Jan. 14, 1969 W. R. BAINS 3,421,324

FLUID FLOW CONTROL APPARATUS

Filed May 3, 1966

FIG. 1.

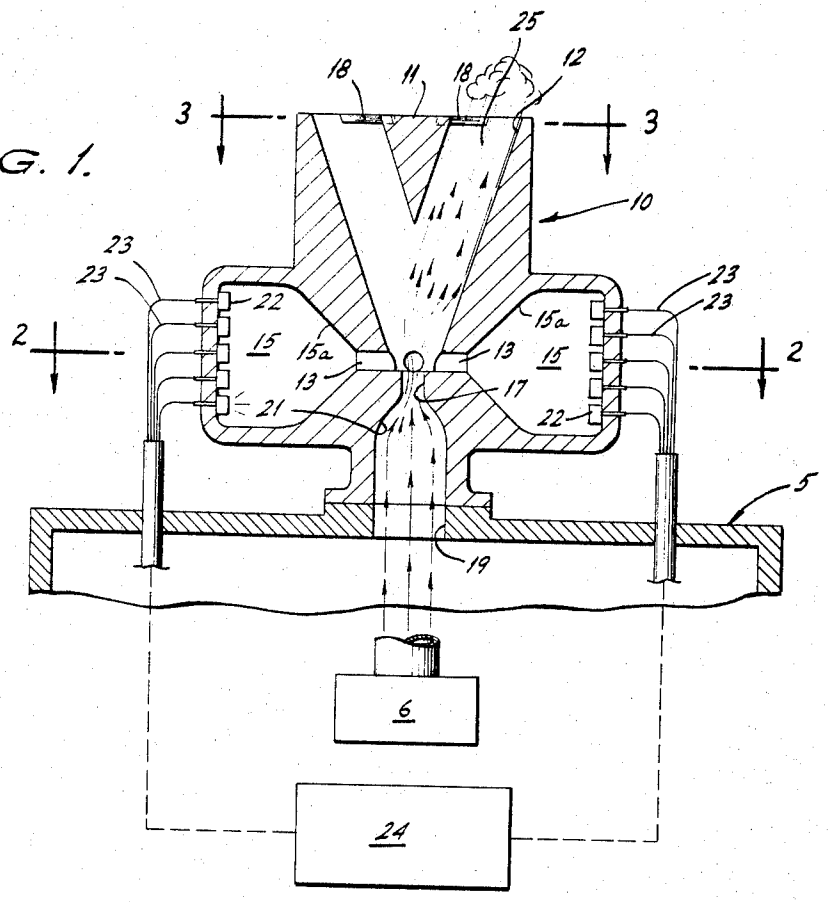
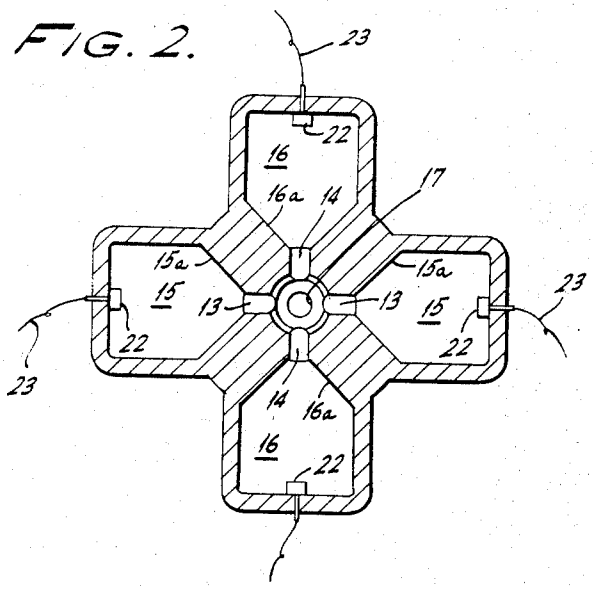


FIG. 2.



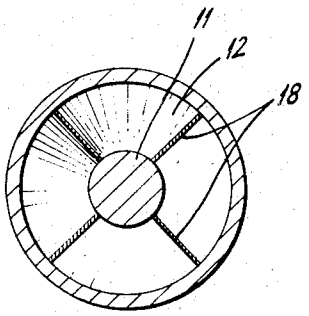


FIG. 3.

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FLUID FLOW CONTROL APPARATUS

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U.S. Cl. 60—231 3 Claims

Int. Cl. F02k 1/14; F15c 1/08; B05b 7/08

ABSTRACT OF THE DISCLOSURE

A rocket propulsion system including a split-path propulsion nozzle and means for deflecting the propellant gas stream to cause it to flow through one or the other of said paths to steer the rocket. Deflection of the gas stream is achieved by the fluid amplification principle, and the required control jets are produced by suitably positioned control-jet ports energized by arrays of pyrotechnic charges (squibs). Each array of squibs is housed in an individual chamber communicating with the ports and can be fired in desired sequence by the missile's guidance system.

This invention relates to apparatus for controlling fluid flow, and more particularly to improved apparatus for controlling the direction of flow of a stream of gas as it is discharged from the nozzle of a reaction motor. While of broader applicability, the invention has particular utility in the field of guidance systems for missiles or rockets.

One known system for propelling a missile by use of a gas stream issuing from a nozzle utilizes an auxiliary gas stream to control the direction of thrust of the propelling stream, whereby to steer the missile. In such apparatus, the issuing gas stream may be deflected from one position to the other by means of jets as gas released from a suitable auxiliary source and directed transversely of the main gas stream in the throat section of the reaction motor. The auxiliary source, in a typical prior arrangement, may comprise a container of gas under pressure. Gas is released from the container through electromechanical valves, as directed by the missile's guidance control system, thereby to deflect the path of the issuing gas stream and steer the missile.

It is a general objective of the present invention to provide improved auxiliary gas supply means of the above-mentioned type for controlling deflection of the propelling stream, which means overcomes the need for maintaining a supply of control gas under pressure.

It is a further objective of the invention to provide improved auxiliary gas supply means that is both positive acting and rapid in achieving control of a main gas stream.

It is a still further objective of the invention to provide improved guidance control means which minimizes the use of moving parts and is highly reliable in operation.

To these general ends the invention contemplates, in a preferred embodiment thereof, the use of at least a pair of oppositely disposed control ports extending transversely of and into gas flow communication with the constricted neck portion of the missile nozzle, means defining at least a pair of chambers each in gas flow communication with a corresponding one of the control ports, and a plurality of combustible, gas generating charges disposed within each of the chambers. Means is provided for igniting the charges in accordance with a desired sequence required to guide the missile, ignition of a charge establishing instantaneous flow of a jet of gas through a corresponding one of the control ports. The jet is operable to deflect the stream of propellant gas flowing through the nozzle, and the vehicle is steered accordingly.

Advantageously, the invention overcomes the need for storing control gas under pressure, as well as the electromechanical valves usually associated with means for storing gas.

The manner in which the foregoing as well as other objectives and advantages of the invention may best be achieved will be understood from a consideration of the following description, taken in light of the accompanying drawing in which:

FIGURE 1 is an elevational showing, partly in section, of apparatus embodying a preferred form of the invention, with some parts broken away and other parts shown diagrammatically;

FIGURE 2 is a sectional view taken along the line indicated by arrows 2—2 applied to FIGURE 1, and illustrating additional constructional features of the invention; and

FIGURE 3 is a sectional view taken along the line indicated by arrows 3—3 applied to FIGURE 1.

With more particular reference to the drawing, and first to FIGURE 1, a missile or rocket **5** is constructed and arranged to be propelled by a stream of gas caused to flow through a convergent-divergent nozzle **10** having symmetry about a central axis common to both the nozzle and the missile. Preferably the nozzle **10** includes a generally conical flow divider **11**, and divergent walls **12** cooperably disposed with respect to flow divider **11** to form an annular outflow port, as is best seen in FIGURE 3. Flow divider **11** conveniently is supported by brackets **18** so dimensioned and spaced as not appreciably to obstruct the annular outflow port.

With reference also to FIGURE 2, first and second pairs of control ports **13** and **14** interconnect pairs of chambers **15** and **16**, respectively, with opposite sides of a restrictive portion **17** of the nozzle **10**. Chambers **15** and **16** include respective tapered portions **15***a* and **16***a* leading up to ports **13** and **14**. These tapered portions serve to enhance flow of control gas through the control ports, as will be appreciated from further consideration of apparatus embodying the invention.

Supply of a main propellant gas stream to nozzle **10** is provided by known means, such as a propellant gas generator designated generally by the numeral **6**, and connected to a nozzle inlet port **19** communicating with convergent nozzle portion **21** disposed upstream with respect to restrictive portion **17**.

In particular accordance with the invention, arrays or groups of combustible, gas generating charges, such for example as squibs **22**, are disposed in each of chambers **15** and **16**, preferably on side walls of the chambers opposite the ports **13** and **14** communicating with narrow neck portion **17** of nozzle **10**. Apparatus for igniting squibs **22** comprises individual control circuits **23** that extend through walls of chambers **15** and **16** and are connected, through cable portions thereof, to guidance control means associated with the missile and designated generally by the numeral **24**. A sufficient number of squibs **22** is provided so that control may take place for the duration of energization of the gas generator **6** with which the nozzle is associated.

Each of squibs **22** comprises a self-contained gas generator energizable by propellant of suitable composition, a number of which are known in the art. Ignition of the propellant also may be accomplished by suitable known bridge wire circuit means associated with control circuits **23**. It of course will be understood that selection of the squib propellant will be such as to ensure compatibility of gases generated by a squib **22** and by the generator **6**. Moreover, the construction and disposition of the squibs is such that firing of a squib in a chamber **15** will not adversely affect any other squib in that chamber.

Objectives and advantages of the invention will be more

fully understood from a consideration of operation of the apparatus thus far described. Assuming first that energization of the gas generator **6** will cause a stream of propellant gas to issue from nozzle **10** in substantially equal quantities about flow divider **11**, the missile will be steered on a substantially straight course. To effect a change of course, a signal is generated by control **24** igniting a squib **22** in chamber **15** to create a gas pressure wave that moves with substantial force. The art provides a number of ways in which the control signal may be generated. However these will not be described herein since the invention is directed essentially to the novel squib and control port combination for controlling gas flow through a nozzle, as set forth in the appended claims. If detailed description of suitable means is desired, reference may be had, by way of example, to the copending application of Louis G. Walters et al., bearing Ser. No. 371,715 and assigned to the assignee of the present invention.

The pressure wave created by the burning squib is transformed into a control jet of relatively hot gas as it moves from chamber **15**, through tapered portion **15***a*, and through the port **13** communicating with the restrictive section **17** of nozzle **10**. The control jet in moving from port **13** will impinge upon the issuing gas flow stream **25** and deflect it, e.g. to the right, causing the stream to flow to the right of flow divider **11** as shown in FIGURE 1. The course of the missile is changed accordingly.

Once the force of the control jet has been dissipated, the main gas flow stream **25** will remain in the described deflected position due to the so-called "Coanda" effect, as is characteristic of apparatus of the type disclosed. In general, the Coanda effect is the tendency of a stream of fluid flowing close to a surface to be deflected toward the surface, and, under proper conditions, to flow tangentially to the surface and attach thereto.

As viewed in the two-dimensional showing of FIGURE 1, the flow of gas through nozzle **10** is stable in at least two states, and is therefore termed bistable. Since stability is achieved in at least two states, the issuing gas stream can be switched from the right side of the nozzle to the left side by igniting a squib to induce flow of a control jet through the control port that is nearer the displaced portion of the gas stream flowing through the restrictive nozzle portion **17**. Since the issuing stream is maintained stable in its displaced position because of the Coanda effect, the control gas jet need only flow until deflection is achieved. Flow of a control jet from another direction, i.e. from one of the other control ports illustrated, must be initiated to switch the issuing stream to another position.

While operation of apparatus embodying the invention has been described in terms of a two-dimensional, bistable device, it will be understood that the illustrated apparatus is three-dimensional in construction, affording control in a plane perpendicular to the plane of FIGURE 1. This constructional feature is fully illustrated in FIGURE 2, where both such planes of control are illustrated.

It will be appreciated that steering is achieved in the disclosed nozzle **10** by alternate ignition of appropriately positioned squibs **22** under the control of means **24**, and that a sufficient number of squibs will be provided in each chamber to achieve control for the duration of gas flow through the nozzle.

From the foregoing description it will be appreciated that the invention affords improved auxiliary gas supply means for controlling deflection of a gas stream issuing from a nozzle, which means overcomes the need for maintaining a supply of control gas under pressure. Moreover, the disclosed gas supply means is both positive acting and rapid in achieving control of the main gas stream. These

characteristics adapt the apparatus of the invention to particular use in the guidance control means for a missile propelled by a reaction motor.

I claim:

1. Fluid flow control means comprising: nozzle means having a constricted throat section and a divergent exhaust portion through which a stream of gas may flow; at least a pair of spaced control ports positioned to direct jets of gas transversely of the stream of gas caused to flow through said nozzle means; means defining a pair of separate chambers, each chamber communicating with one of said ports; at least a pair of groups of individual, selectively energizable gas generating charges, the group of each said pair being disposed within a corresponding one of said chambers; and means for energizing said charges individually, in accordance with a desired sequence characterized by the energization of one charge of one group then one charge of the other group, the construction and arrangement being such that energization of a single charge is operable to create rapid flow of gas through a corresponding one of said control ports and to deflect the stream of gas flowing through said nozzle, such deflected stream thereafter flowing in adjacency to a surface of a divergent portion of said nozzle until another charge is fired and gas is caused to flow through the other control port.

2. Control means according to claim **1** and characterized in that ports of said pair are disposed opposite one another.

3. Fluid flow control means for guiding a vehicle propelled by a high velocity stream of gas flowing through nozzle means having a constricted neck portion and a wall portion divergent therefrom to form the exhaust for the flowing gas, said control means comprising: at least a pair of spaced control ports arranged to direct a jet of gas transversely of the recited stream of gas caused to flow through the constricted neck portion; a plurality of combustible, gas generating charges comprising a pair of groups each disposed to effect the recited flow of gas through a corresponding control port; and means for igniting said charges in accordance with a vehicle guiding sequence characterized by ignition of charges of alternate groups, ignition of a single charge of one group being operable to establish the recited flow of a jet of gas through a corresponding one of said control ports and to deflect the stream of gas flowing through said nozzle to a position in which it is thereafter caused to flow adjacent a surface of the divergent wall portion until a generating charge of another group is ignited to deflect the stream of gas for flow adjacent another surface of the divergent wall portion.

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U.S. Cl. X.R.

137—81.5; 239—265.23