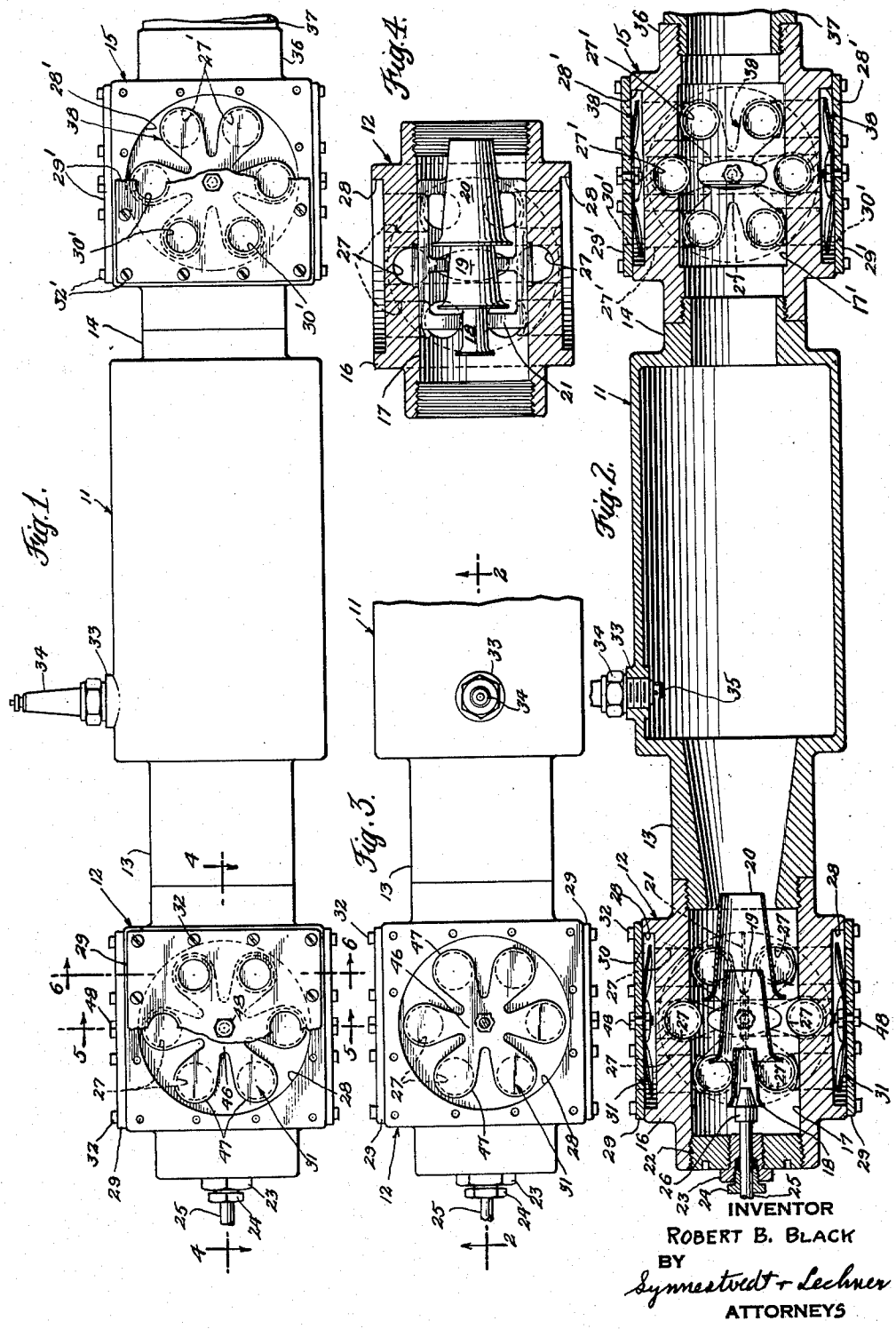
April 13, 1965 R. B. BLACK 3,177,663

PULSE JET ENGINE

Filed July 12, 1962 2 Sheets-Sheet 1



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PULSE JET ENGINE

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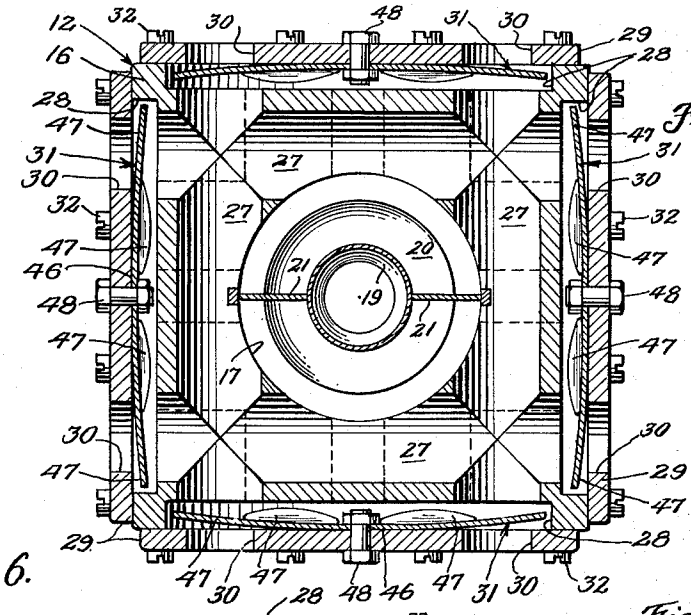


Fig. 5.

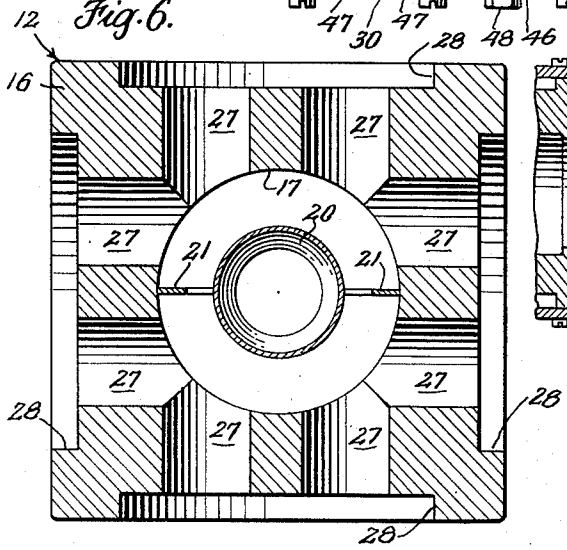


Fig. 6.

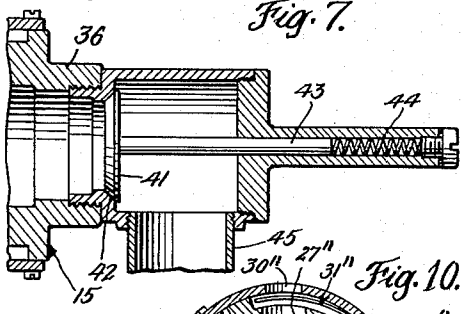


Fig. 7.

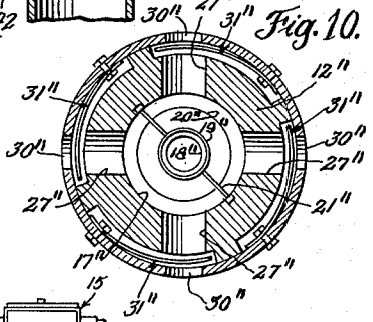


Fig. 10.

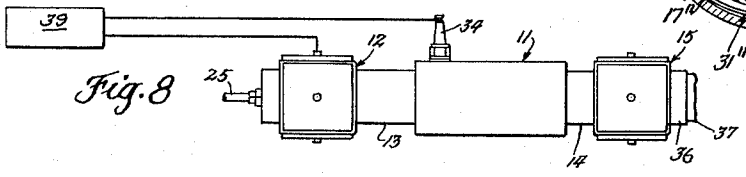


Fig. 8

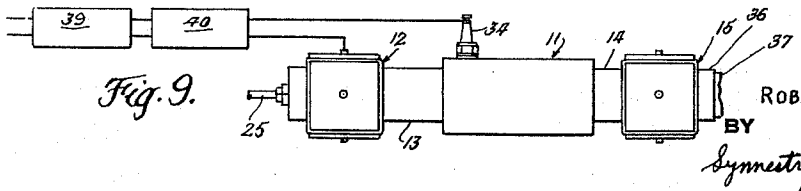


Fig. 9.

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3,177,663

PULSE JET ENGINE

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15 Claims. (Cl. 60—39.77)

The present invention deals broadly with an internal combustion apparatus and more specifically with a pulse type combustion gas generating device adapted either for producing power or for delivering products of combustion for transmission to a point of use.

Pulse jet engines have been very commonly used for generating power, but have presented many serious limitations because of their normally closed inlet flaps valves. Such engines also require a comparatively long exhaust or tail pipe to create the resonance forces necessary for aspiration and ignition of the fuel-air mixture. The long exhaust or tail pipe is necessary since this creates an inertial gas column and confines the exhaust in order that there be a residual flame which ignites the incoming combustible gas in the engine. Also, these engines cannot discharge against back pressure aside from that nominal amount in the open ended tail pipe which holds the residual flame in readiness to ignite the next combustible charge delivered into the cylinder. The outward flow of the inertial gas column creates a partial vacuum which opens the normally closed valves for inlet of air to mix with the fuel and be ignited by the residual flame when the proper combustible mixture is attained. It was a recognition of these shortcomings of the pulse jet engines and the need of a construction which would operate at all times on a back pressure far greater than that created by the pulse jet engine tail pipe, which led to the conception and development of the present invention.

Accordingly, among the objects of the present invention is the provision of a pulse type engine which does not use normally closed inlet valves which open only when the pressure inside the engine is less than that outside, but rather uses normally open valves which remain open even when the pressure inside the engine is moderately greater than on the outside.

Another object of the invention is to utilize the delivery of fuel under moderately high pressure to draw air into the inlet end of the assembly where it mixes with the fuel on the way to the combustion chamber.

Another object of the invention is to provide an engine which is self-starting without the use of compressed air or other starting auxiliaries.

Another object is to have not only normally open intake valves ahead of the combustion chamber, but also normally open breather valves immediately following the combustion chamber so as to make aspiration and combustion possible with the use of a very minimum of energy.

A further object is to provide a pulse or intermittent type engine having the ability to discharge combustion gasses against moderately high back pressure thus making the engine practical for many applications where the ordinary pulse jet engine would be useless.

A further object of this invention is to eliminate dependence upon residual flame for ignition of the combustible mixture, which dependence is essential to the ordinary pulse jet engine, and to substitute therefor an electrical spark ignition which may be continuous or timed, and in this way to provide for better, more complete combustion cycles, and at the same time to make possible phased operation of multiple units.

A still further object is to produce a very compact engine of this type which eliminates the comparatively long tail pipe heretofore required in order to create the essential resonance forces necessary for aspiration and ignition of the fuel-air mixture.

Still further objects and advantages of the invention will appear as the description proceeds.

I have illustrated my invention in preferred form in the accompanying drawings wherein

FIGURE 1 is an elevational view with part of the covers of the valve assemblies broken away to show the petal valves in full line in circular recesses.

FIGURE 2 is a longitudinal section taken as indicated by line 2—2 of FIGURE 3.

FIGURE 3 is a fragmentary plan view with the top cover of the inlet valve assembly removed.

FIGURE 4 is taken on the line 4—4 of FIGURE 1 and is a plan section of the inlet valve housing with the covers and petal valves omitted.

FIGURE 5 is an enlarged cross-section taken on the line 5—5 of FIGURE 1.

FIGURE 6 is a cross-section on the same scale as FIGURE 5 taken on the line 6—6 of FIGURE 1 with the covers and petal valves omitted.

FIGURE 7 is a cross-section through a check valve which may be used if the combustion unit is to be used for compressing gases.

FIGURE 8 is a wiring diagram for the ignition system of the combustion unit.

FIGURE 9 is a modified form of ignition for the combustion unit, and

FIGURE 10 is a fragmentary cross-section of a modified construction taken substantially at the same point on FIGURE 1 as is shown in FIGURE 5.

Referring now particularly to FIGURES 1 and 2 of the drawings, the combustion chamber, indicated by reference numeral **11**, is connected to an inlet valve assembly or aspiration chamber **12** by throat **13**. At the opposite end, the combustion chamber **11** is connected by outlet throat **14** to a breather valve chamber or assembly **15**. The aspiration chamber has a body member **16** which is provided with a cylindrical bore **17** lengthwise of the same, with such bore being internally threaded at opposite ends. Inside the bore **17** are mounted tubular frustroconical throat inserts **18**, **19**, and **20** connected together co-axially and mounted on the side walls of the cylindrical bore **17** of the body member **16** by means of elongated support members **21**.

The outer end of the cyindrical bore is closed by a plug **22** which is threaded into the end of the bore. A nut **23** is threaded into the center of the plug **22** and a nut **24** is threaded into nut **23** with the two nuts being co-axially bored and acting as a packing gland to adjustably grip feed inlet tube **25** which carries a nozzle **26** on the end thereof for discharging fuel under pressure co-axially into the throat inserts **18**, **19**, and **20** within the bore **17** thereby creating a partial vacuum in the aspiration chamber.

It is to be noted in this connection that the packing gland assembly of the nuts **23** and **24** permits adjustment of the location of nozzle **26** over a range of positions relative to throat insert **18** to facilitate the best positioning of the nozzle **26** for creation of the maximum suction effect through the throat inserts.

Body member **16** is formed with cross-bores **27** both vertically and crosswise as seen in FIGURES 2, 5, and 6 to provide air inlet openings into the cylindrical bore **17** Body member **16** is also provided with counter-bores **28** on its four faces which are covered by means of cover plates **29** having inlet ports **30** in alignment with the cross-bores **27** in body member **16**. These inlet ports **30** are preferably a little smaller than the diameter of the cross-bores **27** for purposes to be hereinafter explained. Mounted inside the counter-bores **28** on the inner face of the cover plates **29** of body member **16** are moderately stiff resilient reed valves **31** which cover

and uncover the inlet ports **30**. These reed valves are of petal shape and are normally open, i.e., in the position in which the inlet ports **30** are uncovered. They are of low inertia type and are ground and polished to seat accurately and provide a tight seal against escape of gases through the inlet ports during the pressure phase of the combustion cycle. These reed valves have a central portion **46** and radially extending individual outer petal shaped portions **47** adapted to overlie and cover the inlet ports **30**. The central portion **46** of each of the valve members is secured in position on the cover plates **29** of the valve assemblies by means of a bolt **48**. The cover plates **29** may be secured in place on the body member **16** in any convenient manner as by means of cap screws **32**.

The end of body member **16** opposed to that of plug **22** is in threaded engagement with inlet throat **13** of the combustion chamber **11**, such inlet throat portion providing a cone shaped passage between the aspiration chamber and the combustion chamber with the small end of the passage freely receiving the small end of throat insert **20** and the larger end opening into the combustion chamber **11**. This combustion chamber has a boss **33** into which is threaded a spark plug **34** with the points **35** extending inside the combustion chamber **11** in position to ignite a combustible mixture when the same is admitted through the inlet throat portion **13** of the combustion chamber **11**.

The outlet throat **14** of the combustion chamber has a threaded connection with an outlet or breather valve assembly **15** and the outlet end **36** of the breather valve provides an exhaust port or opening from the breather valve assembly which is threaded to permit connection thereof to a line **37** leading to a point of use of the products of combustion of chamber **11**. The outlet or breather valve assembly **15** is substantially the same as inlet valve assembly **12** except that it is open ended and does not have throat inserts. The reed valves **38** of the breather valve assembly are substantially the same as the reed valves **31** of the inlet valve assembly **12** and are mounted to cover and uncover exhaust opening **30'** in the cover plates of the breather valve assembly (parts in the breather valve assembly which are similar to those in the aspiration valve assembly have prime numbers added).

The power unit above described can operate on a continuous spark delivered from spark coil **39** as shown in FIGURE 8 and is also adapted for operation on a timed spark delivered through a spark timer **40** as illustrated in FIGURE 9.

The operation of the engine is as follows:

Gaseous fuel such as propane is led to the nozzle **26** through the fuel line **25** at a pressure of approximately 125 p.s.i. The fuel is discharged from the nozzle into the conical throat inserts and as it passes through these throat inserts it creates a partial vacuum and thereby entrains combustion air through the open valve controlled inlet ports **30** which allow the air to enter the aspiration chamber with a minimum resistance. The combustion chamber is quickly filled with a fuel-air mixture at the correct ratio for efficient combustion. The fuel-air mixture in the combustion chamber **11** is ignited by the spark of spark plug **34**. When the fuel-air mixture is ignited by the spark plug the combustion results in a substantial and very sudden increase in pressure which immediately closes all of the reed valves in both the aspiration chamber and the breather valve assembly. The hot combustion gases thus created have no place to escape but through the exhaust outlet **36** of the breather valve where they pass at a pressure of 90–110 p.s.i. and may be utilized to do useful work.

It has been found that the best performance obtained is by timed ignition in which case the combustible mixture is fired at the precise point when the combustion chamber and breather valve chamber are completely filled. Another advantage of the timed ignition is that any number of these combustion units may be used together and kept in perfect phase with one another by a small synchronizer.

To summarize, the combustion unit above described operates on a three phase cycle, i.e.

(1) *Aspiration phase.*—Fuel-air mixture is forced into the combustion chamber.

(2) *Combustion phase.*—The fuel-air mixture is ignited and the hot expanded gases are forced from a discharge port to do useful work. During this phase all of the reed valves instantly close.

(3) *Exhaust phase.*—When the pressure has been dissipated the spring-loaded, normally open reed valves instantly open allowing the burned gases to escape from the breather valve assembly as the fresh fuel-air mixture is admitted to the combustion chamber through the aspiration chamber.

It will be noted that the aspiration phase and the exhaust phase occur simultaneously, the aspiration action scavenging the burned gases from the previous cycle. As was pointed out above, the spark ignition might be continuous in which case the fuel-air mixture will fire when a critical ratio is reached in the area of the spark plug. In this case, cycle frequency is determined by the rate at which the fresh fuel-air mixture is supplied to fill the chamber after each combustion cycle.

In certain instances it is advantageous to time the fuel admission, inasmuch as continuous admission may result in some loss of the combustible mixture through the exhaust openings in the breather valve chamber prior to the combustion cycle. In such system, fresh fuel-air mixture should enter the combustion chamber only until the combustion chamber and breather valve chamber are completely filled. The fuel flow should then be terminated and the mixture fired.

Continuous fuel admission may be employed efficiently if the correct ignition frequency is used. In this case the fuel-air mixture will be fired at the precise interval required to refill the combustion unit with fresh fuel-air charge which scavenges the burned gases from the previous cycle.

If the combustion unit is to be used for compressing gas, a check valve as shown in FIGURE 7 is employed. This valve is located at the outlet port **36** of the breather valve assembly **15**. This valve consists of valve member **41** which seats against valve seat **42**. The valve stem **43** holds the valve in alignment with the valve seat and spring **44** and keeps the valve in normally closed position. When the combustion phase of the cycle takes place, the pressure of the hot combustion gases opens the spring-loaded valve **41** allowing the gases to escape through outlet port **45**. This port may lead to a pressure tank for storage of the exhaust gases prior to use for paints, spray guns or other purposes requiring compressed gases.

The reed valve assemblies are shown in more detail in FIGURES 2 and 5. Referring to FIGURE 5, it is pointed out that when combustion takes place, the hot gases at high pressure back up through cylindrical bore **17** and the cross-bores **27** of the aspiration chamber in line with the inlet ports **30**. The expanding gases act against the under face of the petal valves and since the inlet ports **30** are a little smaller than the cross-bores, this back pressure in the cross-bores will assure the instant closing of the petal valves to cover the inlet ports. The same action takes place in the breather chamber when combustion occurs in the combustion chamber.

In FIGURE 10 I have illustrated my invention as applied to an engine having a cylindrically shaped aspiration valve assembly. (Like parts in this figure to those in FIGURE 5 have double prime marks added.) In this figure the aspiration chamber **12''** is circular in cross-section. The body of the aspiration chamber has a cylindrical bore **17''**, throat inserts **18''**, and **19''** and **20''** as

shown in FIGURES 2, 4, 5, and 6 supported by throat insert supports 21". Cross-bores 27" extend radially from cylindrical bore 17" and lead to openings 30" in the cylindrical cover of the aspiration chamber. Reed valves 31" are bolted to the interior of the cylindrical cover and are adapted to cover and uncover the inlet openings. As in the other figures, these valves will close instantly when back pressure from the combustion chamber is transmitted through cross-bores 27" to the under faces of the valves. The breather valve assembly can also be of cylindrical form, but, of course, the throat inserts would be omitted.

The use of a breather valve assembly as shown in the drawings with spark plug ignition of the fuel-air mixture gases completely eliminates need for a long tail pipe and permits operation of the engine against a much higher back pressure than is possible with the usual type of pulse jet engines.

I claim as my invention:

1. A pulse jet engine having a combustion chamber and an aspiration chamber and breather chamber communicating therewith a plurality of air inlet openings formed in the walls of said aspiration chamber, a plurality of reed valves supported to cover and uncover said openings, said reed valves being normally open; means to introduce fuel under pressure through said aspiration chamber thereby lowering the internal pressure in said chamber and drawing combustion air through said openings, means in said combustion chamber to ignite the fuel-air mixture therein, an outlet port in said breather chamber, a plurality of exhaust openings in the walls of said breather chamber, a plurality of reed valves supported to cover and uncover said exhaust openings, said reed valves being normally open, the reed valves in the aspiration chamber and the breather chamber being constructed and arranged to be closed by pressure of the expanded gases on explosion of the fuel-air mixture in the combustion chamber.

2. A pulse jet engine having a combustion chamber and an aspiration chamber and breather chamber communicating therewith a plurality of air inlet openings formed in the walls of said aspiration chamber, a plurality of reed valves supported to cover and uncover said openings, said reed valves being normally open; a throat connecting said aspiration chamber and combustion chamber, frustro conical tubular members mounted in said aspiration chamber to discharge into said throat co-axially thereof, means to introduce fuel under pressure into said tubular members coaxially thereof, thereby drawing combustion air through said openings, means in said combustion chamber to ignite the fuel-air mixture therein, an outlet port in said breather chamber, a plurality of exhaust openings in the walls of said breather chamber, a plurality of reed valves supported to cover and uncover said exhaust openings, said reed valves being normally open, the reed valves in the aspiration chamber and the breather chamber being constructed and arranged to be closed by pressure of the expanded gases on explosion of the fuel-air mixture in the combustion chamber.

3. A construction according to claim 1 wherein the aspiration chamber has a housing having a central cylindrical bore, a throat connecting said bore to the combustion chamber, means to discharge fuel under pressure into said cylindrical bore, a plurality cross bores in said housing connecting said central bore and the air inlet openings in the walls of the chamber, the normally open reed valves being interposed between the ends of said cross bores and said air inlets.

4. A construction according to claim 1 wherein the breather chamber has a housing having a central cylindrical bore with the outlet port at the end thereof, a throat connecting said bore to the combustion chamber, a plurality of cross bores in said housing connecting said central bore and the exhaust openings in the walls of the chamber, the normally open reed valves being interposed between the ends of said cross bores and said exhaust openings.

5. A construction according to claim 1 wherein the ignition means comprises an intermittently operating spark plug.

6. A construction according to claim 2 wherein the aspiration chamber has a housing having a central cylindrical bore, said throat connecting said bore to the combustion chamber, the frustro conical tubular members being mounted co-axially in said cylindrical bore, and a plurality of cross bores in said housing connecting said central bore and the air inlet openings in the walls of the chamber, the normally open reed valves being interposed between the ends of said cross bores and said air inlet openings.

7. A construction according to claim 2 wherein the aspiration chamber has a housing having a central cylindrical bore having said frustro conical members mounted therein, a throat connecting said bore to the combustion chamber, a plurality of cross bores in said housing connecting said central bore and the air inlet openings in the walls of the chamber, the normally open reed valves being interposed between the ends of said cross bores and said air inlets.

8. A construction according to claim 2 wherein the breather chamber has a housing having a central cylindrical bore with the outlet port at the end thereof, a throat connecting said bore to the combustion chamber, a plurality of cross bores in said housing connecting said central bore and the exhaust openings in the walls of the chamber, the normally open reed valves being interposed between the ends of said cross bores and said exhaust openings.

9. A construction according to claim 2 wherein the ignition means comprises an intermittently operating spark plug.

10. A pulse jet engine having a combustion chamber and an aspiration chamber communicating therewith, said aspiration chamber having a housing having a central cylindrical bore and a plurality of air inlet openings formed in the walls thereof, a plurality of cross bores in the housing connecting said central bore and the air inlet openings, a plurality of reed valves interposed between the ends of said cross bores and the air inlet openings, said reed valves being supported to cover and uncover said air inlet openings and being in normally open position, means to introduce fuel under pressure into said cylindrical bore thereby lowering the internal pressure in said chamber and drawing combustion air through said openings, means in said combustion chamber to ignite the fuel-air mixture therein, the said reed valves being constructed and arranged to be closed by the expanded gases on explosion of the fuel-air mixture in the combustion chamber.

11. A construction according to claim 10 wherein the fuel under pressure is discharged into a plurality of frustro conical tubular members mounted in said central tubular bore co-axially therewith.

12. A construction according to claim 10 wherein the ignition means comprises an intermittently operating spark plug.

13. A pulse jet engine having a combustion chamber, means to inject a fuel air mixture into said combustion chamber and means in said chamber to ignite the fuel-air mixture therein, a breather valve chamber communicating with said combustion chamber, an outlet port in said valve chamber, a plurality of exhaust openings formed in the walls of said valve chamber, a plurality of reed valves adapted to cover and uncover said exhaust openings, said reed valves being in normally open position and being constructed and arranged to be closed by pressure of the expanded gases on explosion of the fuel-air mixture in the combustion chamber.

14. A construction according to claim 13 wherein said breather valve chamber has a housing with a central bore

therein communicating with the combustion chamber and a plurality of cross bores leading from said central bore to the exhaust openings, the said reed valves being interposed between the ends of said cross bores and the exhaust openings.

15. A construction according to claim 13 wherein said breather valve chamber has a housing having a central bore therein communicating with the combustion chamber, a plurality of cross bores leading from said central bore to the exhaust openings, the said reed valves being interposed between the ends of said cross bores and the exhaust openings, and a normally closed valve member covering said outlet port, said valve member being constructed and arranged to be opened by the pressure of the expanded gases on explosion of the fuel-air mixture in the combustion chamber.

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