July 21, 1964 | J. F. MENKE | 3,141,411

TARGET FINDER FOR MISSILES

Filed Jan. 9, 1961 | 3 Sheets-Sheet 1

Fig. 1

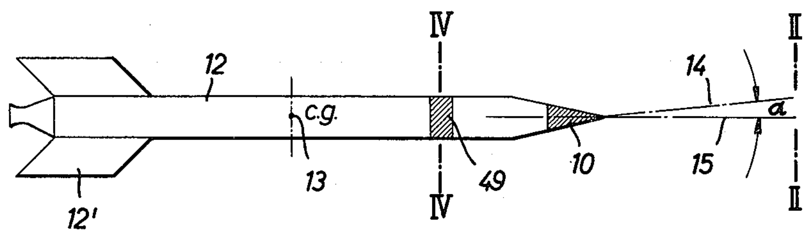

Fig. 2

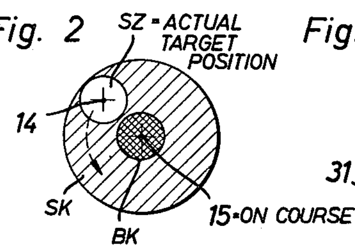

Fig. 4

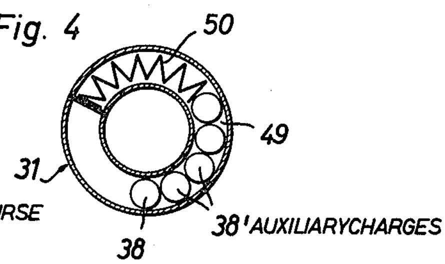

Fig. 5

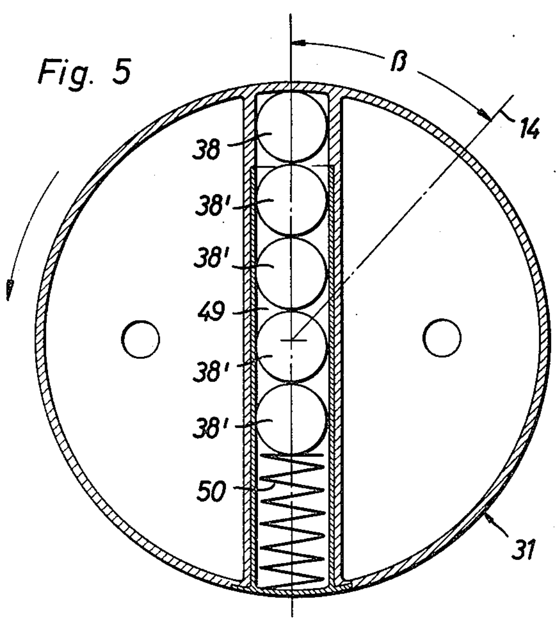

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Fig. 3

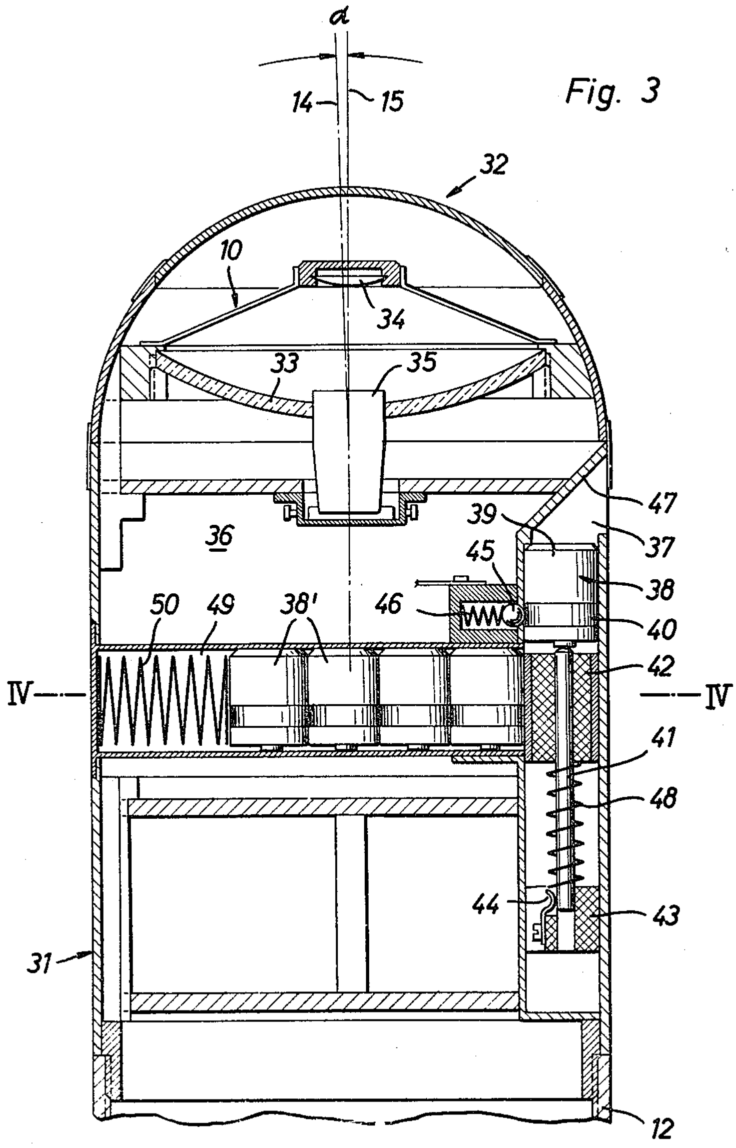

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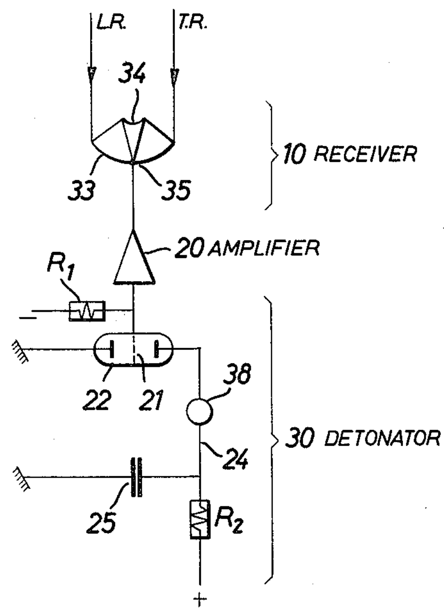
Fig. 6



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TARGET FINDER FOR MISSILES

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7 Claims. (Cl. 102—50)

The present invention relates to a target finder for projectiles, especially for missiles of small caliber, which may be stabilized by rotation around a longitudinal axis.

Heretofore it has not been possible to guide projectiles, e.g. small-caliber rockets, toward their targets except, to a limited extent, with the aid of an attached wire. This is so because the known radar and infrared-ray control mechanisms are too bulky and too heavy to be practical, say, for use with missiles of small size. Thus, the presence of the necessary receiver, translating and steering devices, together with a high-frequency transmitter in the case of self-contained radar systems, would so reduce the payload of a small-size missile as to make it almost useless militarily, apart from greatly increasing its cost. Not even by the use of subminiature electronic circuits has it been possible to build guided missiles of a caliber smaller than 15 cm., save through the use of rocket bodies of considerable length.

The necessity for guiding rocket-powered missiles after launching results from their tendency to stray, which is considerably more marked than in the case of nozzle-launched projectiles and is due to the instability of the missile in the initial part of its trajectory. This instability can be traced to the relatively low launching speed and the asymmetry of propulsion prevailing up to the moment of fuel exhaustion.

In a missile, e.g. a rocket, it is known how to achieve an angular displacement of the rocket's longitudinal axis about its center of gravity by having a secondary flow of the propellant gas emerge laterally, at right angles to the rocket axis, ahead of its center of gravity, transmitting an appropriate correction pulse by means of the resistance of the atmosphere and the recoil of the gas emerging from the rocket. The discharge velocity and the discharge duration are controlled, for example, by a gyro setup. Such a system is disclosed in Edwards et al. patent 2,822,755.

A receiving device is also known, which receives an infrared pulse that is radiated by the target object only in a conical region lying in a certain angle about the longitudinal axis of the missile, the received pulse being employed to correct the trajectory toward the target. This correction impulse can be produced either by the motion of a rudder (Rylsky, Patent 2,421,085) or by a pulse charge (Haigney, Patent 2,415,348). In the latter arrangement (Haigney), pulse charges are distributed in a row throughout the length of the projectile, two charges located at the same distance ahead of and behind the center of gravity and ignited at the same time, thus effecting a parallel displacement of the projectile axis with respect to the target.

The known devices for producing steering impulses have several very serious short-comings. The employment of known rudders requires a highly complicated and heavy device for transmitting the exciting impulse to the rudder, especially because the rudder must be returned to its initial position after the corrective motion has been completed. Furthermore, a rudder canot be used in missiles that rotate about their longitudinal axis.

The known devices that transmit a correction impulse by means of the reaction of an outflowing gas, are very complicated because of the devices required for controlling the discharge velocity and the discharge time, and

these devices do not operate accurately because not only must the impulse be released, but its magnitude and duration must also be controlled. Moreover, such impulses produced by outflowing gas are either usable only during the time during which the propellant burns, i.e. at a time when the projectile is still very far from its goal, or an appropriate gas tank must be carried along. The high weight of such gas tanks involve an additional load on the projectile. As the impulse transmitted to the projectile by the outflowing gas depends not only upon the reaction, but is also largely dependent upon the resistance of the surrounding air, this control depends upon atmospheric conditions, especially the altitude, and the resultant inaccuracy must either be accepted or balanced out by complicated devices.

The known charges arranged all along the longitudinal axis and ignited in pairs whose distances in front of and behind the center of gravity are always the same, produce a lateral displacement of the projectile, with its longitudinal axis remaining essentially parallel, and hence require a very large impulse because of the necessary acceleration of the entire mass of the projectile, in order to secure the necessary displacement of the projectile in the direction of the target. As the kinetic energy transmitted to the projectile by the impulse would produce further motion, even beyond the direction of the target, independently of any eventual spin stabilization, means must be provided to release a counterimpulse when the line to the target has been reached.

The principal object of the invention is to control a rocket in its flight to a target so as to point the trajectory axis toward the target with practically no delay and with a very small charge whenever the trajectory axis deviates from the target by a small angle.

Another object of the invention is to correct the trajectory axis of a projectile or missile toward the target by a device that is simple, reliable and accurate and is so light as to be usable even in very small projectiles, such as small-caliber rockets, the so-called air-to-air rockets.

One feature of the present invention is that a receiver is provided with sensing means for receiving impulses radiated or reflected from the target, its narrowly limited receiving range being tilted with respect to the longitudinal axis of the projectile at such an angle that a conical space is produced about the longitudinal axis in which the means for receiving the impulses do not respond, the space flaring in direction from the missile toward the target.

Another feature of the invention is the arrangement for transforming the received pulses into a detonating current. The arrangement may include an infrared sensitive photoelectric cell, a thyratron, a capacitor, and a D.-C. source, as well as means for transmitting the current pulses produced by the infrared rays striking the photocell to the grid of the thyratron, and means for transmitting the plate current of the thyratron to the said capacitor, as well as means for impressing the negative voltage of the current source upon the grid of the thyratron and the positive voltage of the current source upon the capacitor.

Another feature of the invention is the provision of a firing device for a charge that transmits a motional impulse to the projectile, the said firing device including a gas discharge orifice located at a point between the mass center of the projectile and the tip of the rocket and located at such an angular distance in the peripheral direction from the axis of the said receiving range of the receiver that the impulse transmitted by the burning of the impulse charge acts in the direction in which the axis of the receiving range was aimed at the instant the target was sighted, and in the provision of means for connecting the amplifier for the received pulse to the ignition device for the impulse charges in such a way that a charge lying in the firing device is ignited when the receiver receives an impulse.

This firing device has a firing mounting for the charge, which is so arranged that the outflowing explosion gases exert a reactive force, substantially perpendicular to the axis of the projectile, the firing mounting being connected to a magazine for other impulse charges in such a way that after the charge located in the firing mounting has burned away and after the unburned residues have been removed from the firing mounting, a new impulse charge is conveyed into the firing mounting from a magazine.

In this the invention utilizes the fact that when the actual trajectory of the projectile deviates from the direction of the target, as the projectile progressively approaches the target, the latter must traverse a region, viewed from the projectile, that lies like a conical shell at a certain angle about the actual projectory. Independently of the extent of the linear deviation from the target, the trajectory and the line of sight to the target form a certain constant angle, depending upon the approach of the projectile to the target, with progressive deviation from the target at a given instant during flight. This error angle, which is the same for any deviation in a definite specific ratio of the distance between the projectile and the target, can be corrected very accurately in any case occurring during flight by an impulse of predeterminable constant magnitude in a circumferential angle with respect to the axis of the receiving range that makes allowance for the ignition delay and the rotation of the control device. Thus, in contrast to known controls, the control for the projectiles of the invention operating on this principle does not require any arrangement for measuring the error angle and evaluating it as a control impulse of different magnitudes and direction for every case.

In conformity with the invention the target is sighted as it travels through a constant error angle along a conical shell in a region surrounding the axis of the trajectory by a receiving device for radiation emitted by the target or reflected by it, such as an infrared receiver, which responds only to this region and is insensitive to radiation emanating from the conical space within the shell. The received impulse, by means of the laterally acting detonation reaction of a previously determined charge, sets off a control impulse that corresponds to the error angle in the direction of flight and the error direction with respect to the trajectory, i.e. the angular position of the target, the magnitude and direction of this impulse, corresponding to the stability of the trajectory and the mass of the projectile, being previously determined in such a way that the trajectory of the projectile is accurately deflected in the direction of the target.

In the case of a gyration-stabilized rocket, the receiver can simply be a radiation-optical array, such as a receiving surface sensitive to infrared rays, the optical system having an axis inclined (e.g. by 1°) with respect to the missile axis and having a sharply defined blind spot in its field of sight so as not to pick up radiation from a cone centered on this latter axis. Whenever the target comes into view of the receiver, the detonator is actuated to set off an auxiliary charge of predetermined intensity which produces an impulse having a radial component of such magnitude and direction as to re-align the missile with the target.

The magnitude and axial position with respect to the center of gravity of the impulse control mentioned above are so dimensioned that the missile is deflected by the correction angle, and it is ignited in a position of the missile with respect to the plane of rotation at which the impulse transmitted to the projectile effects a deflection toward the target in the necessary direction of correction with respect to the plane of rotation.

This type of system is especially suitable for craft-to-craft firing, which requires only minor in-flight course corrections after a radar-assisted launching of the missile.

The advantage of spin stabilization is, first of all, that when spin stabilization is used the lateral impulse produces a change in the rocket's direction only as long as the impulse force acts. In a projectile that is not spin-stabilized the force produced by the lateral impulse would act upon the flight direction of the rocket even after its inherent action had come to an end, because of the kinetic energy transmitted to the projectile, until the target would again be picked up by the target-sighting device at the opposite side of the scanned conical shell, releasing a contrary impulse. In the invention this solution is also possible, of course, though the invention can advantageously be applied to spin-stabilized projectiles, in which the kinetic energy is canceled out by the stabilizing gyro action after the control impulse ceases, so that accurate correction to the direction of the target is feasible by an appropriate arrangement and dimensioning of the impulse charge.

This arrangement of the terminal control makes possible an extremely simple construction of the entire control system and, in spin-stabilized rockets, a construction having no moving parts for scanning the target field. Only the auxiliary charges arranged in a magazine, which are used to produce the control impulse are moved one after another to the point of ignition which is constantly fixed with respect to the center of gravity of the rocket and the axis of the receiving range of the receiver. This movement of the charges is effected after the charge that is located in the firing mounting has burned away, by, say, the pushing force exerted by a spring, as in the magazine of an automatic pistol, in order that the auxiliary charges always lie in the same position in the plane of rotation with respect to the axis of rotation of the scanning infrared receiver for ignition.

In the following description and the accompanying drawing, reference is made to a system according to the invention having a receiver responsive to infrared rays; but it will be understood that, particularly in the case of a target which does not emit or reflect such rays, other types of radiation, e.g. high-frequency waves from a transmitter aboard the launching craft, may likewise be used.

In the drawing:

FIG. 1 is a side view of a missile equipped with a target finder embodying the invention.

FIG. 2 diagrammatically illustrates the appearance of a target in the sight of the receiver projected upon the plane II—II of FIG. 1.

FIG. 3 is a vertical cross-sectional view through the front part of a rocket and illustrates the arrangement of the means for receiving impulses radiated or reflected from the target, as well as the arrangement of the firing means for one charge and the magazine for other charges.

FIG. 4 is a schematic cross-sectional view taken on the line IV—IV of FIG. 1.

FIG. 5 is a cross-sectional view similar to FIG. 4 and illustrates a further embodiment of the magazine for the charges.

FIG. 6 is a circuit diagram of the radiation receiver and of a charge detonator controlled thereby.

Reference is first made to FIG. 1, which shows a missile **12** provided with stabilizing fins **12'** and having its center of gravity in the longitudinal axis at **13.** The missile carries in its nose cone a radiation receiver **10,** more fully illustrated in FIG. 6, and behind it a magazine **49** containing a plurality of auxiliary charges **38'** (see FIGS. 3, 4 and 5). Only one of these charges, designated **38,** is in firing position and capable of being set off by a detonator **30** (FIG. 6); it will be noted that this firing position is well ahead of the center of gravity **13,** so that the detonation of the charge will cause the missile to veer from its course.

The radiation receiver **10** shown in FIGS. 3 and 6 comprises an optical system including a principal reflector **33** and an auxiliary reflector **34.** A transducer **35,** such as an infrared-responsive cell, is so designed that when it rotates around the axis of the missile, its field of sight excludes a conical region centered on an axis, i.e. the missile axis 15, which makes a small angle with its optical axis 14; this region defines a circular blind spot BK (FIG. 2) around axis 15 within the annular sighting area scanned by the optical system when the missile rotates.

Reference is now made to FIG. 2. Normally, i.e. with the missile substantially on course, the target occupies a position registering with the blind spot BK and the receiver 10 remains inoperative. If, for any reason, the aspect of the target shifts sufficiently to reach a point outside the afore-mentioned conical region and within the annular sighting area at which the optical system is aimed, as indicated at SZ, the infrared-ray responsive cell 35 transmits an electric pulse through an amplifier 20 to the grid 21 of a thyratron tube 22 forming part of a detonator 30. Grid 21 is normally biased negatively by its connection through a resistor R1 to a suitable voltage source. The plate of tube 22 is connected through the operatively positioned charge 38 and a lead 24 to a capacitor 25 which, after conduction through the tube has ceased, is recharged by a source of positive voltage by way of a resistor R2. When the thyratron 22 fires, the charge 38 is ignited.

Because of the corresponding angular displacement of the position angle in the peripheral direction of the optical axis 14 and of the gas stream released by the impulse charge, the correction impulse effects a rotation of the rocket about its mass center 13 toward the picked-up target through the angle of deviation α of the optical axis 14 of the receiver from the trajectory axis 15, so that the trajectory axis again coincides with the line of sight to the target, and the target again vanishes for the receiver optical system in the blind spot BK, that is, within the scanned cone.

FIGURE 3 shows a cross section through the front part of a rocket, e.g. of FIG. 1, in which the design and construction of the control device according to the invention is illustrated. The front section 31, containing the control device, is fastened to the body of the missile 12 by means of an internal sleeve 16. This front section 31 of the missile is provided at its tip with a protective cap or nose 32 that is permeable for infrared rays. Beneath this protective cap 32 there is an optical system including a concave mirror 33, whose optical axis 14 is obliquely inclined through a predetermined acute angle of deviation α from the longitudinal axis of the missile 15. As a result of the reflection of the rays collected by the concave mirror 33 at the convex mirror 34, whose radius of curvature is greater than that of the concave mirror, the focus of the concave mirror 33 is approximately at the thermocouple 35. The impulse emitted by the thermocouple 35 when infrared radiation strikes it is amplified by amplifying equipment located in the space 36, in a preferred embodiment explained below in connection with FIG. 6.

The stream of gas generated by the impulse charge 38 is released from the missile through an orifice 37 into a path radially outward of the missile and tangential relative to a circle about the center of gravity 13. The circle is located in an axial plane spaced a definite angular distance β relative to the missile axis from the axial plane defined by the optical axis 14. The peripheral angle β is so large that the orifice 37 is moved by the rotation of the missile during the time elapsing until the correction impulse becomes effective, allowing for ignition delay and the time required for combustion, into a position at which the radial centripetal component of the impulse produces motion of the missile about its center of gravity toward the target, i.e. in the direction that the optical axis 14 had at the time the impulse was received, allowing for the projectile's inherent kinetic energy due to rotation.

With the missile having a rotational velocity of 30 r.p.s., we get a circumferential angular velocity of some 10,000°/sec. As the triggering accuracy of an electrically detonated auxiliary charge is about 2 microseconds for a delay of 10 microseconds, we find the accuracy of position of the correction impulse to be about 5′ in the direction of flight. Thus the course correction error for a course change of 1° can be no more than 5″.

Each impulse charge 38 or 38′ consists of a predetermined charge of propellant powder, e.g. a smokeless gunpowder, which is imbedded in a plastic housing 39 that likewise burns as the powder burns. A contact ring 40, which can be electroplated on its face, for example, and is connected to one pole of an electric detonator, is located in a region around the outer periphery of the plastic housing 39. When in firing position, the other pole of the electric detonator touches a contact pin 41, which is insulated from and fastened in the breechblock-mechanism part 42 and can slide axially in the guide part 43, which is insulated from the housing 31. In the guide part 43 there is a contact spring 44, which is in electric contact with the contact pin 41, at least when the breechblock-mechanism part 42 is in its farthest advanced position. A contact sphere 45 is pressed by a spring 46 against the contact ring 40 of each impulse charge 38 located in the firing mounting. One of the poles of the contact sphere 45 and of the contact spring 44 at the contact pin 41 is connected to the amplifying installation for the impulse picked up by the receiving set 10, while the other pole of each of the contact elements is connected to the other pole of the amplifying set 21–24. In this way the impulse emitted by the target and picked up by the receiving set ignites the impulse charge 38. The combustion gases, which first flow out parallel to the missile axis, are deflected radially through the orifice 37, at right angles to the missile axis, by the inclined deflecting surface 47 located in front of the open side of the firing mounting, and thus the necessary correction impulse is transmitted to the missile by the radial centripetal reaction at the surface 47.

At the same time the reaction in the firing mounting moves the breechblock-mechanism part 42 with the contact pin 41 along the guide part 43 downward in FIG. 3 against the force of a return spring 48. Once the breechblock-mechanism part 42 has completely exposed the upper exit opening of the magazine chamber 49, the magazine spring 50 forces the charges lying in the magazine chamber upward until the top impulse charge 38′ lies in front of the breechblock-mechanism part 42 and is conveyed into the firing mounting by the return motion of the breechblock-mechanism part upward in FIG. 3 effected by the force of the spring 48, while the breechblock-mechanism part at the same time closes this mounting to the rear and closes the upper opening of the magazine chamber. The magazine chamber can either be arranged in the shape of a ring around the outer jacket, as shown in FIG. 4, or, as shown in FIG. 5 can be located across the interior of the front part 31 of the missile 12 and be designed like a pistol magazine.

This is a continuation-in-part of my application Serial No. 742,078, filed June 16, 1958.

What I claim is:

1. A missile comprising, in combination,

(a) an elongated body having a longitudinal axis and a center of gravity located on said axis;

(b) sensing means in said body for sensing radiation from a target when said target is axially spaced from said body and outside a conical space about said axis, said space flaring in a direction from said body toward said target said sensing means being responsive to the sensed radiation for emitting an electric pulse; and

(c) pivoting means for pivoting said axis about said center of gravity, said pivoting means including

(1) firing means in said body responsive to said pulse for releasing an electric detonating current;

(2) a sole combustible charge in said body connected to said firing means for combustion and release of a single stream of gas responsive to said detonating current;

(3) guide means for guiding said stream into a path outward of said body and tangential relative to a circle about said center of gravity in an axially extending plane.

2. A missile as set forth in claim 1, wherein said sensing means includes an optical system having an optical axis obliquely inclined relative to said longitudinal axis and aimed at a point adjacently outside said conical space and radially spaced from said axis for scanning an annular area adjacently outside said conical space when said missile is spun about said longitudinal axis, said axially extending plane being angularly offset relative to a plane defined by said longitudinal axis and said optical axis;

(4) magazine means in said body;

(5) an additional combustible charge in said magazine means; and

(6) conveying means responsive to the combustion of said sole charge for connecting said additional charge to said firing means for combustion of said additional charge responsive to a detonating current released by said firing means.

3. A missile as set forth in claim 1, wherein said sensing elements includes photoelectric cell means responsive to infrared radiation to generate a signal, and amplifier means for amplifying said signal, the amplified signal constituting said pulse.

4. A missile as set forth in claim 1, wherein said firing means include a capacitor, means for storing an electric charge in said capacitor, and current releasing means for releasing said charge responsive to said pulse, the released charge constituting said detonating current.

5. A missile as set forth in claim 4, wherein said current releasing means includes thyratron tube means in circuit with said sensing means, said capacitor and said sole combustible charge.

6. A missile comprising, in combination,

(*a*) an elongated body having a longitudinal axis and a center of gravity located on said axis;

(*b*) sensing means in said body for sensing radiation from a target when said target is axially spaced from said body and outside a predetermined conical space about said axis, said space flaring in a direction from said body toward said target, said sensing means being responsive to the sensed radiation for emitting an electric pulse; and

(*c*) pivoting means for pivoting said axis about said center of gravity, said pivoting means including

(1) firing means in said body responsive to said pulse for releasing an electric detonating current;

(2) a plurality of combustible charges in said body;

(3) conveying means for sequentially conveying individual ones of said charges to a predetermined sole firing position in said body and for sequentially connecting the conveyed individual charges at said firing position to said firing means for combustion and release of a stream of gas from each charge responsive to a detonating current released from said firing means; and

(4) guide means for guiding said stream into a path outward of said body and tangential relative to a circle about said center of gravity in an axially extending plane.

7. A missile comprising, in combination,

(*a*) an elongated body having a longitudinal axis and a center of gravity located on said axis;

(*b*) sensing means in said body for sensing radiation from a target when said target is axially spaced from said body and outside a predetermined conical space about said axis, said space flaring in a direction from said body toward said target, said sensing means being responsive to the sensed radiation for emitting an electric pulse;

(*c*) pivoting means for pivoting said axis about said center of gravity, said pivoting means including

(1) firing means in said body responsive to said pulse for releasing an electric detonating current;

(2) a plurality of explosive charges in said body;

(3) conveying means for sequentially conveying said charges to a predetermined firing position in said body and for sequentially connecting each conveyed charge at said firing position to said firing means for explosion of said charge and release of a stream of gas from said charge responsive to a detonating current released from said firing means; and

(4) guide means for guiding said stream into a path outward of said body and tangential relative to a circle about said center of gravity in an axially extending plane.

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