

CONTROLLED PYROTECHNIC TRAIN

FIELD OF THE INVENTION

The present invention relates to igniters and detonation in the context of a pyrotechnic train, in particular the invention relates to igniters in which a controllable interrupter is embedded.

BACKGROUND OF THE INVENTION

Igniting an energetic device such as a warhead or a rocket motor requires that the device is assembled and delivers its energy according to a schedule. Such a schedule ensures that the device does not undergo unintentional activation. A "detonation train" also known as "explosive train" is the reference given to the chain of activation elements, starting with the initiating element and ending with the explosive device itself. Generally, each link in the chain is separated from the preceding one by a barrier such as activation energy barrier or mechanical barrier that has to be surpassed in order to facilitate activation of the next link.

The pyrotechnic train is a term relating to a succession of initiator and charges that eventually respond to the initiator. In various applications, the prevention of unintentional detonation of the explosive device is of special significance. The "safe and arm" approach is one such method, in which an electrical powering first stage is required to initiate the train, and a mechanically manipulated interrupting mechanism is responsible for the controlled prevention of train conveying the activation energy to the explosive device.

MEMS (micro electromechanical systems) devices were disclosed that perform as safe and arm devices, for example US patent 7,069,861, US patent 7,052,562.

Such micro-devices function in micro scale as to mechanically manipulate the explosive train to prevent unintentional activation of the explosive device.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic sequence diagram showing the detonation train in which the present invention is implemented;

Fig. 2 is a schematic isometric view showing the external structural aspects of an igniter of the present invention;

Fig. 3A - C is a series of schematic isometric views showing the assembly of the MEMS chip on the header of the igniter;

Fig. 4A- C is a series of schematic isometric views showing the functional aspects of a blocker, and its displacement mechanism;

Fig. 5A- B is a series of schematic isometric views showing the functional aspects of the blocker blocking the entrance to an output charge capsule;

Fig. 6A-D is a series of schematic isometric views showing some structural aspects of the blocker blocking the optical path in the case of the initiator being a laser beam.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

Definition and clarification: throughout the present description, the term charge relates to a pyrotechnic device, also known as explosive device and not to an electric charge.

In accordance with an embodiment of the present invention, an igniter features a detonation train interruptible by a barrier implemented using MEMS technology. As the initiator in this embodiment, a semiconductor bridge (SCB) is employed. Such SCB igniter was demonstrated in several prior art publications. US patent 5,861,570 describes the SCB structural aspects, its juxtaposition with respect to the primary charge is essential to the transfer of energy of the igniter in the form of plasma.

Referring first to **Fig. 1**, there is shown in general, the detonation train in accordance with an embodiment of the invention. Typically, the detonation train of the invention is implemented in association with a rocket to provide safe ignition. The detonation train, constituting a sequence of events, is initiated by SCB initiator **22** which is fed by a predetermined current, causing it to heat, producing reactive environment that is able to set input charge **24**, which is disposed contacting initiator **22**, into a activation, such that it detonates and produces heat and energetic products. At this point along the detonation train, block **26** may be deployed or shifted away, according to which state the detonation train may stop or progress, respectively. Passageway **28** disposed after block **26** is able to channel hot plasma and gasses, if the block is shifted away, delivering some of it to output charge **30**. The output charge, when and if detonated activates propellant **32** that drives the rocket.

To describe structural aspects of the igniter of the invention, reference is made to **Fig. 2** first. Igniter **42** has four galvanic contacts **44**, the role of which will be explained below. The contacts connect to detonation train housing **46** and residing on top is output charge capsule **48**. The charge in this capsule is either a primary or a secondary charge. More details are described in **Figs. 3A-C**. In **Fig. 3A**, galvanic contacts **44** of which only three are shown, end each in the header **56**, their exposed ends **58** (two) and **60** (two) are shown on the topside of header **56**. In **Fig. 3B**, contact layer **62** is shown laid over the topside of header **56**, covering the exposed ends of galvanic contacts **44**. However, contact layer **62**, includes two galvanic contact pads **66**, which correspond each to one respective contact end **60**. In between contact pads **66**, initiator **70** connects at its two ends

to a respective contact **66**. As to the nature of the initiator, this can be inferred from US patent number 7,430,963 the contents of which relating to the initiator are incorporated herein by reference. In **Fig. 3B**, another link in the pyrotechnic train of the invention is shown. Perpendicular assembly (PA) **76** made of inert substrate resides with its narrow flank on contact layer **62**. Further details of the PA and its relations with other parts of the system in which the present invention is implemented are explained with reference to **Figs. 4A - C**. In **Fig. 4A** Contact layer **62** resides on top of the header, not shown, contact pad **66** connects to initiator **70**, while PA **76** is attached to contact layer **62**, covering some or almost all of initiator **70**. Input charge **82** is inserted inside a compatible niche inside PA **76**, in this example in the shape of a trapezoid with the narrow base pointing upwards. Two contact pads **84** are visible on top of contact layer **62**, and their role is to provide current to an actuation mechanism on the PA, as will be elaborated below. In **Fig. 4B**, another feature of the system is shown. Blocker **86** is attached to a deflector, which in this case is angular deflector **88**, capable of displacing the blocker sideways as can be seen in **Fig. 4C**, typically on a plain perpendicular to PA **76**. When the blocker is displaced sideways, the input charge, designated **82**, wedged inside PA **76**, has its upper side exposed except for a thin layer of the silicon of the PA, which in most cases covers the input charge.

In the detonation train, embodying the present invention, an output charge capsule **48**, typically containing a secondary charge, is described externally in **Fig. 2**, and further dealt with in more details hereinafter, with reference to **Figs 5A- 5B**. In **Fig. 5A**, blocker **86** is shown located right above input charge **82**, while a through bore **92** connecting the outside atmosphere with the inside of output charge capsule **48** is located right above blocker **86**. When blocker **86** is deflected sideways as shown in **Fig. 5B**, the passage of energetic material from the detonation of input charge **82** through bore **92** is unhindered and flow of such material as shown by arrows **96** and **98** into inner space **102** of capsule **48** is made possible. The displacement of blocker **86** is caused by the curving of angular deflector **88**.

Actuation mechanisms

A deflector as described above as part **88** may be embodied by employing one of several technical approaches. A piezoelectric element is one viable option. In such a case the piezoelectric element, typically a thin layer of specially fabricated piezoelectric material is fed by electric leads such that when an electric field is applied to it, the piezoelectric element curves, thus deflecting the attached blocker. Piezoelectric devices of the type applicable in this case, are such devices containing more than one type of ceramic element or a ceramic element as a component and a metal component. When voltage is applied across the junction between the two elements a considerable curvature occurs.

In such a case as an SMA (shape memory alloy) metal alloy is used, the bending of the angular deflector such as described in **Fig. 4C** above may be brought about by a change in temperature. The change in temperature in turn may be brought about by a Peltier cooler or heater. Another option is that instead of the angular deflector a linear deflector shortens upon heating/cooling exposing the input charge without bending.

In another aspect of the invention, the initiator is a laser beam, typically issuing power in the form of light rays of more than one watt, which is utilized to detonate a secondary charge. An example of an embodiment in such aspect is described schematically in **Figs 6A-B**. In **Fig. 6A**, laser diode **122** or a LED, is incorporated in a MEMS based assembly **124** in which a blocker **86** is capable of blocking the optical path between diode **122** and fiber adaptor **128** attached to block **130**, and subsequently preventing the optical signal from travelling along fiber **132**. In **Fig. 6B**, a cross sectional view in the MEMS assembly of **Fig. 6A** is described, showing bore **140** in sectioned block **130**. This bore allows light coming from laser diode **122** to reach fiber **132** when blocker **86** is displaced sideways. In **Fig. 6C**, selector switch **134** is capable of selecting a specific fiber adaptor out of a plurality of adaptors **128** connected. Such a selection is brought about by electric interaction with control module (not shown) connected to the MEMS chip. Selector switch **134** facilitates passage of light energy from laser

diode **122** to a specific fiber connected by the respective adaptor and eventually to respective charge, provided two conditions are met: a, blocker **86** is set out of the way and b. selector switch is set to select a the specific route associated with the selected adaptor. In **Fig. 6D** a cross sectional view in selector switch **134** is shown which demonstrates light input canal **138** in which light from laser diode **122** (not shown) is sent into diverter **140** which directs the beam to any channel such as channel **142**. Diverter **140** is actuated by power arriving from a source on the MEMS based assembly. The shifting of light rays from input canal **138** into any of adaptors **128** may be achieved by a rotating mirror or a rotating prism having a rotation axis normal to the large face of switch **134**. Accurate rotation of such optical ray diverter may be actuated by a piezoelectric actuator.

In the light actuation embodiments of the invention, the blocker is not necessarily a mechanical appliance, it may be embodied as a device used in optics such as a shutter, a mirror, a polarizer etc. If a mirror is used as a blocker, a beam dump may be required to absorb/dissipate the reflected beam.

CLAIMS

1. A controlled pyrotechnic train—implemented in a MEMS based assembly— for use as a detonator of a secondary charge, said train comprising:
 - a controllable mechanical blocker for blocking said pyrotechnic train, and
 - a deflector of said blocker;wherein said blocker is at least the only mechanical component existing between said detonator and said secondary charge.
2. A controlled pyrotechnic train according to claim 1, wherein said deflector is a piezoelectric actuator.
3. A controlled pyrotechnic train according to claim 1, wherein said deflector is a mechanical angular deflector .
4. A controlled pyrotechnic train according to claim 1, wherein said deflector is a mechanical linear deflector .
5. A controlled pyrotechnic train according to claim 1, wherein said blocker can controllably block a laser beam.
6. A controlled pyrotechnic train according to claim 5, wherein a selector switch is interposed between a source of said laser beam and wherein said selector switch is capable of selecting one fiber adaptor of a specific fiber that is associated with a respective charge.