Feb. 4, 1964 D. J. EDWARDS 3,120,360

VECTOR AIRBORNE INFRARED FIRING ERROR METHOD AND SYSTEM

Filed Jan. 30, 1959 2 Sheets-Sheet 1

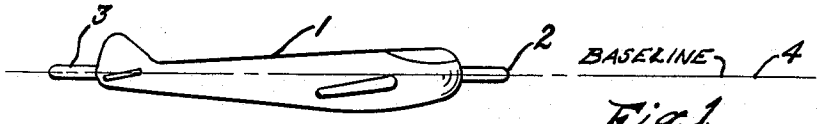



Fig. 1

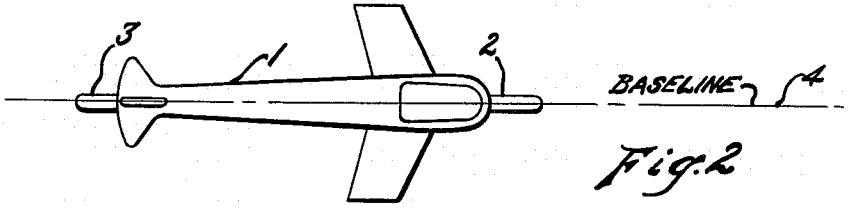



Fig. 2

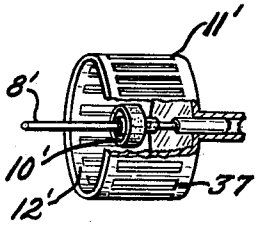



Fig. 4

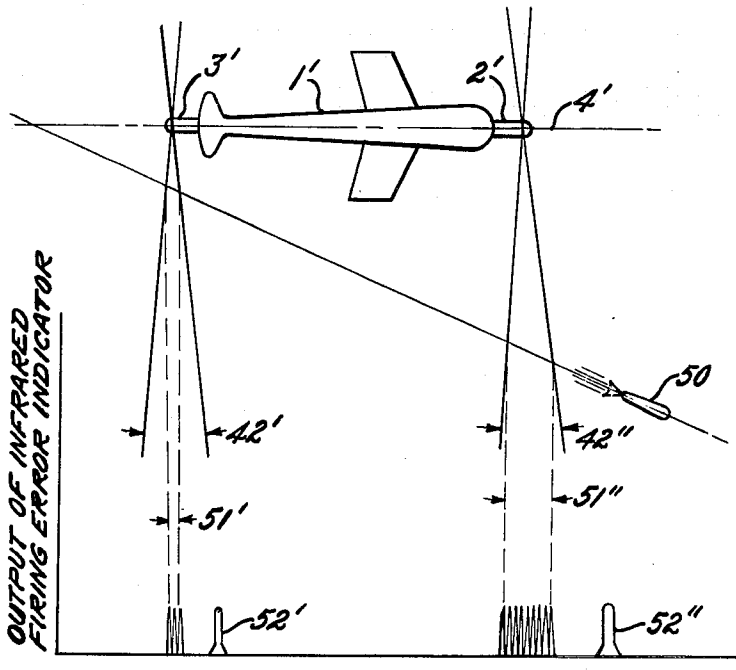



Fig. 5

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Feb. 4, 1964 D. J. EDWARDS 3,120,360

VECTOR AIRBORNE INFRARED FIRING ERROR METHOD AND SYSTEM

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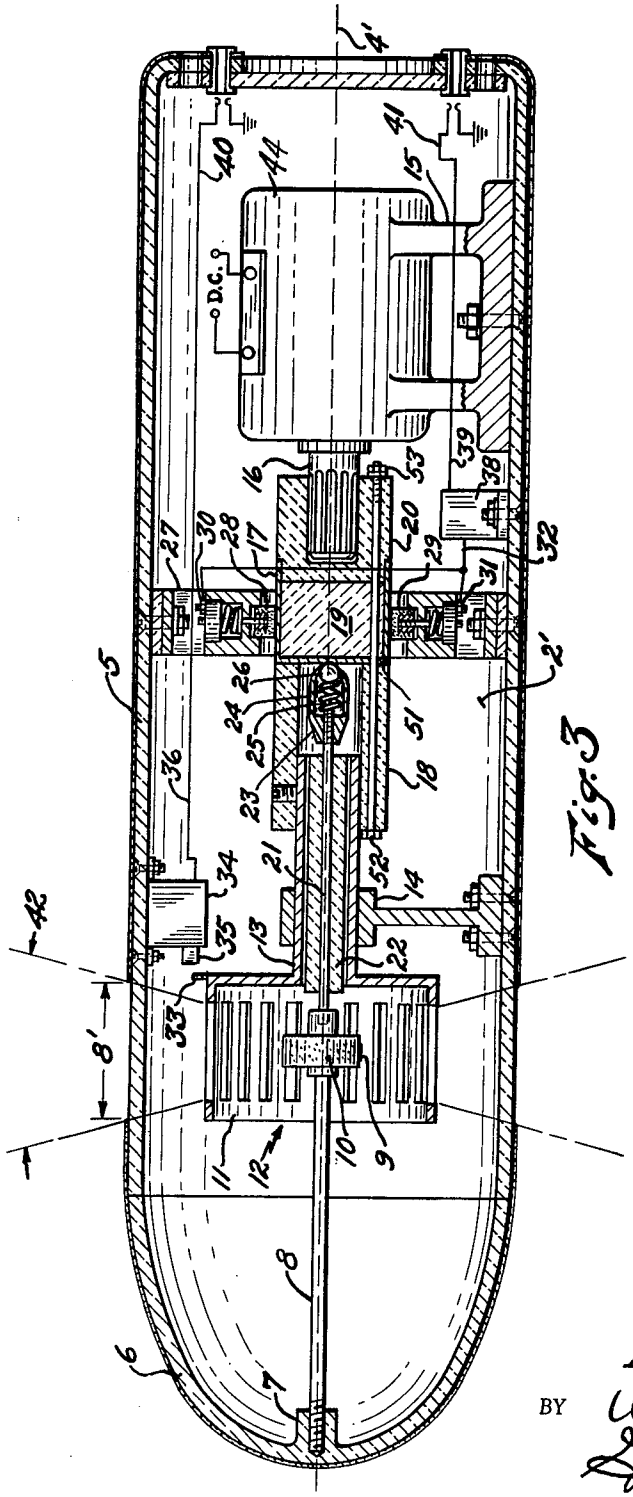



Fig. 3

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# 3,120,360
# VECTOR AIRBORNE INFRARED FIRING ERROR METHOD AND SYSTEM

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11 Claims. (Cl. 244—14)
(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the United States Government for governmental purposes without payment to me of any royalty thereon.

This invention relates to a method and apparatus for scoring missile and rocket firings at various type towed targets, and more particularly to a method and apparatus utilizing infrared energy to provide information relative to both miss distance and miss angle.

In accordance with the present invention there is provided two standard infrared detectors, with the active surface in cylindrical form, each of aforesaid detectors being mounted in a boom extension from a towed target. One boom extends beyond the nose of the tow target, while the other boom extends beyond the tail section. Both booms are of material which transmits infrared energy, and are blackened except over the area which provides the desired field of view. This area may be filtered to minimize spurious radiation from the sun. These boom extensions are necessary to provide each infrared detector cell with a 360° unobstructed conical field of view as well as to provide an extension of the reference base line. The infrared energy is supplied by a visible tracking flare attached to the missile aimed at the towed target or by the infrared energy emanating from the missile engine itself. Since the target is being towed the velocity thereof is known or in the alternative can be precisely controlled and predetermined by whoever is towing said target. The missile aimed at said target is conventional and its velocity is well known. Therefore, the relative velocity of said missile to said target is known or can be easily prearranged prior to the scoring firings.

Each detector is fixed and mounted inside a synchronized rotating chopping reticle. The output of each cell is comprised of a series of electrical pulses by keeping the speed of rotation constant, the number of pulses generated is determined by the length of time the infrared energy from the aimed missile is in the field of view of each of the infrared detectors, and since the field of view is conical around 360°, the time the missile is in the field of view and consequently the number of electrical pulses generated, is related to the distance from missile to detector. As the chopping reticle is kept at constant rotational speed, angular information is obtained from a reference or orientation marker provided by the operation of aforesaid chopper. By referencing the range and angular data to an adequate time base, information relating to miss distance and miss angle is achieved. Information relating to the missile distance from the target is of limited usefulness when the missile approaches the target in a plane perpendicular to the longitudinal axis of the target. The missile will either pass between fields of view or through a field of view in a plane parallel to the field of view. In the latter case, many more pulses would be generated than if the missile passed through the field of view at the same distance from the target but in a perpendicular plane. In the former case, no pulses would be generated

An object of the present invention is to provide a novel vector infrared firing error indicator.

Another object of the present invention is to provide a



novel method and apparatus for scoring missile and rocket firings at various type towed targets.

A still further object of the present invention is to provide a novel infrared energy operated firing error indicator.

Yet another object of the present invention is to provide a vector infrared firing indicator utilizing energy emanating from a missile aimed at a towed target to derive data representative of the miss distance and miss angle.

For a better understanding of the present invention, together with other and further objects thereof, reference is made to the following specification and claims and to the accompanying drawing in which:

FIG. 1 shows a side view of the towed target;

FIG. 2 shows a top view of the towed target;

FIG. 3 is a diagrammatic view partly in section showing the boom extension including the infrared detector, chopping reticle and its associated motor and also including a magnetic amplifier operating with the chopping reticle to generate a reference marker;

FIG. 4 shows a perspective view of the chopping reticle including an infrared cell; and

FIG. 5 shows the number of electrical pulses generated during the time the aimed missile is in the field of view of the infrared detectors mounted in the towed target and also shows reference markers.

FIG. 1 shows a side view of towed target **1**. Boom extension **2** is attached to and extends beyond the nose of tow target **1**, while boom extension **3** is attached to and extends beyond the tail section.

FIG. 2 shows a top view of towed target **1**. In both FIGURES 1 and 2 there is shown baseline **4**. Boom **2** and **3** provide an extension of baseline **4** which is utilized as a reference, and represents the longitudinal axis of the towed target.

FIG. 3 is a diagrammatic view partly in section showing boom extension **2'** with apparatus included therein. The reference line is longitudinal axis **4'**. Boom extension **2'** is comprised of extruded shell **5** of generally cylindrical contour closed at its outboard end by semi-spherical closure plate **6** having at its center bearing element **7** serving as an anchorage for horizontally extending post **8** carrying at its inboard end an infrared detector **10** of generally cylindrical shape whose outer surface is coated with an active surface **9** which is conventional material utilized for infrared detection. Post **8** is constructed from nylon based Bakelite. Extruded shell **5** and semi-spherical closure plate **6** are comprised of lithium fluoride which will readily permit infrared energy to pass. Any material having properties similar to lithium fluoride may also be utilized in its place. Extruded shell **5** and semi-spherical closure plate **6** are coated black to prevent infrared energy from penetrating. However area **8'** remains uncoated and thereby permits free access of infrared energy into the interior of boom extension **2'** within the confines of aforementioned area **8'**.

Chopping reticle **11** is in the form of a drum with end wall **12** open. Reticle **11** is provided with a hollow driven shaft **13** which is an integral part thereof. Bearing **14** is affixed to extruded shell **5** by suitable bolts and serves to position the cylindrical portion of chopping reticle **11** so that it is concentric with area **8'** of extruded shell **5**.

Synchronous motor **44** is concentrically positioned within extruded shell **5** by mounting base **15**. Mounting base **15** is attached to shell **5** by suitable screws. Driving shaft **16** is splined at its outer end and is affixed to driven shaft **13** by coupler **17**.

Coupler **17** is comprised of three nylon based Bakelite elements **18**, **19**, and **20**. Element **19** is a cylinder having copper plate **51** pressure fitted thereupon. Elements **18**, **19**, and **20** are clamped together by any suitable bolts such as **52** and **53**. Element **20** is a cylinder open at

one end to receive splined driving shaft 16. Element 18 is a cylinder open at one end to receive shaft 21. Shaft 21 is comprised of an electrical conducting material such as aluminum and is attached to infrared detector 9 both physically and electrically. Bearing element 22 consists of nylon based Bakelite and serves to position shaft 21 concentrically within hollow shaft 13. Shaft 21 has affixed at one end metal spring and ball retainer 23. Spring 24 is fitted on spring guide 25. Metal ball 26 thereby is pressed firmly against copper plate 51 to make electrical contact. Brush retainer 27 is affixed to extruded shell 5 by suitable screws and serves as a container for brushes 28 and 29. Retainer 27 consists of nylon based Bakelite. Metal lugs 30 and 31 are attached to brushes 28 and 29 respectively. Lugs 30 and 31 are connected together electrically by line 32. Line 32 is then connected to amplifier 38 which provides an output to line 39.

Tip 33 is an integral part of chopping reticle 11. Magnetic amplifier 34 is mounted on the inner wall of extruded shell 5 so that the field of reception of magnetic detector head 35 is intercepted once every 360° revolution by tip 33 at the point represented 0° of the conical scan. Magnetic amplifier then provides an output from line 36. Lines 36 and 39 are connected to jacks 40 and 41 respectively. Plugs may be then fitted into jacks 40 and 41. Lines are connected thereto by means of plugs. The lines then are connected to recording equipment in the aircraft towing the target. The recording equipment may be an oscilloscope.

Now referring to FIGURE 4, chopping reticle 11' is comprised of a drum with outer end 12' open to receive infrared detector 10'. Detector 10' is positioned concentrically within chopping reticle 11' by mounting post 8'. Chopping reticle 11' has a number of slits located in its outer periphery. Slit 37 is representative of all the slits and may be formed either by punching or etching depending on the material used.

Now referring again to FIGURE 3, field of view 42 is the area from which infrared detector 10 will receive signals. The signals are generated by a missile radiating infrared energy, which has been aimed at and missed the towed target but nevertheless passed within aforesaid field of view.

Chopping reticle 11 is rotated at a constant rate of speed by synchronous motor 44. Electrical pulses are generated when infrared energy is transmitted to infrared detector 10 through slits on rotating chopper reticle 11. The number of electrical pulses generated is determined by the length of time the infrared energy from the aimed missile is present in the field of view, and since the field of view is conical around 360°, the time aforesaid missile is in the field of view and consequently the number of electrical pulses generated is related to the distance from missile to detector 10 as illustrated in FIGURE 5.

As chopping reticle 11 rotates, there is generated electrical pulses in infrared detector 10. The electrical pulses are transmitted along shaft 21 through spring and ball retainer 23 to ball 26. From ball 26, the pulses are fed to rotating copper plate 51 and from there to lugs 30 and 31 by way of brushes 28 and 29 respectively. Line 32 connects interconnect lugs 30 and 31 and feeds amplifier 38 with the electrical pulses generated in infrared detector 10. The amplified pulses are fed to jack 41 by way of line 39.

As chopping reticle 11 is rotating, magnetic tip 33 cuts the field of view of magnetic detector head 35 at the point representing 0° in the 360° conical scan. This generates an electrical impulse utilized as a reference market at 0° of the 360° conical scan. The electrical marker pulse is fed through magnetic amplifier 34 to line 36 and thence to jack 40. Plugs with connecting lines are then inserted in jacks 40 and 41 and the aforesaid lines are connected to a recording device such as an oscilloscope installed in the aircraft pulling the tow target.



Now referring to FIGURE 5, there is shown boom extension 2' attached to and extending beyond the nose of tow target 1' and boom extension 3' attached to and extending beyond the tail. Reference base line 4' is common to tow target 1', boom extensions 2' and 3'. Each of boom extensions 2' and 3' contain identical apparatus having the same mode of operation as described and shown in FIGURE 3. The chopping reticles in each of the boom extensions rotate synchronously since they both are driven by synchronous motors.

The field of view for boom extension 2' is 42'' and for boom extension 3' is 42'. As aimed missile 50 cuts fields of view 42' and 42'', there are generated a number of pulses as indicated on the time baseline. This time baseline may be obtained on the oscilloscope mounted in the towing aircraft. The number of pulses generated in field of view 42' is determined by distance 51' which is in turn governed by the distance between the point missile 50 cuts field of view 42' and the infrared detector contained in boom extension 3'. The number of pulses generated in field of view 42'' is determined by distance 51'' which in turn is governed by the distance between the point missile 50 cuts field of view 42'' and the infrared detector contained in boom extension 2'. Reference marker 52', which is generated in boom extension 3', indicates 0° position in the 360° conical sweep at the tail position; while reference marker 52'' indicates 0° in the 360° conical sweep at the nose position of the towed target.

The data then present on the time base line may be utilized to calculate the miss distance, the miss angle and the angular position of the aimed missile in relationship to the towed target.

The number of slits in the chopping reticle is governed by the rotational speed of the chopper and the time constant of the detector used. The shorter the time constant, the greater number of slits may be utilized, and, consequently the greater the accuracy. The accuracy of fabricating the slits is the limiting factor in the overall accuracy of the device.

What is claimed is:

1. The system of determining the angular relationship between an aimed missile and its airborne target exclusive of the condition wherein said missile approaches said target in a plane perpendicular to the longitudinal axis of said target comprising means for defining the limits of an infrared field of view from the nose and from the tail of said target, each of said fields of view having the shape of a rotating cone whose central axis defines, as it rotates, a plane normal to the longitudinal axis of said target, means for generating a set of electrical pulses for each of said fields of view as said missile passes therethrough, and means for recording each of said sets of pulses on a common time baseline.

2. A system for determining the angular relationship between an aimed missile and its airborne target exclusive of the condition wherein said missile approaches said target in a plane perpendicular to the longitudinal axis of said target, as defined in claim 1 including means to generate a reference signal to be utilized to indicate the angular position of said aimed missile in relationship to said target.

3. A system for determining the spatial relationship between an aimed missile and its airborne target exclusive of the condition wherein said missile approaches said target in a plane perpendicular to the longitudinal axis of said target comprising first infrared detector means located at an extension of the tail of said target, said infrared detector means having a field of view in the shape of a rotating cone whose central axis defines, as it rotates, a plane normal to the longitudinal axis of said

target, means located in said target to generate electrical pulses from the infrared energy transmitted by said aimed missile as it passes within said field of view of said first infrared detector means, the number of said pulses being determined by the distance between said missile and said infrared detector means, means to amplify said electrical pulses, means to record said pulses on a preselected time baseline, and means to generate a reference signal to be utilized to indicate the angular position of said aimed missile in relationship to said target.

4. A system for determining the spatial relationship between an aimed missile and its airborne target exclusive of the condition wherein said missile approaches said target in a plane perpendicular to the longitudinal axis of said target as defined in claim 3 wherein said means to generate pulses is comprised of a rotating drum having slits in its outer periphery, said drum having said infrared detector means enclosed concentrically therein.

5. A system for determining the spatial relationship between an aimed missile transmitting infrared energy and its airborne target exclusive of the condition wherein said missile approaches said target in a plane perpendicular to the longitudinal axis of said target comprising infrared detector means with active surface in cylindrical form, said detector means being located at the terminal end of said target, means located in said terminal end of said target for defining the limits of the field of view of said infrared detector means, said field of view being in the shape of a rotating cone whose central axis defines, as it rotates, a plane normal to the longitudinal axis of said target, means located in said terminal end of said target to generate electrical pulses from said infrared energy as said missile passes within said field of view, the number of said pulses being determined by the distance between said aimed missile and said infrared detector means, means to record said electrical pulses on a preselected time baseline, and means to generate a reference signal to be utilized to indicate the angular position of said aimed missile in relationship to said target.

6. A system for determining the spatial relationship between an aimed missile transmitting infrared energy and its airborne target exclusive of the condition wherein said missile approaches said target in a plane perpendicular to the longitudinal axis of said target as defined in claim 5 wherein said means to generate electrical pulses from said infrared energy includes a peripherally, slitted drum enveloping said detector means, power driven means for transmitting rotation to said drum and means coaxially disposed with respect to said power driven means for delivering said electrical pulses from said detector means.

7. A system for determining the spatial relationship between an aimed missile transmitting infrared energy and its airborne target exclusive of the condition wherein said missile approaches said target in a plane perpendicular to the longitudinal axis of said target as defined in claim 5 wherein said means for defining the limits of said field of view also includes a housing enclosing and supporting said detection means, said housing having a selected portion of its exterior surface exposed for free passage of said infrared energy therethrough, the remainder of the exterior surface being treated to inhibit passage of said infrared energy.

8. A system for determining the spatial relationship between an aimed missile transmitting infrared energy



and its airborne target exclusive of the condition wherein said missile approaches said target in a plane perpendicular to the longitudinal axis of said target comprising first infrared detector means located at the terminal end of said airborne target, means to define the limits of the field of view of said first infrared detector means, said field of view having the shape of a rotating cone whose central axis defines, as it rotates, a plane normal to the longitudinal axis of said target, means located at said terminal end to generate a first set of electrical pulses from said infrared energy as said missile passes within said field of view of said first infrared detector means, the number of pulses being determined by the distance between said missile and said first infrared detector means, means to record said first set of pulses on a preselected time baseline, and means for generating a first angular reference marker for said first set of electrical pulses.

9. A system for determining the spatial relationship between an aimed missile transmitting infrared energy and its airborne target exclusive of the condition wherein said missile approaches said target in a plane perpendicular to the longitudinal axis of said target as defined in claim 8 also including second infrared detector means located in an extension of the nose of said target, means to define the limits of the field of view of said second infrared detector means, said field of view having the shape of a rotating cone whose central axis defines, as it rotates, a plane normal to the longitudinal axis of said target, means located at said extension to generate a second set of electrical pulses from said infrared energy as said missile passes within said field of view of said second infrared detector means, the number of pulses being determined by the distance between said missile and said second infrared detector means, means to transmit said second set of pulses for recording in conjunction with said first set of pulses and means for generating a second angular reference marker for said second set of electrical pulses.

10. A system for determining the spatial relationship between an aimed target transmitting infrared energy and its target exclusive of the condition wherein said missile approaches said target in a plane perpendicular to the longitudinal axis of said target comprising a pair of infrared detector means, the first being located in a tail extension of said target, the second being located in a nose extension of said target, means to define the limits of field of view for each of said infrared detector means, said field of view having the shape of a rotating cone whose central axis defines, as it rotates, a plane normal to the longitudinal axis of said target, synchronized means operating in conjunction with each of said pair of infrared detector means to generate a set of electrical pulses from said transmitted infrared energy as said missile passes each of said fields of view, and means to record each set of electrical pulses on a common time baseline.

11. A system for determining the spatial relationship between an aimed target transmitting infrared energy and its target exclusive of the condition wherein said missile approaches said target in a plane perpendicular to the longitudinal axis of said target as defined in claim 10 also including means for generating an angular reference marker for each of said sets of electrical pulses.

No references cited.