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VARIABLE AREA ORIFICE INJECTOR

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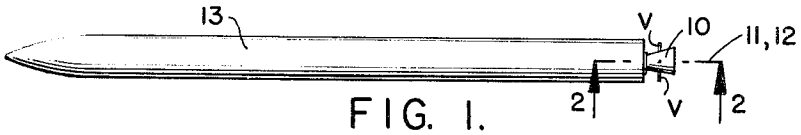


FIG. 1.

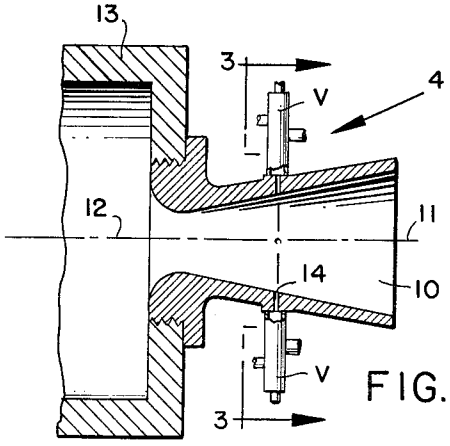


FIG. 2.

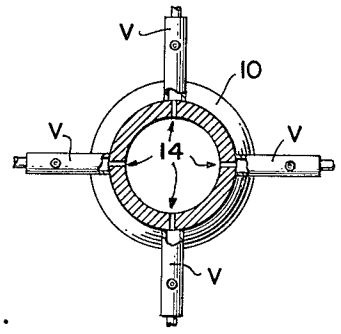


FIG. 3.

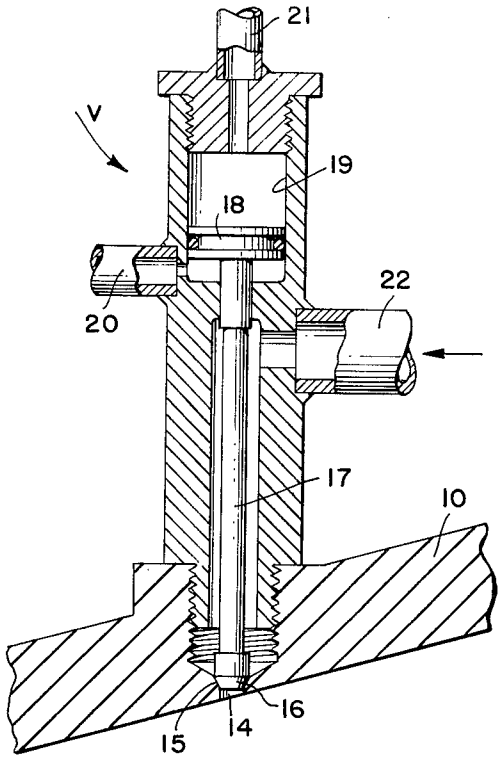


FIG. 4.

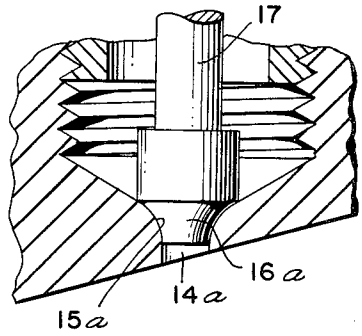


FIG. 4A.

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VARIABLE AREA ORIFICE INJECTOR

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4 Claims. (Cl. 60—35.54)
(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to jet propulsion apparatus and more particularly to improvements for controlling the direction of thrust produced by a nozzle to thereby control the direction of movement of a missile or the like which is propelled by a jet motor.

The directional control of jet propelled missiles which operate only in the atmosphere presents a relatively simple problem in that movable surfaces may be provided on the missile which utilize aerodynamic forces for changing direction of the missile. When the missile must move beyond the atmosphere such type of guidance system is no longer feasible and it has been conventional practice to guide the missile by effecting movement of the direction of thrust away from the direction of movement. The nozzle through which the gases issue may, for example, be universally swiveled and oriented as desired under some sort of guidance command. It has also been the practice to immovably affix the nozzle to the missile and in some way disturb the nozzle blast to produce lateral forces which will effect directional control.

One of the recent innovations in controlling direction with a fixed nozzle is to provide its discharge cone with a plurality of angularly spaced apertures through which a fluid may be selectively injected. When such fluid is injected through one or more of these apertures the axis of thrust is moved away from the geometrical axis of the nozzle, producing the desired lateral force. With such type of directional control apparatus it is desirable, also, that the quantity of fluid flowing through one or more of the apertures be varied as desired and to produce guidance controlling forces in some proportion to the rate at which a turn of direction is desired. It has accordingly been the practice to provide throttling valves in the fluid supply conduits ahead of the fixed apertures. The fluid was thus delivered first through a throttling valve open to varying degree and thence through a fixed aperture in the wall of the nozzle.

It has been found that the method of control just referred to provides optimum results only when the throttling valve is at or near its wide open position; when operating near its closed position with low rates of flow the controlling forces are materially decreased or are nonexistent.

One of the objects of the invention is to obviate disadvantages of injection systems of the type just referred to.

Another object is to control the direction of thrust of a propulsion nozzle by injection of fluid into a nozzle exhaust stream in a manner to obtain maximum effectiveness of the injected fluid.

Another object is to inject the fluid at maximum velocity regardless of its mass rate of flow.

A further object is to eliminate certain parts of a heretofore employed nozzle injection system and improve its performance.

Further objects, advantages, and salient features will become more apparent from a consideration of the description to follow, the appended claims, and the accompanying drawing, in which:

FIG. 1 is a side elevation of a rocket propelled missile

embodying a thrust nozzle forming the subject of the invention,

FIG. 2 is an enlarged section taken on line 2—2, FIG. 1,

FIG. 3 is a section taken on line 3—3, FIG. 2,

FIG. 4 is an enlarged cross section of the injection valve indicated by arrow 4, FIG. 2, and

FIG. 4A is a modified form of the valve shown in FIG. 4.

Referring now to the drawing, the subject of the invention comprises a conventional nozzle **10**, such as of the converging-diverging De Laval type, having a longitudinal axis **11** aligned with longitudinal axis **12** of a rocket propelled missile **13**, and which is provided with a plurality of angularly spaced discharge orifices **14** in its divergent cone through which fluid may be selectively injected into the rocket discharge gases. In the prior art referred to, these orifices are of fixed area and their control valves (not shown) are remotely located, the valves communicating with the fixed orifices through suitable conduits.

The present invention differs from the prior art just referred to in that orifices **14** are of variable area, suitable valving apparatus being disposed directly adjacent the point of fluid discharge rather than remotely as in the prior art. As a result of this arrangement the fixed orifices are eliminated, along with the pressure drop which occurs across them, and only a single pressure drop, rather than two pressure drops, exists between the source of fluid pressure (not shown) and the discharge side of the variable area control valves.

Each variable area control valve V employed comprises a conical seat **15** and a conical valve **16** which may be suitably actuated by a valve stem **17** attached to a piston **18**, disposed in a cylinder **19** and having conduits **20**, **21** adapted to supply fluid pressure to opposite sides of the piston. By creating differential pressures the rate of movement and position of the piston may be controlled as desired. Such type of valve actuator is exemplary, however, and any other type of actuator may be employed. The fluid which is injected into the rocket nozzle by each valve V is delivered through a conduit **22** connected to a source of fluid under pressure (not shown).

In the operation of the device it will be assumed that missile **13** is provided with a conventional guidance system which senses directional changes which are necessary to guide the missile to a target or other destination. When a turn in direction is required as dictated by the guidance system, differential pressure is applied to opposite sides of one of the valve actuating pistons which opens the valve to apply fluid into the rocket exhaust gases. This changes the direction of thrust and moves axes **11**, **12** relatively, producing a transverse component of force which effects turning movement of the rocket. As illustrated, four equi-angularly spaced valves are employed, each of which may change the direction in one of the four directions in space. If turns in two directions are required at the same time it is to be understood that two of the valves may be open at the same time and to different degree. As will also be apparent, by locating the valve and its seat directly adjacent the point of fluid discharge into the nozzle, there is no conduit between the valve and the point of discharge, as in the prior art previously referred to. This eliminates filling the volume of such conduit when the valve opens, which causes a time delay or lag in effecting desired guidance, and also eliminates guidance override after the valve closes due to discharge of fluid remaining in the conduit, which discharge occurs due to pressure differential, vaporization or decomposition of such remaining fluid. While such lag and override are both objectionable, the override is probably the more objectionable since the remaining fluid pro-

duces further turning of the missile after the guidance system has called for cessation of the turn by closing the valve and thus may produce "hunting" of the missile about the desired direction of guidance.

While the location of valve **16** directly adjacent the point of discharge, as distinguished from remotely located, materially improves the effectiveness of the system, this may be further improved by using a contoured valve member **16***a* as shown in FIG. 4A to produce linearly a change in the direction of thrust with linear movement of the valve member. As will be apparent, also, the valve may be conical and the valve seat contoured in its stead. In either case, the effective area of the annular opening will vary non-linearly with increments of opening but the exit velocity of the injected fluid will be substantially linear.

The injected fluid may be either a liquid or a gas, examples of the former which have been effectively employed including various Freons, such as Freon 12, $12B_2$, 113, 114 or $114B_2$, or nitrogen tetroxide (N_2O_4) and examples of the latter including nitrogen or air.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A rocket propelled device having a converging-diverging nozzle through which gases exhaust and which is steered by injecting fluid laterally into the exhaust through angular spaced ports around the inner surface of the divergent portion of the nozzle, the improvements, in combination, comprising:

(a) a circular inwardly tapering valve seat disposed within the wall of the nozzle directly adjacent each of said ports,

(b) a valve for each seat having an end conforming to the shape of its seat,

(c) a valve stem affixed to each valve mounted for rectilinear movement,

(d) an actuator affixed to each valve stem for selectively moving a valve independently of the others and to varying positions of opening,

(e) a source of fluid under pressure communicating with each of said ports whereby fluid may be delivered to each valve, and

(f) the proximity of said valve seats to said ports being so near as to produce no substantial pressure drop therebetween, substantially all pressure drop between the source of pressure and the nozzle occurring across each valve, the fluid discharge from a valve flowing directly into the nozzle and substantially no fluid remaining between each valve and its port after it closes on its seat.

2. A device in accordance with claim **1** wherein each said actuator comprises a piston slidable within a cylinder, and a source of fluid under pressure interconnected with said cylinder for moving said piston.

3. A device in accordance with claim **1** wherein the pressurized fluid communicating with each valve port is Freon.

4. A device in accordance with claim **1** wherein each seat is spaced from the inner surface of the nozzle a sufficient distance to protect it from erosion by the exhaust gases.

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