United States Patent

Allen

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[54] SAFE ARM INITIATOR

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[52] **U.S. Cl.** **102/70.2**, 102/76

[51] **Int. Cl.** **F42b 5/08**

[58] **Field of Search** 102/70.2

[56] **References Cited**

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2,978,982 4/1961 Bianchi ..... 102/70.2 A

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Primary Examiner—Samuel Feinberg

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[57] **ABSTRACT**

An initiator in which the igniter is separated from the output charge by a rotor of magnetic material. The rotor provides an ignition path between the igniter and the output charge only when the rotor is rotated into an armed position. The rotor is normally magnetically restrained in a safe position, and is rotated into its armed position by the application of an electrical arming signal to an electromagnetic coil acting upon the rotor.

1 Claims, 4 Drawing Figures

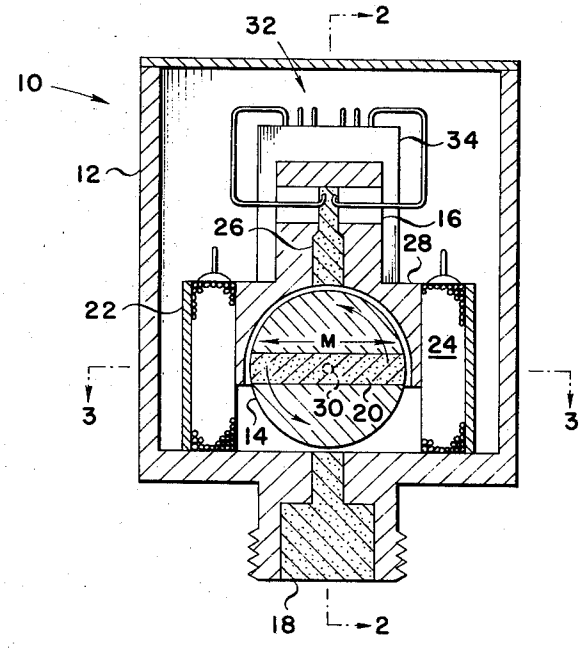


FIG. 1

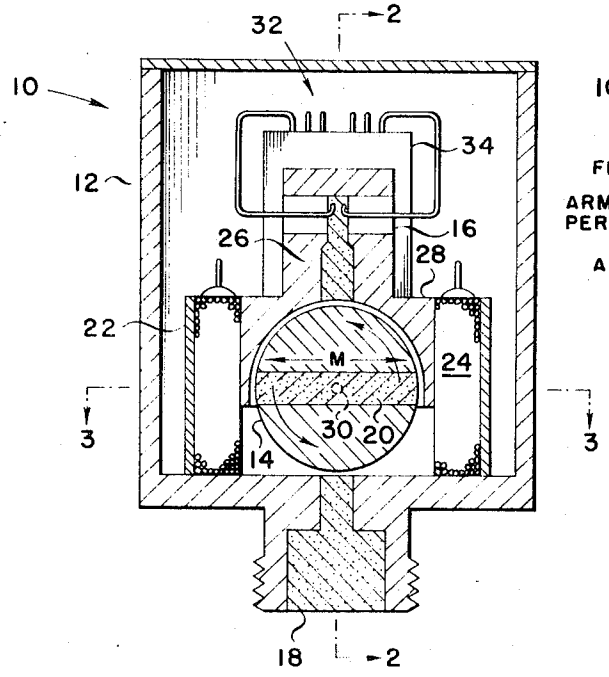
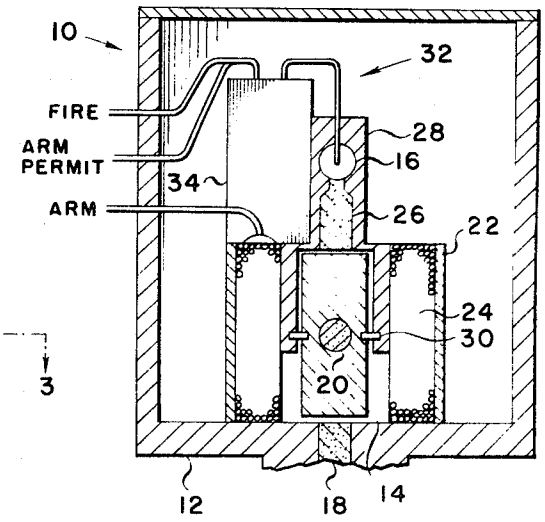


FIG. 2



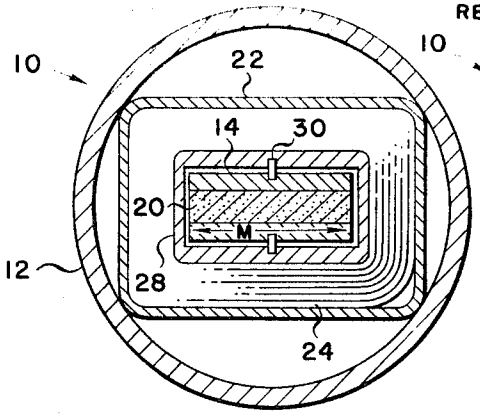


FIG. 3

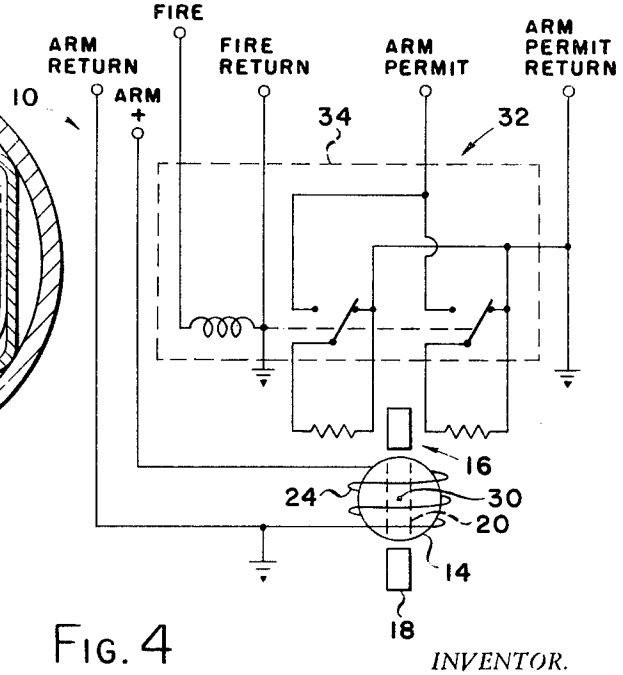


FIG. 4

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SAFE ARM INITIATOR

The present invention relates to a safe/arm initiator in which positive mechanical interruption of the firing train is achieved by a simple electrical system utilizing an electromagnetically actuated rotor. A simple, reliable and miniaturized initiator which may be actuated by low voltage is provided.

The providing of a lightweight and highly reliable initiator is of great importance in the fields of explosives, pyrotechnics, propulsion systems and the like. Such igniters are often subjected to severe environmental conditions and forces, yet must ignite the desired charge with high reliability upon the firing command, and must positively insure against accidental or premature ignition through electrical or mechanical malfunctions. The size and weight of the initiator is critical in missiles and other projectiles, particularly where a large number of separate initiators are required. Low voltage initiators are preferable from a weight standpoint to the high voltage exploding bridge wire initiators presently in wide use, as the latter require a large and heavy electrical power supply arrangement. However the sensitivity of low voltage ignition charges necessitates a positive mechanical interruption of the ignition train from the igniter for absolute safety. Various complicated mechanically driven arrangements have been developed for interrupting the ignition train, some using rotors as shown for example in U.S. Pat. Nos. 2,915,013, 3,306,207, 3,311,058 and 2,978,982. These initiators require an external mechanical power source or, as in U.S. Pat. No. 2,978,982, the application of centrifugal forces. These prior arrangements are deficient in the light of the stringent requirements discussed above.

The initiator described herein may be completely sealed, requires only low voltage and low current arming and ignition signals, and is insensitive to environmental conditions or forces. It is highly suitable for miniaturized packaging in a self-contained hermetic unit of less than 1 cubic inch weighing only a few ounces. It can be directly connected to provide reliable ignition of any desired charge.

Further objects, features and advantages of the invention pertain to the particular arrangement and structure whereby the above mentioned aspects of the invention are attained. The invention will be better understood by reference to the following discussion and to the drawings forming a part thereof, which are substantially proportional, wherein:

FIG. 1 is a central cross-sectional view of an exemplary embodiment of the invention;

FIG. 2 is a cross-sectional view taken along the line 2 — 2 of FIG. 1;

FIG. 3 is a cross-sectional view taken along the line 3 — 3 of FIG. 1; and

FIG. 4 is a schematic of the initiator embodiment of FIGS. 1–3.

Referring to FIGS. 1 – 4, there is shown therein an exemplary safe/arm initiator **10** in accordance with the present invention. The initiator **10** includes a housing **12** containing a magnetic rotor **14** and an igniter **16** mounted therein. There is an output charge **18** adjacent the rotor **14** and spaced from the igniter **16**. The rotor **14** separates the igniter **16** from the output charge **18** to prevent ignition of the output charge by the igniter for any position of the rotor **14** other than an armed position. The rotor **14** has an ignition lead **20** extending therethrough. When the rotor is rotated into its armed position, the ignition lead **20** is interposed between the igniter **16** and the output charge **18** to complete the firing train. The rotor **14** is urged into and maintained in its safe position (shown in FIGS. 1–3) by the magnetic interaction of the rotor **14** with a magnetic shield **22**. The rotor **14** is rotated into its armed position (as shown in FIG. 4) solely by the application of a low voltage arming signal to an electromagnetic coil **24** surrounding the rotor **14**. The electromagnetic force provided by the coil **24** overcomes the permanent magnetic force urging the rotor **14** in its safe position.

Preferably the housing **12** is a rigid sealed container providing a complete hermetic seal for the entire initiator **10**, in which all components thereof are enclosed. No mechanical shafts or the like extend through the housing **12**. The only external connections are electrical circuits and the only mechanical movement is that of the rotor **14** itself, which is entirely inside the housing **12**.

The igniter **16**, or detonator, is shown here as having dual headers and dual bridge wires connecting with a single explosive column **26**. This provides a dual electro-explosive interface for increased reliability. The igniter **16** is otherwise conventional and the explosive material can be lead styphanate, lead azide or other suitable material.

The rotor **14** is mounted to, and partially enclosed within, a support frame **28** of non-magnetic material fixed to the housing **12**. The explosive column **26** of the igniter **16** is contained within the support frame **28** and opens only closely adjacent the outer surface of the rotor **14**. This opening of the explosive column **26** is preferably co-extensive in area and position with the corresponding end of the ignition lead **20** in the rotor **14** (when the rotor **14** is in its firing position). The support frame **28**, being of a non-ferromagnetic material, does not affect the magnetic circuits. It will be appreciated that other igniters, optical, percussion, etc., may also be used.

The housing **12** contains an output charge **18** designed to connect with and ignite the desired propellant, explosive or pyrotechnic. It may be seen that the output charge **18** communicates through the housing **12** to an opening directly adjacent the outer surface of the rotor **14**, opposite the explosive column **26**. It may be seen in FIGS. **1–3** that there is no communication between the igniter **16** and the output charge **18** with the rotor **14** in its normal or safe condition. The solid body of the rotor **14** and the support frame **28** confine and block any output of the igniter **16** from reaching the output charge **18**.

The rotor **14** (as well as part of its support frame **28**) is closely surrounded by the coil **24**. The coil **24** is of conventional construction, having a sufficient number of turns (e.g., 1400 turns of No. 40 wire) in a toroidal configuration to be able to overcome the low frictional forces on the rotor **14** with the application of a low battery voltage to the coil. The axis of rotation of the rotor **14** is perpendicular to the axis of the coil **24**. The coil **24**, when actuated, produces a magnetic field through the rotor **14** parallel the axis of the coil **24**. The outer surface of the coil **24** is surrounded by a continuous shield **22** of soft magnetic sheet metal. For example, permalloy of 0.006 inches thickness. Thus, the magnetic shield **22** also surrounds and encloses the rotor **14**, although spaced therefrom.

The rotor **14** is preferably entirely constructed as a solid cylinder of permanent magnetic material, for example Alnico. The rotor **14** is preferably magnetized, along a central radial axis as conventionally illustrated in FIGS. 1 – 3 by the symbol M and its associated arrows. It will be appreciated that a variable reluctance arrangement can be employed instead. The rotor **14** requires no mechanical support or connection other than conventional low friction bearings **30** on each side with which the rotor is rotatably mounted to the support frame **28**. No other mechanical connection or restraint is required for the rotor **14**. Of course additional indicators or switches may be provided for actuation by the rotor **14** to provide an external indication of the rotor position. Preferably the rotor is a solid balanced mass with its center of mass at the axis of rotation (the bearings **30**) so that the rotor **14** is not moved by external forces. The rotor **14** may be small and lightweight. The thickness need only be sufficient to confine the ignition lead **20**, and the diameter need only be sufficiently large to provide adequate separation between the igniter **16** and output charge **18**. The strength of the magnetization of the rotor **14** need not be large as in the rotating of the rotor **14** by the application of magnetic fields thereto only the low frictional forces in the bearings **30** need be overcome. The rotor **14** may thus be rapidly rotated from its safe position to its armed position upon the application of the arming current to the coil **24**. Eddy current effects are not utilized and do not affect the operation of the rotor **14**.

The ignition lead **20** through the rotor **14** comprises a continuous enclosed passageway opening at opposite sides of the rotor **14** and containing a suitable explosive material. Suitable conventional secondary explosives such as RDX or PETN may be used, for example. When the rotor **14** is in its firing position one end of the ignition lead **20** overlies and is closely spaced from the explosive column **26** and output charge **18**, respectfully, so as to provide a direct firing train or explosive column between the igniter **16** and the output charge **18**. With the rotor **14** in its safe position as illustrated in FIGS. **1–3** the ignition lead **20** is at right angles to the path between the igniter and the output charge and communicates with neither, i.e., the ignition lead **20** is misaligned and provides a positive safety.

The initiator **10** is maintained in its safe position without any mechanical restraints by the magnetic interaction of the rotor **14** with the magnetic shield **22**. The magnetic field of the rotor **14** magnetically couples to the shield **22** to rotate the rotor to a position in which the magnetic air gap is a minimum, which is the safe position. Thus, it may be seen that the rotor **14** is continuously magnetically urged out of its armed position into the safe position, and is magnetically maintained in its safe position. Only when sufficient arming current is applied to the coil **24** to establish a second and stronger magnetic field will the rotor **14** be rotated out of its safe position. With the configuration of the initiator **10** the rotor **14** will move from the safe to the arm condition upon the application of current to the coil **24** irrespective of the polarity of the arming current or the magnetic polarity of the rotor **14**. (The rotor **14** rotates 90°.) The initiator **10** provides excellent security against accidental arming by electrical noise or spurious electrical signals, even if applied through the arming circuit. The rotor **14** is not moved by alternating currents or brief intermittent electrical signals applied to the coil **24** irrespective of their intensity.

The rotation of the rotor **14** from its safe position to its armed position is accomplished solely by the application of a DC arming signal to the coil **24**. The coil **24** directly magnetically couples with the rotor to achieve the rotation and alignment in the firing position of the rotor **14** without any mechanical connection to the rotor. The rotor **14** will remain in its firing position, as shown in FIG. **4**, as long as the arming signal is applied. As soon as the arming signal is removed the rotor **14** is rotated back into its safe position by the magnetic attraction of the rotor by the shield **22**. The rotor **14** may be repeatedly armed or disarmed for test purposes without affecting its safety characteristics. The interaction of the magnetic field of the rotor **14** with the shield **22** continues to urge the rotor out of the armed position. However, the torque on the rotor due to this magnetic force is much less than the torque impressed on the rotor by the magnetic field of the coil **24**. Thus, the magnetic field of the coil **24** readily overcomes the existing magnetic force to align the rotor **14** with the magnetic field of the coil **24**.

A generally conventional safety firing circuit **32** is illustrated in FIG. **4** here. The firing circuit **32** incorporates a conventional double pole double throw relay **34** for a conventional firing and arm permit circuitry. It will be appreciated that this arrangement is not essential and that a simple initiator **10** can be provided with only an arm lead and fire lead (eliminating the relay and arm permit circuitry). However, it may be seen in FIGS. **1** and **2** that the initiator **10** readily provides for the integration of the firing circuit **32** therein, as the relay **34** may be mounted directly to the support frame **28** inside the housing **12**. The return circuits (ground leads) have been eliminated in FIGS. **1** and **2** for purposes of clarity. Conventional grounding of return circuits at a common point is indicated in FIG. **4**. Conventional electrical connectors and leads may be utilized to connect the initiator **10** to the external circuitry. As previously indicated all input circuits, both firing and arming, carry only low voltage, low power signals, unlike conventional exploding bridge wire circuitry.

It may be seen that there has been described herein an improved initiator which is simple, reliable and provides excellent safety against undesired ignition without requiring high voltage or high power circuitry or complex mechanical arrangements. The initiator may be manufactured at low cost in various forms. While the apparatus described herein is presently considered to be preferred, it is contemplated that further variations in modifications within the purview of those skilled in the art can be made herein. The following claims are intended to cover all such variations and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A safe/arm initiator comprising:

a housing;

a permanent magnetic rotor rotatably mounted in said housing;

said rotor having an ignition lead extending therethrough;

an igniter in said housing adjacent said rotor;

an output charge adjacent said rotor and spaced from said igniter;

said ignition lead being operatively interposed between said igniter and said output charge upon the rotation of said rotor into an armed position;

magnetic path means fixed in said housing around said rotor magnetically coupled to said rotor continuously magnetically urging said rotor out of said armed position;

and a non-magnetic material field coil in said housing magnetically coupled to said rotor and excitable by an arming signal applied thereto to overcome said magnetic path means by a stronger electro magnetic force acting angularly thereto and magnetically rotate said rotor into said armed position;

said rotor being magnetically rotated into and maintained in said armed position by the application of said arming signal to said field coil until said arming signal is removed;

said rotor being magnetically rotated out of said armed position and maintained out of said armed position by said magnetic path means automatically upon the removal of said arming signal from said field coil.

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