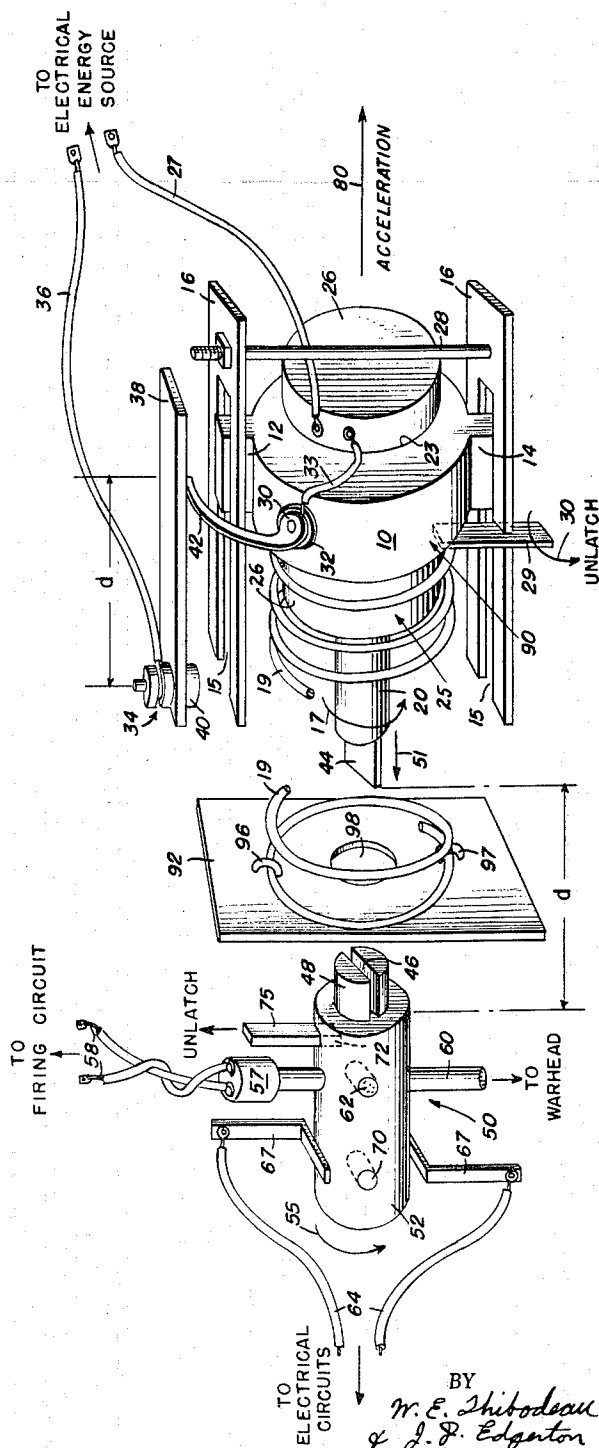


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1

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SAFETY AND ARMING DEVICE HAVING REMOTELY LOCATED ROTOR ACTUATING MEANS

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The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment to us of any royalty thereon.

This invention relates to safety and arming devices for use on ordnance missiles.

Safety in explosive ordnance devices has always been one of the most important design considerations. Beside protecting personnel, manpower and equipment, the provision of adequate safety is also an important psychological factor. Troops have been found to operate more effectively, with greater efficiency, and with higher morale, when they have faith in the safety of the devices which they are handling.

In explosive missiles such as bombs, rockets, projectiles, etc., it has been found that a reliable way of providing safety is to keep one portion of the explosive train out of line from the remaining portions until after the missile is launched. At some time after launching, the explosive train is caused to be aligned and the missile is said to be armed. A device which accomplishes the above is known as a safety and arming device. The out-of-line feature has become a basic principle in the design of safety and arming devices.

In the design of safety and arming devices for missiles, conventional practice in arming the missile has been to rotate an interrupter rotor so as to align a detonator with a missile firing train at some time after launching. One way of rotating the interrupter rotor which was used in the prior art, involved employing some rotor actuating means, such as a compressed spring or a solenoid, directly connected to the rotor. One or more latches, located either on the rotor or on the rotor actuating means, were used to prevent the rotor from being rotated until after launching.

It may be thought that the use of multiple latches on the rotor and the rotor actuating means, or some other complex restraining device to hold the rotor, would be capable of providing the required safety for most applications. Unfortunately, this is not the case. A degree of safety of the order of 1 premature detonation in 10,000 may be sufficient for conventional applications, but with the advent of atomic warheads, a safety of 1 premature detonation in 1,000,000 or more may be necessary. With such high degrees of safety required, any feature in the design which has even the remotest possibility of causing detonation must be considered and prevented if possible. Therefore, even where many latches are used to restrain the rotor, consideration must be given to the possibility of all the latches failing and the catastrophic results which would occur if the rotor actuating means were to become energized.

It has been found in the field that where the rotor actuating means is directly connected to the rotor, there is a greater tendency for premature detonation to occur and high degrees of safety cannot be obtained. In fact, because of this tendency to cause premature detonation, a

2

great aversion has developed to the use of such directly-connected rotor actuating means in ordnance devices. For these reasons there is a great need in the ordnance art for safety and arming devices which do not have directly-connected rotor actuating means.

One technique for providing a safety and arming device which has no directly-connected rotor actuating means capable of arming the rotor upon energization utilizes the forces of setback occurring upon launching to store up energy in a spring. For this purpose a g-weight type of cocking mechanism may be employed. This technique, although adding complexities in design, has proved satisfactory for relatively high-g missiles where large forces of setback are available. For relatively low-g missiles like some rockets and some of the modern guided missiles, the use of a g-weight cocking mechanism is not practical. This is because an unduly large g-weight is necessary to make use of the relatively low acceleration forces available. Large g-weights are impractical and tend to reduce the reliability and safety of the system.

This invention presents a new concept in safety and arming design which retains the advantages of the directly-connected rotor actuating device, but overcomes its main disadvantages. This device is applicable to low-g missiles where there is no equivalent device, and will provide considerable simplification over high-g missile safety and arming devices which store up energy upon launching. Therefore, the safety and arming device of this invention will be advantageous for use on both high and low-g missiles.

The present invention makes use of a relatively simple but unobvious technique for providing a safety and arming device in which there is no direct connection between the rotor actuating means and the rotor until after the missile is launched. This is accomplished by providing a rotor actuating means having a high energy potential which is initially located in a remote position from the rotor. In such a remote position, even if all latches failed, and the rotor actuating means were energized, there would be no rotation of the rotor. No safety and arming device of the prior art has this important feature. Means are provided for bringing about a direct connection between the rotor actuating means and the rotor in response to a condition which is unique to proper missile operation. The condition that the forces derived from missile environment, such as acceleration, motor pressure, heating effect, etc., be present for some minimum time after launching is an example of such a condition. For example, the forces of acceleration due to launching may be used to move the rotor actuating means from its remote position where it is disconnected from the rotor, to a position where it will be in direct connection with the rotor when the requisite missile acceleration is present for a predetermined minimum time. Since the forces of acceleration are only used to engage the rotor actuating means, and are not used to provide the stored energy as is done in the high-g missile, an unduly large g-weight is not necessary.

A chief object of this invention, therefore, is to provide a simple safety and arming device having no direct connection between the rotor actuating means and the rotor until after some condition which is unique to missile operation.

Another object is to provide a safety and arming device as just described which can be adapted for use on both low-g and high-g missiles.

A further object of this invention is to provide a reliable safety and arming device having a very high degree of safety.

The specific nature of the invention, as well as other objects, uses, and advantages thereof, will clearly appear

from the following description and from the accompanying drawing, in which:

The drawing is a perspective view of a safety and arming device in accordance with the invention.

Referring to the drawing, the perspective view has been chosen to clearly show the functional interrelation of the parts of the device; this functional interrelation is the chief feature of this invention. The device there shown is housed within a casing (not shown) having suitable cavities and supporting structure (not shown) to receive and support the parts. Since the casing, cavities, and supporting structure can readily be supplied by those skilled in the art, these structures have been omitted so that the drawing may clearly illustrate what are believed to be the novel features of this invention.

In the drawing, an acceleration-sensitive mass 10, which may be disc-shaped as shown, has guide bars 12 and 14 affixed thereto. These guide bars 12 and 14 ride in the grooves 15 of a guiding framework 16 so that the acceleration sensitive mass 10 is movable only along the guiding framework 16. Within the acceleration-sensitive mass 10 is a bore 23 in which a rotor actuating means 25 having a shaft 20 is placed and affixed to the acceleration-sensitive mass 10 by suitable means (not shown). The acceleration-sensitive mass 10, and the rotor actuating means 25 with shaft 20 comprise the movable unit 90. The rotor actuating means 25 may be a cylindrically-shaped solenoid 26 passing through the bore 23 which rotates the shaft 20 ninety degrees in the direction of the arrow 17 when electrical energy is applied to the solenoid. Alternatively, the rotor actuating means 25 may comprise a cocked spring (not shown) which rotates the shaft 20 through a desired angle when the spring is released.

A spring 19, fragmentarily shown in the drawing, biases the acceleration-sensitive mass 20 and the rotor actuating means 25 affixed thereto against a rod 28 supported by the guiding framework 16. The spring 19 is supported at one end by a stationary plate 92 having retaining members 96 and 97. The plate 92 has a hole 98 which is large enough to pass the shaft 20. The other end of the spring 19 presses against the acceleration-sensitive mass 10. A launch latch 29 may be provided to prevent vibration or unwanted movement of the movable unit 90 until after launching.

A terminal 30 is mounted on the outside of the acceleration-sensitive mass 10 and electrically insulated therefrom by means of the insulating washer 32. One solenoid lead 33 is connected to the terminal 30 and the other solenoid lead 27 is connected to an electrical energy source (not shown). The other end of the electrical energy source is connected by means of a lead 36 to another terminal 34 mounted in a flat member 38 of insulating material running parallel to the guiding framework 16. The terminal 34 includes a screw having a head 40 which projects from the underside of the member 38. The terminal 30 has a spring arm 42 which presses against the insulating member 38 and is adapted to make electrical connection with the screw head 40 when the movable unit 90 moves the distance d .

A rotor assembly 50, shown in the unarmed position, comprises a rotor shaft 48 and a cylindrical rotor portion 52, adapted for 90-degree rotation to an armed position around the longitudinal axis of the rotor assembly 50 in the direction of the arrow 55. The rotor assembly 50 is prevented from longitudinal movement by suitable supporting structure (not shown). A missile explosive train is represented by a detonator 57 on one side of the rotor portion 52, a powder filled tube 60 axially disposed on the opposite side of the rotor portion 52, and a powder-filled tube 62 located within the rotor portion 52, 90 degrees out of line with the detonator 57 and the powder filled tube 60. An associated electrical circuit which is to be completed upon arming is represented by the leads 64, metal members 67 pressing on opposite sides

of the rotor portion 52, and a tubular metallic member 70 mounted within the rotor portion 52 ninety degrees out of line with the metal members 67. Certain sections of the rotor portion 52 may be made of insulation material to prevent shorting of members 67. The rotor portion 52 may have a recess 72 into which a rotor latch 75 may be inserted to prevent the rotor assembly 50 from being joggled by vibration during transportation and handling.

The rotor shaft 48 has a slot 46 which is adapted to mesh with a flattened end 44 of the shaft 20 when the movable unit 90 moves the distance d along the guiding framework 16. Any equivalent coupling scheme may be employed for this same purpose. The rotor latch 75 may be used to insure that the slot 46 of the rotor shaft 48 remains in line with the flattened end 44 of the shaft 20.

Prior to launching, the launch latch 29 prevents the movable unit 90 from moving or vibrating during handling and transportation. Similarly, the rotor latch 75 prevents the rotor assembly 50 from vibrating during handling and transportation. Even if both latches 29 and 75 were to fail, and the rotor actuating means 25 were energized so that the shaft 20 rotated, the rotor assembly 50 would not rotate into an armed position. This is because there is no direct connection between the rotor assembly 50 and the rotor actuating means 25. Only one situation can be imagined which might cause premature arming of the rotor assembly 50. For such premature arming to occur both latches 75 and 29 must fail or have failed, some shock or vibration must cause the movable unit 90 to move the distance d , and simultaneously, the rotor actuating means 25 must be energized. The possibility of such a combination of circumstances is extremely remote. This is because it would be practically impossible for the type of vibration and shock which occur in handling and transportation to cause the movable unit 90 to remain at the required distance d for a time sufficient to cause arming if the rotor actuating means 25 were simultaneously to become energized. The distance d may be chosen to prevent this from occurring. Furthermore, even if the movable unit 90 were to momentarily be moved the distance d , this condition would only exist as long as the proper acceleration in the proper direction were present. Once the acceleration ceased, the movable unit 90 would move back to its remotely located position.

The operation of the safety and arming device of the drawing may be explained as follows. The device shown is placed in a missile so that the acceleration caused by launching is in the direction of the arrow 80. Upon initiation of launching, the launch latch 29 is rotated out of the path of the acceleration-sensitive mass 10 in the direction of the arrow 30. This may be accomplished by electrical, mechanical, manual, or any other suitable means well known to those skilled in the art. As the missile is launched, acceleration due to launching causes the movable unit 90 to move in the direction of the arrow 51, compressing the spring 19. Under continued acceleration for a sufficient time, this unit 90 moves substantially the distance d so that the flattened end 44 of the shaft 20 meshes with the slot 46 in the rotor shaft 48. The flattened end 44 will remain meshed in the slot 46 as long as the acceleration remains above some minimum value. For a given missile launching acceleration, the weight of the movable unit 90 and the characteristics of the spring 19 are chosen so that the movable unit 90 will move in the direction of the arrow 17 under the acceleration of launching. The distance d is chosen so as to require that the launching acceleration be present for a predetermined minimum time before the stored energy means 25 becomes directly connected to the rotor assembly 50. This assures that the missile is a safe distance from the launching site before arming is possible. The distance d may also be chosen to be sufficiently large so that the movable unit 90 will not be

moved the distance d by the shock and vibration which may occur during transportation or handling.

When the launching acceleration is present for the requisite time and the movable unit 90 has moved the distance d , the rotor actuating means 25 is directly connected to the rotor assembly 50 and the spring arm 42 of the terminal 30 is in electrical contact with the screw head 40 of the terminal 34 completing the electrical circuit to the solenoid 26. At some predetermined time after launching the rotor latch 75 is unlatched freeing the rotor assembly for rotation. Unlatching of the rotor latch 75 may be accomplished by a timing mechanism, a pressure device, or any other suitable means well known in the art. When arming is desired which may be determined by altitude, time, pressure, or whatever means is used to initiate final arming, electrical energy is applied to leads 36 and 27 energizing the solenoid 26 which rotates the shaft 20 and the directly connected rotor assembly 50 through an angle of 90° in the direction of the arrow 17. For this to occur, sufficient acceleration must of course still be present so that the flattened end 44 is meshed in the slot 46. Rotation of the rotor assembly by 90 degrees lines up the explosive train 57, 62, 60 and completes the associated electrical circuit 67, 70, 67 so that the device is now in the armed condition.

For some missiles it may be desirable or necessary to complete final arming after motor burnout where missile acceleration has ceased. For such missiles, means may be provided for locking the movable unit 90 at the distance d so that the flattened end 44 will remain meshed in the slot 46 when the acceleration ceases. This locking may take place when the movable unit 90 has been held at the distance d for some predetermined minimum time. In the device shown in the drawing, this may be accomplished by making the launch latch 29 serve a second purpose. At some time after launching when the movable unit 90 is at the distance d , the latch 29 may be rotated back (opposite to arrow 30) so that it is in the path of the movable unit 90 and will hold the unit 90 at the distance d after acceleration ceases. If so desired this may be accomplished at the same time, and by the same means, which unlatches the rotor latch 75. Thus, final arming may now be initiated by energizing the solenoid 26 even after burnout where acceleration has ceased.

Although a specific embodiment is shown in the drawing various modifications may be made within the scope of the invention. For example, the movable unit 90,

the rotor assembly 50, the guiding framework 16, the latches 29 and 75, and any of the other elements, may be changed and modified to suit any particular application.

It will be apparent that the embodiments shown are only exemplary and that various modifications can be made in construction and arrangement within the scope of the invention as defined in the appended claims.

We claim as our invention:

1. A safety and arming mechanism for use in a missile comprising: a first rotatable shaft, a movable unit housing said first shaft for movement therewith, shaft rotating means housed by said unit, said shaft rotating means rotating said first shaft after said unit moves a predetermined distance in response to sustained missile acceleration, a second rotatable shaft, a rotatable rotor assembly for arming said missile upon rotation thereof to an armed position, said second rotatable shaft extending from said rotor assembly and adapted to rotate said assembly to said armed position, a slot formed in one end of said second shaft, means for mating with said slot formed on one end of said first shaft, said slot and means for mating with said slot coupling said first and second shafts together upon movement of said movable unit through said predetermined distance, a coil spring positioned between said movable unit and said rotor assembly and resiliently urging said slot and said means for mating with said slot apart in the absence of missile acceleration, said movable unit moving said predetermined distance and compressing said spring under sustained missile acceleration until said slot and said means for mating with said slot couple, said shaft rotating means rotating said first shaft upon movement of said unit through said predetermined distance until said rotor assembly rotates to said armed position.

2. A safety and arming mechanism as recited in claim 1, in which a first latch means for preventing movement of said movable unit is provided, said first latch means being released at missile launching, and a second latch means preventing rotation of said rotor assembly, said second latch means being released after missile launching.

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