Oct. 4, 1955 H. J. PLUMLEY ET AL 2,719,486

FUZE FOR A BOMB

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FIG. 1.

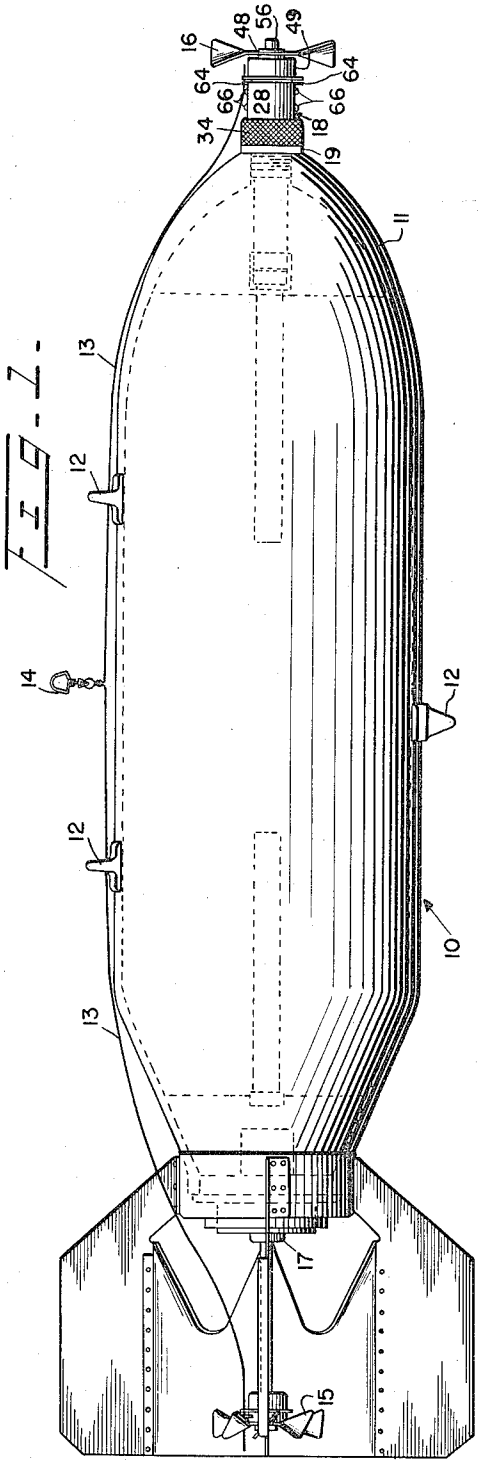


FIG. 2.

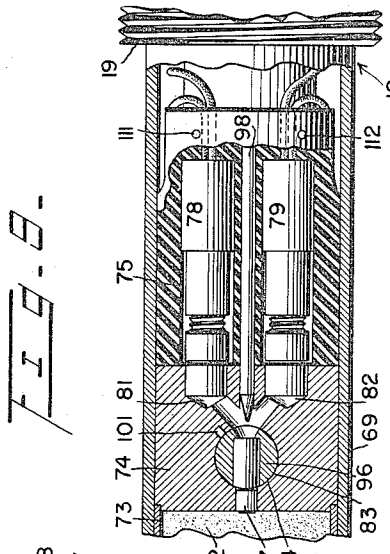
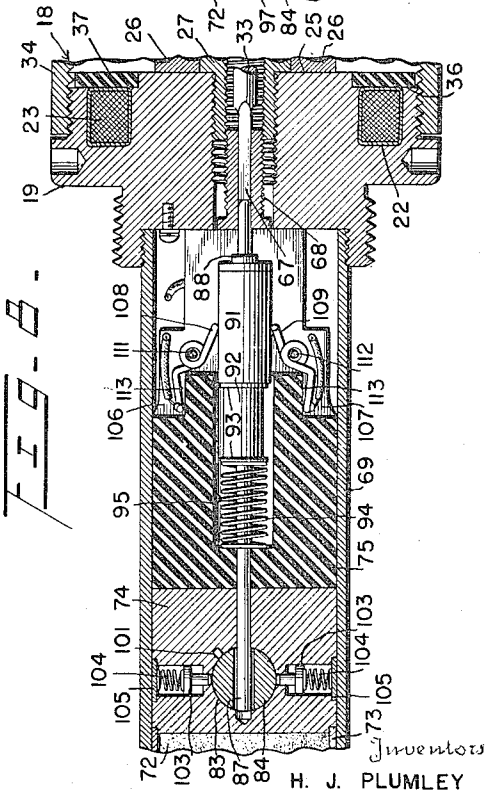


FIG. 3.



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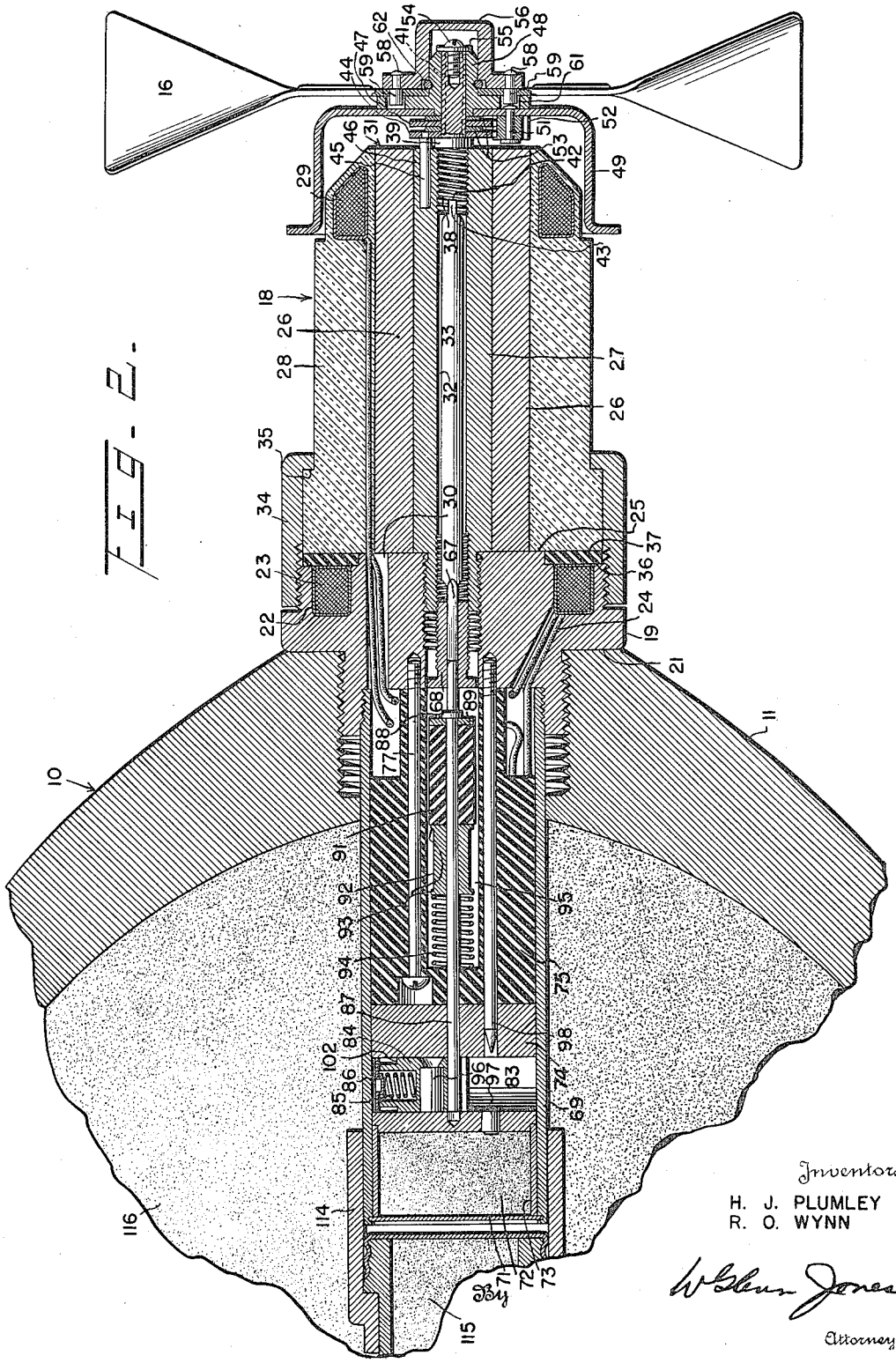
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FIG. 2.



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FUZE FOR A BOMB

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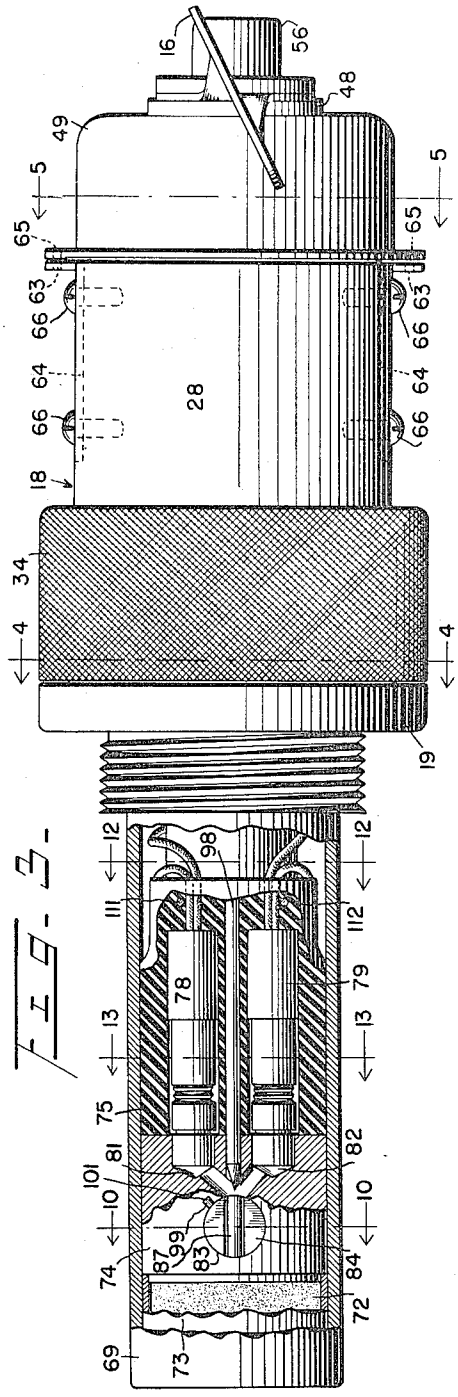


FIG. 3.

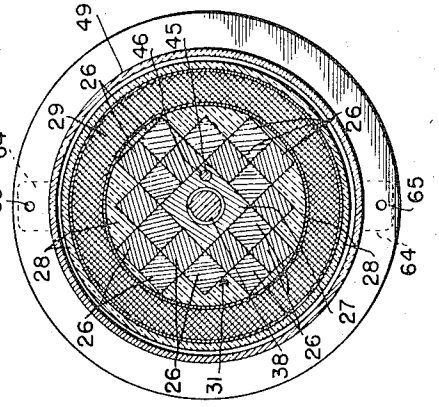


FIG. 5.

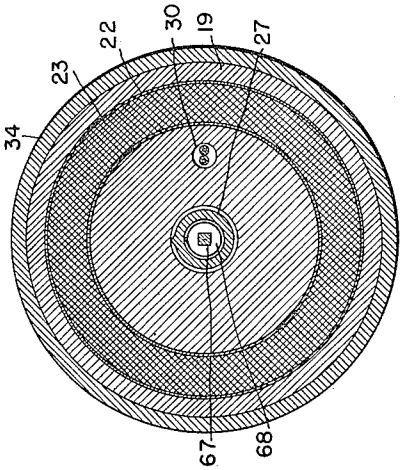


FIG. 4.

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FUZE FOR A BOMB

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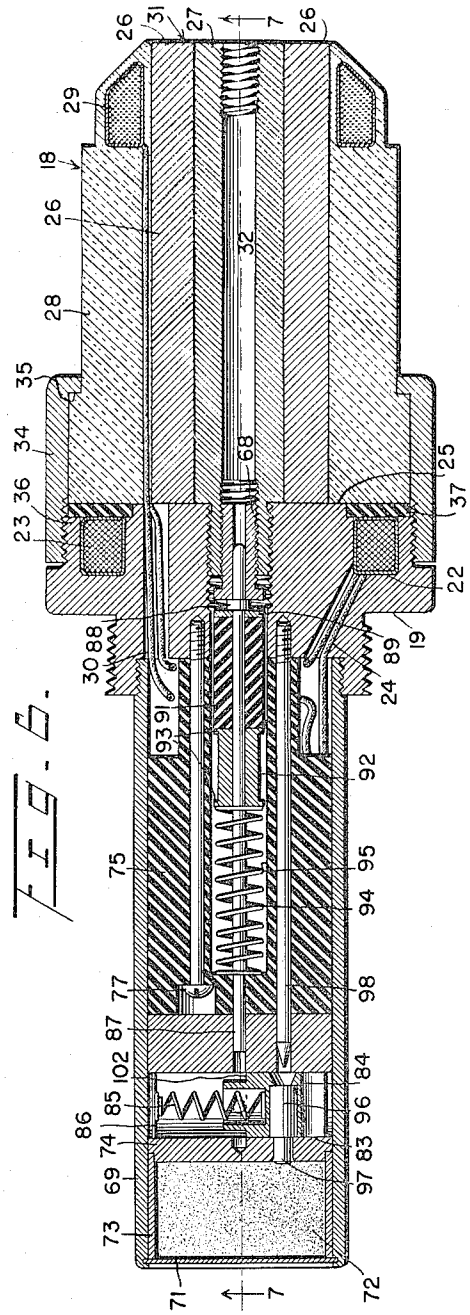


FIG. 6.

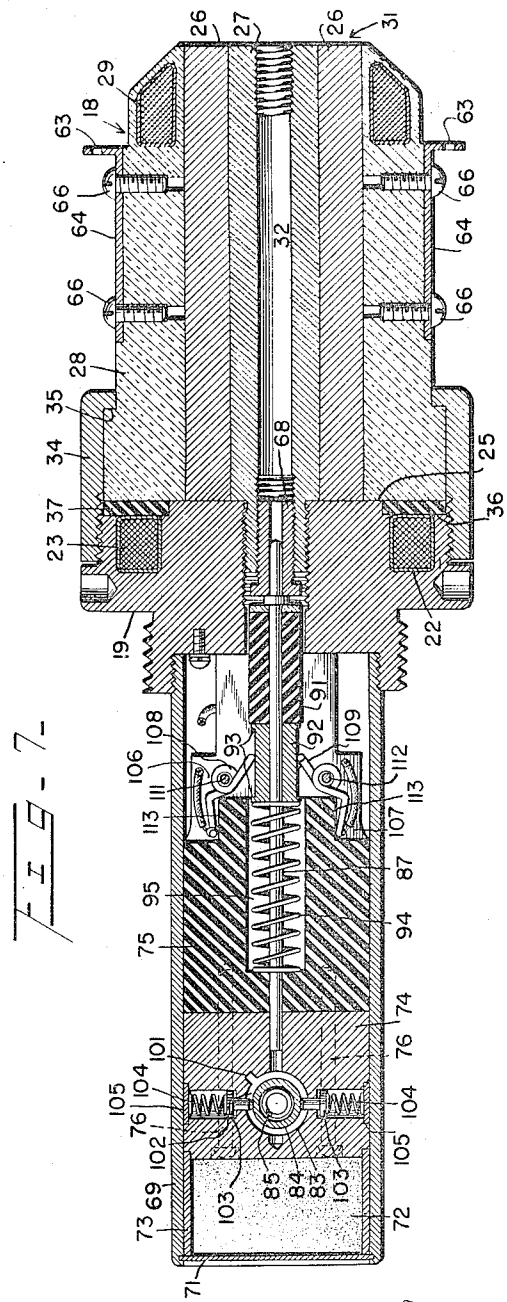


FIG. 7.

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FUZE FOR A BOMB

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Fig. 10.

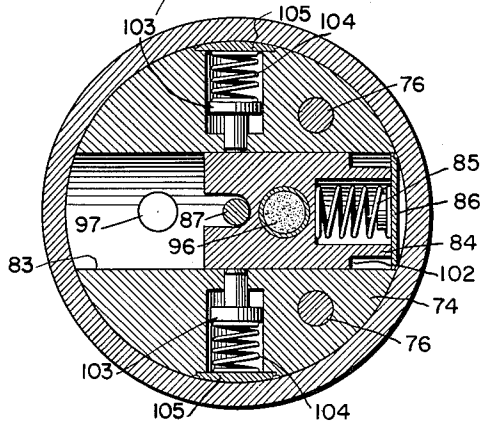


Fig. 12.

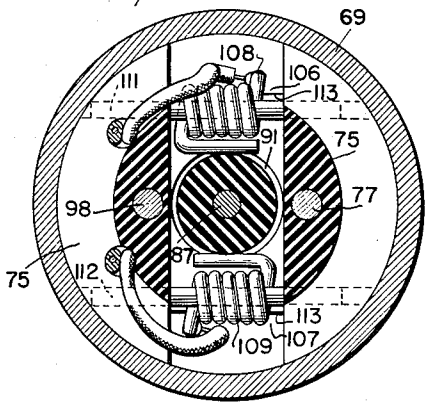


Fig. 11.

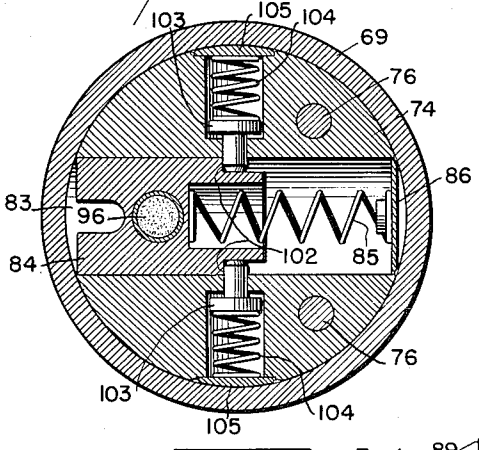


Fig. 13.

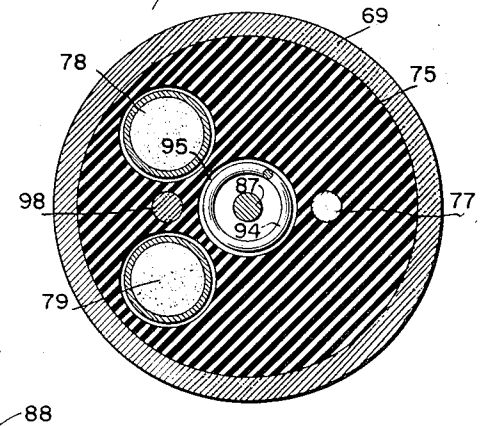
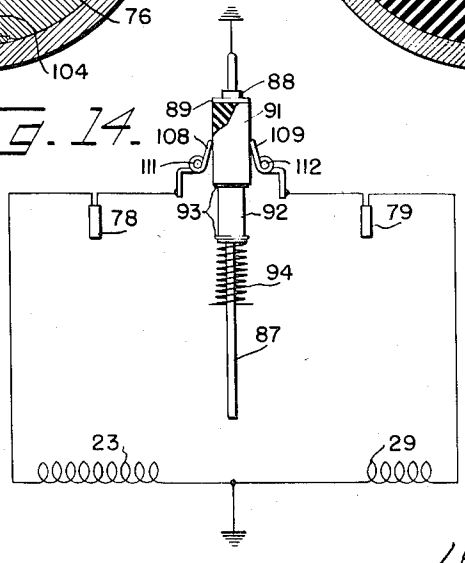


Fig. 14.



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FUZE FOR A BOMB

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Fig. 15.

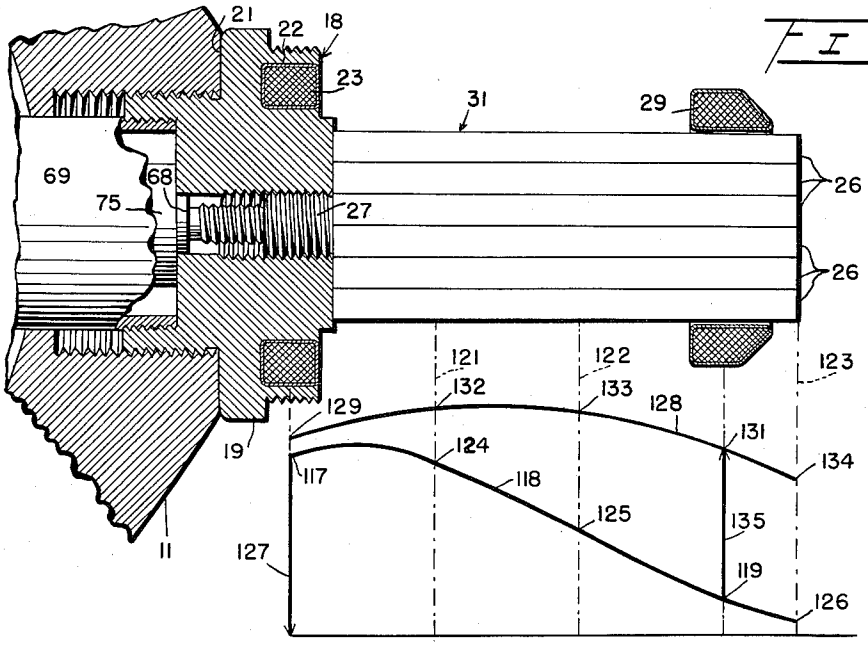


Fig. 16.

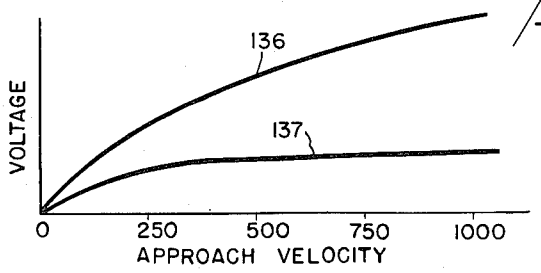
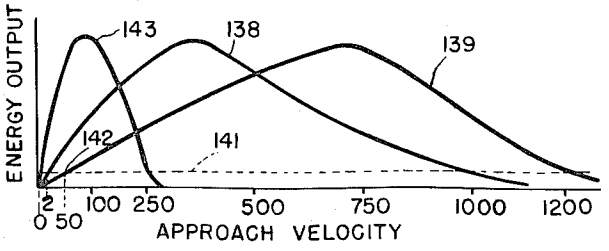


Fig. 17.



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FUZE FOR A BOMB

Harold J. Plumley and Robert O. Wynn,
Washington, D. C.

Application June 20, 1944, Serial No. 541,257

21 Claims. (Cl. 102—70.2)

(Granted under Title 35, U. S. Code (1952), sec. 266)

This invention relates to a fuze for detonating an explosive charge, and particularly to a fuze in which the firing is accomplished by a change in the magnetic field within a coil as the fuze approaches a target or as a result of the blow received as the fuze strikes the target, in which means are employed to delay the firing of the fuze selectively in accordance with the rate of approach of the fuze with respect to the target and the material of which the target is composed.

In magnetically controlled fuzes of the type heretofore devised for firing an explosive charge, it has been the general practice to employ a firing control mechanism comprising a bar magnet composed of magnetic material, known in the trade as "Alnico" having a core or nose piece of iron secured to the end thereof, a coil comprising a large number of turns of wire being arranged about the nose piece and adapted to generate an electrical firing impulse as the fuze approaches a target composed of magnetic material. Such devices have been found to be not altogether satisfactory under all conditions of service for the reason that the voltage generated by the coil is impaired by the eddy current losses within the iron core and magnet and additionally impaired by the self inductance of the coil sufficiently to prevent firing of the fuze at the relatively high velocities employed in modern warfare in which, for example, the bomb within which the fuze is arranged is dropped upon a target at a considerable altitude from an aircraft in flight.

In the device of the present invention this difficulty is overcome by employing a segmented core structure composed of permanent magnetic material such, for example, as a material known in the art as "Remalloy" and having a coil composed of a relatively small number of turns of wire arranged about the forward end of the core. The trailing end of the magnetic core is clamped in abutting relation with a ferrous body secured to a bomb and having a coil arranged therein with the axis thereof in substantial alinement with the axis of the permanent magnetic core. Each of the coils is respectively connected to a pair of electroresponsive detonating devices by a firing circuit having an arming switch therein adapted to close the circuit when a propeller secured to the nose section of the fuze has made a predetermined number of revolutions during the free flight of the bomb through the air. The aforesaid ferrous body is also connected to a firing pin adapted to operate a percussion sensitive detonating cap in response to a violent shock of severity sufficient to demolish the bomb as the bomb strikes a target. Each of the electroresponsive detonators is adapted to provide a predetermined time delay between the ignition thereof in response to a firing impulse received over the associated firing circuit and the firing of the aforesaid detonating cap whereby the time required to fire the cap in response to the firing impulse received from the front coil is less than the time required to fire the cap in response to the firing impulse

received from the rear coil, as will be more clearly apparent as the description proceeds.

The percussion cap is not brought into alinement with the firing pin and in operative position with respect to the aforesaid electroresponsive detonators until the arming switch has closed the aforesaid firing circuits. With the detonating cap in the armed position an explosive train is established between the detonators and a booster explosive charge whereby the booster charge is adapted to be fired by either one of the electroresponsive detonators or by the operation of the aforesaid firing pin, as the case may be. The fuze of the present invention is adapted to be fired by a change in the number of flux linkages of the front coil as the fuze moves into close proximity to a target composed of magnetic material such, for example, as the deck of a vessel. In the event that the bomb strikes a non ferrous target or the surface of a body of water with sufficient force to dislodge the permanent magnetic structure from the magnetic body supporting the rear coil, or with only sufficient force to disarrange the spaced relation of the magnets with respect to one another or to partially demagnetize the magnetic core, the decrease in the number of flux linkages of the rear coil with the field set up by the permanent magnetic core causes a firing impulse to be generated by the rear coil of sufficient strength to fire the slow operating detonator thereby delaying the firing of the bomb until the bomb has traveled for a predetermined period of time such, for example, as .25 second after the firing impulse has been received. In the event that the bomb should strike a target comprising a thickness of heavy armor plate with sufficient force to burst the bomb casing, the force of impact of the bomb against the target causes the firing pin to strike the detonator cap with sufficient force to fire the bomb instantly before the rupture of the bomb has proceeded sufficiently to render the firing thereof ineffective.

One of the objects of the present invention is to provide a new and improved fuze for a bomb controlled by a variation in the magnetic field adjacent thereto in which the eddy current losses have been substantially reduced.

Another of the objects is a fuze of new and improved construction adapted to be fired by a sudden variation in the magnetic field adjacent thereto as the fuze approaches a magnetic body.

Another object is to provide a new and improved fuze for a bomb controlled by the rate of approach of the bomb toward a target.

Another object is to provide a new and improved fuze for a bomb in which the firing of the fuze is controlled by the material of which the target is composed.

Another object is a new and improved fuze for a bomb controlled by the rate of approach of the bomb toward a target and the material of which the target is composed.

A further object is to provide a new and improved magnetically controlled fuze for a bomb in which the fuze is fired by a variation in the magnetic field adjacent thereto as the fuze moves into close proximity to a target and irrespective of the angle of impact of the fuze with respect to the target.

A further object is to provide a new and improved fuze for a bomb in which the fuze is fired in response to a sudden decrease in the reluctance of the magnetic circuit adjacent the fuze or in response to a decrease in the magnetomotive force in the magnetic circuit within the fuze.

Another object is to provide a magnetically controlled fuze for a bomb having new and improved means for firing the bomb in predetermined time delayed relation with respect to the moment of impact of the bomb against a predetermined type of target and for firing the bomb in different time delayed relation with respect to the mo-

ment of impact of the bomb against a different type of target.

Another object is to provide a magnetically controlled fuze for a bomb having new and improved means for firing the bomb in predetermined time delayed relation with respect to the moment of impact of the bomb against a predetermined type of target and for firing the bomb in different time delayed relation with respect to the moment of impact of the bomb against a different type of target in which means are provided for firing the bomb instantly as the bomb strikes a still different type target.

Still another object is to provide a new and improved fuze for a bomb controlled by a variation in the magnetic field adjacent thereto in which the fuze is fired selectively in accordance with a predetermined characteristic of said variation.

A still further object is to provide a new and improved fuze for a bomb which is economical to manufacture, reliable in operation and which possesses all the qualities of ruggedness and dependability in service.

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

Fig. 1 is a view in elevation of a bomb employing the fuze of the present invention according to a preferred embodiment thereof;

Fig. 2 is an enlarged view partly in section and partly broken away of the fuze of Fig. 1;

Fig. 3 is a plan view of the fuze of Fig. 2 partly broken away and partly in section thereby to show the pair of electroresponsive detonating devices and the firing pin employed for firing the detonating cap;

Fig. 4 is a view taken along the line 4—4 of Fig. 3;

Fig. 5 is a view taken along the line 5—5 of Fig. 3;

Fig. 6 is a view in section showing the fuze in an armed condition;

Fig. 7 is a view taken along the line 7—7 of Fig. 6;

Fig. 8 is a view partly in section and partly broken away of the fuze showing the arming switch and detonator holder in an initial safe position;

Fig. 9 is a sectional view of the fuze partly broken away and showing the detonator holder in an armed position;

Fig. 10 is a view somewhat enlarged taken along the line 10—10 of Fig. 3 and showing the detonator holder locked in an initial safe position;

Fig. 11 is a view similar to Fig. 10 showing the detonator holder in an armed position;

Fig. 12 is a view somewhat enlarged taken along the line 12—12 of Fig. 3;

Fig. 13 is a view somewhat enlarged taken along the line 13—13 of Fig. 3;

Fig. 14 shows in diagrammatic form the electrical circuits and instrumentalities employed for selectively firing the detonators;

Fig. 15 is a chart showing the number of flux linkages per turn of each of the coils and the total number of lines of magnetic flux at various cross sections of the core as the device moves into close proximity to a magnetic target and when the device is at a remote distance from the magnetic target respectively;

Fig. 16 is a chart showing the open circuit voltage generated by the device of the present invention and the open circuit voltage generated by the device of the prior art as the approach velocity to a target is increased; and,

Fig. 17 is a chart showing the output energy generated by various front coils having different numbers of turns with respect to various approach velocities to a target.

Referring now to the drawings for a more complete understanding of the invention and more particularly to Fig. 1 thereof on which is shown a bomb indicated generally by the numeral 10 comprising a casing 11 to which is secured a plurality of eye bolts 12 by means of which the bomb is adapted to be releasably supported by an aircraft in flight. An arming wire 13 connected to the airplane as by a static line secured to the eye bolt 14 is preferably employed to prevent rotative movement of the propellers 15 and 16 associated with a hydrostatic tail fuze 17 and with the fuze 18 of the present invention respectively. The fuze 18 comprises a body or support 19 adapted to be secured to the nose of the bomb in any convenient manner as by threading the parts together, a shoulder 21 being preferably formed on the bomb, Fig. 2, thereby more securely to attach the fuze thereto. The support 19 is composed of magnetic material suitable for the purpose such, for example, as iron or low carbon steel and is provided with an annular recess 22 within which is disposed a coil 23, hereinafter referred to as the rear coil. An external electrical connection to the coil is established by means of a pair of conductors within the duct 24 extending inwardly and rearwardly from the recess 22, a similar duct 30 being provided within the support 19 for the pair of conductors connected to the front coil 29. The front portion of the support 19 is formed in a plane surface 25 and adapted to be engaged by one end of a plurality of permanent bar magnets 26 composed of magnetic material suitable for the purpose and having high remanence and a relatively high permeability while in the magnetized state such, for example, as a material known in the art as "Remalloy." Each of the bar magnets is preferably square in cross section and in close abutting relation with respect to the adjoining magnets and all of the magnets are poled in the same direction.

In the arrangement shown on Fig. 5 of the drawings, twenty permanent magnets are employed to provide a unitary segmented core structure disposed about a rod 27 composed of nonmagnetic material such, for example, as brass and securely maintained in the unitary structure by a molded plastic sleeve 28 formed about the magnets. The plastic sleeve 28 may be composed of any material suitable for the purpose such, for example, as a material composed of cellulose butyro acetate and known in the trade as "Tenite II." There is also molded within the sleeve a coil 29, hereinafter referred to as a front coil, arranged about the forward end of the magnetic structure or core 31 comprising the aforesaid plurality of bar magnets, and provided with a pair of conductors molded within the sleeve and extending rearwardly along the magnetic structure and insulated therefrom for establishing an external electrical connection to the coil 29. The rod 27 is secured at the inner end thereof to the support 19 as by threading the parts together and provided with a bore 32 axially arranged therein within which is slideably and rotatably disposed a plunger or rod 33.

The sleeve 28 is secured to the support 19 as by the coupling member 34 and shoulder 35 formed on the sleeve. The coupling 34, it will be noted, is composed of magnetic material such, for example, as iron thereby to reduce the eddy currents set up therein as the rear coil operates. The support 19 is also provided with an annular recess 36 adapted to receive a suitable gasket 37 thereby to protect the rear coil from injury and prevent the seepage or leakage of water therein.

Threaded within the outer end of the rod 27 is a shaft 38 provided with a collar 39 and having a spline 41 formed thereon. The shaft is also provided with a notched portion 42 adapted to engage a tongue 43 on the rod 33 and rotate the rod during the free flight of the bomb through the air. A gear 44 is supported by the shaft 38 and rotatable with respect thereto. The gear, however, is prevented from rotating by a pin 45 secured thereto and slideably disposed within an aperture 46 formed within the front end portion of the rod 27. There is also provided a gear 47 slideably secured to the shaft 38 by the spline 41 whereby the gear 47 is adapted to impart rotative movement to the shaft 38. The gear 47, it will be noted, is provided with one more tooth than the number of teeth on the gear 44 and arranged on the same pitch diameter as the teeth on gear 44.

There is also rotatably secured to the shaft 38 a hub

48 to which is secured, in any convenient manner a shield or guard 49 having a stud or bearing 51 thereon adapted to support for rotation an idle gear 52 in continuous mesh with gears 44 and 47. From the foregoing, it will be apparent that a structure has been disclosed in which the shaft 38 is adapted to rotate at a greatly reduced rate of speed with respect to the rotation of the hub 48 by reason of the planetary gear arrangement disclosed. In the specific arrangement hereindescribed, the gear 47 is adapted to be moved angularly through a distance subtended by a pair of teeth thereon during each revolution of the hub 48. A pair of washers 53 are disposed between the pair of gears 44 and 47 and between the gear 47 and the guard 49 respectively. The hub 48 is rotatably secured to the shaft 38 by a screw 54 and washer 55. The hub 48 is adapted to receive and support a cap 56 having a propeller 16 secured thereto as by the pins 58. The pins 58 are provided with enlarged heads 59 adapted to engage complementary recessed portions 61 within the hub 48 and impart rotative movement thereto as the result of the pressure of the air against the propeller 16 during the free flight of the bomb toward a target.

The propeller and cap 56 are secured to the hub 48 in any suitable manner such, for example, as by the snap ring 62 illustrated. The hub 48 is restrained from rotation during the transportation of the bomb by the aircraft by the aforesaid arming wire 13 which is normally arranged within an aperture 63 within one of the pair of members 64 and one of a pair of complementary apertures 65 arranged within the guard 49. The members 64, Fig. 7, are secured to the sleeve 28 in any convenient manner as by the screws 66. By providing a pair of L-shaped members 64 diametrically arranged on the sleeve 28, the guard 49 may be secured thereto by a pair of cotter pins prior to the installation of the bomb on the aircraft, thereby preventing rotative movement of the hub during the handling and transportation of the bomb to the aircraft. When the bomb is releasably secured to the aircraft, the cotter pins are removed and the arming wire 13 is inserted within the apertures 63 and 65 aforesaid. Furthermore, by employing a snap ring for securing the cap 56 to the hub 48, the propeller 16 may be attached to the fuze quickly and easily at the time the bomb is releasably secured to the aircraft.

The inner end portion of the rod 33 is provided with a spline 67 adapted to fit slideably within a splined portion of the threaded member 68 and impart rotative movement thereto as the shaft 33 rotates under control of the propeller 16. The member 68 is threaded within the rod 27 and adapted to be moved forward from an initial position shown on Fig. 2 to a final position shown on Fig. 6 during the free flight of the bomb from the aircraft. Secured to the rear portion of the support 19 is a tubular member 69 having one end thereof closed at 71 thereby to receive and support an explosive booster charge 72 arranged within an annular container 73, the container 73 being in registered engagement with an adapter 74. The adapter is secured to a support 75 as by the screws 76, Fig. 7, the support 75 being secured to the support 19 as by the screw 77, Fig. 6. The support 75 is composed of insulating material suitable for the purpose such, for example, as "Bakelite" and recessed to receive a pair of electroresponsive detonating devices 78 and 79, the detonating devices projecting within a pair of recessed portions 81 and 82 in communication with a transverse bore 83 within the adapter 74.

A plunger or detonator holder 84 is slideably arranged within the bore 83 and urged toward an armed position by a spring 85 having one end thereof in engagement with a plate 86, the plunger being releasably locked in the initial safe position shown on Fig. 2 by a slideable rod 87 having one end thereof in abutting relation with the plunger 33. The rod 87 is provided with a collar 88 adapted to engage a washer 89 arranged on the rod in substantial abutting relation with a cylinder or sleeve 91 composed of suitable insulating material such as "Bakelite." A sleeve 92 composed of electrical conducting material such, for example, as brass is secured to the rod 87 in any suitable manner in abutting relation with the sleeve 91 and provided with a pair of enlarged portions 93 of slightly greater diameter than the body of the sleeve. A spring 94 having one end in engagement with a well 95 within the support 75 and the other end in engagement with the sleeve 92 is adapted to urge the rod 87 continuously toward an armed position. The rod 87, however, is prevented from moving to the armed position by the rod 33 until the propeller has made a predetermined number of revolutions. As the rod 87 moves into the armed position, the detonator holder 84 is released and is moved within the bore 83 by the spring 85 to the armed position shown on Fig. 6. When the detonator holder 84 is in the armed position, a sensitive detonator 96 arranged therein is moved into alinement with a tetryl lead 97 thereby establishing an operative explosive train between the detonator and the booster charge 72. Furthermore, with the detonator holder 84 in the armed position the sensitive end of the detonator is brought into operative relation with respect to the detonating devices 78 and 79 and with respect to a firing pin 98 secured at one end thereof to the support 19. An arrangement is thus provided in which the sensitive detonator is adapted to be fired selectively by either of the detonators 78 or 79 or by the firing pin 98, as the case may be.

The plunger 84 is provided with a dowel pin 99 slideably disposed within a slot 101 arranged parallel to the bore 83 thereby to prevent rotative movement of the plunger with respect to the adapter 74. The plunger 84 is also provided with a shoulder 102 adapted to be engaged by a pair of detents 103 slideably arranged within the adapter 74 when the plunger is moved to an armed position, the detents being continuously urged toward the plunger by a pair of springs 104, each of the springs being in engagement at one end thereof with a pair of plates 105 secured respectively to the adapter 74 in any convenient manner.

The support 75 is recessed as at 106 and 107 to receive a pair of contact springs 108 and 109 pivotally secured to the support as by the bearing pins 111 and 112 respectively. One end of each of the springs is in engagement with a shoulder 113 formed on the support 75 and in electrical connection with a pair of conductors respectively connected thereto. The opposite end of each of the springs is in engagement with the insulated sleeve 91 when the rod 87 is in the initial locked position. As the rod 87 moves toward the released position, the insulated sleeve 91 is disengaged from the springs 108 and 109 and the springs 108 and 109 are brought into engagement with the contact sleeve 92 thereby closing a circuit to the detonating devices 78 and 79, Fig. 14, as will more clearly appear as the description proceeds.

The detonating devices 78 and 79 are arranged to provide a predetermined time delay between the operation of the electro-responsive element thereof and the firing of the sensitive detonator 96 thereby, the detonating device 78 being arranged to provide a delay of approximately .25 second and the detonating device 79 a delay of .01 second between the detonation of the respective detonating devices and the operation of the electro-responsive ignition means therefor.

The inner end of the tubular member 69 is in registered engagement with a sleeve 114 whereby the booster charge 72 is in operative relation with respect to an auxiliary booster charge 115 adapted to fire the main explosive charge 116, Fig. 2, as is well known in the art to which the present invention pertains.

On Fig. 15 is shown in diagrammatic form the number of flux linkages per turn of each of the firing coils

and the total number of lines of magnetic flux at various cross sections of the magnetic core as the device moves into close proximity to a magnetic target and when the device is at a remote distance from the target respectively. The number of lines of flux within the coil **23** when the external field of the magnetic core **31** is undisturbed by the presence of a foreign magnetic body is indicated by the point **117** of the curve **118** and the number of flux linkages within the coil **29** is indicated by the point **119** of the curve **118**. The total flux at each of the various cross sections **121**, **122** and **123** of the core **31** is indicated when the external magnetic field is undisturbed by the points **124**, **125** and **126** respectively of the curve **118**. The magnetic core **31**, it will be recalled, is composed of a plurality of permanent magnets having high remanence and arranged in a unitary segmented structure with one end of the magnetic core in abutting relation with the magnetic support **19** which is supported by the magnetic casing **11** of the bomb in abutting relation therewith. As clearly shown by the curve **118**, the number of flux lines per unit cross section, or the density of the magnetic flux within the coil **23**, is greater than the density of the magnetic flux within the coil **29** by reason of the magnetic antenna effect of the support **19** and the casing **11** of the bomb on the magnetic circuit of the core **31**.

When the bomb strikes a target with sufficient force to dislodge the magnetic core **31** from the support **19**, the magnetic flux through the coil **23** is suddenly decreased to substantially zero as indicated by the arrow **127** thereby generating a voltage within the coil **23** sufficient to ignite the detonator **78**. In the event that the aforesaid force of impact of the bomb against the target is of insufficient strength to dislodge the magnetic core **31** from the support **19** but of sufficient strength to derange the magnets composing the core, the number of lines of flux within the coil **23** would be reduced sufficiently to ignite the detonator **78** by reason of the fact that the ignition element of the detonator **78** is sufficiently sensitive to ignite on a small fractional part of the change in flux represented by the arrow **127**. The detonator **78** is also adapted to be ignited by the voltage generated within the coil **23** in response to a shock or blow received by the magnetic core **31** of insufficient strength to derange the permanent magnets thereof but of sufficient strength to partially demagnetize the magnets by shock demagnetization.

The number of flux linkages per turn of each of the coils **23** and **29** with the lines of flux set up within the coils by the magnetic core **31** and the flux density of the core at the sections **121**, **122** and **123** thereof when the fuze strikes a target composed of magnetic material is shown by the curve **128** at points **129**, **131**, **132**, **133** and **134** respectively. The change caused by the increase in the flux linkages per turn of the coil **29** with the magnetic flux set up by the core **31** is indicated by the arrow **135**, and the voltage generated within the coil **29** as a result of this change causes the detonator **79** to be ignited. More specifically, the voltage generated by the coil **29** as the fuze strikes the magnetic target is considerably in excess of the voltage required to ignite the detonator **79** and the detonator **79**, therefore, is ignited just before the fuze strikes the target.

On Fig. 16 is shown in diagrammatic form by the curve **136** thereof the open circuit voltage of the coil **29** as the fuze strikes a magnetic target at different approach velocities including the velocities of 0, 250, 500, 750, and 1,000 feet per second. The curve **136** clearly shows a substantial increase in the open circuit voltage of the coil as the approach velocity to a target is increased. This increase of voltage is brought about as the result of the segmented magnetic core structure employed in combination with the specific plastic structure for supporting the magnets comprising the magnetic core **31** in which eddy currents have been reduced to a negligible value, in contradistinction to the voltage of the device of the prior art indicated by the curve **137**, which does not increase substantially with an increase in the approach velocity toward a target after an approach velocity of 300 feet per second is reached.

The energy output of the coil **29** when connected to a load such, for example, as the electroresponsive igniter for the detonating device **79** is shown in diagrammatic form in Fig. 17 by the curves **138** and **139** thereof in which the coil employed for generating electrical energy indicated by the curve **138** comprises 60 turns of wire and the coil employed for generating the energy output shown by the curve **139** is composed of 20 turns of wire. The electrical energy required to ignite the detonator **79** is shown diagrammatically by the curve **141**. In the preferred form of the invention, the coil **29** is composed of 60 turns of wire whereby the detonator **79** is adapted to be ignited by the voltage generated therein as the fuze strikes a target within a range of two feet per second to 1000 feet per second in the approach velocity toward the target. The fuze of the present invention, therefore, is especially suited for use with a bomb adapted to be dropped from an aircraft in flight at a considerable altitude in which the detonator **79** is ignited by the voltage generated within the coil **29** as a result of a sudden change in the external magnetic circuit of the magnetic core **31** caused by the bomb striking the side of a vessel below the water line thereof at a relatively slow rate of travel such, for example, as two feet per second or as the bomb strikes the deck of a vessel at an approach velocity of 1000 feet or less per second, as the case may be. By decreasing the number of turns of the coil **29** from 60 turns to 20 turns of wire, the self inductance of the coil may be reduced sufficiently to cause the ignition of the detonator **79** at an approach velocity of 1200 feet per second, the minimum approach of velocity of the bomb toward the target at which the detonator **79** is ignited being shown by the point **142** of the curve **139** corresponding to an approach velocity of 50 feet per second.

The energy output of the device when a relatively large number of turns such, for example, as 300 turns of wire is employed for the coil **29** is shown by the curve **143** in which the electrical energy generated thereby is insufficient to ignite the fuze at approach velocities toward a target in excess of 200 feet per second.

The operation of the device under the various conditions of attack will now be described. Let it be assumed, by way of example, that the bomb is released from an aircraft in flight at an altitude of 8000 feet and that the bomb makes a direct hit on the deck of a vessel such, for example, as a destroyer in which the deck is composed of steel one fourth inch in thickness and having a two inch layer of wood thereon. As the bomb falls away from the aircraft the arming wire **13** is withdrawn by the static line thereby releasing the propellers **15** and **16** for rotation. When the propeller **16** has made a predetermined number of revolutions during the free flight of the bomb through the air, the shaft **38** is rotated by the planetary gearing sufficiently to be disengaged from the rod **27** thereby moving the threaded member **68** forwardly sufficient to permit movement of the arming switch to a circuit closing position. The arming assembly comprising the shaft **38**, the propeller **16** and shield **49** now falls away from the fuze and the rod **33** is free to fall away from the fuze. When this occurs, the arming switch contacts are closed thereby completing a firing circuit between the coil **29** and the detonating device **79** and an additional firing circuit between the coil **23** and the detonating device **78**, Fig. 14. Concurrently with the closing of the arming switch contacts, the rod **87** is moved forward by the spring **94** sufficiently to release the detonator holder **84**. The detonator holder is moved to the armed position by the spring **85** with the sensitive detonating cap **96** thereof in substantial abutting relation with the tetryl lead **97** and adapted to be fired by either

of the detonating devices 78 or 79 or by the firing pin 98, as the case may be. The bomb is now armed.

As the bomb strikes the deck of the vessel, the momentum of the bomb is sufficient to cause the bomb to pierce the deck and to continue the downward flight thereof into the hold of the vessel. As the bomb strikes the deck of a vessel, the magnetic flux within the coil 29 is increased sufficiently to ignite the detonating device 79. The detonating device 79, it will be recalled, is arranged to provide a delay of .01 second between the operation of the ignition element thereof and the firing of the detonator. By reason of this delay, the bomb is exploded just below the deck of the vessel. The sensitive detonating cap 96 is not fired by the firing pin 98 in the instant case by reason of the insufficient thickness of the deck of the vessel. In the event that the vessel should not be provided with a wood covering for the deck, the bomb would be exploded just below the deck of the vessel as in the instant example.

Let it now be assumed that the bomb in the foregoing example missed the ship and strikes the surface of the water at a point adjacent thereto. As the bomb strikes the surface of the water, the magnetic core 31 is disengaged from the support 19 by the force of the impact of the bomb thereagainst. When this occurs, the magnetic flux within the coil 23 is quickly reduced to substantially zero thereby generating an electromotive force within the coil 23 sufficient to ignite the detonating device 78. The detonating device 78, it will be recalled, is adapted to fire the bomb when a period of .25 second has expired after the electrical firing impulse thereto has been received. The bomb is thus fired at a predetermined depth such, for example, as 30 feet below the surface of the water at which the air cavitation within the water above the bomb has been reduced sufficiently to effect the most efficient transmission of the force of the explosion through the surrounding water and thereby cause the maximum damage to the vessel.

In the event, however, that the bomb should strike a heavy armored portion of the vessel such, for example, as the forward gun turret, the violent shock received by the bomb is sufficient to drive the firing pin 98 into the detonating cap 96 and fire the bomb instantly and before the bomb casing is ruptured by the force of the impact of the bomb against the thick armor of the vessel. The maximum destructive effect of the bomb under this condition of use is thus made effective.

In the event that the bomb is dropped from a relatively low altitude such, for example, as an altitude of 2000 feet, and the bomb strikes the water, the bomb is not fired by the rear coil in response to the shock received as the bomb strikes the water by reason of the fact that the bomb strikes the water at an angle at a relatively low velocity insufficient to cause the magnetic core 31 to be dislodged from the support 19. The bomb may continue to travel in the general direction of the trajectory at a depth of approximately 20 feet beneath the surface of the water and parallel to the surface thereof. If the bomb strikes the hull of the vessel during this underwater travel, the detonating device 79 is ignited by the front coil 29 of the fuze and the bomb is exploded, either adjacent the hull of the vessel or within the hull of the vessel, as the case may be, when a period of time of .01 second has elapsed after the bomb strikes the hull. If, on the other hand, it be assumed that the bomb did not strike the vessel during its underwater travel, the hydrostatic tail fuze 17 causes the bomb to fire when the bomb reaches a predetermined depth of submersion such, for example, as 35 feet.

The fuze of the present invention is also suitable for use with bombs dropped at a sufficiently low altitude from an aircraft in flight as to cause the bomb to ricochet on the surface of the water by a method generally known as skip-bombing, it being merely necessary to provide a time delay of substantially four seconds within each of the detonating devices 78 and 79, thereby to delay the explosion of the bomb sufficiently for the attacking aircraft to move beyond the effective zone of damage of the bomb before the bomb explodes.

The fuze of the present invention is rendered perfectly safe in the event that the bombing plane should land on the deck of a carrier with an unexploded bomb attached thereto in such a manner that the bomb is torn loose from the plane during the landing and moves along the deck of the carrier for a distance of several hundred feet before coming to rest. This safety feature is accomplished by providing a sufficient number of turns of thread on the member 68, such that the propeller 16 makes an insufficient number of revolutions to move the member 68 within the rod 27 a distance sufficient for the arming switch contacts to close before the bomb is brought to rest.

Whereas the invention has been described in detail with respect to a bomb adapted to be dropped on a surface craft from an aircraft in flight, it will be understood that it may be employed, if desired, with a depth bomb of the type adapted to be fired from an attacking surface vessel or aircraft toward a submarine target.

Briefly stated in summary, the present invention contemplates the provision of a new and improved fuze for firing an explosive charge in response to a sudden variation in the magnetic field disposed therein and adjacent thereto as the fuze moves into proximate spaced relation with respect to a magnetic target, in which means are provided for firing the fuze in the event that the fuze strikes the target with sufficient force to derange or partially demagnetize the magnetic element therein, and in which additional means are employed to detonate the fuze in the event that the fuze strikes the target with a predetermined degree of force regardless of the magnetic character of the target. Furthermore, the present invention provides means for firing an explosive charge in predetermined timed delayed relation with respect to the movement of the fuze into approximate relation with respect to a magnetic target and for firing the explosive charge in different timed delayed relation with respect to the aforesaid derangement or demagnetization of the magnetic element.

While the invention has been described with reference to a preferred example thereof which gives satisfactory results, it will be obvious to those skilled in the art to which the invention pertains, after understanding the invention, that various changes and modifications may be made without departing from the spirit and scope of the invention, and it is our intention, 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 fuze of the character disclosed, in combination, a segmented magnetic core having low eddy current losses and comprising a plurality of closely spaced permanent bar magnets arranged within the fuze, a mass of magnetic material in abutting relation with one end of said core, a coil of wire of low self inductance arranged about the other end of the core and adapted to be linked by the magnetic flux set up by said magnets, and an electro-responsive detonating device connected to the coil and adapted to be operated by the voltage generated therein as the flux linkages of the coil with said flux is suddenly increased in response to the approach of the core toward a target comprising a magnetic mass and without contact with the target.

2. In a fuze of the character disclosed, in combination, a segmented magnetic core comprising a plurality of permanent bar magnets arranged within the fuze, means composed of non-electrical conducting material for sup-

porting said magnets in closely spaced relation with respect to one another, a mass of magnetic material, means including said supporting means for clamping the core to said magnetic mass with one end of each of the magnets in abutting relation therewith, a coil having a small number of turns of wire arranged about the other end of the core and within said supporting means, and an electroresponsive detonating device connected to the coil and adapted to be operated by the voltage generated therein as the magnetic flux set up by said magnets within the coil is suddenly increased in response to the approach of the fuze toward a target comprising a magnetic mass and without contact with the target.

3. In a fuze for a bomb adapted to be dropped on a target composed of magnetic material from an aircraft in flight, in combination, a magnetized core disposed within said fuze and composed of permanent magnetic material, a mass of magnetic material in abutting relation with one end of said core for increasing the magnetic flux at the end of the core adjacent thereto, a coil of wire arranged about the other end of the core and adapted to generate an electromotive force therein as the magnetic flux is increased in said other end of the core in response to the approach of the core toward said target, an electroresponsive detonating device operatively connected to said coil, and means for reducing the eddy currents within the core and the self inductance of the coil whereby said electromotive force generated by the coil as the fuze moves into proximate spaced relation with respect to the magnetic target is sufficient to operate said detonating device over a wide range of approach velocities of the bomb toward the target and without contact with the target.

4. In a fuze for a bomb adapted to be dropped on a target from an aircraft in flight, the combination of a segmented magnetic core comprising a plurality of closely spaced permanent bar magnets arranged within the fuze, a mass of magnetic material in abutting relation with one end of each of said magnets for securing the fuze to the nose of the bomb with the magnetic core extending forwardly of the bomb, a coil of wire arranged within said magnetic mass and substantially coaxially with respect to the axis of said core, means including a sleeve composed of nonmagnetic material coaxially arranged about said core for detachably securing the core to said magnetic mass, and an electroresponsive detonating device operatively connected to said coil and adapted to be operated by the voltage generated within the coil as the core is suddenly detached from the magnetic mass by the shock of impact of the core against the target.

5. In a fuze for a bomb adapted to be dropped on a target from an aircraft in flight, the combination of a mass of magnetic material for securing said fuze to the nose of the bomb and having a coil of wire arranged therein, a segmented magnetic core comprising a plurality of closely spaced permanent bar magnets detachably secured at one end only to said mass in substantially coaxial relation with respect to the coil and in forwardly extending relation with respect to the nose of the bomb, and an electroresponsive detonating device connected to said coil and adapted to be operated by the voltage generated therein in response to a sudden decrease in the magnetic flux through the coil as the magnets are detached from said magnetic mass by the shock of impact of the core against the target.

6. In a bomb fuze of the character disclosed, the combination of a segmented magnetic core comprising a plurality of closely spaced bar magnets arranged within the fuze, a coil of wire arranged about one end of the core, a mass of magnetic material in abutting relation with the other end of the core for securing the fuze to the nose of the bomb with the magnetic core extending forwardly thereof, a second coil arranged within said magnetic mass in substantial coaxial relation with respect to the core, and a pair of electroresponsive devices respectively connected to each of the coils, said first named coil having a voltage generated therein for operating the electroresponsive device connected thereto in response to the sudden increase in the flux in said one end of the core as the bomb moves into close proximity with a target composed of magnetic material and said second coil having a voltage generated therein for operating the electroresponsive device connected thereto as the flux in said other end of the core is suddenly decreased in response to the shock of impact of the core with the target.

7. In a fuze for a bomb adapted to be dropped on a target from an aircraft in flight, in combination, a segmented magnetic core comprising a plurality of closely spaced permanent bar magnets arranged within the fuze, means including a mass of magnetic material in abutting relation with one end of said core for securing the fuze to the nose of the bomb with the core extending forwardly thereof and in axial alinement therewith, a coil of wire arranged about said core and adapted to generate an electrical firing impulse as the core approaches and strikes a target composed of magnetic material, a normally open firing circuit connected to said coil, an electroresponsive detonating device included within said firing circuit and adapted to fire the bomb in response to said electrical impulse, and means including a propeller rotatably supported at the forward end of said core for closing said firing circuit during the free flight of the bomb through the air after the bomb has been released from the aircraft.

8. A magnetically controlled fuze for a bomb adapted to be dropped on a magnetic target from an aircraft in flight comprising a segmented magnetic core composed of a plurality of closely spaced permanent bar magnets, means including a mass of magnetic material in abutting relation with one end of the core for securing the fuze to the nose of said bomb with the core extending forwardly thereof, a coil of wire arranged about the other end of said core and adapted to generate an electrical firing impulse as the magnetic flux through the coil is suddenly increased in response to the movement of the bomb into proximate relation with the magnetic target, a normally open firing circuit connected to said coil, an electroresponsive detonator included within said firing circuit and adapted to fire the bomb in response to said electrical impulse, means for closing the firing circuit, and means including a propeller rotatably supported at the forward end of said core for operating said circuit closing means when the propeller has made a predetermined number of revolutions during the free flight of the bomb from the aircraft toward said target.

9. A magnetically controlled fuze for a bomb adapted to be dropped on a magnetic target from an aircraft in flight comprising a segmented magnetic core composed of a plurality of closely spaced permanent bar magnets, means including a mass of magnetic material in abutting relation with one end of the core for securing the fuze to the nose of said bomb with the core extending forwardly thereof, a coil of wire arranged about the other end of said core and adapted to generate an electrical firing impulse as the magnetic flux through the coil is suddenly increased in response to the movement of the bomb into proximate relation with the magnetic target, a normally open firing circuit connected to said coil, an electroresponsive detonator included within said firing circuit adapted to fire the bomb in response to said electrical impulse, means for closing said firing circuit, means including a shaft rotatably supported within said core for operating said circuit closing means when the shaft has made a predetermined number of revolutions, means including an arming wire detachably secured to the fuze for preventing rotation of the shaft until the bomb has been released from the aircraft, and a propeller detachably secured to said shaft at the forward end of said core for rotating the shaft during the free flight of the bomb through the air after the arming wire has been withdrawn from the fuze.

10. In a magnetic controlled fuze for a bomb, the combination of a segmented magnetic core comprising a plurality of closely spaced permanent bar magnets arranged within the fuze, means including a magnetic mass in abutting relation with one end of said core for securing the fuze to the nose of said bomb with the core extending forwardly thereof and for substantially increasing the flux density at the end of the core adjacent thereto, a coil of wire arranged about the opposite end of the core and adapted to generate an electrical firing impulse in response to a sudden increase in the density of the magnetic flux within said opposite end of the core just before the core strikes a target composed of magnetic material, and an electroresponsive detonating device connected to said coil and adapted to fire the bomb in response to said firing impulse.

11. In a magnetically controlled fuze for a bomb adapted to be dropped on a magnetic target from an aircraft in flight, the combination of a segmented magnetic core comprising a plurality of closely spaced permanent bar magnets arranged within the fuze, a mass of magnetic material in abutting relation with one end of said core for increasing the magnetic flux within the end of the core adjacent thereto and for securing the fuze to the nose of the bomb with the core extending forwardly thereof, a coil of wire arranged about the other end of the core and adapted to generate an electrical firing impulse as the magnetic flux set up by the bar magnets within the coil is suddenly increased in response to the movement of the core into proximate relation with the magnetic target and without contact therewith, a normally open firing circuit connected to said coil and having an electroresponsive detonating device therein adapted to fire the bomb in response to said firing impulse, means for closing said firing circuit during the free flight of the bomb from the aircraft toward the target, and means for operating said circuit closing means, said last named means comprising a rod slideably and rotatably arranged within said core, and means including a propeller operatively connected to said rod at the forward end of the core and adapted to be detached from the fuze during said free flight of the bomb when the propeller has made a predetermined number of revolutions.

12. In a magnetically controlled fuze for a bomb adapted to be dropped on a magnetic target from an aircraft in flight, the combination of a segmented magnetic core composed of a plurality of closely spaced bar magnets arranged within the fuze, means including a mass of magnetic material in abutting relation with one end of the core for securing the fuze to the nose of the bomb with the core extending forwardly thereof, a coil of wire arranged about the other end of said core and adapted to generate an electrical firing impulse as the magnetic flux through the coil is suddenly increased in response to the movement of the core into proximate relation with the magnetic target and without contact therewith, a normally open firing circuit connected to said coil and having an electroresponsive detonator therein adapted to operate in response to said electrical impulse, a shaft slideably arranged within the core, means controlled by said shaft for closing said firing circuit when the shaft has moved a predetermined distance from an initial position, an explosive charge arranged within the bomb, a sensitive detonating cap slideably arranged within said fuze and adapted to be moved from an initial safe position into an armed position in operative relation with respect to said electroresponsive detonator and said explosive charge, means including said shaft for locking the detonating cap in said safe position until the shaft has been moved through said predetermined distance, and means including a propeller operatively connected to said shaft at the forward end of the core for moving the shaft through said predetermined distance during the free flight of the bomb through the air after the bomb has been released from the aircraft.

13. In a fuze for a bomb adapted to be dropped on a target from an aircraft in flight, the combination of a segmented magnetic core comprising a plurality of closely spaced permanent bar magnets arranged within said fuze, a bomb casing, means composed of magnetic material for supporting the fuze on the nose of said casing and for increasing the density of the magnetic flux within one end of said core, a coil of wire disposed within said supporting means and adapted to generate an electrical firing signal in response to a sudden decrease in the density of the magnetic flux within the coil when the core is dislodged from the supporting means by the force of impact of the bomb against the target, a second coil arranged about the other end of said core and adapted to generate an electrical firing signal as the bomb moves into proximate relation to a magnetic target, a pair of electroresponsive detonating devices respectively connected to each of said coils and adapted to be detonated in predetermined timed delayed relation with respect to each of said firing signals respectively, a percussion sensitive detonating cap adapted to be fired by either of said detonating devices, an explosive charge within the casing and adapted to be fired by said detonating cap, and means including a firing pin secured to said magnetic mass for firing the detonating cap instantly when the bomb strikes a target with sufficient force to rupture said casing.

14. In a fuze for a bomb adapted to be dropped on a target from an aircraft in flight, the combination of a segmented magnetic core comprising a plurality of closely spaced permanent bar magnets arranged within the fuze, means including a magnetic support in abutting relation with one end of said core for securing the fuze to the nose of the bomb with the core extending forwardly thereof and for increasing the flux density at the end of the core adjacent thereto, a pair of electroresponsive detonating devices within the fuze and adapted to fire the bomb, a coil of wire arranged within said magnetic support in substantial abutting relation with said one end of the core and adapted to generate an electrical firing impulse when the bomb strikes the target with sufficient force to derange said magnets, a normally open firing circuit including said coil and one of said detonating devices, a second coil arranged about the opposite end of the core and adapted to generate an electrical firing impulse sufficient to operate the other one of the detonating devices as the fuze moves into proximate relation with a magnetic target without making contact therewith, a second normally open firing circuit including said second coil and said other one of the detonating devices, means including a releasably locked propeller rotatably supported at the forward end of said core and a movable stop member adapted to be moved by the propeller an amount sufficient to close said firing circuits when the propeller has made a predetermined number of revolutions during the movement of the bomb through the air, and means including an arming wire secured to the aircraft for releasing the propeller as the bomb moves away from the aircraft, said stop member being constructed and arranged to move an amount insufficient to operate the circuit closing means in response to rotation of the propeller when the aircraft makes a landing with the bomb attached thereto and the bomb is disengaged from the aircraft sufficiently to release the propeller during said landing.

15. A magnetically controlled bomb fuze of the character disclosed comprising a segmented magnetic core composed of a plurality of closely spaced permanent bar magnets, a magnetic circuit for the magnetic field set up by said bar magnets, said magnetic circuit including a mass of magnetic material arranged in abutting relation with one end only of the core for securing the fuze to the nose of the bomb with the core extending forwardly thereof, and means including a coil of wire arranged within said mass in substantial coaxial relation with the core for firing the fuze in response to a sudden

decrease in the magnetomotive force in the magnetic circuit within said coil as the bomb strikes a target with sufficient force to fire the fuze in response to a decrease in the magnetization of the core caused by the shock of impact of the core with the target.

16. A magnetically controlled fuze of the character disclosed comprising a segmented magnetic core composed of a plurality of closely spaced permanent bar magnets, a magnetic circuit for the magnetic field set up by said bar magnets, said magnetic circuit including a mass of magnetic material arranged in abutting relation with one end of the core, and means including a coil of wire arranged about the other end of the core for firing the fuze in response to a sudden decrease in the reluctance of said magnetic circuit as the fuze moves into close proximity to a target composed of magnetic material and without contact therewith.

17. In a fuze for a bomb adapted to be dropped on a target from an aircraft in flight, means including a plurality of closely spaced permanent magnets arranged within the fuze for setting up a local magnetic field adjacent thereto, an explosive charge within the bomb, electroresponsive detonating means for firing said explosive charge, and a coil of wire disposed adjacent one end only of said permanent magnets and adapted to operate said detonating means selectively in accordance with a predetermined change in said magnetic field as the fuze moves into proximate spaced relation with a target composed of magnetic material and without contact with the target.

18. In a fuze for a bomb, the combination of a segmented magnetic core comprising a plurality of closely spaced permanent bar magnets, each of said magnets being composed of magnetic material having high remanence and high permeability, a mass of magnetic material in abutting relation with one end of said core and adapted to increase the density of the magnetic flux within the end of the core adjacent thereto, an electroresponsive detonating device within said fuze, and a coil of wire arranged about the other end of the core in electrical connection with said detonating device and adapted to operate the detonating device by the voltage generated therein as the flux density within the coil is suddenly increased in response to movement of the fuze into proximate spaced relation with respect to a magnetic target and without contact therewith.

19. In a nose fuze for a bomb adapted to be dropped from an aircraft in flight onto a marine vessel, the combination of means including a segmented magnetic core of high remanence and high permeability for firing the bomb under control of the magnetic influence of a magnetic target on said core as the bomb approaches the target, means including said core for firing the bomb in response to the shock of impact of the fuze with the surface of the water when the bomb misses the target, and percussion firing means including a firing pin arranged in shock transmitting relation with respect to the core for firing the bomb in response to the shock of impact of the fuze with a target having sufficient hardness and inertia to bring the bomb substantially to rest at the instant of impact.

20. In a proximity fuze of the character disclosed, a core, a coil arranged on one end of said core, the other end of the core being remote from said coil, said core being formed of magnetic material of high remanence and high permeability so that the linkages of the coil with the flux of the core is substantially increased as said end of the core is moved into close proximity to a ferromagnetic mass, said core being formed in a manner to have low eddy current losses therein and said coil being formed of a small number of turns to have low self inductance thereby to increase the voltage induced in the coil in response to said movement of the core, and an electroresponsive detonator connected to the terminals of said coil and adapted to be fired by the voltage generated therein when the approach velocity of the core toward said mass falls within a predetermined range of approach velocities controlled by the number of turns of the coil.

21. In a magnetically controlled fuze of the character disclosed, a segmented bar magnet constructed and arranged to have low eddy current losses and low flux densities at the ends of the magnet in the absence of a pair of ferromagnetic masses disposed respectively adjacent said ends, a pair of coils arranged to link the flux emanating from the ends of said magnet, a mass of ferromagnetic material disposed in abutting relation with one end of said magnet, an electroresponsive detonator connected to the terminals of the coil linked by the flux at said one end of the magnet and adapted to be fired by the voltage generated in the coil as the magnet is suddenly removed from said mass, the other one of said pair of coils having a small number of turns, and a second electroresponsive detonator connected to the terminals of said other one of the coils and adapted to be fired by the voltage generated therein as the other end of the core is moved into close proximity to a second ferromagnetic mass when the approach velocity of the magnet toward said second mass falls within a predetermined range of approach velocities controlled by the number of turns of said other one of the coils.

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