March 17, 1970 L. C. PARKER 3,500,747

SAFE-ARM INITIATOR

Filed May 17, 1968 3 Sheets-Sheet 1

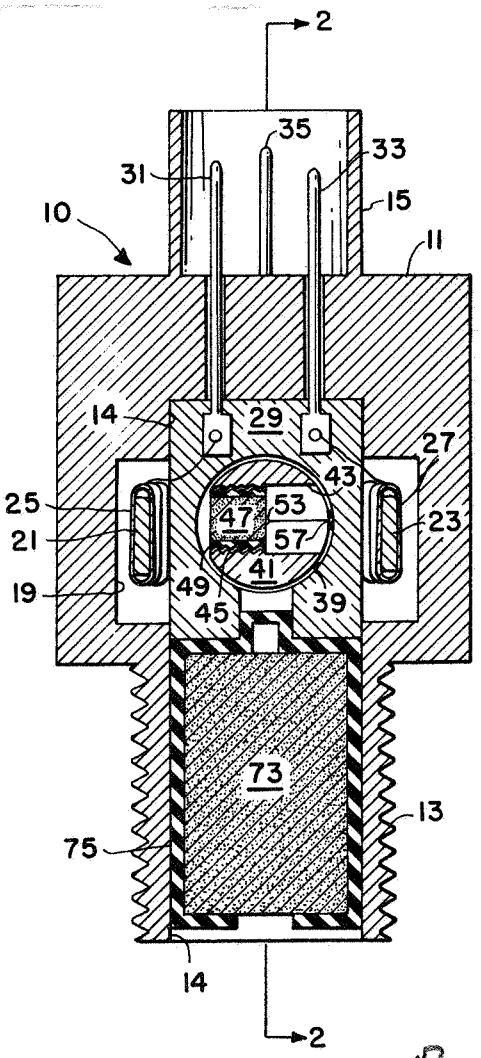

FIG. 1

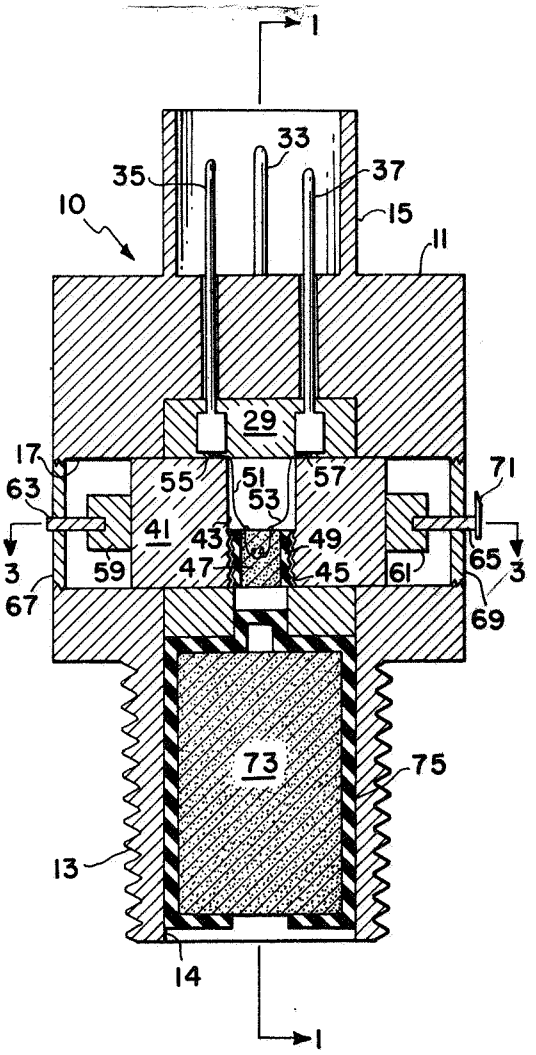

FIG. 2

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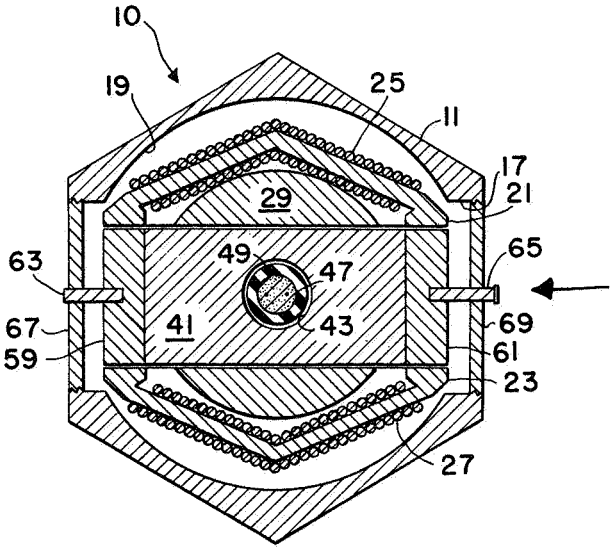

FIG. 3

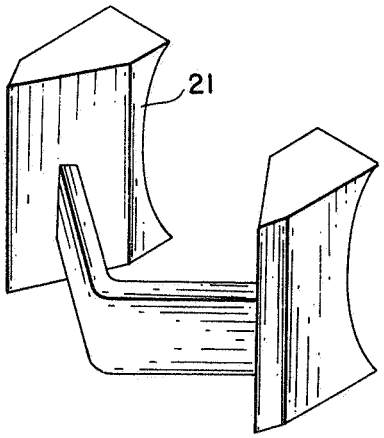

FIG. 5

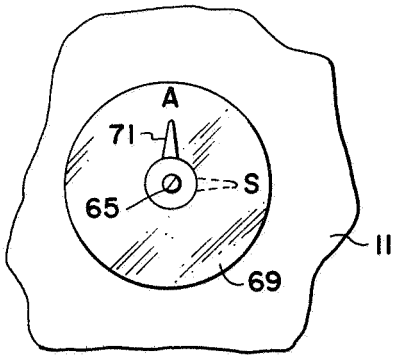

FIG. 4

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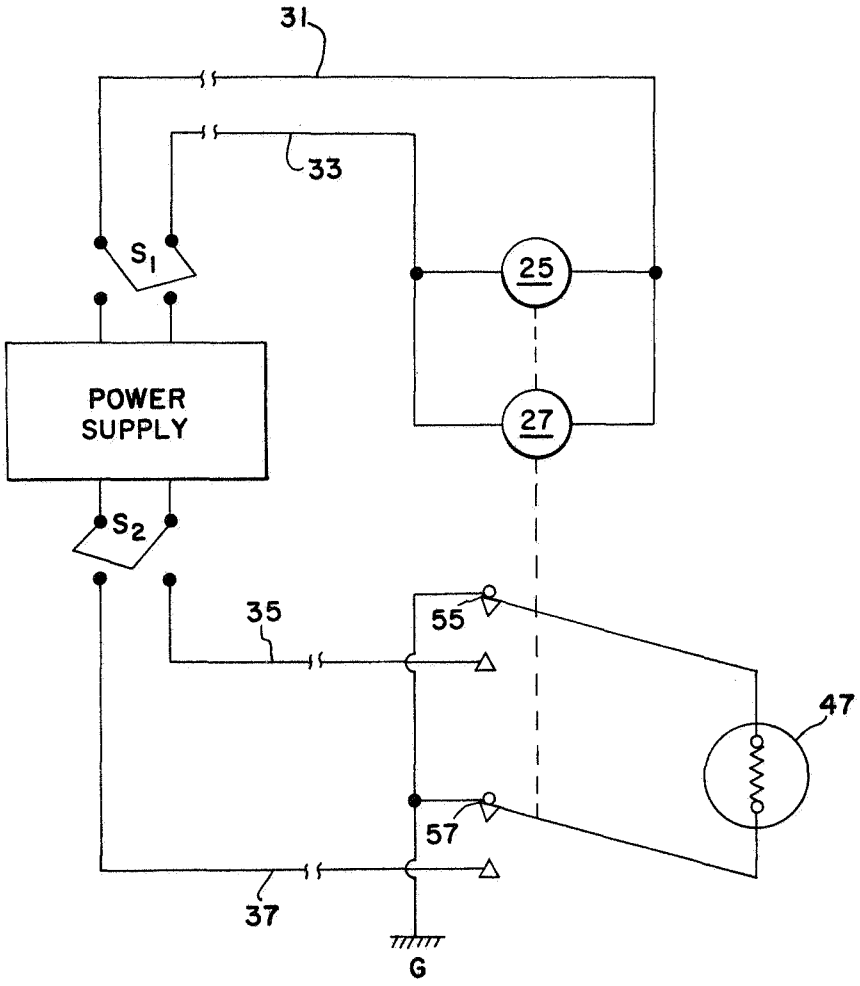

FIG. 6

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SAFE-ARM INITIATOR

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Int. Cl. F42c 13/08
U.S. Cl. 102—70.2 5 Claims

ABSTRACT OF THE DISCLOSURE

A safe-arm firing-type initiator in which a first charge of electrical current is passed to electromagnetic rotor drive coils and electromagnets to cause rotation of an out of line ignition bead or primary charge housed within a rotor to a second position in which the primary charge is in line with an explosive output charge and a second electrical current is passed to the ignition bead through internal contacts that close upon alinement and cause sufficient heat to be generated by the bridge wire to thereby ignite the ignition bead and initiator output charge by means of heat, deflagration or detonation, depending upon the type of primary explosive ignition bead employed in a particular initiator.

This invention was made by an employee of the National Aeronautics and Space Administration and may be manufactured and used by or for the Government of the United States without the payment of any royalties thereon or therefor.

This invention relates generally to an electroexplosive initiator and relates in particular to a safe-armed firing-type initiator (SAFTI) wherein all the safety advantages of currently employed electro-mechanical safe-arm fuze systems are incorporated in a standard weight and size initiating unit which has the functioning speed of a relay and construction that enables comprehensive testing to be performed thoroughly, yet inexpensively.

All presently employed electromechanical and mechanical safe-arm devices are designed to house the full-size initiator as an internal component. These devices provide mechanisms which prevent propagation of the explosive or heat and pressure output of the initiator unit to the rest of the explosives system such as the detonators, igniters, etc. The electromechanical safe-arm device also provides electrical safety to the enclosed initiator by disconnecting its electrical inputs from any outside source and by maintaining a short circuit and internal ground across the initiator bridge wire or heater element until the unit is placed in an armed position.

Prior designs of electromechanical and mechanical safe-arm devices are normally constructed to withstand the rated output of the enclosed initiator of heat, pressure and shrapnel, while in the safe position without allowing propagation to occur or without exploding and creating hazards to anyone handling or installing the unit. These prior art devices have inherent disadvantages in that in order to withstand the forces generated by the internal initiator, the unit must be large and heavy as compared to the parameters of a single initiator. In addition, the size and weight requirements of the safe-arm prior art devices generally restrict their usage to only those vehicles or explosives systems where space and weight are not too important. Since it is difficult to adapt these units for general use, because of the weight and space limitations, they are not presently used on sounding rocket systems or for providing protection on ancillary explosive systems on both small and large rocket vehicles and the use thereof is almost entirely restricted to destruct systems and to very large military rocket motor systems.

In the present invention an attempt is made to provide an electroexplosive initiator which, by its internal design features, has all the safety advantages of the presently used electromechanical safe-arm devices but has the weight, size, and features of a standard initiator; the functioning speed of a relay; and construction that enables comprehensive testing to be performed thoroughly, yet inexpensively.

Accordingly, it is an object of the present invention to provide a new and novel safe-arm firing-type initiator.

Another object of the present invention is to provide an initiator having safe-arm features but the weight and size of standard initiators.

Another object of the present invention is a safe-arm firing-type initiator so constructed as to enable comprehensive testing to be performed thoroughly, yet inexpensively.

Another object of the present invention is to provide, in a safe-arm initiator, a rotor which interrupts the explosive energy train at the lowest practical point internal to the initiator unit.

Another object of the present invention is to provide a relay type action which performs safe-arming or safe-armed firing actions in an initiator.

Another object of the present invention is to provide a readily replaceable ignition bead or primer mix in an explosive initiator which can be tested and replaced without destruction of the entire initiator heat unit.

According to the present invention, the foregoing and other objects are attained by providing an electroexplosive initiator which, by its internal features, has all the safety advantages of the currently used electromechanical safe-arm fuze devices but has the weight, size and features of a standard initiator. The initiator unit includes a houisng having an explosive train therein and adapted to initiate a missile firing system, or the like, wherein a rotatable rotor disposed in the housing and containing an electrically responsive bridge wire and ignition bead is rotatably movable from a first position in which the ignition bead is diametrically opposed to the remainder of the explosive train to a second position in which the ignition bead is in alinement with the explosive train. A magnet is provided at each end of the rotor unit with a pair of electrical coils being provided in the initiator housing which, upon actuation, serve as an electrical magnet and influence rotation of the rotor from its first safe position to its second armed position. The circuit for electrically igniting the initiator bead is shorted out and grounded internally when the rotor is in its first safe position and, upon rotation of the rotor to its second position the firing circuit is completed by removing the short and closing internal contacts. Upon application of electrical power to the bridge wire the initiator bead is then fired.

A more complete appreciation and many of the attendant advantages thereof will be readily apparent as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIG. 1 is a sectional view of the initiator of the present invention when the rotor is in the safe position;

FIG. 2 is a sectional view taken along lines 2—2 of FIG. 1, but with the arming rotor being disposed in the armed position;

FIG. 3 is a sectional view taken along lines 3—3 of FIG. 2;

FIG. 4 is a partial view of the initiator unit of the present invention when looking along the arrow in FIG. 3;

FIG. 5 is a view of one of the electromagnets with the coil thereof removed; and

FIG. 6 is a schematic diagram of the electrical arming and firing circuit of the present invention.

Referring now to the drawings wherein like reference numerals designate identical or corresponding parts throughout the several views, and more particularly to FIG. 1 there is shown an initiator unit according to the present invention and generally designated by the reference numeral **10**. Initiator unit **10** includes a housing **11** having an open threaded end **13** and a connector pin protective sleeve **15** provided at the opposite end. The major length of ignition housing **11** is provided with a longitudinal bore **14** extending from threaded end **13** into the housing unit. A diametrically opposed bore **17** (FIG. 2) is provided through housing **11** and intersects bore **14** adjacent the internal end thereof. Housing **11** is also provided with a counterbore **19** adjacent the end of longitudinally extending bore **14** as will be further explained hereinafter.

As shown more particularly in FIG. 3, a pair of electromagnet pole faces, designated by reference numerals **21** and **23**, are disposed in counterbore **19** and each of which is provided with a coil of electrically conductive wire around the electromagnet core thereof as designated respectively by reference numerals **25** and **27**. Electromagnets **21** and **23** are retained in position within counterbore **19** by means of a rotor receiving unit **29** which is slidably received within bore **14** of housing **11**. Rotor receiving unit **29** also has four integrally secured electrical leads attached thereto. These two pair of electrical leads are designated respectively as **31** and **33** (FIG. 1), **35** and **37** (FIG. 2). Leads **31** and **33** serve to provide an electrically parallel connection to electric coils **25** and **27**, respectively, while leads **35** and **37** serve to provide electrical connection to the ignition charge as will be further explained hereinafter. Rotor receiving unit **29** is also provided with a diametrically opposed bore **39** of essentially the same diameter as bore **17** in housing **11**. When placed in the position as shown in FIG. 1 and FIG. 2, rotor receiving unit **29** slidably receives the rotor unit **41**. Rotor **41** is provided with a diametrically opposed stepped bore **43** intermediate the length thereof with the smaller step thereof being provided with threads **45** throughout its length. An ignition bead or primer mix **47** is disposed in a suitable threaded cup **49** and threadingly positioned within threaded step **45** of rotor **41**. Threaded cup **49** may be composed of any suitable plastic or nonconductive material. A bridge wire is disposed within primer mixed **47** in a conventional manner and connected by way of lead wires **51** and **53** to a pair of electrical contacts **55** and **57** disposed on the exterior circumference of rotor **41**. As shown in FIG. 2, when rotor **41** is disposed in the armed condition the electrical contacts **55** and **57** will make electrical connection respectively with the contacts of electrical leads **35** and **37**.

As shown more particularly in FIG. 2 and 3, a pair of permanent magnets **59** and **61** are provided integrally secured to opposite ends of rotor **41**. The end faces of each magnet **59** and **61** are provided on an arc serving to provide a continuous circumferential surface with the rest of rotor unit **41**. As shown more particularly in FIG. 5 the ends of the electromagnets are of concave configuration so as to receive the arc surface of magnets **59** and **61** therein when rotor **45** is moved to the armed position. Each magnet **59** and **61** is provided with an axle for rotor **41** and as designated by reference numerals **63** and **65**. Diametrically opposed bore **17** in housing **11** is closed by suitable end closures **67** and **69**, threadingly or otherwise conventionally sealed to housing **11**, and serving as bearing structures for axles **63** and **65**, respectively. As shown more particularly in FIG. 4, end closure **69** is provided with suitable indicia thereon. A pointer **71**, which is conventionally attached to axle **65**, serves to point to the indicia on closure **69** to indicate the position of rotor **41** when it is in the safe and armed condition and to manually reposition rotor **41** in safe position when so desired.

ASSEMBLY

For assemblying the initiator **10** of the present invention, housing **11** which may be formed by any conventional cast, molding or milling operation and provided with the necessary bores and counterbores therein for receiving the electrical leads **31**, **33**, **35** and **37**, rotor receiving unit **29**, electromagnets **21** and **23**, and end closures **67** and **69**. Electromagnets **21** and **23** are electrically connected to leads **31** and **33** and placed in position within counterbore **19** in housing **11** with rotor receiving unit **29** being slidably received through bore **14** so as to maintain the electromagnets in position. As mentioned hereinbefore, electrical leads **31**, **33**, **35** and **37** are integrally secured to rotor receiving unit **29** and adapted to be received by suitable insulated bores within housing **11** when the rotor receiving unit **29** is placed in position. Leads **31** and **33** remain internally connected to electromagnets **25** and **27** when the rotor receiving unit **29** is placed in position. Rotor unit **41** with its primer charge having previously been inserted therein is slidably received through diametrically opposed bore **17** in housing **11** and bore **39** within rotor receiving unit **29**. Rotor **41** is positioned within housing **11** in the unarmed or safe condition with the electrical contacts **55** and **57** thereon being shorted out against rotor receiving unit **29**. End closures **67** and **69** are then placed about axle **63** and **65**, respectively, and pointer **71** attached to axle **65** to indicate the rotor is in the safe condition. A suitable propagating charge or explosive train **73** contained, for example, in plastic cup **75** is then slidably positioned within bore **14** of housing **11** so as to be in alinement with primer **47** when the primer charge is ignited. The initiator unit **10** is then in condition to be employed in any suitable initiating system.

OPERATION

The operation of the initiating unit **10** of the present invention is now believed apparent but will further be explained in reference to the schematic circuit diagram of FIG. 6. As described hereinbefore electrical leads **31** and **33** are provided in electrical connection with the electrical coils **25** and **27** disposed respectively about the electromagnets **21** and **23** and serve to provide the arming energy to initiator unit **10**. When a suitable current is provided through leads **31** and **33**, as for example when switch S_1 is closed, electromagnets **21** and **23** are actuated through coils **25** and **27** to influence the rotation of rotor **41** from the safe position shown in FIG. 1 to the armed position shown in FIG. 2 through the influence of the attached magnets **59** and **61**. This armed position is indicated by exteriorly disposed pointer **71** provided on axle **65** of rotor **41** and removes rotor contacts **55** and **57** from their ground to a closed position and mated with the contacts formed by electric leads **35** and **37**. In the event it is desired not to fire the initiator at this time a reverse polarity current may be applied to leads **31** and **33** causing rotation of rotor **41** in the reverse position to its safe condition where ignition bead **47** is again shorted. Alternatively, pointer **71** may be manually turned from the armed position indicated in FIG. 4 to that position shown in dotted lines therein to the safe position to provide the initiator **10** again safe with primer charge **47** being shorted out. However, in most instances, once the initiator unit is armed it will be desrable to fire the initiator unit **10** and electrical current will be applied to electrical leads **35** and **37** as, for example, by closing switch S_2, to send current flow through contacts **55** and **57** and leads **51** and **53** to cause heating of the bridge wire within primer **47** to thereby heat or explode the bridge wire and cause ignition or detonation of primer mix **47** with subsequent ignition or detonation of the main explosive train **73** leading to the system in which firing is desired.

When it is desired to utilize the initiator **10** as a relay type firing system, switch S_2 would be closed first in order that upon actuation of switch S_1 the primer charge **47** would be ignited simultaneously upon being moved to the armed position.

Although the invention has been described in regard to a specific ignition system, it is to be understood that, by the substitution of specific type charges for primer charge **47** and the explosive train **73**, the initiator **10** of the present invention may be adapted for the initiator unit in any explosive or ignition type system.

The advantages of the present invention are now believed apparent. Specifically, the present invention provides both electrical and mechanical safety systems internal to a normal size electroexplosive initiator or squib which prevent initiation or propagation of the initiator due to any external forces acting thereon. The electrical arrangement internal to the initiator of the present invention provides complete protection from accidental ignition by electrical, electrostatic or R-F sources. In addition, the internal mechanical safety features of the present invention block the initiator propagation at a point where the explosive energy is normally at its lowest level rather than at some point later in the explosive train where the energy levels become much greater. Also, the relay type action capable of the safe-arm mechanism of the present invention provides an alternate high-speed method of firing this device.

For these applications where it is desirable to provide complete protection, as for example during flight of a vehicle, the unit would remain in the safe condition with voltage veing supplied the initiator output pins **35** and **37** prior to arming. Firing would then be accomplished by the arming command to the safe-arm initiator through pins **31** and **33**. This mode of operation would be especially desirable in manned vehicle systems where an early or unplanned firing would be disastrous. The delay time required for this type of alinement and firing is approximately 30 milliseconds which is comparable with existing firing relays based on measurements made on a specific embodiment of the invention as described herein. This mode of operation, thus, in effect, combines the initiator, the firing relay and the inter-connecting cable into a single unit thereby greatly improving circuit reliability and safety.

As described hereinbefore, certain features of the present invention provide flexibility in selecting the input-output characteristics and for low-cost quality assurance testing. Thus, the initiation charge or primer **47** which is packeged in a bead within its separate, easily replaceable, threaded cup **49**, provides for testing of this charge separately from the main initiator unit to thereby provide a low-cost assurance test of the initiator unit. This low cost item is readily variable with power and resistance requirements suitable to the proposed systems usage. The output charge **73** is also flexible in that both quantity and quality, that is, detonation or deflagration type explosive trains can be carried within the capability of bore **14** within igniter housing **11**. Since both the primer and output charge are low-cost, they can be purchased in large quantities for qualification testing and these tests performed in fixtures to verify their reliability. Thus, SAFTI (an acronym for the safe-arm firing-type initiator of the present invention) can be qualified using non-destructive testing techiques applicable to standard relays.

Modifications of the present invention would include, for example, in a purely mechanical system, the rotor could be spring-driven to armed position with a suitable lanyard serving to release the spring pressure to permit the drive of the motor rotor to its armed position. This would involve a simple modification of the end closure bearings to provide a driving spring for rotor **41** with a suitable lanyard release mechanism being disposed on pointer **71** or a suitable extension of axle **65**. Also rotor **41** could be spring-loaded to the safe position and be adapted to return to safe position when rotor drive coil voltage is removed giving unit time relay type action. Modification of the end closure bearings and safe arm indicator to provide the spring and removal of the external indicator would readily accomplish this type of modification with the unit being provided with a vacuum seal to prevent out-gassing. In addition to the above, the use of dual bridge wires and dual drive coil design is readily feasible and may be incorporated in the present invention.

There are obviously many other modifications and variations of the present invention readily apparent to those skilled in the art in the light of the above teachings.

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

1. A safe-arm firing type explosive initiator comprising:
an initiator housing,
electrical circuitry contained in said housing and in electrical connection with a power supply,
said circuitry including a firing circuit and an actuating circuit,
an explosive train disposed in said housing,
a rotatable rotor in said housing,
said rotor containing an explosive primer and rotatably movable from a first position in which said primer is out of operative alinement with said explosive train to a second position in which said primer is in operative alinement with said explosive train,
means for shorting the electrical connection of said firing circuit and said electrical power means when said rotor is in said first position,
said rotor being rotated by said actuating circuit from said first to said second position and upon reaching said second position said firing circuit serving to ignite said primer to initiate said explosive train,
said housing being provided with
(a) a longitudinal cavity extending along the major length thereof and
(b) a transverse cavity extending through said housing and intersecting said longitudinal cavity,
said explosive train being disposed in said longitudinal cavity and said rotatable rotor being disposed in said transverse cavity,
said rotor consisting of a metallic electrically conductive material, and
said actuating circuit leading electromagnet means disposed about said rotor for influencing rotor rotation.

2. A safe-arm initiator as in claim **1** including:
a pair of end closures for said transverse cavity and adapted to hermetically seal said rotor in said housing,
one of said closures being provided with indicia thereon,
an axle secured to each end of said rotor for rotation therewith and extending through each said closure,
said axle extending through said one closure having a pointer secured thereto and adapted to point to said indicia to indicate the safe and armed position of said rotor.

3. A safe-arm initiator as in claim **2** wherein said pointer also serves as means permitting manual rotation of said rotor from armed to safe position.

4. A safe-arm firing type explosive initiator comprising:
a housing,
an explosive train in said housing,
a rotatable rotor containing an ignition bead for said explosive train and rotatably movable from a first position in which said ignition bead is out of operative alinement with said explosive train to a second position in which said ignition bead is in operative alinement with said explosive train,
electrical firing means for said ignition bead contained within said housing,
means for rendering said electrical firing means inoperative when said rotor is in said first position,

electrical means for influencing rotor rotation from said first position to said second position,

said electrical firing means causing ignition of said ignition bead to ignite said explosive train upon movement of said rotor to said second position, and

said electrical means for influencing rotor rotation including a pair of electromagnets disposed in said housing and a pair of permanent magnets disposed on said rotor.

5. A safe-arm firing type initiator for use as the initiator element in a missile firing system comprising:

an initiator housing,

an explosive train in said housing and adapted to initiate a missile firing system when actuated,

a rotatable rotor in said housing,

said rotor containing an electrically responsive bridge wire and ignition bead,

said rotor being rotatably movable from a first position in which said ignition bead is diametrically opposed to said exlosive train to a second position in which said ignition bead is in alinement with said explosive train,

means for electrically shorting said electrically responsive bridge wire when said rotor is in said first position to thereby render it safe from electrical actuation,

electromagnet means disposed about said rotor for effecting rotation of said rotor from said first to said second position to simultaneously (1) nullify said means for electrically shorting said bridge wire and (2) position said bridge wire and ignition bead in operative alinement with said explosive train, and

means for heating said bridge wire and igniting said ignition bead for actuation of said explosive train upon rotation of said rotor from said first to said second position,

said means for heating said bridge wire being actuated simultaneously with said rotor reaching said second position.

References Cited

UNITED STATES PATENTS

2,748,704	6/1956	Dinsmoor	102—70.2
3,052,784	9/1962	Ousley	102—70.2 X
3,207,075	9/1965	Semenoff	102—70.2
3,311,058	3/1967	Fohrmann et al.	102—70.2

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