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(54) **A method and an apparatus for tracking a missile in its trajectory.**

(57) The disclosure relates to a method and an apparatus (2) for tracking an unguided rocket projectile during at least a part of its trajectory. According to the invention, it is possible, with the knowledge of the difference between the actual trajectory of the rocket projectile and its theoretically calculated trajectory, to decide on and execute those corrections which are required in order that subsequent rocket projectiles (3) launched at the same target area shall register hits. According to the invention, the rocket projectile (3) is tracked by means of an IR sensor, or alternatively, a TV camera (2) which senses the contrast between the projectile (3), or parts thereof, and preferably the nozzle of the rocket motor, and the background (the heavens).

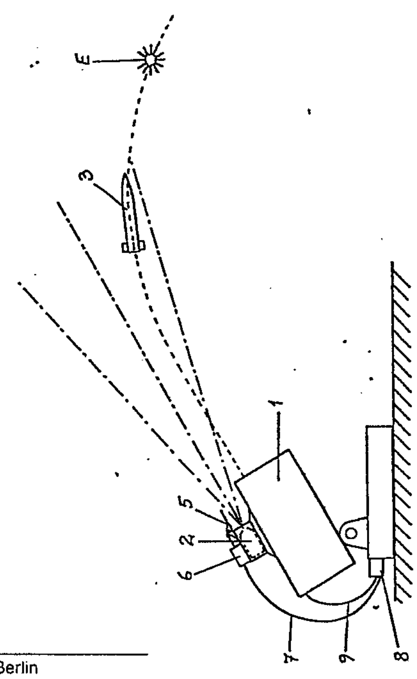

Fig. 1

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Description

A METHOD AND AN APPARATUS FOR TRACKING A MISSILE IN ITS TRAJECTORY

TECHNICAL FIELD

The present invention relates to a method and an apparatus for tracking a missile during at least the first part of its trajectory.

The invention is primarily intended for utilization in the calculation of requisite trajectory corrections for artillery missiles in respect of, above all, ground winds in order that the missile make a hit within a predetermined target area.

BACKGROUND ART

The designation artillery missiles is here intended to mean unguided missiles which are discharged in ballistic trajectories towards determined targets. Such artillery missiles are often discharged in salvoes for blanket bombardment. Initially, the aiming and direction of such artillery missiles towards their respective targets are effected by the launcher in compliance with theoretical ballistic calculations supplemented with measured correctional values in respect of wind forces etc. within the contemplated missile trajectory. Such artillery missiles may also be provided with means for course correction during the final - or homing - part of their trajectory without, as a result, being classified as guided missiles, since these latter are guided throughout all or the major part of their trajectory.

As in all rocket projectiles, artillery missiles are highly sensitive to the effect of the wind, primarily during the first part of their trajectory while the motor is burning and the rocket is accelerating. While anemometrical indications and measurement of ground wind speed may provide a basis for adjusting or correcting the direction of discharge of the missile, a considerable amount of uncertainty remains because such anemometrical indication cannot - for practical reasons - be effected in immediate conjunction with launching, or discharge, of the missile, and because ground wind speed is not representative of the velocity of the wind throughout the entire range of altitude through which the missile passes during that time when the motor is burning.

One prior art method of reducing the influence of the wind is to discharge a test missile and track it by radar. By comparing the calculated trajectory with the physically measured trajectory, a correction may be introduced which reduces the deviation for a subsequent salvo to a minimum. The test rocket is normally destroyed before it reaches the target, thereby revealing the contemplated target to the enemy.

The drawbacks inherent in this prior-art solution are that the radar equipment involved will, first, be relatively expensive, and, secondly, that it will, using present-day technology, be extremely bulky and require extra vehicles and personnel.

The present invention calls, instead of the use of the radar echo of the test rocket, for the utilization of the powerful light and IR radiation of the rocket motor nozzle during the burning time of the motor, or alternatively their contrast against the background (the heavens) in order to track, using an IR sensor or TV camera, the rocket during at least the first part of its trajectory. By such means, it will, thus, be possible to attain, using an economical, small and light IR sensor or TV camera, substantially the same results as achieved using prior-art technology which required a sophisticated radar installation.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

The nature of the present invention and its aspects, as defined in the appended Claims, will be more readily understood from the following brief description of the accompanying Drawings, and discussion relating thereto.

In the accompanying Drawings, Figs. 1 and 2 show basic dispositions of rocket launchers discharging artillery rockets supplemented with an IR sensor or TV camera of the type contemplated herein; and

Fig. 3 shows, on a larger scale, a cross section through the contemplated sensor; while

Fig. 4 shows an indicator for direct monitoring of the deviation of the rocket from the reference alignment of the launcher.

DESCRIPTION OF PREFERRED EMBODIMENT

Referring to the Drawings, in which the same details have been given the same reference numerals in all Drawings, Fig. 1 schematically illustrates a launcher 1 fitted with an IR sensor or TV camera 2 and a rocket 3 which is at that point along its trajectory where the motor cuts out. The sensor or camera 2 may either be fixedly mounted to the elevating system and register the position of the rocket (the nozzle of the rocket) as a video signal or the like for subsequent image processing, or may be a tracking sensor which, by means of a servo system (not shown) aims the IR or light sensor towards the rocket and measures angular deviations between the sensor and the elevating system of the launcher. Both of these systems utilize prior-art technology. Point E marks the point of destruction of the test rocket.

If the camera or sensor is of that type which indicates the position of the rocket from a fixed determined point, the result may be presented on an image generated by IR or TV technique of the type shown in Fig. 4 where point 10 marks the reference direction of the launcher and point 12 the actual position of the rocket. y and z, respectively, thus provide directly readable values of the deviation of the rocket from the reference line of the launcher, which, in its turn, coincides as a rule with the aiming alignment of the rocket launcher.

In tracker sensors which, hence, follow or track the trajectory of the rocket projectile, corresponding values y and z will be obtained from angular indicators on the sensor. Irrespective of the type of sensor, y and z are suitably measured at one or a plurality of points along that part of the trajectory of the rocket where its motor is operative. By comparison with the values calculated by fire control, a measure will be obtained of the effect which the ground wind speed - and possibly other sources of disturbance - may have upon the rocket. This information is fed back to fire control for calculation of correctional aiming angles. If it is assumed that the ground wind conditions are the same at the launching site and the target, such calculation may also correctionally compensate for the effects of the ground wird during the homing phase of the ballistic trajectory.

Fire control is that function which calculates, either manually or by machine, the trajectories of the rockets. It may be disposed at the launcher or in a separate fire control central unit.

If weather conditions prevent the IR or TV sensor from tracking the rocket right up to the point when the motor cuts out, only a short part of the trajectory may be used for correctional purposes. This reduces overall accuracy, but since the effects of the wind are greatest at the beginning of the trajectory, a considerable degree of the contemplated effect will nevertheless be attained.

Fig. 2 illustrates the same principle as that shown in Fig. 1, but with that difference that the IR or TV sensor has been disposed a distance from the launcher. Hereby, the sensor is further protected from the rocket flame and those propellant gases which the rocket thrusts rearwardly on launching, but this is at the cost of a problem which occurs in parallel adjustment of the launcher and the sensor. Such adjustment requires certain auxiliary equipment and adds to the entry error from the dispersion in the time-distance relationship of the projectile which always occurs.

Under good weather conditions, the tracking may continue even after the motor has cut out. This is particularly possible if a TV sensor or a sensor in the close IR band is employed such that the rocket makes a clear contrast against the heavens. In such cases, the tracking may be extended as far as is permitted by the range of the sensor, which provides a further improved basis for correction of the aiming angles and parameters of the launcher.

To protect the sensors - and in particular their optics -these are housed in special protective devices which are fitted at their front with a lowering protective lid 5. Their design is apparent from Fig. 3 which shows the protective device with the protective lid 5 in the closed position.

The protective lid 5 is suitably operated by an electromechanical or electro-hydraulic apparatus 6 and is synchronized with the discharge of the rocket 3 such that the lid is closed and protects the optics until such time as the rocket projectile has travelled so far along its trajectory that its propellant gases can no longer damage the optics. Experience has shown that this point along the trajectory is reached well before the cut-out time of the rocket.

Also in Fig. 3, the sensor 2 is provided with a protective casing 4 and a protective lid 5. In the illustrated embodiment, the opening movement is obtained by the intermediary of a hydraulic cylinder 6 which, via a linkage system 11, is in communication with the protective lid. The hydraulic cylinder receives its operating oil from the hydraulic system of the launcher. Opening is controlled by means of an electro-hydraulic valve 8 in a per se known manner. The hydraulic communication between the launcher and the cylinder is designated 7 in Figs. 1 and 2. The electric communication between the launcher and the valve is designated 9.

The present invention should not be considered as restricted to that described above and shown on the Drawings, many modifications being conceivable without departing from the spirit and scope of the attended Claims.

Claims

1. A method of tracking a rocket projectile during at least the first part of its trajectory, characterized in that the trajectory of the rocket projectile is indicated by a sensor disposed in the proximity of the launcher of the rocket, the sensor being operative to sense the contrast between the projectile or parts thereof and its background (the heavens).

2. The method as claimed in Claim 1, characterized in that the nozzle of the rocket motor emitting powerful light and IR radiation is utilized for indicating, by means of a sensor such as a TV camera or an IR sensor, the position of the rocket along its trajectory.

3. The method as claimed in Claim 1, characterized in that the contrast of the rocket projectile against its background is utilized for indicating, by means of a TV camera as sensor, the position of the rocket projectile along its trajectory.

4. The method as claimed in any one or more of Claims 1-3, characterized in that the sensor is caused, by a servo system, to track the projectile along its trajectory for direct indication of angular deviations between the projectile and the aiming alignment of its launching system at the moment of discharge.

5. The method as claimed in any one or more of Claims 1-3, characterized in that the sensor transmits the information on the relative position of the rocket projectile in relation to the aiming alignment of the launching system in the form of coordinates which indicate the deviations of the rocket projectile from said alignment.

6. The method as claimed in any one or more of Claims 1-5, characterized in that the sensor transmits its information on the actual trajectory of the projectile in the form of a video signal suitable for subsequent image processing.

7. The method as claimed in any one or more of the preceding Claims, characterized in that information received via the sensor on the actual trajectory of the rocket projectile is utilized for determining, by means of comparisons with the calculated theoretical trajectory of the projectile, necessary corrections to

subsequent rocket projectiles launched at the same target area.

8. An apparatus for tracking a rocket projectile (3) in its trajectory in accordance with the method as claimed in any one or more of Claims 1-7, characterized in that it consists of a sensor (2) disposed in the proximity of the launching apparatus (1) of said rocket projectile, said sensor indicating the contrast of said rocket projectile (3) against its background (the heavens) for at least a part of its trajectory.

9. The apparatus as claimed in Claim 8, characterized in that said sensor (2) is interconnected with a servo system controlled by said sensor proper, said servo system centering said sensor (2) against said rocket projectile (3) and indicating the the position thereof in such a manner that the value of such indication may be directly compared with the angular deviation from the theoretically calculated position of the projectile at the same moment in time.

10. The apparatus as claimed in Claim 8 or 9, characterized in that the said sensor (2) consists of a device which is IR sensitive

11. The apparatus as claimed in Claim 8 or 9, characterized in that said sensor (2) consists of a TV camera.

12. The apparatus as claimed in any one of Claims 8-11, characterized in that said sensor (2) is provided with a collapsably removable protective lid (5) facing along the calculated trajectory of said rocket projectile (3), said protective lid (5) being connected to synchronization means (6) which automatically displace said lid (5) only when said rocket projectile (3) has travelled so far away from said sensor (2) that its propellant gases can no longer cause damage thereto.

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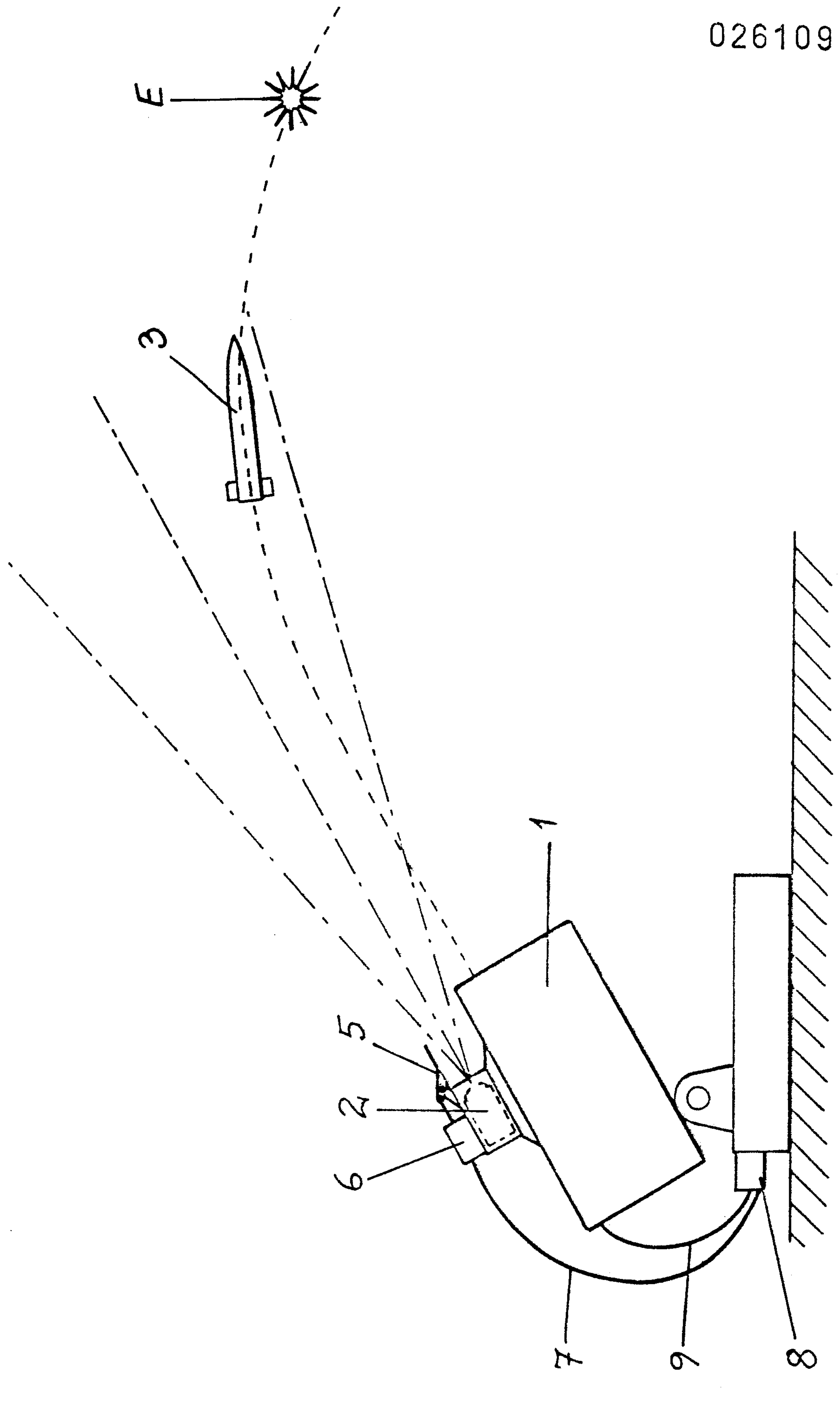

Fig. 1

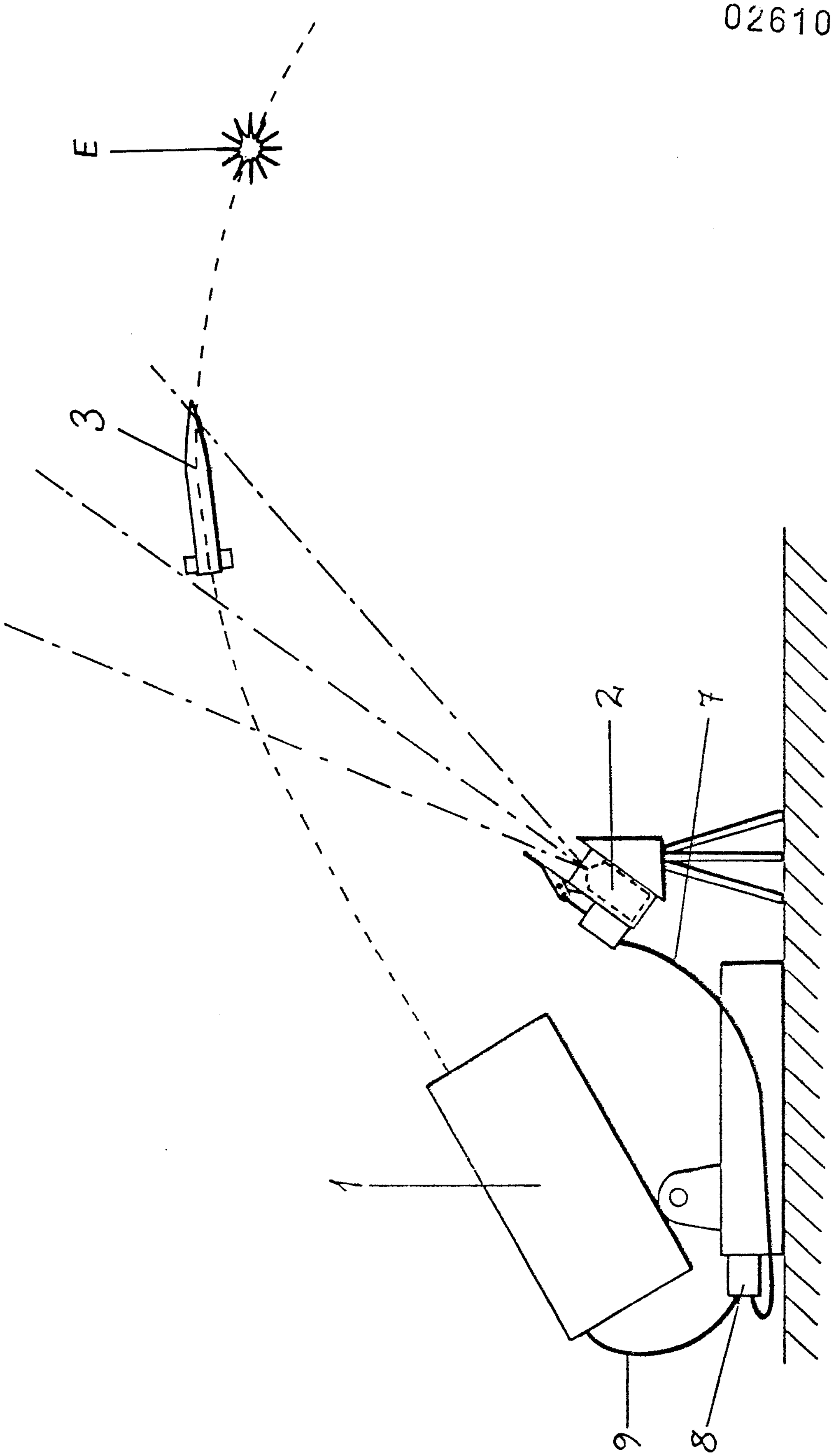

Fig. 2

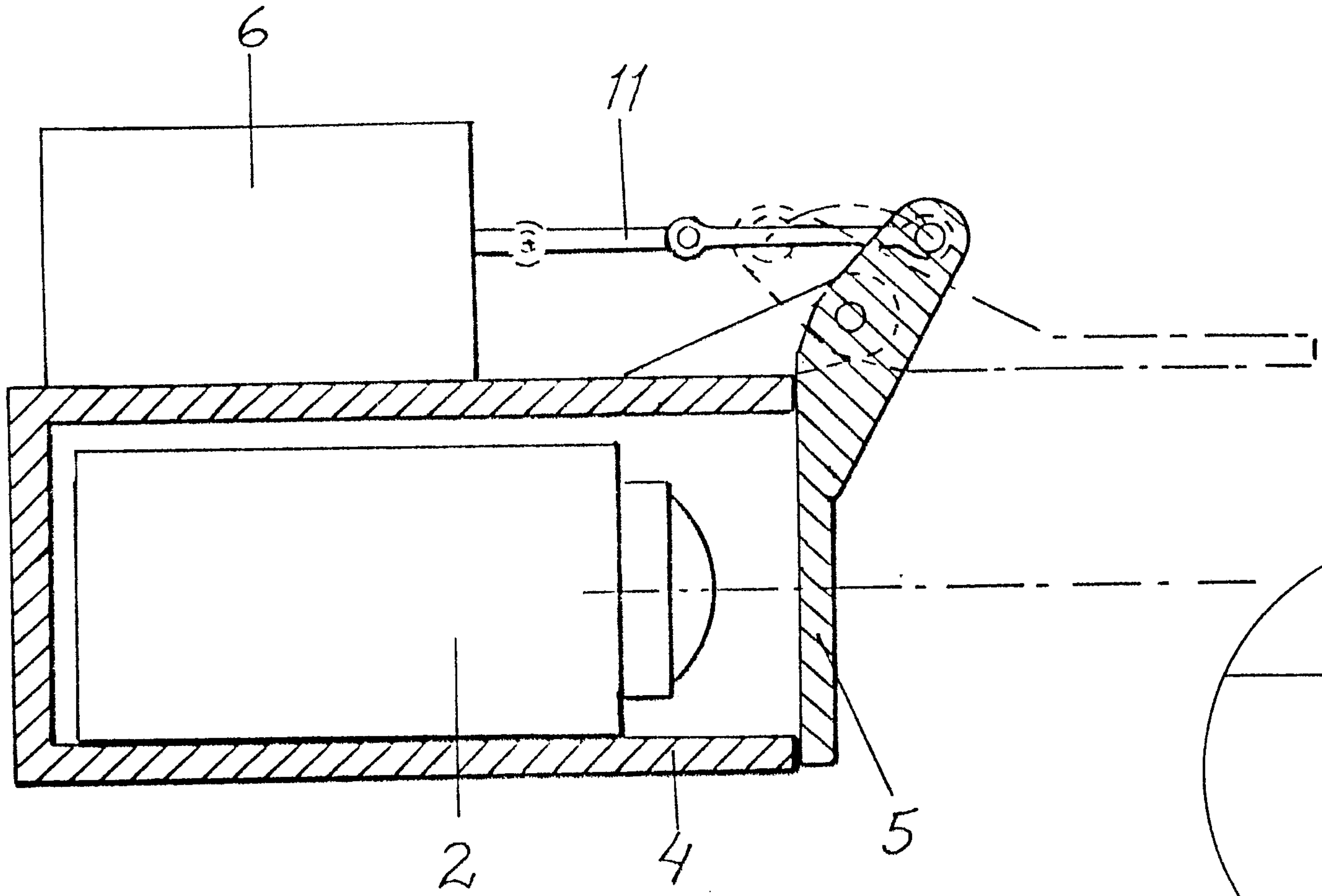

Fig. 3

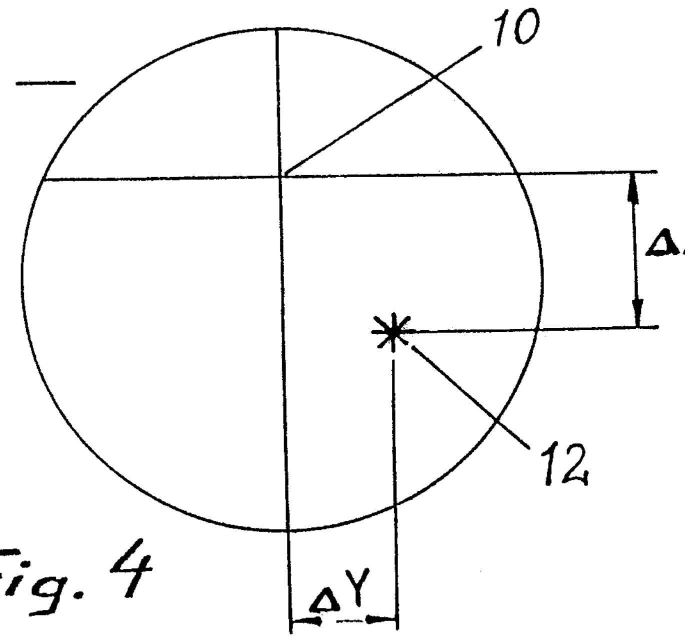

Fig. 4