Dec. 10, 1963 E. D. GEISSLER ETAL 3,113,520

ARTIFICIALLY STABILIZED MISSILE

Filed Nov. 2, 1960 3 Sheets-Sheet 1

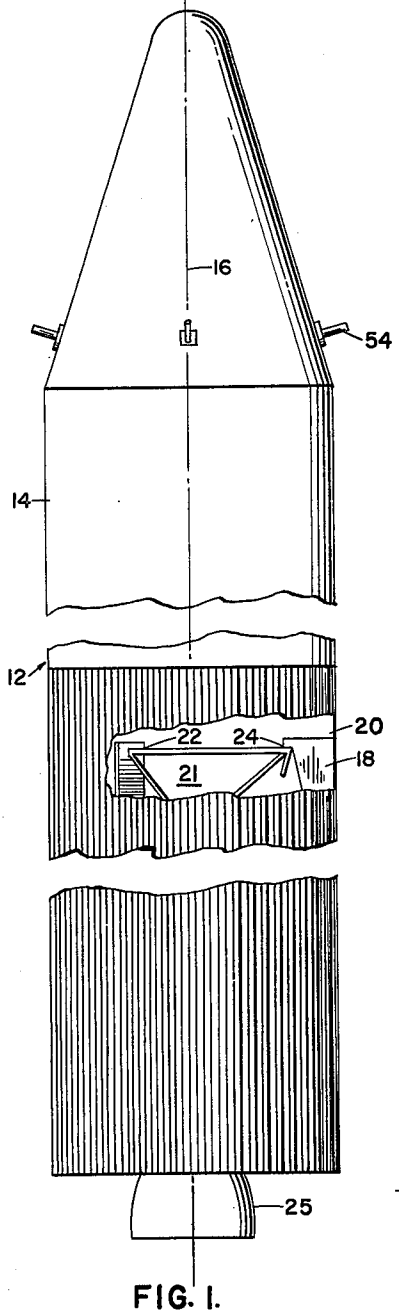


FIG. 1.

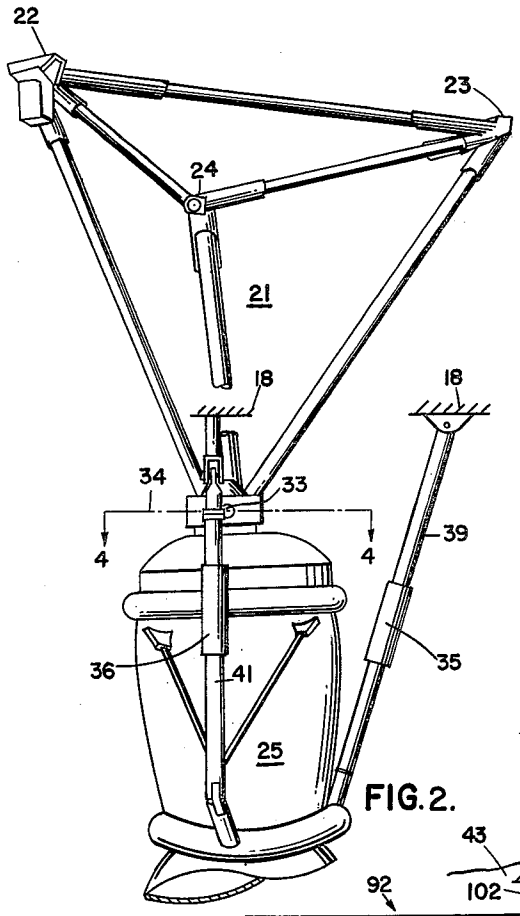


FIG. 2.

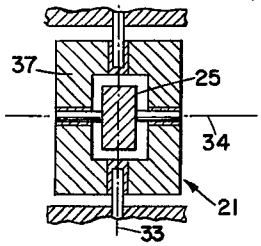


FIG. 4.

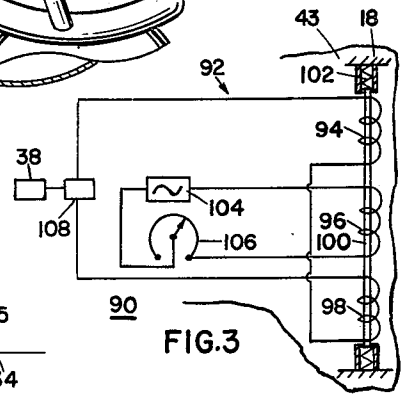


FIG. 3

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ARTIFICIALLY STABILIZED MISSILE

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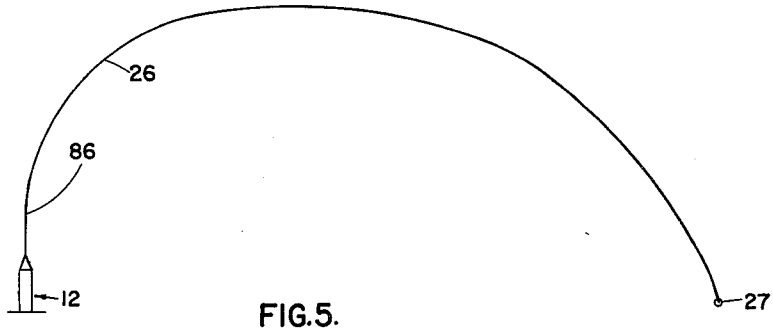


FIG.5.

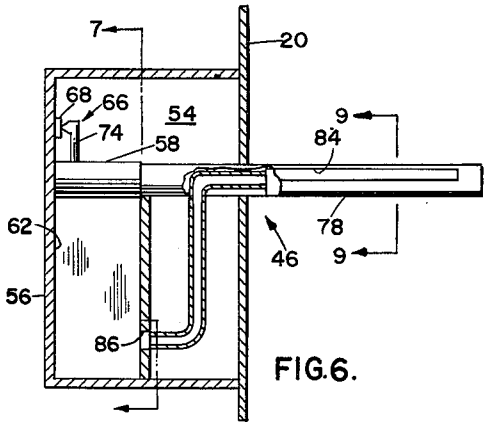


FIG.6.

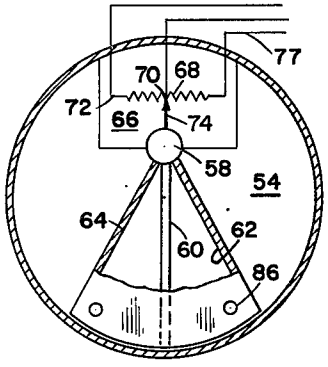


FIG. 7.

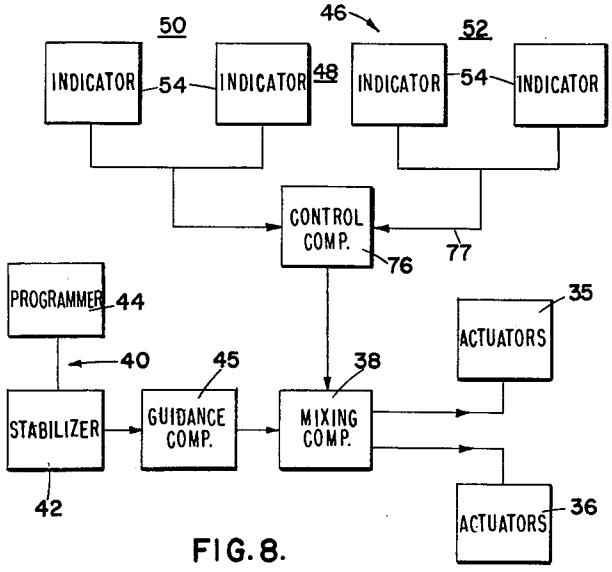


FIG. 8.

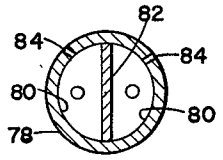


FIG. 9.

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ARTIFICIALLY STABILIZED MISSILE

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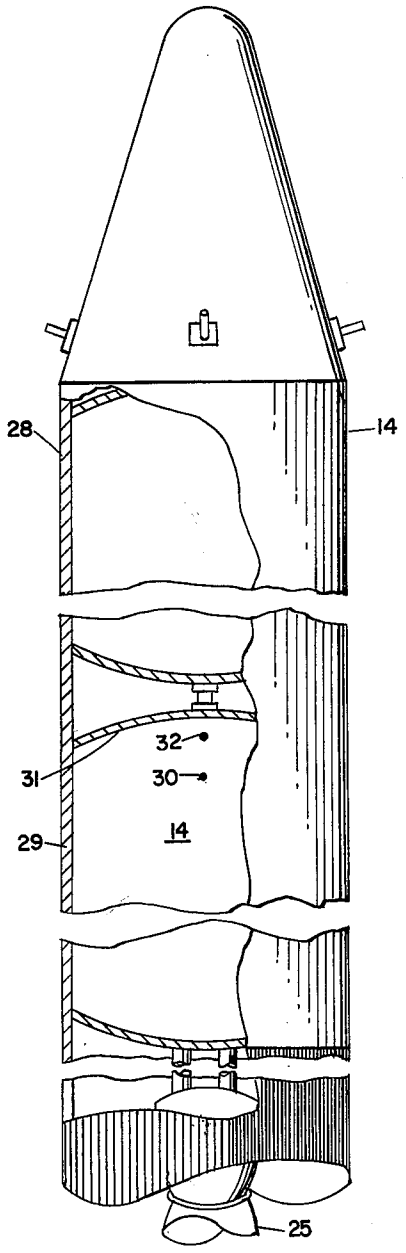


FIG. 11.

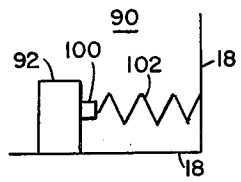


FIG. 10

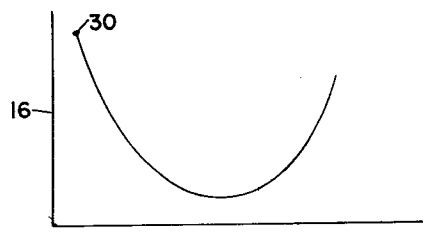


FIG. 12

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3,113,520

ARTIFICIALLY STABILIZED MISSILE

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Filed Nov. 2, 1960, Ser. No. 66,887
2 Claims. (Cl. 102—50)
(Granted under Title 35, U.S. Code (1952), sec. 266)

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

Our invention relates to aerodynamically unstable missiles and more particularly to a device for stabilization thereof.

Conventional missiles are disposed for transportation of payloads to targets in trajectories including initial and final portions within the atmosphere and the missiles are provided with aerodynamic stability.

The fuselages of such missiles are usually cylindrical to provide storage of fuels and provided with substantially conical noses. The centers of pressure and gravity of the fuselages are disposed in serial relation for aerodynamic stability of the fuselages. Fins are secured to each of the fuselages in axial flanged relation therewith to displace the center of pressure rearwardly from the center of gravity and provide the aerodynamic stability of the missile.

In the atmospheric portions, winds acting on the aeroballistically stable missiles at angles to the trajectories apply torques to the missiles for rotation thereof out of the trajectories. The missiles are provided with apparatus to augment the restoring torques of the missiles and direct the missiles to courses for compensation of the winds.

The overall diameters of the aeroballistically stable missiles are strictly limited to a predetermined maximum value by considerations of surface transportation, and the requirement for fins further limits the diameter of the fuselages.

Missiles provided with fuselages having diameters equal to the predetermined value for increased capacity are unstable as the fuselages described above and since no fins are attached to the fuselages, the respective missiles have negative restoring torques. It is an object of our invention to provide such unstable missiles with a device for stabilization thereof.

Similar winds acting on the unstable missiles apply torques thereto to augment the negative restoring torques for rotation of the missiles substantially to the direction of the winds. Compensation for such winds in a conventional unstable missile would be accomplished by application to the conventional missile of a torque equal to the sum of the negative restoring torque and the wind torque after deviation of the conventional missile from the trajectory and such a compensation torque would frequently be of such magnitude as to apply peak loads to the missile structures.

The missiles are provided with relatively high slenderness ratios and with high inertia due to the large fuel and payloads and consequently rotation of the missiles responsive to normal wind velocities is relatively slow.

Another object of our invention therefore is to provide such a device disposed to apply torques to the missiles for compensation of the wind torques.

Other aims and objects of our invention will appear from the following description.

In carrying out our invention, an aerodynamically unstable missile comprises a fuselage with an engine secured therein to provide thrust; a pair of actuators to pivot the engine about the pitch and yaw axes of the missile; a mixing computer connected to the actuators; and a

programmer, a level mechanism and a guidance computer connected to the mixing computer to pivot the engine and stabilize the missile in the initial portions of the trajectories.

The fuselage includes indicators and a control computer secured in the missile and connected for transmission thereto of signals proportionate to angles of attack of winds encountered in the atmosphere. The angles of attack are defined as the angles between wind directions and the longitudinal axis of the missiles. The control computer is also connected to the mixing computer to operate the actuators for compensation of the winds.

In an alternate embodiment of our invention, normally disposed accelerometers are secured to the missile and control computers are connected between the accelerometers and the mixing computer for application to the missile of torques to compensate for the effect of winds thereon.

For more complete understanding, reference is directed to the following description and the accompanying drawing, in which:

FIGURE 1 is an elevation, partly in section, of a missile incorporating our invention;

FIGURE 2 is a perspective view of the engine with the supports and actuators thereof;

FIGURE 3 is a diagrammatic view of the accelerometer coil mounting;

FIGURE 4 is an enlarged view along the line 4—4 of FIGURE 2;

FIGURE 5 is a diminished schematic view of a missile disposed for launching in a trajectory;

FIGURE 6 is an enlarged elevation partly in section of one of the indicators of FIGURE 1;

FIGURE 7 is a view along line 7—7 of FIGURE 6;

FIGURE 8 is a schematic view of the guidance and control connections in which the connecting lines indicate flow of electric signals;

FIGURE 9 is a view along line 9—9 of FIGURE 6;

FIGURE 10 is a schematic view of an accelerometer;

FIGURE 11 is a partial sectional view of the missile showing the fuel tanks; and

FIGURE 12 is a graph of location of the center of gravity with respect to fuel consumption. The vertical reference line is in the direction of the missile axis and represents the longitudinal position of the center of gravity. The horizontal axis represents fuel consumption.

Accordingly a missile 12 includes a fuselage 14 having a longitudinal axis 16, a frame 18, a skin 20 secured thereto, a support 21 secured to the frame at points 22, 23, 24 and provided with capital 47 having an axis 33, a member 37 pivoted about axis 33, and an engine 25 pivoted in member 37 about axis 34 to provide thrust for propulsion of the missile in a predetermined trajectory 26 to a target 27 (FIG. 5).

Missile 12 includes a pair of tanks 28 and 29 for storage of respective fuels therein. The tanks are secured in fuselage 14 in serial relation and disposed for respective communication with engine 25. The missile is provided with a center of gravity disposed at a point 30 adjacent the forward end 31 of the rearward tank when the tanks are full of fuel.

Pressure of air in the atmosphere decreases from atmospheric pressure at launching to zero as the missile leaves the atmosphere. Engine 25 is disposed to produce thrust for rapid acceleration of the missile and the missile is provided with a center of pressure disposed at a point 32 in forward relation to point 30. The air pressure and thrust are in opposite directions and deviation of the missile direction produces a torque therebetween for overturning the missile.

Engine 25 is pivoted in support 21 about intersecting

transverse pitch and yaw axes **33** and **34** disposed in mutual normal relation with axis **16**, and an operating mechanism includes a pair of actuators **35** and **36**, respectively disposed in arms **39** and **41** secured between frame **18** and the engine to control the lengths of the respective arms and rotate the engine about the respective axes and counteract the overturning torque to stabilize the missile. A mixing computer **38** is electrically connected to the actuators for operation thereof.

As fuel is withdrawn from tank **28**, and from tank **29** above point **30**, the center of gravity is displaced rearwardly until the level of fuel in the rearward tank overtakes the center of gravity, after which the rate of rearward displacement decreases. The rearward displacement ceases when the fuel levels are equidistant from the center of gravity and the center of gravity moves forwardly responsive to further withdrawal of the fuel.

A guidance mechanism **40** includes a stabilizer **42** with a level platform **43** and a programmer **44** electrically connected to a guidance computer **45**. The guidance computer is electrically connected to mixing computer **38** to transmit signals thereto for the operation of the actuators. The variations in the air pressure and thrust produce variations in the forces of the overturning torque and displacement of the center of gravity produces changes in the lever arm of the torque to result in nonlinear variation of the torque with respect to time of flight. Guidance computer **45** is disposed to modify the signals in accordance with the overturning torque.

The missile is provided with a control mechanism **46** (U.S. Science Corp. Part #10,000,070) including a sensing device **48** with normally related diametral pairs **50** and **52** of indicators **54** disposed respectively to detect wind load components affecting pitch and yaw of the missile. Each of the indicators includes a housing **56** secured to skin **20**, a shaft **58** journaled in the housing in normal relation to skin **20**, and a paddle **60** secured to shaft **58** for rotation in a sector chamber **62** of housing **56** having angled walls **64**. Control mechanism **46** is provided with electrical means for converting the wind load components to electrical signals and transmitting the signals to a control computer **76** including a potentiometer member **66** with a resistance **68** secured to housing **56** and provided with an intermediate point **70** and end points **72**. An arm **74** is secured to shaft **58** and disposed for electrical contact with resistance **68**, and the points and the arm are electrically connected to control computer **76** of the control mechanism by conductors **77** for transmission of signals to the control computer.

Mixing computer **38**, guidance computer **45** and control computer **76** are included in a component entitled "Control Computer Part Number 8974865" manufactured by Ford Instrument Company.

An extension **78** of shaft **58** projects from skin **20** and includes semicylindrical apertures **80** separated by a diametral partition **82** and provided with respective symmetrically disposed slits **84** respectively communicating into apertures **80** for entry of air therein. Apertures **80** respectively communicate with chamber **62** through a pair of holes **86** adjacent walls **64**.

Partition **82**, arm **74**, and paddle **60** are aligned, and arm **74** is disposed for engagement with point **70** for a null signal from potentiometer **66** responsive to equal wind pressures communicated through slits **84** to apertures **80** for progress of missile **12** along trajectory **26**. Partitions **82** are aligned with axis **16** and slits **84** are disposed in the forward portions of extensions **78** for development of the equal positive pressures in apertures **80** as missile **12** proceeds along trajectory **26**.

Paddles **60** are disposed for rotation responsive to differences of pressure in apertures **80** from a wind load at an angle to trajectory **26** for potentiometer **66** to transmit load signals to control computer **76**. Computer **76** is electrically connected to mixing computer **38** for operation of the actuators to pivot engine **25** about the respective axes and direct missile **12** to a course for compensation of the wind load.

The response of sensing device **48** and computers **76** and **38** to the wind loads is substantially immediate to provide operation thereof similar to that of an aerodynamically stable missile.

In an alternate embodiment of our invention, an accelerometer **90** includes a pair of devices **92** disposed in normal relation and each provided with coaxial coils **94** and **98** secured to frame **18** in serial relation transversely to enclose a slug **100**. Slugs **100** are biased by springs **102** to neutral positions within the coils, and coils **96** respectively coaxial with coils **94** and **98** are supplied with alternating current by sources **104**. The values of current are controlled by potentiometer **106**. Coils **94** and **98** are disposed in series connection with a control computer **108** disposed for connection to mixing computer **38** for the artificial stabilization, and the coils are differentially wound to produce zero signal responsive to the neutral position.

Slugs **100** are displaced responsive to accelerations resulting from wind components in the directions of the axes thereof for application of corresponding signals to control computer **108** and the computer is disposed for operation of the actuators to counteract the wind components for artificial stabilization of missile **12**.

Missile **12** is vertically erected on a launching pad for take off in a trajectory **26** to a target **27** with the initial portion **86** of the trajectory in vertical relation as shown in FIGURE 5. Guidance mechanism **40** operates the actuators to direct the missile in the trajectory. In initial portion **86** with zero wind, the direction of thrust of engine **25** is in axis **16**.

When the missile encounters a wind in angular relation with axis **16** differences of pressure in apertures **80** are applied to the appropriate paddles for rotation thereof and of arm **74** to apply signals to computer **76**. The computer operates the actuators to pivot engine **25** to angular relation with axis **16** to stabilize missile **12** by direction thereof in a course for compensation of the wind.

In the compensation course the paddles are driven to a new position reflecting the angle of the wind to the compensation course and the resulting signal from potentiometer **66** is nullified by an equal and opposite signal from computer **76**. Such missiles are provided with considerable inertia, and the computer and the actuators operate to gimbal the engine responsive to signals from sensing device **48**, before deviation of the missile from the trajectory can be accomplished by the wind. Signals from devices **92** reflect the force and direction of the winds on the missiles and computers **108** are disposed to gimbal engine **25** and apply torques to missile **12** to counteract the effect of the winds.

Mechanism **46** is more sensitive to weather influences but less sensitive to vibrations than an accelerometer.

While the foregoing is a description of the preferred embodiment, the following claims are intended to include those modifications and variations that are within the spirit and scope of our invention.

We claim:

1. A missile for propulsion in a predetermined trajectory including an initial portion traversing the atmosphere comprising: a fuselage with mutually normal longitudinal, pitch and yaw axes; and an engine and operating guidance and control mechanisms secured in said fuselage for instability thereof; said engine being disposed for operation to provide thrust for the propulsion and for pivotal engagement with said fuselage to provide a variable angular relation of the direction of the thrust with said longitudinal axis; said operating mechanism including a pair of actuators secured between said fuselage and said engine to control the angular relation and a mixing computer electrically connected to said

actuators; said guidance mechanism comprising a stable mechanism, a programmer, and a computer electrically connected to transmit signals to said mixing computer for stabilization of the missile and direction of the missile in the trajectory; and, said control mechanism including a device for sensing the force and direction of winds imposed on said fuselage having pairs of indicators disposed for normal relation and secured to said missile in normal relation with said longitudinal axis, shafts with paddles disposed in each of said indicators for rotation responsive to components of winds in the atmosphere, electrical means secured to said shafts to transmit signals proportionate to the wind components, and a control computer connected between said electrical means and said mixing computer for modification of the stabilization and direction signals to compensate for the winds.

2. A missile as in claim 1 with said fuselage provided with a pair of tanks secured to said fuselage in serial relation for storage of fuels and connected to said engine for operation thereof, a center of gravity disposed within the rearward of said tanks and adjacent the head thereof

for rearward and forward displacement responsive to the engine operation, and said fuselage, engine, and said mechanisms disposed to provide a center of pressure disposed forwardly of said center of gravity, to provide a negative restoring torque to said missile for the aerodynamic instability, said guidance mechanism disposed to modify the stabilization signals in accordance with the values of the negative restoring torque, and said control mechanism disposed to modify the stabilization signals in accordance with the winds for stabilization of said missile.

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