Jan. 1, 1957 H. J. PLUMLEY 2,775,941

MAGNETIC INERTIA CONTROLLED FUZE

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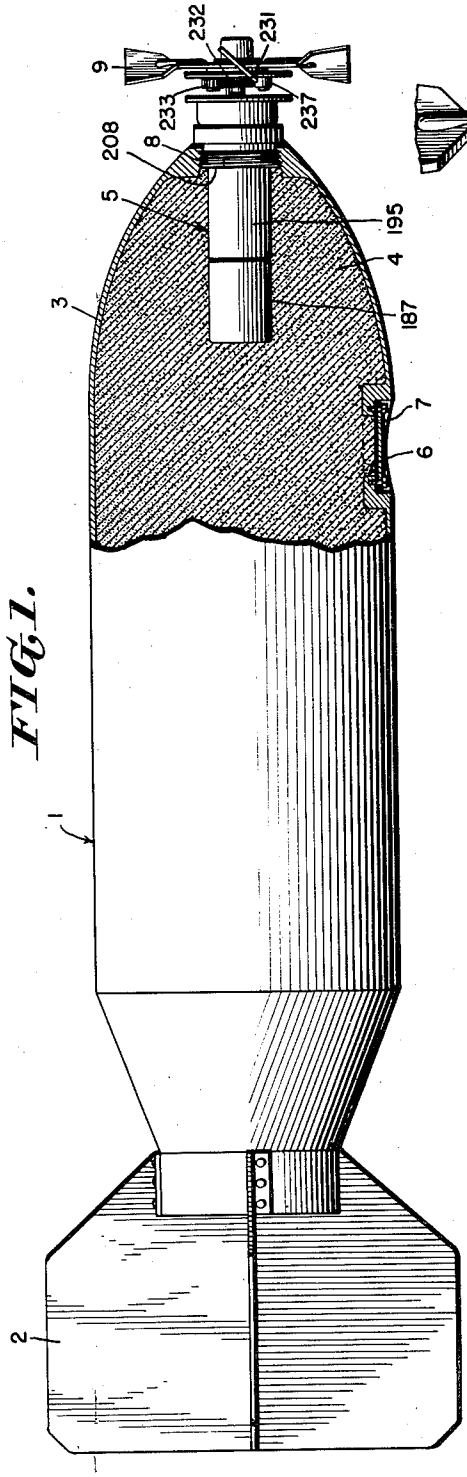


FIG. 1.

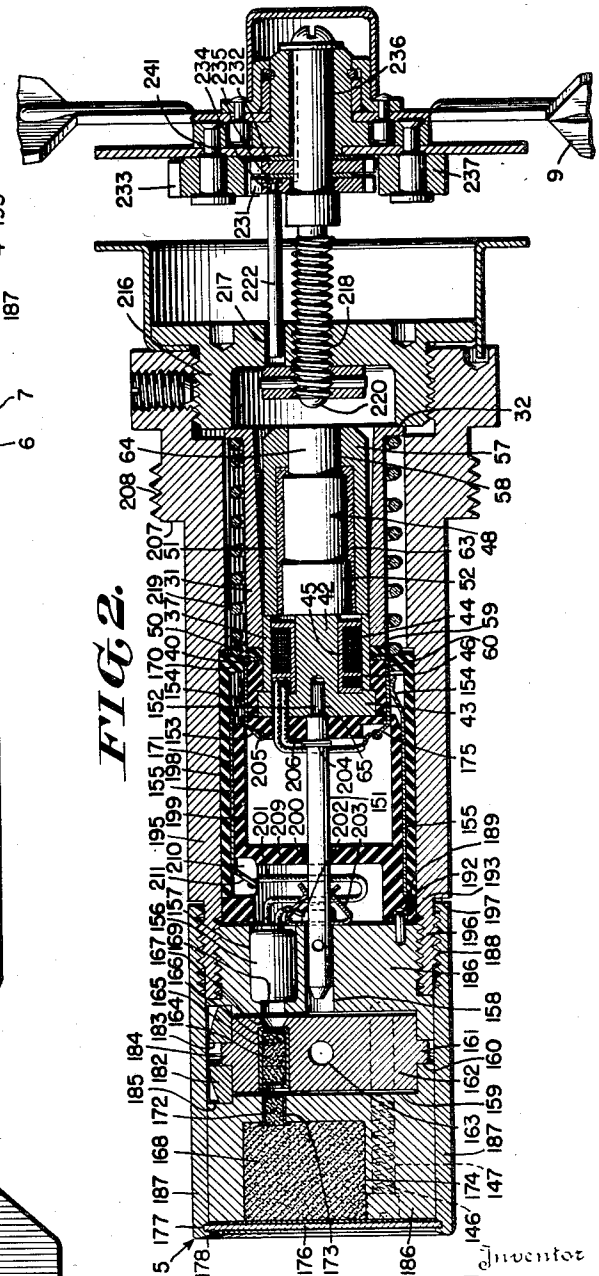


FIG. 2.

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FIG. 3.

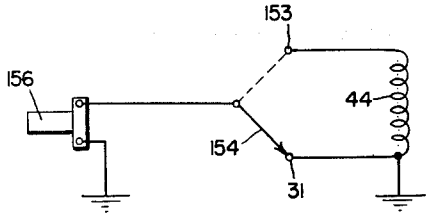


FIG. 4.

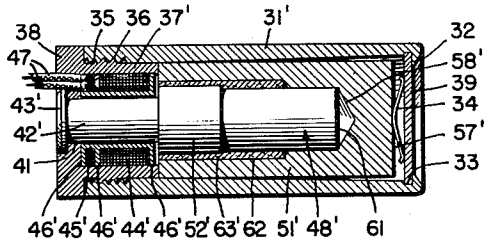


FIG. 5.

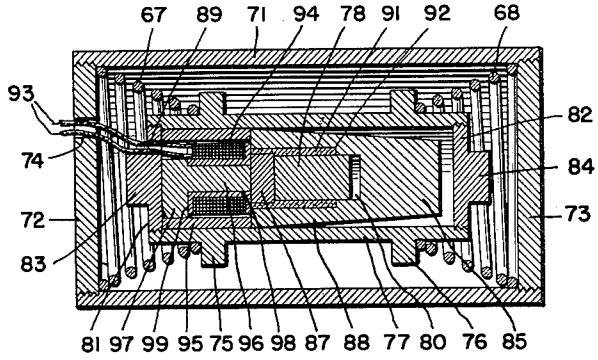
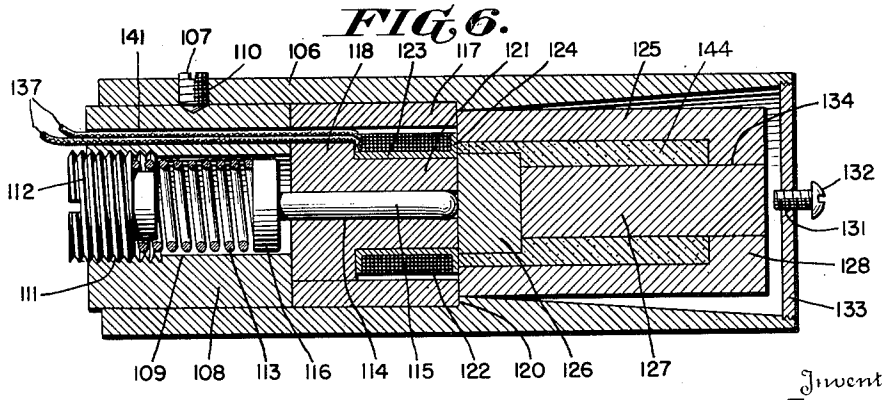


FIG. 6.



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MAGNETIC INERTIA CONTROLLED FUZE

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Application December 23, 1946, Serial No. 718,098

21 Claims. (Cl. 102—70.2)

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

This invention relates to an inertia voltage generator suitable for use in a magnetically controlled inertia fuze for detonating an explosive charge, and more particularly to improvements in the inertia generator disclosed in my copending application for Magnetic Inertia Controlled Fuze, Serial No. 535,799, filed May 16, 1944, in which the sudden movement of a magnetic element in response to inertia forces applied thereto causes a change in the flux of a magnetic circuit thereby to generate a current in a coil disposed adjacent the magnetic circuit sufficient to fire a low energy detonating device.

As was fully pointed out in the aforesaid copending application, prior art inertia controlled devices have been of limited value for a variety of reasons. Spring means were sometimes employed to retain the inertia element yieldably in its initial position, and such arrangements were subject to the influence of friction which sometimes prevented satisfactory operation of the device when the projectile struck the target a glancing blow. Furthermore, such prior art devices were relatively insensitive, so that when used in a projectile which struck a target comprising a relatively thin plate, the set forward force generated was insufficient to cause the dislodging or movement of the inertia element.

The inertia voltage generator of the present invention is suitable for use in projectiles having all ranges of velocities, and is adapted for use in projectiles which do not spin, such as rockets, guided missiles, and depth charges. As will subsequently be explained, the generator is characterized by high sensitivity, making it suitable for use with projectiles to which the target offers very little resistance, for example, a target such as the wing of an aircraft. When a high velocity projectile strikes and passes through the wing of an aircraft, very little retardation force is generated upon impact. The subject inertia generator has sufficient sensitivity to render it useable in such an application.

The inertia generator of the subject invention is suitable also for use with projectiles which are normally subjected to small random inertia forces due to movement, such as those which would be received in a torpedo due to broaching or yawing. By the use of a spring suspension, an arrangement is provided in which inertia forces of short duration caused by the aforementioned random movements are insufficient to generate a voltage, whereas small forces of somewhat longer duration received from striking a target are sufficient to cause the operation of the device.

In the subject invention, the increased sensitivity mentioned before is achieved in part by providing a magnetic bridge arrangement. The inertia element described in my prior application identified hereinbefore, is in the subject apparatus replaced by an inertia assemblage comprising a magnetic casing having disposed therein a magnetic element adapted to generate a flux. When the casing and element are in their initial positions, the magnetic flux follows one magnetic circuit; when the assemblage has been dislodged by inertia forces acting thereon, a second magnetic circuit is established.

Whereas the inertia voltage generator described herein is particularly well adapted for use in projectiles, it may be employed in a number of other applications, for example, a crash control system for aircraft.

The increased sensitivity of the generator of the present invention is also obtained by the use of a spring suspension for the generator which transforms inertia forces of long duration and small magnitude into inertia forces of large magnitude whereby the generator is adapted to be actuated by forces of long duration and small magnitude and is prevented from being actuated by countermine shock. In one embodiment of the invention, the sensitivity is further increased by using spring biasing means adapted to exert a force on the inertia assemblage which adds to any inertia force received, and reduces the strength of inertia forces required to actuate the device.

The subject invention also provides means adapted to control the forces acting on the inertia assemblage, thereby to predetermine the character of an inertia force adapted to move the keeper or inertia assemblage, where character means magnitude and/or duration.

In general, two means of accomplishing this are used. A magnetic bridge circuit is provided for rapidly removing the force of magnetic attraction on the inertia assemblage by providing an alternate path for the lines of flux. The effect of the presence of this alternate path is to insure that inertia forces of relatively short duration, when applied directly to the inertia assemblage, are sufficient to dislodge it from the body of the generator. Spring means is also employed, operatively connected to the inertia assemblage, and adapted to add, algebraically, to the total of forces acting thereon. Several arrangements of the spring are provided, in which the spring may oppose the force of magnetic attraction, oppose the inertia force, or modify the duration and magnitude of the inertia force.

One of the objects of the present invention is to provide a new and improved inertia voltage generator having sufficient sensitivity for use in the fuze of a projectile which receives low inertia forces upon impact with the target.

Another object is to provide an inertia generator in which movement of an inertia element or assemblage a predetermined distance results in substantial modification of the magnetic circuit so that no magnetic restoring force is thereafter applied to the assemblage.

Another object is to provide a new and improved inertia voltage generator of increased sensitivity and which is responsive to inertia forces applied thereto in or from substantially any direction.

Still another object is to provide an inertia voltage generator of increased sensitivity in which a magnetic retaining force on the inertia element or assemblage is only slightly greater than a spring removing force on the inertia assemblage, whereby very small inertia removing forces are sufficient to dislodge the assemblage and generate a voltage.

A further object is to provide an inertia voltage generator in which means is provided to predetermine the character of an inertia force adapted to move the keeper or inertia assemblage.

A further object is to provide an inertia generator having force transforming means for changing inertia forces of relatively long duration and small magnitude into forces of relatively short duration and large magnitude.

Still a further object is to provide an inertia voltage generator particularly adapted for use in torpedoes and resistant to countermining operations.

Still other objects, advantages and improvements will become apparent from a consideration of the following

description taken in connection with the accompanying drawings, of which:

Fig. 1 is a view partly in elevation and partly in section of a bomb employing the device of the present invention;

Fig. 2 is an enlarged detailed view in section of the fuze of Fig. 1;

Fig. 3 is a schematic circuit diagram of the electrical firing circuit of Fig. 2;

Fig. 4 is an enlarged sectional view of a slightly modified inertia voltage generator from that of Fig. 2, showing spring restoring means for the inertia assemblage;

Fig. 5 is a detailed sectional view showing another embodiment of the invention; and

Fig. 6 is a detailed sectional view showing a third embodiment of the invention.

Referring now to the drawings in which like numerals are used throughout to designate like parts, and more particularly to Fig. 1 thereof, there is shown a bomb having the general designation 1 and having tail fins 2, a portion of the walls 3 being cut away near the nose of the bomb to reveal the fuze having the general designation 5, the fuze being inserted in threaded fuze aperture 8 in the nose of the bomb, the fuze having propellers or vanes 9 for arming the mechanism thereof in a manner to be more fully explained subsequently, the fuze being surrounded by the explosive charge 4 which may be inserted into the body of the bomb through aperture 6 having closure plate 7.

Reference is made now to Fig. 2, which shows an enlarged cross sectional view of the fuze 5 of Fig. 1, as it appears when in an armed condition. The mechanism of the fuze is contained largely within a main housing 195 having a somewhat enlarged threaded portion 208 near one end thereof forming a shoulder 207, the threads being adapted to engage the threads in the aforementioned fuze bore 8, Fig. 1, in the nose of the bomb, thereby to secure the fuze to the body of the bomb. The housing 195 has a reduced end 196 threaded both internally and externally, a shoulder 197 being formed for receiving the end of a casing extension 187 in threaded engagement with the housing 195.

Disposed within the housing 195 is the inertia generator, comprising an outer supporting casing 31 composed of non-magnetic material and preferably having the inside wall slightly tapered as shown, and having an outwardly extending flange 32 at one end thereof for purposes to be subsequently apparent, the diameter of the flange being such that it may be moved or slide within the central opening of the housing 195, when the fuze is in an unarmed position, as will be more fully described later. The casing 31 has an extended end section 60 of insulating material, which is separated from the main portion by an insulating ring 50, with a small space 40 between insulating members 50 and 60 for receiving a clamping lip 59 of metallic cap or contact member 153, thereby to securely fix the cap to the body of the inertia generator, the cap or contact member being provided for purposes to be explained subsequently, and being insulated from the main body 31 of the casing. Disposed within the casing 31 is a cylindrical sleeve or casing 37 composed of magnetic material. The term "magnetic material" as used herein is defined as material capable of being magnetized but not necessarily possessing any residual or permanent magnetization. Disposed within the magnetic casing 37 is a coil frame 45 having raised flanges 46 for securely supporting and positioning a coil 44 which is adapted to have a voltage induced therein in a manner to be presently more fully described, and which may be composed of a large number of turns, the size of the wire and the resistance thereof being chosen to permit optimum energy to be delivered to the load, in the application shown the explosive squib 156. Disposed within the coil is a core 42 of any suitable magnetic material, having an enlarged head portion 43 adapted to abut against the casing 37. The inner end of core 42 may be approximately in alignment with the inner end of casing 37, as shown, for reasons to be subsequently apparent.

Disposed within casing 31 also is an inertia assemblage comprising a relatively long sleeve or casing 51 composed of magnetic material and having a closed end portion 57 having a bore 58 therein in which is fixed an element 64 of magnetic material having disposed adjacent thereto a permanently magnetized element 48 having positioned at one end thereof an adjacent magnetic element of somewhat larger diameter 52. Disposed between the members 48 and 51 is a suitable non-magnetic filler material 63, for example lead, for purposes to be hereafter explained. The ends of elements 51 and 52 abut on the adjacent ends of casing 37 and core 42 respectively, being normally maintained in abutting relation by the force of magnetic attraction.

In the operation of the inertia generator, when the elements are in the position shown, the flux generated by permanently magnetized element 48 follows a magnetic circuit including elements 48 and 52, core 42, head 43, casing 37, casing 51, end portion 57, and member 64. Upon the dislodging of the inertia assemblage comprising elements 51, 64, 48, and 52 in response to inertial forces applied thereto, gaps of high reluctance are introduced between core 42 and element 52, and between casing 37 and casing 51 respectively. When the elements of the assemblage have moved a sufficient distance whereby the combined reluctances of the gaps exceed the reluctance of the path through non-magnetic material 63 between elements 52 and 51, a new magnetic circuit including elements 52, 48, 64, and 51 is established. The lines of force linking coil 44 collapse, inducing a substantial voltage therein.

Whereas the element 48 is shown and described as generating a flux for energizing the magnetic circuit, and may be of any suitable material, it is understood that any one, or several of the elements of the inertia assemblage could be flux generating elements if desired.

The casing 187 has in the end thereof, as shown, an annular recess 177 and an inwardly extending lip 178 for receiving and holding the end or closure plate 176. Disposed within the casing 187 is the block or retaining member 186 having a longitudinal bore 174 of substantial diameter in the end thereof for receiving a booster charge 168. Near longitudinal bore 174 is a transverse bore 159 having a much smaller bore extension or bearing hole 160 at one end thereof, and a considerably enlarged portion 185 at the other end thereof, the bore 159 having disposed therein a detonator rotor 162 having bearing studs 161 and 184 on the ends thereof, stud 161 being adapted to rotate in bore 160 and stud 184 being adapted to rotate in a bore 183 in a cover or keeper 182 for the enlarged portion 185 of bore 159.

The longitudinal bore 174 has a small bore 173 connecting it with transverse bore 159, bore 173 having disposed therein a lead-in charge 172. The rotor 162 has provided therein a transverse bore 166 having a flaring end 167 and containing a housing 165 having therein detonator charge 164, the bore 166 being located in rotor 162 whereby bore 166 and bore 173 in block 186 will register when the rotor is mounted in the position shown. The rotor also has another transverse bore 163 for receiving the end of plunger or rod 151 when the fuze is in an unarmed condition, as will be hereafter explained, bore 163 and bore 166 being at right angles to each other as shown.

Within the block 186 at the opposite end thereof from bore 174, is a longitudinal bore 157 having a smaller bore 169 connecting it with transverse bore 159, the bore 157 having disposed therein an explosive squib 156 for exploding the bomb in a manner to be hereafter more fully explained, the bore 169 registering with bore 167 in rotor 162 when the rotor is turned to the position shown and the fuze is armed. Disposed somewhat be-

neath, Fig. 2, bore 157 is a longitudinal bore 158 for receiving plunger 151 and permitting movement thereof in a manner to be more fully explained subsequently.

Disposed within the casing 195 is a sleeve of non-conductive or insulating material 198 having an inwardly extending flange or lip 170 on one end thereof, for purposes to be hereafter apparent, and having therein a pair of oppositely disposed grooves 171 in which are positioned a pair of metal strips 155 having inwardly flaring end portions 154 at one end thereof to form an electrical contact with the aforementioned metallic member or contact piece 153 fixed to the cap or head 205 of the inertia generator for purposes to be hereafter explained. The metal strips 155 are securely held in their respective grooves by an annular sleeve or casing 199 of non-metallic and non-conductive material, the casing having a rib 209 therein with a bore 200 therethrough for passage of the rod or plunger 151. The sleeve 199 has at one end thereof an enlarged extended portion forming shoulder 189 against which the end of sleeve 198 abuts, the shoulder portion 189 having therein a bore 193 for receiving dowel pin 192 securely fixed in block 186, thereby to prevent relative rotary movement between the two parts. In the cut-away portion 210 of sleeve 199 is disposed the terminal portion 211 of one of the metal strips 155. To this terminal is attached a lead wire 201 connecting the strip 155 with squib 156. The other lead from the squib runs to a binding post 202 mounted on block 186, the binding post having fixed thereto a contact member 203 adapted to maintain an unbroken electrical connection to metallic rod 151 while allowing movement of the rod with respect to the contact member 203.

The right hand end, Fig. 2, of rod 151 passes through a bore 206 in cap 205, and a reduced portion 152 of rod 151 is securely fixed in a bore 65 in the core 42 of the inertia generator, whereby axial movement of the generator within the casing 195 in response to the action of coiled spring 219 exerting tension between the shoulder formed by flange 170 and flange 32 causes plunger or rod 151 to move within the bore 158, thereby to cause the rotor 162 to be freed to rotate, as will be later explained.

Fixed on rod 151 is an electrical terminal or connection 204, from whence a lead connection goes to coil 44, the other lead to coil 44 being connected at terminal 175 to metallic contact member 153 which is adapted, when the fuze is in armed condition, to make contact with member 154, thereby completing an electrical circuit between coil 44 and squib 156, the circuit being traced as follows: coil 44 through terminal 175 to contact sleeve 153 to upper contact 154 to strip 155 to terminal 211 through lead 201 to squib 156 to post 202 to contact 203 to rod 151 to connection 204 through the associated lead wire to coil 44.

Whereas the view of Fig. 2 shows the fuze in armed condition with the electrical circuit complete, in the unarmed condition the whole inertia generator is moved back to the left, Fig. 2, and maintained in that position by the action of member 220 pressing against the adjacent end of the inertia generator, before action of the propellers 9, as the bomb moves through the air, has unscrewed the screw 220 to the position shown, as will be hereafter explained. When the inertia generator is moved to the left, and when the fuze is in an unarmed condition, the rotor 162 is rotated 90 degrees from the position shown, and rod 151 is then inserted in bore 163 and maintains the rotor in that position until withdrawn due to movement of the generator to the right in response to action of spring 219. When the rod 151 is withdrawn from bore 163, a spring actuated plunger, not shown, of conventional design causes rotor 162 to turn 90 degrees, the spring being shown in dashed outline at 146 within bore 147.

In the unarmed condition, when the inertia generator is moved somewhat to the left from the position shown in Fig. 2, the spring contacts 154 make contact with the metallic casing 31, instead of the metallic contact cap 153 as shown, thereby electrically grounding one end of the squib lead connection 201. The electrical circuit when the fuze is in unarmed condition is shown in Fig. 3, the circuit or position of switch contact 154 when the fuze is in armed condition being indicated by the dotted line.

Assume now by way of explanation that the bomb is about to be launched from the aircraft or other carrier. The fuze is in unarmed condition. The rotor 162 is turned 90 degrees from the position shown in Fig. 2, so that bores 163 and 158 are in alignment, and rod 151 is inserted in bore 163. The inertia generator is maintained by the action of screw 220 in a position considerably to the left of that shown in Fig. 2, the coil spring 219 being considerably compressed and exerting considerable pressure on shoulder 170 and flange 32.

After the bomb is launched, the vanes 9 cause screw 220 to turn in a direction which withdraws the screw to the right, Fig. 2. Spring 219 exerting pressure on flange 32 and shoulder 170 causes the inertia generator to move to the right, maintaining the head or end 64 of the inertia element in contact with the screw. As the generator moves, rod 151, which is attached to core 42, moves to the right, being slowly withdrawn from bore 163. When the bomb has descended an amount sufficient to withdraw screw 220 a predetermined distance, rod 151 is completely withdrawn from bore 163, and the action of the aforementioned spring actuated plunger causes the rotor 162 to turn to the position shown. When the vanes have withdrawn screw 220 sufficient to permit rotor 162 to turn, the inertia generator has also moved substantially to the position shown, where arms 154 make contact with member 153, electrically connecting coil 44 to squib 156.

The movement of the inertia generator to the right is limited by flange 32 abutting against the shoulders of retaining member 216, the position shown in Fig. 2. The screw 220 is adapted to be withdrawn somewhat beyond the position which allows full movement of the casing 31, thereby to free the inertia assemblage for movement in response to inertial forces applied thereto.

Assume now by way of description that the bomb strikes its target. A considerable set forward force applied to the inertia assemblage comprising members 51, 64, 48, and 52 causes them to be dislodged from the position shown, where they were held by magnetic attraction after the withdrawal of screw 220 had freed them. Upon the movement of the aforementioned assemblage of magnetic elements, the magnetic field about coil 44 collapses, inducing a voltage in the coil. The voltage is applied through leads 201 to explosive squib 156, which is designed to explode upon the energy received. Explosion of squib 156 ignites detonator charge 164 which fires lead-in charge 172 and booster charge 168, the explosion of which explodes the main bomb charge 4.

For arming the fuze, the aforementioned arming screw 220, vanes 9, and associated apparatus are provided. The arming screw is threaded for movement in threaded bore 218 in the fuze head 216. The head also has a bore 217 for receiving and permitting movement of retaining rod 222, for purposes to be hereafter apparent. The screw 220 has an extended shank or hub portion 236 to which is fixed a gear 232, having adjacent thereto a gear 231 free to rotate on the shaft but fixed against rotary movement with respect to the fuze by pin 235 in bore 234, the pin being connected to rod 222. Both gears mesh with gear 233 rotatably mounted on pin 241 which is fixed to the supporting arm of one of the vanes, the vanes rotating upon the bearing provided by shaft 236. Counter-weight 237 is provided for proper balancing of the apparatus. Rotation of the vanes, then, as the bomb descends, causes screw 220 to turn, and the

end of the screw to be withdrawn away from the inertia generator, releasing the generator to be moved by action of spring 219 to the armed position.

Reference is made now to Fig. 4 which shows a cross sectional view of an inertia voltage generator similar to that of Fig. 2, but having spring restoring means for the inertia assemblage. An outer casing 31' which may be substantially cylindrical, has an end 35 with threads disposed internally thereof, and may have the other end slightly tapered as shown, with an annular recess 33 around the periphery thereof for receiving end plate 39 and may have an annular overhanging lip 32 as shown. In threaded engagement with the inside of the threaded end of casing 31' is an inner casing or ring support 37' having threads 36, and having an extended or flaring head portion 38. The casing 31' should preferably be of non-magnetic material, whereas the casing 37' should be of magnetic material. The head 38 has a bore 41 substantially centrally disposed thereof for receiving a core 42' of magnetic material, the core having head 43'. The end of the core 42' may be in substantial alignment with the adjacent end of casing 37'. Disposed around the core 42' is a coil support 45' having flanges 46' extending therefrom defining a coil compartment in which coil 44' is disposed, lead wires 47 connecting the coil with the load circuit. The coil 44' may be composed of a predetermined number of turns of wire of predetermined size and resistance, whereby optimum energy is delivered to the load. Disposed within the other end of the outer casing 31' is a relatively heavy sleeve 51' of magnetic material and having a solid end portion 57' having a recess 58' therein for receiving fixedly the end 61 of a member 48' of permanently magnetized material, the member having an adjacent enlarged magnetic element 52'. The inner wall of the casing has a recessed portion 62 to provide a space between the casing 51' and the members 48' and 52' to receive a filler of non-magnetic material 63'.

Whereas the member 48' is described as being of permanently magnetized material, it is understood that at least one of the casing 51' or elements 48' or 52' must be of flux generating material whereby, when the member 52' abuts with the core 42' and casing 37' abuts with casing or sleeve 51', an energized magnetic circuit including the four elements is established. Once established, the magnetic attraction in the circuit tends to maintain the elements of the inertia assembly in the abutting relation shown. The spring 34, disposed between the end 57' of the sleeve and the plate 39, provides a restoring force for returning the member 48' and sleeve 51' of the inertia assembly into their normal positions, when they have been moved therefrom in response to inertial forces applied thereto. Whereas the magnetic attraction between elements is sometimes alone sufficient to restore the inertia assemblage, when the generator is designed for maximum sensitivity, the addition of the spring may be necessary.

Assume now by way of description that the leads 47 are connected to an explosive squib of suitable design, and that the inertia generator of Fig. 4 is utilized in the fuze of a bomb which strikes its target so that a substantial inertial or set forward force is applied to the inertia assemblage substantially along the longitudinal axis thereof. Just prior to the application of the force, the magnetic lines of force extend centrally through the core 42' and members 52' and 48', thence looping back through sleeve 51' and casing 37' to complete the circuit. The inertial force, when of sufficient magnitude, causes the inertia assemblage including member 48' and sleeve 51' to be dislodged, so that a gap exists between these and core 42' and casing 37' respectively. The reluctance of the magnetic circuit is sharply increased, causing at least some of the lines of force linking coil 44' to collapse, inducing a voltage therein. When the member 52' and sleeve 51' have moved a sufficient distance from core 42' and casing 37' respectively that the combined distances are slightly greater than the distance through the non-magnetic filler 63' between member 52' and the adjacent portion of sleeve 51', the magnetic flux is shunted through the path through the filler or non-magnetic material, and substantially all the lines cutting coil 44' collapse, generating the maximum voltage therein, and firing the explosive squib.

Assume now that in handling the inertia generator, shocks cause the inertia assemblage including members 52' and 48', and sleeve 51' to be prematurely dislodged from the remainder of the device, the tension of spring 34 restores it to its abutting position, where it is normally maintained by magnetic attraction.

Reference is made now to Fig. 5, which shows another embodiment of the invention, one particularly well adapted for use on projectiles of very low velocity, such as a homing torpedo, and adapted to fire a fuse when the projectile strikes the target at any angle.

These two features are accomplished by spring mounting the housing for the inertia generator within a tubular casing or outer housing, whereby slow decelerations of the device bearing the inertia generator result in compression of the spring unitl the housing for the generator receives a sharp impact against the ends or wall of the outer housing whereupon the inertia element or inertia assemblage is dislodged and the voltage generated. The springs mount the generator housing for free movement in substantially any direction in response to inertial forces applied thereto. In Fig. 5, an outer cylindrical casing 71 of non-magnetic material may be suitably mounted in the projectile, and has threaded ends to receive end pieces 72 and 73, end 72 having a bore 74 therein through which lead-wires 93 pass to the coil of the inertia generator. Disposed within the chamber formed by casing 71 and ends 72 and 73 is an inertia generator having a non-magnetic casing or housing 77 to which are attached near the ends thereof, as by welding or sweating, two annular rings 75 and 76. Disposed around the ends of the casing 77 are two frusto-conical coiled springs 67 and 68, the inner ends of the springs abutting against the rings 75 and 76 respectively, the outer ends of the springs abutting against the end pieces 72 and 73 respectively, tensions of the two springs maintaining the casing 77 and contents thereof normally in suspension within the outer casing 71.

The casing 77 has the ends thereof threaded to receive end pieces 81 and 82, end piece 81 having a bore 89 therein for passage of lead wires 93, the end pieces having fixed thereon or integral therewith studs 83 and 84 respectively, these being adapted to strike against the chamber ends 72 and 73 respectively selectively as the springs 67 and 68 are compressed in response to axial or orthogonal inertial or set forward forces applied to the inertia generator, and to thereby impart a sharp shock to the generator sufficient to dislodge the inertia elements or assemblage and cause the generation of a voltage therein.

The rings 75 and 76 are also adapted to abut against the inside wall of the cylinder 71 selectively in accordance with transverse or orthogonal inertial forces applied to the generator which cause the springs to yieldably permit movement of the generator within the casing. When the rings come in contact with the wall, a sharp shock is imparted to the generator sufficient to dislodge the inertia assemblage and generate a voltage in the coil.

The generator casing 77 may contain an inertia generator somewhat similar to that of Fig. 4. A casing 95 of magnetic material is disposed within one end of sleeve or casing 77, which should be of non-magnetic material. Inside the casing 95 is a chamber in which is disposed a coil 94, and within the coil a core 96 of magnetic material having a head 97 thereon, the head having a bore therein for the passage of the lead wires 93. The coil 94 is supported within its chamber by frame 98 having retaining flanges 99 on the ends thereof. The inner end

of casing 95 may be in alignment with the inner end of core 96.

Disposed adjacent the above described structure is a sleeve 88 of magnetic material having a closed end 85 and an aperture 80 therein for receiving magnet 78 which may have adjacent thereto an element 87 of somewhat larger diameter and composed of magnetic material. The aperture 80 may have a recessed or enlarged section 92, the space between the sleeve 88 and the members 78 and 87 being filled with a non-magnetic material 91, for example, lead.

Operation of the generator is similar to operation of the aforedescribed device of Fig. 4. The magnetic circuit prior to the application of the inertial force includes elements 96, 97, 95, 88, 78 and 87, the lines of force generated in the circuit by magnet 78 linking coil 94. Upon the application of inertial forces, the inertia assemblage comprising sleeve 88, magnet 78, and element 87, is dislodged from its normal position, the lines of force cutting coil 94 collapse, and a voltage is generated therein. It may be observed that the end 85 of sleeve 88 is relatively solid and heavy, to insure that inertial forces applied transversely or angularly to the axis of the generator housing are sufficient to dislodge the inertia assemblage.

The springs 67 and 68 provide a force transformer whereby small inertial forces of relatively long duration resulting from slow decelerations of the projectile and housing 71 are changed into inertial forces of relatively short duration but large magnitude sufficient to dislodge the inertia elements and generate a voltage in coil 94. Sustained application of small inertia forces upon casing 77 from any direction causes the spring or springs to be compressed and casing 77 to move toward an end or the wall of casing 71. When contact is made between one of the rings 75 or 76, or one of the studs 83 or 84, and the outer housing, a shock of short duration is transmitted to the inertia generator, the instantaneous inertial force thereby applied to inertia assemblage comprising elements 78, 87, and 88 being sufficient to dislodge it from its initial position and thereby generate a voltage in coil 94.

The device of Fig. 5, when used on a torpedo, has the further advantage of being relatively immune to countermining operations, since the spring mounting filters out the short, sharp shocks resulting from nearby detonations, and thus discriminates against them.

Reference is made now to Fig. 6, which shows a third embodiment of the invention, characterized by maximum and adjustable sensitivity to small inertial forces. An outer casing of non-magnetic material 106, which forms the main supporting means for the inertia generator, has a recessed wall portion forming a shoulder 120, the remainder of the wall being tapered somewhat as shown, the tapered end of the casing being threaded to receive an end piece 133. The end piece 133 has a threaded bore 131 centrally disposed therein to receive a screw 132, for purposes to be hereafter more fully described. Disposed within the casing 106 in abutting relation to the shoulder 120 is a casing 117 of magnetic material, and disposed within said casing is a coil support 123 having flanges 124 on the ends thereof. Disposed within the coil 122 is a core 121 of magnetic material having a head portion 118 designed to fit snugly in the casing 117. The core has a bore 114 centrally disposed therein, through which a plunger 115 composed of non-magnetic material passes.

Disposed within casing 106 adjacent casing 117 is a somewhat heavier casing 108 of non-magnetic material, held fixedly in place by set screw 107 passing through threaded bore 110 in casing 106. The casing has a large bore 109 centrally disposed therein, the inner wall of the casing being threaded at 111 to receive a set-screw 112. The bore has disposed therein the head 116 of plunger 115, and a coiled spring 113 abutting against the head 116 and the set-screw 112, tension of the spring tending to move the head and plunger to the right, Fig. 6. The casing 108 also has a smaller bore 141 therein for the passage of coil lead wires 137.

On the other side of magnetic casing 117 and core 121 is disposed a casing 125 of magnetic material, having a closed end 128 having a bore 134 therein for receiving fixedly a magnet 127 having an adjacent member 126 of magnetic material. When in the position shown, a magnetic circuit is established including flux generating magnet 127, enlarged magnetic element 126, core 121, head 118, casing 117, casing 125, and end 128. The lines of flux cut coil 122. Magnetic attraction tends to maintain element 126 in abutting relation with core 121, and casing 125 in abutting relation to casing 117, whereas tension of spring 113 against head 116 and plunger 115 tends to dislodge element 126 from core 121.

In the operation of the device, the tension of spring 113 is adjusted by set screw 112 until the difference between the spring force and the force of magnetic attraction represents the magnitude of the inertia force which is desired to actuate the device. For maximum sensitivity, the spring tension is increased until it is just insufficient to dislodge the inertia assemblage comprising elements 126, 127, and 125, the force of the spring being then slightly less than the force of magnetic attraction. When the inertia assemblage is dislodged in response to inertial or set forward forces applied thereto, a very small opening or space between them and the remainder of the magnetic circuit is sufficient to reduce the magnetic attraction to a value where it is insufficient to overcome the force of spring 113, which then acts to complete the disengagement by a substantial distance, and the collapse of the lines of force cutting coil 122 induces a considerable voltage therein, a new magnetic circuit including only elements 126, 127, and 128 being established as the lines of force are shunted through non-magnetic material 144. By adjustment of the tension of spring 113, the amount of inertial force necessary to cause the generation of a voltage in coil 122 may be regulated and adjusted.

Since the first magnetic circuit, once broken or attenuated by introduction of a high reluctance air gap, is maintained in this condition by action of spring 113, arming means for restoring the member 126 and casing 125 to their original positions respectively is provided, and consists of the aforementioned screw 132, which may be turned in threaded bore 131 until the end thereof restores the generator to operative condition, when the screw is again turned outward to permit movement of the movable parts in response to inertial forces.

Whereas a magnet has been shown as the means for generating a flux, it is understood that other means, for example, a suitably energized coil around one of the elements of magnetic material could be used if desired.

Whereas the embodiments of Figs. 5 and 6 reveal a magnetic bridge arrangement, the advantages of the spring means shown would be retained were the inertia bridge assemblages replaced by keeper elements of permanently magnetized material.

Whereas my invention has been shown and described with respect to some embodiments thereof which give satisfactory results, it is understood that various modifications of form or structure may be made without departing from the scope of the invention, and I therefore, in the appended claims, included all such modifications and equivalents.

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 the payment of any royalties thereon or therefor.

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

1. An inertia generator comprising a coil, a first casing

of magnetic material having one end thereof open and enclosing said coil, a core of magnetic material disposed within said coil and having one end in abutting relation with the closed end of said casing, the other end of said core being in substantial alignment with the open end of said casing, a second casing of magnetic material having one end open and having a diameter corresponding roughly to the diameter of said first casing and adapted to be normally positioned whereby the open ends of said casings are in abutting relationship, a member of magnetic material mounted within said second casing substantially axially thereof and having the end thereof in substantial alignment with the open end of the second casing, said member being of substantially smaller cross-section than said second casing whereby a gap exists between the end of said member and the open end of said second casing, at least one of said second casing and said member being of substantially permanently magnetized material whereby an energized magnetic circuit including said first and second casings and said core and said member is established, said first and second casings being normally maintained with their open ends in abutting relation by magnetic attraction, said second casing and member being adapted to be moved away from said first casing and core respectively in response to inertial forces applied thereto whereby a gap is introduced between the casings of higher reluctance than said first mentioned gap thereby to cause said magnetic circuit to be altered to include substantially only said second casing and said member, the change in said magnetic circuit causing a voltage to be generated in said coil as the lines of force cutting said coil collapse.

2. Apparatus according to claim 1 including in addition spring means for restoring said casings to abutting relation when the inertial force is no longer applied.

3. In an inertia generator, a coil; means for setting up a normally closed magnetic circuit including a pair of casings of magnetic material, permanently magnetized element disposed centrally of one of said casings, and a magnetic core disposed centrally of the other of said casings; said casings being normally in abutting relationship to each other, and said core and element being normally in abutting relationship; said coil being disposed around said core whereby a change in the reluctance of said circuit causes a voltage to be induced in said coil; said casings, and said core and element, being adapted to be moved away from each other respectively in response to inertial forces applied to said element and one of said casings whereby said magnetic circuit is opened and the reluctance thereof is changed.

4. In an inertia generator, a coil, means for setting up a magnetic circuit including a core of magnetic material for said coil, said core having an enlarged head portion, a first casing of magnetic material disposed around said core and coil, a second casing having a closed end portion, at least one magnetic element disposed within said second casing and adapted to generate a flux, said casings and said core and element being normally disposed and maintained in abutting positions respectively by the force of magnetic attraction therebetween and adapted to form a closed magnetic circuit, said second casing and element being adapted to be dislodged from their initial positions in response to inertial forces applied thereto whereby at least one gap of high reluctance is introduced in said circuit and a voltage is generated in said coil as the lines of flux in the core associated with said coil collapse.

5. An inertia generator comprising a cylindrical housing of non-magnetic material, one end of said housing having an annular recess around the inside thereof and an inwardly extending flange adjacent thereto, a cover plate mounted in said recess and engaged by the flange for sealing the end of said housing, the other end of said housing having fixed on the inside thereof a cylindrical casing of magnetic material, said casing having a closed outer end and being of shorter length than said housing, a coil disposed within said casing, a core of magnetic material disposed inside said coil and in abutting relation with the outer end of said casing, a second casing of magnetic material disposed within said housing and having a closed end and an open end normally abutting on the open end of said first named casing, a magnetic element fixed within said second casing and normally abutting against the closed end thereof and against said core, at least one of said second casing and said element being of permanently magnetized material whereby an energized magnetic circuit is established, said second casing and said element being adapted to be moved from their initial positions in response to inertial forces applied thereto, and a spring disposed between said cover plate and the end of said second casing and adapted by the tension thereof to restore said second casing and element to their initial positions when the inertial forces are removed therefrom.

6. An inertia generator comprising a first cylindrical housing of non-magnetic material, a second cylindrical housing of non-magnetic material and of substantially smaller dimensions than the corresponding dimensions of said first housing, said second housing being disposed within said first housing, a plurality of springs disposed within said first housing and engaging said second housing for yieldably maintaining said second housing in suspension therein, said second housing having disposed therein means including a plurality of magnetic elements for setting up an energized magnetic circuit, a coil disposed in predetermined position with respect to one of said elements and adapted to have a voltage induced therein when the amount of flux in said magnetic circuit changes, at least one of said elements being adapted to be moved from an initial position in response to an inertial force of predetermined character applied thereto thereby to alter the flux in said magnetic circuit and generate a voltage in said coil, said second housing being adapted to be moved against the tension of said springs in response to inertial forces of different character applied to said second housing until the second housing abuts against the inner walls of said first housing, contact between said two housings applying said inertial force of predetermined character to said movable magnetic element thereby to move said element from its initial position.

7. An inertia generator comprising a coil, means including a plurality of magnetic elements for setting up and energizing a magnetic circuit, said coil being disposed in predetermined position with respect to at least one of said magnetic elements whereby a change of flux in said circuit induces a voltage in said coil, at least one of said magnetic elements being adapted to be moved from an initial position in response to inertial forces applied thereto whereby the flux in said circuit is changed and a voltage is generated in said coil, said last named magnetic element being normally maintained in its initial position by magnetic attraction, and initially tensioned spring actuated means engaging said last named element and adapted to yieldably oppose the force of magnetic attraction and to add to said inertial force thereby to reduce the magnitude of the inertial force required to move said last named element from its initial position.

8. In an inertia device of the character disclosed, voltage generator means including a coil and at least a pair of magnetic elements disposed in predetermined relation to said coil, one of said elements being adapted to generate a flux, said pair of magnetic elements being movable relative to each other whereby the flux linking said coil is altered and a voltage is generated in the coil when relative movement occurs between said elements, said elements being maintained in initial relative positions by the force of magnetic attraction therebetween, and initially tensioned spring means engaging one of said elements and adapted to yieldably oppose the force of magnetic attraction thereon, said last named element being adapted to be moved from its initial position upon the application of an inertia force of predetermined character applied thereto,

the character of said force being determined in part by the tension of said spring and said force of magnetic attraction.

9. In an inertia generator of the character disclosed, a magnetic circuit including an inertia assemblage of magnetic elements, one of said elements being adapted to set up a flux within said circuit, a coil normally positioned with respect to said circuit whereby the lines of force link said coil, said inertia assemblage occupying an initial position in said circuit and being normally maintained in said initial position by the force of magnetic attraction, and initially tensioned spring actuated means engaging said inertia assemblage and adapted to yieldably oppose the force of magnetic attraction thereon, said inertia assemblage being adapted to be moved from said initial position in response to an inertia force of predetermined character applied thereto thereby to alter the reluctance of said magnetic circuit and induce a voltage in said coil, the character of said inertia force being determined at least in part by the tension of said spring means and the force of magnetic attraction.

10. An inertia generator comprising an external housing composed of non-magnetic material; spring suspension means; an internal housing composed of non-magnetic material yieldably mounted by said spring suspension means within said external housing; and generator means disposed within said internal housing and including a coil, flux generating means, and at least a pair of magnetic elements, one of said elements being disposed in predetermined position relative to said coil; said elements being movable relative to each other for generating a voltage in said coil when relative motion occurs between said elements; said elements being adapted to be maintained in their initial positions by the force of magnetic attraction; said spring suspension means providing a force transformer whereby small forces of relatively long duration resulting from movement of said external housing are changed into inertia forces of relatively short duration and large magnitude sufficient to dislodge said last named element from its initial position as said internal housing moves into engagement with said external housing.

11. In an inertia generator, the combination of a coil, means for setting up a magnetic field within the coil, an inertia element of magnetic material within said field and adapted to be moved in response to inertia forces applied thereto thereby to generate a voltage in said coil, and spring actuated means engaging said inertia element and adapted to exert a force thereon supplementing said inertia forces whereby the magnitude of an inertia force adapted to move the element is reduced to a predetermined value.

12. In a fuze for a projectile, a coil; means for setting up a normally closed magnetic circuit including a pair of casings of magnetic material, a permanently magnetized element disposed centrally of one of said casings, and a magnetic core disposed centrally of the other of said casings; said casings being normally in abutting relationship to each other, and said core and element being normally in abutting relationship; said coil being disposed around said core whereby a change in the reluctance of said circuit causes a voltage to be induced in said coil; said casings, and said core and element, being adapted to be moved away from each other respectively in response to inertial forces applied to said element and one of said casings whereby said magnetic circuit is opened and the reluctance thereof is changed; and electroresponsive detonating means operated by the voltage generated in said coil.

13. In a fuze of the character described, means for establishing a normally closed magnetic circuit including a pair of substantially coaxial casings of magnetic material initially maintained in end engagement with one another, a core disposed centrally within one of said casings, a coil carried by said core, a plurality of magnetic elements, at least one of said elements being of permanently magnetized material and disposed centrally of the other of said casings whereby magnetic flux is generated, at least one of said elements being disposed in predetermined position with respect to said coil whereby a change in the flux in said last named element induces a voltage in said coil, said plurality of magnetic elements being initially disposed in predetermined positions whereby a first magnetic circuit is established in which a substantial number of magnetic lines of force link said coil, a group comprising some of said magnetic elements being adapted to be moved from their initial positions to second positions in response to inertial forces applied thereto whereby a second magnetic circuit is established in which the flux includes substantially only said group of elements and the number of magnetic lines of force in the element associated with said coil is substantially zero, the change in the lines of force resulting in a voltage generated in said coil, and electroresponsive detonating means operated by the voltage generated in said coil.

14. In a fuze of the character disclosed; a plurality of abutting coaxial casings of magnetic material, a plurality of relatively movable magnetic elements disposed within said casings whereby a magnetic field comprising first and second paths of relatively low and high reluctance respectively is effected; said magnetic elements normally occupying positions whereby the flux lines of said magnetic field follow said first path of low reluctance; said plurality of elements being adapted to be moved relative to each other to second positions in response to inertial forces applied thereto, substantially all the lines of force of said magnetic field taking said second path when said elements are in said second positions thereof; a coil disposed within one of the casings and in predetermined position with respect to at least one of said elements and adapted to have a voltage induced therein when the lines of flux shift from said first to said second paths; and electroresponsive detonating means operated by the voltage generated in said coil.

15. In a fuze of the character disclosed, an external housing composed of non-magnetic material; spring suspension means; an internal housing composed of non-magnetic material yieldably mounted by said spring suspension means within said external housing; generator means disposed within said internal housing and including a coil, flux generating means, and at least a pair of magnetic elements, one of said elements being disposed in predetermined position relative to said coil; said elements being movable relative to each other for generating a voltage in said coil when relative motion occurs between said elements; said elements being adapted to be maintained in their initial positions by the force of magnetic attraction; said spring suspension means providing a force transformer whereby small forces of relatively long duration resulting from movement of said external housing are changed into inertia forces of relatively short duration and large magnitude sufficient to dislodge said last named element from its initial position as said internal housing moves into engagement with said external housing; and electroresponsive detonating means operated by the voltage generated in said coil.

16. In a fuze of the character disclosed, a coil, means including a plurality of magnetic elements for setting up and energizing a magnetic circuit, said coil being disposed in predetermined position with respect to at least one of said magnetic elements whereby a change of flux in said circuit induces a voltage in said coil, at least one of said magnetic elements being adapted to be moved from an initial position in response to inertial forces applied thereto whereby the flux in said circuit is changed and a voltage is generated in said coil, said last named magnetic element being normally maintained in its initial position by magnetic attraction, and initially tensioned spring actuated means engaging said last named element and adapted to yieldably oppose the force of magnetic attraction and to add to said inertial force thereby to reduce the magnitude of the inertial force required to move said last named element from its initial position, and electrorespon-

sive detonating means operated by the voltage generated in said coil.

17. In a fuze of the character disclosed, generator means including a coil and at least a pair of magnetic elements, one of said elements being disposed in predetermined relation to said coil, one of said elements being adapted to generate a flux, said pair of magnetic elements being movable relative to each other whereby the flux linking said coil is altered and a voltage is generated in said coil when relative movement occurs between said elements, said elements being maintained in initial relative positions by the force of magnetic attraction, and initially tensioned spring actuated means engaging one of said elements and adapted to oppose the force of magnetic attraction, said last named element being adapted to be moved from its initial position in response to an inertia force applied thereto, said spring means and said magnetic force determining at least in part the character of the inertia force adapted to move said last named element, and electroresponsive detonating means operated by the voltage generated in said coil.

18. In a fuze for a projectile, in combination, an explosive charge arranged within the projectile, electroresponsive detonating means for detonating said charge, and a voltage generator within the fuze and adapted to generate sufficient voltage to operate said detonating means as the projectile strikes a target, said voltage generator comprising a coil, a plurality of magnetic elements arranged to form a magnetic circuit, energizing means for said circuit, at least one of said elements being disposed in predetermined position with respect to said coil, at least two of said magnetic elements being maintained in their initial positions by the force of magnetic attraction, said last named elements being adapted to be moved from their initial positions in response to inertial forces applied thereto whereby the reluctance of said circuit is altered and a voltage generated in said coil, and spring means operatively connected to said last named elements and adapted to yieldably oppose the force of magnetic attraction thereby to predetermine the character of the inertia force adapted to move said elements.

19. In a fuze of the character disclosed, in combination, a first casing of magnetic material, structure disposed within said first casing comprising a core element and a coil carried by said core element, a second casing of magnetic material in substantially coaxial and abutting relationship with the first casing, a structure within said second casing comprising a plurality of elements composed of magnetic material and including a permanently magnetized element, said elements being in abutting relationship with one another, and a sleeve of non-magnetic filler material positioned between the second casing and said elements whereby one of said casings together with the structure contained therein is magnetically urged into engagement with the other casing and the structure contained therein.

20. An inertia device of the character disclosed for mounting on a moving body, comprising in combination, generator means including a coil and at least a pair of magnetic elements movable relative to each other, said elements being adapted to generate a flux and induce a voltage in the coil when one of said elements is moving relative to the other one of said elements, one of said elements being adapted to be dislodged from its initial position in response to an inertial force of predetermined duration and magnitude applied thereto, and force transforming means comprising at least one spring for yieldably supporting said generator means from the body, whereby the generator means is moved gradually in response to inertial forces applied to said body.

21. An inertia generator comprising a coil, a plurality of magnetic elements, at least three of said elements being movable as a unit with respect to the other elements, said magnetic elements comprising a magnetic bridge circuit including a path of relatively high reluctance and a path of relatively low reluctance, at least one of said three elements being adapted to set up a magnetic field within said circuit whereby said plurality of elements is maintained in initial positions by the force of said field following said first and second paths selectively in accordance with the position of said movable elements with respect to the other elements, said movable elements being adapted to be moved from said initial positions thereof in response to a predetermined inertial force applied thereto, said coil being disposed in predetermined position with respect to at least one of said other of the elements and adapted to have a voltage induced therein when the lines of force shift between said two paths, and spring actuated means engaging said movable unit of elements and adapted to exert a force opposing the force of magnetic attraction thereon thereby to reduce the magnitude of said predetermined inertia force.

References Cited in the file of this patent

FOREIGN PATENTS

506,280	France	May 26, 1920
525,333	Great Britain	Aug. 27, 1940