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P-385528 25 June 2008 (25.06.2008) PL(71) Applicants (for all designated States except US): **CEN-TRUM INNOWACJI, BADAN I WDROZEN** [PL/PL]; Kaliski Inkubator Technologiczny, ul.Czestochowska 25, 62-800 Kalisz (PL). **SVENSSON, Karol** [PL/PL]; Dworska 1, 05-503 GLOSKOW (PL).

(72) Inventor; and

(71) Applicant : **PAWLAK, Zdzislaw** [PL/PL]; Tatrzańska 32, 62-800 KALISZ (PL).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **SVENSSON, Ingemar** [SE/—]; Louisiana House, South Esplanade, St. Peter Port, Guernsey, Channel Islands GY1 1 BJ (GB).(74) Agent: **MALEWSKA, Ewa**; c/o Ewa Malewska & Partners, Klaudyny 32/299, 01-684 Warszawa (PL).

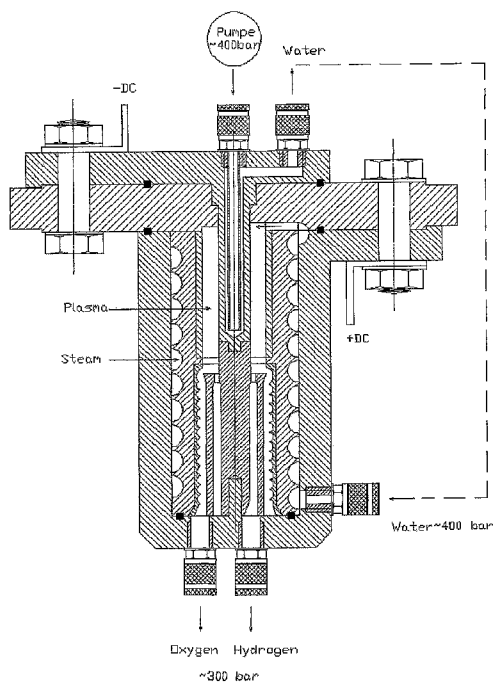
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(54) Title: A METHOD AND REACTOR FOR THERMAL DECOMPOSITION OF WATER



(57) Abstract: The invention relates to a method for thermal decomposition of water, wherein hydrogen and oxygen are centrifugally separated in the high-temperature plasma reactor with the preferably tungsten cylindrical housing (1) that holds a number of tungsten and ceramic components (3, 6, 7, 8), and the entire assembly is interconnected with connecting and sealing agents, wherein a thermolysis process is conducted under a preferably high pressure and at high temperature over 27000C generated by the electric arc, high-frequency field effect, or the heating element that may be a tungsten rod or a flow through a pipe inside the reactor of helium heated up in a nuclear reactor, which method is supported by the vortex phenomenon and the large centrifugal force occurring therein, as well as 1 : 15 ratio of hydrogen and oxygen respective specific gravities at their separation in the reactor's hot zone. According to the invention the components of the reactor in its various embodiments are serially cooled by water pumped under high pressure, first through the internal electrode (4), and then through the tungsten heat exchanger (6) where the water converts to steam, which further cools the reactor's remaining part, then the steam is partially decompressed in the nozzle (11) and whirling at the high speed in the heat source effect zone the steam converts to plasma and the large centrifugal forces separate the process gases. The invention relates also to a plasma reactor used in the method according to the invention.

## DESCRIPTION

## A METHOD AND REACTOR FOR THERMAL DECOMPOSITION OF WATER

This invention relates to a method of thermal decomposition of water and a reactor suitable for realization of the method, operating at a preferably high pressure and a very high temperature, and at the same time utilising the large difference between hydrogen and oxygen specific gravities, and vortex centrifugal force to separate the gases.

RU2041039 C1 patent application discloses a plasmatron solution whereby water steam is the plasma-creating gas. Water is first cooling the plasmatron's components and then, flowing through a spiral heater, it converts to steam, and at the final stage, flowing through the plasmatron's arc, it becomes plasma decomposing into hydrogen and oxygen. The plasma, when used for metal cutting for instance, is cutting the metal and, while cooling down, hydrogen atoms immediately react with oxygen atoms, returning heat still in the cut gap, and reconverts to water. In the cutting process the entire plasmatron thermal power is released outside it, and since there is not enough thermal energy received by water in the plasmatron cooling process to convert cooling water to steam, there is a spiral heater provided in the plasmatron that evaporates water still upstream of the plasmatron nozzle.

World-wide attempts – so far unsuccessful – are known to control the process of thermal water decomposition into hydrogen and oxygen. For thermal water decomposition high temperature is required over 2700°C that may be accomplished in solar power plants and high-temperature nuclear reactors. It is also permanently achievable in various: arc, microwave and laser plasmatrons.

This problem is solved with the present invention related to a new thermal water decomposition method and a plasma reactor that concurrently utilises various physical phenomena.

In the reactor design according to the present invention the subassemblies are cooled with water forced-in under a very high pressure and then with steam, with as much heat recuperated as possible. The hot steam is then injected at a speed exceeding Mach 2 through a flat nozzle (11) shown in Fig. 3, tangent to the perimeter of reactor's cylindrical internal chamber. The internal reactor chamber's small diameter makes the steam whirl at a very high speed. The nozzle is extended with an appropriately designed worm that enforces the vortex' laminar shift along the reactor chamber. The whirling steam right away reaches

the thermal effect zone of the heating element, electric arc or the microwave effect zone, where it immediately heats up to a very high temperature and, once the temperature is over 2700°C, the steam becomes plasma. Water molecules decompose to hydrogen and oxygen atoms with their respective specific gravities' ratio 1 : 15. Since the plasma is brought up  
5 to speed over 800 m/s, in the chamber with ca. 20 mm diameter it yields to centrifugal acceleration of ca. 60 000 000 mm/s<sup>2</sup>, that is - over 6 million times higher than the gravitational acceleration. Such highly accelerated oxygen and hydrogen atoms of significantly different specific gravities are centrifugally separated, and fifteen times heavier oxygen is separated to the reactor chamber's external wall. With the assumed hot  
10 reactor chamber length (ca. 45 mm) the travelling plasma vortex makes ca. 20 rotations and it covers the total perimeter route of ca. 1 200 mm. When the plasma is still hot, the gases are separated. Whirling outside, the oxygen moves to a ceramic spiral sleeve (7), where the oxygen, still whirling, returns its heat indirectly to a tube (6), where in turn it heats up the circulating steam, and the cooled down oxygen is discharged off the reactor.  
15 Whirling inside, the lighter hydrogen moves to an internal sleeve (8) also made of a high temperature resistant ceramic material, and following its heat's transfer to the walls it is discharged off the reactor as well.

The reactor's operation should be started and ended with input of a neutral gas (e.g. argon or helium).

20 Since in a temperature above 2800°C hydrogen and oxygen are very reactive gases, the reactor shall be built of high temperature super resistant materials, such as tungsten, HfC or TaC carbides and their alloys, ThO<sub>2</sub> oxides, and others.

The reactor may be disassembled, and its worn-out components are easily replaceable.

25 If some hydrogen gets in to the oxygen zone and vice versa, at the moment of the gases' cooling down a reaction occurs and the gases reconvert to steam. When the gases are completely cooled down and water condensates, it should be discharged off the reactor and may be returned to feed it.

The subject reactor is described in the following examples presenting embodiments  
30 of the invention.

E x a m p l e 1. Plasma reactor according to the invention with electric arc as its plasma-creating heat source is presented in Fig. 1. Fig. 2 is an assembly drawing of the

basic components. An external housing (1), preferably made of tungsten, holds a preferably tungsten sleeve (6) that is provided with a spiral turning for steam in its external wall and inside it contains a replaceable sleeve (5) and a ceramic sleeve (7) with an internal spiral turning. In the very centre there is centrically set another ceramic sleeve for hydrogen separation. All these components are closed with an insulating ring (2) most preferably made of thorium dioxide ( $\text{ThO}_2$ ). Screwed-down on the insulating ring (2) is a shield (3), most preferably made of tungsten, that in its central part holds the protruding reactor's internal electrode that is hollow and holds inside a pipe (4) for cooling water flow. The entire assembly is sealed with three adequately heat-resistant gaskets (9) set in turned ducts (10). Electric power is supplied to the device's DC clamps.

**E x a m p l e 2.** Plasma reactor according to the invention with high-frequency microwave power supplied over capacitive coupling as its plasma-creating heat source is presented in **Fig. 4**. An external housing (1), most preferably made of tungsten, holds a preferably tungsten sleeve (6) that is provided with a spiral turning for steam in its external wall, and inside it contains a centrically set ceramic sleeve (7), most preferably made of thorium dioxide ( $\text{ThO}_2$ ), provided inside, over a part of its length, with a spiral turning. All these components are closed with an insulating ring (2), most preferably made of thorium dioxide ( $\text{ThO}_2$ ). The ring is provided with a tongue terminated with a hydrogen separator and at the same time it provides a protective jacket for a tungsten half-wave high-frequency antenna. The entire assembly is sealed with adequately resistant gaskets (9).

**E x a m p l e 3.** Plasma reactor according to the invention with helium gas heated to temperature ca.  $3000^\circ\text{C}$  in a nuclear reactor as its plasma-creating heat source is presented in **Fig. 5**. A ceramic tube (12), being the hot helium conduit, is preferably made of an alloy of hafnium and tantalum carbides ( $\text{TaHfC}_5$ ) with melting point  $4215^\circ\text{C}$ . The other components are designed as in the previous Examples, provided that the external components may also be made of the above mentioned super-alloy.

**E x a m p l e 4.** Plasma reactor according to the invention with a tungsten heating rod as its plasma-creating heat source is as shown in **Fig. 5**, the difference being that the hot helium flow inside the ceramic protective jacket, most preferably made of an alloy of hafnium and tantalum carbides ( $\text{TaHfC}_5$ ) with melting point  $4215^\circ\text{C}$ , is replaced with the tungsten heating rod. Also the reactor's other internal components may be made of the alloy.

E x a m p l e 5. In the plasma reactor as described in Examples 1-4 a method for thermal decomposition of water is conducted. Hydrogen and oxygen are centrifugally separated in the high-temperature plasma reactor, where a thermolysis process is conducted under a preferably high pressure and at high temperature over 2700°C generated by the electric arc, high-frequency field effect, or the heating element that may be a tungsten rod or a flow through a pipe inside the reactor of helium heated up in a nuclear reactor, which method is supported by the vortex phenomenon and the large centrifugal force occurring therein, as well as 1 : 15 ratio of hydrogen and oxygen respective specific gravities at their separation in the reactor's hot zone. The components of the reactor in its various embodiments are serially cooled by water pumped under high pressure, first through the internal electrode (4), and then through the tungsten heat exchanger (6) where the water converts to steam which further cools the reactor's remaining part, then the steam is partially decompressed in the nozzle (11) and whirling at the high speed in the heat source effect zone the steam converts to plasma and the large centrifugal forces separate the process gases.

A part of hydrogen penetrating into the oxygen zone at separation, when cooled down reacts with oxygen and reconverts to steam. Also a part of oxygen penetrating into the hydrogen zone at separation, when cooled down reacts with hydrogen and reconverts to steam. After cooling the gases and condensation, the water is recycled to the process.

A neutral gas, preferably argon or helium, is used to start and stop the reactor's operation.

## CLAIMS

1. A method for thermal decomposition of water, wherein hydrogen and oxygen are centrifugally separated in the high-temperature plasma reactor with the preferably tungsten cylindrical housing (1) that holds a number of tungsten and ceramic components (3, 6, 7, 8), and the entire assembly is interconnected with connecting and sealing agents, wherein a thermolysis process is conducted under a preferably high pressure and at high temperature over 2700°C generated by the electric arc, high-frequency field effect, or the heating element that may be a tungsten rod or a flow through a pipe inside the reactor of helium heated up in a nuclear reactor, which method is supported by the vortex phenomenon and the large centrifugal force occurring therein, as well as 1 : 15 ratio of hydrogen and oxygen respective specific gravities at their separation in the reactor's hot zone.

2. The method according to claim 1, **characterised in that** the components of the reactor in its various embodiments are serially cooled by water pumped under high pressure, first through the internal electrode (4), and then through the tungsten heat exchanger (6) where the water converts to steam which further cools the reactor's remaining part, then the steam is partially decompressed in the nozzle (11) and whirling at the high speed in the heat source effect zone the steam converts to plasma and the large centrifugal forces separate the process gases.

3. The method according to claim 1, **characterised in that** a part of hydrogen penetrating at separation into the oxygen zone, when cooled down reacts with oxygen and reconverts to steam, and vice versa, and after cooling the gases and condensation, the water is recycled to the process.

4. The method according to claim 1, **characterised in that** a neutral gas, preferably argon or helium, is used to start and stop the reactor's operation.

5. A plasma reactor for thermal decomposition of water with centrifugal separation of hydrogen and oxygen, that utilises various plasma-creating heat sources, **characterised in that** in the cylindrical housing (1), preferably made of tungsten, and resistant to high operating temperatures and pressures, a cylindrical heat exchanger (6) preferably made of tungsten is set, which heat exchanger may hold inside a replaceable sleeve (5) and a ceramic sleeve (7), and in its very centre a ceramic sleeve (8), and the

entire assembly is closed with the ceramic ring (2) and the shield (3), preferably made of tungsten, which holds the water-cooled electrode (4) - in the embodiment involving electric arc.

5           6.       The reactor according to claim 5, **characterised in that** the sleeve (6), preferably made of tungsten, is provided with the spiral turning on its outside to increase heat exchange surface for the circulating steam, and it holds sleeves (5) and (7) inside.

          7.       The reactor according to claim 5, **characterised in that** the sleeve (6) - in embodiments described in Examples 2, 3 and 4, is provided also inside with the spiral turning to increase heat exchange, over a part of its length.

10           8.       The reactor according to claim 5, **characterised in that** the ceramic ring (2), in its central part is provided with the nozzle (11) terminated with the worm to force laminar plasma flow.

Fig 1

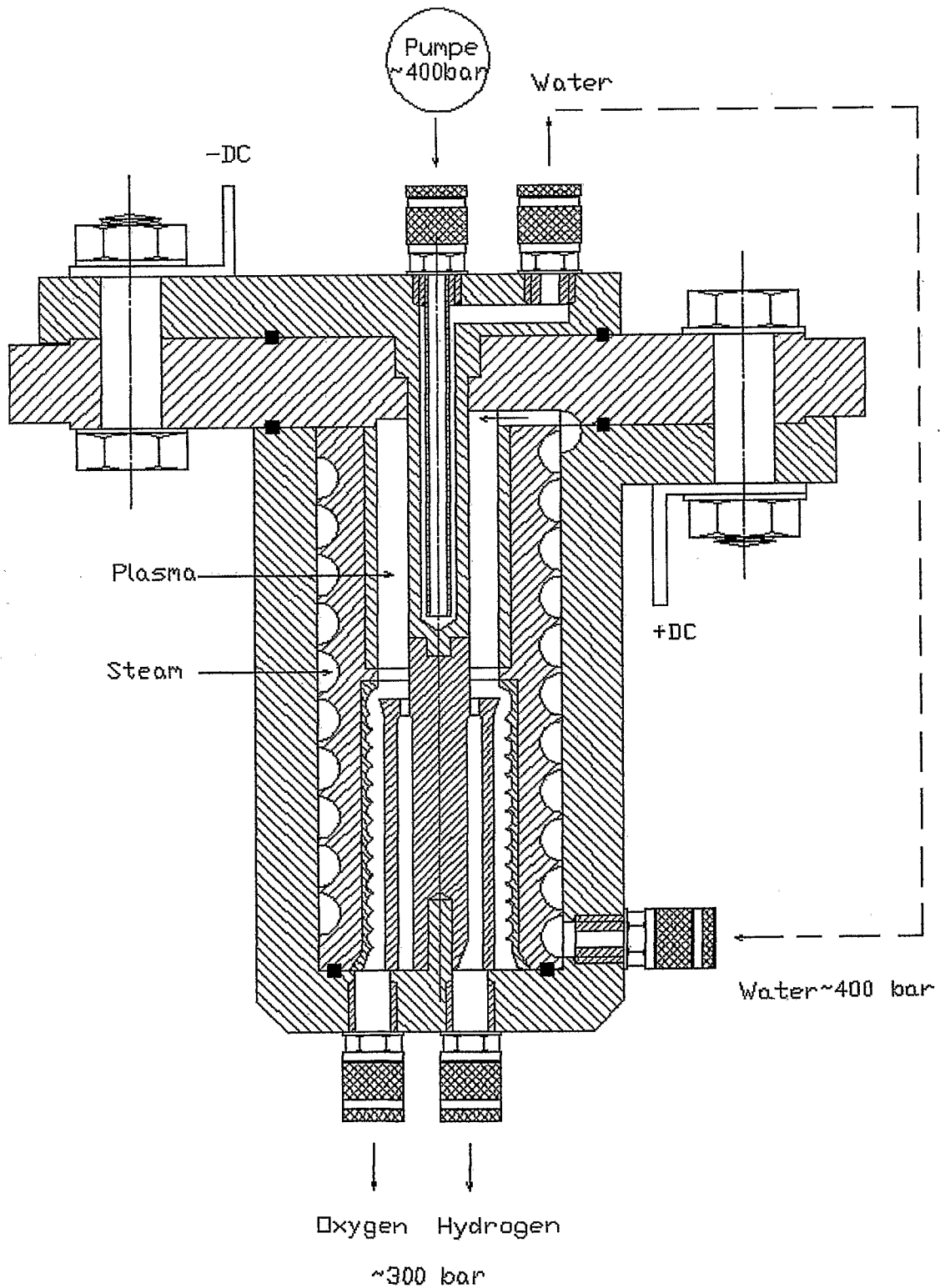


Fig 2

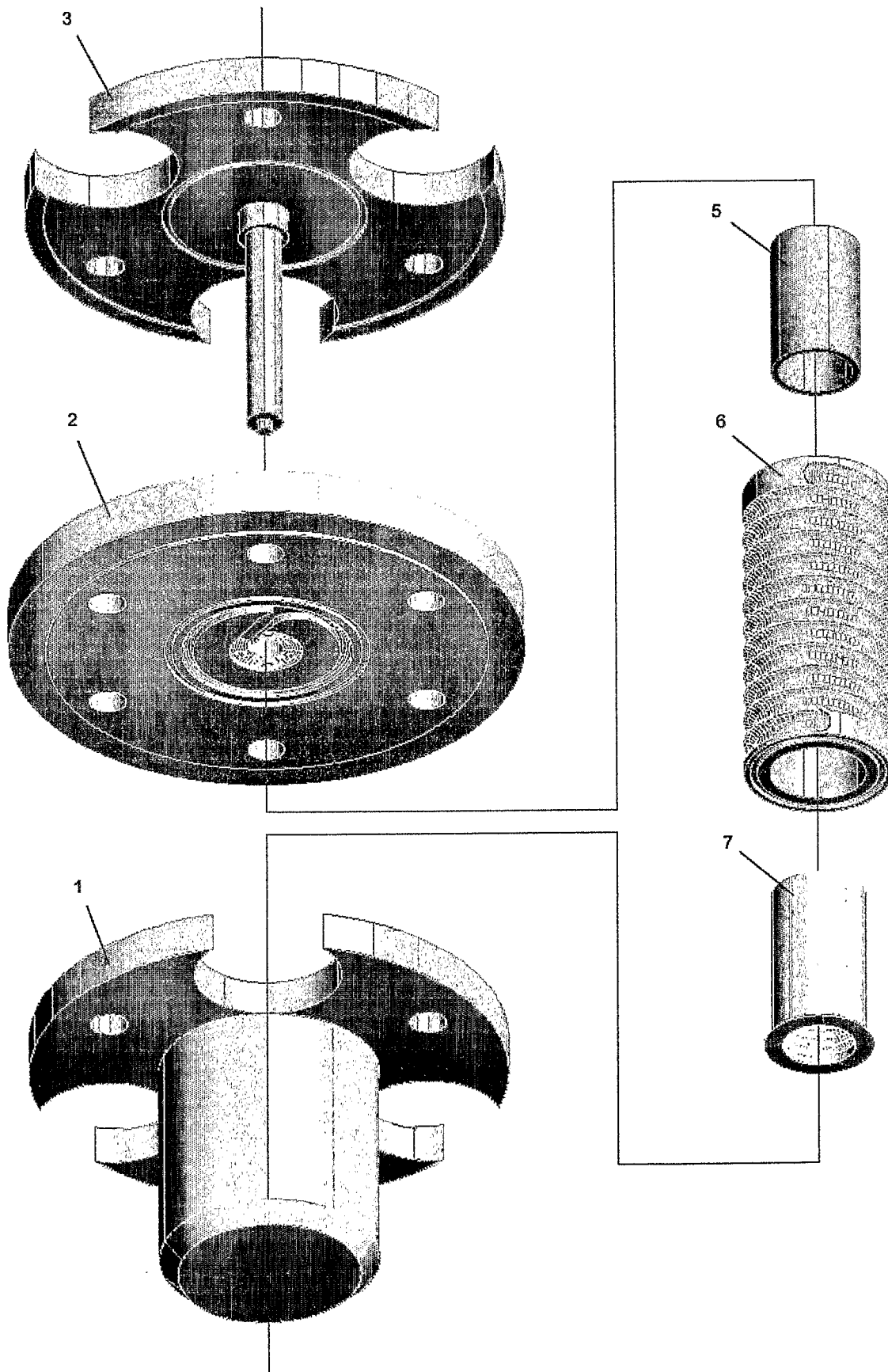


Fig 3

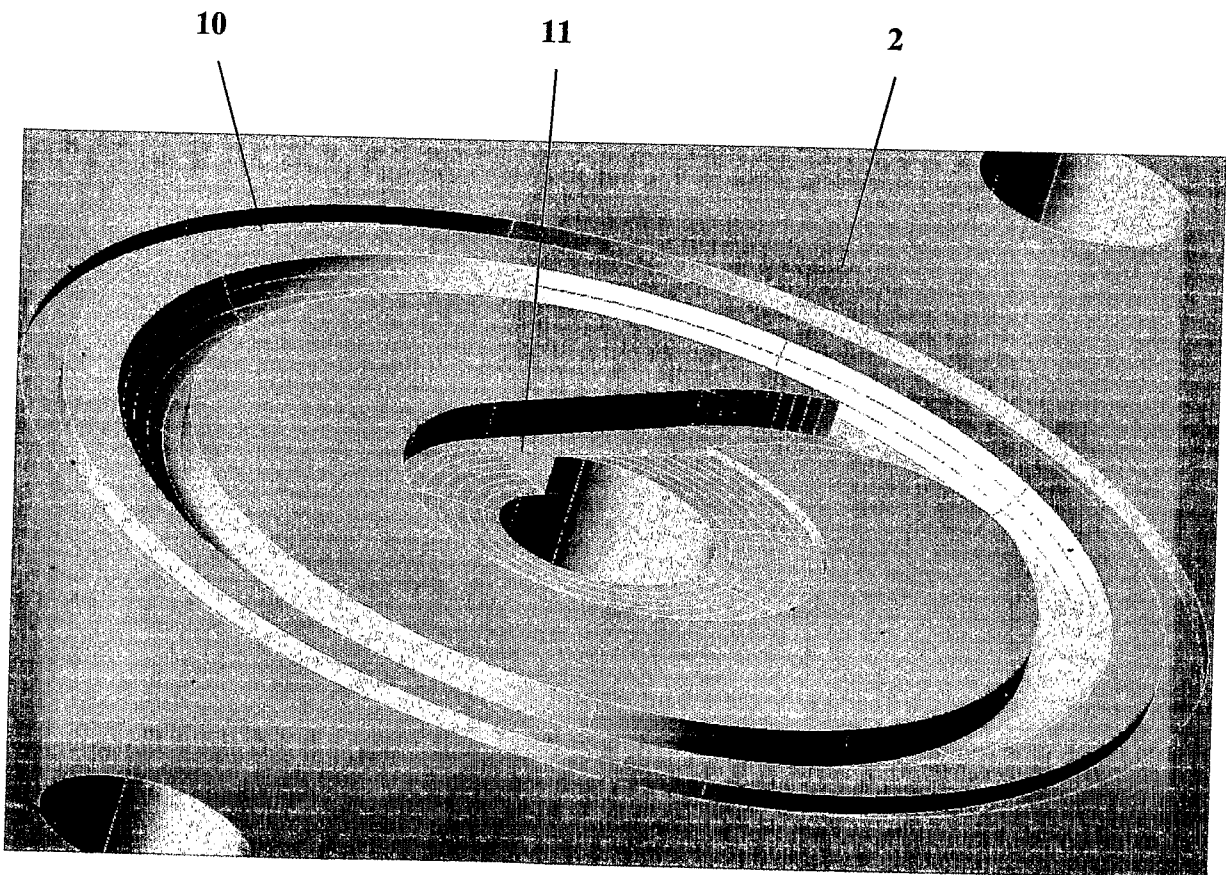


Fig 4

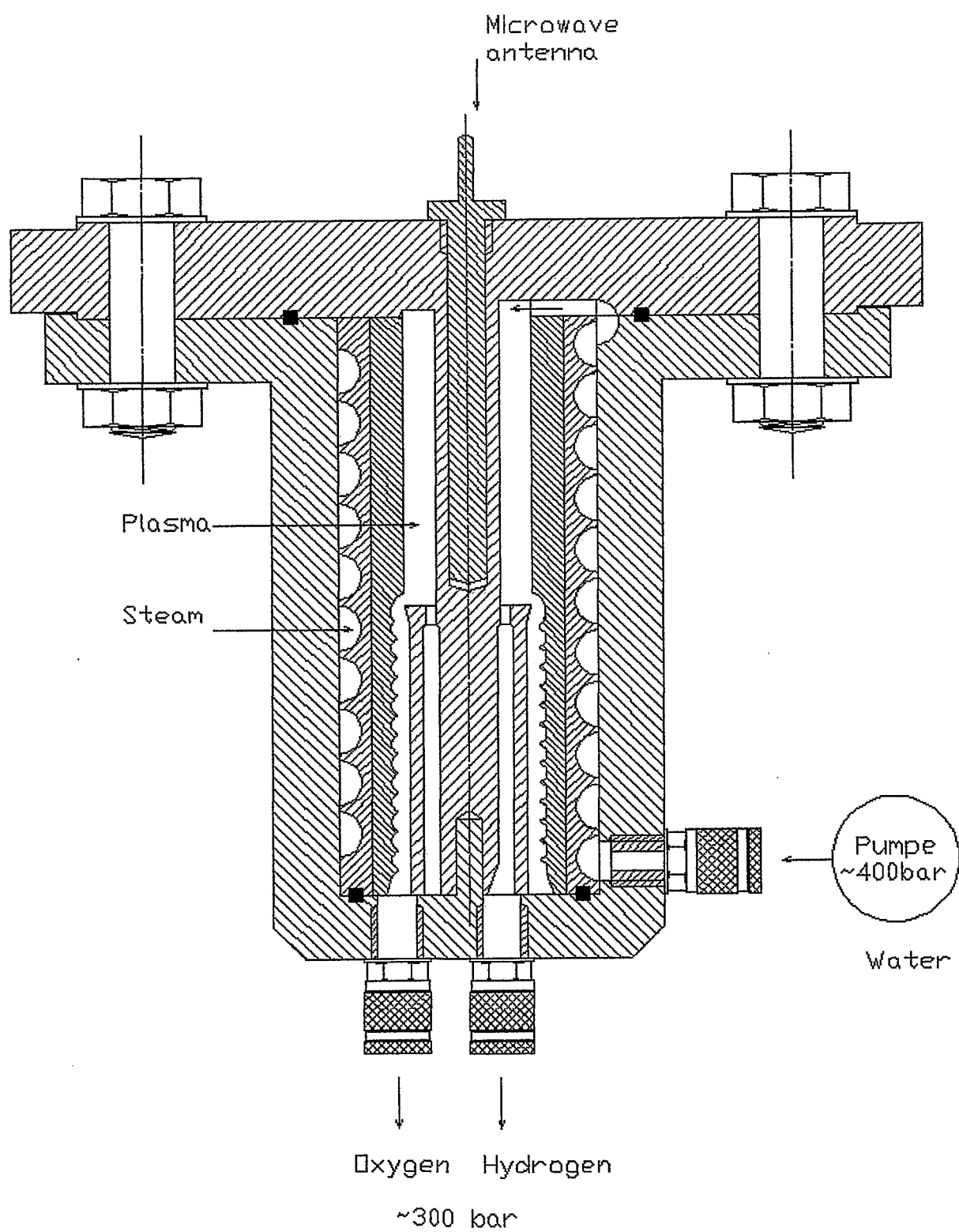
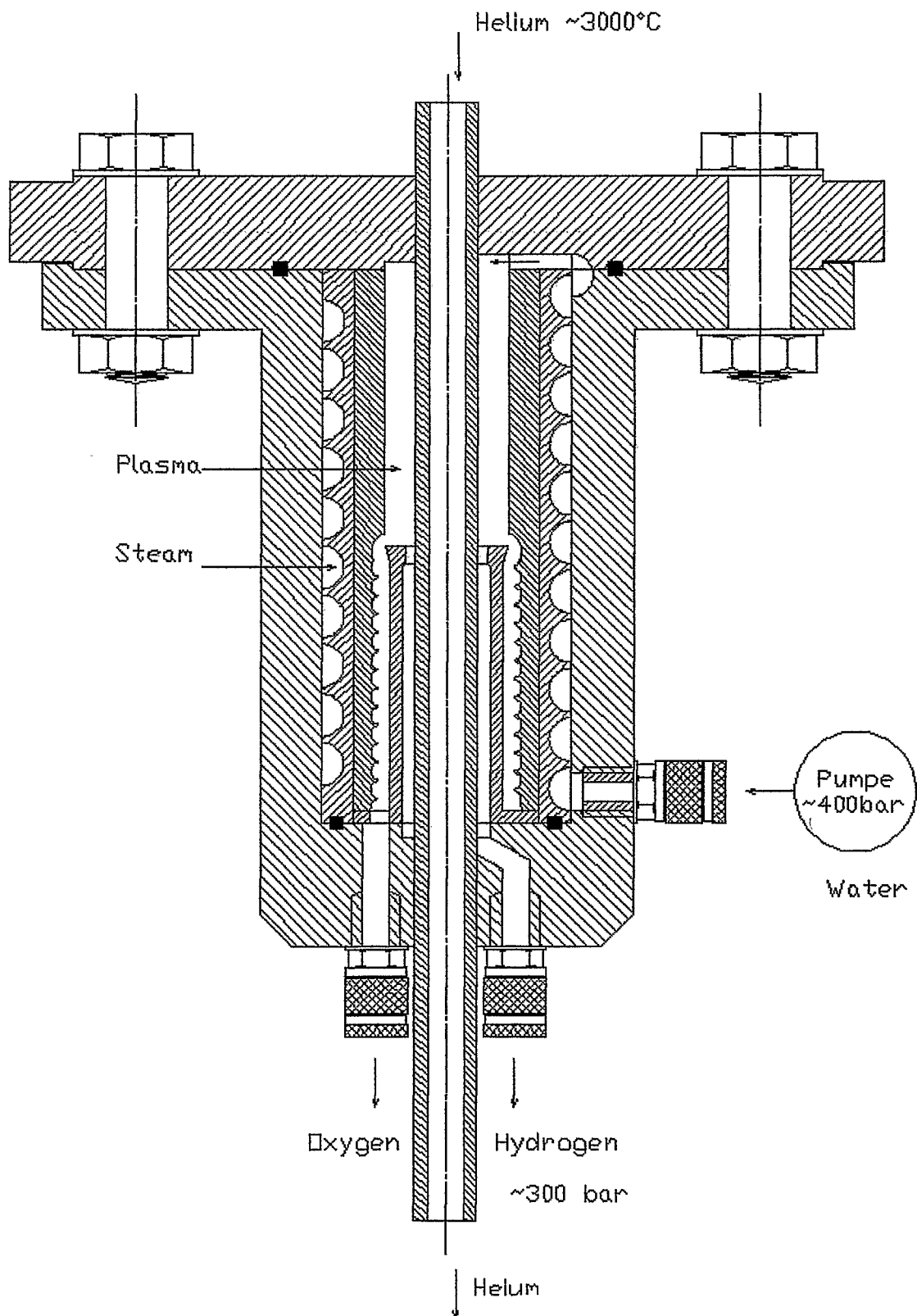


Fig 5



# INTERNATIONAL SEARCH REPORT

International application No  
PCT/PL2009/000069

## A. CLASSIFICATION OF SUBJECT MATTER

INV. H05H1/48

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
H05H C01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2005/005009 A (BAR GADDA LLC [US]) 20 January 2005 (2005-01-20) page 10, line 5 - line 14 page 14, line 16 - line 19 page 15, line 11 - line 22 page 18, line 31 - line 33	1, 4
Y	claims 7,32,78; figures 1,2	2, 5
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Y	US 6 245 309 B1 (ETIEVANT CLAUDE [FR] ET AL) 12 June 2001 (2001-06-12) column 6, line 44 - line 58 figure 2	5
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☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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\*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search

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Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040,  
Fax: (+31-70) 340-3016

Authorized officer

Capostagno, Eros

# INTERNATIONAL SEARCH REPORT

International application No

PCT/PL2009/000069

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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