United States Patent

Stripling

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[54] FLUID AMPLIFIER WITH DIRECT-COUPLED GYROCONTROL

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[73] Assignee: **The United States of America as represented by the Secretary of the Army**

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[52] **U.S. Cl.** **244/3.22**

[51] **Int. Cl.** **F42b 5/18**

[58] **Field of Search** 244/3.22; 102/DIG. 3

[56] **References Cited**

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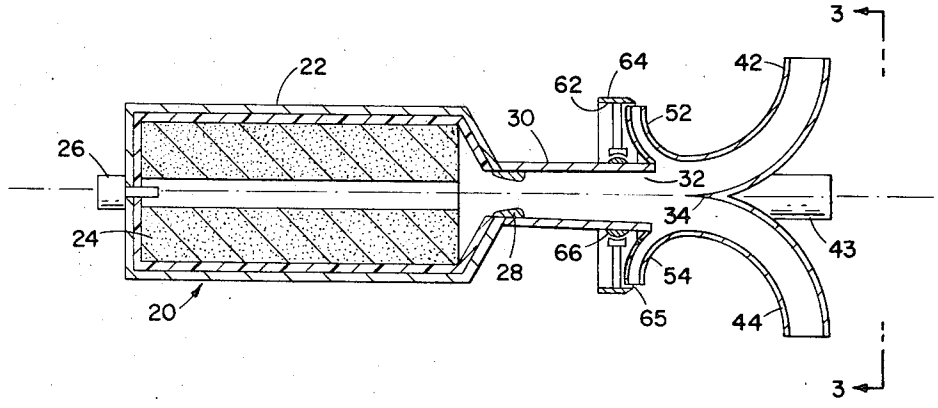
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[57] **ABSTRACT**

A large power-flueric amplifier is controlled by selective restriction of opposing control parts. An inertially stabilized wheel serves to orifice the amplifier control ports to generate a control moment for directional control of a rocket or missile. A hot gas generator furnishes output gases that exhaust through the fluid amplifier, exiting through opposing exhaust ports around the periphery of the missile to maintain the missile on the original flight path. The inertially stabilized wheel, spinning in a plane normal to the missile flight path, spins on a sleeve or bearing through which the nozzle of the flueric amplifier passes. Tubular members extend radially from the flueric amplifier interaction chamber and terminate adjacent the interior annular surface of the spinning wheel. The wheel covers a portion of each tube inlet and varies the opening of each control inlet in response to relative motion between the spinning wheel and the missile. Ambient air pressure at each control inlet is constantly applied to uniformly exhausting gases when the missile is aligned with the spinning gyrowheel. Deviation in missile direction results in increased ambient pressure at one control port and decreased pressure at the opposing control port, causing the exhaust gases to move toward one wall, thus, producing an imbalance in the exhaust port gases which restore the missile to the flight path.

6 Claims, 3 Drawing Figures



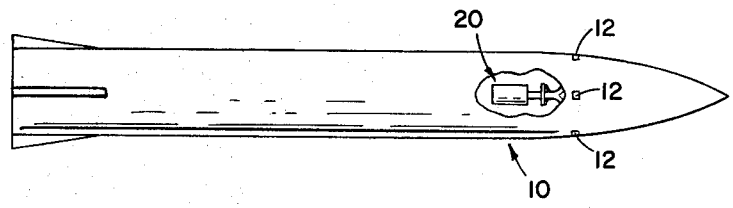


FIG. 1

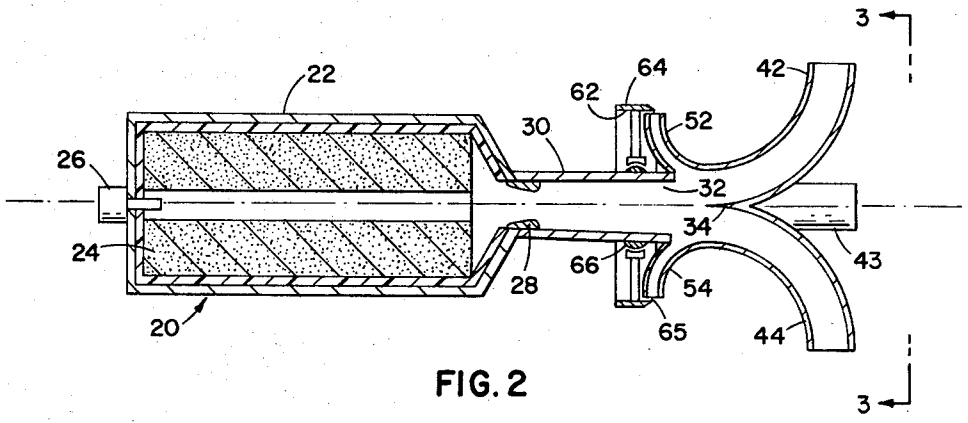


FIG. 2

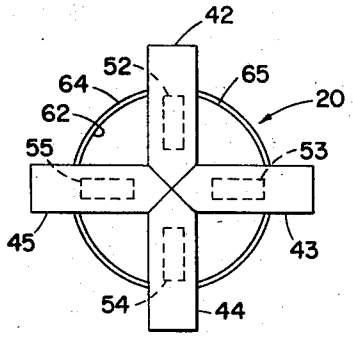


FIG. 3

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FLUID AMPLIFIER WITH DIRECT-COUPLED GYROCONTROL

BACKGROUND OF THE INVENTION

In providing attitude control systems for missiles and rockets, relatively complex systems are employed to maintain control of the missile trajectory. These controlling systems can employ a combination of electrical, mechanical and pneumatic systems and interfacing therebetween. For line-of-sight or predetermined trajectories of small missiles, the complex guidance systems are expensive and accurate for a range much greater than the need.

In a less complex system of existing fluid amplifiers, a fluid power stream is controlled or directed to provide thrust from missile output ports to provide pitch, yaw and roll control. However, many of the devices have moving parts and require considerable force to open or close a duct when a high-velocity stream of fluid is involved. Moving parts are often employed in the fluid stream and are susceptible to corrosion and subsequent malfunction. Other fluid amplifiers employ separate power sources, which may be other fluid amplifiers, to obtain a control stream of fluid. This control fluid impinges on the sides of the fluid power stream and the momentum of the control stream will deflect the power stream to provide the desired thrust forces.

SUMMARY OF THE INVENTION

In a proportional fluid amplifier having input control ports, a difference in pressure applied to opposing control ports will cause more of the power stream to flow out of one exhaust port than will flow out of the opposite exhaust port. By allowing the control port to be open to the ambient pressure within the missile housing, venting is accomplished which prevents reflection and high-speed switching of the power stream to the chamber wall. Simultaneously, through selective restriction of the control ports, variable deflection of the power stream or jet is accomplished for relatively small restrictive action at the control ports.

The apparatus of the present invention is a fluid amplifier having a direct-coupled gyro for providing attitude control of missiles and which does not require interfacing with additional support systems. Deviation of the missile from a desired flight path is sensed by the gyro and directly coupled to the fluid amplifier with no intermediate stages therebetween. The gyro is brought up to speed prior to launch of the missile and is uncaged at launch to maintain the missile on a course normal to the plane of the gyro spinning wheel. The spinning wheel rotates on a sleeve or bearing which encompasses a portion of the fluid amplifier. Exhaust gases from a gas generator pass through the interaction chamber of the fluid amplifier and exhaust to the missile surface through a series of evenly spaced tubular passageway forming members extending radially from the interaction chamber to the missile skin and having an exhaust nozzle or jet on the distal end thereof. When the missile is on course the output exhaust gases are balanced and provide no restoring force. A series of control ports around the periphery of the interaction chamber are similar to and adjacent the exhaust ports and have an opening external to the chamber that is partially covered by the edge of the spinning wheel. The rotating wheel covers a portion of each control port opening and varies the opening thereof in response to relative motion of the missile axis with respect to the spinning wheel axis. Changes in missile trajectory cause some control ports to become less restricted while opposing ports are more restricted, allowing the ambient air pressure outside the interaction chamber to become unbalanced across the exhaust gas stream within the chamber. The exhaust gas is deflected by the differential pressure applied thereto to provide a restoring force.

An object of the present invention is to provide apparatus for proportionately varying a stream of fluid applied to a plurality of output ports in response to deviation of said apparatus about a reference line.

Another object of the present invention is to provide a missile attitude control system in which a direct-coupled fluid amplifier and gyro initiate and control pitch and yaw deviations of said missile.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view of a missile incorporating the invention therein.

FIG. 2 is a sectional, elevational view of a preferred embodiment of the invention.

FIG. 3 is a view along the lines 3—3 of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings wherein like numerals represent like parts in all figures, there is disclosed a preferred embodiment of the invention. FIG. 1 discloses a missile 10 wherein a gyro-controlled fluid amplifier 20 (flueric gyro) is shown to be mounted in the fore part of the missile. Openings 12 in the skin of missile 10 allow exhaust gas from the fluid amplifier to escape the missile, applying a thrust force thereto. If flueric gyro 20 should be mounted behind or below the center of gravity of the missile (aft end), the system would be rotated 180° so that the exhaust ports would be nearest the aft end of the missile.

FIG. 2 discloses a sectional view of flueric gyro 20 wherein a hot gas generator 22 is connected to a fluid amplifier housing 30 enclosing an interaction chamber 32 having input and output ports thereto. Gas generator 22 includes a solid grain propellant 24, an igniter 26 for activating the propellant and a nozzle 28 connecting the generator to amplifier 30. High-pressure gas is thus generated and coupled to the interaction chamber 32.

As noted in FIGS. 2 and 3, a plurality of tubular passageway forming members 42, 43, 44 and 45 form a series of exhaust nozzles or ports for interaction chamber 32. Exhaust ports 42, 43, 44 and 45 extend radially outwardly from housing 30 and terminate adjacent openings 12 in the missile skin. These exhaust ports terminate in a position normal to the missile longitudinal axis for the exhausting gas therethrough. Each of members 42, 43, 44 and 45 are spaced 90° from adjacent members on a plane perpendicular to the missile flight axis. Member 42 is located opposite member 44 and adjacent to members 43 and 45. A series of control ports 52, 53, 54 and 55 are formed by a plurality of tubular passageway forming members in communication with chamber 32. These control ports are 90° from adjacent members and aligned in the same longitudinal plane as a corresponding exhaust port. Member 52 is diametrically opposed to member 54 and adjacent to members 53 and 55. Thus, a longitudinal plane passing through exhaust ports 42 and 44 will also pass through control ports 52 and 54. Members 52, 53, 54 and 55 extend radially outwardly from chamber 32 and terminate adjacent the interior annular surface 62 of a high-momentum gyrowheel 64. Wheel 64 is rotatably supported on a spherical bearing 66 (or a sleeve) having a cylindrical hole therethrough which encompasses a portion of housing 30. A longitudinal axis passing through the cylindrical hole is coaxial with the longitudinal axes of fluid amplifier 20 and missile 10.

In operation, the gyrosystem must be brought up to speed while in a caged position. This is done before missile 10 is launched. In general, caging is along the rocket axis. Missile 10 is committed to a particular flight path, the gyrowheel 64 is brought up to speed and the missile is launched. Gyrowheel caging and spin-up techniques can be of any conventional methods. Generator 22 is ignited and hot gas therefrom is forced through nozzle 28 into interaction chamber 32 at a reduced pressure and a high speed. These high-speed gases are directed along the centerline of chamber 32 and are evenly divided by slitter 34, unless acted upon by outside forces. While missile 10 remains on the selected flight path, and also prior to launch, gyrowheel 64, rotating at a high momentum covers an equal amount of the input nozzles of all control ports 52, 53,

54 and 55, allowing an equal amount of ambient pressure to be directly coupled through the ports to the power stream of exhaust gas passing through interaction chamber 32. Thus the stream remains unchanged until evenly divided by splitter 34 and is then exhausted to the missile surface. Because of equal gas flow in all exhaust ports, the wheel spin axis coincides with the missile flight axis, maintaining the plane of the spinning wheel perpendicular to the flight axis.

During flight, any tendency of missile 10 to deviate from an axis normal to the plane of spinning wheel 64 causes restoring force to be applied to the missile. For example, if the nose of missile 10 deviates toward port 42, the missile axis is no longer aligned with the axis of spinning wheel 64. The gyro-controlled fluid amplifier 20 is fixed coaxially or parallel with the missile longitudinal axis. The gyro spin axis is free, allowing for example, 4°–6° of freedom for the wheel. The relative deviation of missile 10 and housing 30 causes the input opening of control port 52 to move further under an edge 65 of wheel 64, reducing the amount of ambient air pressure allowed through the port. Similarly, port 54 is opened to the ambient air pressure allowing an increase in the force applied to the low-pressure, high-speed exhaust gas. An increase in the pressure applied through control port 54 and a corresponding decrease in the pressure applied through control port 52 causes the power stream to deflect toward output port 42. Thus, the exhaust gas through ports 43 and 45 is balanced, the gas through port 42 is greatest and the exhaust gas through port 44 is least. This change in the balance of the restoring exhaust gas causes the missile nose to be forced back toward the flight path until the spin axis and missile longitudinal axis coincide.

Since wheel 64 is free to move with respect to the chamber housing 30 and missile 10 axes and therefore remains unmoved from the caged position of revolution, missile drift in any direction around the flight axis results in restoring action by all exhaust ports. For example fore end drift of missile 10 into the quadrant formed by ports 52 and 53 results in wheel 64 covering more of ports 52 and 53 while uncovering more of ports 54 and 55. A restoring force is then provided by each exhaust or output port and is proportional to the amount of drift toward the particular exhaust jet. An increase in gas flow from ports 44 and 45 and a decrease in diametrically opposed output ports 42 and 43 return the missile to the trajectory path.

In the event that gas escaping from ports 12 on the missile surface increases turbulence or provides intermittent control due to airflow around the missile nose, the gyrosystem can be mounted in the rear of the missile, as already noted. Obviously a more or less elaborate system may be employed using the identical principles. For example, six exhaust ports and six control ports can be employed, each being spaced 60° from adjacent ports in their respective planes. Similarly, three exhaust ports at 120° intervals may be employed with an equal number of control ports, providing an equally successful system.

I claim:

1. A large power-flueric amplifier comprising: a means for producing a stream of fluid at a uniform rate of flow, a chamber housing having an input port connected to receive said fluid stream and having a plurality of evenly spaced output ports for exhausting said fluid therethrough, at least three control ports projecting from said chamber around the periphery thereof in a plane normal to the longitudinal axis of said chamber for varying the surface pressure on said fluid stream, gyro control means adjacent to and partially covering said control ports for increasing and decreasing the opening to said control ports in response to deviation of said chamber housing from a fixed line of reference with said control means for controlling the direction of fluid flow through said outlets to return the chamber housing to said line of reference, and said gyro control means having a spinning wheel rotating on a sleeve or bearing that surrounds a portion of said chamber housing, the inner surface of said wheel covering at least a portion of the opening of said control ports.

2. A fluid amplifier as set forth in claim 1 wherein each of said exhaust ports include a tubular passageway forming member extending radially from said housing chamber in a plane perpendicular to the axis of said chamber and spaced evenly apart for exhausting a balancing fluid flow therefrom only when the spin axis of said spinning wheel coincides with the longitudinal axis of said chamber for maintaining said axes in coincidence.

3. A fluid amplifier as set forth in claim 2 wherein said fluid producing means is a gas generator and said fluid is the exhaust gas of said generator, said output ports comprise first, second, third and fourth output ports for said fluid that are radially spaced 90° apart, and said control ports include first, second, third and fourth control ports having chamber openings longitudinally adjacent said first, second, third and fourth output ports respectively.

4. In a guided missile, an attitude control system for maintaining the missile on a predetermined launch path comprising an elongated chamber housing having a fixed longitudinal axis thereof aligned with the longitudinal axis of said missile and having an input port at one end thereof and a plurality of exhaust ports at the other end thereof, a gas generator having an output thereof connected to said chamber input for directing a uniform flow of exhaust gas therethrough to exit through said exhaust ports, direct-coupled control means adjacent said chamber housing having a reference axis in parallel with the chamber longitudinal axis prior to missile launch, and a plurality of chamber control ports having openings in said chamber adjacent said exhaust ports, and responsive to axial changes between said chamber and said control means for varying the surface pressure applied to said exhaust gas flowing through said chamber after missile launch.

5. An attitude control system as set forth in claim 4 wherein said chamber housing is a proportional fluid amplifier, said exhaust ports are 4 tubular passageway forming members equally spaced about the chamber longitudinal axis for connecting said chamber to the external surface of said missile for exhausting said gas therethrough to control the direction of missile flight, said ports intersecting said missile surface in a plane perpendicular to the missile flight axis to produce uniform thrust therefrom when said missile is on said predetermined launch path.

6. An attitude control system as set forth in claim 5 wherein said direct-coupled control means is a gyro having a spinning wheel rotating on a sleeve or bearing around the periphery of said chamber housing adjacent said control ports, said spinning wheel having an inner surface edge covering at least a portion of the opening of each control port for varying ambient pressure applied therethrough a restore said missile to said flight path when the missile deviates from said flight path, and wherein said reference axis is the gyro spin axis.

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