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Schmidt et al.

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[54] **FIRE RANGING METHOD FOR LAUNCHERS OF SELF-PROPELLED MISSILES**

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** .... **89/1.8,** 89/41 E, 89/41 TV, 250/203 CT

[51] **Int. Cl.** **F41g 3/02**

[58] **Field of Search** .... 33/245; 89/1.8, 1.815, 89/1.819, 41 E, 41 L, 41 TV; 102/87; 250/203 R, 203 CT; 356/140

[56] **References Cited**

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Attorney, Agent, or Firm—Finnegan, Henderson, Farabow & Garrett

[57] **ABSTRACT**

A fire ranging method for launchers of self-propelled missiles consisting in measuring the angular deviation between the theoretical trajectory of the missile and the point where combustion of the acceleration propulsive charge ceases and in subjecting the launcher to an angular displacement in the opposite direction, the amplitude of said angular displacement being proportional to that of the measured deviation.

10 Claims, 3 Drawing Figures

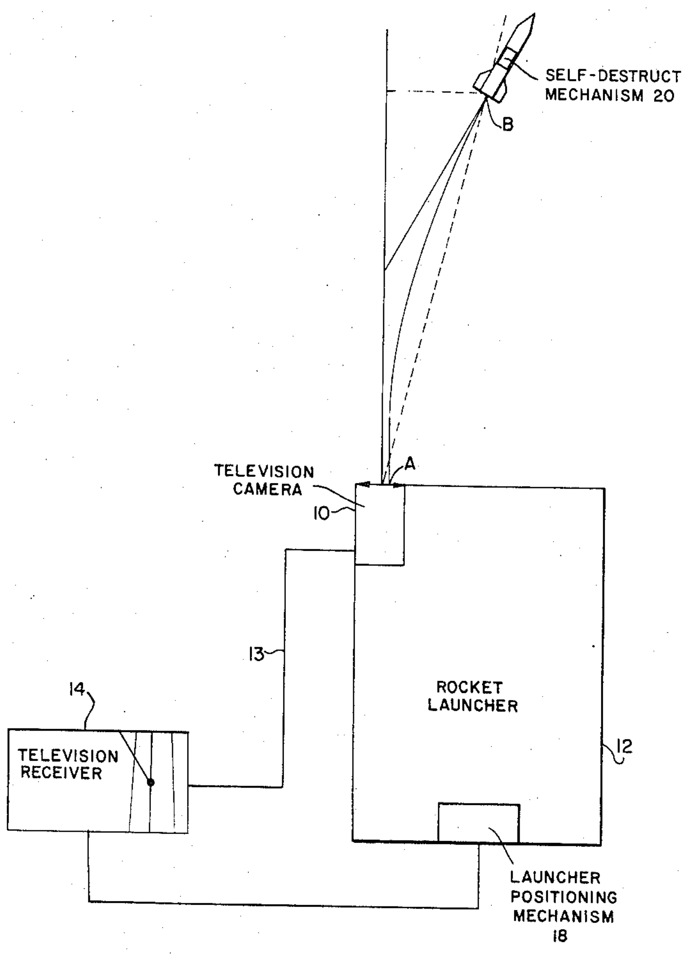


Fig:1

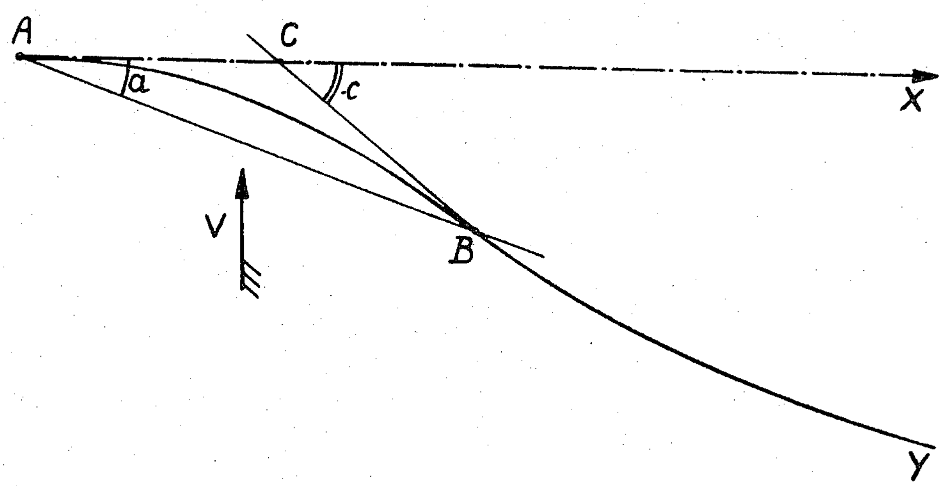
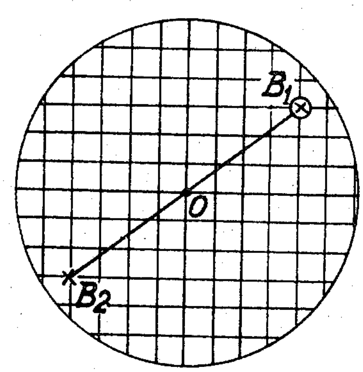


Fig:2



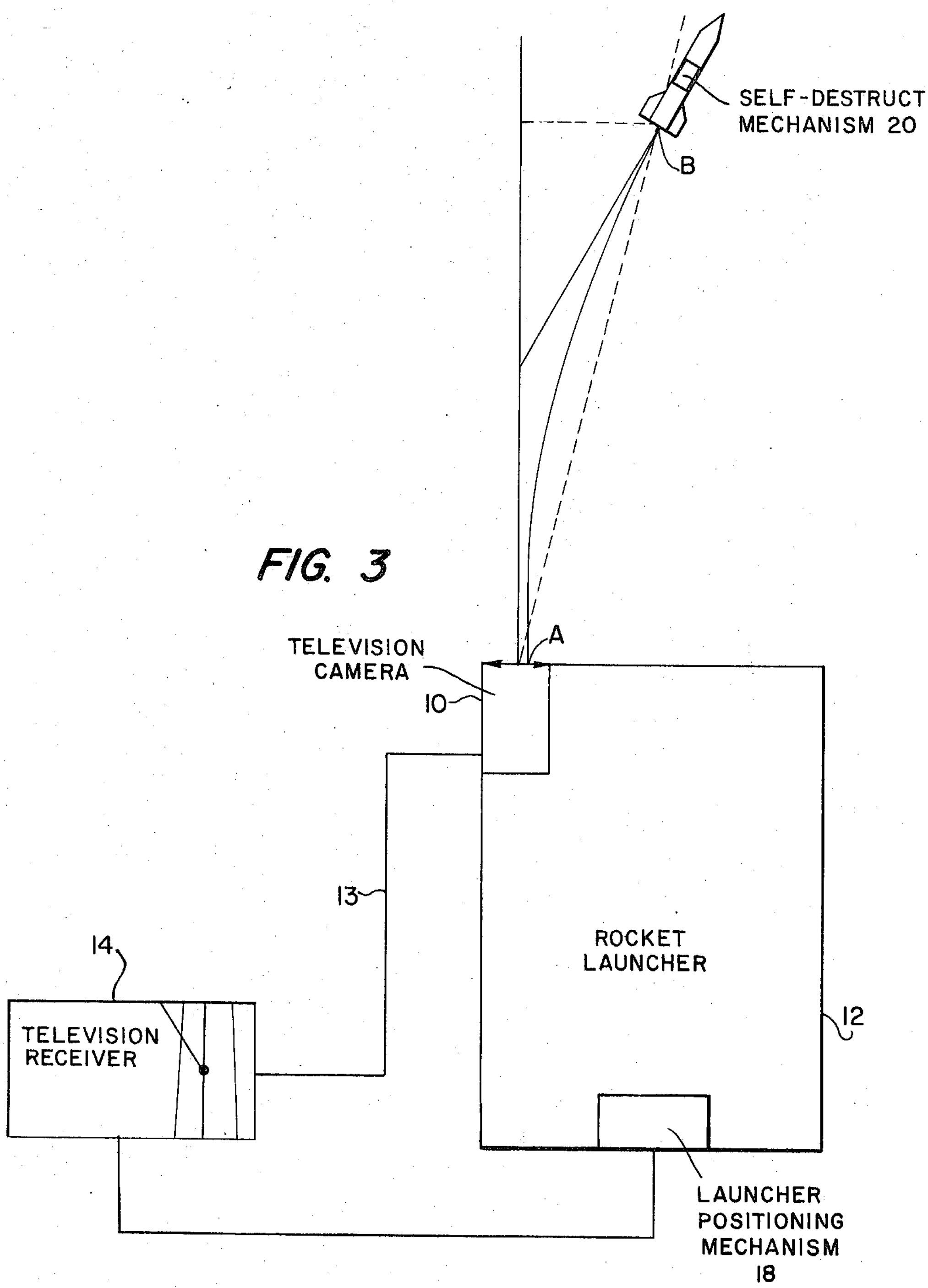

SELF-DESTRUCT MECHANISM 20
B
A
TELEVISION CAMERA
10
13
14
TELEVISION RECEIVER
ROCKET LAUNCHER
12
LAUNCHER POSITIONING MECHANISM 18

FIG. 3

FIRE RANGING METHOD FOR LAUNCHERS OF SELF-PROPELLED MISSILES

This invention relates to a fire ranging method for launchers of self-propelled missiles.

Ranging of self-propelled missiles is made very difficult owing to the magnitude of the deviations in accuracy caused by the effect of winds, this being particularly strong on missiles provided with a tail fin unit and having a relatively low speed of departure from the launcher.

In fact, at the missile acceleration phase, the action of side wind on the tail fin unit, which is situated at the rear, causes the missile to pivot slightly and come round to the wind; then in the ballistic phase of the path of travel of the missile the wind by a drift effect brings the missile towards the ideal trajectory it would have without wind effect. However, with missiles having a low starting speed, the divergence caused at the beginning of the missile trajectory is much greater then the subsequent drift. As a result, ranging with this kind of missile is very uncertain.

Furthermore, ranging operations based on observation of impact are very difficult because these divergences are of such an amount that the points of impact may go out of the field of vision of the observer, and also the correction elements thus determined at the moment of impact have lost some of their value at the moment they are used for the purpose of subsequent firing owning to the rapid variations in air conditions at ground level and low altitudes. Furthermore, ranging by observation of points of impact considerably reduces the effect of surprise.

The aim of the present invention is to provide a method of ranging which obviates these various disadvantages.

According to the present invention there is provided a fire ranging method for launchers of self-propelled missiles, in which the angular deviation between the theoretical trajectory of the missile and the point where combustion of the acceleration propulsive charge ceases is measured, and the launcher is subjected to angular movement in the opposite direction and with an amplitude proportional to that of the measured deviation, the proportion factor being adapted to the type of missile in question and is determined experimentally.

Embodiments of the invention will now be described by way of example only, with reference to the accompanying drawings, in which:

FIG. 1 shows a curve illustrating diagrammatically the horizontal projection of the trajectory of a self-propelled missile;

FIG. 2 shows a diagram illustrating a visual method of ranging.

FIG. 3 is a schematic illustration illustrating a remote controlled method of ranging.

Referring now to the drawings in detail, FIG. 1 illustrates, in a diagrammatic manner, the trajectory deviation of a self-propelled missile. The straight line AX shows the trajectory followed by the missile when there is no wind and the curve AY represents the trajectory followed by the missile when acted upon by a side wind from a direction perpendicular thereto, illustrated by the vector V.

At the beginning, at A, the speed of the missile is very low, the deviation caused by the wind is at the maximum and then decreases asymptotically, to maintain a

stable value from the instant at which the combustion of the propulsive acceleration charge is completed. From this moment, the trajectory of the missile is purely ballistic; the missile being situated in a mass of moving air, will be moved with the said mass of air, in other words the trajectory will bend in the reverse direction in the direction towards AX.

By way of example, in the case of a certain rocket having a range of 15 kilometres, a combustion period for the acceleration propulsive charge of 2 seconds and a launcher departure speed of 35m/sec, it is estimated that the deviation caused by a side wind of 1 metre/second is about 240 metres, whereas the compensation due to drift is only about 40 metres, that is to say the deviation at the point of impact is about 200 metres.

As a result, for a wind of 5 m/s the deviation is of the order of 1 km. This explains why regulating fire by observation of the point of impact can only be very uncertain.

Work carried out by the applicants has shown that if one considers on the one hand the angle a defined by the straight lines AB and AX and on the other hand the angle c defined by the tangent BC to the trajectory at the point B and the straight line AX, there exists, for a very great variety of winds, a correlation between these two angles a and c which can be expressed as $a=kc$, and this factor k can be considered with quite adequate approximation as constant for a given type of projectile.

Thus, if the missile is observed during its acceleration phase, it is easy to determine the angle a by any sighting or aiming means; once this angle a is measured, it is sufficient to make the launcher pivot through an angle $c=a/k$ to obtain the desired correction of the trajectory.

According to a first constructional form the launcher is equipped with a fixed grid-type collimator similar to that shown in FIG. 2, the optical axis of this collimator being strictly parallel to the axis of the launcher, and a visual reference mark represents the axis of the launcher. In the neutral position the reference mark is situated at the centre O of the collimator. When firing, the operator follows the missile visually during the acceleration trajectory section AB, this being more easily done since a considerable flame is discharged by the nozzle of the missile. At the moment of extinction, which corresponds to the point B, the operator locates the position B1 of the missile on his grid; he then engages the training mechanism and modifies the training setting so that the reference mark representing the axis of the launcher is situated on the grid in the position B2 symmetrical to B1 relatively to the centre O of the collimator.

The training mechanism is calculated so that the movement of the reference mark and the movement of the launcher are in the proportion $1/k$ in order that the desired correction is automatically effected.

It is also possible to arrange the training mechanism so as to obtain the ratio $-1/k$: in this case the operator has to bring the reference from O to position B1, which is simpler.

According to another way of carrying out the invention, the sight comprises a reticle which the operator maintains by visually following the image of the missile until the end of the acceleration phase, the launcher being in a slave relationship whereby it is made to follow the movement of the sight in the reverse sense and with an amplitude which is in accordance with the value $1/k$.

It is also possible to couple with the launcher a television camera to avoid the operator having to be in the immediate vicinity of the launcher. This television camera can either be used in combination with a grid in a similar fashion to the first constructional form or can be used to follow the missile visually in a manner similar to the second form.

For example, as shown in FIG. **3**, a television camera **10** is mounted on a launcher **12** such that its optical axis is parallel to the axis of the launcher **12.** The television camera **10** is coupled by conventional means, such as a cable **13,** to a receiver **14.**

When the rocket is fired, the operator follows the missile on the receiver **14** during the acceleration trajectory section A-B (FIG. **1**) until flame out in the same manner as was described above in connection with the use of the collimator of FIG. **2** and the appropriate launcher correction can then be made. The appropriate launcher correction could be accomplished remotely by a correction signal to any conventional launcher repositioning mechanism **18.**

This arrangement makes it possible to arrange the ranging means at the same place as the firing control means, all being under cover. Furthermore, it is possible to arrange that there should be some slight retention of the image on the screen, which facilitates the work of the operator entrusted with ranging; on the other hand it is possible to regulate the luminosity of this image relatively to the background.

Visual following of the missile is all the easier since the combustion of the propulsive charge is usually accompanied by a considerable emission of light. This process permits particularly easy ranging when firing at night.

It is also possible to arrange an infra-red sight.

Furthermore, this method makes it possible to obtain particularly inconspicuous ranging by carrying out for adjustment purposes, a first firing of a trial rocket of small size, the deviation of which will be observed in order to determine which correction has to be made.

According to a first form of embodiment the aerodynamic and propulsive features of the trial rocket are so determined that its acceleration trajectory corresponds as far as possible to the trajectory AB, even with different wind effects.

According to a second form of embodiment these features are determined so as to amplify the effect of certain deviation factors, the correction law being adapted appropriately.

The said rocket may be a blank but it may also be self-destroyable by means of any conventional destruct mechanism **20.**

It is also possible to introduce into the fuel charge of the trial rocket a constituent which increases the brilliance of the flame and reduces the emission of smoke, so as to make visual sighting easier.

Thus the trial rocket is fired; the correction angle is determined by means of this rocket, which explodes shortly after passing the point B, that is to say without a possibility of it being logged by the enemy; the launcher is trained and the real firing stage may then commence immediately.

This method thus eliminates all difficulties due to logging the point of impact, all the causes of errors due to too great a time lag between ranging firing and real firing, and makes it possible to achieve complete surprise and to carry out ranging at night.

What we claim is:

1. A fire ranging method for launchers of self-propelled missiles comprising the step of firing a missile from a launcher, measuring the angular deviation between the theoretical trajectory of the missile and the actual location of the missile at the point where combustion of the missile propulsive charge ceases, moving the launcher in a direction opposite to the angular deviation at a predetermined proportional amplitude to that of the measured deviation, the predetermined proportion being a function of the particular missile being launched.

2. A method according to claim **1** wherein the measuring of the angular deviation is effected by logging on a grid the position of the missile at the end of the combustion phase.

3. A method according to claim **1,** wherein the measuring of the angular deviation is effected by following the missile by means of a reticle.

4. A method according to claim **1** wherein the angular deviation is measured by tracking the missile with a television camera, transmitting a signal from said camera to a receiver remote from the launcher and transmitting a signal back to the launcher to effect moving of the launcher in the direction opposite to the angular deviation by said predetermined proportional amplitude.

5. A method according to claim **4** wherein the launcher is moved through an angle c where $c=a/k$, a is the angle defined by a first projection on a horizontal surface of a theoretical trajectory of a missile launched in the absence of wind and a second projection on a horizontal surface of the actual trajectory of a missile from the launcher until combustion of the propulsive charge ceases and where k is a contant which is determined by the aerodynamic and propulsive characteristics of the missile launched.

6. A method according to claim **1** wherein the launcher is moved through an angle c where $c=a/k$, a is the angle defined by a first projection on a horizontal surface of a theoretical trajectory of a missile launched in the absence of wind and a second projection on a horizontal surface of the actual trajectory of a missile from the launcher until combustion of the propulsive charge ceases and where k is a constant which is determined by the aerodynamic and propulsive characteristics of the missile launched.

7. A fire ranging method for launchers of self-propelled missiles comprising the steps of launching a trial missile having propulsive and aerodynamic features which correspond during the combustion phase of flight of the trial missile to those of primary missiles to be launched from the launcher, measuring the angular deviation between the theoretical trajectory of the trial missile and the actual location of the trial missile at the point where combustion of the propulsive charge ceases, moving the launcher in the direction opposite to the angular deviation at a predetermined proportional amplitude to that of the measured deviation, the predetermined proportion being a function of the particular missile being launched.

8. A method according to claim **7** wherein the trial rocket is of a self-destroying type.

9. A method according to claim **7** wherein the aerodynamic and propulsive features of the trial missile are determined so that the acceleration trajectory of the trial missile is substantially identical to the acceleration trajectory of the primary missile intended to be launched from said launcher.

10. A method according to claim **9** wherein the aerodynamic and propulsive features of the trial missile are determined so that the acceleration trajectory deviations of the trial missile is amplified by a predetermined proportion relative to the acceleration trajectory of the primary missile which is intended to be launched by said launcher.

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