

CONTINUOUS DETONATION WAVE ENGINE AND AIRCRAFT
PROVIDED WITH SUCH AN ENGINE

DESCRIPTION

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The present invention relates to a continuous detonation wave engine operating with a detonating fuel/oxidant mixture, as well as to a flying craft that is provided with such an engine.

10 It is known that most propulsion systems that are used in the aeronautics and space field are based on a constant pressure thermodynamic combustion cycle.

It is also known that the use of a constant volume thermodynamic combustion cycle allows the theoretical performance of an engine to be substantially increased
15 (by 15 to 25%). However, due to the displacement speeds of most aircraft, the realisation of constant volume combustion proves to be quite difficult and results in systems that are complex and difficult to implement.

The use of a thermodynamic detonation cycle can provide the same advantages in
20 terms of energy efficiency. A detonation cycle is very similar to a constant volume cycle (the reaction occurs very quickly in a very low thickness of mixture that does not have enough time to dilate in order to limit the increase in pressure) and corresponds to thermodynamic efficiency that is even slightly better.

25 A Pulsed Detonation Engine (PDE) is known as a detonation engine, for which a tube, which is closed at one of its ends, is filled with a fresh fuel/oxidant mixture, and then a detonation is initiated in this fresh mixture. For the entire time that the detonation wave moves along the length of the tube, an overpressure exists on the closed end and momentarily creates a thrust. It is then necessary to wait for the
30 discharge of the hot gases originating from the chemical reaction in the tube, and

then for it to be refilled with a fresh mixture, before being able to initiate a new detonation wave and to obtain a new thrust pulse.

5 The pulsed nature of the thrust (operating between 50 and 200 Hz) generates a vibration environment that is very severe for the rest of the engine and, in addition, requires energy to be provided during each cycle in order to initiate the detonation, which can constitute a significant problem in terms of overall efficiency when the intention is to use low detonation fuel/oxidising agent pairings. These characteristics limit its use to highly specific applications (for
10 example, in simple and inexpensive subsonic systems) or to highly complex systems associating a plurality of PDE type tubes.

In order to overcome the problem of the very severe vibration environment that is, a priori, generated by a pulsed detonation engine, the use of a Continuous
15 Detonation Wave Engine (CDWE) is possible. In such a continuous detonation engine, a continuous production of hot gases originating from self-sustained detonation waves is generated in an annular chamber. A fuel/oxidant mixture is continuously injected at one of the ends of the annular chamber. A detonation wave is then initiated. This wave is circumferentially propagated in the fresh
20 detonating mixture, whereas the hot gases that it produces expand into the rest of the annular chamber. As the injection of fresh mixture is continuous, when the wave returns to its start point it re-encounters fresh mixture and continues its circumferential movement, which thus becomes continuous.

25 An annular chamber is thus available in which a series of circumferential detonation waves, running at a frequency of several kHz (up to 30 kHz), produces hot gases that expand toward the open end of the chamber. There is therefore, as is the case for a constant pressure combustion chamber, a generator of hot gases that constitute, upon exiting the detonation chamber, a supersonic flow, the
30 characteristics of which are relatively uniform.

The advantage of this CDWE engine is that, in terms of the thermodynamic cycle, the detonation has the potential (as is the case for a PDE engine) for 15 to 25% greater efficiency than that of constant pressure combustion. Furthermore, its operating principle prevents the generation of a very severe vibration environment, as is the case for a pulsed detonation engine (PDE).

Nevertheless, the applications of this CDWE continuous detonation engine are limited by the use of a closed, generally annular shape for the detonation chamber. This annular chamber comprises, at the upstream end, a transverse surface (referred to as injection base hereafter) that represents a ring shape, that is to say its width is constant and its length is defined by a general line forming a closed curve, generally a closed circle. However, the maximum performance levels can only be achieved within a relatively narrow range of local operating conditions (in particular richness of the fuel/oxidising agent mixture). Therefore, it is difficult to design an annular chamber operating within a very broad field of use whilst complying with the conditions that are required to obtain satisfactory energy efficiency at all points of this chamber.

The object of the present invention is to improve the aforementioned continuous detonation engine, in particular by overcoming these disadvantages.

To this end, according to the invention, said continuous detonation wave engine, which operates with a detonating fuel/oxidant mixture and which comprises:

- at least one detonation chamber;
- an injection system for continuously injecting the detonating mixture into said detonation chamber at an upstream end, said detonation chamber comprising an injection base at said upstream end, as well as two walls which extend on either side of this injection base; and
- initiation means which are disposed in said detonation chamber, to initiate in the detonating mixture a detonation wave which is then propagated in said

mixture and is the cause of successive self-initiated detonation waves, so as to generate continuous production of hot gases,
is noteworthy in that said detonation chamber comprises an injection base of which the length is defined by an open line, so as to form a detonation chamber
5 having an elongate form in a transverse plane, and in that said injection system is disposed so as to inject the fuel/oxidant mixture into said detonation chamber at at least one portion of said injection base. This injection system in particular is formed so as to generate (jointly with the wave initiated by the initiation means) specific local conditions that allow said series of detonation waves (naturally
10 initiated) to be created in said detonation chamber.

In this way, by virtue of the invention, a continuous detonation wave engine is obtained that comprises a detonation chamber that does not have (and is not limited to) a (closed) annular shape and can have multiple other different (open)
15 shapes, as specified hereafter.

This detonation chamber comprises an elongate upstream injection base, the length of which can be of any open, but not closed, shape, in particular straight or curved, as opposed to an annular chamber. This chamber further comprises two
20 walls, which are preferably parallel, that extend on either side of this injection base. Said chamber thus has a three-dimensional geometric shape having faces (flat or non-flat) that meet at edges. Said chamber can, in particular, be in the shape of any type of hexahedron (polyhedron having six flat faces), and in particular a parallelepiped (hexahedron having parallel faces in pairs). In the case
25 of a rectangular injection base that is thus defined by a straight line, the chamber can, for example, assume the general shape of a rectangular parallelepiped (all of the faces of which are rectangles).

By virtue of the multitude of shapes that can be contemplated for the detonation
30 chamber according to the invention, the possible applications of said engine are increased considerably in relation to a conventional annular detonation chamber

engine, and it is possible to overcome the aforementioned disadvantages, as specified hereafter.

It will be noted that, inside the detonation chamber, downstream of the initial
5 detonation wave (that is initiated by the initiation means), there is a layer of fresh
mixture (injected by the injection system) which, as it is in contact with the hot
gases and under particular conditions that can be defined (in an empirical manner
in particular), will give rise to a new self-initiated detonation wave. According to
the invention, said series of successive detonation waves (self-initiated, that is to
10 say naturally initiated) in the detonation chamber along the length of the injection
base is thus obtained by virtue of the generation (by the preceding wave and the
injection system) of local conditions allowing automatic initiation each time.
Beyond the injection zone, along the length of the injection base, the detonation
wave degenerates into a single compression wave.

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Within the context of the present invention, the ends of the detonation chamber (at
each end of the injection base) can be opened or closed, independently of each
other, and the initiation (implemented by said initiation means) can be located
anywhere along the length of the injection base of the chamber.

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Due to the aforementioned specific features of the present invention, numerous
applications can be contemplated, in particular for liquid propellant rocket
engines, turbine engine systems or even ramjets.

25 In one specific embodiment, said injection system is capable of producing the
injection over a variable length along the length of said injection base, which
provides the following advantages:

- a possibility of optimal operation over a wide range as regards requested
thrust (for a ramjet application) or total richness (for a turbine engine
30 application): a larger or smaller portion of the length of the chamber is

supplied and the rest is only supplied by the oxidising agent (air, a priori);
and

- a limitation of the start-up shock and a progressive increase in speed.

- 5 Furthermore, in this case, if two engines of this type are mounted on a flying craft so as to generate propulsions respectively on either side of an axis of rotation of said flying craft, a rotation of the flying craft about this axis can be generated from an asymmetric injection. By way of illustration, it is possible to mount such an engine on each wing of an aeroplane, the injection base being defined each
10 time along the trailing edge of the corresponding wing, and create a yawing moment by carrying out different injections on these two engines. It is thus possible to create an aid for controlling the craft by asymmetric injection modulation.
- 15 In addition, the engine can advantageously comprise at least one cooling circuit for said detonation chamber, in which cooling circuit fuel can circulate before it is injected into said chamber. Preferably, said cooling circuit extends along at least one side wall of said detonation chamber, over at least a portion of its length.
- 20 In this way, the detonation chamber can be cooled using all or some of the fuel before injecting it into said chamber. This ensures the thermal resistance of the detonation chamber whilst vaporising at least some of the fuel to be injected as it circulates in said circuit. Direct injection of the pre-vaporised fuel ensures initiation and the stability of the detonation of the fuel-air detonating mixture.
- 25 Problems associated with delays in the evaporation of the fuel droplets and chemical reaction are also prevented.

Furthermore, in one particular embodiment, said detonation chamber has a bifurcation at the injection base, allowing at least two elongate branches to be
30 created beyond said bifurcation, each of which is supplied with detonating

mixture by said injection system, which allows the creation of two propulsive lines by propagation of the waves in the two branches.

In this case, said injection system advantageously can be formed so as to supply
 5 each of these branches over a longer or shorter length and thus provide a possibility of controlling (vector thrust) the flying craft equipped with said engine.

Furthermore, in one particular embodiment, said engine comprises, in addition to said bifurcation chamber, an annular detonation chamber, and said bifurcation
 10 chamber is connected to said annular chamber so as to form a hybrid chamber. This particular embodiment thus combines the advantages of an annular chamber (ensured operating stability) and those of a bifurcation chamber:

- optimal operation over a wide range of conditions (thrust/richness): a larger or smaller portion of the length of the chamber is supplied and the
 15 rest is only supplied by the oxidising agent (air, a priori);
- limitation of the start-up shock: only the annular chamber is started; and
- distributed propulsion (and distributed control).

Furthermore, in one particular embodiment, said hybrid chamber is in the form of
 20 an annular detonation chamber that is provided with concentric extensions (or branches) of variable feed lengths. These concentric extensions can be disposed inside said annular detonation chamber or outside said annular detonation chamber. It is then easy to modulate the thrust in a continuous manner by supplying a longer or shorter length of the extensions with fuel (or fuel and
 25 oxidising agent for a rocket system). In the same way, it is easy to control the orientation of the thrust (for a ramjet or a rocket).

The present invention further relates to a propulsive system (for example, of the ramjet, turbine engine or rocket type) for a flying craft, that is provided with at
 30 least one continuous detonation wave engine, as previously described.

In one particular embodiment, this propulsive system is provided with at least two engines of this type, each of which comprises an injection system capable of modulating the injection. It is thus possible to generate an asymmetric injection modulation that can assist in the control of the flying craft.

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The present invention further relates to a flying craft, in particular an aeroplane or a missile, that is provided with an engine and/or a propulsive system, as previously described.

- 10 The present invention can also be applied to an energy generation system that is installed on the ground, in particular a gas turbine, that is provided with at least one continuous detonation wave engine, as previously described.

The figures in the appended drawings provide an understanding of how the invention can be realised. In these figures, identical reference numerals designate similar elements.

Figures 1 and 2 are highly schematic perspective views of a continuous detonation wave engine according to the invention, for two different shapes of detonation chamber, respectively.

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Figure 3 is a perspective schematic view of a specific embodiment of an engine according to the invention, comprising a bifurcation detonation chamber.

25 Figure 4 is a schematic plan view of figure 3.

Figure 5 is a schematic view of a specific embodiment of an engine according to the invention, comprising a hybrid chamber.

30 Figures 6 and 7 are schematic views of embodiments of an engine having a hybrid chamber, comprising internal and external extensions, respectively.

The engine 1 according to the invention and schematically shown in figure 1 is a continuous detonation wave engine and belongs to a propulsive system 2 intended to be used in the aeronautics and/or space field by being mounted on a flying
5 craft.

In a conventional manner, this continuous detonation wave engine 1 operates with a detonating mixture of fuel and oxidant (particularly air) and comprises, in a conventional manner:

- 10 - at least one detonation chamber 3;
- an injection system 4 for continuously injecting the components (fuel, oxidant) of said detonating mixture into said detonation chamber 3 at an upstream end 5. These components can originate from conventional storage means 6 and 7; and
- 15 - initiation means 8 that are shown highly schematically. These conventional initiation means 8 (for example, an exploding wire or a pre-detonation tube) are disposed in said detonation chamber 3 so as to initiate in the detonating mixture a detonation wave which is then propagated in said mixture and is the cause of successive self-initiated detonation waves, so as to generate
20 continuous production of hot gases, escaping from the chamber 3 through an open downstream end 9.

It should be noted that, in this description, the notions of upstream and downstream are defined in relation to the general direction of flow E of the gases.
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According to the invention, said detonation chamber 3 comprises, at the upstream end 5 (relative to said direction E), at the inlet, a transverse surface referred to as injection base 10. This surface is transverse in relation to the longitudinal direction of the chamber 3, which is generally defined by the general direction of
30 flow E of the gases. This injection base 10 has a length L1 which is defined by an open line so as to form a detonation chamber 3 having an elongate, and not

annular, shape in the transverse plane. In terms of the width L2 of the injection base 10, it can be variable, but is preferably constant.

This upstream injection base 10 can have a length of any open shape, particularly
 5 straight or curved, but not closed, as opposed to a conventional annular chamber. The chamber 3 further comprises two walls 12 and 13 that are parallel, for example, and that extend longitudinally on either side of this injection base 10. The chamber 3 thus has a three-dimensional geometric shape having faces (flat or non-flat), in particular six faces, that meet at edges. In the examples of figures 1
 10 and 2, the chamber 3 comprises the following faces:

- the injection base 10 at the upstream end 5;
- an open face 14 at the downstream end 9;
- the two walls 12 and 13; and
- two faces 15 and 16 at the two ends of the injection base 10 along the open
 15 line.

The chamber 3 can in particular be in the general shape of any type of hexahedron (polyhedron having six flat faces) and in particular that of a parallelepiped (hexahedron having parallel faces in pairs).
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In the example of figure 1, the length of the injection base 10 is defined by a curved line, as illustrated for example by a line 17.

Furthermore, in the case of a rectangular injection base 10 that is thus defined by a
 25 straight line (according to the length L1 of the rectangle, as illustrated by a line 18), the chamber 3 can, for example, assume the shape of a rectangular parallelepiped (all of the faces of which are flat and are rectangles), as shown in figure 2.

In this way, the engine 1 according to the invention comprises a detonation chamber 3 that does not have (and is not limited to) an annular shape, but can have multiple other different shapes.

5 Furthermore, according to the invention, said injection system 4 is disposed so as to inject the fuel/oxidant mixture at at least one portion 20 of said injection base 10, as shown in figure 2. This injection system 4 is particularly formed so as to generate (jointly with the wave initiated by the initiation means 8) specific local conditions, which allow the creation of the series of detonation waves (naturally
10 initiated) in the detonation chamber 3. The specific local conditions for creating this series of detonation waves can be defined by a person skilled in the art, particularly in an empirical manner.

The conventional initiation means 8 (for example, an exploding wire or a pre-
15 detonation tube) are disposed in said detonation chamber 3 so as to initiate in the detonating mixture a detonation wave 8 which is then propagated in said mixture in the longitudinal direction (arrow F) of the injection base 10 and is the cause of automatically initiated successive detonation waves 22. This wave is propagated in the fresh detonating mixture along the injection base 10, whereas the hot gases
20 that it produces expand into the rest of the chamber 3 (as shown by the lines 23 illustrating the expansion of the detonation products) and will be evacuated through the open end 9 of the detonation chamber 3. These hot gases which expand toward the open end 9 of the chamber 3 can be used in different ways, particularly by being accelerated by a pipe so as to obtain a thrust.

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Beyond the injection zone (or portion) 20, along the injection base 10, the detonation wave degenerates into a single compression wave 24, as shown in figure 2. In the example of figure 2, various injection zones 25 have been provided, only some of which are supplied (arrows 26).

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Within the context of the present invention, the ends 15 and 16 of the detonation chamber 3 can be open or closed independently of each other. Furthermore, the initiation (implemented by the initiation means 8) can be located anywhere along the injection base 10.

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By virtue of the multitude of shapes that can be contemplated for the detonation chamber 3, according to the invention, the possible applications of the engine 1 are considerably increased in relation to a conventional engine having an exclusively annular detonation chamber.

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In this way, numerous applications can be contemplated, in particular for liquid propellant rocket engines, turbine engine systems or even ramjets.

Furthermore, the injection system 4 injects the conventional fuel separately from the air. The injection of a pre-mixture is thus not intended, which avoids any risk of ignition upstream of the detonation chamber 3. Moreover, in the case of a fuel that can be stored, such as a liquid hydrocarbon, it is also possible to provide a regenerative circuit (not shown) allowing the fuel to be pre-vaporised (before its injection) and thus satisfactory mixing and detonation conditions to be obtained without pre-mixing. Preferably, this regenerative circuit (or cooling circuit), in which fuel circulates, extends along at least one side wall of said detonation chamber 3, over at least a portion of its length.

In one specific embodiment, said injection system 4 is capable of producing the injection over a variable length along said injection base 10. It is thus possible to provide various injection zones 25 along the injection base 10, a variable number of which can be supplied (arrows 26 in figure 2). It is thus possible to provide separate injection means for these various injection zones 25.

By virtue of this specific embodiment, it is possible to supply a larger or smaller portion of the detonation chamber 3 with fuel and/or oxidising agent so as to

modulate the thrust (for an aerobic system, only a modulation of fuel injection is provided).

If two engines 1 of this type are mounted on a flying craft so as to generate
 5 propulsions on either side of an axis of rotation, respectively, a rotation of said
 flying craft can be generated about this axis by producing an asymmetric
 injection. By way of illustration, such an engine 1 can be mounted on each of the
 wings of an aeroplane (not shown), the injection base 10 of the chamber 3 being
 defined each time along the trailing edge of the corresponding wing, and a yawing
 10 moment can be created by carrying out different injections on these two engines 1.
 It is thus possible to create a possibility of contributing to the control of a flying
 craft by asymmetric injection modulation, by providing a propulsive system 2
 comprising a plurality of engines 1 (with variable feed length).

15 Furthermore, in one specific embodiment, said detonation chamber 3 has a
 bifurcation 27 at the injection base 10, as shown in figures 3 and 4, so as to create,
 beyond this bifurcation 27, at least two elongate branches 28 and 29 and to thus
 form a bifurcation chamber 30. Each of these branches 28 and 29 is supplied with
 detonating mixture by said injection system 4, as illustrated in figure 4 by series
 20 31 of dots representing injection lines. This specific embodiment allows the
 creation of two (or more) propulsive lines by propagating the waves in the two (or
 more) branches 28 and 29. Of course, each engine 1 comprises, in addition to a
 detonation chamber, all of the aforementioned means, in particular the injection
 system 4 and the initiation means 8 that are necessary for its operation, even if, for
 25 the sake of simplifying the drawing, only the chambers have been shown in
 figures 3 and 4, as well as in figures 5 to 7. In figures 4 to 7, the direction of
 displacement of the detonation waves 22 has been shown by means of arrows F.

In the case of a bifurcation chamber 30, the injection system 4 can supply each of
 30 the branches 28 and 29 over a longer or shorter length, as illustrated by the double
 arrows D1 and D2 in figure 4, and thus provide a possibility of realising vector

control of the thrust by asymmetrising the injection conditions (thus without steerable pipe) of the flying craft equipped with said engine 1. These branches 28 and 29 can thus be supplied over lengths which can vary over time and independently of each other.

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Furthermore, in one specific embodiment, shown in figure 5, said engine 1 can comprise, in addition to a bifurcation chamber 30, an annular detonation chamber 33 of the conventional type. Moreover, said bifurcation chamber 30 is connected to said annular chamber 33 (by a longer or shorter link) so as to obtain a hybrid

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chamber 34. This specific embodiment thus combines the advantages of an annular chamber (ensured operating stability) and those of a bifurcation chamber:

- optimal operation over a wide range of conditions (thrust/richness): a larger or smaller portion of the length of the chamber is supplied and the rest is only supplied by the oxidising agent (air, a priori);
- 15 - limitation of the start-up shock: only the annular chamber that is disposed upstream is started; and
- distributed propulsion (and distributed control).

Furthermore, said annular chamber 33 of this hybrid chamber 34 can also be connected, via one or more bifurcations 27, to one or more additional extensions 35 (or branches).

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Moreover, in one specific embodiment, shown in figures 6 and 7, a hybrid chamber 37, 38 can be provided that is in the form of an annular detonation chamber 36 provided (via bifurcations 27) with extensions 39, 40. These extensions 39, 40 are concentric in relation to the annular chamber 36. Preferably, these extensions 39, 40, of which there are four, for example, are evenly distributed over the (internal or external) periphery of the annular chamber 36 and can have variable feed lengths, as shown by arrows D3A to D3B and D4A to D4B. In one specific embodiment, in order to obtain a variation in the length of the fuel supply, it is possible, for example, to provide a disc that rotates between

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the fuel supply system 4 and the detonation chamber 3 and which exposes, to a greater or lesser extent, oblong openings provided in a fuel header.

5 In the specific variant in figure 6, the concentric extensions 39 are disposed radially inside said annular detonation chamber 36, whereas, in the variant in figure 7, the concentric extensions 40 are disposed radially outside said annular detonation chamber 36.

10 It is then easy to continuously modulate the thrust by supplying a longer or shorter length (D3A to D3B and D4A to D4B) of these extensions 39, 40 with fuel (or with fuel and oxidising agent for a rocket system). Similarly, it is possible to easily control the orientation of the thrust (for a ramjet or a rocket).

15 Such a hybrid chamber 37, 38 can in particular be used to replace a single annular chamber or concentric annular chambers in a ramjet, a turbine engine or a rocket engine

CLAIMS

1. Continuous detonation wave engine operating with a detonating fuel/oxidant mixture and comprising:
 - 5 - at least one detonation chamber (3);
 - an injection system (4) for continuously injecting the detonating mixture into said detonation chamber at an upstream end (5), said detonation chamber (3) comprising an injection base (10) at said upstream end, and two walls (12, 13) which extend on either side of this injection base; and
 - 10 - initiation means (8) which are disposed in said detonation chamber (3), to initiate in the detonating mixture a detonation wave (22) which is then propagated in said mixture and is the cause of successive self-initiated detonation waves, so as to generate continuous production of hot gases, escaping through a downstream end (9) of said detonation chamber (3), characterized in that said detonation
 - 15 chamber (3) comprises an injection base (10) of which the length is defined by an open line (17, 18), so as to form a detonation chamber (3) having an elongate form in a transverse plane, and in that said injection system (4) is disposed so as to inject the fuel/oxidant mixture into said detonation chamber (3) at at least one portion (20) of said injection base (10).
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2. Engine according to claim 1, characterized in that said injection base (10) is defined by an open curved line (17).
3. Engine according to claim 1, characterized in that said injection base (3) is
- 25 defined by an open straight line (18).
4. Engine according to either claim 1 or claim 3, characterized in that said injection system (4) is capable of producing the injection over a variable length.
- 30 5. Engine according to any one of the preceding claims, characterized in that it comprises at least one cooling circuit for said detonation chamber, in which

cooling circuit fuel can circulate before being injected into said detonation chamber.

6. Engine according to claim 5, characterized in that said cooling circuit
5 extends along at least one side wall of said detonation chamber, over at least a portion of its length.

7. Engine according to any one of the preceding claims, characterized in that
10 said detonation chamber (30) has a bifurcation (27) at the injection base (10), allowing at least two elongate branches (28, 29) to be created beyond said bifurcation, each of which can be supplied with detonating mixture by said injection system (4).

8. Engine according to claim 7, characterized in that said injection system (4)
15 is capable of supplying these branches (28, 29) over different lengths which can vary over time and independently of one another.

9. Engine according to either claim 7 or claim 8, characterized in that it
20 further comprises an annular detonation chamber (33, 36) and in that said bifurcation chamber (30) is connected to said annular chamber (33, 36) so as to form a hybrid chamber (34, 37, 38).

10. Engine according to claim 9, characterized in that said hybrid chamber
25 (37, 38) takes the form of an annular detonation chamber (36) provided with concentric extensions (39, 40) of variable feed lengths.

11. Engine according to claim 10, characterized in that said concentric
extensions (39) are disposed outside said annular detonation chamber (36).

30 12. Engine according to claim 10, characterized in that said concentric extensions (40) are disposed inside said annular detonation chamber (36).

13. Energy generation system, in particular a gas turbine, characterized in that it is provided with at least one engine (1) such as that specified in any one of claims 1 to 12.

5 14. Propulsive system for flying craft, in particular of the ramjet, turbine engine or rocket type, characterized in that it is provided with at least one engine (1) such as that specified in any one of claims 1 to 12.

10 15. Propulsive system according to claim 14, characterized in that it is provided with at least two engines (1), each of which comprises an injection system (4) capable of modulating the injection.

16. Flying craft, characterized in that it is provided with at least one propulsive system (2) such as that specified in either claim 14 or claim 15.

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