proportional to the difference in frequency of the impulses, transmitted by the transducer 22 and the reflected signal received thereby.

The closure of switch S2 causes the tubes T1 and T2 to function and apply a high frequency alternating current to the driving coil 31 thereby setting the rod 26 and flexible diaphragm 23 into operation to transmit a continuous high frequency acoustical signal through the water in the direction of the submarine. As the signal engages the surface of the submarine, a portion of the signal is reflected back to the diaphragm 23 and because the depth charge is now moving toward the submarine along the path of travel 14, the reflected signal will impinge upon the diaphragm 23, be received by the coil 37 and thus be applied to the detector T2. The frequency of the reflected signal will differ from the frequency of the transmitted signal in accordance with the well-known Doppler principle. A heterodyne or beat signal having a frequency equal to the numerical difference between the frequencies of the transmitted signals and the received signals is generated by the detector tube T2 and applied to the amplifier tube T3. The path of travel 14 of the depth charge, it will be noted, is such that the depth charge is adapted to pass relatively close to the submarine S during the downward travel of the depth charge within the water and the frequency of the heterodyne signal received by the receiving coil 37, therefore, varies continually during the downward movement of the depth charge within the water, the frequency of the heterodyne signal becoming progressively less until the transducer has descended within the water to the same depth of submersion as the submarine.

When this occurs, the rate of approach of the depth charge with respect to the submarine is zero and the frequency of the heterodyne signal, therefore, is also reduced to zero. Downward movement of the depth charge past the submarine would cause the frequency of the heterodyne signal to increase progressively as the depth charge moves past the submarine. This condition is illustrated on FIG. 7 in which the frequency of the heterodyne signals during the travel of the submarine through the water is illustrated by the curve 84 corresponding to the frequency of the heterodyne signal received by the transducer 22 as the depth charge moves along the path of travel 14. The curve 85 is employed to illustrate the increase in the strength of the received heterodyne signal as the depth charge moves along the path of travel 14, the strength of the received signal being greatest as the transducer moves into a position opposite the submarine and thereafter decreasing rapidly in strength in the event that the transducer should move past the submarine, by reason of the acoustic shadow cast by the casing of the depth charge. The dashed line 86 is employed to indicate a frequency corresponding to the frequency of the tuned relay 41 which, in the assumed example, is 30 cycles a second. When the frequency of the received heterodyne signal is reduced to 30 cycles per second, illustrated at 87 of the curve 84 the tuned relay 41, FIG. 8, is operated thereby closing a circuit from battery BA1 by way of the contacts of switch S3 to the detonator 73 and firing the charge in the position indicated at 15 on FIG. 1 substantially opposite the submarine.

In the event that the depth charge should have been launched at a somewhat greater distance from the submarine than the path of travel 14 therefrom such, for example, that the depth charge would come to rest on the bed of the body of water at 16, FIG. 1 and in which the submarine was disposed at a distance from the path of travel of the depth charge through the water such that damage or injury to the submarine would not be effected by the explosion as it passes the submarine during the downward travel thereof through the water. The frequency of the heterodyne signal received by the transducer during the downward movement of the depth charge within the water is illustrated by the curve 88 and the strength of the received heterodyne signals is illustrated by the curve 89. The depth charge is not fired as the frequency of the received heterodyne signal is reduced to operating frequency of the tuned relay 41 at 91, however, for the reason that the strength of the heterodyne signal received by the transducer at this time is insufficient to cause relay 41 to operate.

Briefly stated in summary, the present invention contemplates the provision of a mechanism for firing an explosive charge selectively in accordance with the frequency and strength of signals reflected from a target in which the received signals or echo comprise a portion of the energy of the signals transmitted by a transducer and in which a heterodyne or beat signal resulting from the

combination of the transmitted and received impulses is employed to control a frequency responsive device and fire the charge opposite a target when the frequency of the heterodyne signal has decreased to a predetermined value.

While the invention has been described in detail with respect to a preferred form of underwater ordnance which gives satisfactory results, it will be understood by those skilled in the art, after understanding the invention, that various features of the system disclosed and claimed herein may advantageously be employed for firing other ordnance weapons such, for example, as bombs, projectiles and the like other than underwater ordnance, and that various modifications may be made without departing from the spirit and scope of the invention, and it is intended therefore, in the appended claims to cover all such changes and modifications.

The invention herein described and claimed may be manufactured and used by or for the Government of the United States of America for governmental purposes without 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 device of the character disclosed for firing an explosive charge by heterodyne signals, a casing for said device, means including a flexible diaphragm secured to said casing for transmitting sonic waves toward a target during relative movement of the device with respect to the target, means for receiving waves reflected from said target, means controlled by said receiving means for detecting the beat frequency between the waves transmitted by said diaphragm and said reflected waves and for producing a heterodyne signal proportional thereto, an electro-responsive device controlled by said heterodyne signal and adapted to be operated when the frequency thereof is reduced to a predetermined value corresponding to a position of the device opposite the target, and means controlled by said electroresponsive device for firing the explosive charge when said predetermined frequency is produced.

2. In a device of the character disclosed for controlling the firing of an explosive charge, a streamline casing within which the explosive charge is disposed, means for causing the casing to follow a predetermined path of travel relative to a target having a sound reflecting surface, a transducer having a vibrational element secured to said casing at the lowermost portion thereof, means for causing said vibrational element to transmit a continuous series of sonic waves toward said reflecting surface, means for receiving waves reflected from said surface, means associated with the transducer and controlled by said receiving means for producing a varying heterodyne signal caused by relative movement of the transducer with respect to said reflecting surface, means for amplifying said heterodyne signal, and means including a frequency selective device operatively connected to said amplifying means for firing said charge during the movement of the transducer along said path of travel when the frequency of the heterodyne signal has been reduced to a predetermined value.

3. In a device o fthe character disclosed for controlling the firing of an explosive charge, means carried by the device for projecting a continual signal comprising a series of sonic impulses of uniform frequency toward a target during relative movement of the device with respect thereto, means for receiving the impulses reflected from said target, means for detecting the beat frequency between the projected inmpulses and the received impulses, and means for firing the charge when the beat frequency detected by said detecting means has been reduced to a predetermined value.

4. In a system adapted to be controlled by variations in a heterodyne signal corresponding to the beat frequency between a series of projected waves and a series of waves received from a reflecting surface in accordance with the Doppler effect, a casing means carried by said casing for transmitting waves comprising a series of impulses of uniform frequency through a fluid medium toward a target having a sound reflecting surface during relative movement of the transmitting means with respect to the surface, means for receiving waves reflected from said surface, means for detecting a varying heterodyne signal corresponding to the beat frequency between the projected waves and the reflected waves received by said receiving means, a control circuit, and means controlled by said heterodyne signal for closing said control circuit when the frequency of the heterodyne signal has decreased to a predetermined value.

5. In an apparatus of the character disclosed for firing a depth charge by signals received from a reflecting surface as the depth charge sinks within the water, a streamline casing having an explosive charge therein and adapted to sink within the water, a transducer comprising a vibratory diaphragm arranged on the lower end of said casing in communication with the surrounding water and in substantial conformity with the outline of said casing, means including a magnetostrictive rod secured to the central portion of said diaphragm and movable therewith for causing the diaphragm to project signals of predetermined frequency through the surrounding water as the depth charge sinks within the water in proximate spaced relation with respect to a target having a sound reflecting surface, means including a receiving coil disposed about said magnetostrictive rod for detecting signals reflected from said surface, means operatively connected to said receiving coil for detecting the beat frequency between the projected signals and the signals received by the receiving coil, and means including a frequency selective device controlled by said detecting means for firing said explosive charge when the beat frequency has been reduced to a predetermined value.

6. An apparatus for firing an explosive depth charge by heterodyne signals and comprising a vibratory element in communication with the surrounding water, a magnetostrictive rod secured to said diaphragm and movable therewith, a driving coil disposed about said rod and adapted to actuate the diaphragm vibrationally in response to current impulses applied thereto and thereby project signals into the surrounding water towards a target disposed adjacent the path of travel of said depth charge and having a surface adapted to reflect said projected signals, a receiving coil on said rod adapted to detect the reflected signals received by said diaphragm, means including a pair of electron discharge devices for applying said current impulses to said driving coil continually during the travel of the depth charge within the water, means operatively connected to said discharge devices for detecting the beat frequency of the projected impulses and the frequency of the reflected impulses detected by said receiving coil, means for amplifying the beat frequency of said reflected signals, and means including a frequency selective device operatively connected to said amplifying means for firing the depth charge when said beat frequency has been reduced to a predetermined value.

7. An apparatus for firing an explosive depth charge by heterodyne signals comprising a vibratory element adapted to be carried by said depth charge in communication with the surrounding water, a magnetostrictive rod secured to said diaphragm and movable therewith, a driving coil disposed about said rod and adapted to actuate the diaphragm vibrationally in response to current impulses applied thereto and thereby project impulses into the surrounding water towards a target disposed adjacent the path of travel of said depth charge and having a surface adapted to reflect the projected impulses, a receiving coil on said rod adapted to detect the reflected impulses received by said diaphragm, means including at least one electron discharge device for applying said current impulses to said driving coil continually during the travel

of the depth charge within the water, means operatively connected to said discharge device for detecting the difference in the frequency of the projected impulses and the frequency of the reflected impulses detected by said receiving coil and for producing varying heterodyne signals corresponding thereto, means for amplifying said heterodyne signals, and means including a frequency selective device operatively connected to said amplifying means for firing the depth charge when the frequency of said heterodyne signals has been reduced to a predetermined value.

8. In a device of the character disclosed for firing an explosive depth charge by reflected signals in accordance with the Doppler effect as the depth charge moves to a position opposite a target, a transducer carried by the device and comprising a vibrational element in communication with the surrounding water, a magnetostrictive rod secured to said vibrational element and movable therewith, a transmitting coil disposed about said rod, means including an oscillator for applying current impulses of predetermined frequency to said transmitting coil such that two vibrational nodes are formed therein, one of said nodes being disposed within said transmitting coil, a receiving coil arranged about said rod at the second vibrational node thereof, an electron space discharge device operatively connected to said receiving coil and adapted to be controlled thereby, means for coupling said electron discharge device to said oscillator thereby to produce a varying heterodyne signal corresponding to the difference in the frequencies of said current impulses and the signals received by said receiving coil, means for amplifying said heterodyne signal, and means including a frequency responsive device operatively connected to said amplifying means for firing the depth charge when the frequency of the heterodyne signal has been reduced to a predetermined value.

9. In an ordnance weapon of the character disclosed adapted to fire an explosive charge under control of signals reflected from a target, a firing system comprising a vibratory diaphragm carried by the weapon and in communication with the fluid medium surrounding the weapon, a magnetostrictive rod secured to said diaphragm and movable therewith, a driving coil on said rod at one of the vibrational nodes thereof, a source of electrical power, means including an electron discharge device for applying current impulses of predetermined frequency to said driving coil such that the rod has two vibratory nodes, a receiving coil disposed about said rod at the other of said nodes, means operatively connected to said receiving coil for detecting said reflected signals and for producing a varying heterodyne signal corresponding thereto, means for amplifying said heterodyne signal, and means including an electroresponsive device controlled by said amplifier for firing said explosive charge selectively in accordance with the frequency of said heterodyne signal.

10. An underwater ordnance weapon adapted to be fired by signals reflected from a target in accordance with the Doppler effect during relative movement of the weapon with respect to the target, means on said weapon for projecting a continual series of uniform signals of predetermined frequency through a fluid medium, means for receiving said reflected signals, means for comparing the frequency of the reflected signals received by said receiving means with the frequency of the signals projected by the projecting means and for producing a varying heterodyne signal corresponidng thereto, and means controlled by said receiving means for firing the weapon during movement thereof with respect to the target when the frequency of said heterodyne signal has been reduced to a predetermined value.

11. In a device of the character dislosed for firing an explosive charge by signals reflected from a target during relative movement of the charge with respect to the target, a casing within which the explosive charge is disposed, a transducer secured to said casing and adapted to project uniform signals of predetermined frequency toward said target, means for receiving the signals reflected from said target, means for detecting the changing beat frequency between the signals projected from said transducer and the signals received by said receiving means and for producing a varying heterodyne signal corresponding thereto, means for amplifying said heterodyne signal, a tuned relay operatively connected to the output of said signal amplifying means and adapted to be operated selectively in accordance with the strength of the received signals when the frequency of the received signals has been reduced to a predetermined value, a firing circuit, and means on said relay adapted to close said firing circuit as the relay operates.

12. In a device of the character disclosed for firing an explosive charge by heterodyne signals, in combination, a streamline casing for said device adapted to sink within the water along a predetermined path of travel, a vibrational diaphragm secured to said casing at the lower portion thereof and in communication with the surrounding water, a magnetostrictive rod secured to said diaphragm and movable therewith, a driving coil adapted to supply impulses to said rod, a vacuum tube having the output thereof connected to said driving coil, a receiving coil on said rod, a second vacuum tube having the input thereof operatively connected to said receiving coil, a vacuum tube amplifier operatively connected to the output of said second vacuum tube, a source of electrical power, means controlled by the pressure of the surrounding water for connecting said vacuum tubes and said vacuum tube amplifier to said source of power when the casing has reached a predetermined depth of submergence therein, means for causing said first and second vacuum tubes to oscillate thereby to project sonic impulses of predetermined frequency from said flexible diaphragm, means for producing a varying heterodyne signal corresponding to the difference in frequency of the projected signals and the frequency of the signals reflected from a target adjacent said path of travel and received by said receiving coil, an electroresponsive device connected to the output of said signal amplifier, a firing circuit for said explosive charge, and means on said electroresponsive device for closing said firing circuit when the frequency of said heterodyne signal has decreased to a predetermined value.

13. In a device of the character disclosed for firing a depth charge opposite a target regardless of the depth of submergence of the target within a body of water, a streamline depth charge casing having an explosive charge therein, means secured to said casing for projecting a continual signal comprising a series of impulses toward a target during the downward movement of the depth charge within the water, means for detecting the beat frequency between the projected impulses and the impulses reflected from said target and for producing a varying heterodyne signal corresponding thereto, a vacuum tube amplifier connected to said receiving means and adapted to amplify said heterodyne signal, an electroresponsive frequency selective device connected to the output of said amplifier and adapted to be operated thereby, a firing circuit having means therein for detonating said explosive charge, and means on said electroresponsive device for closing said firing circuit when the frequency of said heterodyne signal is reduced to a predetermined value corresponding to substantially the same depth of submergence within the water as the depth of said target.

14. In a device of the character disclosed for firing an explosive charge opposite a target disposed within a body of water adjacent the path of travel of the device by signals comprising a series of sound waves reflected from the target, a casing within which the explosive charge is arranged, a transducer secured to said casing and having a vibrational diaphragm in communication with the surrounding water, a magnetostrictive rod secured to said diaphragm and movable therewith, a driving coil ar-

ranged on said rod adapted to actuate the diaphragm in response to current impulses received by the coil and thereby project said signals, means including a vacuum tube oscillator for applying said current impulses to the driving coil, a second coil on said rod for receiving sound signals reflected from the target during said travel, a vacuum tube operatively connected to said receiving coil and adapted to be controlled thereby, means including said magnetostrictive rod for regenerating the received signals, means for producing a varying heterodyne signal corresponding to the difference in the frequency of the projected signals and the frequency of the received signals, means for amplifying said heterodyne signal, and means including a frequency selective device operatively connected to the output of said amplifier for firing the explosive charge when the frequency of the heterodyne signal has decreased to a predetermined value.

15. In a device for controlling the firing of a depth charge by reflected signals received through the water, a streamline casing for the depth charge, a transducer comprising a vibrational diaphragm secured to the lower portion of said casing in communication with the surrounding water, a magnetostrictive rod secured at one end thereof to said diaphragm and disposed within the casing and in coaxial relation therewith, a driving coil adapted to cause the rod to vibrate longitudinally and continually in response to current impulses of predetermined frequency applied thereto thereby to project a continuous series of sound impulses through the water from said diaphragm as the depth charge moves along a predetermined path of travel within the water, means including an electron discharge device for applying said current impulses to the driving coil, a second coil on said rod adapted to receive impulses reflected from a target disposed adjacent said path of travel, an electron discharge detector tube operatively connected to said second coil and adapted to be controlled by signals received thereby, means controlled by said electron discharge device and the detector tube for producing a heterodyne signal varying in frequency in accordance with the difference between the frequency of said current impulses and the frequency of the reflected signals received by said second coil, means for amplifying said heterodyne signal, and means including a frequency selective device operatively connected to the output of said amplifying means for firing the charge when the frequency of the heterodyne signal is reduced to the responsive frequency of said frequency selective device.

16. In a device of the character disclosed adapted to be moved relative to a sound reflecting surface, means carried by the device for projecting a continuous series of sound impulses, means for receiving impulses reflected from said reflecting surface, means controlled by said projecting means and receiving means for producing a heterodyne signal of varying frequency corresponding to the difference in the frequency of the projected impulses and the reflected impulses received by said receiving means, a control circuit, and means controlled by said heterodyne signal for closing said control circuit when the frequency of the heterodyne signal reaches a predetermined value.

17. In an underwater explosive weapon adapted to be moved relative to a sound reflecting surface, means on the weapon for transmitting a continuous series of sonic waves, means for receiving and heterodyning the waves reflected from said surface, and means for firing said explosive when the Doppler frequency of the heterodyne signal between the transmitted waves and the reflected waves has decreased to a predetermined value.

18. In an underwater explosive weapon, means carried by the weapon for continuously transmitting a signal of predetermined frequency, means for receiving and heterodyning Doppler echoes of said transmitted signals as reflected from a reflecting surface remote from said weapon, and means controlled by said receiving means for firing said explosive when the frequency change of the heterodyne signal as caused by relative movement between the weapon and the reflecting surface has decreased to a predetermined value.

19. In an underwater explosive weapon, heterodyning transducer means on the weapon for emitting a continuous signal and receiving echoes of said signal as reflected from a reflecting surface, and means controlled by said transducer for firing said explosive when the beat frequency between the emitted and reflected signals has been reduced to a predetermined value during relative movement between the weapon and said reflecting surface.

20. In an explosive weapon, means carried by the weapon for continuously transmitting a high frequency signal, means for receiving signals reflected from a reflecting surface, means for producing a heterodyne signal corresponding to the frequency difference between said transmitted and received signals, and means for firing said explosive selectively responsive only to a heterodynye signal below a predetermined frequency.

21. In an explosive weapon, means carried by the weapon for continuously transmitting a signal having a certain frequency, means for receiving signals reflected from a reflecting surface, means for producing a heterodyne signal corresponding to the frequency difference between said transmitted and received signals, and means for firing said explosive selectively responsive only to a heterodyne signal below a predetermined frequency.

22. In an underwater explosive weapon adapted to be moved relative to a sound reflecting surface, means carried by the weapon for continuously transmitting sonic waves, means for receiving waves reflected from the reflecting surface, means for producing a heterodyne signal corresponding to the frequency difference between said transmitted and received waves, and means for firing said explosive selectively responsive only to a heterodynye signal below a predetermined frequency.

23. In an underwater explosive weapon, means carried by the weapon for continuously transmitting a signal of predetermined frequency, means for receiving signals reflected from a reflecting surface, means for producing a heterodyne signal corresponding to the beat frequency between said transmitted and received signals, and means for firing said explosive selectively responsive only to a heterodyne signal below a predetermined frequency.

24. In an explosive weapon, means carried by the weapon for continuously transmitting a high frequency signal, means for receiving signals reflected from a reflecting surface, means for producing a heterodyne signal corresponding to the frequency difference between said transmitted and received signals, and means for firing said explosive selectively responsive only to a heterodyne signal below a predetermined frequency and above a predetermined strength.

25. In an explosive weapon, means carried by the weapon for continuously transmitting a signal having a certain frequency, means for receiving signals reflected from a reflecting surface, means for producing a heterodyne signal corresponding to the frequency difference between said transmitted and received signals, and means for firing said explosive selectively responsive only to a heterodyne signal below a predetermined frequency and above a predetermined strength.

26. In an underwater explosive weapon adapted to be moved relative to a sound reflecting surface, means carried by the weapon for continuously transmitting sonic waves, means for receiving waves reflected from the reflecting surface, means for producing a heterodyne signal corresponding to the frequency difference between said transmitted and received waves, and means for firing said explosive selectively responsive only to a heterodyne signal below a predetermined frequency and above a predetermined strength.

27. In an underwater explosive weapon, means carried by the weapon for continuously transmitting a signal of

predetermined frequency, means for receiving signals reflected from a reflecting surface, means for producing a heterodyne signal corresponding to the beat frequency between said transmitted and received signals, and means for firing said explosive selectively responsive only to a heterodyne signal below a predetermined frequency and above a predetermined strength.

28. In a device of the character disclosed for controlling the firing of an explosive charge, means carried by the device for projecting a continual signal comprising a series of sonic impulses of uniform frequency toward a target during relative movement of the device with respect thereto, means for receiving the impulses reflected from said target, means for detecting the beat frequency between the projected impulses and the received impulses, and means for firing the charge when the beat frequency detected by said detecting means has been reduced to a predetermined value and the strength of the beat frequency signal is above a predetermined minimum.

29. In a device of the character disclosed for firing an explosive charge by heterodyne signals, a casing for said device, means including a flexible diaphragm secured to said casing for transmitting sonic waves toward a target during relative movement of the device with respect to the target, means for receiving waves reflected from said target, means controlled by said receiving means for detecting the beat frequency between the waves transmitted by said diaphragm and said reflected waves and for producing a heterodyne signal proportional thereto, an electroresponsive device controlled by said heterodyne signal and adapted to be operated when the frequency thereof is reduced to a predetermined value corresponding to a position of the device opposite the target and the strength of said signal is greater than a predetermined minimum, and means controlled by said electroresponsive device for firing the explosive charge when said predetermined frequency is produced.

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