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Norton

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[54] **SAFING AND ARMING SYSTEM FOR A PROJECTILE FUZE AND FLUIDIC CONTROL MEANS FOR USE THEREWITH**

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[52] **U.S. Cl.** ..... **102/81,** 102/7.4, 102/70 B, 102/70.2 R

[51] **Int. Cl.** **F42c 5/00**

[58] **Field of Search** ..... 102/81, 70.2, 7.4, 76 R, 102/76 P, 70, 70 B

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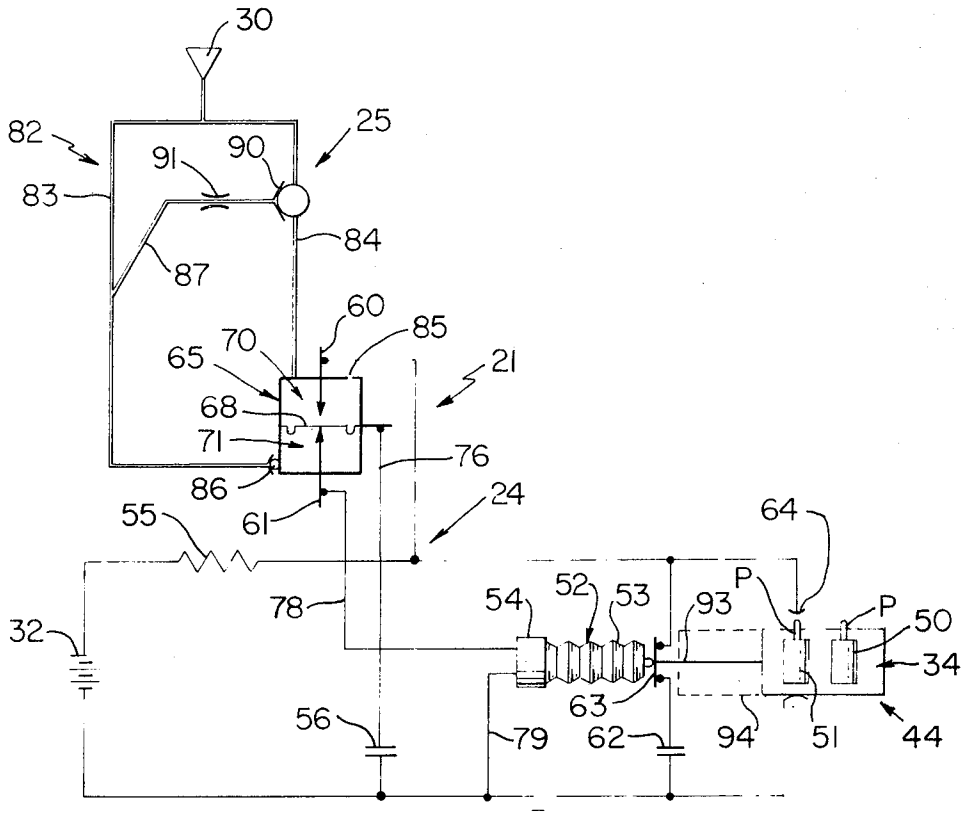
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[57] **ABSTRACT**

A safing and arming system for a projectile fuze comprises an apparatus for readying a detonator of the fuze for firing upon impact thereof and fluidic control means for the apparatus. During ascent of the projectile and its fuze through its trajectory toward the summit thereof, the control means operates to actuate a first component which makes available an energy source which is required to detonate the detonator, and after the projectile and fuze pass through the summit the fluidic control means operates to actuate another component of the apparatus which moves the detonator into position to be detonated upon impact whereby the projectile and fuze are a considerable distance from their associated launch site before the detonator is in position to be detonated to thereby assure maximum safety for the launch crew.

20 Claims, 8 Drawing Figures



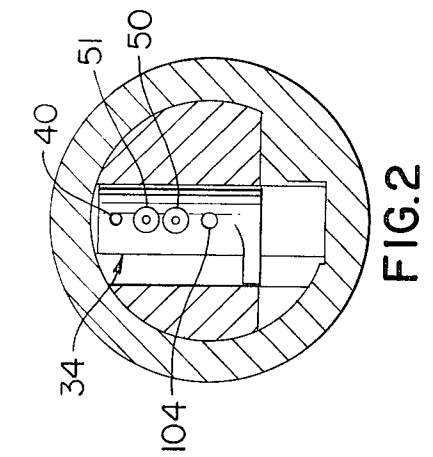


FIG.2

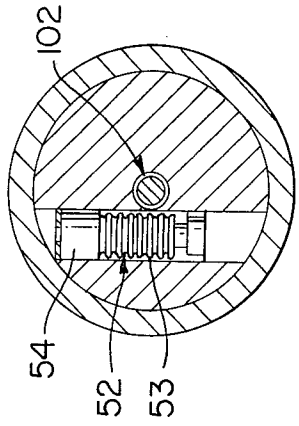


FIG.3

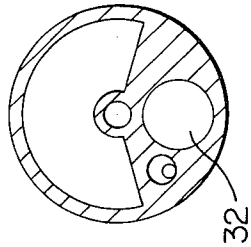


FIG.4

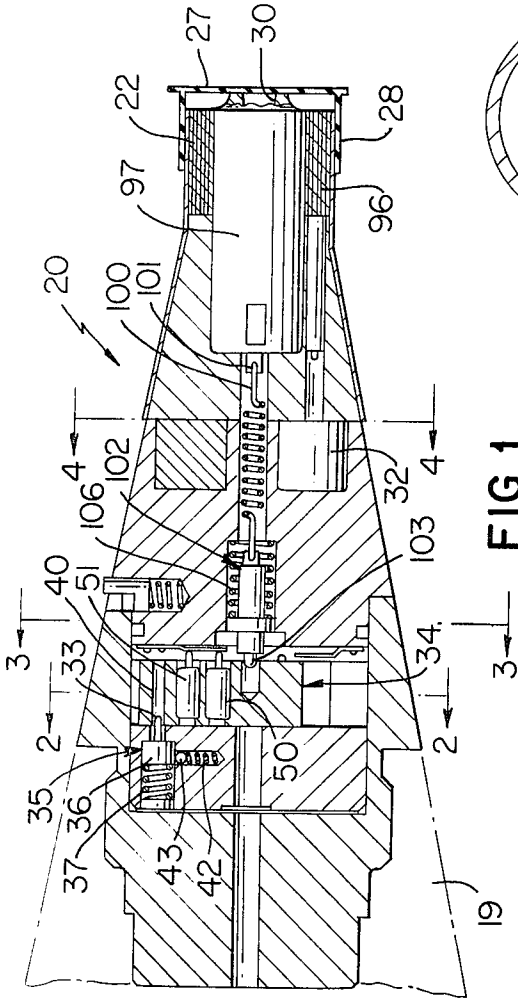


FIG.1

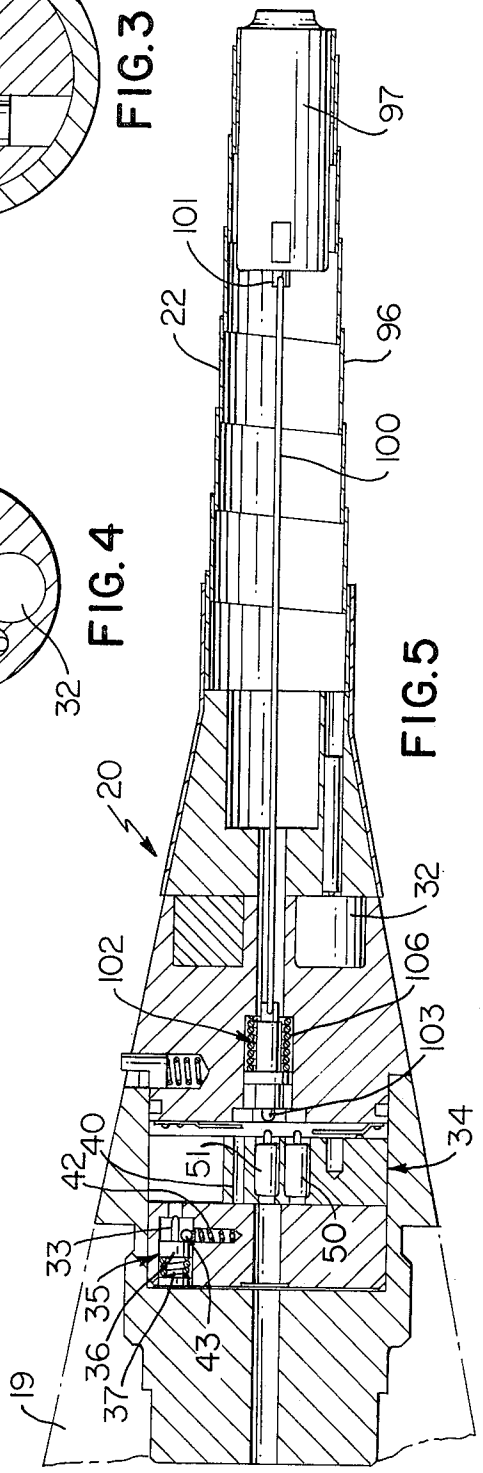


FIG.5

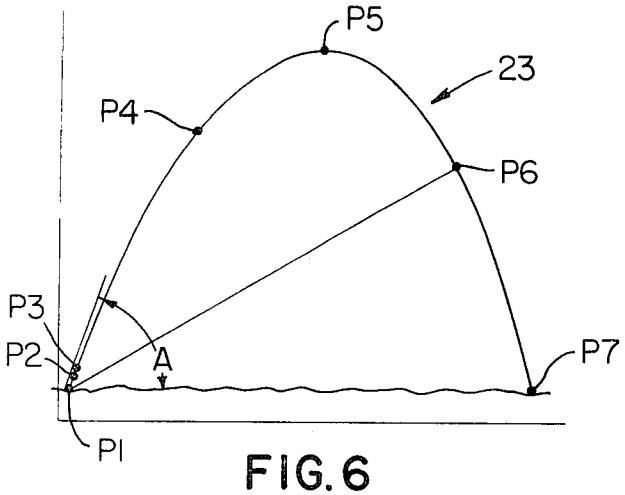


FIG. 6

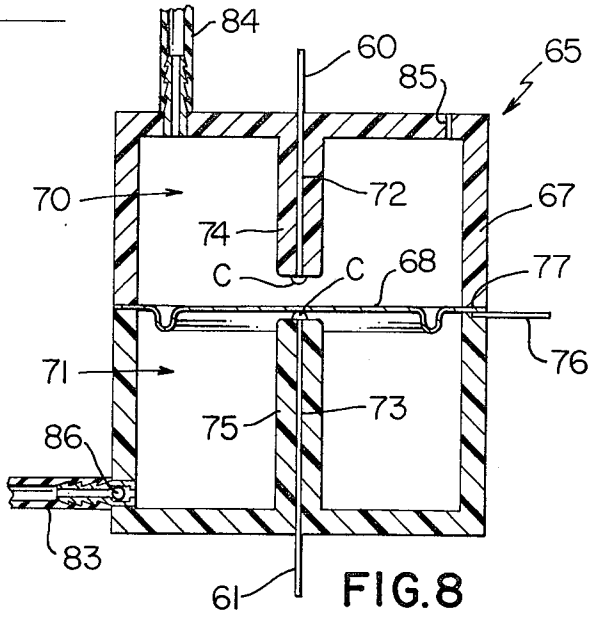


FIG. 8

FIG. 7

SAFING AND ARMING SYSTEM FOR A PROJECTILE FUZE AND FLUIDIC CONTROL MEANS FOR USE THEREWITH

BACKGROUND OF THE INVENTION

During the launching or firing of weapons including missiles, mortars, artillery projectiles, and the like, which move through a substantially parabolic trajectory after launch, it is desirable that these weapons, which will be referred to hereinafter as projectiles, be provided with fuzes which arm the projectile so as to assure maximum safety for the launch crew. To increase the destructive capability thereof these projectiles often employ extendible probes on their associated fuzes to provide projectile explosion before the warhead is buried in the ground, thereby resulting in a more lethal weapon.

Numerous so-called safing and arming mechanisms have been proposed heretofore in an effort to provide a safe launching of projectiles; however, these previously proposed safing and arming mechanisms are generally either too complicated and expensive or are comparatively unreliable. Further, these previously proposed mechanisms which have been used with fuzes having extendible probes provide premature extension of the probes resulting in the projectile becoming unstable and often tumbling.

SUMMARY

This invention provides a simple and economical safing and arming system for a projectile fuze which is adapted to be used with projectiles having either nonextendible or extendible fuze probes and which assures optimum safety for a launch crew. The system comprises an apparatus for readying a detonator of the fuze for firing upon impact thereof and fluidic control means for the apparatus. The control means operates to actuate a first component which makes available an energy source which is required to detonate the detonator during ascent of the projectile and its fuze through its trajectory toward the summit thereof and after the projectile and fuze pass through the summit the fluidic control means operates to actuate another component of the apparatus which moves the detonator into position to be detonated upon impact whereby the projectile and fuze are a considerable distance from their associated launch site before the detonator is in position to be detonated.

Other details, uses, and advantages of this invention will be readily apparent from the embodiment thereof presented in the following specification, claims, and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings show a present preferred embodiment of this invention, in which

FIG. 1 is a cross-sectional view with certain parts in elevation illustrating an exemplary projectile and fuze which has an extendible probe and which utilizes one exemplary embodiment of the safing and arming system of this invention with the fuze being shown in an unarmed condition;

FIG. 2 is a view taken essentially on line 2—2 of FIG. 1;

FIG. 3 is a view taken essentially on the line 3—3 of FIG. 1;

FIG. 4 is a view taken essentially on the line 4—4 of FIG. 1;

FIG. 5 is a view similar to FIG. 1 illustrating the projectile fuze with its extendible probe in an extended position and with the safing and arming system in an armed condition;

FIG. 6 is a graph illustrating a typical trajectory of a projectile which uses the fuze of FIG. 1 and particularly illustrating representative points in the trajectory where various operations are performed by the system of this invention;

FIG. 7 is a schematic presentation of the safing and arming system for the projectile fuze shown in FIGS. 1 and 5 particularly illustrating the electromechanical apparatus of such system and fluidic control means for such apparatus; and

FIG. 8 is an enlarged cross-sectional view of a fluidic sensor comprising the fluidic control means included in the system illustrated in FIG. 7.

DETAILED DESCRIPTION

Reference is now made to FIG. 1 of the drawings, which illustrates a fragmentary forward portion of a weapon which will be referred to hereinafter as a projectile and designated by the reference numeral **19**. The projectile **19** has a fuze **20** which includes one exemplary embodiment of a safing and arming system of this invention which is designated generally by the reference numeral **21** and the system **21** is shown schematically in FIG. **7**. The fuze **20** has an extendible probe **22** of known construction which is extended with optimum efficiency by the system **21** because such system delays probe extension until after the projectile **19** passes the summit of its trajectory, and in a manner to be described in detail subsequently, and this assures that the projectile will remain ballistically stable until impact thereof.

The projectile **19** and its fuze **20** travel through a substantially parabolic trajectory illustrated at **23** in FIG. **6**; and, as shown schematically in FIG. **7**, the system **21** of this invention comprises an electromechanical apparatus **24** and control means therefor in the form of fluidic control means **25** and such control means assures that the system prevents arming of the fuze until after the projectile has passed the summit of its trajectory and thereby assures greater safety for the launch crew.

The projectile **19** has a cover **27** over its fuze which is frictionally held in position by a cylindrical skirt portion **28** thereof and the cover **27** is used to prevent foreign objects from entering a ram air inlet duct **30** which is used to supply air flow to the fluidic control means **25**. Prior to launch the cover **27** is removed from the outer end of the fuze to thereby expose the inlet duct **30**.

At launch the projectile and fuze experience substantial so-called setback forces caused by acceleration of the projectile and these setback forces initiate or activate a battery in the form of a thermal battery **32** of known construction, see FIGS. **4** and **7**, and the manner in which the battery **32** is activated is well known in the art and hence will not be described in detail.

The setback forces at launch also remove a positive mechanical lock which includes a lock pin **33** which is used to lock a slider assembly which will be referred to hereinafter simply as a slider **34**, whereby such slider is free to be moved from the position of FIG. **1** to the po-

sition of FIG. 5 and as will be described in detail subsequently. The lock pin 33 is part of a slider lock assembly 35 which includes a piston portion 36 which is urged by a compression spring 37 in a direction tending to move the pin 33 into a bore 40 in the slider 34. The assembly 35 also has a latching mechanism which serves to latch or prevent reentry of the pin 33 within bore 40 once it has been removed therefrom by the setback forces and such latching mechanism comprises a compression spring 42 which in the position of FIG. 1 resiliently urges a latch or ball 43 against a right circular cylindrical surface of the piston portion 36. Once the setback forces act upon the piston 36 and lock pin 33 to override the spring 37, the piston moves to the position illustrated in FIG. 5, allowing the compression spring 42 to urge the ball 43 beyond the forward face of the piston portion 36 and thereby prevent the pin 33 from moving forwardly into the bore 40 of the slider 34 whereby such slider is free to be moved by the apparatus 24 of the system 21 of this invention and in a manner to be described subsequently.

The apparatus 24 of system 21 is primarily an electromechanical apparatus and is particularly adapted for readying detonator means of the projectile fuze 20 for firing upon impact thereof; and, the term readying as used herein is intended to define that the detonator means which is designated generally by the reference numeral 44 is carried by the slider 34 and placed in position to cause the fuze 20 to explode the projectile 19 upon ground impact of such fuze and projectile. The detonator means 44 in this example of the invention comprises what will be referred to as a delay detonator 51 which has a built in time delay and an instantaneous detonator 50. One detonator will be selected prior to the launch of the projectile 19 by the insertion of a suitable stop (not shown) to limit the motion of the slider 34.

The apparatus 24 also includes actuating means in the form of a so-called bellows actuator 52 which has a bellows portion 53 and a motor 54. The actuator 52 is connected in an electrical circuit with the battery 32, a resistor 55, an energy storage device in the form of a capacitor 56 and a pair of electrical switches 60 and 61. The electromechanical apparatus also has a firing device in the form of a firing capacitor 62, a switch 63 for energizing the capacitor 62 and switches 64 which operatively associate with either the delay detonator 61 or the instantaneous detonator 50 as selected prior to launch. The manner in which the above-mentioned components of the electromechanical apparatus 24 operate in the overall system 21 and the detailed operation of the fluidic control means 25 for such apparatus will be discussed in more detail subsequently.

The fluidic control means 25 comprises a fluidic sensor which will be referred to hereinafter simply as a sensor 65 and the sensor 65 has a housing 67 which may be made of any suitable material but in this example is made of a nonelectrically conducting, i.e., electrically insulating, material such as plastic. The sensor 65 has means dividing the housing 67 into two chambers and such dividing means is in the form of a flexible diaphragm 68 made of an electrically conducting material such as an electrically conducting metallic material. The diaphragm 68 divides the overall volume of the housing 67 into a first chamber 70 having the switch 60 associated therewith and a second chamber 71 having the switch 61 associated therewith.

The switches 60 and 61 are defined by electrical leads 72 and 73 extending through and supported by associated central posts 74 and 75 each provided as a part of the housing 67 and each extending inwardly within its associated chamber. Each electrical lead 72 and 73 has a hemispherical contact C which is adapted to be engaged or contacted by the central portion of the flexible diaphragm 68. As will be apparent from FIGS. 7 and 8 of the drawings the electrically conductive diaphragm 68 is electrically and mechanically connected to an electrical lead 76 as illustrated at 77 in FIG. 8, and the lead 76 is connected to a capacitor 56.

The switch 61 is connected by an electrical lead 78 to one terminal of the motor 54 of actuator 52. The other terminal of motor 54 is connected by a lead 79 to the battery 32. However, the battery 32 is not capable of energizing the motor 54 of such actuator without an energy transfer provided by the energy storage device or arming capacitor 56 as will be described in detail subsequently.

The fluidic control means 25 includes pressurizing means 82 for controlling the pressures in the chambers 70 and 71 of sensor 65 and such pressurizing means includes the previously mentioned ram air intake duct 30, a first conduit 83 connected between the duct 30 and the chamber 71, a second conduit 84 connected between the duct 30 and the chamber 70, and means for venting the chamber 70 in the form of a passage 85 through the housing 67. The pressurizing means also includes flow control means allowing flow of raw air first through the conduit 83 and then through the conduit 84 in response to pressure conditions created by ram air flow as the projectile 19 goes through its trajectory.

The flow control means which selectively allows air flow through conduits 83 and 84 is in the form of a one way valve device 86 which connects the conduit 83 to the chamber 71, a conduit 87 which extends between the conduits 83 and 84 and is adapted to place such conduits in fluid flow communication, and a valve means or device 90 operatively associating with the conduits 84 and 87 and operating to allow flow through the conduit 84 once a predetermined pressure is reached in the lower chamber 71 of the sensor 65 and thereby simultaneously allow flow through the conduit 84 to pressurize the chamber 70 in accordance with the pressure determined substantially by the trajectory traversed by the fuze 20 and its associated projectile 19. The one way valve device 88 may be of any known construction and need not be described in detail and to assure that the flow control means operates in a precise manner the conduit 87 may be provided with a fluidic resistor 91 which operates in a manner which is well known in the art.

Having described the various components of the safing and arming system 21 the detailed description will now proceed with a description of the manner in which system 21 and in particular the fluidic control means 25 for such system operates to assure that the fuze 20 is not armed and the extendible probe 22 of fuze 20 is not extended, until after the projectile 19 carrying such fuze passes the summit of its trajectory.

Immediately at launch air flow to the chamber 70 is blocked momentarily by the action of the valve device 90 to thereby prevent the dynamic pressure associated with the launch velocity from reaching the upper cham-

ber 70. During this time the chamber 71 is charged or pressurized to a total pressure equal to atmospheric pressure at the launch altitude plus approximately one-half the dynamic pressure and this pressurization is achieved through ram air inlet duct 30, conduit 83, and one way valve device 86. The magnitude of the pressure in chamber 71 is controlled by the operation of the valve device 86, the air flow resistance of ducts 83 and 87, and the operating characteristics of the valve means or device 90 and fluidic resistor 91. Once the chamber 71 has been pressurized as described above, this pressure remains constant throughout the remainder of the flight of the fuze 20 and its projectile 19 and upon initial pressurization the pressure in chamber 71 is greater than in chamber 70 whereby switch 60 is closed and switch 61 is open. The time to pressurize the chamber 71 is very short and generally will be completed in most instances before the projectile and its fuze have left the launch tube or barrel of an associated launching device.

Once chamber 71 has been pressurized, ram air flow proceeds through the secondary flow path provided by the interconnecting conduit 87, through the fluidic resistor 91 which serves as a time delay mechanism, and acts on the valve device 90 to thereby actuate such valve device and allow flow from the ram air nozzle 30 to flow through the conduit 84 and pressurize the chamber 70 of sensor 65. However, the chamber 70 has the previously mentioned vent 85 to ambient, whereby once the valve 90 is actuated the pressure in chamber 70 is always equal to the atmospheric pressure at each altitude in the trajectory 23 plus all of the dynamic pressure due to ram air entering the inlet duct 30. Once the valve 90 is actuated the total pressure in the chamber 70 is greatest so that the switch 60 in chamber 70 is opened and the switch 61 in chamber 71 is closed; and, this event also occurs very rapidly and in most instances before the fuze and projectile have left the launching device and always before the thermal battery 32 has become activated. However, as indicated above the pressure in chamber 70 will vary as the projectile 19 and its fuze 20 move through the trajectory 23 to control the operation of system 21 and as will now be described in detail. In particular, both the atmospheric and dynamic pressure decrease as the altitude of the fuze 20 approaches the summit of its trajectory and increase as the altitude decreases from such summit, i.e., the fuze approaches ground level.

The sequence of events is depicted in the graph presented in FIG. 6 which shows a plot of the trajectory 23 with the altitude of the projectile and fuze above the launch being the ordinate and the horizontal distance of the weapon or projectile from the launch point being the abscissa. The trajectory 23 starts at the launch point P1 and ends at the ground impact point P7 and the projectile with its fuZe 20 is launched through the launch angle A. Point P2 is the position of the projectile when the chamber 71 of the sensor 65 is charged or pressurized and point P3 is the position of the projectile when the total pressure of the upper chamber 70 is greatest. The capacitor 56 will remain uncharged during this period since the battery 32 is not activated. Point P4 represents the position of the projectile during the ascent phase when the pressure in chamber 70 decreases below the pressure in the sealed chamber 71 with the trajectory summit being point P5 and point P6 being the position of the projectile during the descent phase when the pressure in chamber 70 once again is greatest and is the point at which the fuze 20 of the projectile 19 is armed. As will be readily apparent from FIG. 6 point P6 represents a safe separation distance between the launch point P1 and hence the launch crew and the projectile at the time of arming with the distance therebetween being along the line P1–P6.

At point P4 during the ascent phase of the flight, and as stated above, the total pressure in the chamber 70 has decreased so that it is lower than the pressure in the lower chamber 71 whereupon switch 61 is opened and switch 60 is closed. This action, as will be seen from FIG. 7, places the arming capacitor 56 in the circuit with the battery 32 whereby the capacitor 56 begins to charge. The projectile 19 continues through its trajectory ascending to the summit shown at P5 and then starts its descent. The switch 60 remains closed from point P4 to a point P6 in the descent of the projectile 19 and its fuze 20 and during this period the capacitor 56 is fully charged.

At point P6 during the descent of the projectile 19 and fuze 20 the total pressure in the chamber 70 becomes greater than the pressure in the chamber 71 whereupon the switch 60 is opened and the switch 61 is closed. This action places the now charged arming capacitor 56 in the circuit containing the motor 54 for the bellows actuator 52 thereby energizing such motor whereupon the actuator 52 moves the slider 34 through the use of a mechanical link 93 from the dotted line position illustrated at 94 in FIG. 7 to the illustrated solid line position. Additionally, the actuator releases the volute spring 96 in the extendible probe 22. As the slider 34 is moved to the solid line position illustrated in FIG. 7 the switch 64 is open while another electrical switch 63 is closed placing the previously mentioned firing capacitor 62 in the circuit with the battery 32 and the capacitor 62 now begins to charge. At ground impact electrical switch 64 is mechanically actuated bringing it into contact with a pin P of the delay detonator 51 whereby the now charged capacitor 62 is placed in the electrical circuit to cause the delay detonator 51 to detonate initiating the explosive portion of the projectile 19.

The extendible probe 22 of the fuze 20 has a volute type spring 96 of known construction and the fluidic control means 25 including the fluidic sensor 34 are housed in a module 94, see FIGS. 1 and 5, suitably attached to the end coil of the volute spring 96.

A cable 100 made of a substantially inextensible material such as steel has one end 101 thereof attached to the module 97 and the opposite end of such cable is attached to and carried by a preloaded spring device 102 which is carried by the fuze 20. The device 102 has a pin 103, see FIG. 1, which is initially received within bore 104 of the slider 34. Once the extendible probe 22 is extended by expansion of the volute spring 96 a spring 106 of the deivce 102 is compressed and held in a compressed condition until ground impact and the cable 100 is pulled taut, as shown in FIG. 5, whereby the pin 103 is pulled away from the pin P of its associated delay detonator 51. Upon impact the end of the volute spring 96 collapses allowing the cable 100 to become slack whereupon the coiled spring 106 urges the pin 103 against the pin P of the detonator 51 thereby closing the switch 64 shown in FIG. 7 and initiating the explosive train of the projectile 19.

In this disclosure of the invention the fluidic sensor is shown as a sensor which employs a flexible diaphragm. However, it will be appreciated that such sensor need not necessarily be of the detailed construction illustrated as long as the operation thereof is such as to provide pressures in associated chambers **71** and **70** thereof in a similar manner as described herein. Further, although the valve device **90** is illustrated schematically, it will be appreciated that such valve device may be a fluidic device such as a flip-flop which is free of moving parts or such device may include movable components and be operated by any suitable means including fluidic controls, mechanical controls, electrical controls, hydraulic controls, etc.

The fluidic resistor **91** is preferably free of moving parts and such resistor serves to provide a precisely controlled restriction in the secondary flow path or conduit **87** which helps assure that the valve device **90** will be operated after a desired pressure has been reached in the chamber **71.**

Thus, it is seen the safing and arming system **21** of this invention basically monitors the three environments of setback force, muzzle velocity and trajectory after a projectile and its fuze have been launched. If any one of these environments is not proper the safing and arming system of this invention assures that the projectile will not arm. The system **21** is insensitive to projectile spin and is thereby compatible with all types of weapons that experience a suitably parabolic trajectory including artillery, surface to surface missiles and mortars, and the like.

While present exemplary embodiments of this invention, and methods of practicing same, have been illustrated and described, it will be recognized that this invention may be otherwise variously embodied and practiced within the scope of the following claims.

What is claimed is:

1. A safing and arming system for a projectile fuze comprising; an apparatus for readying detonator means of said projectile fuze for firing upon impact thereof; said apparatus having, an energy storage device, a first switch for activating said energy storage device, an actuator for moving said detonator means into position to be detonated upon impact, and a second switch for placing said energy storage device in the circuit with said actuator to enable actuation of said actuator; and fluidic control means for said apparatus, said fluidic control means operating to actuate said first switch during ascent of said projectile through its trajectory toward the summit thereof and operating to actuate said second switch after said projectile passes through said summit.

2. A system as set forth in claim **1** in which said fluidic control means comprises a sensor having a housing defining a volume, means dividing said volume into a first chamber having said first switch associated therewith and a second chamber having said second switch associated therewith, and pressurizing means for controlling the pressure in said chambers so that the pressure in said first chamber is less than the pressure in said second chamber below a first altitude during said ascent enabling said dividing means to actuate said first switch at said first altitude and the pressure in said first chamber being greater than the pressure in said second chamber above a second altitude during said descent enabling said dividing means to actuate said second switch at said second altitude.

3. A system as set forth in claim **2** in which said pressurizing means comprises a source of ram air, a first conduit connected between said source and said second chamber, a second conduit connected between said source and said first chamber, means venting said first chamber to ambient, and flow control means allowing flow of ram air through said first conduit into said second chamber until an initial predetermined pressure is reached therein and then allowing flow into said first chamber so that the pressure in said first chamber is equal to atmospheric air pressure plus all of the dynamic pressure caused by said ram air, and as said projectile passes through said first altitude traveling toward said summit said first switch is actuated and as said projectile descends from said summit through said second altitude said second switch is actuated.

4. A system as set forth in claim **3** in which said dividing means is in the form of a flexible diaphragm.

5. A system as set forth in claim **1** in which said energy storage device comprises an electrical capacitor.

6. A system as set forth in claim **4** in which said flow control means comprises a one way valve device which allows pressurization of said second chamber until said predetermined pressure is reached, a third conduit connected between said first and second conduits, and valve means operatively associated with said second and third conduits and operating to allow flow through said third conduit once said predetermined pressure is reached and simultaneously allow flow through said second conduit to pressurize said first chamber.

7. A system as set forth in claim **6** in which said flow control means comprises a fluidic resistor in said third conduit.

8. A system as set forth in claim **1** in which said apparatus is an electromechanical apparatus.

9. A system as set forth in claim **1** in which said actuator is an electrical actuator.

10. A system as set forth in claim **1** in which said detonator means comprises a delay detonator and an instantaneous detonator for selective detonation upon impact.

11. A system as set forth in claim **4** in which said housing of said sensor is made of an electrical insulating material and said diaphragm is made of a metallic material.

12. A system as set forth in claim **10** in which said fuze has an extendible probe and means in said probe for actuating said detonator upon impact.

13. In combination: a projectile having a fuze and a safing and arming system for said fuze; said system comprising; an electromechanical apparatus for readying detonator means of said fuze for firing upon impact thereof; said apparatus having, an electrical circuit including a battery, an energy storage device, a first switch for activating said energy storage device by placing it in said circuit with said battery, an electrical actuator for moving said detonator means into position to be detonated upon impact, and a second switch for placing said energy storage device in the circuit with said actuator to enable actuation of said actuator; and fluidic control means for said apparatus, said fluidic control means operating to actuate said first switch during ascent of said projectile through its trajectory toward the summit thereof and operating to actuate said second switch after said projectile passes through said summit.

14. A combination as set forth in claim 13 in which said battery is a thermal battery.

15. A combination as set forth in claim 13 in which said energy storage device is an electrical capacitor.

16. A combination as set forth in claim 13 in which said fuze has an extendible probe and means in said probe for actuating said detonator means upon impact.

17. A combination as set forth in claim 16 in which said extendible probe comprises a volute spring.

18. A combination as set forth in claim 13 in which said fluidic control means comprises a sensor having a housing defining a volume, means dividing said volume into a first chamber having said first switch associated therewith and a second chamber having said second switch associated therewith, and pressurizing means for controlling the pressure in said chambers so that the pressure in said first chamber is less than the pressure in said second chamber below a first altitude during said ascent enabling said dividing means to actuate said first switch at said first altitude and the pressure in said first chamber being greater than the pressure in said second chamber above a second altitude during said descent enabling said dividing means to actuate said second switch at said second altitude.

19. A combination as set forth in claim 18 in which said pressurizing means comprises a source of ram air, a first conduit connected between said source and said second chamber, a second conduit connected between said source and said first chamber, means venting said first chamber to ambient, and flow control means allowing flow of ram air through said first conduit into said second chamber until an initial predetermined pressure is reached therein and then allowing flow into said first chamber so that the pressure in said first chamber is equal to atmospheric air pressure plus all of the dynamic pressure caused by said ram air, and as said projectile passes through said particular altitude traveling toward said summit said first switch is actuated and as said projectile descends from said summit through said other altitude said second switch is actuated.

20. A combination as set forth in claim 19 in which said dividing means is in the form of a flexible metal diaphragm.

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