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(54) Title: ENERGY CONVERSION AND TRANSFER ARRANGEMENT FOR THERMOPHOTOVOLTAIC DEVICES AND THERMOPHOTOVOLTAIC DEVICES COMPRISING SUCH

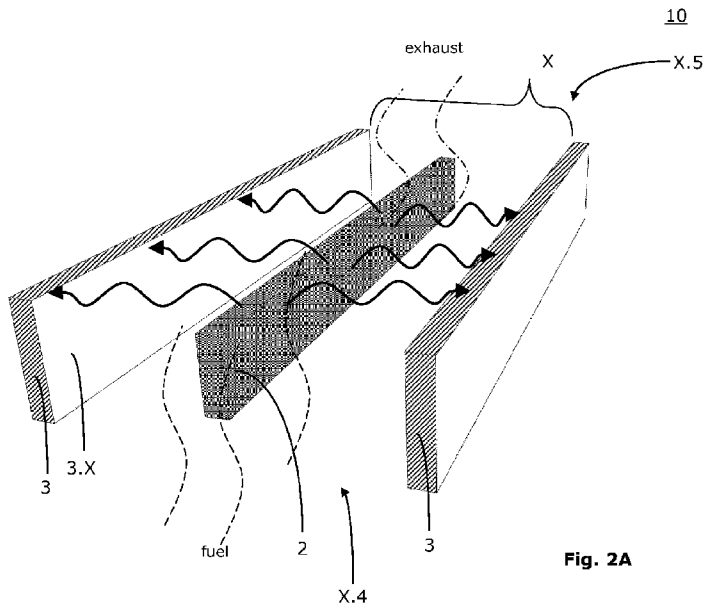


Fig. 2A

(57) Abstract: An energy conversion and transfer arrangement (10) comprising a spectral shaper (3) with an input surface (3.X) defining a flow-through heat transfer area (X) and an electro-magnetic radiation emitter (2) arranged within said flow-through heat transfer area (X) to allow for surface specific fuel combustion processes such as catalytic conversion which heat up the emitter to high temperatures, the electro-magnetic radiation emitter (2) being configured for emitting predominantly near-infrared radiation when exposed to high temperature; wherein the spectral shaper (3) is configured as a band pass filter for a first, optimal spectral band of the radiation emitted by the electro-magnetic radiation emitter (2) when exposed to high temperature; and/ or as a reflector for further, non-optimal spectral band(s) of the radiation emitted by the electro-magnetic radiation emitter (2), so that said second, non-optimal spectral band radiation is recycled as radiation redirected towards the electro-magnetic radiation emitter (2).

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Energy conversion and transfer arrangement for thermophotovoltaic devices and thermophotovoltaic devices comprising such

FIELD OF THE INVENTION

[0001] The present invention relates to an energy conversion and transfer arrangement for thermophotovoltaic devices and thermophotovoltaic devices comprising such an energy conversion and transfer arrangement.

BACKGROUND OF THE INVENTION

[0002] With the high demand of electricity and even more of clean, CO_2 neutral energy sources, the efficiency with which the energy is harvested plays a more and more important role. As gradually many industrialized countries aim for shifting away from nuclear power production, the demand for alternative energy sources is greater than ever. However, so far few if any really viable alternatives are known. Many of the "classical" renewable energy sources such as wind-turbines or solar power plants have significant drawbacks preventing their wide-spreading.

[0003] Still, even if these drawbacks of "classical" renewable energy sources such as wind-turbines or solar power plants would be solved, there is still the major problem that quite often these sources of renewable energy are

available at a very different location than where the electrical energy is needed. The great distances between the generation location and the energy consumers require very complex, expensive and environmentally unfriendly infrastructure to transport the produced electrical energy. Furthermore, regardless of the improvements of such infrastructures in the latest period, there are still significant losses in the transport of electrical energy over long distances. Therefore there is an urgent need for decentralized energy production. In other words, the future of energy production lies in producing energy as close as possible to the consumer. This not only reduces/ eliminates transmission losses but relives the electrical grid while ensuring much higher levels of flexibility.

[0004] One of the fields of great interest for decentralized energy production is the field of thermophotovoltaic devices, devices designed to transform chemical energy stored in a fuel into electro-magnetic radiation and then into electricity. However, the relatively reduced efficiency of the existing thermophotovoltaic devices has limited their use and mass-deployment.

[0005] Furthermore there is an increasing demand for mobile energy carriers/ generators, ranging from portable electronic devices to electrically-powered heavy machinery. There is also a need for multi-purpose energy generators, providing for selective or simultaneous generation of heat; and/or light and/or electric.

[0006] As for efficiency, the most problematic aspect efficiency of these chemical-to-electric energy converters is one side the inefficiency of the conversion of chemical energy into electro-magnetic radiation and on the other hand the inefficiency of the conversion of the electro-magnetic radiation into electricity.

TECHNICAL PROBLEM TO BE SOLVED

[0007] The objective of the present invention is thus to provide an energy conversion and transfer arrangement enabling a highly efficient

transformation of chemical energy into electricity by means of a thermophotovoltaic element.

[0008] A further objective of the present invention is to provide a thermophotovoltaic device comprising such an energy conversion and transfer arrangement.

[0009] An even further objective of the present invention is to provide a thermophotovoltaic system for selective and/or simultaneous generation of heat, light and electricity.

SUMMARY OF THE INVENTION

[0010] The above-identified objectives of the present invention are solved by an energy conversion and transfer arrangement, comprising a spectral shaper with an input surface 3.X defining a flow-through heat transfer area and an electro-magnetic radiation emitter arranged within said flow-through heat transfer area to be exposable to thermal radiation, the electro-magnetic radiation emitter being configured for emitting predominantly near-infrared radiation when exposed to high temperature.

[0011] The spectral shaper is configured as a band pass filter for a first, optimal spectral band of the radiation emitted by the electro-magnetic radiation emitter when exposed to high temperature. The spectral shaper is further configured as a reflector for further, non-optimal spectral band(s) of the radiation emitted by the electro-magnetic radiation emitter, so that said second, non-optimal spectral band radiation is recycled as radiation redirected towards the electro-magnetic radiation emitter.

[0012] Said further objectives of the present invention are solved by a thermophotovoltaic device comprising such an energy conversion and transfer arrangement and a photovoltaic cell arranged adjacent to said energy conversion and transfer arrangement in a radiating direction of its electro-magnetic radiation emitter.

[0013] The even further objectives of the invention are solved by a thermophotovoltaic system comprising such a thermophotovoltaic device and a fuel source arranged such as to direct a combustible fuel mixture from the fuel source towards an input side of the flow-through heat transfer area, wherein the fuel source and/or the flow-through heat transfer area are configured such that the combustion is essentially limited to the surface of the heat transfer- emitter unit and so that combustion of the fuel mixture in the gas phase is minimized.

ADVANTAGEOUS EFFECTS

[0014] The most important advantage of the present invention is that achieves a very high efficiency by optimizing all stages of the energy conversion to minimize losses in each stage:

I) Conversion of chemical energy into thermal radiation:
By concentrating the combustion process of the chemical energy carrier (fuel) to the surfaces facing (surfaces of 3.X and 2) the flow-through heat transfer area and / or suppressing the combustion reactions in the gas phase, the heat and thus energy transfer between the fuel and the heat transfer- emitter unit is maximized while heat losses as exhaust gases are minimized;

II) Conversion of thermal energy into electro-magnetic radiation:
By the use of an appropriate electro-magnetic radiation emitter configured for emitting predominantly near-infrared radiation, the amount of thermal energy transformed into electro-magnetic radiation is maximized;

III) Shaping the spectrum of the electro-magnetic radiation and recycling eventual losses:

- By the use of the spectral shaper configured as a band pass filter for a first, optimal spectral band of the radiation; and/or
- By providing the spectral shaper with a self emitting material, such as Ytterbium- oxide Yb2O3 or Platinum

the spectrum of the electro-magnetic radiation emitted is shaped for efficient transformation of the electro-magnetic radiation into electric energy by a photovoltaic cell.

In addition, by configuring the spectral shaper as a reflector for further, non-optimal spectral band(s) of the radiation emitted by the electro-magnetic radiation emitter, non-optimal spectral band radiation is recycled as radiation redirected towards the electro-magnetic radiation emitter further minimizing losses.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Further characteristics and advantages of the invention will in the following be described in detail by means of the description and by making reference to the drawings. Which show:

Fig. 1 a schematic cross-sectional diagram of an energy conversion and transfer arrangement according to the present invention;

Fig. 2A a schematic perspective view of an energy conversion and transfer arrangement according to the present invention;

Fig. 2B a schematic perspective view of the heat transfer- emitter unit with a second embodiment of the electro-magnetic radiation emitter;

Fig. 3 a schematic cross-sectional diagram of a photovoltaic cell according to the present invention;

Fig. 4 a schematic cross-sectional diagram of a thermophotovoltaic device according to the present invention;

Fig. 5 a schematic perspective view of a thermophotovoltaic device according to the present invention;

Fig. 6 a schematic perspective view of a thermophotovoltaic system according to the present invention.

Note: The figures are not drawn to scale, are provided as illustration only and serve only for better understanding but not for defining the scope of the invention. No limitations of any features of the invention should be implied form these figures.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0016] Certain terms will be used in this patent application, the formulation of which should not be interpreted to be limited by the specific term chosen, but as to relate to the general concept behind the specific term.

[0017] Fig. 1 shows a schematic cross-sectional diagram of an energy conversion and transfer arrangement 10 according to the present invention. The main functional elements of the energy conversion and transfer arrangement 10 are the spectral shaper 3 and the electro-magnetic radiation emitter 2.

[0018] As shown on figure 1 as well, the other main functional element of the energy conversion and transfer arrangement, the spectral shaper 3 is arranged with an input surface 3.X adjacent to said electro-magnetic radiation emitter 2. Energytransfer between 2 and 3.X is mainly done by thermal induced electromagnetic radiation.

[0019] The spectral shaper 3 comprises an input surface 3.X which defines a flow-through heat transfer area X. The spectral shaper 3 has the following functions:

- Act as a band pass filter for a first, optimal spectral band of the radiation emitted by the electro-magnetic radiation emitter 2 when exposed to high temperature. This is illustrated in the figures with waving arrows with continuous lines;

- Act as a reflector for further, non-optimal spectral band(s) of the radiation emitted by the electro-magnetic radiation emitter 2, so that said second, non-optimal spectral band radiation is recycled as radiation redirected towards the electro-magnetic radiation emitter 2; and/or

- According to a particularly advantageous embodiment, act as an emitter itself, the spectral shaper 3 comprising a layer of selective emitter material such as a rare-earth containing layer, preferably an Ytterbium- oxide Yb_2O_3 or Platinum emitter layer and/or a nanostructured filter layer.

[0020] The electro-magnetic radiation emitter 2 allows for surface specific fuel combustion processes such as catalytic conversion which heat up the emitter to high temperatures. It either comprises a material which provides sufficient stability and/or it comprises a substrate made of a high temperature resistant material, preferably a ceramic material coated by a material supporting surface specific fuel combustion processes. In addition this electro-magnetic radiation emitter 2 may also serve itself as a spectral shaper (same as 3) which may support the function of the spectral shaper 3 or replace it alltogether. There is also the possibility that 2 and 3 act together as an optical cavity type arrangement to both enhance energy conversion processes and spectral shaping functions.

[0021] Optionally, a barrier layer 3.1 which is transparent to predominantly near infrared radiation - preferably a quartz barrier layer 3.1 - is provided between the heat transfer- emitter unit 2 and the spectral shaper 3 in order to suppress heat conduction as well as to account for possible heat expansion induced forces and to even better filter out/ reflect all non-optimal spectral band(s) of the radiation emitted by the electro-magnetic radiation emitter 2, so that said second, non-optimal spectral band radiation is recycled as radiation redirected towards the electro-magnetic radiation emitter 2.

[0022] Fig. 2A shows a schematic perspective view of an energy conversion and transfer arrangement 10 according to the present invention.

[0023] The figures depict functionally and structurally symmetric embodiments of the energy conversion and transfer arrangement 10 with a symmetric spectral shaper 3 located on opposite sides electro-magnetic radiation emitter 2, wherein the electro-magnetic radiation emitter 2 is arranged to emit predominantly near-infrared radiation in two opposing directions. The embodiment shown on figure 2B is a bilaterally symmetric embodiment. The energy conversion and transfer arrangement 10 may have the shape of other symmetrical (e.g. hexagonal, octagonal, elliptical spherical) or non symmetrical bodies.

[0024] This figure illustrates well how a pair of spectral shapers 3 define the flow-through heat transfer area X having an input side X.4 and an output side X.5. An in-flow of combustible fuel mixture at an input side X.4 of the flow-through heat transfer area X is shown on the figures with waving dashed lines, while the out-flow of exhaust gases at said exhaust side X.5 of the flow-through heat transfer area X is shown with dotted-dashed waving lines.

[0025] Fig. 2B shows a schematic perspective view of the heat transfer-emitter unit 2 with a second embodiment of the electro-magnetic radiation emitter 2. According to this embodiment, the electro-magnetic radiation emitter 2 comprises fin-like structures extending outwards from the heat transfer- emitter unit 2, the fin-like structures being provided to maximize the radiating surface of the electro-magnetic radiation emitter 2. These fin-like structures can be various two- or three-dimensional structures and may extend from the nanoscale to the macroscopic scale.

[0026] Fig. 3 shows a schematic cross-sectional diagram of an exemplary photovoltaic cell 7 according to the present invention, which shall be arranged adjacent to said energy conversion and transfer arrangement 10 in a radiating direction of its electro-magnetic radiation emitter 2 (as shown in following figures). The radiating direction of its electro-magnetic radiation emitter 2 is illustrated with a waving arrow. The photovoltaic cell 7 comprises a conversion area 7.5 arranged in the radiating direction of the spectral shaper 3 and/ or the electro-magnetic radiation emitter 2 of the energy

conversion and transfer arrangement 10. The photovoltaic cell 7 is optimized for predominantly near-infrared radiation in order to improve the efficiency of transforming the "spectral shaped" radiation from the energy conversion and transfer arrangement 10 into electric energy.

[0027] In its most preferred embodiment (as shown on figure 3), the photovoltaic cell 7 comprises an anti-reflection layer 7.1 situated on a first surface of the conversion area 7.5 directed towards said radiating direction of the spectral shaper 3 and/ or the electro-magnetic radiation emitter 2 of the energy conversion and transfer arrangement 10. In a particularly preferred embodiment, the anti-reflection layer 7.1 comprises a plasmonic filter configured to act as an anti-reflection layer for radiation at a predefined wavelengths while reflecting radiation outside said predefined wavelength. For example the anti-reflection layer 7.1 comprises a thin metal film – preferably gold – which is perforated with an array of sub- wavelength holes. The holes are spaced periodically, so that diffraction can excite surface plasmons when the film is irradiated. The surface plasmons then transmit energy through the holes and re-radiate on the opposite side of the film. The spacing of the holes is determined based on the wavelength of the emission to be transmitted through the anti-reflection layer 7.1.
Furthermore, the photovoltaic cell 7 comprises a reflective layer 7.9 on a second surface of the conversion area 7.5 situated on an opposite direction as said first surface. Additionally electrical back plane contacts 7.7 are located for example between said conversion area 7.5 and said reflective layer 7.9 and wherein electrical front plane contacts 7.3 are located for example between said anti-reflection layer 7.1 and the conversion area 7.5. Alternatively (not shown on this figure), both electrical front- and back- plane contacts may be arranged either between said conversion area 7.5 and said reflective layer 7.9, or both between said anti-reflection layer 7.1 and the conversion area 7.5. Some of the above described functional layers may also be missing or several functions may be combined in one layer.

[0028] Figures 4 and 5 show a schematic cross-sectional diagram respectively a perspective view of a thermophotovoltaic device 100 according

to the present invention, comprising an energy conversion and transfer arrangement 10 (as hereinbefore described) and a photovoltaic cell 7 (as hereinbefore described) arranged adjacent to said energy conversion and transfer arrangement 10 in radiating directions of its electro-magnetic radiation emitter 2.

[0029] As shown on figures 4 and 5, in a preferred embodiment, a heat conduction barrier 4, e.g. in the form of a vacuum or aerogel layer or another transparent material such as quartz glass is provided between said spectral shaper 3 and the photovoltaic cell 7. In an even further embodiment, a spectral filter 5 is provided between the spectral shaper 3 of the energy conversion and transfer arrangement 10 and the photovoltaic cell 7.

[0030] For cooling of the thermophotovoltaic device 100 and or for providing a heating function, an active cooling layer 6 is provided between the spectral shaper 3 of the energy conversion and transfer arrangement 10 and the photovoltaic cell 7 and/or at a back side of the photovoltaic cell 7 directed in opposite direction as the spectral shaper 3, wherein said active cooling layer 6 comprises a cooling agent, such as water or other coolant between a cooling agent input 6.1 and a cooling agent output 6.2. The cooling layer 6 is configured so as to absorb lower wavelength radiation emitted by the spectral shaper 3 and/ or the electro-magnetic radiation emitter 2 of the energy conversion and transfer arrangement 10, providing cooling to the photovoltaic cell 7 by thermal connection.

[0031] A cooling layer, optimized for contact cooling, may be located behind the total reflector 1 in addition to other cooling measures or stand alone.

[0032] In order to improve the radiation absorption of the cooling layer 6, micro-channels are provided in the cooling layer 6, connecting said cooling agent input 6.1 and said cooling agent output 6.2.

[0033] However this active cooling layer 6 may be employed to provide a heating function as well by warming up a cooling agent or simply water at

the cooling agent input 6.1, thereby providing heat at the cooling agent output 6.2. This option shall be exploited in a thermophotovoltaic system 200 (described in following paragraphs with reference to figure 6).

[0034] In further embodiments (not shown on the figures), the spectral shaper 3 and/or the photovoltaic cell 7; and/or the barrier layer 3.1; and/or the heat conduction barrier 4 are configured as open cylindroids, preferably open cylinders preferably arranged coaxially around the electro-magnetic radiation emitter 2. Polygonal structures are also possible. The thermophotovoltaic device 100 may have the shape of other symmetrical (e.g. hexagonal, octagonal, elliptical spherical) or non symmetrical bodies.

[0035] One shall note that the thermophotovoltaic device 100 must not be completely symmetrical, certain layers (such as the barrier layer 3.1, the heat conduction barrier 4, the spectral filter 5 or the active cooling layer 6) being provided on one but not the other directions.

[0036] In a thermophotovoltaic system 200 (described in following paragraphs with reference to figure 6) configured as a portable energy source such as to simultaneously or selectively act as a heat source, a source of electric energy and a light source, an arrangement of the thermophotovoltaic device 100 can be realized, wherein the energy conversion and transfer arrangement 10 and the entire thermophotovoltaic device 100 are configured such that different sides in each direction of radiation are optimized for one or more of the functionalities of the multifunctional thermophotovoltaic system 200. Thus the thermophotovoltaic system 200 can selectively or simultaneously provide:

- heat radiation from the thermal energy source 50 and/or the flow-through heat transfer area X and/or through the cooling agent output (6.2) of the cooling layer (6);
- electric energy at an output terminal of the photovoltaic cell 7;
- light, i.e. electro-magnetic radiation in the visible spectrum.

Therefore such a thermophotovoltaic system 200 is very flexible regards the form of energy provided while being very efficient in each operating mode (heat/ electricity/ light source).

[0037] Fig. 6 depicts a schematic perspective view of a thermophotovoltaic system 200 according to the present invention comprising a thermophotovoltaic device 100 (as hereinbefore described) and a fuel source 50, arranged such as to direct a combustible fuel mixture from the fuel source 50 towards the input side X.4 of the flow-through heat transfer area X. The flow-through heat transfer area X is configured such that the combustion is essentially limited to the surface of the electro-magnetic radiation emitter 2 and so that combustion of the fuel mixture in the gas phase is minimized.

[0038] The fuel source 50 is a chemical energy source, wherein the chemical energy carrier is preferably a fossil fuel such as methanol or hydrogen.

[0039] As shown on figure 6, the thermophotovoltaic system 200 further comprises a waste heat recovery unit 55 configured to recover heat from exhaust gases at the exhaust side X.5 of the flow-through heat transfer area X and feed back said recovered heat to said input side X.4.

[0040] A further advantageous embodiment of the thermophotovoltaic system 200 comprises in addition a condenser unit 60 configured to recover liquid by condensing vapour in the exhaust gases at said exhaust side X.5 of the flow-through heat transfer area X. In case the fuel is Methanol for example, the condenser unit 60 is laid out for condensing water vapours resulting from combustion of the Methanol. In this way, the thermophotovoltaic system 200 is also capable of acting (simultaneously or selectively) as a source of pure water.

[0041] Quantitative example:
In the specific example of Methanol as fuel, at an efficiency of about 20% a thermophotovoltaic system 200 according to the present invention combusting 1L of Methanol, will produce:

- about 1kWh electric energy at the output terminal of the photovoltaic cell 7;
- about 4kWh heat from the thermal energy source 50 and/or the flow-through heat transfer chamber 2.2 and/or through the cooling agent output 6.2 of the cooling layer 6; and
- about 1L pure Water at an output side of the condenser unit 60.

[0042] It will be understood that many variations could be adopted based on the specific structure hereinbefore described without departing from the scope of the invention as defined in the following claims.

REFERENCE LIST:

energy conversion and transfer arrangement	10
total reflector	1
electro-magnetic radiation emitter	2
flow-through heat transfer area	X
input side	X.4
output side	X.5
electro-magnetic radiation emitter	2
spectral shaper	3
input surface	3.X
barrier layer	3.1
heat conduction barrier	4
spectral filter	5
active cooling layer	6
cooling agent input	6.1
cooling agent output	6.2
photovoltaic cell	7
anti-reflection layer	7.1
front plane contacts	7.3
conversion area	7.5
electrical back plane contacts	7.7
reflective layer	7.9
thermophotovoltaic device	100
thermophotovoltaic system	200
fuel source	50
waste heat recovery unit	55
condenser unit	60

CLAIMS:

1. An energy conversion and transfer arrangement (10) comprising:
   - a spectral shaper (3) with an input surface (3.X) defining a flow-through heat transfer area (X);
   - an electro-magnetic radiation emitter (2) arranged within said flow-through heat transfer area (X) allowing for surface specific fuel combustion processes such as catalytic conversion which heat up the emitter to high temperatures, the electro-magnetic radiation emitter (2) being configured for emitting predominantly near-infrared radiation when exposed to high temperature;

   wherein the spectral shaper (3):
   - is configured as a **band pass filter for a first, optimal spectral band** of the radiation emitted by the electro-magnetic radiation emitter (2) when exposed to high temperature; and/ or
   - is configured as a **reflector for further, non-optimal spectral band(s)** of the radiation emitted by the electro-magnetic radiation emitter (2), so that said second, non-optimal spectral band radiation is recycled as radiation redirected towards the electro-magnetic radiation emitter (2).

2. An energy conversion and transfer arrangement (10) according to claim 1, **characterized in that** the input surface (3.X) of the spectral shaper (3) defining said flow-through heat transfer area (X) is provided with a catalytic coating in order to maximize heat transfer between a thermal energy carrier (fuel) within the flow-through heat transfer area (X) and the electro-magnetic radiation emitter (2).

3. An energy conversion and transfer arrangement (10) according to claim 1 or 2,
   characterized in that a barrier layer (3.1) which is transparent to near infrared radiation - preferably a quartz barrier layer - is provided between said heat transfer- emitter unit (2) and the spectral shaper (3).

4. An energy conversion and transfer arrangement (10) according to one of the claims 1 to 3,
characterized in that said spectral shaper (3) comprises a layer of selective emitter material such as a rare-earth containing layer, preferably an Ytterbium- oxide Yb_2O_3 or Platinum emitter layer and/or a nanostructured filter layer.

5. A thermophotovoltaic device (100) comprising:
- an energy conversion and transfer arrangement (10) according to one of the claims 1 through 4; and
- a photovoltaic cell (7) arranged adjacent to said energy conversion and transfer arrangement (10) in a radiating direction of its electro-magnetic radiation emitter (2).

6. A thermophotovoltaic device (100) according to claim 5,
characterized in that a heat conduction barrier (4), e.g. in the form of a vacuum or aerogel layer is provided between said spectral shaper (3) and the photovoltaic cell (7).

7. A thermophotovoltaic device (100) according to claim 5 or 6,
characterized in that a spectral filter (5) is provided between the spectral shaper (3) of the energy conversion and transfer arrangement (10) and the photovoltaic cell (7).

8. A thermophotovoltaic device (100) according to one of the claims 5 to 7,
characterized in that an active cooling layer (6) is provided between the spectral shaper (3) of the energy conversion and transfer arrangement (10) and the photovoltaic cell (7) and/or at a back side of the photovoltaic cell (7) directed in opposite direction as the spectral shaper (3), wherein said active cooling layer (6) comprises a cooling agent, such as water or other coolant between a cooling agent input (6.1) and a cooling agent

output (6.2), the cooling layer (6) being configured so as to absorb lower wavelength radiation emitted by the spectral shaper (3) and/ or the electro-magnetic radiation emitter (2) of the energy conversion and transfer arrangement (10), providing cooling to the photovoltaic cell (7) by thermal connection.

9. A thermophotovoltaic device (100) according to claim 8, **characterized in that** micro-channels are provided in the cooling layer (6), connecting said cooling agent input (6.1) and said cooling agent output (6.2) in order to improve the radiation absorption of the cooling layer (6).

10. A thermophotovoltaic device (100) according to one of the claims 5 to 9, **characterized in that** the photovoltaic cell (7) comprises a conversion area (7.5) - optimized for predominantly near-infrared radiation - arranged in an emitting direction of the spectral shaper (3) and/ or the electro-magnetic radiation emitter (2) of the energy conversion and transfer arrangement (10).

11. A thermophotovoltaic device (100) according to claim 10, **characterized in that** the photovoltaic cell (7) comprises an anti-reflection layer (7.1) situated on a first surface of the conversion area (7.5) directed towards said emitting direction of the spectral shaper (3) and/ or the electro-magnetic radiation emitter (2) of the energy conversion and transfer arrangement (10) and a reflective layer (7.9) on a second surface of the conversion area (7.5) situated on an opposite direction as said first surface, wherein electrical back plane contacts (7.7) are located between said conversion area (7.5) and said reflective layer (7.9) and wherein electrical front plane contacts (7.3) are located between said anti-reflection layer (7.1) and the conversion area (7.5).

12. A thermophotovoltaic device (100) according to one of the claims 5 to 11, **characterized in that** it is arranged structurally and/or functionally

symmetrical with respect to the electro-magnetic radiation emitter (2) with at least one spectral shaper (3) and photovoltaic cell (7) in each direction of symmetry.

13. A thermophotovoltaic device (100) according to claim 12, **characterized in that** it is arranged in a cross shape, with at least one spectral shaper (3) and photovoltaic cell (7) in each direction of the cross.

14. A thermophotovoltaic device (100) according to one of the claims 6 to 11, **characterized in that:**
- the spectral shaper (3); and/or
- photovoltaic cell (7); and/or
- the barrier layer (3.1); and/or
- the heat conduction barrier (4); and/or

are configured as open cylindroids, preferably open cylinders preferably arranged coaxially around the electro-magnetic radiation emitter (2).

15. A thermophotovoltaic system (200) comprising:
- a thermophotovoltaic device (100) according to one of the claims 5 to 14;
- a fuel source (50), arranged such as to direct a combustable fuel mixture from the fuel source (50) towards an input side (X.4) of said flow-through heat transfer area (X), configured such that the combustion is essentially limited to the surface of the electro-magnetic radiation emitter (2) and so that combustion of the fuel mixture in the gas phase is minimized.

16. A thermophotovoltaic system (200) according to claim 14, **characterized in that** said fuel source (50) is a chemical energy source, wherein the chemical energy carrier is a fossil fuel such as methanol.

17. A thermophotovoltaic system (200) according to claim 15 or 16, **characterized in that** the system further comprises a waste heat

recovery unit (55) configured to recover heat from exhaust gases at an exhaust side (X.5) of the flow-through heat transfer area (X) and feed back said recovered heat to said input side (X.4).

18. A thermophotovoltaic system (200) according to one of the claims 15 to 17,
characterized in that it is configured as a portable energy source such as to simultaneously or selectively:
- act as a heat source providing heat radiation from the fuel source (50) and/or the flow-through heat transfer area (X);
- act as a source of electric energy providing electric energy at an output terminal of the photovoltaic cell (7);
- act as a light source, the electro-magnetic radiation emitter (2) being configured such as to provide electro-magnetic-radiation in the visible spectrum when exposed to high temperature.

19. A thermophotovoltaic system (200) according claim 18,
characterized in that it further comprises a condenser unit (60) configured to recover liquid by condensing vapour in the exhaust gases at said exhaust side (2.5) of the flow-through heat transfer area (X), preferably condensing water vapours resulting from combustion of Methanol as fuel, the thermophotovoltaic system (200) thus being further configured as a source of pure water.

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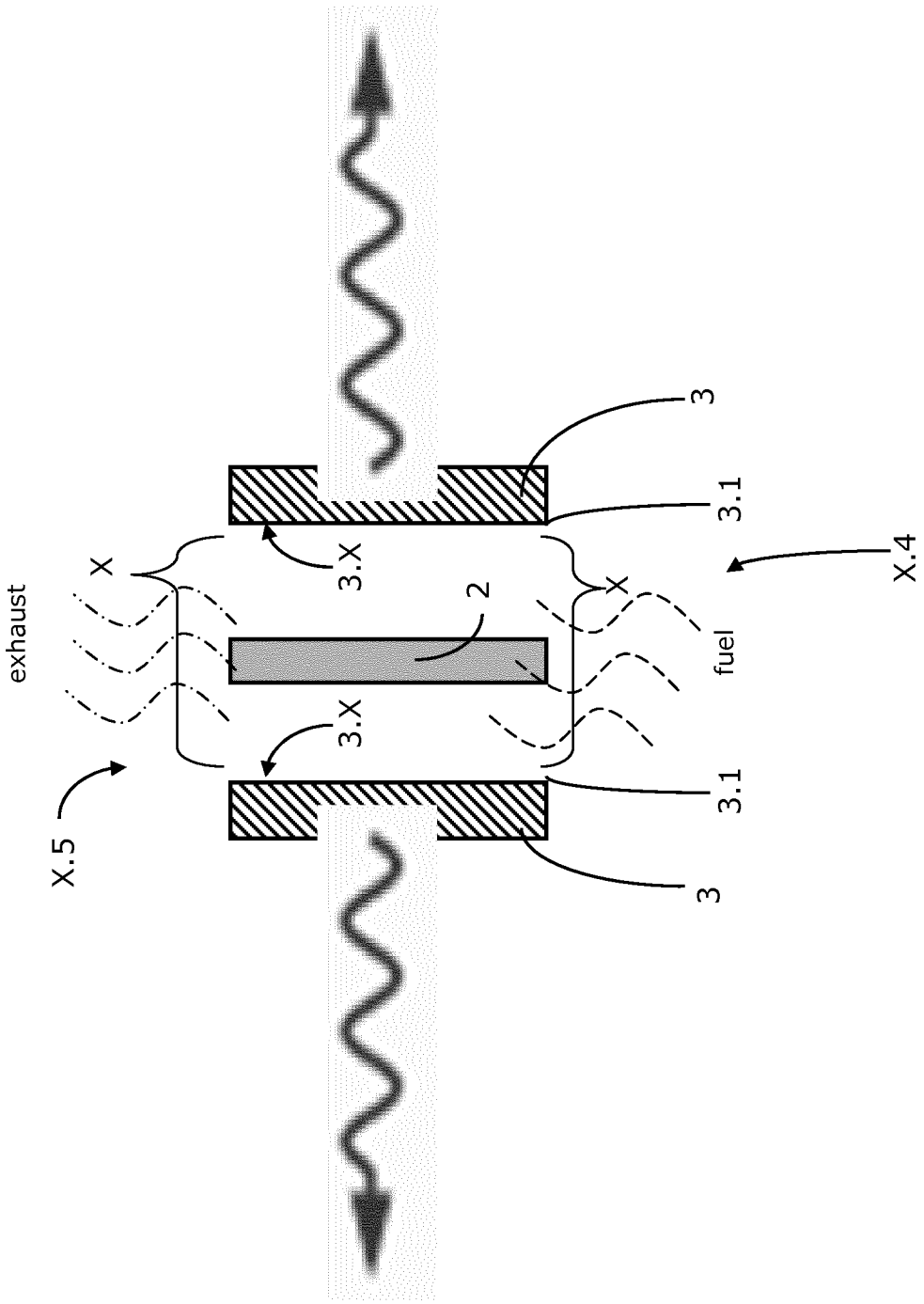


Fig. 1

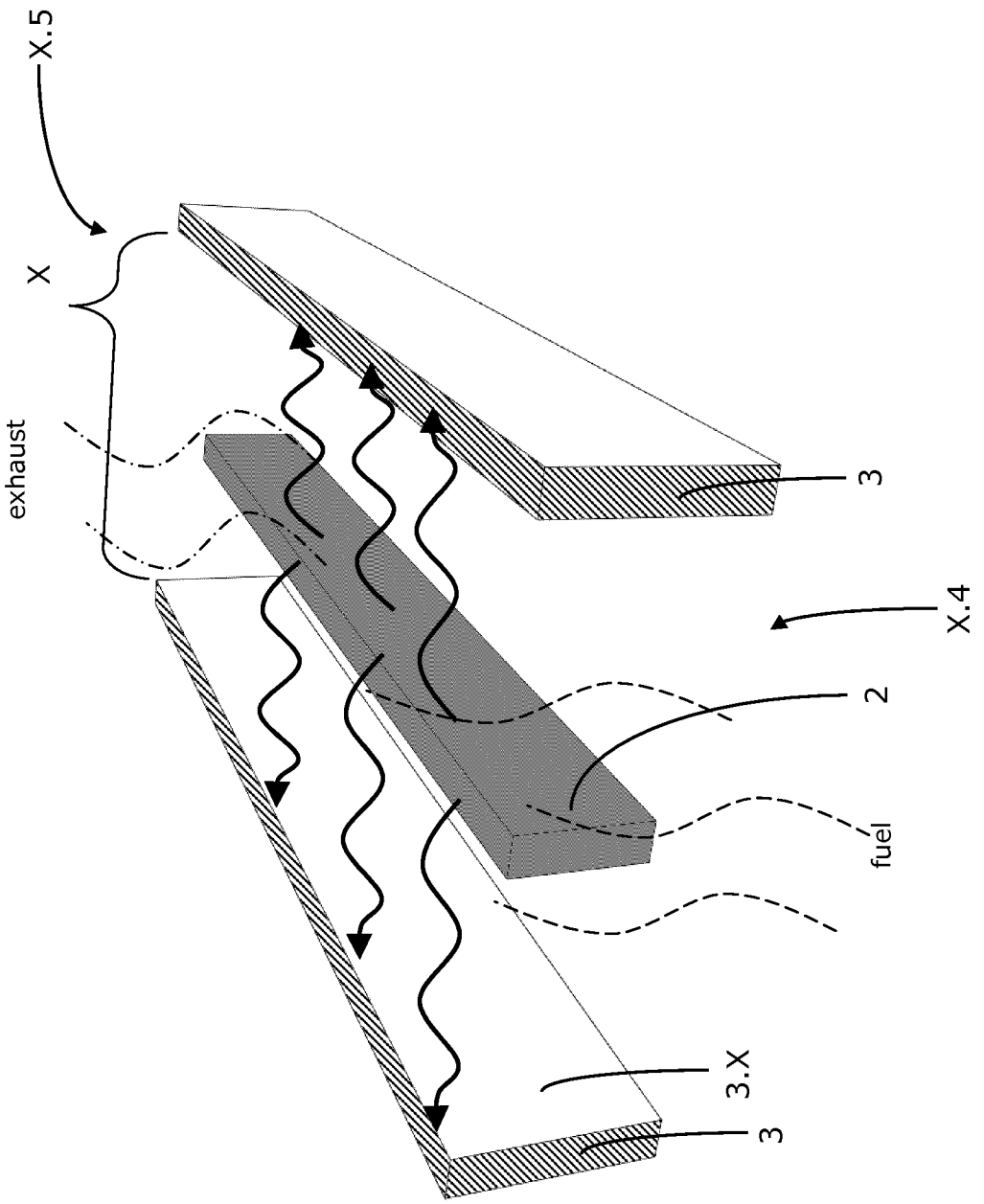


Fig. 2A

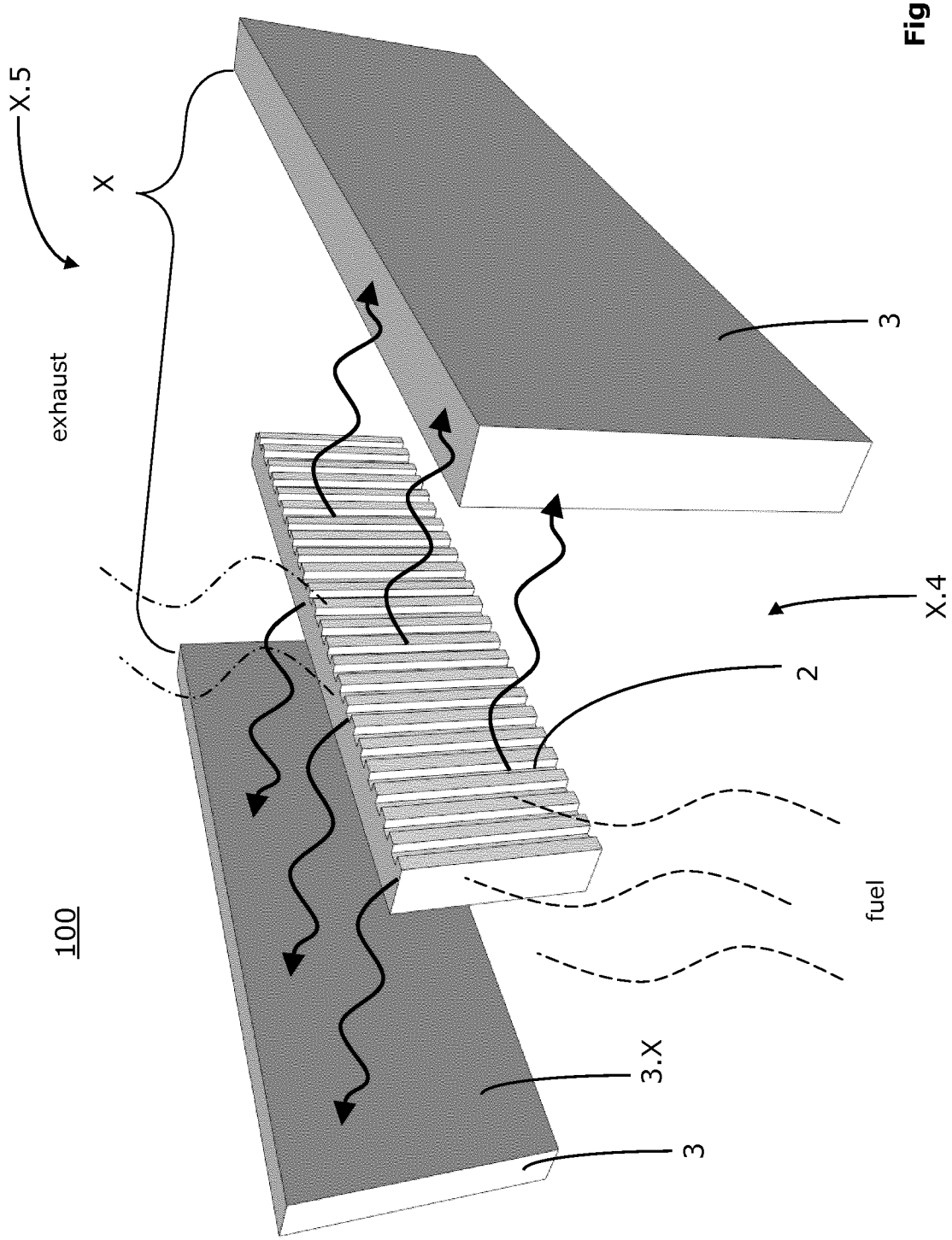


Fig. 2B

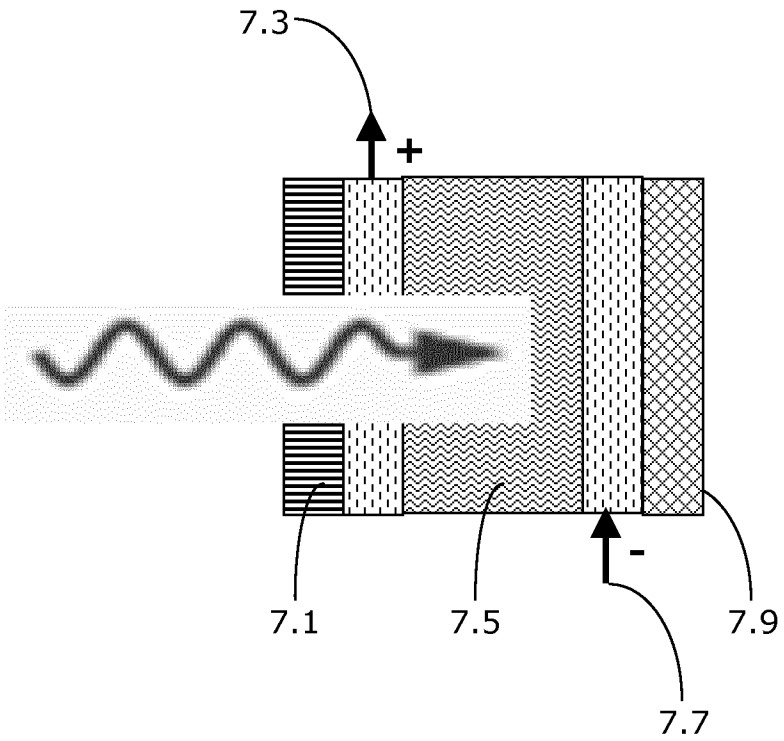


Fig. 3

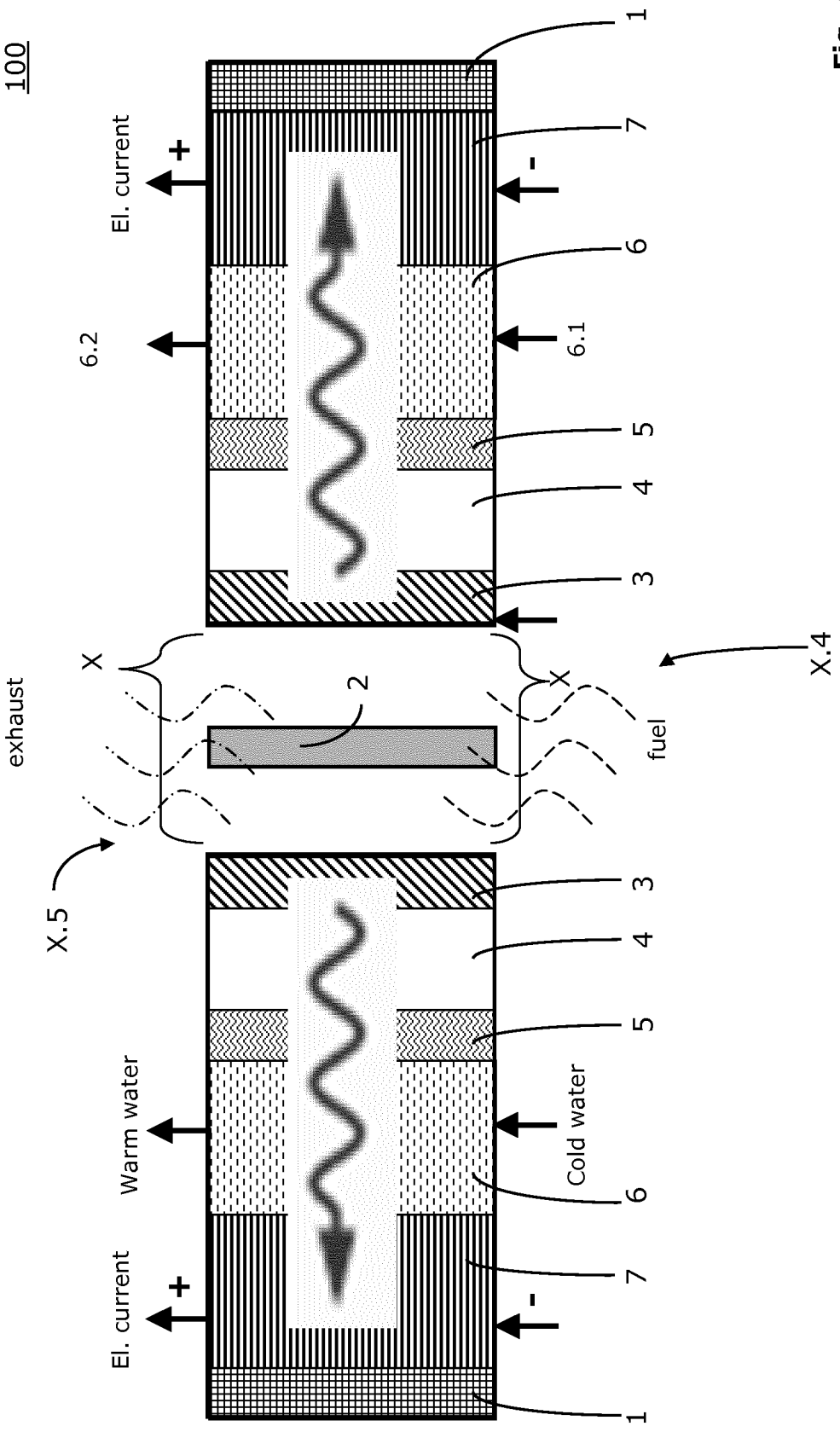

100
El. current
+
-
6.2
6.1
1
7
6
5
4
3
exhaust
X
2
fuel
X.4
X.5
Warm water
Cold water
El. current
+
-

Fig. 4

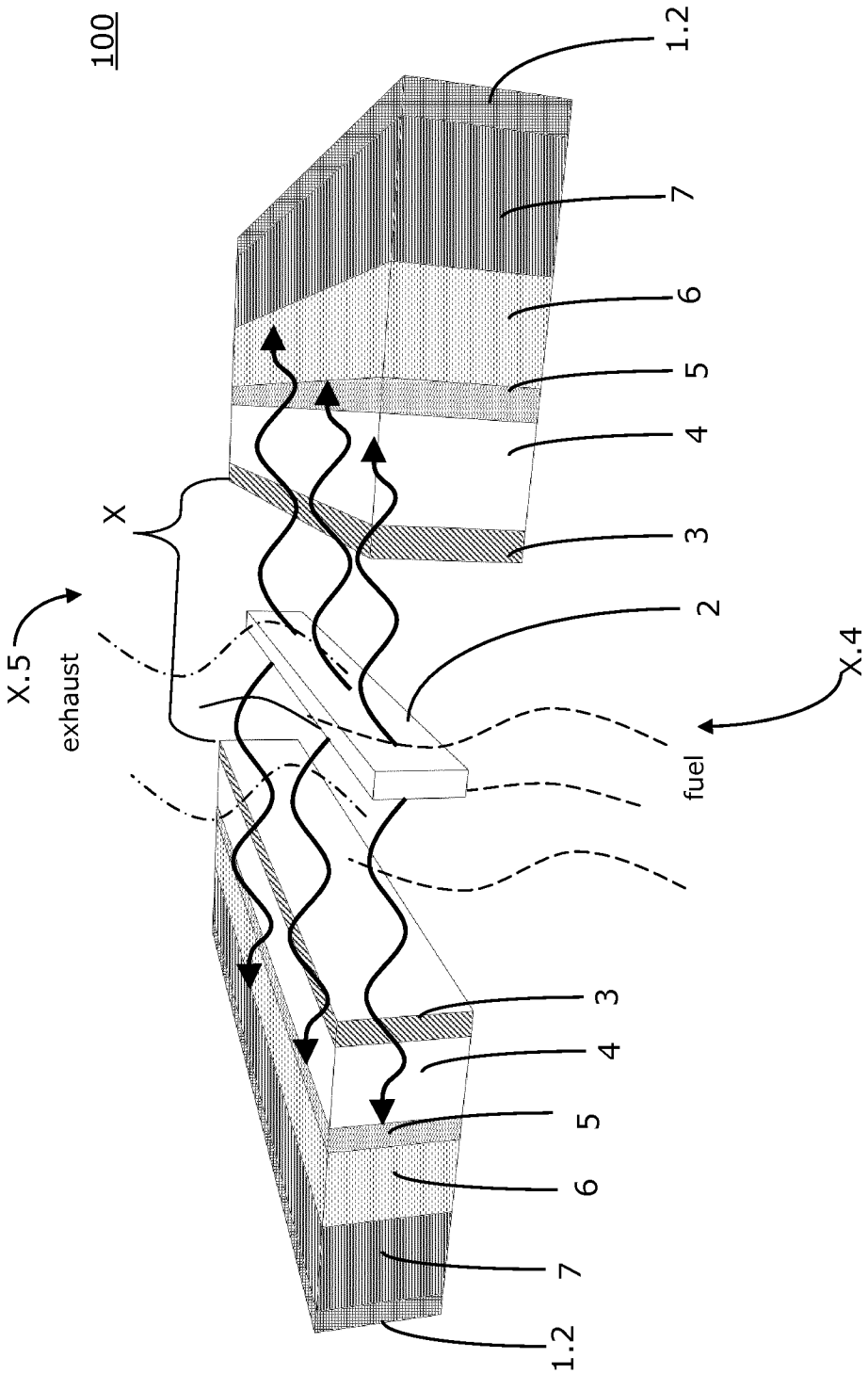
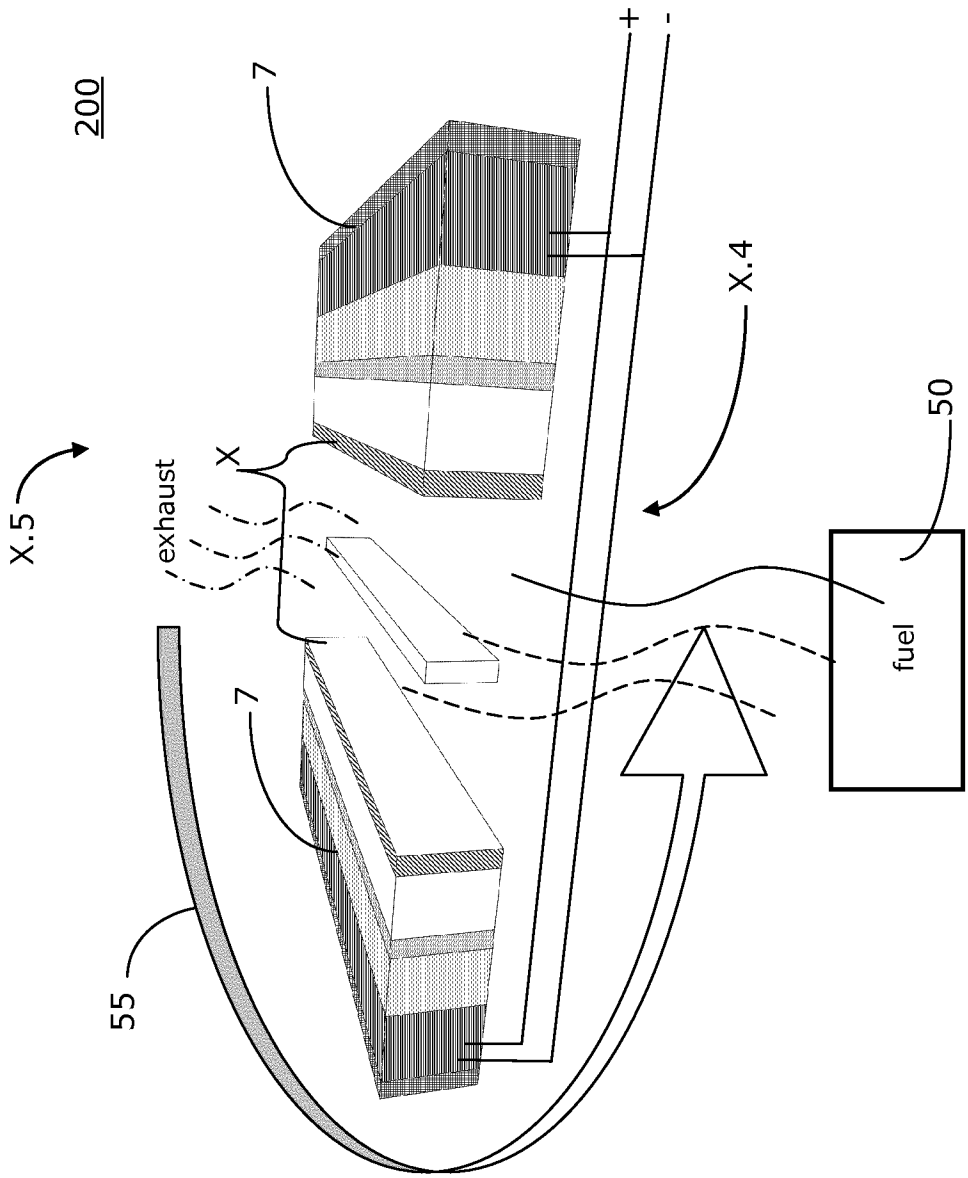


Fig. 5

Fig. 6



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/066798

A. CLASSIFICATION OF SUBJECT MATTER
INV. F23M99/00 F23D14/18 F23D14/16 F23D14/12 F23C13/00 H01L31/04
ADD.
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)
F23M F23D F23C H01L

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 practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] 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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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 January 2014	17/01/2014

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Coli, Enrico

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/066798

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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