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Evers-Euterneck

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[54] **CRUISE CONTROL FOR NON-BALLISTIC MISSILES BY A SPECIAL ARRANGEMENT OF SPOILERS**

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[73] Assignee: **The United States of America as represented by the Secretary of the Army,** Washington, D.C.

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[52] **U.S. Cl.** **244/3.21,** 244/3.27

[51] **Int. Cl.** **F42b 13/32,** F42b 15/02

[58] **Field of Search** ..... 244/3.21, 3.22, 3.24–3.3, 244/1 R, 1 SS, 90, 89, 113

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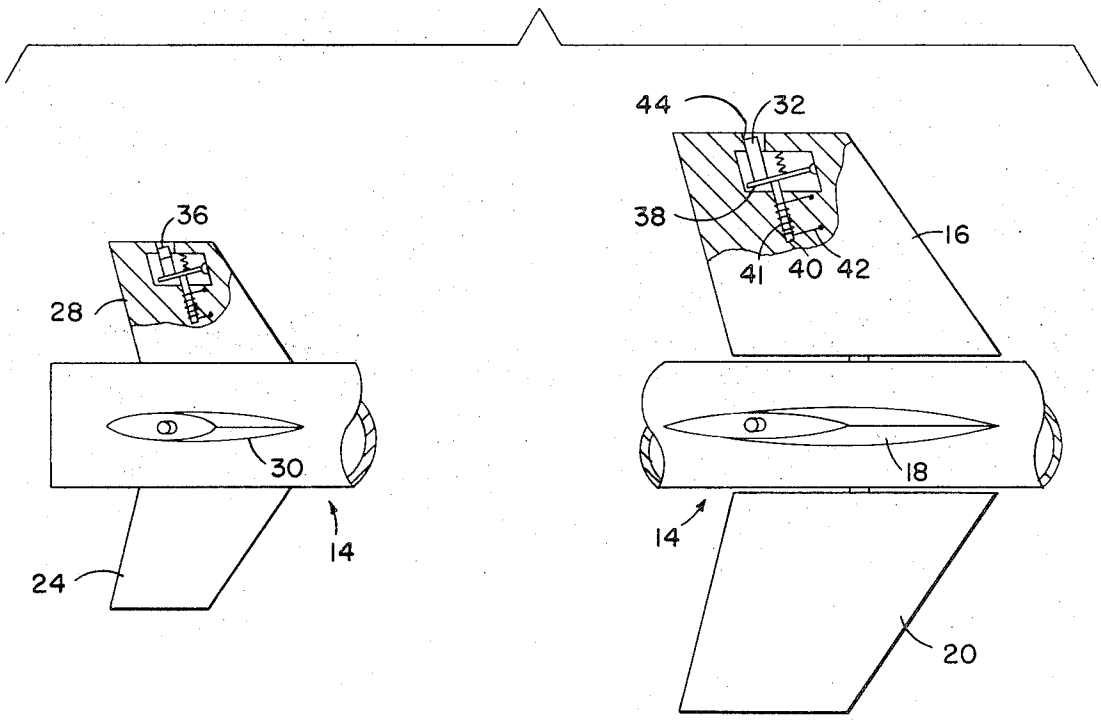
[57] **ABSTRACT**

A missile control system for a guided missile wherein spoilers are used for making small corrections in the trajectory of the guided missile during the launch and cruise phase and conventional control surfaces are employed to make large trajectory corrections in the final homing phase of its trajectory. The spoilers are mounted in the extremities of a missile's wing members and tail fins; those mounted in the wing members accomplishing pitch and yaw corrections and those in the tail fins roll corrections. The spoilers are extended and retracted by solenoid devices.

1 Claim, 5 Drawing Figures



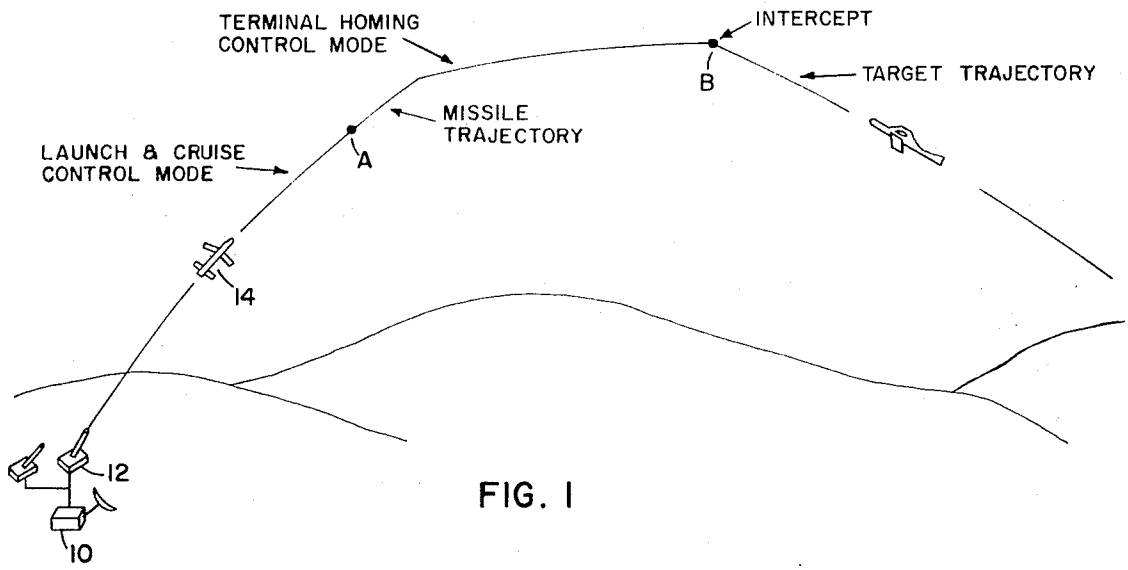

TERMINAL HOMING
CONTROL MODE
INTERCEPT
B
TARGET TRAJECTORY
MISSILE
TRAJECTORY
A
LAUNCH & CRUISE
CONTROL MODE
14
12
10

FIG. 1

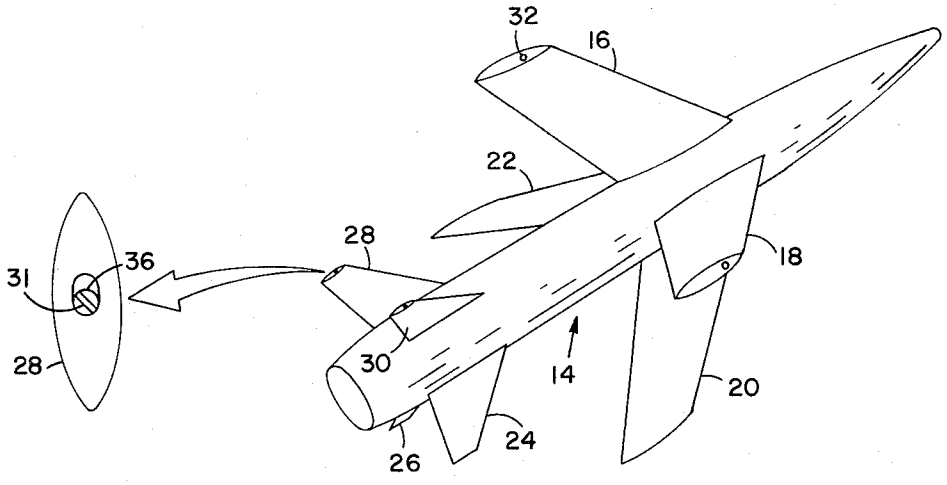

32
16
22
28
18
31
36
28
30
14
20
24
26

FIG. 2

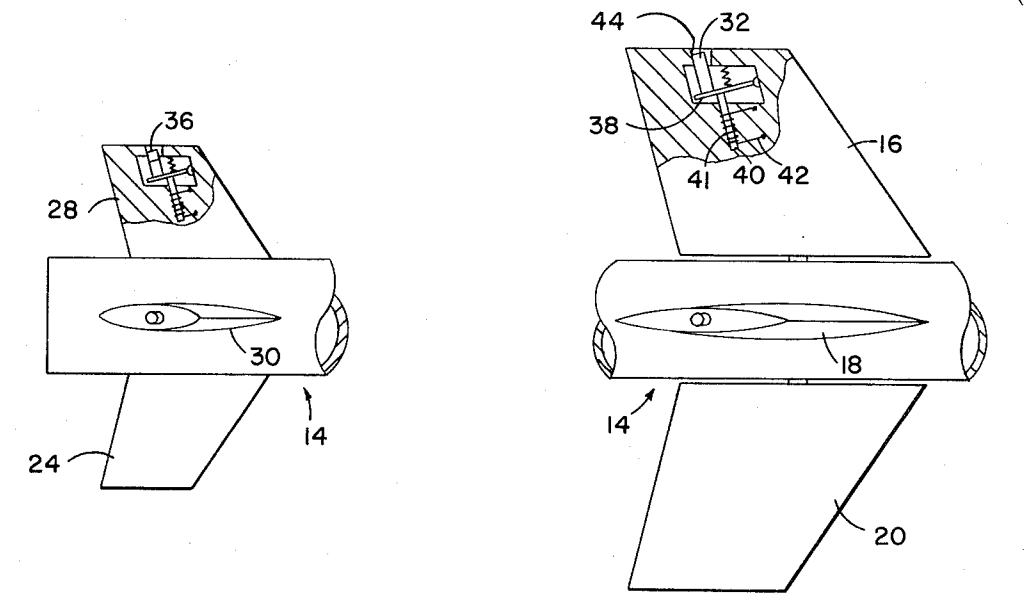


FIG. 3

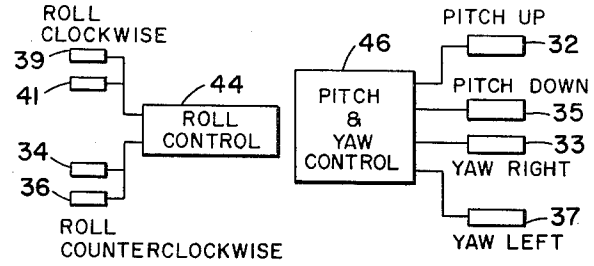


FIG. 5

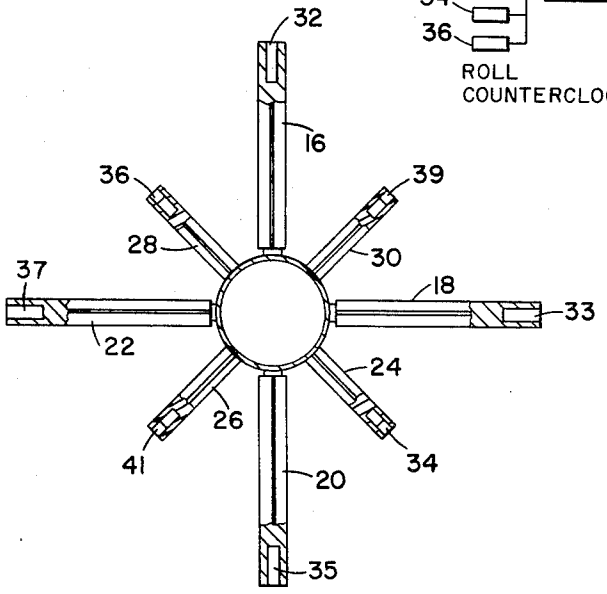


FIG. 4

CRUISE CONTROL FOR NON-BALLISTIC MISSILES BY A SPECIAL ARRANGEMENT OF SPOILERS

BACKGROUND OF THE INVENTION

The invention relates to control systems for indirectly deployed homing guided missiles. In particular the invention is a guidance control system in which minor trajectory changes are made with a special arrangement of spoilers during those portions of a missile's trajectory wherein such corrections are all that is needed before the missile acquires its target.

In certain missile applications, for example in a missile having a semi-active homing guidance system, it is necessary to provide a control system capable of making drastic changes in the trajectory of the missile during its final homing stages. In such a missile it is desirable at times to make mild trajectory changes during the early launch and cruise phases of the missile's flight. The reason for this is that in a semi-active homing system the missile's homing guidance system becomes effective only after the missile arrives in the vicinity of the target. Just how close the missile must approach its target before acquisition can take place is of course dependent upon the homing system installed in the missile. It is normally the case that very severe alterations in the missile's trajectory will be required during the final homing phase in order to achieve intercept with a target.

A missile to be effective must be simple and reliable and it has been found that the ultimate in simplicity and reliability in control systems is bang-bang controls wherein the control is either full on or full off with no intermediate degree of control possible. Since large trajectory corrections are sometimes required the missile must be capable of severe trajectory changes. Thus, full control means that a considerable trajectory change is caused each time a change is indicated by the guidance system of the missile. Often this will be an over control which requires a counter control movement, also a full control movement, made to off set this over control. As is apparent this can result in many more control movements than would be necessary if a more sophisticated control system were employed capable of a variable degree of control. However this over control situation is tolerated in order to achieve the simplicity and reliability that is necessary to an effective missile system.

The range at which a semi-active homing system in a guided missile can acquire a target is limited and there are instances where it would be desirable to correct the trajectory of a guided missile during its early phases so as to assure that the missile approaches its target at a close enough range to permit acquisition of the target by the missile's homing system. If the bang-bang control system used for trajectory correction during terminal homing is also used to make corrections in the launch and cruise portion of the trajectory then many trajectory changes will be required due to over control. This mode of operation while providing effective missile control significantly increases the amount of fuel and power required to achieve intercept with the target, thus adding to the weight, cost and handling difficulties of the system.

SUMMARY OF THE INVENTION

An object of the invention is to provide a supplementary control system that can be used in conjunction with conventional control systems used in guided missiles to provide effective control throughout all of their trajectory without any significant change in cost, weight or complexity of the missiles.

Another object of the invention is to provide a missile control system that is capable of bang-bang operation and yet retains the capability of making either large or small changes in the trajectory of the missile.

A missile system constructed in accordance with this invention will accomplish the objectives mentioned above. The missile includes moveable wings used as control members for making severe trajectory changes in the pitch and yaw direction, tail fins for stabilization, and a system of spoilers wherein each of the moveable wing members and each of the tail fins are provided with a retractable spoiler that exerts control over the trajectory of the missile when extended. Placing the spoilers in the tips of the wings and tail fins insures effective lever arms for the spoilers. Thus the drag forces that result when the spoilers are extended are effective control forces, but these forces are small and fuel economy, especially during the cruise mode, is enhanced. The spoilers mounted in the moveable wing members can be individually extended and retracted to generate up and down pitch corrections and right and left yaw corrections. The spoilers mounted in the tail fins achieve roll control. Roll forces are generated by simultaneously extending, in pairs, the spoilers mounted in diametrically opposed tail fins. The spoilers mounted in the tail fins are provided with pitched lift surfaces to prevent or cause, as desired, roll of the missile about its longitudinal axis when a pair of spoilers are extended.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a simplified pictorial illustration of a deployed missile system that shows the various portions of a guided missile's trajectory from launch to point of intercept with a target.

FIG. 2 is a pictorial illustration of a guided missile with a spoiler control system mounted in the ends of its wing members and tail fins.

FIG. 3 is a view of the missile partially in cross-section with the middle portion thereof broken away.

FIG. 4 is a view partially in cross-section and partially broken away, from the aft end of the missile that illustrates the spoilers mounted in the wing tips and tail fins.

FIG. 5 is a schematic showing of the spoiler control system that illustrates how the tail fin spoilers are electrically connected to operate in pairs whereas the wing tip spoilers operate singly.

DETAILED DESCRIPTION OF THE INVENTION

The trajectory of a guided missile and that of its target is shown in FIG. 1. A target is usually detected by means of a radar 10 or other suitable surveilance means and notice of the target is forwarded to a battery 12 of guided missiles. The missiles in this instance are of the surface to air type. Missile 14 is launched and that portion of its trajectory from the launcher to point A is termed the launch and cruise control mode of the missile's flight. That part of the trajectory between point A and point B, the intercept point, can be called the homing mode or terminal homing phase of the missile's flight.

The spoiler control system disclosed herein has particular application to a missile having a semi-active homing guidance system for terminal guidance or final

homing. With this type of control system it is necessary that the missile be launched and directed to the general vicinity of the target which is being tracked so as to place the missile close enough to its target so that the homing guidance system in the missile can acquire and track the target. The acquisition range of semi-active homing systems is usually somewhat limited and should the launch and cruise phase of the missile's trajectory be misdirected to a considerable extent it is possible that the missile will not close sufficiently with the target to allow its semi-active homing guidance system to acquire and track the target. Thus, it is desirable, in order to assure proper target acquisition and tracking, to make corrections in the missile's trajectory during the launch and cruise phases thereof.

An effective missile system must have a simple and reliable control system for making changes in its trajectory. Experience has shown that the best control system, so far as simplicity, reliability and weight is concerned, is a bang-bang control system; that is, a control system wherein either the system is on and making a maximum control effort or it is off and exerting no control.

A bang-bang type control system having a capability of making the severe trajectory changes required while the missile is homing on a target is not well suited for making the small trajectory corrections required during the launch and cruise phase because such a system tends to over control the missile each time a change is made and this results in many changes being made during the cruise part of the trajectory. The missile described herein has two separate control systems, both capable of bang-bang operation; one for the terminal homing phase and one for the launch and cruise phase of the missile's trajectory.

FIG. 2 illustrates how this is accomplished. Missile 14 has four wing members 16, 18, 20 and 22 that are moveably mounted on the body of the missile. Wings 18 and 22 are moved to either pitch the missile up or down whereas wing members 16 and 20 are moved to yaw the missile to the right or left. Tail fins 24, 26, 28 and 30 mounted in a fixed position on the aft end of the missile stabilize the missile.

In FIGS. 3 and 4 the manner in which the spoilers are mounted in the tips of the wing members and tail fins is illustrated. Each of the spoilers mounted in the wing members, spoiler 32 for example, is mounted and controlled so as to be individually extended and retracted. Spoiler 34 (see FIG. 4) mounted in the tip of tail fin 24 is paired with spoiler 36 mounted in tail fin 28 and the two are connected and simultaneously controlled, see FIG. 5, so as to roll the missile about its longitudinal axis. All of the spoilers are extended and retracted in a similar manner so only one will be described herein. Spoiler 32 is mounted on one end of a lever 38 whose other end is pivotally mounted to the structure of wing member 16. Lever 38 is attached to moveable core 40 of a solenoid 41. When the current flows through coil 42 the solenoid is energized and core 40 is moved which in turn moves lever 38, compresses a spring 43, and extends spoiler 32. Spring 43 retracts the spoiler when the solenoid is deenergized. The spoilers mounted in the wing tips are small cylinders that slide within a small bore or well 44 formed in the extremities of the wing tips.

The spoilers mounted in the tail fins are similar to those mounted in the wings, differing only in that they are provided with pitched lift surfaces, as illustrated in the blown up portion of FIG. 2. In FIG. 2 for example, spoiler 36 is shown having a rectangular shaped tab 31 formed on the outer end thereof, but it could have any other configuration desired so long as when canted at an angle to the longitudinal axis of the missile it forms a lift surface that rolls the missile about its longitudinal axis. The spoilers are shaped and arranged in diametrically opposed pairs so that spoilers 39 and 41 roll the missile in a clockwise direction and spoilers 34 and 36 roll the missile in a counter clockwise direction.

In contrast to this the spoilers mounted in the wing tips are extended and retracted individually to make corrections in pitch and yaw. For example, extending spoiler 32 mounted in wing member 16 will cause the missile to change its trajectory in an upward direction, or as more commonly termed, will cause the missile to pitch up. Likewise, extending spoiler 35 in wing member 20 will cause the missile to pitch down. The spoilers are constructed so that they are fully extended or fully retracted to give bang-bang operation. The spoilers mounted in the tail fins for roll control are connected to and actuated by a suitable roll control device 44 and the spoilers mounted in the wing tips are actuated by a pitch and yaw control device 46 of a suitable type.

The roll, pitch and yaw control devices are not disclosed in detail herein as there are many state of the art devices which could be used and the one selected would depend to a large extent on the design of the missile. The spoiler system disclosed herein is used in conjunction with a semi-active homing guidance system, but it should be understood that it could be used in combination with other types of guidance systems.

I claim:

1. A trajectory control system for a guided missile that includes spoiler control means and control surface means employed in combination for suitably altering the trajectory of the missile at any point in its flight,

said control surface means being adapted for making large pitch and yaw trajectory changes during the homing phase of the missile's trajectory and stabilizing the missile, said control surface means comprising:

a first pair of diametrically opposed moveable wing members, arranged to generate large trajectory changes in pitch,

a second pair of diametrically opposed moveable wing members disposed for making large trajectory changes in yaw, and

two pairs of diametricayly opposed tail fins for stabilizing the missile,

said spoiler control means being adapted for making small pitch and yaw corrections in the launch and cruise phases of the trajectory of the missile and controlling the roll of the missile, said spoiler control means comprising:

a cylindrical spoiler mounted in the tip of each moveable wing member,

a spoiler mounted in the tip of each tail fin that includes control surfaces shaped so as to provide lift surfaces that are pitched at a desired angle with respect to the longitudinal axis of the missile so as to roll the missile when selectively extended in diametrically opposed pairs,

actuator means mounted in each wing member and tail fin for selectively and fully extending and retracting the spoilers mounted therein to accom-

plish small trajectory changes in pitch and yaw and control the roll of the missile,

pitch and yaw control means mounted in said missile and connected to the actuator means mounted in the wing members for selectively and individually actuating the cylindrical spoilers in the wing members for making trajectory changes in pitch and yaw, and

roll control means mounted in said missile and connected to the actuator means mounted in the tail fins for selectively extending diametrically opposed pairs of spoilers mounted in the tail fins so as to roll the missile.

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