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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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REPLY TO
ATTN OF: GP

TO: KSI/Scientific & Technical Information Division
Attn: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General
Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U.S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code KSI, the attached NASA-owned U.S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 3,812,783

Government or Corporate Employee : Cal/Tech Pasadena, CA

Supplementary Corporate Source (if applicable) : ~~~~~

NASA Patent Case No. : NPO-11,743-1

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:

YES NO

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of column No. 1 of the Specification, following the words "...with respect to an invention of ..."

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Enclosure

- [54] **OPTICALLY DETONATED EXPLOSIVE DEVICE**
- [75] Inventors: **Lien C. Yang**, Los Angeles; **Vincent J. Menichelli**, Glendale, both of Calif.
- [73] Assignee: **The United States of America as represented by the Administrator of the National Aeronautics and Space Administration**, Washington, D.C.
- [22] Filed: **Aug. 3, 1972**
- [21] Appl. No.: **277,904**
- [52] U.S. Cl. **102/70.2 R, 102/28 EB, 102/70.2 A**
- [51] Int. Cl. **F42c 13/02, F42d 1/04, F42c 19/08**
- [58] Field of Search **102/70.2, 70.2 A, 28 EB**

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Assistant Examiner—Thomas H. Webb
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[57] **ABSTRACT**

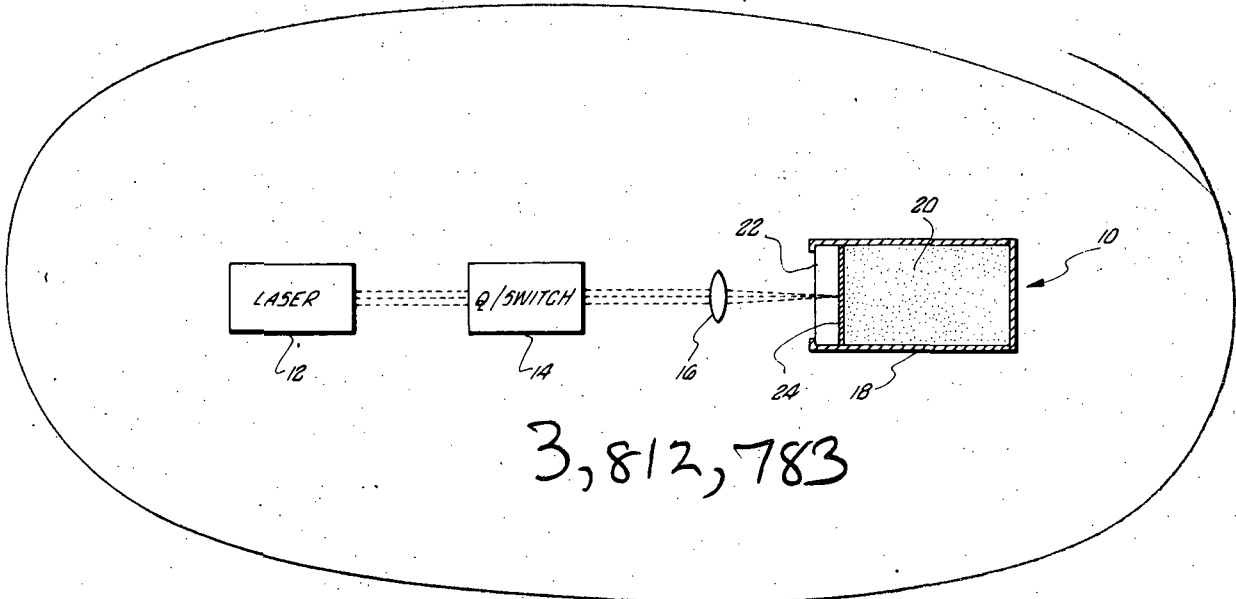
A technique and apparatus for optically detonating insensitive high explosives, is disclosed. An explosive device is formed by containing high explosive material in a housing having a transparent window. A thin metallic film is provided on the interior surface of the window and maintained in contact with the high explosive. A laser pulse provided by a Q-switched laser is focussed on the window to vaporize the metallic film and thereby create a shock wave which detonates the high explosive. A plurality of explosive devices may be concurrently or sequentially detonated by employing a fiber optic bundle to transmit the laser pulse to each of the several individual explosive devices.

14 Claims, 3 Drawing Figures

[56] **References Cited**

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(NASA-Case-NPO-11743-1) **OPTICALLY DETONATED EXPLOSIVE DEVICE Patent (NASA) CSCL 19A** N74-27425
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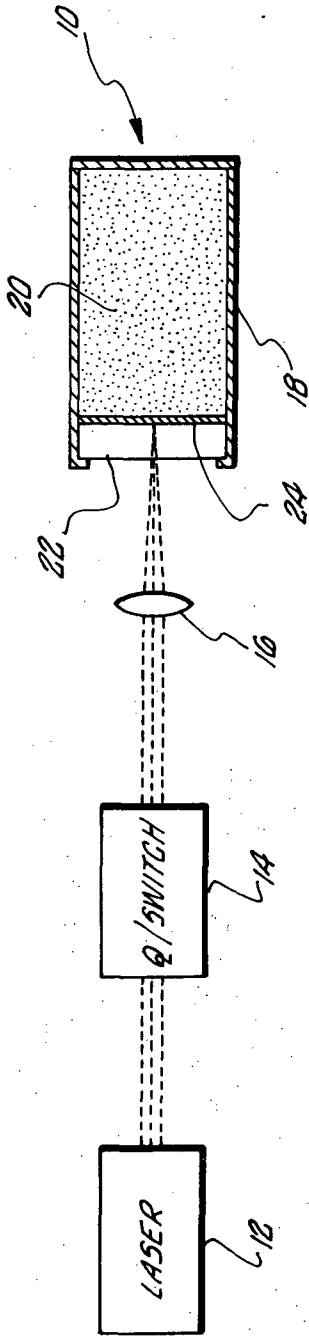


FIG. 1.

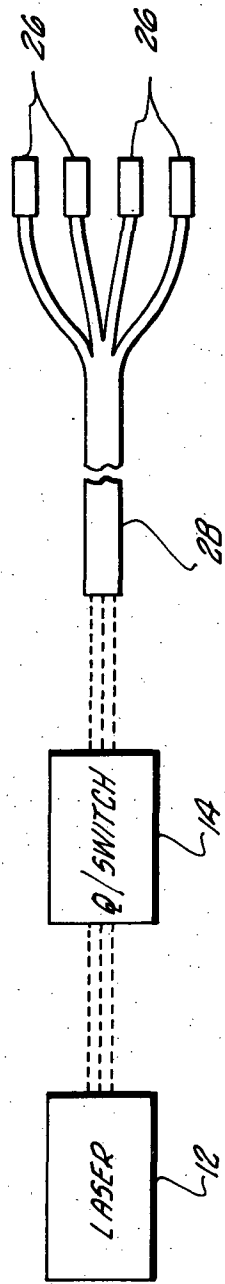


FIG. 2.

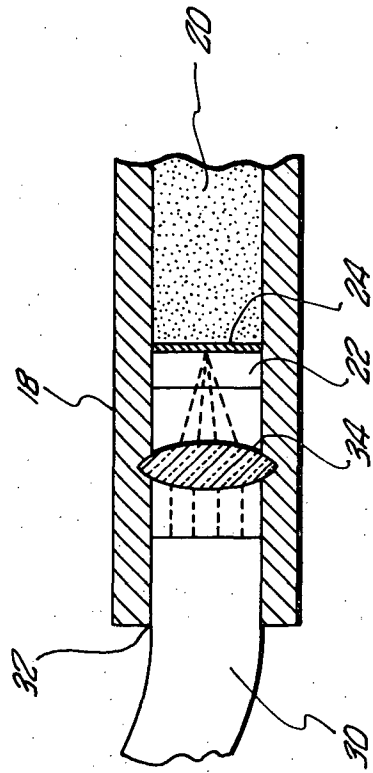


FIG. 3.

OPTICALLY DETONATED EXPLOSIVE DEVICE**BACKGROUND OF THE INVENTION****1. Origin of the Invention**

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 Stat. 435; 43 U.S.C. 2457).

2. Field of the Invention

This invention generally relates to a technique and apparatus for optically detonating high explosives. More particularly, the present invention concerns an optical system for producing instantaneous detonation of primary high explosives as well as certain secondary high explosives.

3. Description of the Prior Art

Generally, the field of high explosives involves a number of different compounds which vary in sensitivity. The more sensitive the explosive, the more readily it may be ignited. Such high explosives are conventionally categorized by sensitivity as either a primary high explosive or as a secondary high explosive. The primary high explosives are more sensitive and are accordingly generally more easily detonated with the exception of non-detonating primary high explosive materials or compositions.

The well known high explosives PETN, RDX and tetryl are recognized as having a median sensitivity and would be placed at or near a line separating a list of high explosives, in order of sensitivity, into the primary or secondary categories. Of the three exemplary materials, PETN is universally accepted as a primary high explosive. RDX is generally considered to be a primary high explosive but is permitted by certain governmental agencies to be used as a secondary high explosive for certain specific applications. Tetryl is universally accepted as a secondary high explosive.

Immediate detonation of secondary high explosives requires a strong shock input, the threshold magnitude of the shock being dependent upon various parameters such as explosive density, particle size, and confinement. Conventionally, detonation of secondary high explosives is achieved by the use of an explosive train. These explosive trains are generally initiated mechanically such as by firing pins or electrically such as with a hot bridgewire.

The first component in the explosive train is typically a primary high explosive which is ignited by the application of heat, friction, impact, or electricity. The resulting reaction serves to lead to a burn-to-detonation of the secondary high explosive.

The use of a primary high explosive makes an explosive device or system extremely vulnerable to inadvertent detonation in that only a nominal amount of energy is required to initiate detonation. As a result, extreme care must be taken in the fabrication, transport, storage, and use of any explosive device that includes a primary high explosive. The significantly reduced sensitivity of secondary high explosives generally precludes inadvertent detonation and thereby presents the obvious advantages over primary high explosives. As an example, to the inventors' knowledge, tetryl the most sensitive of the commonly used secondary high explosives, has not heretofore been detonated without the use of a primary high explosive to create the necessary shock.

Considerable effort has been devoted to the development of techniques to make safer the use of high explosives. The conventional safe and arming mechanism is the result of such effort.

Techniques for directly detonating secondary high explosives without the use of a primary high explosive have also been investigated, but without success. The most successful technique heretofore has been the use of an exploding bridgewire which is embedded in a high explosive and exploded by the application of electrical energy. Both PETN and RDX have been detonated with this technique. However, such detonation has been found to be highly dependent upon a variety of parameters such as loading density, particle size and shape, purity, bridgewire size and material, and discharge circuitry. Also, this technique requires the use of electrical wires which may be cumbersome for certain applications such as aboard a spaceship.

The detonation of secondary high explosives by strong light sources, such as a laser, has also been investigated. Successful detonation of primary high explosives such as PETN and RDX has been accomplished by use of a laser pulse; but efforts to detonate tetryl and even less sensitive high explosives have heretofore been unsuccessful.

It is thus the intention of the subject invention to provide a technique and apparatus that permits secondary high explosives to be instantaneously detonated without the use of primary high explosives, which technique is also readily useable to efficiently produce instantaneous detonation of primary high explosives.

OBJECTS AND SUMMARY OF THE INVENTION

Accordingly, it is a primary object of the present invention to provide a technique and apparatus for optically detonating either primary or certain secondary explosives.

It is another object of the present invention to provide means for instantaneously detonating secondary high explosives without the use of primary high explosives.

It is a further object of the present invention to provide an explosive device which is adapted to be detonated only by the application of laser energy.

It is a yet further object of the present invention to provide a system including a plurality of explosive devices that may be concurrently or successively detonated by the use of a single source of laser energy.

It is a still further object of the present invention to provide a technique and apparatus that permits explosive devices to be safely fabricated, transported, stored and used.

Briefly described, the present invention involves a technique and apparatus for optically producing instantaneous detonation of both primary and secondary high explosives.

More particularly, an explosive device in accordance with the present invention includes a housing containing a high explosive. The housing is provided with a transparent window panel on the interior surface of which is provided a metallic film. Laser energy from a Q-switched laser is focussed on the window to produce vaporization of the metallic film. The resulting shock wave detonates the high explosive. Multiple explosive devices may be detonated concurrently or successively by transmission of the laser pulse through a fiber optic bundle to each of several individual explosive devices.

For purposes of this application, a Q-switched laser is intended to be any laser system that generates a single laser pulse having a time duration of less than one tenth of a microsecond.

Further objects and the many attendant advantages of the invention may be best understood by reference to the following detailed description taken in conjunction with the accompanying drawings in which like reference symbols designate like parts throughout the figures thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram illustrating a preferred embodiment of the present invention.

FIG. 2 is a block diagram illustrating the use of a fiber optic bundle to permit detonation of multiple explosive devices with a single source of laser energy.

FIG. 3 is a diagram illustrating an explosive device that has been modified to receive focussed laser energy via an optic fiber.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1 of the drawings, an explosive device 10 is positioned to receive laser energy from a Q-switched laser system including a laser 12 operated in conjunction with a Q-switch 14. A suitable lens or lens system 16 serves to focus the laser energy on the explosive device 10.

Any conventional pulsed laser system and Q-switch may be used. As an example, the Korad K-1Q laser system used in conjunction with a KDP Pockel cell has been found to be suitable.

The explosive device 10 essentially includes a housing or cannister 18 in which is contained a high explosive 20. The housing 18 may be any material that is conventionally used to contain explosives. For example, steel, glass, or the like, may be used. The cannister 18 is provided with a window including a transparent window panel 22 made of glass or the like. The interior surface of the window panel 22 is provided with a metallic film 24.

The metallic film 24 may be made of any suitable metal which is opaque and which will be readily vaporized by the direct application thereto of pulsed laser energy. For example, it has been found that an aluminum film 24 deposited on the surface of a glass window panel 22 to a thickness of 1,000 Angstroms is readily vaporized when a laser pulse of less than 1 joule is applied thereto. Vaporization of the metallic film 24 creates a rapidly expanding plasma that is directed away from the window plate 22 and into the high explosive 20. Also found to be suitable for this purpose are carbon and bismuth of appropriate thickness.

Although the optimum metal, and thickness therefor, has not been determined yet, it has been found that the metallic film should be sufficiently thick to permit total absorption of the laser energy by the film prior to complete vaporization thereof. Also, it has been found that there is no apparent advantage in increasing the thickness of the metallic film 24 beyond a dimension at which the additional mass results in a lower temperature and pressure in the plasma produced by vaporization during the laser absorption period.

The rapidly expanding plasma resulting from vaporization of the film 24 by the pulse of laser energy that is directed through the window 22, will create a shock

wave of sufficient force to produce instantaneous detonation of the high explosive 20. The term "instantaneous" is intended to mean that sustained detonation of the high explosive 20 occurs within 0.5 microseconds after transmission of a laser pulse from the pulsed laser system.

Using the subject invention, it has been found that the primary high explosive PETN can be detonated with less than one joule of laser energy. Similarly, the primary high explosive RDX has been found to be detonated using as little as one joule of laser energy. Such detonation with low laser energy levels enables a plurality of explosive devices that are fabricated with primary high explosives to be readily simultaneously detonated with the energy from a single present-day portable laser system that is generally characterized by a maximum energy output in the neighborhood of 10 to 15 joules. Laser systems having a larger energy output may obviously be used for the same purpose.

Also, of considerable significance is the fact that the present invention has for the first time enabled a secondary high explosive, tetryl, to be instantaneously detonated using 4.0 joules of laser energy. Such instantaneous detonation of tetryl is significant in that the present invention thus permits explosive devices 10 to be readily fabricated, transported, stored and used without any inclusion of primary high explosives and without the attendant danger of inadvertent detonation. Since a pulse of laser energy is not known to naturally occur, an explosive device 10 including a secondary high explosive would be virtually fail-safe.

FIG. 2 illustrates a manner in which laser energy provided by a single laser system may be furnished to a plurality of explosive devices 26. An optical fiber bundle 28 is positioned to receive at one end thereof a pulse of laser energy, a portion of which is transmitted to each of the several explosive devices 26 connected to the far end of the respective optical fibers of the bundle 28. Variation in the length of the optical fibers of the bundle 28, or the selected insertion of conventional optical delay devices, may be used to have the explosive devices 26 detonated in a prescribed succession. Obviously, optical fibers of precisely the same length may be used to have the explosive devices 26 concurrently detonated.

FIG. 3 illustrates a manner in which the explosive device 10 shown in FIG. 1 may be modified to accept an optical fiber. As shown, the walls of the housing 18 in the region fronting the window panel 22 may be extended to accept an optical fiber 30 at a mouth portion 32 thereof. A lens 34 may then be interposed between the end of the optical fiber 30 and the window panel 22 to have the laser energy focussed on the metallic film 24. It is to be understood that the illustrative configuration for the housing 18 is not intended to be indicative of a preferred configuration and that any suitable shape therefor may be used.

It is to be understood that although a system including a fiber optic bundle has been discussed in conjunction with multiple detonations, an optical system including, for example, a beam splitter or the like, may be used to concurrently direct laser energy to a plurality of explosive devices. In such a case, air would be the propagating medium instead of fiber optics.

From the foregoing discussion, it is now clear that the present invention provides an explosive device that is adapted to be optically instantaneously detonated and

which permits certain secondary high explosives, such as tetryl, to be used without any requirement for a conventional explosive train including a primary high explosive, or the like. It is also clear that explosive devices in accordance with the present invention can be made highly safe by the use of secondary high explosives thereby eliminating the danger of inadvertant detonation.

While a preferred embodiment of the present invention has been described hereinabove, it is intended that all matter contained in the above description and shown in the accompanying drawings be interpreted as illustrative and not in a limiting sense and that all modifications, constructions, and arrangements which fall within the scope and spirit of the invention may be made.

What is claimed is:

1. An explosive device adapted to be optically detonated in response to a pulse of laser energy, said explosive device comprising:

high explosive material of a single type;
a housing for containing said high explosive material, said housing having a window opening exposing the high explosive material contained by said housing; and

a transparent window panel covering said window opening, said panel having a metallic film covering an interior surface, thereof, said metallic film being maintained in contact with said high explosive material, said metallic film forming initiator means for applying a shock wave to said high explosive material to cause detonation thereof in response to said metallic film being at least partially vaporized by application thereto of a pulse of laser energy to produce said shock wave.

2. The explosive device defined by claim 1, said high explosive material being a secondary high explosive.

3. The explosive device defined by claim 1, said metallic film being aluminum.

4. A primerless explosive device for being instantaneously detonated by application thereto of a pulse of laser energy, said explosive device comprising:

high explosive material; and
initiator means for applying a shock wave to said high explosive to cause detonation thereof, said initiator means including a metallic film maintained in contact with said high explosive material, said metallic film being at least partially vaporized by application thereto of a pulse of laser energy to produce said shock wave.

5. The explosive device defined by claim 4, said explosive device further including a housing for containing said high explosive material at a selected loading pressure, said housing having an aperture communicating with the interior of said housing, said aperture being covered by a transparent panel, said metallic film being situated on an interior surface of said transparent panel.

6. The explosive device defined by claim 4, said me-

tallic film being aluminum.

7. The explosive device defined by claim 4, said high explosive material being a secondary high explosive.

8. The explosive device defined by claim 5, said high explosive material being a single secondary explosive.

9. A method for detonating a high explosive device including a high explosive material and a metallic film situated in contact with said high explosive, said method comprising vaporizing said metallic film to produce a shock wave that is directed into said high explosive, wherein vaporizing includes the step of focussing a pulse of laser energy on said metallic film.

10. A method for detonating a high explosive device including a high explosive material and a metallic film situated in contact with said high explosive, said method comprising vaporizing said metallic film to produce a shock wave that is directed into said high explosive, wherein vaporizing includes the steps of:

generating a pulse of laser energy; and
focussing said pulse of laser energy on said metallic film.

11. A method for detonating a plurality of explosive devices each including a high explosive material and a metallic film in contact with the high explosive material, said method including the steps of:

generating a pulse of laser energy;
conducting a portion of the pulse of laser energy to each of said explosive devices with a bundle of optical fibers; and

focussing said portion of the pulse of laser energy on said metallic film corresponding to each of said explosive devices.

12. A system for optically detonating a plurality of explosive devices, said system including:

a source of pulsed laser energy;
a bundle of optical fibers having a first end thereof bundled and a second end thereof unbundled, said pulse of laser energy being applied to said bundled first ends to be conducted to the second ends of said optical fibers; and

lens means associated with each of said optical fibers and positioned at the second ends thereof for focussing the laser energy conducted by said optical fibers on initiators of said explosive devices.

13. The system defined by claim 12, said explosive devices each including:

a high explosive material; and
an initiator for applying a shock wave to said high explosive material in response to application of said laser energy, said initiator including a metallic film in contact with said explosive material.

14. The system defined by claim 13, said explosive device further including a housing for containing said high explosive material, said housing having a transparent window portion, said metallic film covering said transparent window portion of said housing, said lens means focussing said laser energy on said metallic film.

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