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(56) Documents Cited:
GB 1605406 A **EP 1063627 A2**
US 3618526 A **US 20100307363 A1**

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(54) Title of the Invention: **Device for detection of impact of a projectile**
Abstract Title: **Device for detecting the impact of a projectile**

(57) A device is disclosed for detecting the impact of a projectile 1. The device comprises an optical fibre 2, an optical source 30 arranged to emit a continuity signal into the optical fibre, and a module 31 arranged to detect the absence of the optical signal at the output of the optical fibre. The device is characterised in that the optical fibre 2 comprises an opaque protective sheath 20. In contrast to known systems using electrical loops, the use of an optical loop prevents detection errors due to strong electromagnetic fields. The opaque sheath 20 protects the fibre from external light, e.g. flash or laser illumination.

FIG. 2

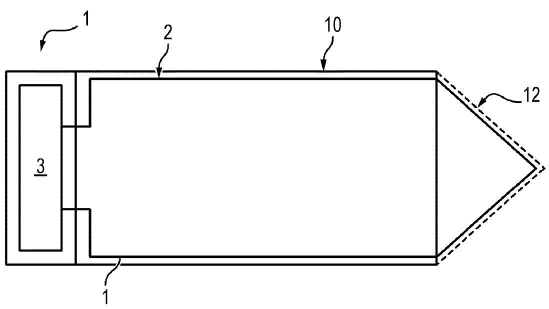

FIG. 3

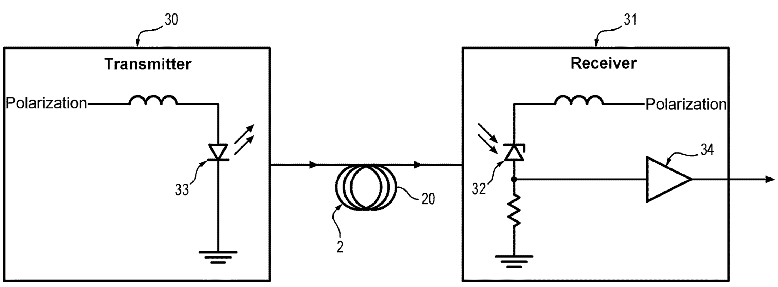

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FIG. 1

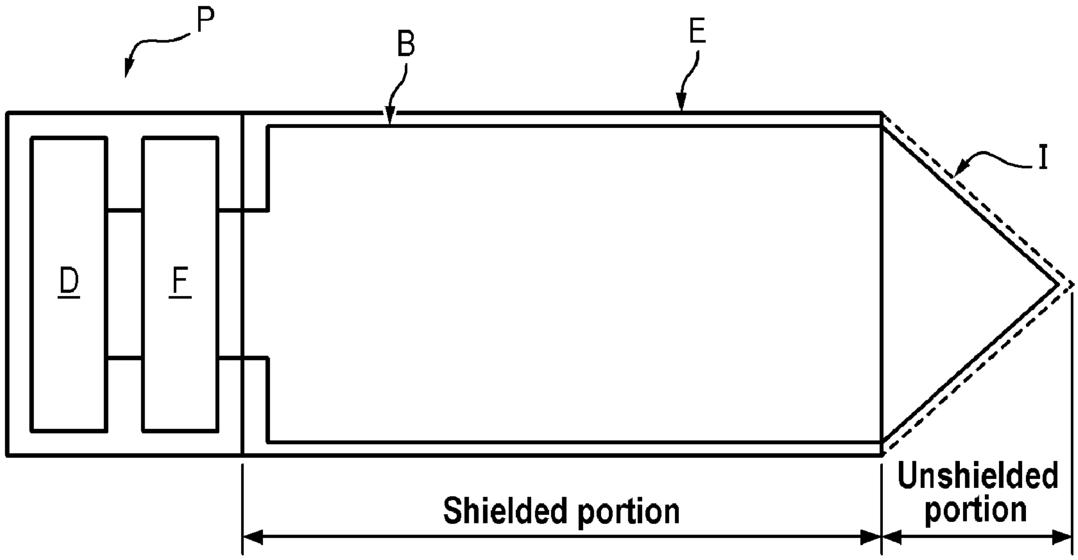
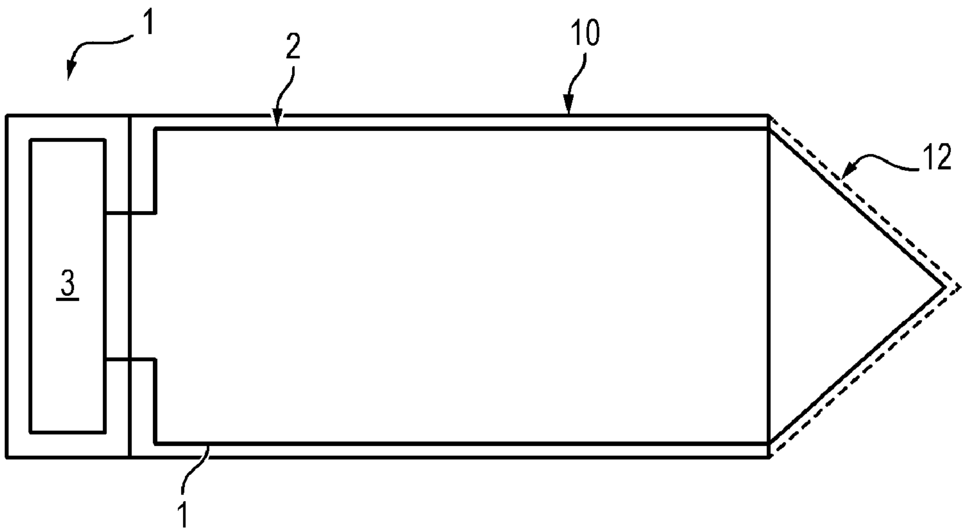


FIG. 2



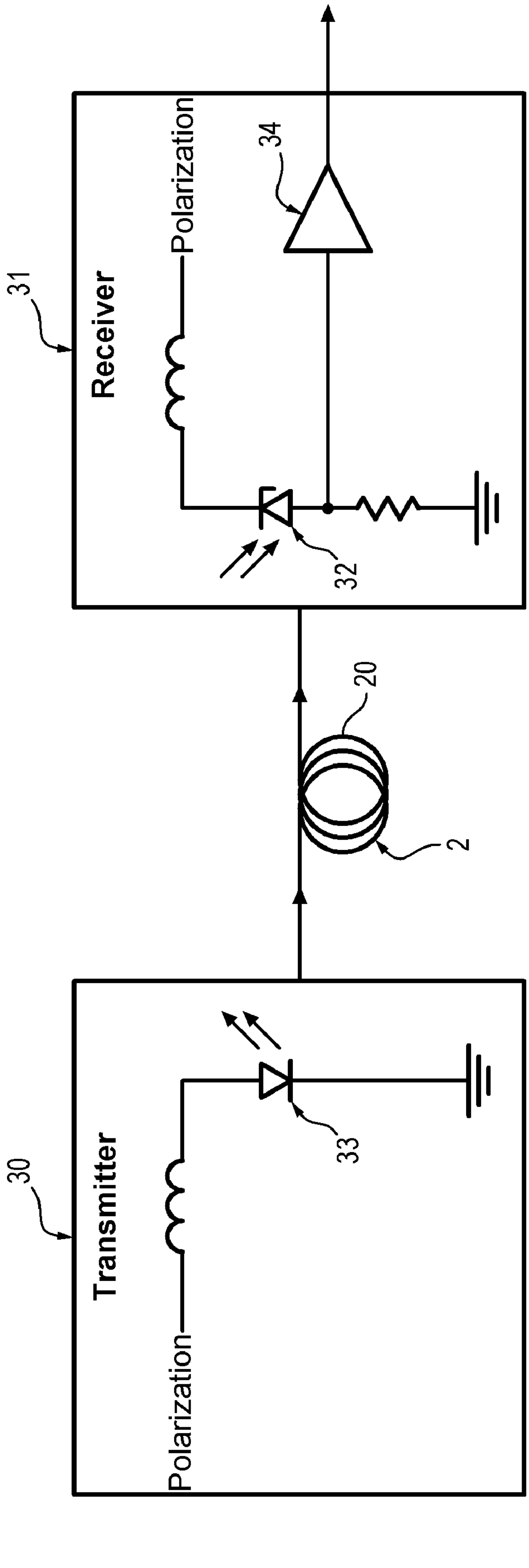

Transmitter
30
Polarization
33
Receiver
31
Polarization
32
34
20
2

FIG. 3

Device for detection of impact of a projectile

GENERAL FIELD

The invention relates to an impact detection device of a projectile, and a method for detection of impact executed by such a device.

PRIOR ART

Detection of impact of a projectile such as munitions is a functional need at a high level of reliability to primer a charge contained in the projectile, or else its pre–charge.

A known technique for detecting an impact consists of using in a projectile P shown in **figure 1** a detection device comprising an electric impact loop B and a detection module D for cutting off the electric impact loop B.

The projectile P also comprises an autodirector (not illustrated) for performing functions such as image detection or laser tracking.

The detection principle used by the device of the projectile P comprises measuring a loss in electrical continuity due to cutting off of the impact loop during collision of the projectile P with a target.

The projectile P comprises a shield E for protecting most of the electric impact loop against interference signals.

However, part of the impact loop B, generally located to the front of the projectile, is not shielded so as to offer an execution window by the autodirector of functions such as image detection or laser tracking.

This window of strong electromagnetic fields of type HIRF (High Intensity Radiated Filed) in the electric impact loop B, typically in a frequency band from ten MHz to a dozen GHz.

The electric impact loop B then behaves like an antenna: the useful electric signal necessary for electric continuity in the loop B is superposed with an electric signal induced by the radiated field of perturbation. This potentially causes false detection of cutting off of the electric impact loop B by the detection module D.

To prevent such detection errors, the projectile P comprises a filter F adapted to filter these ambient electromagnetic perturbations received by the electric loop B, and to prevent error detection.

However, the resulting projectile remains subject to many disadvantages:

- the mechanical shield E is necessary to protect most of the electric loop B from strong fields, increasing the bulk and weight of the projectile.
- The filter F necessarily introduces a delay in detection of cutting off of the impact loop: the response time of the loop, critical in the triggering chain of a charge of the projectile, is then prolonged.
- controlling the impedance of the electric loop B is very difficult.

To resolve these problems it has been proposed to use an optical fiber in the guise of an impact loop. Rather than monitor the continuity of an electric signal, the continuity of an optical signal emitted by an optical source is monitored.

However, an impact loop of optical fiber type can be subject to false detection, caused by interference light signals such as flashes which enter the body of the optical fiber.

Such flashes can originate in the first instance from equipment internal to the projectile or else in a second instance can originate from outside, for example when the device has a translucid surface part (this is the case in particular of an IR dome).

In this second case, flashes can be triggered deliberately to make the projectile inoperable.

PRESENTATION OF THE INVENTION

The aim of the invention is to enable detection of the impact of a projectile, which is faster and more robust to false detections.

Another aim of the invention is to reduce risks of false detection of such impact.

Another aim of the invention is to the bulk and mass of the projectile.

For this purpose, according to a first aspect an impact detection device of a projectile is proposed, the device comprising an optical fiber, an optical source adapted for emitting a continuity signal at input of the optical fiber, and a detection module of absence of said signal at output of the optical fiber, the device being characterized in that the optical fiber comprises an opaque protective sheath.

The opaque sheath prevents external flashes from penetrating inside the optical fiber. In this way, the optical signal which circulates in the optical fiber is not interfered by such flashes, and detection by the detection module does not risk occurring as anticipated or too late.

The invention can also be completed by the following characteristics, taken singly or in any of their technically possible combinations.

The source can be a continuous polarized diode.

This diode can be a light–emitting diode, of low cost, a laser diode allowing high optical propagation speed, or else an infrared diode offering a good compromise between cost and speed of optical propagation.

The device can comprise a detonator configured to trigger the explosion of a charge after a predetermined period as from detection of the absence of the continuity signal by the detection module.

Such delayed operation is particularly effective for the main charge to explode inside a large target, following impact against an edge of the target.

The device can also comprise a detonator configured to trigger an explosion of a pre–charge during detection of the absence of the continuity signal by the detection module.

The use of such a pre–charge is efficacious for piercing the shield of a target.

The detection module can comprise a photo–detector adapted to receive an optical signal transmitted to the optical fiber.

According to a second aspect, a projectile comprising an impact detection device as per the first aspect of the invention is also proposed.

This projectile is advantageously a missile of anti–tank type.

As a variant, this missile is of surface–to–air type.

According to a third aspect, a method for detection of impact of a projectile is proposed, the method comprising emitting a continuity signal to the input of a impact loop and the detection of absence of the continuity signal at output of the impact loop, the method being characterized in that the continuity signal sent is an optical signal and the impact loop is an optical fiber.

This method can comprise the primer of a pre–charge contained in the projectile, on detection of the absence of the continuity signal.

DESCRIPTION OF FIGURES

Other characteristics, aims and advantages of the invention will emerge from the following description which is purely illustrative and non–limiting and which much be considered in conjunction with the appended drawings, in which:

- Figure 1, already discussed, schematically illustrates a projectile equipped with an impact detection device known from the prior art.
- Figure 2 schematically illustrates a projectile equipped with an impact detection device according to an embodiment of the invention.
- Figure 3 details an impact detection device according to an embodiment of the invention.

In all figures, similar elements bear identical reference numerals.

DETAILED DESCRIPTION OF THE INVENTION

Figure **1** has already been discussed in introduction.

In reference to **figure 2**, a projectile 1 includes an impact detection device.

The impact detection device comprises an impact loop 2 and a detection module 3 for cutting off the impact loop 2.

The impact loop 2 is an optical fiber having two opposite ends attached to the detection module 3.

The projectile 1 extends along a longitudinal axis between a rear end and a front end forming an IR dome 12 (delimited by dots). The detection module 3 is located to the rear of the projectile 1. The optical fiber 2 has the following successive portions: a first portion extending longitudinally along a first side of the projectile 1, a second portion in a hairpin bend extending along the IR dome 12, and a third portion extending longitudinally along a second side of the projectile 1 opposite the first side. The trajectory of the fibre has a substantially U–shaped form.

But it is possible to provide other trajectories for the fibre 2, and/or extend the length of the optical fiber so as to cover a larger surface of the projectile and improve the sensitivity of the loop to impact from the projectile.

The projectile 1 can also comprise an autodirector (not illustrated). The autodirector is adapted to perform functions such as image detection or laser tracking. It can be arranged at the level of the IR dome 12, but also at other placements of the projectile, these other placements being made possible by an absence of mechanical shield along the optical fiber 2.

In reference to **figure 3**, the detection module 3 comprises a transmitter 30 and a receiver 31.

The optical fiber 2 has an input connected to the transmitter 30 and an output connected to the receiver 31.

The transmitter 30 comprises an optical source.

The optical source is for example a continuous polarized diode 33 adapted to emit an optical signal (light) polarized continuously. The diode 33 is fed by a power source (not illustrated).

The diode 33 can be light–emitting (LED), which has the advantage of low cost, despite a relatively slow propagation speed (a light–emitting diode in fact emits in the visible red range with a wavelength of around 850 nm).

As a variant, the diode 33 is a laser diode which allows a very high propagation speed. In fact, a laser diode emits in the invisible with wavelengths between around 1300 and 1550 nm.

According to another variant, the diode 33 is an infrared diode. Such an infrared diode emits in the invisible field with a wavelength of around 1300 nm. Such a diode offers a good compromise between propagation speed and cost.

The receiver 31 comprises a photo–detector 32 and an electronic detection system 34 of cutting off of the optical signal. This photo–detector 32 is adapted to generate an electric signal on receipt of an optical signal. A principal characteristic of the photo–detector 32 is its rapidity of detection. The detection system 34 is connected to the photo–detector and adapted to receive the electric signal produced by the photo–detector 32.

The photo–detector 32 can be a phototransistor or a photodiode.

The optical fiber 2 has low mechanical resistance which favours its physical rupture. Yet it is possible to use a sheath 20 to protect the optical fiber from external light which is also an electromagnetic wave (flash, laser illumination). An opaque sheath 20 to protect the optical fiber 2 will preferably be selected. The mechanical resistance of the sheath 2 is selected as a function of the sensitivity for expected detection of impact.

An impact detection method used by the device comprises the following steps.

In a preliminary step, the diode 33 fed by the power source emits out a polarized optical signal to the input of the impact loop formed by the optical fiber. This optical signal passes through the entire impact loop 2 until it exits. The optical signal is detected by the photo–detector 32. The photo–detector 32 emits an electric signal from optical the continuity signal it receives. The electric signal is received by the detection system 34.

When the projectile 1 undergoes impact, the structure of the optical fiber breaks, the consequence of which is breaking transmission of the continuity signal to the fibre 2. This rupture in transmission can be caused by cutting of the fibre, or an obstruction to the latter.

The photo–detector 32 stops delivering the optical continuity signal to the electronic detection system. The electronic detection system 34 considers that impact has taken place from the moment when this electric signal ceased to be delivered to it.

The binary rate of an optical fiber can nowadays reach several hundreds of Gbit/s. With a binary rate of 100 Gbit/s, the transmission time corresponding to the maximal detection time of rupture of the optical impact loop 2 is round 10 picoseconds.

Also, signal attenuation in an optical fiber modern is around 0.3 dB/km, while for a copper conductor attenuation is around 0.3 dB/m. The attenuation achieved with an optical continuity signal in the fibre 2 is therefore diminished by a factor of 1000 relative to an electric continuity signal, preventing false impact detections. It is therefore possible to use an optical impact loop much longer than an electric impact loop for equivalent or inferior attenuation.

The device 1 also comprises a detonator connected to the detection module.

The detonator is configured to trigger the explosion of two charges: a main charge, and a pre–charge less powerful than the main charge.

The detonator is configured to trigger an explosion of the pre–charge when the detection module 3 detects the absence of the continuity signal optical.

The same detonator can be utilised to trigger the explosion of the main charge and of the pre–charge. As a variant, two separate detonators are used.

The detonator is also configured to trigger an explosion of the main charge after a predetermined period detection of the absence of the continuity signal by the detection module 3.

The explosion of the main charge occurs after that of the pre–charge.

So, when the projectile reaches the shield of a shielded target, the pre–charge explodes, destroying this shield but the main charge does not explode immediately.

The projectile can penetrate inside the target (building, tank, etc.), before the main charge explodes, on expiration of the predetermined period.

The proposed detection device is particularly adapted to a projectile 1 of anti–tank missile type.

The detection device can also be executed in a projectile of anti–aircraft missile (surface–to–air) type.

It is possible of course to use more than one optical fiber 2 in the impact loop to perform detection of the impact. Each optical fiber 2 will be associated with a transmitter and a receiver as per the preceding description, specific to the latter or shared with other optical fibers.

CLAIMS

1. A device for detection of impact of a projectile (1), the device comprising an optical fiber (2), an optical source adapted for emitting a continuity signal at input of the optical fiber (2), and a detection module (3) of absence of said signal at output of the optical fiber (2), the device being characterized in that the optical fiber (2) comprises an opaque protective sheath (20).

2. The device according to claim 1, wherein the source is a continuous polarized diode (31).

3. The device according to claim 2, wherein the diode (31) is a light–emitting diode.

4. The device according to claim 2, wherein the diode (31) is a laser diode.

5. The device according to claim 2, wherein the diode (31) is an infrared diode.

6. The device according to one of claims 1 to 5, wherein the detection module (3) comprises a photo–detector (32) adapted to receive an optical signal transmitted to the optical fiber (2).

7. The device according to claims 1 to 6, comprising a detonator configured to trigger the explosion of a charge after a predetermined period as of detection of the absence of the continuity signal by the detection module (3).

8. The device according to one of claims 1 to 7, comprising a detonator configured to trigger an explosion of a pre–charge during detection of the absence of the continuity signal by the detection module (3).

9. A projectile (1) comprising an impact detection device according to one of claims 1 to 8.

10. The projectile (1) according to claim 9, of missile anti–tank type.

11. The projectile (1) according to claim 9, of surface–to–air missile type.

12. A method for detection of impact of a projectile (1), the method comprising emitting an optical continuity signal at input of an optical fiber (2) and detection of absence of the continuity signal at output of optical fiber (2), the method being characterized in that the optical fiber comprises an opaque protective sheath (20).

13. The method according to claim 12, further comprising the primer of a pre–charge contained in the projectile (1), on detection of the absence of the continuity signal.

Intellectual Property Office

Application No:	GB1511496.0	**Examiner:**	Bill Riggs
Claims searched:	1 - 13	**Date of search:**	26 January 2016

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
Y	1 - 13	GB 1605406 A (EMI Ltd.) See e.g. fig.2
Y	1 - 13	US 2010/307363 A1 (RAFAEL ADVANCED DEFENSE SYS.) See e.g. par.19-20 & figs.
X,Y	X:1; Y:1-13	EP1063627 A2 (TRIPSEAL Ltd.) See e.g. par.4, 34 & 35
Y	1 - 13	US 3618526 A (US NAVY) See e.g. col.2 ll.17-27

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

F41G; F41J; F42B; F42C

The following online and other databases have been used in the preparation of this search report

Online databases: EPODOC, TXTE, WPI

International Classification:

Subclass	Subgroup	Valid From
F42C	0007/02	01/01/2006