Feb. 14, 1967 M. W. BEARDSLEY 3,303,643

METHOD AND STRUCTURE FOR SUPPLYING AND CONFINING FLUID IN A REACTION CHAMBER

Filed Oct. 22, 1965

FIG. 1

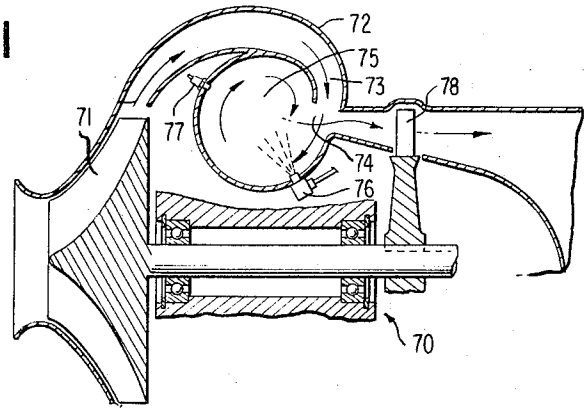


FIG. 2

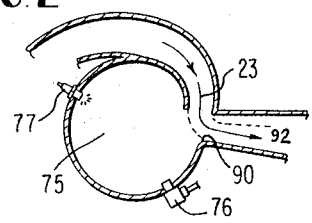
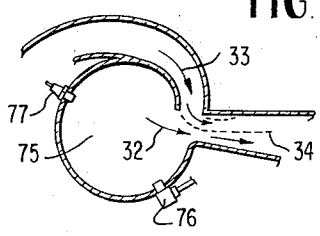


FIG. 3



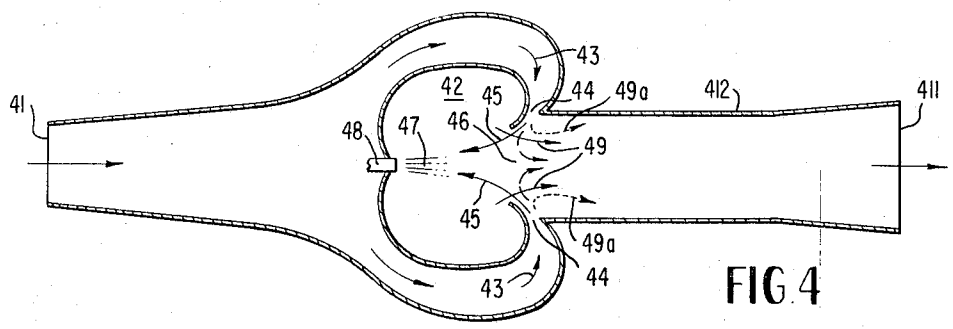


FIG. 4

FIG. 5

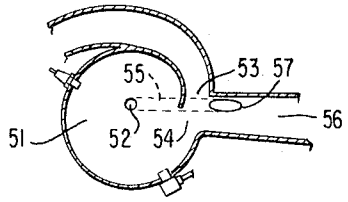
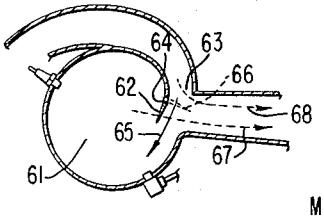


FIG. 6



INVENTOR

MELVILLE W. BEARDSLEY

BY Browne, Schuyler & Beveridge

ATTORNEYS

United States Patent Office 3,303,643 Patented Feb. 14, 1967

3,303,643

METHOD AND STRUCTURE FOR SUPPLYING AND CONFINING FLUID IN A REACTION CHAMBER

Melville W. Beardsley, 40 Windward Drive, Severna Park, Md. 21146

Filed Oct. 22, 1965, Ser. No. 502,103
19 Claims. (Cl. 60—39.02)

The present invention relates generally to fluid dynamics, and more particularly to a method and structure for introducing fluid into an enclosure and confining it therein at raised pressure. This application is a continuation-in-part of my copending application, Serial No. 650,583, filed April 4, 1957.

One illustrative embodiment of my invention is a type of vehicle which can travel over almost any type of terrestrial surface without benefit of roads, tracks, or other types of surface preparation as described in my above-identified copending application.

The subject embodiment of my invention concerns a unique valve means for reaction chambers such as the combustion chamber of a gas turbine engine or other thrust producing device.

As is well-known in the art, internal combustion engines utilizing constant-volume combustion are in general more efficient than those utilizing constant-pressure combustion. In spite of the higher efficiency of constant-volume combustion, however, conventional gas turbines operate on the constant-pressure combustion principle. This has been due to the fact that constant-volume operation requires mechanical valving at the inlet and outlet of the combustion chamber and the problems inherent in such valving mechanisms outweigh the advantages of constant volume combustion.

By utilizing entirely aerodynamic means to control the combustion chamber pressures, the advantages of constant-volume combustion can be achieved without the hitherto unavoidable disadvantages of mechanical valves.

The greater efficiency of constant-volume combustion is also applicable to thrust-producing engines such as ram jets in which the maximum pressure available, at a given altitude, for constant-pressure combustion is limited to the dynamic or ram pressure of the air flow entering the engine. The thermal efficiency of these engines is determined by the expansion ratio of the combustion products. The greater pressure produced by nearly constant-volume combustion allows a greater expansion of the combustion products than is possible with constant-pressure combustion as conventionally employed, and thereby produces greater thermal efficiency.

Constant-volume reaction also provides greater efficiency for water ram jets such as those in which energy is supplied by the reaction of water and a chemical such as lithium hydride. In such a case, greater efficiency would be achieved by accomplishing the reaction at nearly constant-volume conditions as compared with constant pressure.

Greater efficiency is also achieved with engines in which the energy is supplied by nuclear or thermo-electrical reactions when these reactions are caused to take place with the working fluid held at constant volume. In such cases the working fluid could be air or water which carried in suspension very small particles of reactant materials.

Bearing in mind the foregoing, it is an object of my invention in the subject embodiment to provide a method and means for supplying fluid and constraining it at raised pressure in a reaction chamber.

A further object of the present invention is to provide entirely non-mechanical valve means for a gas turbine combustion chamber or the like.

It is another object of the present invention to combine the above-described valve means with means for charging the reaction chamber with compressed air or the like.

It is a still further object of the present invention to provide valve means of the character described which will automatically release the ignited mixture from the reaction chamber when a predetermined pressure is reached in the reaction chamber.

It is a yet further object of this embodiment to provide a novel valve and charging means for a reaction chamber in ram-jet engines or the like.

The foregoing and additional objects and advantages of the invention will be apparent from consideration of the following detailed description, consideration being given also to the accompanying drawings in which:

FIGURE 1 is one embodiment of this invention, being an axial section of a gas turbine combustion chamber;

FIGURES 2 and 3 are diagrammatic sketches of the combustion chamber shown in FIGURE 1, illustrating the flow during various phases of the operating cycle.

FIGURE 4 is a sectional view of an embodiment of this invention in the form of a ram jet engine with diagrammatic representations of the flow at various phases of the operating cycle.

FIGURE 5 is a sectional view of a combustion chamber incorporating an auxiliary discharge port.

FIGURE 6 is a sectional view of an embodiment of this invention, being an internal-combustion engine combustion chamber incorporating a deflectable lip on the jet-sheet producing nozzle.

The subject embodiment of my invention is, in general, a means for generating and maintaining pressure in a reaction or combustion chamber having an opening in its wall. This is done by ejecting a high-velocity jet sheet across the opening with a component of velocity perpendicular to the axis of the opening.

By way of specific example of the subject embodiment, the invention is shown incorporated in a quasi-constant-volume gas turbine **70**, illustrated schematically in FIGURE 1. The induction air for the turbine **70** is compressed by a compressor **71** and pumped through a connecting duct **72** to a jet sheet nozzle **73**. Although not specifically shown, any suitable jet sheet producing nozzle may be employed. From the nozzle **73** the air is ejected across opening **74** into the combustion chamber **75** in which a circular flow pattern is established.

Now referring to FIGURE 2, when the combustion chamber **75** has been filled and the pressure raised by an amount determined by the velocity of the jet sheet **73**, the flow pattern changes. As indicated by the arrow **23**, the jet sheet flow now turns away from the combustion chamber **75** and flows through the turbine buckets **78** in discharge passage **92**. This jet sheet flow away from chamber **75** is directed by a deflecting surface **90** which in the shown embodiment of FIG. 2 is formed by a portion of discharge duct **92**. The directional change of momentum of the turning jet sheet **23** produces an opposite reaction force causing compression of the contents of the chamber **75**. In passing through the turbine buckets **78** the air flow also serves to cool buckets **78**.

Due to the earlier-described membrane-like character of a jet sheet, the sheet of moving air from the nozzle **73** across the opening **74** prevents air in the chamber from escaping through the opening **74** and causes a rise in pressure within the chamber **75**. In effect, the jet sheet acts as a valve.

At a proper time, determined by conventional timing means, fuel is injected through an injector **76** to mix with the compressed air in the chamber **75** and the fuel-air mixture is ignited by glow-plug or spark-plug **77**.

As the pressure rises due to combustion, a pressure is finally reached that can no longer be contained by the jet-sheet valve and the chamber **75** discharges through the opening **74** causing the discharged gas to impinge on the buckets **78** of the turbine wheel. Due to the start of discharge from the combustion chamber before combustion is completed, the conditions are not those of rigorous constant volume. However, the rate of pressure increase in the combustion chamber due to the rate of combustion is more rapid than the rate of pressure drop due to discharge of the combustion products from the chamber. Thus the peak pressure generated is substantially greater than the pressure of the air leaving the compressor so that thermal efficiency approaching that of true constant-volume combustion is achieved by this quasi-constant-volume combustion reaction. The flow conditions during this phase are indicated in FIGURE 3, where the deflected jet sheet flow is represented by the arow **33** and the flow of the combustion products is represented by the arrow **32**. The interface mixing region between these two flows is represented by the dashed line **34**.

When, due to the inertia of the rapidly discharging products of combustion, the pressure in the combustion chamber **75** falls below the compressor discharge pressure, compressed air is again discharged through the jet-sheet nozzle **73** into the combustion chamber and the cycle is repeated.

The flow of the jet-sheet across opening **74** functions as a valve to prevent flow out of the combustion chamber through opening **74** until the pressure in the combustion chamber rises to a value having a predetermined relation to the total pressure of the jet sheet flow. In this way mechanical valves are eliminated and the more efficient constant-volume combustion is achieved.

FIGURE 4 illustrates an embodiment of this invention in a ram jet engine. In the case of an air-breathing engine, the air enters at the inlet **41** and flows around the reaction chamber **42** as indicated by the arrows **43**. At the initial phase of the operating cycle when the pressure in the chamber **42** is low, the air flow continues through the nozzle **44** and enters the chamber **42** through the opening **46** as indicated by the arrows **45**.

When the chamber **42** is filled with air, the pressure rises and causes the jet sheet flow from the nozzle **44** to be deflected away from the chamber **42** and opening **46** as indicated by the arrows. The directional change of momentum caused by this deflection of the jet sheet flow generates a positive pressure in the chamber **42** similar to that described above.

At about this point of time a reaction-producing substance **47**, such as hypergolic rocket fuel, is introduced into the chamber **42** through a means such as a spray nozzle **48**. When the reaction takes place, the temperature and pressure of the contents of the chamber **42** increase above the pressure that can be maintained by the deflected jet sheet with the result that the contents of the chamber **42** are discharged through the opening **46**. For this phase of the cycle the flow from the chamber **42** is represented by arrows **49** while the further deflected jet sheet flow is represented by dotted arrows **49*a***. After outflow from chamber **42** starts, the flow of reactant **47** from the nozzle **48** is terminated. Mixing of the reaction products and the deflected jet sheet occurs as they flow to the point of discharge at high velocity through ejection nozzle **411**.

Due to the inertia of the mixture flowing through the nozzle tube **412**, the pressure in chamber **42** is reduced to the degree that jet sheet flow through nozzle **44** again turns and flows through opening **46** into the chamber **42** for a repetition of the operating cycle.

The general arrangement shown in FIGURE 4 could also be employed for an embodiment of this invention in a water ram jet, making such changes as are necessary to allow for the different reactants involved.

I have found that in order to produce maximum power, it is advantageous to exhaust the reaction products from the reaction chamber more completely than accomplished by the action of the inertia of the discharged products. I have found that this result can be accomplished by the incorporation of an additional, properly located, auxiliary discharge port in the reaction or combustion chamber.

This embodiment of my invention is illustrated in FIGURE 5 which shows a sectional view of a gas turbine combustion chamber such as previously illustrated in FIGURES 1, 2 and 3 but also incorporating an auxiliary discharge port **52** in the wall of the combustion chamber **51**. The cross-sectional area of this auxiliary discharge port **52** is preferably less than the cross-sectional area of the jet-sheet producing nozzle **53** or of the chamber opening **54**. Connected to receive the discharge from port **52** is a conduit **55** which is shown with its other end **57** opening into discharge passage **56**.

In operation, the air flow entering chamber **51** through the opening **54** after discharge from the jet-sheet producing nozzle **53** follows a peripheral path around the wall of the chamber **51**, spiraling inwardly. Thus as the combustion products in the chamber **51** are pushed ahead of the entering air flow, they converge on the auxiliary discharge port **52** and are thereby discharged before any of the fresh charge arrives at the port **52**. The remainder of the operation is substantially the same as previously described, except that there is continuous discharge flow through the auxiliary discharge port **52**.

Another embodiment of this invention is illustrated in FIGURE 6 which shows the sectional view of an internal-combustion engine combustion chamber of the type also shown in FIGURES 1, 2 and 3, but also incorporating a deflectible inner lip **62** on the jet-sheet producing nozzle **63**. I have found that under some conditions, for some reaction rates, the deflectible lip provides more positive protection against reverse flow through the jet-sheet producing nozzle **63** and thereby gives improved performance.

The deflectible nozzle inner lip **62**, shown hinged along axis **64**, is free to move under the influence of pressure. During the charging phase of the cycle, when the pressure on the face adjacent to the jet-sheet producing nozzle **63** is greater than the pressure on the face adjacent to the interior of the chamber **61**, the nozzle lip **62** assumes the position shown in the solid line **62** and the flow through the jet-sheet nozzle **63** is as indicated by the solid-line arrow **65**.

Following combustion in the chamber **61**, the greater pressure therein causes the deflectible lip **62** to swing outwardly to the position **66** shown by the dotted outline. During this phase the flow from the combustion chamber **61** is indicated by the dashed arrow **67** and flow through the jet sheet nozzle **63** is indicated by the dashed arrow **68**.

Although shown as a hinged member, the deflectible nozzle lip **62** may also be a flexible member and may deflect at a point other than the illustrated hinge line **64**.

While the forms of the invention shown and described herein are fully capable of achieving the objects and providing the advantages hereinbefore stated, it will be realized that they are capable of considerable modification without departure from the spirit of the invention. For this reason I do not mean to be limited to the forms shown and described, but rather to the scope of the appended claims.

What is claimed is:

1. In combination in an internal combustion engine of the type having means to compress air, means to mix fuel with said compressed air, means to ignite said air-fuel mixture, and means to transform the kinetic energy of the resultant combustion products into useful work, a combustion chamber comprising: a rigid enclosure having an inlet port connected to receive induction air from said

compression means and an outlet port to discharge combustion products from said enclosure, said inlet port being a jet producing nozzle positioned and adapted to introduce said induction air substantially in a jet sheet across said outlet port whereby to resist discharge of gas through said outlet port and cause compression of air in said enclosure, and a deflecting surface positioned in the path of said jet sheet to deflect at least a portion of said jet sheet through said outlet port into said combustion chamber during a first condition when the pressure in the combustion chamber is less than the total pressure of said jet sheet and for deflecting said jet sheet away from said outlet port during a second condition when the pressure in the combustion chamber is at least equal to the total pressure of said jet sheet.

2. For use in an internal reaction chamber, the combination including means defining a reaction chamber having a port for emitting fluid into said chamber for reaction and for discharging fluid from said chamber after reaction, means for directing a ribbon-like stream of fluid across said port to enter through said port into said chamber when pressure in said chamber is below a predetermined value and to subsequently flow away from said port while preventing discharge of fluid from said chamber through said port when the pressure in said chamber increases to said predetermined value, said last recited means including means for causing said stream of fluid to flow away from said discharge port generally along the axis of said discharge port when the pressure in said chamber reaches said predetermined value such that a reaction force is imposed on the fluid in said chamber, and means defining a second discharge port in said chamber having an area less than said first discharge port.

3. For use in an internal reaction chamber, the combination including means defining a reaction chamber having a port for emitting fluid into said chamber for reaction and for discharging fluid from said chamber after reaction, and means for directing a thin ribbon-like stream of fluid across said port to enter through said port into said chamber when pressure in said chamber is below a predetermined value and to subsequently flow away from said port while preventing discharge of fluid from said chamber through said port when the pressure in said chamber increases to said predetermined value said last recited means including a nozzle positioned generally on one side of said port and a deflecting surface positioned generally on the opposite side of said port in the path of said fluid stream.

4. The combination defined in claim 3 wherein said last recited means includes means for causing said stream of fluid to flow away from said discharge port generally along the axis of said discharge port when the pressure in said chamber reaches said predetermined value such that a reaction force is imposed on the fluid in said chamber.

5. For use in an internal reaction engine of the type having means to induct fluid, means to mix a reactant with said fluid, and means to produce a release of energy from a mixture of said reactant and said fluid; the combination including a rigid enclosure defining a reaction chamber having a discharge port, means positioned externally of said chamber adjacent said discharge port for directing a jet-sheet of fluid across said discharge port to cause at least a part of said jet-sheet to enter said port and said chamber when the pressure in said chamber is less than the total pressure of said jet-sheet and to cause said jet-sheet to resist fluid discharge from said chamber through said port until the pressure in said chamber becomes greater than the total pressure of said jet-sheet said last recited means including a nozzle on one side of said discharge port and a deflecting surface on the other side of said discharge port in the path of the jet sheet as directed from the nozzle.

6. A method of supplying and controlling the volume of fluid in a reaction chamber of an internal reaction engine or the like; comprising the steps of directing a jet-sheet of fluid across a port in the chamber to impinge on a deflecting surface and cause at least a portion of said jet-sheet of fluid to enter into said chamber through said port, and continuing the flow of said jet-sheet of fluid across said port to prevent discharge of fluid out of said chamber through said port until the pressure in said chamber becomes greater than the total pressure of said jet-sheet of fluid as caused by a release of energy from a reaction in said chamber.

7. For use in an internal reaction engine or the like, the combination including means defining a reaction chamber having a discharge port, supply means generally on one side of said port for directing a fluid stream in a direction generally across the port, deflecting means including a surface positioned in the path of the fluid stream for deflecting at least a portion of the fluid stream into the reaction chamber through the port during a first condition when the pressure in the reaction chamber is less than the total pressure of the fluid stream and for deflecting the fluid stream away from the port during a second condition when the pressure in the reactor chamber is at least equal to the total pressure of the fluid stream, the fluid stream during the second condition serving to prevent discharge of the fluid from the chamber until a reaction is initiated in the chamber.

8. The combination defined in claim 7 wherein said supply means includes a nozzle dimensioned to direct a jet sheet of fluid.

9. The combination defined in claim 8 wherein said nozzle has a discharge mouth of smaller area than said discharge port.

10. The combination defined in claim 7 further including means defining a discharge passage communicating with said discharge port externally of said chamber.

11. The combination defined in claim 7 wherein the deflecting surface is positioned on the side of said discharge port opposite said supply means.

12. The combination defined in claim 11 wherein said deflecting surface forms a portion of said outlet passage at the inlet side of the outlet passage adjacent said discharge port.

13. The combination defined in claim 7 wherein said deflecting surface is fixed in stationary position and wherein there is further provided a movable deflector means movable through said discharge port in response to differential of pressure between said fluid stream and the fluid in said reaction chamber.

14. For use in an internal reaction engine or the like, the combination including means defining a reaction chamber having a discharge port, supply means for introducing into said chamber a fluid for reaction in said chamber, and means for directing a stream of fluid across said port to constrain fluid in said chamber until the pressure in said chamber increases to an amount sufficient to overcome the constraining force of said stream of fluid, and said chamber having a second discharge port for discharging fluid therefrom.

15. The combination defined in claim 14 wherein said second discharge port has an area less than the mouth of said nozzle and said first discharge port.

16. For use in an internal reaction chamber, the combination including means defining a reaction chamber having a port for emitting fluid into said chamber for reaction and for discharging fluid from said chamber after reaction, means for directing a ribbon-like stream of fluid across said port to enter through said port into said chamber when pressure in said chamber is below a predetermined value and to subsequently flow away from said port while preventing discharge of fluid from said chamber through said port when the pressure in said chamber increases to said predetermined value, said last recited means including means for causing said stream of fluid to flow away from said discharge port generally

along the axis of said discharge port when the pressure in said chamber reaches said predetermined value such that a reaction force is imposed on the fluid in said chamber, and a deflector means movable through said discharge port in response to differential of pressure between said stream of fluid and the fluid in said chamber.

17. For use in an internal reaction chamber, the combination including means defining a reaction chamber having a port for emitting fluid into said chamber for reaction and for discharging fluid from said chamber after reaction, means for directing a ribbon-like stream of fluid across said port to enter through said port into said chamber when pressure in said chamber is below a predetermined value and to subsequently flow away from said port while preventing discharge of fluid from said chamber through said port when the pressure in said chamber increases to said predetermined value, said last recited means including means for causing said stream of fluid to flow away from said discharge port generally along the axis of said discharge port when the pressure in said chamber reaches said predetermined value such that a reaction force is imposed on the fluid in said chamber, a nozzle having a discharge mouth of smaller area than and generally positioned at one side of said discharge port, and a deflecting surface positioned generally opposite said nozzle on the other side of said discharge port to deflect the stream of fluid into or away from said discharge port depending on the fluid pressure in said chamber.

18. A method of supplying fluid to a reaction chamber of an internal reaction device and restraining the fluid in the chamber until reaction, the steps comprising directing a stream of fluid across a discharge port in the chamber to impinge on a deflecting surface to cause at least a portion of the fluid stream to enter into said reaction chamber until the pressure in the reaction chamber reaches a predetermined value, and continuing the stream of fluid across the discharge port into impingement with the deflecting surface for maintaining the pressure in the reaction chamber until reaction.

19. The method defined in claim 18 further including the step of directing the fluid stream after impingement on the deflecting surface away from the port generally along the axis of the port to impose an opposite reaction force on the fluid in the reaction chamber after the fluid in the reaction chamber reaches a predetermined value preventing entry of the fluid stream into the reaction chamber.

References Cited by the Examiner

UNITED STATES PATENTS

2,543,758	3/1951	Bodine	60—39.77 X
2,910,830	11/1959	White	60—39.77
2,912,821	11/1959	Horak	60—35.6

MARK NEWMAN, *Primary Examiner.*

RALPH D. BLAKESLEE, *Examiner.*