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(54) Benevnelse **PROXIMITY FUZE, AND PROJECTILE PROVIDED WITH SUCH A PROXIMITY FUZE**

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The present invention relates to a proximity fuse, in particular able to be fitted to medium calibre munitions. It also relates to a projectile fitted with such a proximity fuse.

Attack helicopters are generally fitted with a medium calibre cannon placed in a nose turret. The munitions used are fitted with an impact fuse initiating the explosive charge of the shell in contact with the target or the ground. On impact with the ground the shell inevitably buries itself before being detonated, even if the delay is small. This configuration leads to considerable loss of effectiveness, all the more so when the explosive charge is relatively small.

A solution for increasing the effectiveness is to trigger detonation before impact, in proximity to the target or the ground, by fitting the explosive projectile with a proximity fuse.

Having regard to the particular configuration of firing from a helicopter, at low altitude, this proximity fuse must be compatible with very grazing firing trajectories. Moreover, the munition must be totally autonomous, without requiring any interaction with the weapons system.

The need for a munition that operates totally independently of a weapons system prohibits certain technical solutions such as those based on a chronometric function, for example a programmable-time function termed "airburst". This type of chronometric solution requires that the munition be programmed. Moreover, the chronometric principle exhibits a major drawback. This drawback is limited precision, which is incompatible with the effectiveness of medium calibre munitions for which the precision sought is of the order of a few tens of centimetres for a nominal detection distance of between 0.5 meter and 2 meters in particular.

There is therefore a need to produce a proximity detection device, or proximity fuse:

- that can be integrated into a 30-mm calibre ogive fuse, in particular;

- that is totally autonomous, requiring no integration into a weapons system;

- that operates in the configurations of firing from a helicopter, at grazing trajectory.

The need can be extended to other calibres and for firing from carriers other than helicopters, ground vehicles for example.

A document EP 0 314646 A2 discloses transmission and reception devices forming part of an optical proximity fuse.

The aim of the invention is therefore in particular to alleviate the aforementioned drawbacks and to address the need expressed hereinabove. For this purpose, the subject of the invention is a proximity fuse able to be fitted to a projectile, said fuse having the mission of detecting an obstacle in proximity, an obstacle in proximity being defined as being an obstacle exhibiting a minimum distance from said fuse, said fuse comprising at least:

- an emission device having a pupil emitting a light beam directed forward of said fuse;

- a reception device having a pupil detecting the luminous fluxes in a cone directed forward of said fuse, said light beam and said cone having relative orientations such that they cross one another, the emission pupil and the reception pupil being off-centred;

a detection volume being the volume where said light beam crosses said cone so that when an obstacle is in said detection volume, the light emitted by said emission device is backscattered toward said detection device, an obstacle in proximity being detected by detecting the maximum of backscattered power, said cone for reception being centred on the axis of said fuse.

The reception pupil has for example a crescent moon shape.

In a particular embodiment, the fuse delivers a signal if at least one condition is satisfied, said condition being the detection of said maximum of backscattered power. Said signal is for example delivered if a second condition is satisfied, said second condition being that said maximum of backscattered power exceeds a given threshold. Said signal is for example able to trip the detonation of an explosive charge.

The emission beam is for example coded to allow its identification by said reception device, said light beam being for example modulated. The light beam can be produced by a laser diode or a light-emitting diode (LED).

The subject of the invention is also a projectile fitted with a fuse such as described above. In a possible embodiment, said projectile comprises a munition of medium calibre type. It is for example able to be fired from an airborne platform and/or from a ground platform.

Other characteristics and advantages of the invention will become apparent with the aid of the description which follows given in relation to appended drawings which represent:

- Figure 1, an exemplary use of a device according to the invention, in the case of projectile firings from a helicopter;

- Figures 2a and 2b, an exemplary proximity fuse according to the prior art;

- Figure 3, an illustration of the operating principle of a proximity fuse according to the invention;

- Figures 4a and 4b, an illustration of a possible embodiment of a fuse according to the invention;

- Figure 5, the profile of a received signal; and

- Figure 6, an exemplary embodiment of a fuse according to the invention.

Figure 1 illustrates a case of using a device according to the invention. A helicopter 1 flying at low altitude fires a projectile fitted with a proximity fuse toward the ground 2, the medium calibre munition following a grazing firing trajectory 3. A function of the proximity detection device fitted to the munition being to allow explosion 4 of the latter at the most appropriate instant before impact on the ground, when the distance between the proximity fuse and the target becomes less than a given threshold. The aim is for the target to be detected before the projectile explodes or penetrates it. The invention can also apply in respect of firings of projectiles from other airborne platforms. It can also apply in respect of projectiles fired from ground platforms, from vehicles for example.

Figures 2a and 2b present an example of proximity fuses 21 according to the prior art.

Proximity fuses for mortar or artillery projectiles are designed to detect the ground by considering arrival angles of generally between 15° and 80°. Figures 2a and 2b present two typical configurations of the main emission lobe 28, 29 obtained on proximity fuses based on radio frequency (RF) technology, based on electromagnetic probes of the miniaturized radar type for example. In Figure 2a, the main emission lobe 28 exhibits an aperture angle of the order of 30° to 45° with respect to the axis 20 of the fuse. In Figure 2b the main emission lobe 29, situated laterally, exhibits a wide angular aperture.

As mentioned previously, a medium calibre application is characterised by extremely small angles of arrival at the target (angle of incidence with respect to the ground).

The implementation of a proximity function must consequently address the need for reliable operation for arrival angles of less than a few degrees. The triggering distances, in relation to the effectiveness of the munition, also require to be greatly reduced, these distances possibly being between 0.5 meter and 1.5 meters for example.

The operation of a proximity fuse for very small angles of incidence then requires a very directional detector, stated otherwise a particularly slender emission lobe, so as in particular to avoid the risks of false alarms due to obstacles situated in proximity to the trajectory of the munition. The configurations of Figures 2a and 2b do not address this requirement.

In particular, as regards RF technology, increased directivity can be obtained by operating at higher working frequencies and by employing antenna arrays. However, despite these adaptations, and when operating in the KA band, obtaining aperture angles of less than 15° remains difficult to achieve. The need cannot therefore be addressed easily and at low cost by an RF solution. Moreover, it is important to note that the operation of an RF proximity fuse at such high frequencies, in addition to increased sensitivity to the environment, poses the problem of the availability of components and as a consequence that of the cost of mass production as has just been mentioned.

The performance to cost ratio of the RF solution implies that the latter is not suitable for addressing the need expressed in an optimal manner.

Figure 3 illustrates the operating principle of a proximity fuse 30 according to the invention. The fuse 30 uses a laser source as emission source. More particularly, a proximity fuse according to the invention comprises in particular:

- an emission device emitting a light beam 31 directed forward of the munition, the beam having the shape of a narrow cone, having an angular aperture of less than a degree;

- a reception device detecting a luminous flux 32 in a narrow cone directed forward of the munition, forming a detection cone or reception cone;

- means for processing the signals received.

The power emitted is advantageously of the order of a few milliwatts.

The pupil 33 for emission and the pupil 34 for reception are separated in such a way in particular that the two cones 31, 32 cross one another in front of the munition. The detection volume is the volume 35 where the light beam 35 is in the reception cone 34. This volume is advantageously centred on the axis 40 of the munition, the axis common to the fuse. When the munition approaches initially the spot of the emission on the obstacle is outside the reception cone 32. There is no detected signal.

Next, with the obstacle approaching, the spot on the obstacle enters the reception field. The signal increases with the increase in the fraction of the spot in the of the reception cone 32.

The spot of the emission on the obstacle enters the detection zone. The fraction of the spot of the emission on the obstacle increases as the munition approaches. When the whole spot is in the reception cone 32 the backscattered flux to be detected grows as the inverse of the square of the distance to the obstacle.

Finally the spot of the emission on the obstacle exits the reception cone 32 progressively. The detected flux decreases rapidly when the emission cone 31 exits the reception cone 32. This passage through a maximum of the detected flux is the temporal marker of proximity of the obstacle.

Figures 4a and 4b illustrate more precisely a possible embodiment corresponding to the example of Figure 3. The emission pupils and the reception pupils are represented in Figure 4a by a sectional view of the emission cone 31 and reception cone 32, in proximity to the pupils. This Figure 4a shows that the emission and reception pupils are off-centred. More precisely the reception pupil has a crescent moon shape inscribed in a circle 10, the emission pupil is situated outside this crescent, centred on the intersection of the axis of symmetry of the crescent and of the circle 10. The emission pupil 31 may be situated somewhere else with respect to the crescent, while being off-centred with respect to the latter. As shown by Figure 4b, the emission cone 31 and reception cone 32 cross, these being represented by a longitudinal sectional view, the emission cone 31 entering the reception cone in front of the munition.

Figure 5 illustrates the detection principle set forth hereinabove corresponding in particular to the exemplary embodiment of Figures 4a and 4b. The power of the received signal along the ordinate is dependent on the distance from the target, along the abscissa.

A curve 61 represents the received signal in the case of a modulated emitted signal. Passage to the maximum 62 of power received serves as marker of distance from the obstacle.

In this case, at large distance from the obstacle or from the target, the reception pupil collects the flux backscattered by the obstacle illuminated by the emission beam 31. On approaching, the signal increases as a function of the inverse of the square of the distance of the munition from the obstacle. Next the signal reaches a maximum 62 when the backscattered flux no longer reaches the whole of the reception pupil in the reception field. Thereafter, the signal decreases rapidly until the emission spot is no longer visible by the reception.

The signals received are for example digitized and analysed by the processing means.

Figure 6 presents a preferential embodiment of a proximity fuse according to the invention. It comprises:

- an emitter with laser diode 51, producing a luminous emission of small divergence, the pupil 33;

- a receiver 52 carrying out a mono-detection element, the cone of which is narrow, a few milliradians for example, observing forward of the fuse precisely in the direction of travel of the munition, preferably the pupil 34 is centred in the front of the fuse and in all cases separated from the emission pupil 33.

The alignment of the axis of the reception cone 32 on the axis 40 of the munition advantageously allows the luminous flux coming from the obstacle illuminated by the ambient light to vary slowly despite the rotation of the munition, thereby facilitating the detection of the emission on the obstacle. Also, the emitted power can thus advantageously be reduced. The detection of the receiver is synchronous with the emission. The direction of emission crosses the reception cone, not necessarily on the axis of the munition. The emission is for example coded and modulated to facilitate its identification by the receiver.

The emitter is for example placed on a first printed circuit 53 whose plane is perpendicular to the axis 40 of the fuse. The emitter is for example placed in an off-centred position so as to cross the emission and reception beams as illustrated by Figure 3. The first printed circuit comprises for example the means for coding or modulating the emitted wave.

The receiver 52 is for example mounted on a second printed circuit 54 whose plane contains the axis 40 of the fuse. The receiver 52 is for example positioned on this axis 40, toward the front in accordance with the centred position of the pupil 34. The second printed circuit 54 comprises for example the processing means. These processing means detect in particular an obstacle in proximity in accordance with the procedure described in Figure 4. In particular, the processing means receive from the receiver the received signal digitized according to an appropriate sampling frequency. The signals received are for example digitized inside the receiver which performs the digital conversion of the received-signal power. On the basis of these digitized data, the processing means detect the maximum. When this maximum is detected, the processing means dispatch for example a signal to activate the explosion of the charge carried by the projectile fitted with the proximity fuse according to the invention. Detection of the maximum makes it possible to circumvent the variations of the level of the received signal because of the nature of the obstacle. A bright obstacle will return more light than a dim obstacle. The maximum is at a fixed distance from the munition on account of the relative geometry of the emission cone 31 and of the reception cone 32. A threshold for the level of power received can be combined with the detection of the maximum of power received. This is in order to avoid triggering on overly weak signals of parasitic origin.

The invention can also be integrated as proximity function, in any munition fuse, including in configurations of indirect firing, such as for artillery or mortar. It is also suitable for all types of calibres.

Patentkrav

1. Nærhetsbrannrør egnet til å anbringes på et prosjektil, hvor brannrøret har som oppgave å detektere en nærliggende hindring (2), hvor en nærliggende hindring er definert som en hindring som befinner seg innenfor en minimumsavstand fra brannrøret, hvor brannrøret (30) i hvert fall omfatter:

- en senderanordning (51, 33) med en senderpupill (33) som sender ut en lysstråle (31) rettet forover fra brannrøret;

- en mottakeranordning (52, 34) med en mottakerpupill (34) som detekterer lysfluksene i en mottakskjegle (32) foran brannrøret, hvor lysstrålen og mottakskjeglen har relative orienteringer som er slik at de krysser hverandre, hvor senderpupillen (31) og mottakerpupillen (32) er eksentriske;

hvor et deteksjonsvolum (35) er det volumet hvor lysstrålen krysser kjeglen slik at når en hindring befinner seg i deteksjonsvolumet, lyset som sendes ut av senderanordningen spres tilbake mot deteksjonsanordningen, hvor en nærliggende hindring blir detektert ved å detektere den maksimale tilbakespredte effekten (62, 72), karakterisert ved at mottakskjeglen (32) er sentrert om brannrørets akse (40).

2. Nærhetsbrannrør ifølge krav 1, karakterisert ved at mottakerpupillen (32) har en månesigdform.

3. Nærhetsbrannrør ifølge et hvilket som helst av de foregående krav, karakterisert ved at det leverer et signal dersom minst én betingelse er oppfylt, hvor betingelsen er deteksjon av den maksimale tilbakespredte effekten.

4. Nærhetsbrannrør ifølge krav 3, karakterisert ved at signalet blir levert dersom en andre betingelse er oppfylt, hvor den andre betingelsen er at den maksimale tilbakespredte effekten overstiger en gitt terskel.

5. Nærhetsbrannrør ifølge et hvilket som helst av kravene 3 eller 4, karakterisert ved at signalet er egnet til å utløse detonasjon (4) av en sprengladning.

6. Nærhetsbrannrør ifølge et hvilket som helst av de foregående krav, karakterisert ved at utsendingsstrålen (31) er kodet for å muliggjøre identifisering av den ved mottaksanordningen.

7. Brannrør ifølge krav 6, karakterisert ved at lysstrålen er modulert.

8. Nærhetsbrannrør ifølge et hvilket som helst av de foregående krav, karakterisert ved at lysstrålen blir frembragt av en laserdiode eller en lysdiode.

9. Prosjektil, karakterisert ved at det er utstyrt med et nærhetsbrannrør ifølge et hvilket som helst av de foregående krav.

10. Prosjektil ifølge krav 9, karakterisert ved at den omfatter en ammunisjon av mellomkalibret type.

11. Prosjektil ifølge et hvilket som helst av de foregående krav, karakterisert ved at det er egnet til å avfyres fra en luftbåren plattform (1).

12. Prosjektil ifølge et hvilket som helst av kravene 1 til 10, karakterisert ved at det er egnet til å avfyres fra en bakkeplattform.

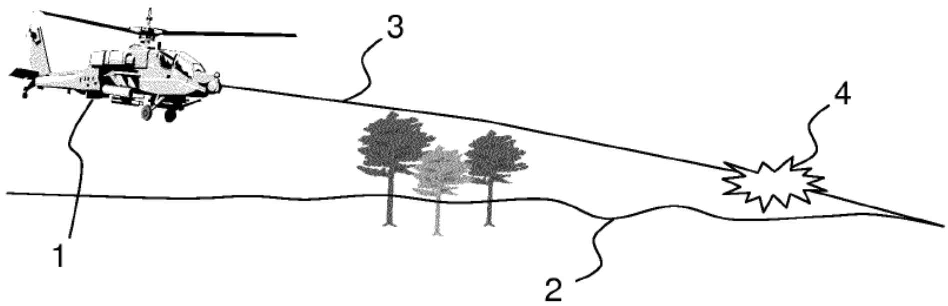

FIG.1

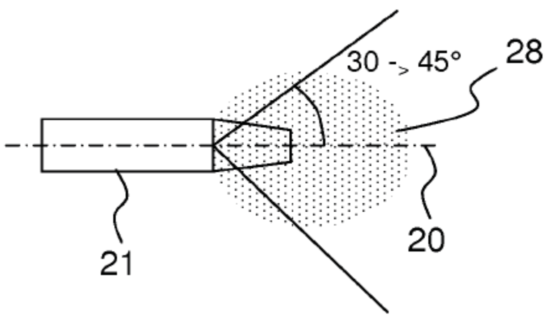

FIG.2a

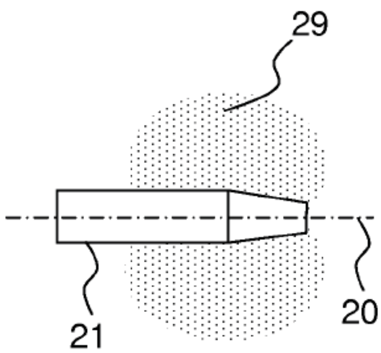

FIG.2b

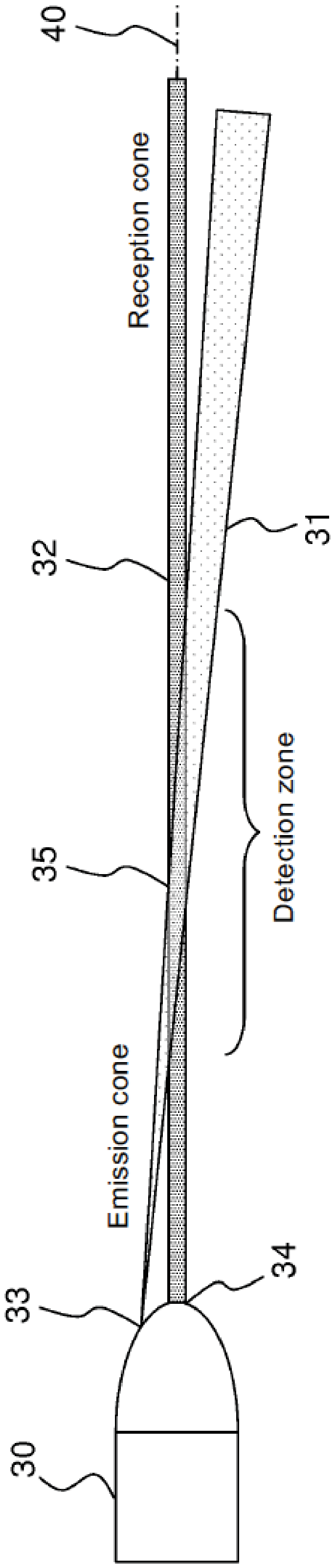
40
Reception cone
32
31
35
Detection zone
Emission cone
33
34
30

FIG.3

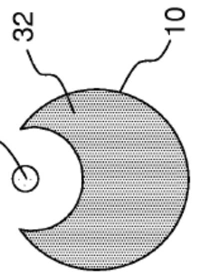

FIG.4a

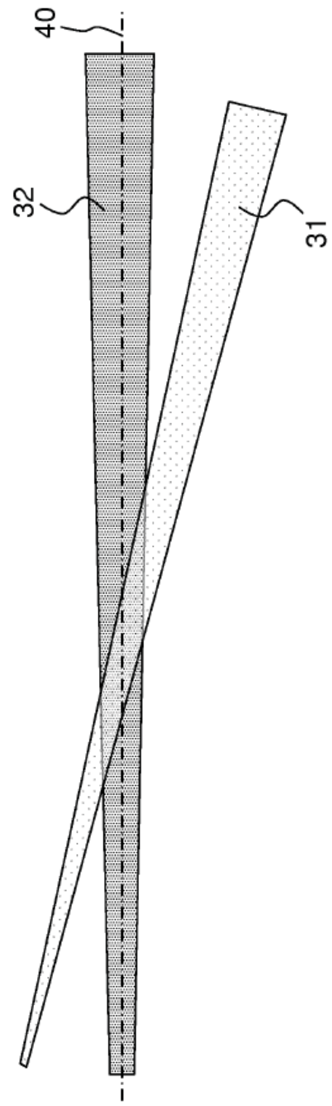

FIG.4b

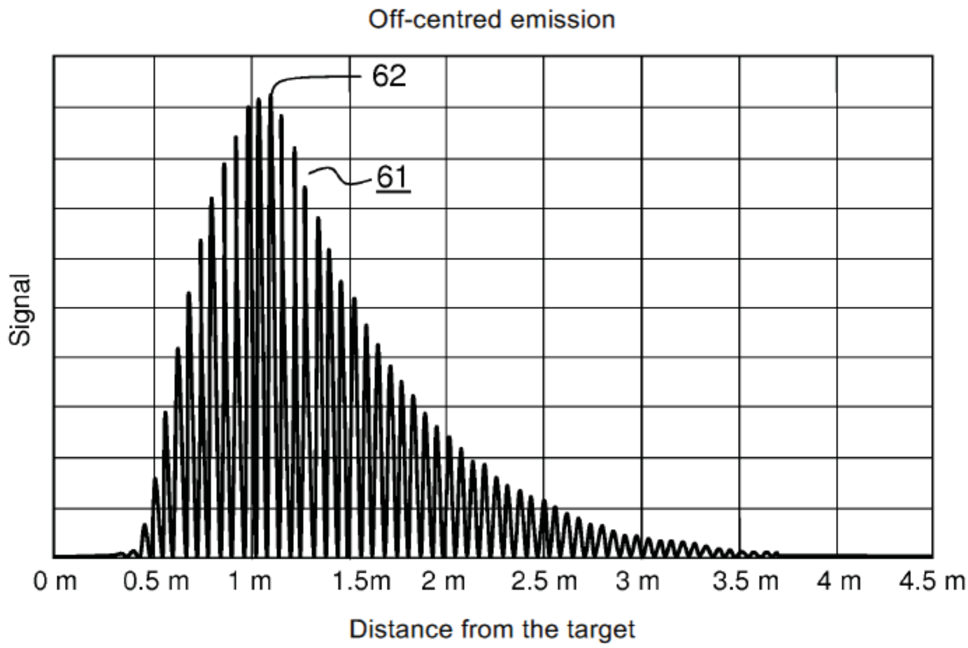
Off-centred emission
62
61
Signal
0 m
0.5 m
1 m
1.5m
2 m
2.5 m
3 m
3.5 m
4 m
4.5 m
Distance from the target

FIG.5

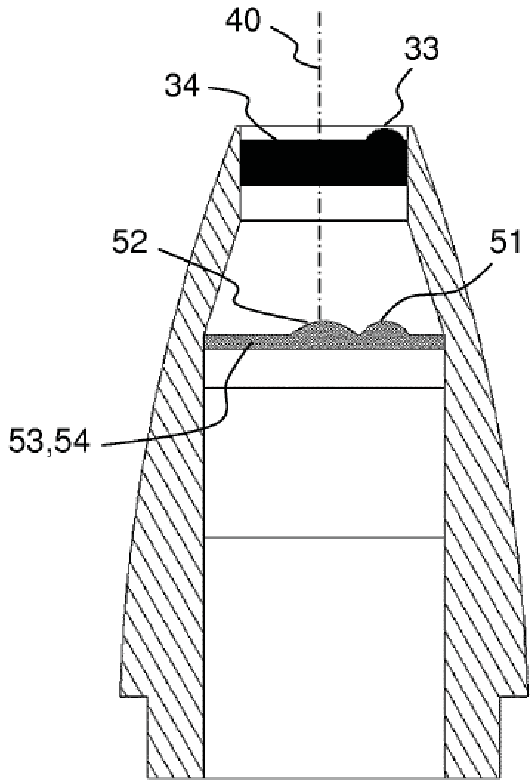

FIG.6