(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 939 881 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
27.11.2002 Bulletin 2002/48

(21) Application number: **97927216.8**

(22) Date of filing: **19.06.1997**

(51) Int Cl.[7]: **F41G 3/14**

(86) International application number:
PCT/FI97/00397

(87) International publication number:
WO 97/048963 (24.12.1997 Gazette 1997/55)

(54) **METHOD FOR CORRECTING THE TRAJECTORY OF A PROJECTILE OF A GUN, A MORTAR OR A ROCKET LAUNCHER OR THE LIKE**

VERFAHREN ZUR FLUGBAHNKORREKTUR EINE GESCHOSSES EINES GESCHÜTZES, EINES MÖRSERS ODER RAKETENWERFERS ODER DESGLEICHEN

PROCEDE DE CORRECTION DE LA TRAJECTOIRE D'UN PROJECTILE TIRE PAR UN CANON, UN MORTIER, UN LANCE-ROQUETTES OU SIMILAIRE

(84) Designated Contracting States:
CH DE FI FR GB IT LI SE

(30) Priority: **19.06.1996 FI 962545**

(43) Date of publication of application:
08.09.1999 Bulletin 1999/36

(73) Proprietor: **Pylkkänen, Pekka**
02270 Espoo (FI)

(72) Inventor: **Pylkkänen, Pekka**
02270 Espoo (FI)

(74) Representative: **Ollikainen, Rauno Johannes**
Leitzinger Oy
Tammasaarenkatu 1
00180 Helsinki (FI)

(56) References cited:
EP-A- 0 261 091
EP-A- 0 624 805
WO-A-90/08936
GB-A- 2 140 538
US-A- 3 344 422

EP 0 939 881 B1

Description

[0001] The present invention relates to a method for correcting the trajectory of a projectile of a gun, a mortar or a rocket launcher or the like firearm, said method comprising a step of determining the site coordinates of a firing position and a recognized target on a map, and of using a compass, an azimuth gyro or some other method for determining the bearing from the firing position to the target at the accuracy of a few degrees. More specifically, the invention is about the speedy adjustment of bearing and elevation of the barrel of a gun for high-precision firing.

[0002] When firing a gun, a mortar and a rocket launcher or the like firearm to far-away targets, the projectile will reach a very high altitude at the highest point of its trajectory, even an altitude of up to 5 - 15 km. Thus, the climatic disturbances have a major effect on target-hitting precision. The force and direction of wind may vary at various altitudes. Also the air density and atmospheric humidity may vary substantially at various altitudes. In order to correct the displacement and elevation of the barrel of a gun so as to account for the climatic disturbance factors, it is prior known to provide a weather data by means of a weather probe which, upon ascending to upper atmospheric layers, transmits information about wind direction and atmospheric pressure. This information is then utilized for calculating a corrected trajectory by means of a so-called layer formula, wherein the trajectory is calculated in increments in various atmospheric layers. This provides an improvement in target-hitting precision, but such prior known method involves several drawbacks. The ascent of a weather sonde to a sufficient altitude may take up to 40 minutes and, thus, the method is slow and not suitable for modern high-speed warfare. In addition, the method involves two inaccuracy factors. First of all, the weather probe is exposed to winds and, hence, during the ascent, it may drift even far away from the location of the projectile trajectory. Secondly, the calculation effected with the layer formula only provides an approximation for the required correction. Attempts have been made to correct the positional inaccuracy by dropping the weather probe from an aircraft. This possibility is not always available. Furthermore, the determination of elevation also requires a temperature correction of gunpowder, since the rate of combustion of gunpowder and the muzzle velocity of a projectile are dependent on the temperature of gunpowder. Taking all the corrections into consideration requires a substantial calculating power and accordingly expensive equipment, if the calculation is to be performed within a reasonable time frame.

[0003] The previously common search firing, in which the fire controllers monitor strikes and supply correction coordinates to the firing position, is no longer widely used since, by such search firing, the firing position reveals its location to the enemy and possibly makes itself a target prior to hitting anything. This is due to the fact that there is modern equipment available which is capable of rapidly clearing the launching site of an approaching projectile on the basis of its trajectory.

[0004] An object of the invention is to provide an improved method for determining the required correction for displacement and elevation of the barrel or tube of a gun, a mortar or a rocket launcher by simultaneously accounting for all firing-related disturbance factors so as to achieve a target-hitting precision better than before. Another object of the invention is to speed up the calculation of required correction and the transfer to a new firing position.

[0005] These objects are achieved by the invention on the basis of the characterizing features set forth in the annexed claim 1. The non-independent claims disclose preferred embodiments for the invention.

[0006] The invention will now be described in more detail with reference made to the accompanying drawing, in which

fig. 1	is a schematic overhead view of the operating principle for a method of the invention, and
figs. 2a and 2b	show alternative embodiments for details associated with one stage in a method of the invention.

[0007] In the depicted case, a gun 1 has been driven to a firing position 2 which has fixed its position accurately e.g. by means of spotting signals received thereby from a GPS-system 6, 7. The reconnaissance has cleared the site coordinates of a target 4 on the map at an accuracy which is sufficient for a projectile finding said coordinates to destroy the target 4.

[0008] A compass utilizing the magnetic field of the earth (e.g. a flux gate compass), an azimuth gyro or some other method is used for determining the bearing from the firing position 2 to the target 4 at an accuracy of a few degrees. An indicator projectile 5 is fired intentionally a few degrees off the target 4 and the elevation is determined such that with standard atmosphere a strike is made at a point P the same distance away as the target 4. If the wind action is e.g. from the direction of an arrow A, the bearing and flying distance of an indicator projectile differ from hypothetical values based on standard atmosphere in such a manner that the indicator projectile falls on the point P. The flying characteristics of the indicator projectile 5, such as weight, shape, and rotative moments relative to various axes, correspond to those of a real explosive projectile.

[0009] The indicator projectile 5 is fitted with an electronic package 8, which contains

- a receiver for picking up positioning signals from an external spotting system, e.g. a GPS-system 6, 7
- conventional electronic elements for fixing a position on the basis of received signals

- a transmitter for sending the site coordinates with a properly ciphered digital radio signal to a receiver unit 3 in the firing position.

[0010] When the receiver unit 3 in the firing position receives the site coordinates of an indicator projectile, the corrections for elevation and bearing can be made easily on the basis of a difference between the coordinates of a hypothetical location P_1 and a real location P_2 of the indicator projectile.

[0011] Although the indicator projectile 5 is fired sufficiently off the target 4 not to be observed in the target area, the indicator projectile must nevertheless travel in substantially the same weather conditions over substantially the same distance as the actual live projectile to the target 4. Thus, all firing-related disturbance factors can be taken into consideration at the same time. This applies also to the temperature of gunpowder, which will be automatically accounted for as the indicator projectile corresponding to the actual explosive projectile in terms of its dimensions and weight is stored at the same temperature as live ammunition.

[0012] The spotting system may be a spotting system based on fixed ground stations or a GPS-system or a differential GPS-system, wherein the inaccuracy intentionally added in satellite spotting 6 is eliminated by means of a ground station 7. These spotting systems are well known and in general use and thus not discussed further in this context.

[0013] If the indicator projectile 5 has its spotting based on a conventional (not differential) GPS-system, the spotting accuracy can be increased according to the invention in such a manner that, in the receiving unit 3 of a firing position, whose site coordinates are precisely known, the spotting is performed simultaneously with the spotting of an indicator projectile by receiving a spotting signal of the GPS-satellites 6 and by comparing the spotting result with the precisely known site coordinates of the firing position 2, 3. This comparison results in the discovery of a position error caused by the fading of system coordinates, whereby a correction equal to said error can be made in the site coordinates received from the indicator projectile 5.

[0014] Fig. 2a illustrates how the electronic unit 8 containing a transmitter and a receiver can be launched or ejected from the indicator projectile 5 rearwards to a substantially stationary position before the indicator projectile 5 hits the ground. Technology for discovering the proper instant is used e.g. in mid-air exploding ammunition.

[0015] Alternatively, the indicator projectile 5 or the electronic unit 8 released therefrom can be decelerated with a parachute 9 prior to hitting the ground, as shown in fig. 2b.

[0016] The arrangements shown in figs. 2a and 2b are used to make sure that the electronic unit 8 does not sink too deep in the ground or disintegrate in case the indicator projectile 5 hits a rock or a stone.

[0017] The release of the electronic unit 8 from the projectile can also be effected on the basis of flying time, in other words the electronic unit has its clock activated during the muzzle acceleration of a projectile and the electronic unit is released after a preset time.

[0018] The electronic unit 8 can be incorporated also in exploding projectiles so as to receive coordinates from all strikes.

[0019] The information supplied by the electronic unit 8 may also include a measured flying time, which can be utilized in fire control calculations.

[0020] The information provided by the electronic unit 8 can also be utilized, such that the received information is used for calculating the corrections necessitated by weather, Coriolis effect, change of gravity (according to latitude), gunpowder temperature and muzzle velocity for conventional fire control calculation.

[0021] The electronic unit 8 can be made self-destructive after it has transmitted site coordinates for its own location. The purpose of this is to avoid revelation of the applied technology.

Claims

1. A method for correcting the trajectory of a projectile (5) of a gun, a mortar or a rocket launcher or the like firearm, said method comprising a step of determining the site coordinates of a firing position (2) and a recognized target (4) on a map, and of using a compass, an azimuth gyro or some other method for determining the bearing from the firing position (2) to the target (4) at the accuracy of a few degrees, and of aiming the direction of fire of a firearm (1) at a desired strike point (P_1), **characterized in that** an indicator projectile (5) corresponding to a live explosive projectile in terms of its flying characteristics is fired at such an elevation that with standard atmosphere, i.e. without disturbance factors, the strike of the indicator projectile (5) or an electronic unit (8) released therefrom is obtained substantially at the distance of the desired strike point (P_1), a receiver included in the electronic unit (8) incorporated in the indicator projectile (5) or released from the indicator projectile is used to receive a positioning signal transmitted by an external positioning system, e.g. a GPS-system (6) for determining the site of the indicator projectile (5) or electronic unit, a transmitter included in the electronic unit (8) is used to transmit signals which contain site coordinates (P_2) of the indicator projectile (5) or the electronic unit (8) to a receiving unit (3) in the firing position and the elevation and bearing of the firearm (1) are corrected on the basis of a difference between the hypothetical (P_1) and real (P_2) sites of the indicator projectile or electronic unit.

2. A method as set forth in claim 1, **characterized in**

that a clock included in the electronic unit (8) activates during the muzzle acceleration of the projectile (5) and the electronic unit (8) is released from the projectile after a preset time lapse.

3. A method as set forth in claim 1, **characterized in that** the information transmitted by the electronic unit (8) includes a measured flying time, which is utilized in fire control calculations.

4. A method as set forth in any of claims 1-3, **characterized in that**, in the receiving unit (3) of a firing position, whose site coordinates are precisely known, the spotting is performed simultaneously with the spotting of the electronic unit (8) by receiving a spotting signal of said external spotting system (6), the spotting result is compared with said precisely known site coordinates of the firing position (2, 3) and the spotting result received from the electronic unit (8) is corrected on the basis of a discovered difference.

5. A method as set forth in any of claims 1-4, **characterized in that** the electronic package (8) containing a transmitter and a receiver is launched or ejected from the indicator projectile (5) rearwards to a substantially stationary position before the indicator projectile hits the ground.

6. A method as set forth in any of claims 1-5, **characterized in that** the indicator projectile (5) or the electronic package (8) released therefrom, which includes a transmitter and a receiver, is decelerated with a parachute (9) prior to hitting the ground.

7. A method as set forth in any of claims 1-6, **characterized in that** the indicator projectile (5) corresponds to an actual explosive projectile in terms of its design and weight and that the indicator projectile (5) is stored at the same temperature as live projectiles.

8. A method as set forth in any of claims 1-7, **characterized in that** the indicator projectile comprises a conventional explosive projectile.

Patentansprüche

1. Verfahren zum Korrigieren der Flugbahn des Projektils (5) eines Geschützes, eines Mörsers oder eines Raketenwerfers oder einer ähnlichen Schußwaffe, wobei man bei dem Verfahren die Ortskoordinaten einer Feuerposition (2) und eines erkannten Ziels (4) auf einer Karte bestimmt und einen Kompaß, einen Azimutkreisel oder ein anderes Verfahren zur Bestimmung der Lage von der Feuerposition (2) zu dem Ziel (4) mit einer Genauigkeit von einigen wenigen Grad verwendet und die Zielrichtung einer Schußwaffe (1) auf einen gewünschten Auftreffpunkt (P_1) einstellt, **dadurch gekennzeichnet, daß** ein Indikatorprojektil (5), das im Hinblick auf seine Flugeigenschaften einem scharfen Explosivprojektil entspricht, bis auf eine solche Höhe abgefeuert wird, daß bei Standardatmosphäre, d.h. ohne Störfaktoren, das Auftreffen des Indikatorprojektils (5) oder einer aus diesem herausgelassenen elektronischen Einheit (8) im wesentlichen in der Distanz des gewünschten Auftreffpunkts (P_1) erreicht wird, ein in der elektronischen Einheit (8), die in das Indikatorprojektil (5) integriert ist oder aus dem Indikatorprojektil herausgelassen wird, enthaltener Empfänger dazu dient, ein Positionierungssignal zu empfangen, das durch ein externes Positionierungssystem, z.B. ein GPS-System (6) zum Bestimmen des Orts des Indikatorprojektils (5) oder der elektronischen Einheit, gesendet wird, ein in der elektronischen Einheit (8) enthaltener Sender dazu dient, Signale, die Ortskoordinaten (P_2) des Indikatorprojektils (5) oder der elektronischen Einheit (8) enthalten, zu einer Empfangseinheit (3) an der Feuerposition zu senden, und die Höhe und Lage der Schußwaffe (1) auf der Grundlage einer Differenz zwischen dem hypothetischen Ort (P_1) und dem tatsächlichen Ort (P_2) des Indikatorprojektils oder der elektronischen Einheit korrigiert wird.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, daß** sich ein in der elektronischen Einheit (8) enthaltener Zeitgeber während der Mündungsbeschleunigung des Projektils (5) aktiviert und die elektronische Einheit (8) nach einer im voraus eingestellten Zeitspanne aus dem Projektil herausgelassen wird.

3. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, daß** die durch die elektronische Einheit (8) gesendeten Informationen eine gemessene Flugzeit enthalten, die bei Schußsteuerberechnungen verwendet wird.

4. Verfahren nach einem der Ansprüche 1-3, **dadurch gekennzeichnet, daß** in der Empfangseinheit (3) einer Feuerposition, deren Ortskoordinaten genau bekannt sind, die Stellenbestimmung gleichzeitig mit der Stellenbestimmung der elektronischen Einheit (8) durch Empfangen eines Stellenbestimmungssignals des externen Stellenbestimmungssystems (6) durchgeführt wird, wobei das Stellenbestimmungsergebnis mit den genau bekannten Ortskoordinaten der Feuerposition (2, 3) verglichen und das aus der elektronischen Einheit (8) empfangene Stellenbestimmungsergebnis auf der Grundlage einer entdeckten Differenz korrigiert wird.

5. Verfahren nach einem der Ansprüche 1-4, **dadurch**

gekennzeichnet, daß der elektronische Baustein (8), der einen Sender und einen Empfänger enthält, nach hinten aus dem Indikatorprojektil (5) zu einer im wesentlichen stationären Position geschleudert oder ausgeworfen wird, bevor das Indikatorprojektil auf dem Boden auftrifft.

6. Verfahren nach einem der Ansprüche 1-5, **dadurch gekennzeichnet, daß** das Indikatorprojektil (5) oder der aus ihm herausgelassene elektronische Baustein (8), der einen Sender und einen Empfänger enthält, vor dem Auftreffen auf dem Boden mit einem Fallschirm amgebremst wird.

7. Verfahren nach einem der Ansprüche 1-6, **dadurch gekennzeichnet, daß** das Indikatorprojektil (5) im Hinblick auf seine Konstruktion und sein Gewicht einem tatsächlichen Explosivprojektil entspricht und daß das Indikatorprojektil (5) mit derselben Temperatur wie scharfe Projektile gelagert wird.

8. Verfahren nach einem der Ansprüche 1-7, **dadurch gekennzeichnet, daß** das Indikatorprojektil (5) ein herkömmliches Explosivprojektil umfaßt.

Revendications

1. Procédé permettant de corriger la trajectoire d'un projectile (5) d'un canon, d'un mortier ou d'un lance-roquette ou d'une arme à feu similaire, ledit procédé comprenant une étape consistant à déterminer les coordonnées de site d'une position de tir (2) et d'une cible reconnue (4) sur une carte et à utiliser un compas, un gyroscope azimutal ou tout autre procédé pour déterminer le pointage depuis la position de tir (2) jusqu'à la cible (4) selon la précision de quelques degrés et à viser la direction de tir d'une arme à feu (1) au niveau d'un point d'impact souhaité (P_1), **caractérisé en ce qu'**un projectile indicateur (5) correspondant à un projectile explosif actif en termes de ses caractéristiques de vol est tiré à une élévation qui est telle qu'avec une atmosphère standard, c'est-à-dire sans facteur de perturbation, la frappe du projectile indicateur (5) ou d'une unité électronique (8) qui est libérée depuis soit obtenue sensiblement à la distance du point d'impact souhaité (P_1), un récepteur inclus dans l'unité électronique (8), incorporée dans le projectile indicateur (5) ou libérée à partir du projectile indicateur, étant utilisé pour recevoir un signal de positionnement qui est émis par un système de positionnement externe, par exemple un système GPS (6), pour déterminer le site du projectile indicateur (5) ou de l'unité électronique, un émetteur qui est inclus dans l'unité électronique (8) étant utilisé pour transmettre des signaux qui contiennent des coordonnées de site (P_2) du projectile indicateur (5) ou de l'unité électronique (8) à une unité de réception (3) à la position de tir, et l'élévation et le pointage de l'arme à feu (1) étant corrigés sur la base d'une différence entre les sites hypothétique (P_1) et réel (P_2) du projectile indicateur ou de l'unité électronique.

2. Procédé selon la revendication 1, **caractérisé en ce que** l'horloge qui est incluse dans l'unité électronique (8) est activée pendant l'accélération de bouche du projectile (5) et l'unité électronique (8) est libérée du projectile après l'écoulement d'un temps préétabli.

3. Procédé selon la revendication 1, **caractérisé en ce que** l'information qui est transmise par l'unité électronique (8) inclut un temps de vol mesuré, lequel est utilisé lors de calculs de commande de tir.

4. Procédé selon l'une quelconque des revendications 1 à 3, **caractérisé en ce que**, dans l'unité de réception (3) d'une position de tir dont des coordonnées de site sont connues de façon précise, le pointage est réalisé simultanément au pointage de l'unité électronique (8) en recevant un signal de pointage dudit système de pointage externe (6), le résultat de pointage est comparé auxdites coordonnées de site de la position de tir (2, 3) connues de façon précise et le résultat de pointage qui est reçu depuis l'unité électronique (8) est corrigé sur la base d'une différence découverte.

5. Procédé selon l'une quelconque des revendications 1 à 4, **caractérisé en ce que** le module électronique (8) qui contient un émetteur et un récepteur est lancé ou éjecté depuis le projectile indicateur (5) vers l'arrière jusqu'à une position sensiblement stationnaire avant que le projectile indicateur ne touche le sol.

6. Procédé selon l'une quelconque des revendications 1 à 5, **caractérisé en ce que** le projectile indicateur (5) ou le module électronique (8) qui en est libéré, lequel module inclut un émetteur et un récepteur, est décéléré à l'aide d'un parachute (9) avant d'atteindre le sol.

7. Procédé selon l'une quelconque des revendications 1 à 6, **caractérisé en ce que** le projectile indicateur (5) correspond à un projectile explosif réel en termes de sa conception et de son poids et **en ce que** le projectile indicateur (5) est stocké à la même température que le projectile réel.

8. Procédé selon l'une quelconque des revendications 1 à 7, **caractérisé en ce que** le projectile indicateur comprend un projectile explosif classique.

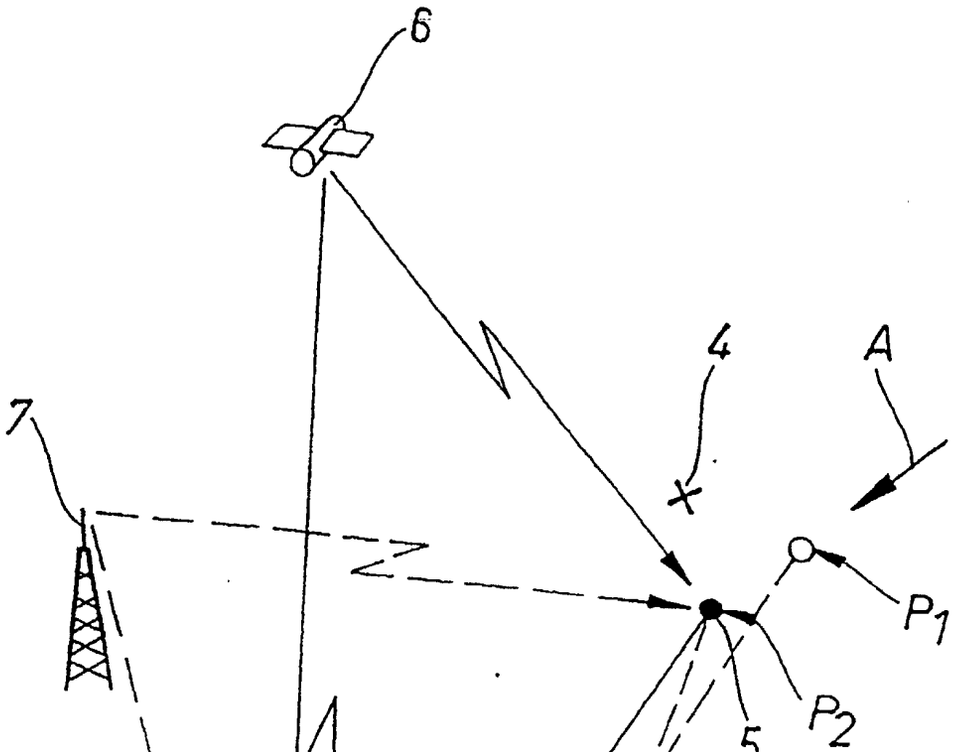

Fig. 1

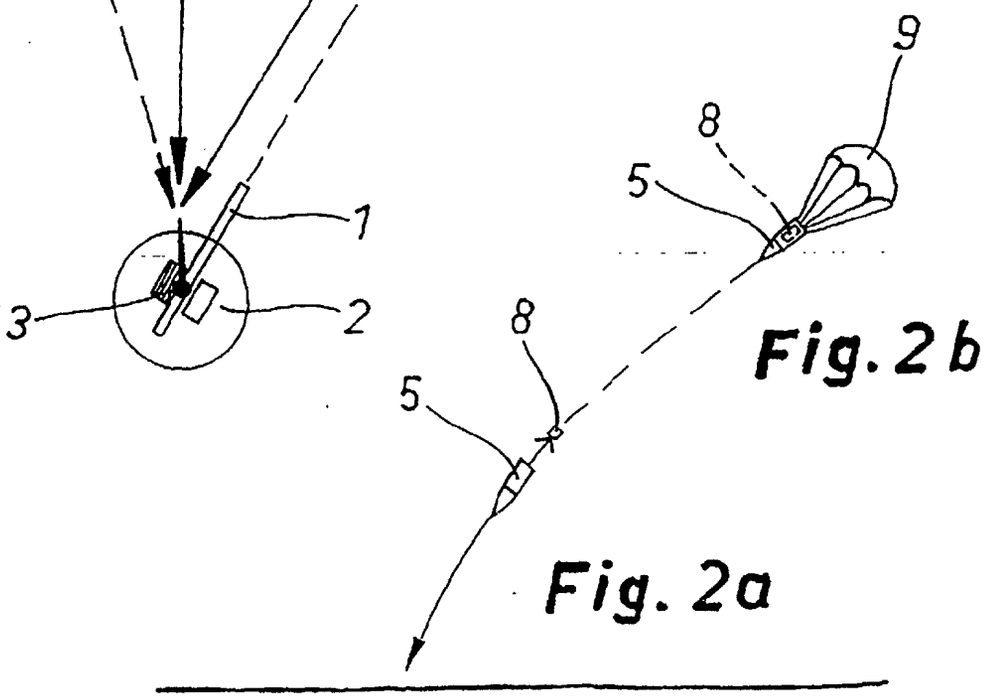

Fig. 2b

Fig. 2a