April 10, 1962 J. R. BURTON ETAL 3,028,807

GUIDANCE SYSTEM

Filed Aug. 24, 1959 2 Sheets-Sheet 1

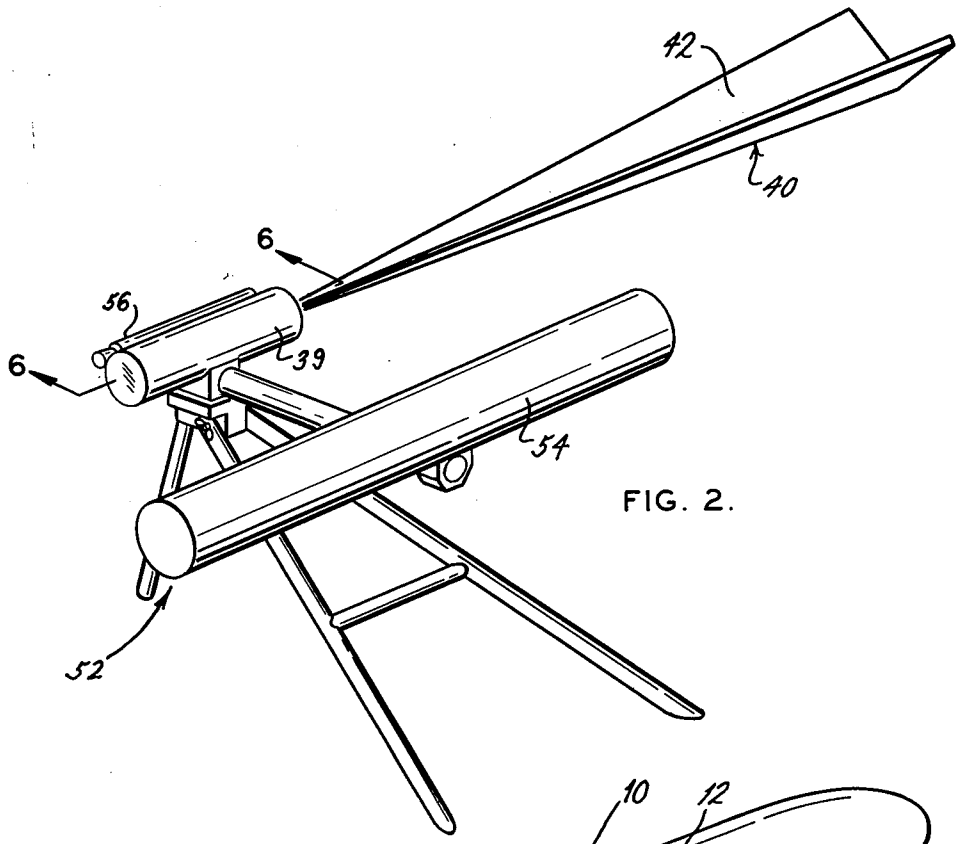


FIG. 2.

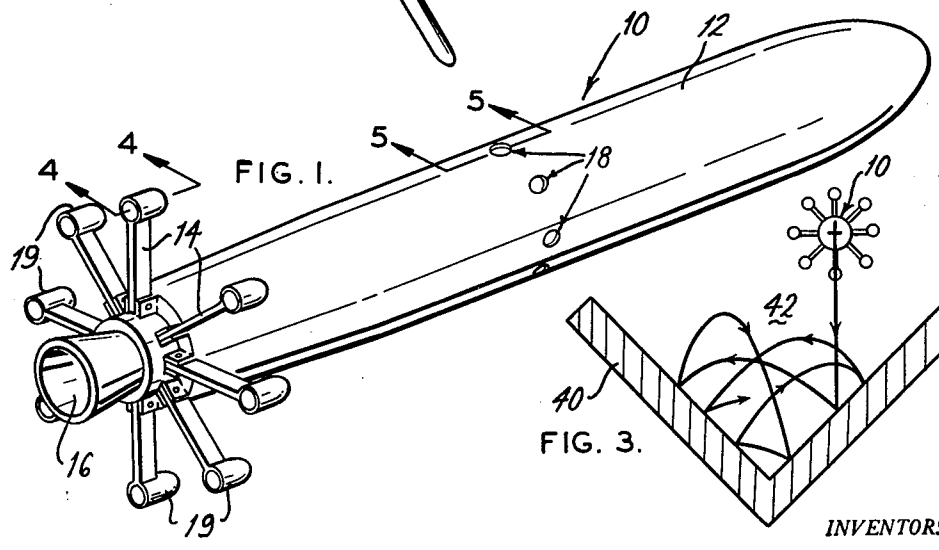


FIG. 1.

FIG. 3.

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FIG. 4.

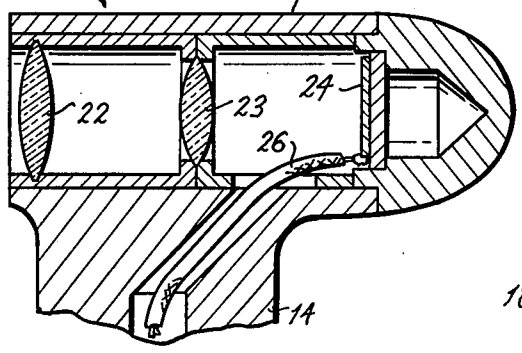
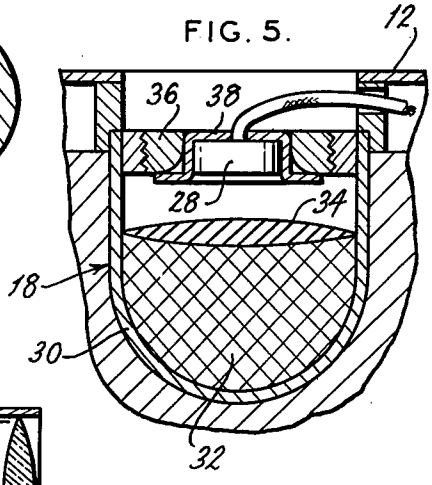


FIG. 5.



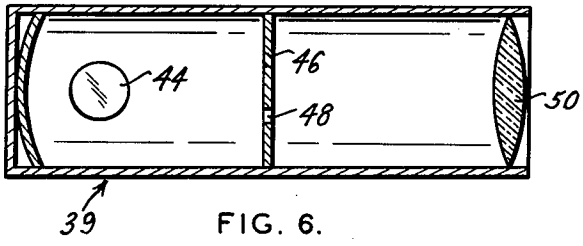


FIG. 6.

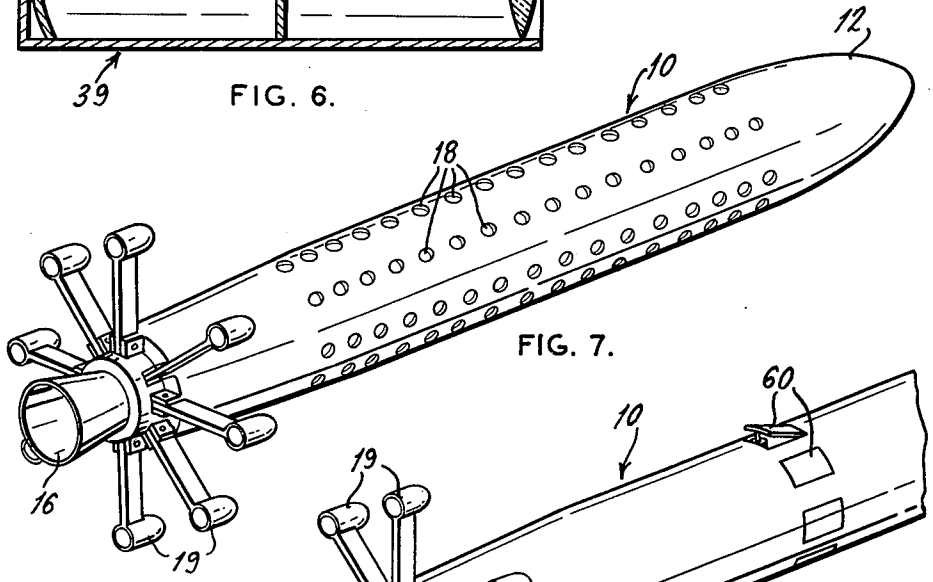


FIG. 7.

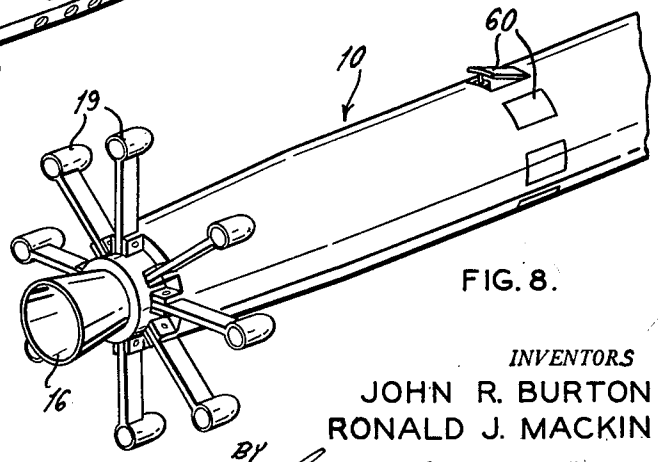


FIG. 8.

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GUIDANCE SYSTEM

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Filed Aug. 24, 1959, Ser. No. 835,551
5 Claims. (Cl. 102—49)

This invention relates to guidance systems in general and more specifically is related to a guidance system for a projectile such as a missile or rocket.

Various means have been devised in the past for guiding projectiles to a target, and particular for guiding projectiles to a target that is in the visual range or line of sight. The known means for the most part have involved devices for accurately aiming the projectile at the target prior to firing and have not provided means for guiding and changing the direction of the projectile after it has been fired and during its flight. This has been particularly true of projectiles fired over relatively short distances where the projectile is in flight a few seconds only. The result is that the known devices are relatively inaccurate because they are not controlled in flight. The present device, however, overcomes these and other inadequacies and disadvantages of known guidance systems, particularly for visual and line of sight operation, and provides means for accurately guiding a projectile to a target during its flight. To accomplish this the present guidance system comprises a projected energy beam, such as a light beam, aimed at the target, and a projectile which is adapted to be fired in a direction adjacent to and substantially following said beam, said projectile including means sensitive to the energy of the beam for producing an electric or other impulse, and other means on said projectile capable of producing thrust to laterally displace the projectile during flight, said thrust producing means being connected to the beam sensitive means and being in a normally de-energized condition when the beam sensitive means are outside of the beam, said thrust producing means being energized by said beam sensitive means to produce lateral thrust for displacing said projectile to a position outside of the beam but adjacent thereto when said beam sensitive means enters the beam.

It is, therefore, a major object of the present invention to improve the accuracy of projectiles.

Another object is to provide an in-flight guidance system for a projectile.

Another object is to provide means for guiding a projectile along a beam of energy, such as a light beam.

Another object is to provide means for producing side thrust in a moving projectile.

Another object is to provide a guidance system for relatively short range projectiles.

These and other objects and advantages of the present invention will become apparent after considering the following detailed specification in conjunction with the accompanying drawings wherein several embodiments of the invention are shown.

In the drawings:

FIG. 1 is a perspective view of a projectile constructed according to the teachings of the present invention;

FIG. 2 is a perspective view of a projectile launcher including a beam projector and sighting means, and a diagrammatic representation of a portion of a typical beam of energy produced by the projector;

FIG. 3 is a diagrammatic cross sectional view of the beam in FIG. 2 showing in dotted line a typical flight pattern of a projectile along the beam trough;

FIG. 4 is a fragmentary cross sectional view taken on line 4—4 of FIG. 1;

FIG. 5 is a fragmentary cross sectional view taken on line 5—5 of FIG. 1;

FIG. 6 is a cross sectional view showing the details of one form of beam projector means;

FIG. 7 is a perspective view similar to FIG. 1 showing a modified form of projectile; and

FIG. 8 is a view similar to FIG. 1 showing another modified form of the projectile.

Referring to the drawings in detail, FIG. 1 shows a projectile **10** having a body **12** with a plurality of finlike elements **14** mounted in spaced circumscribing relationship adjacent to the rearward end thereof. The body **12** also has a main port **16** at the rear end thereof from which a jet stream is emitting to provide the main propelling force for the projectile. The body is also provided with a plurality of circumferentially spaced thrust capsules **18** arranged about the body **12**. The capsules **18** are preferably positioned in the body in a transverse plane that passes approximately through the center of gravity of the projectile for reasons which will be explained hereinafter. One such capsule **18** is provided in association with each of the fin elements **14**, and the capsules **18** are positioned substantially in alignment ahead of the corresponding fin elements **14** on the side of the projectile.

Each fin element **14** has a rounded end portion **19** which houses a beam sensitive detector **20** (FIG. 4). Each detector **20** comprises lenses **22** and **23** positioned in a rearwardly opening counterbore in the portion **19**, and a beam sensitive member **24**. The members **24** are sensitive to the radiated energy which forms the beam, and each member **24** is capable of generating an electrical impulse when exposed to the beam. The members **24** may be constructed of any suitable material. One such material having desirable characteristics when used with an infrared beam is lead sulfide. The particular material used for the detector members **24**, however, depends on the type of beam used. It is contemplated that a beam of light, an infrared beam, an electromagnetic beam, an ordinary radio beam, or any other suitable type of beam can be used.

The light sensitive members **24** are each connected to an associated lead **26** which leads extend through the associated fins **14** and through the body **12** of the projectile to suitable amplifying means (not shown). The output of the amplifier means is connected to associated detonator elements **28** located in the corresponding thrust capsules **18** adjacent to the side of the projectile. One form of thrust capsule **18** is shown in FIG. 5 and comprises a round bottom cup shaped member **30** with a propellant **32** positioned in the bottom thereof. It is contemplated that the propellant **32** be a powder, a liquid, or any other suitable material. A screen **34** closes the propellant chamber and is included to prevent the propellant particles from being blown out when the propellant is ignited. An annular member **36** is positioned in the open end of the cup shaped member **30** and has an opening which receives another cup shaped member **38** in which the detonator or ignitor element **28** is positioned.

When the beam sensitive member **24** is energized by being exposed by the beam and produces an electrical impulse, the electrical impulse ignites the detonator **28** which in turn ignites the propellant **32**. When the propellant is ignited, it blows the cup shaped member **38** out through the opening in the annular member **36**, and as it continues to burn it produces a jet stream which is directed out the same opening to provide side thrust to laterally move the projectile. Since the thrust capsules **18** are positioned approximately at the center of gravity of the projectile the side thrust operates through the center of gravity and, therefore, does not produce any objectionable twisting or angular displacement of the pro-

jectile. It should also be noted that the side thrust takes place in a direction to move the projectile out of the beam 40 and back into the beam trough 42. FIG. 3 shows the path of a typical projectile relative to the V-shaped beam 40 as it moves along the beam trough 42.

FIG. 6 shows a device 39 for producing a V-shaped beam, such as the beam 40 in FIGS. 2 and 3. This particular form of beam producing means is shown for illustrative purposes only and many other forms of beam producing means could be used instead. The beam producing means shown in FIG. 6 consists of a light source, as infrared light source 44, a disc 46 with a V-shaped opening 48 therethrough, and a lens 50 spaced from said disc 46. The light from the light source 44 passes through the V-shaped opening 48, which gives it its V-shape, and then passes through the lens 50 and toward the target.

It is contemplated that many other different forms of beams could also be used to accomplish the same purpose. For example, the beam could have an upwardly facing trough, such as shown, it could have a completely enclosed path with a radiation area surrounding and defining a radiationless path, or the projectile could be guided along a path defined by the radiation beam itself and employ detectors which produce an impulse when they move out of the radiation path.

FIG. 2 also shows a launching device 52 for aiming and launching the projectile. The launching device 52 includes a launching tube 54, the beam projector 39, and a sighting or aiming device 56. When the projectile is fired by energizing its main power source, it passes out the end of the launching tube 54 and is directed along a course in the trough 42. When the projectile is in the trough 42 the guidance system operates to maintain its position in the trough and even to change its direction by moving the beam. FIG. 3 shows a typical projectile course along the beam trough. As the projectile moves along the trough 42 gravity causes it to fall into the beam. In so doing, one, and sometimes more, of the detectors 20 move into the beam and are energized to produce electrical impulses for exciting the associated thrust capsules 18. In so doing the thrust capsules 18 produce sidewise jets which laterally displace the projectile in a direction to move it back into the trough and out of the beam. Subsequently, when the projectile again falls into the beam, another one (or more) of the detectors 20 are energized and the operation repeats. Each time, however, the projectile is moved back into the trough. It is also contemplated that during the flight of the projectile, the projectile will roll and a different one of the capsules 18 will be excited each time.

FIG. 7 shows a modified form of the device in which a plurality of aligned thrust capsules 18 are provided in association with each of the detectors 20. In this construction each detector 20 is able to operate several times during the course of the flight. When a plurality of thrust capsules 18 are provided for each detector 20, it is preferable to have the capsules operate in pairs in order to prevent twisting of the projectile. This is done by simultaneously exciting one capsule positioned ahead of the center of gravity of the projectile and the second spaced an equal distance behind the center of gravity. In FIG. 7 sixteen capsules are shown in alignment with each detector. This means that there can be eight lateral thrust operations for each detector during a flight.

FIG. 8 shows another modified form of the device in which a plurality of flaps 60 or movable aerodynamic surfaces are provided instead of the thrust capsules. The flaps 60 are moved outwardly by suitable motor means which are actuated in response to electric impulses generated by the associated detector means as described above. When one of the flaps is actuated it operates to steer the projectile back into the beam trough. This type of operation is more adaptable to operations where the range of the projectile is relatively greater or the speed is relatively less and more time is available for steering.

It is also contemplated to make the fin elements 14 spring biased so that they can be retracted to positions adjacent to the body of the projectile for launching in the launching tube 54. When the projectile is fired and leaves the launching tube 54, the fin elements 14 move outwardly to provide greater space between the detectors 20. It is also contemplated, however, to mount the detectors 20 directly on the body of the projectile and thus simplify the construction and eliminate the need for the fins.

Thus it is apparent that there has been shown and described novel means for guiding a projectile in a trough defined along a beam of energy such as a light beam. Many modifications, alterations and changes in the details of the specific embodiments of the invention shown and described herein will be apparent to those skilled in the art. All such modifications, alterations and changes which do not depart from the spirit and scope of the present invention are deemed to be covered by the invention which is limited only by the claims which follow:

What is claimed is:

1. The combination of a missile adapted to be guided in flight and remote means adapted to guide the missile in which the improvement includes guidance means emitting a beam of energy shaped with angularly related areas which intersect to provide a sharp line of energy flanked by said angularly related areas, said beam shape forming an upwardly opening energy beam normally substantially perpendicular to the direction of gravity, and a missile provided with lateral thrust producing means spaced about its periphery and energy sensitive control means spaced about its periphery and operatively connected to said thrust producing means, said control means being activated by said beam of energy each time said missile falls into said beam under gravity influence to operate said thrust producing means and cause the missile to move laterally and substantially against gravity and said guidance means being oriented such that said sharp line of energy establishes the direction of the path to be followed by the missile.

2. In a line of sight guided missile system combining a radiant energy sensitive missile having a body elongated in the direction of its movement and with controllable thrust means carried thereby to shift the body laterally of its line of flight, and a missile guiding radiant energy beam projector with optical means to line it up on a target, the improvement in which said missile controllable thrust means includes a plurality of propellant charged elements arranged in spaced array about the periphery of said missile body, and backward facing radiant energy sensors arranged in spaced array about the missile body periphery and connected to said elements to discharge the propellant therein upon sensing radiant energy; and in which said beam projector projects a beam of radiant energy toward a target in the line of sight of said optical means and forms said beam into a shape having a precisely defined line of energy for sighting on the target and adjacent beam areas which provide boundaries of radiant energy diverging from the precisely defined line, said boundary areas defining an upwardly opening trough area which is substantially free of said radiant energy in which said missile is captured under gravitational influence tending to pull said missile toward said precisely defined line.

3. A guiding system for use with missiles directed against targets which are within line of sight of remote guidance means and at elevation angles with respect to said remote means such that an appreciable component of the gravity force is substantially perpendicular to the line of sight; said system comprising remote guidance beam forming means, a beam sighting device for an operator, said beam forming means being adapted to shape the beam of energy into an upwardly opening trough formed by intersecting surfaces with the line of intersection aligned with the sight line, a missile to be guided, a

support from which the missile is launched, said missile being provided with an array of sensors spaced about the periphery of the missile and a similar array of thrust means directed substantially perpendicular to the flight path, said sensors responding to the beam with a measurable signal each time they are exposed in said beam and said signal causing the discharge of one or more of said thrusting means to urge said missile away from the beam surface until gravity causes it to return and the cycle is repeated with a resulting missile path near the sight line.

4. A missile guidance system consisting of: an optical sight for aligning a guidance beam toward a target; means generating a guidance beam composed of radiated energy which is distinguishable from surrounding space and possessing a distinct cross sectional shape consisting in part of an upwardly open V-shape with the apex of the V-shape forming a straight line in space regardless of length, said optical sight being coupled to said beam generating means to direct said beam on the sight line to the target; an elongated missile which is propelled generally in the direction of the target and which is to be guided; a plurality of rearward looking devices sensitive to the energy of the guidance beam, said devices being adapted to produce an electrical signal when exposed to the beam energy; a plurality of thrust producing devices capable of accelerating the projectile essentially transverse to its normal flight path along said elongated axis, said devices being internally related to the energy sensors and emitting thrust in a direction substantially perpendicular to said elongated axis so that the acceleration produced by the generation of thrust moves said missile relative to said beam and in a lateral direction toward said apex and in a vertical direction opposing the gravitational effect tending to pull said missile through said beam.

5. A missile guidance system comprising means forming a sharply defined beam of radiated energy radiated in the direction of a target, said beam forming a trough having at least an upwardly facing surface as a V with the apex of the V pointed substantially in the same direction as the force of gravity and the apex constituting a line of sight to a target, a missile, means to launch said missile into the trough in a ballistic trajectory, and means to maintain said missile within the trough with the influence of the force of gravity tending to pull the missile down into the trough, said means including missile mounted side thrusting elements, missile mounted sensors sensitive to the energy in the guidance beam and generating output signals to said side thrusting elements, said sensors causing said thrusting elements to produce corrective missile motions in the form of a series of nominally ballistic trajectories substantially adjacent to the line of sight along the apex of the trough to the target, the displacement of the missile from the line of sight being primarily a function of the mass of the missile and the amplitude and direction of the lateral acceleration and independent of the size of the guidance beam cross section.

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