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- (54) **Title:** A DEVICE FOR THE THIN FILM REGENERATIVE CONDENSATION, AND THE METHOD THEREOF

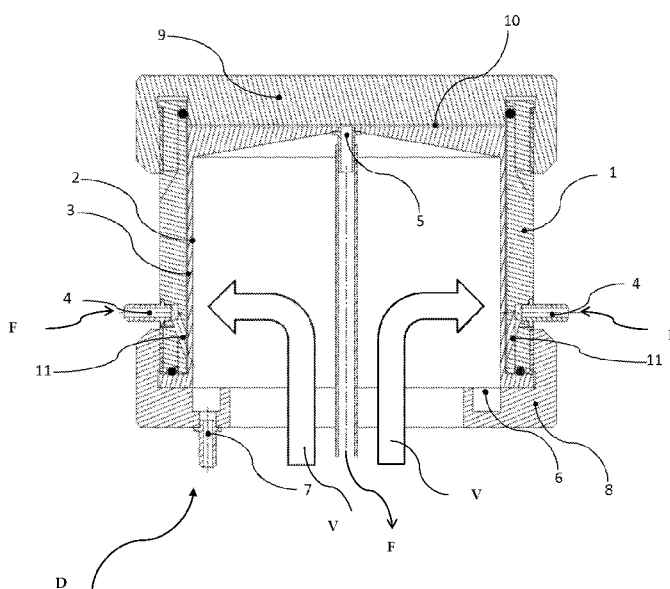


FIG. 1

(57) **Abstract:** The invention refers to a device (D) for the thin film regenerative condensation comprising, in particular, a thin cavity (3) located between a first outer element (1) and a second inner element (2) and suitable to confine as a thin film a fluid (F) to be heated and/ or pre-evaporated by means of a flow of steam (V) introduced into said device (D), said steam (V) being in turn condensed and the condensate thus obtained being collected in a collection tank (6); the invention also refers to the relevant method for the thin film regenerative condensation that uses said device and that provides, in particular, to take advantage of the sensible heat and of the latent heat of condensation of a flow of steam (V) to heat and/ or pre-evaporate a fluid (F). The device and the method according to the present invention are preferably and advantageously employed, in combination with solar steam generators, for condensing steam in purification and/ or desalination plants for sea, river, swamp or rain water; the present invention is particularly suitable for use in remote regions and for so-called "off-grid" applications.

“A device for the thin film regenerative condensation, and the method thereof”

DESCRIPTION

TECHNICAL FIELD

The present invention refers to the energy sector and, specifically, to the recovery of heat, both sensible and latent, from a flow of steam.

More precisely, the present invention relates to a device, and to the relevant method, for the regenerative condensation.

Even more precisely, the present invention relates to a device, and to the relevant method, for the regenerative condensation in which a fluid is confined as a thin film and heated and/or made to pre-evaporate by means of a flow of steam.

The present invention is preferably and advantageously applied when employed, in combination with solar steam generators, for condensing steam in purification and/or desalination plants for sea, river, swamp or rain water; the present invention is particularly suitable for use in remote regions and for so-called “off-grid” applications.

PRIOR ART

Steam condensers are known, namely devices for water condensation from the vapor phase to the liquid one.

Examples of such devices are described, for example, in the International application published at no. WO 2011/035283 A2, in the US Patent application no. US 2008/0164135 A1 and in the International application published at no. WO 2009/009873 A1.

In particular, the International application published at no. WO 2011/035283 A2 describes a distillation device to produce drinking water starting from solar energy and, in particular, among the several proposed alternatives, it provides for the use of a rigid dome structure for pre-heating the non-drinking water to be treated; the solution described in such document, though addressing the technical problem of recovering part of the latent heat of condensation, which becomes available during the distillation process, however is not able to flexibly adapt to different types of

equipment for the production of steam, but it requires a specific form of the steam generator itself being able to realize the mechanical coupling; furthermore, it does not have the possibility of manually or automatically varying the thickness of the thin cavities within which the fluid to be processed flows, so as to adapt them to the particular operating conditions (for example, the intensity of the solar radiation); finally, the conformation as a dome or as a conical pyramid, are neither simple to be realized by means of the traditional mechanical processing nor the most efficient ones.

The US Patent application no. US 2008/0164135 A1 describes a generic paraboloid concentration system for the treatment of water, in which a regenerator formed of a duct, onto which another spiral duct is wound, is also provided; however, such solution is not able to guarantee high regeneration efficiencies, since the steam will transfer only part of its heat of condensation when passing along the central duct, due to the reduced view factor of the cold surface, and moreover the ratio of the heat of condensation to the mass of fluid to be preheated is given by the diameter of the central duct itself.

The International application published at no. WO 2009/009873 A1 describes a desalination generic unit with solar chamber, in which the produced steam transfers part of its heat of condensation to the water feed tank; however, such solution is not able to guarantee high regeneration efficiencies because the heat of condensation is transferred to a tank with the consequent thermal dissipation and, similarly to the previous document, the ratio of the heat of condensation to the mass of fluid to be preheated is given by the size of the feed tank.

In brief, the solutions described in the aforesaid documents, though addressing the technical problem of carrying out the regenerative condensation of steam, neither allow to maximize the view factor of the cold surface that causes the condensation of the steam nor the ratio of the heat of condensation transferred from the steam to the mass of fluid to be preheated. They also neither have the necessary geometrical flexibility to adapt to different evaporators nor the possibility to regulate, manually or automatically, the ratio of the heat of condensation to the mass of fluid to be

preheated.

Devices and methods for the thin film condensation of steam are also known; an example is shown in the US Patent no. US 4,135,985, which describes a desalination unit with solar container, in which the transparent surface for the passage of solar radiation has a siphon for recovering the heat of condensation of the produced steam and a heat recovery system from the concentrated salt solution. However, the aforesaid technical solution provides that the thin film regenerator is transparent, with consequent optical losses due to the passage of the solar radiation through the two surfaces delimiting the thin film, and also that it does not cover the complete condensing surface seen by the produced vapor.

Therefore, the need to carry out a thin film regeneration able to adapt to a generic evaporator, with a high view factor of the condensing surface with respect to the produced vapor, so as to ensure the highest possible efficiencies, remains unsatisfied. Furthermore, the need to effectively adjust the thickness of the thin film, so as to adapt it to the operating conditions of exercise, and in particular to adjust the ratio of the heat of condensation to the mass of fluid to be preheated, remains unsatisfied.

In brief, up to the present time, to the Applicant's knowledge, there are not known solutions allowing to carry out the condensation with a high efficiency recovery of the latent condensation energy as well as of the sensible one; therefore, the Applicant, with the device and the method according to the present invention, intends to remedy such lack.

OBJECTS AND SUMMARY OF THE INVENTION

It is an object of the present invention to overcome the drawbacks of the known prior art related to the steam regenerative condensation.

It is a specific object of the present invention to overcome the drawbacks of the known prior art related to the regenerative condensation in which a fluid under the form of a thin film is heated and/or made to pre-evaporate by means of a steam flow that, in turn, condenses.

More precisely, the present invention intends to solve the problem of carrying out a thin film regeneration, able to adapt to a generic evaporator, with a high view factor

of the condensing surface with respect to the produced steam and the ability to adjust the ratio of the heat of condensation to the mass of fluid to be preheated.

In particular, an object of the present invention is to provide a device for the regenerative condensation in which the fluid that is heated and/or made to evaporate flows in the form of a thin film.

Furthermore, an object of the present invention is to provide a method for the regenerative condensation in which the fluid that is heated and/or made to evaporate flows in the form of a thin film and the heating and/or the pre-evaporation takes place thanks to the transfer of sensible and latent heat of a steam flow.

More precisely, an object of the present invention is to provide a device, and the relevant method, for the regenerative condensation that, thanks to the confinement in a thin film of the fluid to be treated, allow to significantly reduce the residence time and the conduction thermal losses towards the environment and, therefore, to realize a high efficiency recovery of latent and sensible heat.

The aforesaid and other objects and advantages of the invention, as they will appear from the following description, are achieved with a device for the thin film regenerative condensation like the one according to claim 1.

Moreover, the aforesaid and other objects and advantages of the invention are achieved with a method for the thin film regenerative condensation like the one according to claim 7.

Preferred embodiments and variants of the device and the method of the present invention form the subject-matter of the dependent claims; in particular, in a preferred and advantageous embodiment, the device and the method according to the invention provide the combination with a solar steam generator.

In a further embodiment, the device and the method according to the present invention are employed in the purification and/or desalination plants for sea, river, swamp or rain water.

It is understood that all the appended claims form an integral part of the present description and that each of the technical features therein claimed is possibly

independent and autonomously usable with respect to the other aspects of the invention.

It will be immediately evident that countless modifications (for example relevant to shape, sizes, arrangements and parts with equivalent functionality) could be brought to what described without departing from the scope of the invention as claimed in the appended claims.

Advantageously, the technical solution according to the present invention that realizes the thin film regenerative condensation, allows:

- the high efficiency recovery of latent and sensible heat thanks to the confinement in a thin film of the fluid to be treated, which reduces as much as possible the residence time and the conduction thermal losses towards the outside;
- the maximization of the view factor for optimal steam collection (for example, very low steam losses in the environment) thanks to the hollow configuration of the device, able to house the steam generator thereinside;
- the minimization of the convection thermal losses always thanks to the hollow configuration of the device, and in particular to the opening facing downwards, which prevents the formation of the convective flows of air in contact with the hot surfaces;
- the full control of the fluid flow through the adjustment of an interstice within which such fluid flows;
- the easiness of collecting the condensed water in a compact and integrated piping;
- the use in remote regions and for so-called "off-grid" applications thanks to the inherent simplicity and robustness as well as to the fact that it does not require any electrical energy;
- the use in solar applications, such as the purification and/or desalination of sea, river, swamp or rain water, in which the proposed invention allows the use of reflective means for the concentration and for giving the direction of the radiation instead of using lenses systems that typically have lower optical efficiencies;
- the recovery of heat from industrial processes with steam production;
- the increase the optical efficiency because it does not require the use of transparent

materials; and

- the realization by means of innovative technologies, such as the 3D printing, thanks to the use of common materials.

Further advantageous features will appear more evident from the following description of preferred but not exclusive embodiments, merely given by way of explanatory and not limiting example.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be described hereinbelow by means of some preferred embodiments, given by way of explanatory and not limiting example, with reference to the accompanying drawings. These drawings illustrate different aspects and examples of the present invention and, where appropriate, similar structures, components, materials and/or elements in different figures are denoted by similar reference numbers.

FIG. 1 is a schematic representation, in section, of a general embodiment of the device for the thin film regenerative condensation according to the present invention;

FIG. 2 is a flow chart showing the steps of the method for the thin film regenerative condensation according to the present invention;

FIG. 3A is a schematic representation, partially in section, of a first variant of the preferred embodiment of the device for the thin film regenerative condensation according to the present invention; and

FIG. 3B is a schematic representation, partially in section, of a second variant of the preferred embodiment of the device for the thin film regenerative condensation according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

While the invention is susceptible of various modifications and alternative constructions, some preferred embodiments are shown in the drawings and will be described in detail hereinbelow.

It should be understood, however, that there is no intention to limit the invention to the specific illustrated embodiment but, on the contrary, the invention intends to cover all the modifications, alternative constructions and equivalents that fall within

the scope of the invention as defined in the claims.

In the following description, therefore, the use of “for example”, “etc.” and “or” denotes non-exclusive alternatives without limitation, unless otherwise indicated; the use of “also” means “among, but not limited to”, unless otherwise indicated; the use of “includes / comprises” means “includes / comprises, but not limited to”, unless otherwise indicated.

The device and the method of the present invention are based on the innovative concept of confining a fluid to be heated and/or made to re-evaporate in the form of a thin film, so as to very efficiently recover sensible heat and latent heat of condensation of a steam flow.

An important feature of said device and method resides in the fact that they do not require any electrical energy and, therefore, they are particularly suitable - although certainly not limited - to remote or so-called “off-grid” applications.

In the present description, the term “regenerative condensation” means the process of condensation of a vapor, in which the latent heat of condensation is transferred to a fluid so as to pre-heat it and, possibly, to cause also a partial evaporation thereof.

In the present description, the term “thin film” means a thin layer of fluid confined in the thin cavity between two surfaces.

In the present description, with the term “view factor of the condensing surface with respect to the produced steam” means the ratio of the surface area onto which the regenerative condensation takes place (i.e. the transfer of sensible and latent heat transfer to the fluid F) to the area of the total surface onto which the condensation takes place (also including the non-regenerative one).

With reference to Fig. 1, the device D for the thin film regenerative condensation, comprises:

- a thermally insulating first outer element 1,
- a conductive second inner element 2 onto which a flow of steam V to be condensed is made to flow,
- a thin cavity 3 located between said first outer element 1 and said second inner element 2 and suitable to confine as a thin film a fluid F

- to be heated and/or pre-evaporated,
- at least one inlet hole 4 for the entry of said fluid F and at least one corresponding duct 11 connected with said thin cavity 3,
 - an outlet hole 5 for the discharge of said fluid F heated and/or pre-evaporated,
 - a collection tank 6 for the condensate,
 - a nozzle 7 for the discharge and for the collection of the condensate,
 - first means 8 for holding in position said collection tank 6, and
 - second moving means 9 for controlling the passage of said fluid F from said inlet hole 4 to said outlet hole 5 inside an interstice 10.

Preferably, said thermally insulating first outer element 1 is made of plastic material; more preferably is in polymethylmethacrylate; even more preferably it consists in a compartment in which the vacuum was obtained (as in the Dewar flasks), to achieve the maximum thermal insulation.

Preferably said thermally insulating first outer element 1 has a thickness ranging between 4 mm and 20 mm, more preferably has a thickness of 8 mm.

It is intended here to specify that "outer" is considered the element of the device D placed on the opposite side with respect to the chamber in which the flow of steam V to be condensed is fed.

Preferably said conductive second inner element 2 is made of metal, possibly with an antioxidant protective coating; more preferably it is copper or aluminum with an antioxidant protective coating.

Preferably said antioxidant protective coating is realized by means of an antioxidant paint; more preferably is an antioxidant acrylic paint for copper or aluminum.

Preferably said conductive second inner element 2 has a thickness ranging between 1 mm and 3 mm, more preferably has a thickness of 2 mm.

It is intended here to specify that "inner" is considered the element of the device D placed on the side of the chamber into which the flow of steam V to be condensed is

fed.

Said vapor V can be any vapor depending on the specific needs, for example, can be vapor produced as scrap and/or over-production of industrial processes, possibly also contaminated; however, since the device according to the present invention is preferably and advantageously employed in combination with a solar steam generator for steam condensing in purification and/or desalination plant, said vapor V is preferably water steam.

Said vapor V will preferably have a temperature between 100 °C and 130 °C, more preferably will be at a temperature of about 105 °C.

Preferably said thin cavity 3 has a size ranging between 100 µm and 1,000 µm, more preferably equal to 300 µm.

Preferably said thin cavity 3 is obtained by inserting a thin frame or a thin spacer between said first outer element 1 and said second inner element 2 or by means of suitable centering obtained in the first means 8.

Preferably said thin film of said fluid F present in said thin cavity 3 has a thickness ranging between 100 µm and 1,000 µm, more preferably equal to 300 µm.

Preferably said thin film of said fluid F present in said thin cavity 3 has a residence time ranging between 30 seconds and 500 seconds, more preferably equal to 200 seconds.

Said thin film of said fluid F present in said thin cavity 3 allows to achieve a high efficiency in terms of recovery of sensible heat and latent heat of condensation; preferably it said recovery efficiency ranges between 60 % and 95 %, more preferably is equal to 80 %.

Said fluid F can be any fluid depending on the specific needs; however, since the device according to the present invention is preferably and advantageously employed in combination with a solar steam generator for the steam condensation in purification and/or desalination plants, said fluid F is preferably contaminated or salt or brackish, sea , river, swamp or rain water.

Said fluid F in correspondence of the inlet hole 4 will preferably have a temperature between 5 °C and 50 °C, more preferably it will be at the ambient temperature of about 20 °C.

Preferably said at least one inlet hole 4 for the entry of said fluid F has a diameter ranging between 4 mm and 50 mm, more preferably equal to 10 mm.

Preferably said at least one duct 11 corresponding to said at least one inlet hole 4 and connected with said thin cavity 3 has a diameter ranging between 4 mm and 30 mm, more preferably equal to 10 mm, and a length ranging between 3 mm and 20 mm, more preferably equal to 12 mm.

Preferably said outlet hole 5 for the discharge of said heated and/or pre-evaporated fluid F has a diameter ranging between 4 mm and 50 mm, more preferably equal to 10 mm.

Preferably said collection tank 6 for the condensate is a circular gutter, which extends for the entire circumference of said device D, into which the vapor V cooling and condensing glides by gravity.

Preferably said nozzle 7 for discharging and collecting the condensate has a diameter ranging between 4 mm and 50 mm, more preferably equal to 10 mm; said nozzle 7 is connected to said collection tank 6.

Preferably said first means 8 and said second moving means 9 are ferrules.

Preferably said second moving means 9 can vary the size of said interstice 10 between 100 μm and 1,000 μm ; more preferably said second moving means 9 can reduce said interstice 10 to zero, i.e. up to putting said interstice 10 in contact with said second inner element 2, actually acting as an adjusting valve of the flow of the fluid F.

With reference to Fig. 2, it is shown the method for the thin film regenerative condensation, comprising the following steps:

- a. providing at least one device D comprising:
 - a thermally insulating first outer element 1,

- a conductive second inner element 2 onto which a flow of steam V to be condensed is made to flow,
 - a thin cavity 3 located between said first outer element 1 and said second inner element 2 and suitable to confine as a thin film a fluid F to be heated and/or pre-evaporated,
 - at least one inlet hole 4 for the entry of said fluid F and at least one corresponding duct 11 connected with said thin cavity 3,
 - an outlet hole 5 for the discharge of said fluid F heated and/or pre-evaporated,
 - a collection tank 6 for the condensate,
 - a nozzle 7 for the discharge and for the collection of the condensate,
 - first means 8 for holding in position said collection tank 6, and
 - seconds moving means 9 for controlling the passage of said fluid F from said inlet hole 4 to said outlet hole (5) inside an interstice 10,
- (step 101);
- b. feeding said fluid F in said device D (step 102);
- c. confining as a thin film said fluid F inside said thin cavity 3 (step 103);
- d. feeding steam V inside said device D and putting it in contact with said second inner element 2, so that said steam V condensates and said fluid F is heated and/or pre-evaporated (step 104);
- e. controlling the passage of said fluid F into said interstice 10 through said second moving means 9 (step 105);
- f. conveying towards a user said fluid F heated and/or pre-

evaporated (step 106); and

- g. collecting the produced condensate into said collection tank 6 (step 107).

Preferably the device to be used in step 101 of the method according to the present invention will have the following features:

- said thermally insulating first outer element 1 is made of plastic material; more preferably is in polymethylmethacrylate; even more preferably it consists in a compartment in which the vacuum was obtained (as in the Dewar flasks), to achieve the maximum thermal insulation; preferably said thermally insulating first outer element 1 has a thickness ranging between 4 mm and 20 mm, more preferably has a thickness of 8 mm;
- preferably said conductive second inner element 2 is made of metal, possibly with an antioxidant protective coating; more preferably it is copper or aluminum with an antioxidant protective coating; preferably said antioxidant protective coating is realized by means of an antioxidant paint; more preferably is an antioxidant acrylic paint for copper or aluminum; preferably said conductive second inner element 2 has a thickness ranging between 1 mm and 3 mm, more preferably has a thickness of 2 mm;
- preferably said thin cavity 3 has a size ranging between 100 μm and 1,000 μm , more preferably equal to 300 μm ;
- preferably said thin film of said fluid F present in said thin cavity 3 has a thickness ranging between 100 μm and 1,000 μm , more preferably equal to 300 μm ; preferably said thin film of said fluid F present in said thin cavity 3 has a residence time ranging between 30 seconds and 500 seconds, more preferably equal to 200 seconds; preferably said recovery efficiency ranges between 60 % and 95 %, more preferably is equal to 80 %;
- preferably said at least one inlet hole 4 for the entry of said fluid F has a diameter ranging between 4 mm and 50 mm, more preferably equal to 10 mm;

- preferably said at least one duct 11 corresponding to said at least one inlet hole 4 and connected with said thin cavity 3 has a diameter ranging between 4 mm and 30 mm, more preferably equal to 10 mm, and a length ranging between 3 mm and 20 mm, more preferably equal to 12 mm;
- preferably said outlet hole 5 for the discharge of said heated and/or pre-evaporated fluid F has a diameter ranging between 4 mm and 50 mm, more preferably equal to 10 mm;
- preferably said collection tank 6 for the condensate is a circular gutter, which extends for the entire circumference of said device D, into which the vapor V cooling and condensing glides by gravity;
- preferably said nozzle 7 for discharging and collecting the condensate has a diameter ranging between 4 mm and 50 mm, more preferably equal to 10 mm;
- preferably said first means 8 and said second moving means 9 are ferrules; preferably said second moving means 9 can vary the size of said interstice 10 between 100 μm and 1,000 μm ; more preferably said second moving means 9 can reduce said interstice 10 to zero, i.e. up to putting said interstice 10 in contact with said second inner element 2, actually acting as an adjusting valve of the flow of the fluid F.

Said fluid F can be any fluid depending on the specific needs; however, since the method according to the present invention is preferably and advantageously employed by combining said device D with a solar steam generator for the steam condensation in purification and/or desalination plants, said fluid F is preferably contaminated or salt or brackish, sea, river, swamp or rain water.

Said fluid F in correspondence of the inlet hole 4 will preferably have a temperature between 5 °C and 50 °C, more preferably it will be at the ambient temperature of about 20 °C.

Said vapor V can be any vapor depending on the specific needs, for example, can be vapor produced as scrap and/or over-production of industrial processes, possibly

also contaminated; however, since the method according to the present invention is preferably and advantageously employed by combining said device D with a solar steam generator for steam condensing in purification and/or desalination plant, said vapor V is preferably water steam.

Said vapor V will preferably have a temperature between 100 °C and 130 °C, more preferably will be at a temperature of about 105 °C.

The condensation of said vapor V produces a quantity of condensate ranging between 1 kg/h/m² and 20 kg/h/m², preferably equal to 6 kg/h/m², relative to the surface of the downward opening in the first means 8.

Said condensate is, preferably, fresh and/or drinking water.

As regards the operation of the device D for the thin film regenerative condensation, it is observed that vapor V enters, preferably from downwards, in the chamber of said device D and laps the surface of said inner element 2; in this way, the vapor V transfers its sensible heat, upon cooling, and its latent heat, upon condensing.

Fluid F, in its turn, is fed into the inlet hole/s 4 and enters said thin cavity 3 through the duct/s 11; the fluid F present in said thin cavity 3 receives said thermal flows and, in turn, is heated and/or pre-evaporated.

It is wanted here to make notice that, depending on the increasing energy density released by said vapor V, said fluid F can:

- heat up,
- assume the state of incipient evaporation,
- contain vapor bubbles and, therefore, be in a partially evaporated state.

Subsequently, the path of the heated and/or pre-evaporated fluid F proceeds through said interstice 10 and goes out through said outlet hole 5.

As mentioned above, said interstice 10 has a minimum thickness, close to zero, because it can also act as a valve to adjust the flow out of the flow fluid F.

Fluid F flowing out through said outlet hole 5 is conveyed to a user, for example it can be used as a process fluid or as domestic hot water.

It is useful to highlight that, advantageously, the fluid flowing out from the hole 5

has never come into direct contact with the vapor V, and is therefore uncontaminated (and, in the case the fluid F is water, it can remain drinkable) despite the passage through the regeneration device D.

The method according to the present invention provides for the application in a desalination plant; this application of the method according to the present invention is described hereinbelow in more detail and specifically with reference to an example, which is to be understood as illustrative but not limitative of the present invention.

A summer day, in which the solar radiation is equal to 500 W/m^2 , and the use of a parabolic concentrator with a punctual focus (parabolic dish) and a capture surface orthogonal to the solar rays of 1 m^2 , are considered. In these conditions, a solar evaporator is able to produce approximately 0.6 kg/h of steam and consequently, using the regenerative condenser illustrated in the present invention, approximately 0.5 kg/h of condensate, which corresponds to an overall thermodynamic efficiency of about 70 % and of 80 % as regards the sole regenerative condensation.

In the preferred embodiment of the invention, shown in FIGS. 3A and 3B, the regeneration device D is intended to operate in combination with a solar cell for the production of steam 12.

In this case, and with reference to FIG. 3A, the device D is connected to the steam solar generator 12 through the outlet hole 5 and a suitable connection duct.

The steam V goes out from the ducts 13 and is directed onto the surface of the second inner element 2, onto which it condensates; in turn, the heated and/or pre-evaporated fluid F enters the solar steam generator 12 as feeding fluid.

The second variant of the preferred embodiment of the invention shown in FIG. 3B has an efficiency higher than that of the first variant of the preferred embodiment of the invention shown in FIG. 3A thanks to the fact that said solar steam generator 12 is provided to be in contact with the open portion of the chamber of the device D, this minimizing the thermal losses; the efficiency of the device D according to said second variant of the preferred embodiment of the invention shown in FIG. 3B can increase up to 95 %, depending on the thermal insulation degree of the outer element 1.

More precisely, in the preferred embodiment of the invention illustrated in FIGS. 3A and 3B, said solar steam generator 12 is according to one or the other of the types studied by the same Applicant and forming the subject-matter of two separate but simultaneous Italian Patent applications entitled “A method and a system for generating steam in a hollow structure using solar radiation or another radiation” and “A method and a system for generating steam in a planar structure using solar radiation or another radiation”.

The aforesaid preferred embodiment is advantageously applied in purification and/or desalination plants of sea, river, swamp or rain water, and it is particularly suitable for use in remote regions and for so-called “off-grid” applications.

As it can be deduced from the above, the innovative technical solution herein described has the following advantageous features:

- the high efficiency recovery of latent and sensible heat thanks to the confinement of the fluid to be treated in a thin film that reduces as much as possible the residence time and the conduction thermal losses towards the outside;
- the maximization of the view factor for the optimal steam collection (for example, very low steam losses in the atmosphere) thanks to the hollow configuration of the device, able to house the steam generator thereinside;
- the minimization of the convection thermal losses always thanks to the hollow configuration of the device, and in particular to the opening facing downwards, which prevents the formation of the convective flows of air in contact with the hot surfaces;
- the complete control of the fluid flow through the adjustment of an interstice in which the fluid flows;
- the easiness of collecting the condensed water in a compact and integrated channel;
- the use in remote regions and for so-called “off-grid” applications thanks to the intrinsic simplicity and robustness as well as to the fact that it does not require any electrical supply;
- the use in solar applications, such as the purification and/or desalination of sea, river, swamp or rain water, in which the proposed invention allows the use of

reflective means for the concentration and for giving the direction of the radiation instead of using lenses systems that typically have lower optical efficiencies;

- the recovery of heat from industrial processes with steam production;
- the increase of the optical efficiency since it does not require the use of transparent materials; and
- the realization by means of innovative technologies, such as the 3D printing, thanks to the use of common materials.

From the description hereinabove it is clear, then, how the described device and method allow to reach the proposed objects.

It is equally evident, to an expert in the field, that changes and variants can be brought to the solution described with reference to the attached figures, however without departing from the teaching of the present invention and from the scope as defined in the appended claims.

CLAIMS

1. A device (D) for the thin film regenerative condensation, comprising:
 - a thermally insulating first outer element (1),
 - a conductive second inner element (2) onto which a flow of steam (V) to be condensed is made to flow,
 - a thin cavity (3) located between said first outer element (1) and said second inner element (2) and suitable to confine as a thin film a fluid (F) to be heated and/or pre-evaporated,
 - at least one inlet hole (4) for the entry of said fluid (F) and at least one corresponding duct (11) connected with said thin cavity (3),
 - an outlet hole (5) for the discharge of said fluid (F) heated and/or pre-evaporated,
 - a collection tank (6) for the condensate,
 - a nozzle (7) for the discharge and for the collection of the condensate,
 - first means (8) for holding in position said collection tank (6), and
 - second moving means (9) for controlling the passage of said fluid (F) from said inlet hole (4) to said outlet hole (5) inside an interstice (10).
2. A device (D) according to claim 1, wherein said first means (8) and said second moving means (9) are ferrules.
3. A device (D) according to claim 1 or 2, wherein said second moving means (9) can reduce said interstice (10) until being in contact with said second inner element (2).
4. A device (D) according to any of the preceding claims, wherein said fluid (F) is water.
5. A device (D) according to any of the preceding claims, wherein said thermally insulating first outer element (1) is made of plastic material or consists in a cavity in which vacuum is obtained.
6. A device (D) according to any of the preceding claims, wherein said conductive second inner element (2) is made of metal.
7. A method for the thin film regenerative condensation, comprising the

following steps:

- a. providing at least one device (D) comprising:
 - a thermally insulating first outer element (1),
 - a conductive second inner element (2) onto which a flow of steam (V) to be condensed is made to flow,
 - a thin cavity (3) located between said first outer element (1) and said second inner element (2) and suitable to confine as a thin film a fluid (F) to be heated and/or pre-evaporated,
 - at least one inlet hole (4) for the entry of said fluid (F) and at least one corresponding duct (11) connected with said thin cavity (3),
 - an outlet hole (5) for the discharge of said fluid (F) heated and/or pre-evaporated,
 - a collection tank (6) for the condensate,
 - a nozzle (7) for the discharge and for the collection of the condensate,
 - first means (8) for holding in position said collection tank (6), and
 - seconds moving means (9) for controlling the passage of said fluid (F) from said inlet hole (4) to said outlet hole (5) inside an interstice (10),(step 101);
- b. feeding said fluid (F) in said device (D) (step 102);
- c. confining as a thin film said fluid (F) inside said thin cavity (3) (step 103);
- d. feeding steam (V) inside said device (D) and putting it in contact with said second inner element (2), so that said steam (V) condensates and said fluid (F) is heated and/or pre-evaporated (step 104);

- e. controlling the passage of said fluid (F) into said interstice (10) through said second moving means (9) (step 105);
 - f. conveying towards a user said fluid (F) heated and/or pre-evaporated (step 106); and
 - g. collecting the produced condensate into said collection tank (6) (step 107).
8. A method according to claim 7, wherein said thin film of said fluid (F) present inside said thin cavity (3) has a thickness ranging between 100 μm and 1,000 μm , preferably equal to 300 μm .
9. A method according to claim 7 or 8, wherein the condensation of said steam (V) produces a quantity of condensate ranging between 1 kg/h/m^2 and 20 kg/h/m^2 , preferably equal to 6 kg/h/m^2 , relative to the surface of the downward opening in the first means (8).
10. A method according to claim 9, wherein said condensate is fresh and/or drinking water.

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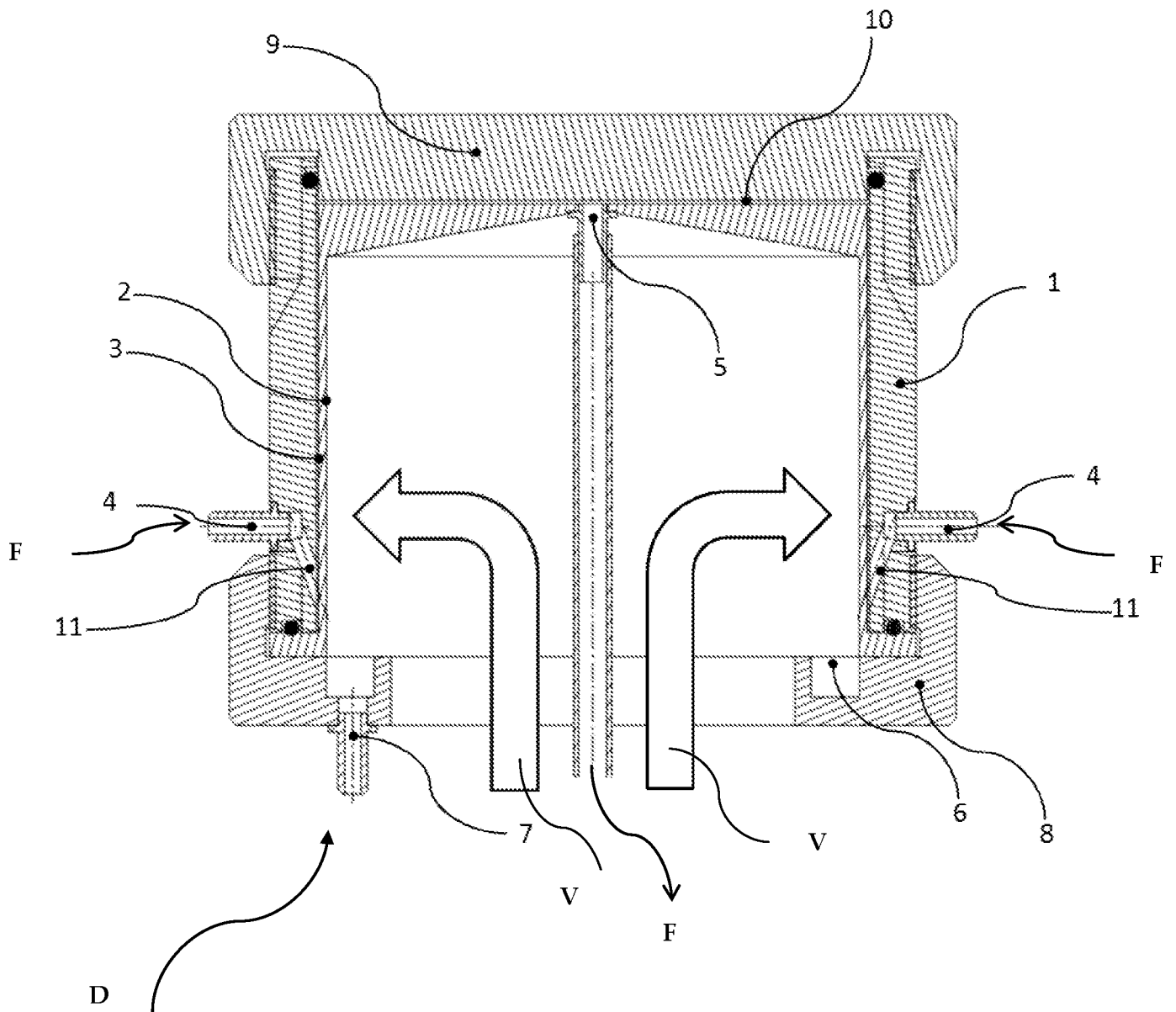


FIG. 1

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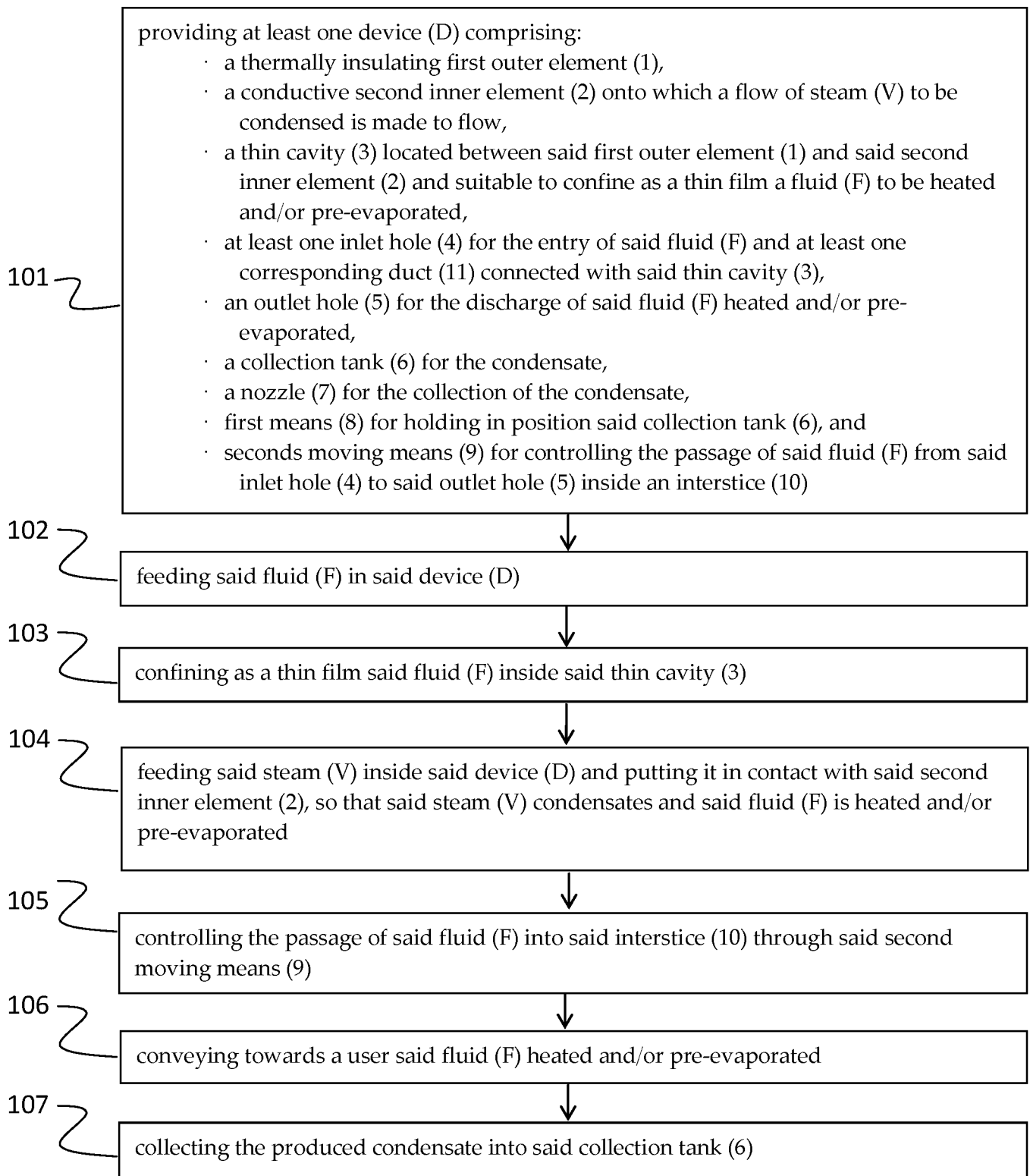


FIG. 2

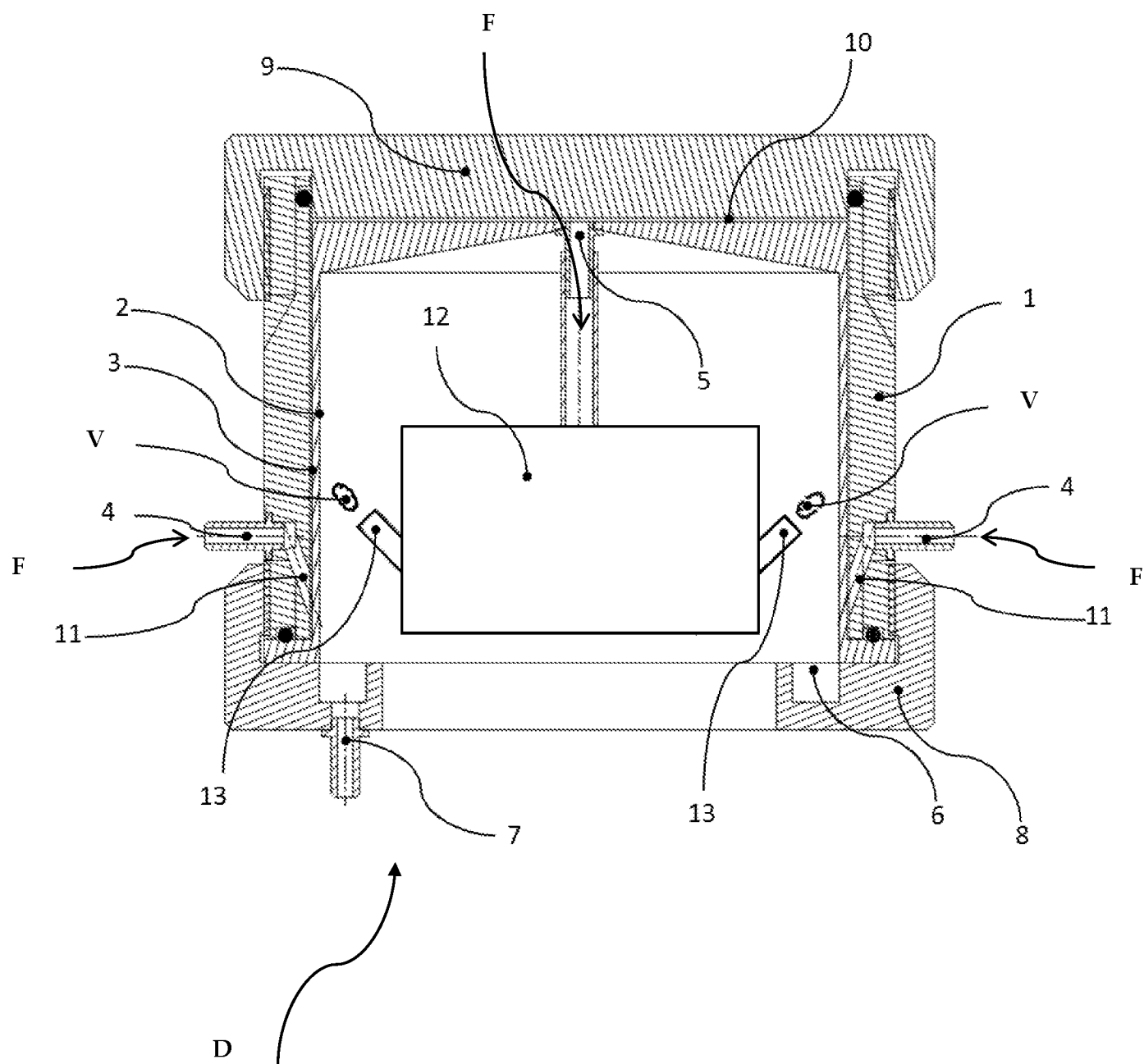


FIG. 3A

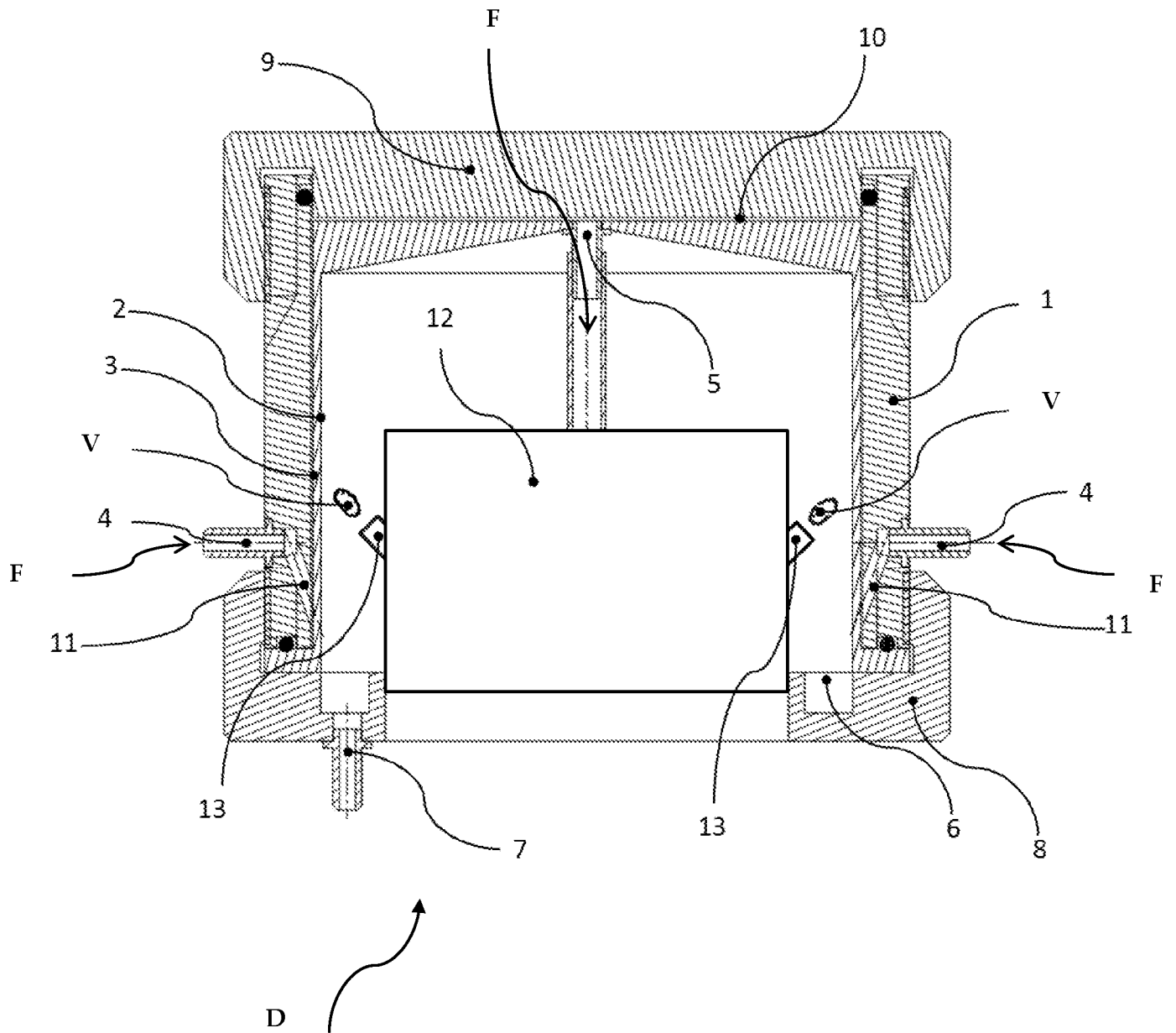


FIG. 3B

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2016/050573

A. CLASSIFICATION OF SUBJECT MATTER
 INV. B01D5/00 F28D9/00
 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)

B01D F28D C02F

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

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 20 2011 051461 U1 (GHATTAS NADER KHALIL [DE]) 4 November 2011 (2011-11-04) paragraphs [0015], [0018], [0032] - [0035]; figures 1-6 -----	1-10
A	DE 20 2006 000195 U1 (DOHM RUDOLF [DE]; SZRAMA FRANK [DE]; BURAKOVSKI DIMITRIJ [DE]; DOHM PA) 8 February 2007 (2007-02-08) figure 1 -----	1-10
A	US 2008/047259 A1 (FRYDMAN ARNALDO [US] ET AL) 28 February 2008 (2008-02-28) figure 2 -----	1-10
A	US 2 330 326 A (ATKESON FLORIAN V) 28 September 1943 (1943-09-28) figures 1-5 -----	1-10



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

5 April 2016

Date of mailing of the international search report

14/04/2016

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2016/050573

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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US 2330326 A	28-09-1943	NONE	