NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

REPLY TO ATTN OF: GP

March 27, 1971

TO: USI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U.S. Patents in STAR

In accordance with the procedures contained in the Code GP to Code USI memorandum on this subject, dated June 8, 1970, the attached NASA-owned U.S. patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 3,336,754

Corporate Source : Marshall Space Flight Center

Supplementary Corporate Source :

NASA Patent Case No.: XMF-06926

Gayle Parker

Enclosure:
Copy of Patent

FACILITY FORM 602

N71-22983 (ACCESSION NUMBER)
(THRU)
5 (PAGES)
00 (CODE)
(NASA CR OR TMX OR AD NUMBER)
28 (CATEGORY)

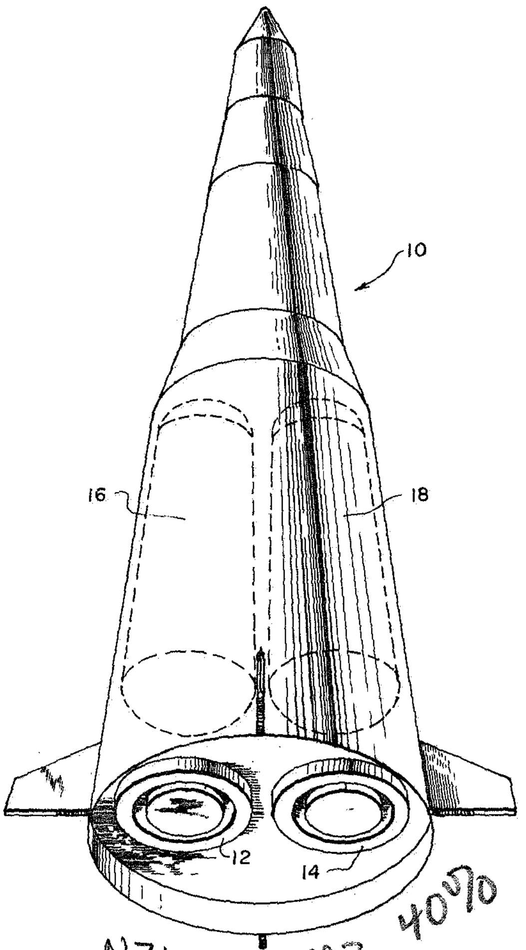
NASA-HQ

N71-22983

Aug. 22, 1967 O. H. LANGE ETAL **3,336,754**

CONTINUOUS DETONATION REACTION ENGINE

Filed March 21, 1966 2 Sheets-Sheet 1



N71-22983
4070

FIG. 1

OSWALD H. LANGE,
RICHARD J. STEIN,
HAROLD E. TUBBS,
INVENTORS.

BY [signature]
Charles C. Wells
ATTORNEYS

1303

CONTINUOUS DETONATION REACTION ENGINE

Filed March 21, 1966 2 Sheets-Sheet 2

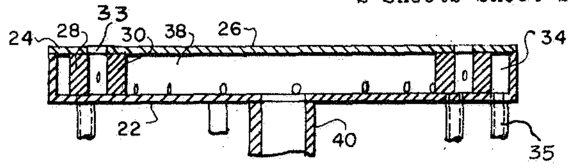


FIG. 3

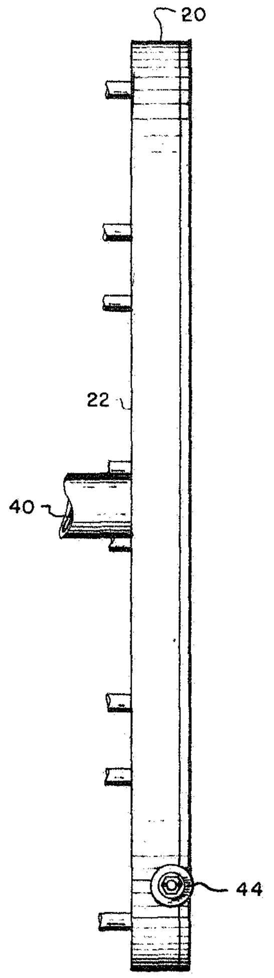


FIG. 5

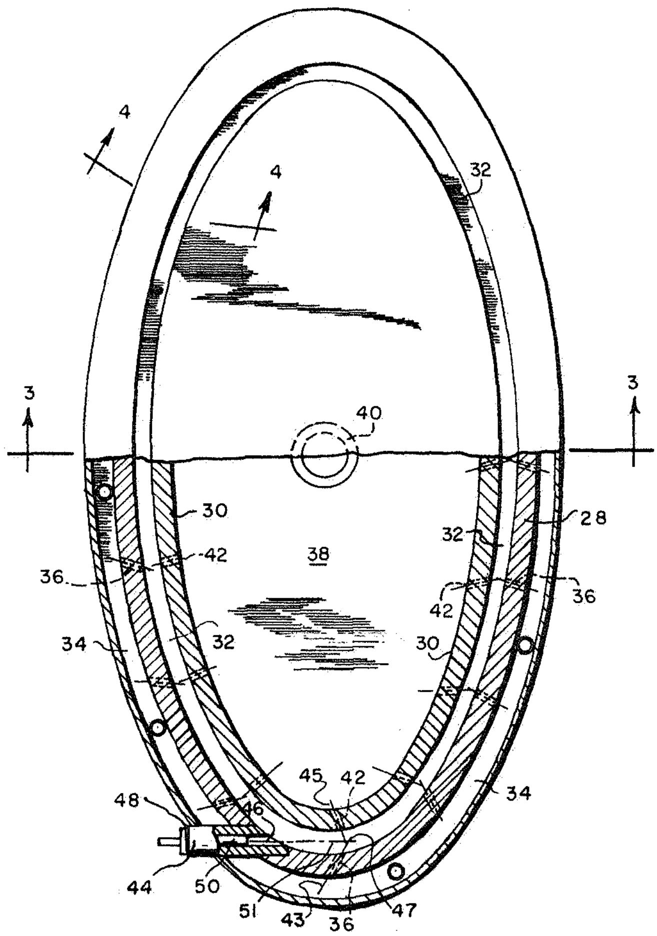


FIG. 2

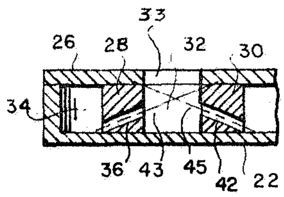


FIG. 4

OSWALD H. LANGE,
RICHARD J. STEIN,
HAROLD E. TUBBS,
INVENTORS.

BY

Charles C. Wells
ATTORNEYS

United States Patent Office

3,336,754

Patented Aug. 22, 1967

3,336,754

CONTINUOUS DETONATION REACTION ENGINE

Oswald H. Lange, 1702 Montdale Road 35801, and Richard J. Stein, 3612 Lakewood Road SW. 35811, both of Huntsville, Ala., and Harold E. Tubbs, 2903 W. 21st St., Panama City, Fla. 32401

Filed Mar. 21, 1966, Ser. No. 537,615
7 Claims. (Cl. 60—258)

ABSTRACT OF THE DISCLOSURE

A detonation reaction engine having an outer housing enclosing a pair of inner walls that form a continuous channel. The channel has one open side and forms a chamber in which a continuous detonation reaction is generated. The inner walls have injector ports formed therein through which fuel and oxidizer are injected to form impingement points of fuel and oxidizer at spaced intervals around the channel. One of the impingement points is initially detonated by a detonation wave generating apparatus and thereafter the reaction is continuous and self-sustaining.

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

This invention relates in general to reaction type engines wherein force or thrust is generated by the expulsion of gaseous products of combustion from an engine. More particularly this invention relates to a reaction type motor wherein the gaseous products expelled to produce thrust are generated by condensed detonation rather than by a burning as in a conventional type reaction engine.

Reaction type motors used heretofore on space vehicles and capable of producing a large amount of thrust have employed a controlled burning of propellants in the combustion or thrust chamber of the motor. The propellants utilized have usually consisted of a liquid fuel and oxidizer or a solid fuel and oxidizer. In any event the propellants are burned in the thrust chamber of the motor to produce gaseous combustion products which are at a high temperature and pressure. The gases in the thrust chamber have a potential energy and when expanded and ejected through a De Laval nozzle, or as it is more commonly termed a rocket nozzle, the potential energy is converted to kinetic energy. The velocity of the gases are greatly increased by expansion through the nozzle and the pressure thereof is decreased. A force is required to accelerate the gases to their increased velocity and the reaction to this force produces thrust.

The development of conventional type engines has progressed to a very sophisticated level and a point has been reached where it is very difficult to obtain any significant increase in thrust from an engine without resorting to increasing the size of the engine. This is true even though very potent and high energy content fuels have been developed as well as very efficient engines for converting the energy content of the propellants into thrust.

The temperature and pressure at which rocket propellants are burned in the thrust chamber of an engine directly affects the exit velocity of the combustion products of a rocket engine. To date the materials available for fabrication of rocket engines and the operating characteristics of such engines has limited the temperature and pressures that such engines can operate at and thus the exhaust velocities which can be obtained have also been limited.

Inasmuch as the specific impulse, a measure of the force

or thrust generated by an engine, is directly proportional to the exhaust or exit velocities of the reaction products formed by the engine, it is readily apparent that increasing the exhaust velocities of an engine will greatly increase the thrust output thereof.

The present invention provides a reaction engine operating on the principles of a controlled condensed detonation rather than on the principles of gas expansion. This results in reaction products that are expelled at a much higher velocity than are the gaseous products resulting from a controlled burning as in a conventional reaction engine. In any detonation reaction a shock wave is produced as well as gaseous products of combustion and in an engine constructed in accordance with this invention the shock wave and gaseous products resulting from the detonation are vectored in a symmetrical pattern and are co-directional. Thus, the exit velocity of the reaction products approaches the velocity of the shock wave.

The engine described herein includes an outer housing enclosing a pair of inner walls that defines an oval or elliptical continuous channel. This channel has one open side and forms a detonation reaction chamber in which a continuous detonation reaction is generated. These inner walls each have a series of orifices or injector ports formed therein through which fuel and oxidizer are injected into the chamber. The engine also includes an oxidizer manifold and a fuel manifold in communication with the injector orifices formed in the inner walls. The injector orifices are canted at an angle and arranged in pairs so that fuel and oxidizer pass through the orifices and form impingement points of propellant mixture at spaced intervals around the channel shaped detonation reaction chamber.

A detonation wave generating apparatus is included in the housing and positioned so that when actuated it will initiate operation of the engine. The detonation wave generator is an explosive device capable of generating a detonation wave that will detonate the fuel and oxidizer mixture at a first one of the impingement points in the detonation reaction chamber.

The shock wave and detonation products resulting from the reaction at the first impingement point will have a resultant direction toward the rear or discharge end of the engine that is oriented at an angle to the longitudinal axis of the engine. The angular direction of the reaction is controlled by the injection angle of the propellant mixture. Thus, the reaction at each impingement point provides a pulse of power that can be broken into two vectorial components, one of which is directed to the rear of the engine to generate a thrust and the other directed towards the next successive impingement point to reinforce the detonation wave generated by the detonation wave generating apparatus and thus detonate the fuel and oxidizer at the next point. The reaction is then repeated and the next in line impingement point of fuel and oxidizer is detonated and so on. Thus, after the initial detonation by the detonation wave generating apparatus the reactions within the detonation reaction chamber are continuous and self-sustaining since the original detonation wave generated by the detonation wave generator is reinforced at each impingement point.

Since the detonation reaction at each impingement point has a resultant direction having one component perpendicular to the longitudinal axis of the engine a torque moment will be generated which tends to rotate the engine about its longitudinal axis. This moment is very undesirable if the engine is to be used in a free bodied vehicle like a rocket and the torque moment must be countered to prevent rotational motion of the rocket. A proper geometrical arrangement of a group of engines with opposite direction of detonation wave travel is one solution. However, in an application wherein it is desirable to use a single engine then the unbalanced force can be balanced by using an engine employing a multiplicity of co-axial and co-planar detonation reaction channels in one engine. The number of channels used would be an even number with the traveling detonation wave going in opposite directions in alternate ones of the channels.

The condensed detonation reaction which occurs at each impingement point of the fuel and oxidizer is similar to the reaction created by detonation of a conventional shaped charge in that the shock wave and gaseous combustion products that result from detonation are squeezed or confined to a very small area or volume. Since the energy released in the reaction due to condensation of reaction products is confined to this small volume the temperature and pressures which result are very high. The velocities of the gases obtainable from such a reaction are, due to the high temperatures and pressures involved, considerably larger than that obtainable from the controlled burning and expansion of gases in a conventional reaction engine.

It is believed readily apparent from the foregoing that a reaction engine constructed in accordance with this invention will have many advantages over those known heretofore.

It is therefore a principal object of this invention to provide a reaction type engine whose thrust or specific impulse is greatly increased when compared to conventional reaction type engines of the same weight and volumetric size.

It is another object of this invention to provide a reaction engine capable of utilizing the energy generated in a condensed detonation reaction to produce thrust.

A yet further object of this invention is to provide a detonation reaction engine capable of generating a series of continuous condensed detonation reactions to produce thrust.

Other objects and attendant advantages of the present invention will become more apparent when considering the following detailed description in conjunction with the attached drawing wherein:

FIGURE 1 is a pictorial view of a pair of continuous detonation reaction engines mounted in a space vehicle.

FIGURE 2 is a view partly in section, of the discharge end of the continuous detonation reaction engine.

FIGURE 3 is a sectional view taken along lines 3—3 of FIGURE 2.

FIGURE 4 is a view, in section and partially broken away, taken along lines 4—4 of FIGURE 2.

FIGURE 5 is a side elevation of the detonation reaction engine.

Referring now to the drawing wherein like elements are referred to by like numerals in each of the several views. In FIGURE 1 a space vehicle **10** is illustrated having a pair of detonation reaction engines **12** and **14** mounted in the aft end thereof. The engines are supplied with fuel and oxidizer from an oxidizer tank **16** and a fuel tank **18**. Since a detonation reaction engine as described herein tends to develop a torque moment about its longitudinal axis which will tend to rotate the space vehicle it is necessary, as mentioned above, to use a plurality of engines. For purposes of simplification the embodiment described herein is limited to an engine type having only a single detonation reaction chamber which necessitates the utilization of at least two of such engines. However, inasmuch as both engines function in an identical manner except for the direction of detonation wave travel only one will be described herein.

The engine includes an outer housing **20** in the form of a short cylinder or tube that is elliptical in cross sectional shape. One end or side of the housing **20** is closed by a wall member **22** and the other side is substantially closed by wall members **24** and **26**. A pair of spaced wall members **28** and **30** are disposed within housing **20** and attached to the wall members that close the housing. Wall members **28** and **30** are concentric with respect to one another and with respect to housing **20**. The wall members form a continuous channel **32** that is elliptical and has an open side or discharge end **33** directed toward the aft end of the missile **10**. Channel **32** forms the detonation reaction chamber. Wall member **24** is in the form of an elliptically shaped ring attached to one end of housing **20** and wall member **28**. Wall member **26** is an elliptical disc attached at its periphery to wall member **30**. Wall members **24** and **26** close the aft or discharge end of the engine except for the aft end of channel **32** which is left open to provide an exit for detonation reaction products generated in channel **32**. Wall member **28** in conjunction with housing **20** and walls **22** and **24** forms a chamber or manifold **34** which is supplied with oxidizer from oxidizer tank **16** via oxidizer lines **35**. Oxidizer is supplied to manifold **34** under pressure and the oxidizer is injected into the channel **32** through orifices or injector ports **36** formed at spaced intervals in wall member **28**. Walls **30**, **22** and **26** form a second chamber or manifold **38** which is supplied with fuel from fuel tank **18** via fuel line **40**. Manifold **38** is in communication with channel **32** by way of orifices **42** formed in wall member **30** at spaced intervals along the length thereof.

A one shot detonation wave generator is mounted through housing **20** and attached to wall member **28**. The wave generator includes a housing or barrel which defines a chamber having an open end **46** which opens into channel **32**. The other end of chamber **44** is closed by a breech block mechanism **48** which is removable from cylinder **44** so that a cartridge **50** can be inserted within housing **44**. An electrical or mechanical firing mechanism is included in breech block **48** to detonate cartridge **50** and generate a shock wave which is directed into channel **32** along axis **51** to the initial impingement point of fuel and oxidizer indicated at **47**. It is apparent from a consideration of FIGURES 2 and 4 that fuel and oxidizer injector ports **36** and **42** are arranged in pairs and each are canted so that the spray of fuel and oxidizer therefrom will be directed around the detonation reaction chamber in a counter-clockwise direction as well as toward the aft or discharge end of the engine. The spray of fuel and oxidizer from the paired injector ports will be injected along axes **43** and **45** and impinge where the two axes intersect as indicated at **47**. Due to the fact that the orifices in the inner and outer walls are canted the shock wave and reaction products resulting from a condensed detonation at the impingement points will have a resultant direction having one vectorial component directed toward the discharge end of the engine and parallel to the longitudinal axis thereof and the other vectorial component will be normal to the axis of the engine and directed around the channel to the next impingement point of fuel and oxidizer. The component of the detonation reaction directed along the channel will reinforce the detonation wave generated by the detonation wave generator and result in detonation of the fuel and oxidizer mixture at the next or second impingement point. The rearwardly directed component provides thrust. Again, because of the slant angles of the injector orifices, the resultant direction of the detonation products will have one vectorial component directed toward the discharge end of the engine and one component directed along the channel. Thus, detonation at each successive impingement point produces a power pulse directed rearwardly towards the discharge end of the engine and also a power pulse directed along the channel to reinforce the detonating wave and detonate the next successive impingement point of fuel and oxidizer mixture. The detonation reaction continues to race around the closed loop channel or detonation reaction chamber so long as the propellants are injected in requisite amounts into the channel at the successive impingement points in sychronism with, but slightly prior to, the arrival of the traveling detonation wave at those points. The rate of travel of the detonation wave around the channel forming the detonation reaction chamber is such that continuous pumping of fuel and oxidizer through the orifices can be used provided control parameters such as orifice size, orifice spacing around the channel, and pumping velocity, are suitably chosen.

Operation of the continuous detonation reaction type engine described herein is as follows: Oxidizer from the oxidizer tank is pumped into the oxidizer manifold from which it is injected into the detonation reaction chamber **32** via orifices **36**. Simultaneously fuel from the fuel tank is supplied through fuel manifold **38** from which it is injected into the detonation reaction chamber through fuel injection ports **42**. Oxidizer and fuel injection ports **36** and **42** are canted at an angle and spaced in a paired relation such that the fuel and oxidizer will impinge upon one another at a particular point within the detonation reaction chamber. A series of these impingement points of fuel and oxidizer will be formed at spaced intervals throughout the length of the continuous detonation reaction chamber. An initial detonation wave is generated by the wave generator which is timed to arrive at the initial impingement point just subsequent to arrival of the impinging streams of fuel and oxidizers. The fuel and oxidizer mixture is detonated at the impingement point and results in a condensed detonation reaction. Because of the slant angles of the fuel and oxidizer orifices the resultant direction of the detonation products will have one vectorial component directed rearwardly toward the discharge end of the engine and a second vectorial component which will reinforce the detonation wave and direct it to the next impingement point of fuel and oxidizer where a second fuel and oxidizer mixture is detonated to result in a second condensed detonation reaction. Detonation at each successive impingement point produces a power pulse directed rearwardly and a channel contained thrust to advance the detonation wave onto the next impingement point of fuel and oxidizer. This reaction continues to race around the closed loop channel forming the detonation reaction chamber so long as the propellants are injected in proper amounts into the channel.

This completes the description of the invention. While a preferred exemplary embodiment has been described herein it should be understood that there will be many changes and modifications thereto which can be made by one skilled in the art to which this invention pertains without departing from the spirit and scope of the invention as defined in the claims appended hereto. For example, in the event it was desired to have an engine with a restart capability, the one shot detonation wave generator apparatus could be replaced with a wave generating assembly having capability of repeatedly detonating an explosive cartridge. Such repeating mechanisms are known and would be readily adaptable for use with an engine such as described herein.

What is claimed is:

1. A detonation reaction engine comprising:

(a) an outer cylindrical housing having one end thereof closed by a first wall member and the other end open,

(b) inner and outer cylindrical wall members attached at one of their ends to said first wall member and disposed in a spaced concentric relation within said housing so as to form a continuous circuilar channel having one open side,

(c) a disc-shaped plate attached to said inner cylindrical wall member so as to form a first chamber within said housing,

(d) an annular plate attached to said outer cylindrical wall member and to said cylindrical housing to form a second chamber within said housing,

(e) means connected to said first chamber for supplying a propellant fuel thereto,

(f) means connected to said second chamber for supplying an oxidizer thereto,

(g) a plurality of canted injector orifices formed in said inner and outer cylindrical walls to permit the flow of oxidizer and fuel from said first and second chambers to said continuous channel, and

(h) means mounted to said engine for initiating a detonation reaction within said continuous channel which generates reaction products which are expelled from the open end of said continuous channel to produce thrust.

2. The detonation reaction engine recited in claim **1** wherein:

(a) said injector orifices are positioned in a spaced relation around the length of said inner and outer walls and arranged in opposing pairs such that a series of impingement points of fuel and oxidizer is formed along the length of the continuous channel.

3. The detonation reaction engine recited in claim **2** wherein:

(a) said injector orifices are canted at an angle such that all are directed in one direction around said continuous channel and toward the open end thereof.

4. The detonation reaction engine recited in claim **3** wherein the means for generating a self-sustaining detonation reaction in said continuous channel is a shock wave generating device for developing a shock wave to detonate the fuel and oxidizer mixture at a first one of the series of impingement points of fuel and oxidizer formed in said continuous channel.

5. The detonation reaction engine recited in claim **4** wherein:

(a) said shock wave generating device comprises a cartridge receiving cylindrical barrel mounted to said engine,

(b) said barrel having one end thereof opening into said continuous channel and the other end thereof closed by a breech mechanism for firing a cartridge inserted in the barrel.

6. A detonation reaction engine for mounting in a space vehicle comprising:

(a) a tubular housing of elliptical shape,

(b) a first plate closing one end of said tubular housing,

(c) a first tubular wall member of elliptical shape attached to said first plate and positioned within said tubular housing and spaced therefrom,

(d) a second tubular wall member of elliptical shape attached to said first plate and positioned in a concentric relation within said first tubular wall member and spaced therefrom; whereby, a continuous channel having one open side is formed by said first and second tubular wall members and said first plate,

(e) a second plate attached to the end of said second tubular member away from said first plate to form a fuel manifold,

(f) an annular ring attached to the ends of said tubular housing and said first tubular wall member away from said first plate to form an oxidizer manifold,

(g) means connected to said engine for supplying oxidizers to said oxidizer manifold and fuel to said fuel manifold,

(h) injector orifices formed in said first and second tubular wall members to permit the flow of fuel and oxidizer to the continuous channel, and

(i) means mounted in said housing for detonating the fuel and oxidizer in the continuous channel and generating a self-sustaining detonation reaction therein.

7. The detonation reaction engine recited in claim **6** wherein:

(a) said injector orifices are spaced around the length of said first and second tubular members and arranged in opposing pairs so as to form a series of spaced impingement points of fuel and oxidizer along the continuous channel, and

(b) said injector orifices are canted at an angle such that all are directed in one direction around said continuous channel and toward the open end thereof.

References Cited

UNITED STATES PATENTS

3,199,295	8/1965	Connaughton ------	60—39.74
3,240,010	3/1966	Morrison ------------	60—213

MARK M. NEWMAN, *Primary Examiner.*

D. HART, *Assistant Examiner.*