



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
06.06.2018 Bulletin 2018/23

(51) Int Cl.:
F22B 21/26 (2006.01) **F22B 37/22** (2006.01)
C11B 3/14 (2006.01)

(21) Application number: **16201980.6**

(22) Date of filing: **02.12.2016**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

- **CHRISTENSEN, Kenneth**
DK-9300 SAEBY (DK)
- **HUA, Ling**
DK-2860 SÖBORG (DK)
- **SHEVCHENKO, Alexey**
DK-1574 COPENHAGEN (DK)

(71) Applicant: **Alfa Laval Corporate AB**
221 00 Lund (SE)

(74) Representative: **Alfa Laval Attorneys**
Alfa Laval Corporate AB
Patent Department
P.O. Box 73
221 00 Lund (SE)

(72) Inventors:
• **GIVERSEN, Mike Dahl**
DK-9200 AALBORG SV (DK)

(54) **VAPOR GENERATION SYSTEM AND METHOD FOR GENERATION OF VAPOR**

(57) The present invention relates to a system (1) and method for generation of vapor. The system comprises a channel (3) for a high temperature fluid, an economizer (7), an evaporator (8) and a superheater (9) arranged in the channel and a liquid-vapor separator (10). The economizer is arranged to preheat a first fluid and the evaporator is arranged to heat a second fluid by heat exchange with the high temperature fluid. The separator is arranged to receive heated second fluid and to separate liquid and vapor thereof. The superheater is arranged to receive vapor discharged by the separator, to heat the vapor by heat exchange with the high temperature fluid and to discharge superheated vapor. The second fluid comprises preheated first fluid and/or liquid discharged by the separator. The system comprises further a heating device (23), which is arranged to heat liquid in the separator so as to convert liquid to vapor.

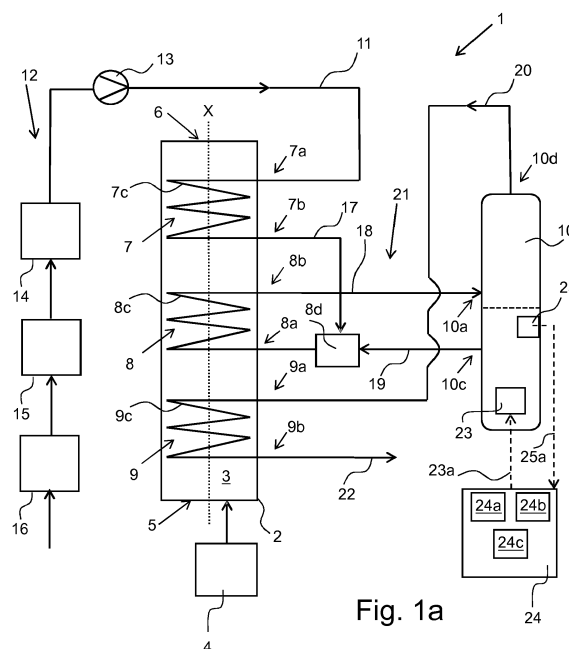


Fig. 1a

Description

Technical Field

[0001] The present invention relates to a vapor generation system, such as a steam generation system, based on heat exchange with a high temperature fluid. In addition, the present invention relates to a method for generation of vapor, such as steam, based on heat exchange with a high temperature fluid.

Background of the Invention

[0002] Many different types of vapor generation systems based on heat exchange with a high temperature fluid, for example a flue gas from a burner or a boiler, are known today and the generated vapor is utilized in various applications.

[0003] One known type of such vapor generation system comprises a channel for a high temperature fluid, an economizer (preheater), an evaporator, a superheater and a liquid-vapor separator. The economizer, the evaporator and the superheater are arranged in the channel and comprise heat transfer surfaces provided by, for example, tubes arranged to convey a respective fluid to be heated. The liquid-vapor separator, which may be a vapor drum or vapor cyclone, is arranged outside the channel.

[0004] This known type of vapor generation system is often utilized for generation of steam, i.e. utilized as a steam generation system. During use as a steam generation system, a high temperature fluid is conveyed through the channel, whereby it passes around the heat transfer surfaces in the channel and transfers heat to the respective conveyed fluid. Feedwater is typically conveyed into the economizer and preheated in the economizer by heat exchange with the high temperature fluid. The feedwater is often heated close to the saturation point in the economizer, but remains typically in liquid phase. Thereafter the preheated feedwater is gradually evaporated and heated to superheated steam in the evaporator and superheater by heat exchange with the high temperature fluid. The liquid-vapor separator, i.e. the water-steam separator of the steam generation system, receives typically a mixture of water and steam from the evaporator, separates water and steam and discharges separate flows of water and steam. The water discharged by the water-steam separator is typically recirculated through the evaporator. The steam discharged by the water-steam separator is typically saturated steam and is conveyed to the superheater, in which the steam is heated to superheated steam before being discharged.

[0005] This known type of vapor generation system may be of, for example, a forced or natural circulation design. In the forced circulation design, a circulation pump is typically utilized for recirculating the liquid discharged by the liquid-vapor separator through the evaporator. In the natural circulation design, the recirculation

of the liquid discharged by the liquid-vapor separator is assured by a thermal siphon effect. Thereby the circulation pump utilized in the forced circulation design may be replaced by a long vertical conduit, a so called downcomer, having a length sufficient to force the liquid discharged by the separator to recirculate through the evaporator.

[0006] One example of a steam generation system of natural circulation design is described in US 7,243,618 and one example of a steam generation system of forced circulation design is described in US 5,588,400.

[0007] However, even though many vapor generation systems of the above mentioned type are known and well-functioning, there is still room for improvements of such vapor generation systems.

Summary of the Invention

[0008] One object of the present invention is to provide an improved vapor generation system of the above mentioned type comprising a channel for a high temperature fluid, an economizer, an evaporator and a superheater arranged in the channel and a liquid-vapor separator, which vapor generation system has the capacity to boost the generation of superheated vapor.

[0009] As a first aspect of the invention, there is provided a vapor generation system comprising:

- a channel for a high temperature fluid;
- an economizer arranged in the channel, wherein the economizer is arranged to receive a first fluid to be preheated via an economizer inlet and to preheat the received first fluid by heat exchange with the high temperature fluid;
- an evaporator arranged in the channel, wherein the evaporator is arranged to receive a second fluid to be heated and to heat the received second fluid by heat exchange with the high temperature fluid;
- a liquid-vapor separator arranged to receive heated second fluid from the evaporator and optionally preheated first fluid from the economizer, wherein the liquid-vapor separator is arranged to separate liquid and vapor of the received heated second fluid and to discharge liquid through a first separator outlet and vapor through a second separator outlet, and
- a superheater arranged in the channel, wherein the superheater is arranged to receive a vapor fluid comprising vapor discharged by the liquid-vapor separator, to heat the received vapor fluid by heat exchange with the high temperature fluid so as to provide superheated vapor and to discharge superheated vapor through a superheater outlet,

wherein the second fluid to be heated by the evaporator comprises preheated first fluid provided by the economizer and/or liquid discharged by the liquid-vapor separator, and

wherein the vapor generation system further comprises a first heating device arranged to heat liquid in the liquid-

vapor separator so as to convert liquid to vapor.

[0010] Thus, the vapor generation system is for generation of superheated vapor from a first fluid. The first fluid may comprise or be constituted by a liquid, such as water. For example, the first fluid may comprise or be constituted by a feedliquid, such as feedwater. However, the first fluid may comprise any other suitable feedfluid. For example, the first fluid may comprise liquid toluene, wherein the vapor generation system is for generation of superheated toluene vapor.

[0011] In embodiments of the first aspect of the invention, the vapor generation system is a steam generation system, i.e. a system for generation of steam (water vapor). In these embodiments the liquid-vapor separator is a water-steam separator, which is arranged to separate water and steam of the received heated second fluid and to discharge water through the first separator outlet and steam through the second separator outlet. In these embodiments the first fluid to be preheated by the economizer comprises water, such as feedwater, and the second fluid to be heated by the evaporator comprises preheated first fluid provided by the economizer and/or water discharged by the water-steam separator. Furthermore, in these embodiments, the vapor fluid to be heated by the superheater is a steam fluid comprising steam discharged by the water-steam separator and the superheated vapor provided and discharged by the superheater is superheated steam. In addition, the first heating device is arranged to heat water in the water-steam separator so as to convert water to steam in these embodiments. The generated superheated steam may be utilized in any application utilizing superheated steam, e.g. a process for refining a vegetable oil or an animal fat (such as a deodorization process), in a steam turbine, in fuel heating or for cleaning purposes in general.

[0012] The channel for the high temperature fluid is arranged to convey the high temperature fluid and may be connected to a source of the high temperature fluid. The high temperature fluid may comprise a flue gas (exhaust gas) or flue gases (exhaust gases) from, for example, a burner, boiler, turbine, or engine. Alternatively, the high temperature fluid may comprise any other suitable high temperature fluid from which heat may be extracted/recovered by the heat exchange devices in the channel. Thus, the source of the high temperature fluid may be a burner, boiler, turbine, engine or other suitable device generating a high temperature fluid from which heat may be extracted/recovered by the heat exchange devices in the channel.

[0013] Thus, the vapor generation system may be a vapor generation system based on heat recovery from an exhaust gas, i.e. a heat recovery vapor generation system. Thus, the vapor generation system may be a system in which exhaust heat is used to generate superheated vapor.

[0014] The channel for the high temperature fluid may be comprised in a vessel. The vessel may comprise an inlet for the high temperature fluid into the channel and

an outlet for the high temperature fluid out of the channel, wherein the channel may be arranged to convey the high temperature fluid in a flow direction from the inlet to the outlet. The inlet may be located at one end of the channel and the outlet at the other end of the channel.

[0015] The economizer, the evaporator and the superheater are arranged in the channel. Thus, they are arranged in the flow path for the high temperature fluid in the channel. The evaporator is arranged downstream of the superheater and the economizer is arranged downstream of the evaporator as seen in a direction of flow of the high temperature fluid through the channel.

[0016] Each of the economizer, the evaporator and the superheater is a heat exchanger, which may comprise heat transfer surfaces provided by a heat transfer arrangement arranged to receive and convey a respective fluid to be heated, e.g. from an inlet end to an outlet end of the heat transfer arrangement. The heat transfer arrangement may comprise one or more tubes or tube bundles. Thus, each of the economizer, the evaporator and the superheater may comprise a heat transfer arrangement in the form of a tube arrangement. Accordingly, the economizer may comprise an economizer tube arrangement, the evaporator may comprise an evaporator tube arrangement and the superheater may comprise a superheater tube arrangement.

[0017] The number of tubes of each tube arrangement may be one single tube or a plurality of tubes. For example, the number of tubes may be 2, 3, 4, 5, 6, 7, 8 or even more tubes. One or more of the tubes may optionally be provided with fins or other surface enlarging elements. For example, the economizer, the evaporator and the superheater may be spiral heat exchangers comprising heat transfer surfaces provided by a heat transfer arrangement comprising one or more spiral finned tubes. Furthermore, the economizer, the evaporator and the superheater may comprise similar or different heat transfer arrangements.

[0018] The economizer is arranged to receive a first fluid to be preheated via the economizer inlet and to preheat the received first fluid by heat exchange with the high temperature fluid. The economizer is thus a preheater and is arranged to provide a preheated first fluid. As mentioned above, the first fluid may be constituted by a liquid. The economizer may then be arranged to preheat the first fluid close to the saturation point but such that it remains in liquid phase. The economizer inlet may be connected to an economizer inlet conduit arranged to convey the first fluid to the economizer from e.g. a first fluid source.

[0019] The evaporator is arranged to receive a second fluid to be heated and to heat the received second fluid by heat exchange with the high temperature fluid. The evaporator is thereby arranged to provide a heated second fluid. The provided heated second fluid may be constituted by a mixture comprising liquid and vapor.

[0020] The second fluid to be heated by the evaporator comprises preheated first fluid provided by the econo-

mizer and/or liquid discharged by the liquid-vapor separator. Thus, the evaporator may be connected to the economizer (e.g. via an economizer outlet conduit) and/or the liquid-vapor separator (e.g. via a first separator outlet conduit) such that the second fluid, which the evaporator is arranged to receive, comprises preheated first fluid provided by the economizer and/or liquid discharged by the liquid-vapor separator. This will be further described below.

[0021] The liquid-vapor separator is arranged to receive heated second fluid from the evaporator and may thus be connected to the evaporator (e.g. via an evaporator outlet conduit).

[0022] The liquid-vapor separator is further arranged to separate liquid and vapor of the received heated second fluid and to discharge liquid through the first separator outlet and vapor through the second separator outlet. The vapor discharged by the liquid-vapor separator may be saturated vapor. The liquid-vapor separator may be arranged to collect liquid in a first part, e.g. a lower part, and vapor in a second part, e.g. an upper part.

[0023] The liquid-vapor separator may be any non-centrifugal device suitable for separating liquid and vapor. For example, the liquid-vapor separator may be a vapor drum, a vapor cyclone or a separation tank/bottle. In embodiments in which the vapor generation system is a steam generation system, the liquid-vapor separator may be a steam drum or a steam cyclone.

[0024] The vapor generation system may further comprise a circulation circuit for recirculation of liquid discharged by the liquid-vapor separator and means for recirculation of liquid discharged by the separator in the circulation circuit. The circulation circuit comprises at least the liquid-vapor separator and the evaporator and is arranged for recirculation of liquid discharged from the separator through the evaporator. This will be further described below.

[0025] The superheater is arranged to receive a vapor fluid comprising vapor discharged by the liquid-vapor separator, to heat the received vapor fluid by heat exchange with the high temperature fluid so as to provide superheated vapor and to discharge superheated vapor through the superheater outlet. The superheater may thus be connected to the second separator outlet of the separator (e.g. via a second separator outlet conduit). The superheater may further be connected via the superheater outlet to a superheater outlet conduit arranged to convey superheated vapor from the superheater.

[0026] The first heating device arranged to heat liquid in the liquid-vapor separator so as to convert liquid to vapor may be positioned, for example, within the liquid-vapor separator, such as in a first part, e.g. a lower part, of the liquid-vapor separator in which liquid is collected. Alternatively, the first heating device may be positioned at any other suitable position completely or partly in the separator, such as in a wall of the separator. Still alternatively, the first heating device may be positioned external of the separator, but connected to the separator

so as to provide released heat to the liquid in the separator.

[0027] The first heating device may be any suitable heating device for releasing heat for converting liquid to vapor in the liquid-vapor separator. For example, the first heating device may be an electric heating device or a heat exchanger, such as e.g. a shell and tube heat exchanger.

[0028] In embodiments of the first aspect of the invention, the vapor generation system comprises further a control unit configured to regulate the amount of heat released by the first heating device (e.g. per unit of time). Regulating may comprise turning on the first heating device and/or increasing the amount of heat released by the first heating device. Regulating may further comprise decreasing the amount of heat released by the first heating device and/or turning off the first heating device. The control unit may be arranged as a separate unit or completely/partly within the separator.

[0029] In embodiments of the first aspect of the invention, the vapor generation system comprises further at least one sensing device (e.g. sensor) configured to detect a respective parameter related to the amount of superheated vapor generated by the vapor generation system (e.g. per unit of time). In embodiments comprising two or more sensing devices, the sensing devices may be arranged to detect the same or different respective parameters related to the amount of superheated vapor generated per unit of time.

[0030] For example, the control unit may comprise a manual control device. The manual control device may comprise an on/off device, e.g. an on/off button, arranged to turn on or off the first heating device or may comprise any other suitable manual regulator for increasing/decreasing the amount of heat released by the first heating device.

[0031] In embodiments of the first aspect of the invention, the vapor generation system comprises the control unit and the at least one sensing device, wherein the control unit is configured to regulate the amount of heat released by the first heating device based on said respective parameter detected by the at least one sensing device. Thus, in these embodiments regulating may comprise turning on the first heating device and/or increasing the amount of heat released by the first heating device, for example if the respective parameter detected by at least one of the at least one sensing device is above/below a threshold value. Regulating may further comprise decreasing the amount of heat released by the first heating device and/or turning off the first heating device, for example if the respective parameter detected by at least one of the at least one sensing device is above/below a threshold value.

[0032] In embodiments comprising the control unit and said at least one sensing device, the control unit may be configured to receive an input signal related to the respective detected parameter from each of the at least one sensing device and to generate an output signal to

regulate the amount of heat released by the first heating device based on the input signal(s) received from the at least one sensing device. The control unit may in these embodiments comprise a processor and an input/output interface for receiving information about the respective parameter from the at least one sensing device and for communicating with the first heating device.

[0033] In embodiments comprising the control unit and said at least one sensing device, regulation may also comprise using a regulation loop to keep the amount of superheated vapor generated by the system at a constant level, i.e. at a certain level, or within a certain range.

[0034] As an example, the respective parameter detected by at least one of the at least one sensing device may be a parameter related to the amount of liquid in the liquid-vapor separator, e.g. the liquid level in the liquid-vapor separator. Accordingly, in these embodiments the vapor generation system comprises at least one sensing device, such as e.g. a liquid level meter, configured to detect the amount of liquid in the liquid-vapor separator.

[0035] Thus, the provision of the first heating device in the vapor generation system implies that the amount of vapor discharged from the liquid-vapor separator may be regulated by regulating the amount of liquid converted to vapor in the liquid-vapor separator, i.e. by turning on/off the first heating device and/or increasing the amount of heat released by the first heating device and/or decreasing the amount of heat released by the first heating device. For example, the amount of liquid converted to vapor in the liquid-vapor separator may be regulated such that the output of vapor from the liquid-vapor separator is at a certain level or within a certain range.

[0036] During certain process conditions the generation of vapor in the evaporator (i.e. the evaporation of the second fluid to be heated) may be reduced since the temperature and/or mass flow of the high temperature fluid conveyed through the channel, and thus through the evaporator, is/are reduced. For example this may occur during a shut-down phase of the source of the high temperature fluid or decrease in load. A reduced generation of vapor in the evaporator implies that the proportion of vapor in the heated second fluid discharged by the evaporator and received by the liquid-vapor separator is reduced. Consequently, the amount of vapor separated from the heated second fluid by the liquid-vapor separator, the amount of vapor discharged to the superheater and the amount of superheated vapor provided by the superheater are also reduced.

[0037] However, by means of the first heating device the generation of vapor (and thus superheated vapor) may be boosted, i.e. liquid in the liquid-vapor separator may be converted to vapor and discharged to the superheater. Thus, it may thereby be at least partly compensated for reductions in the temperature and/or mass flow of the high temperature fluid in the channel. In addition, the generation of vapor (and thus superheated vapor) may also be boosted for other reasons, e.g. during certain process conditions it may be needed or advantageous

to increase the amount of superheated vapor provided to the system/device/process utilizing the superheated vapor generated by the vapor generation system.

[0038] Consequently, the vapor generation system of the first aspect of the invention is advantageous in that the first heating device may provide a boost of the generation of vapor (and thus superheated vapor) when needed, e.g. to at least partly compensate for a reduced production of vapor in the evaporator.

[0039] In embodiments of the first aspect of the invention, the evaporator is arranged to receive preheated first fluid provided by the economizer and liquid discharged by the liquid-vapor separator, wherein the second fluid to be heated by the evaporator comprises preheated first fluid provided by the economizer and liquid discharged by the liquid-vapor separator. Thus, in these embodiments the evaporator may be connected to the economizer (e.g. via an economizer outlet conduit) and to the liquid-vapor separator (e.g. via a first separator outlet conduit) such that the second fluid to be heated, which the evaporator is arranged to receive, comprises preheated first fluid provided by the economizer and liquid discharged by the liquid-vapor separator. In these embodiments the evaporator and the liquid-vapor separator are part of a circulation circuit. Furthermore, in these embodiments the vapor generation system may further comprise a fluid injection device connected to the evaporator, wherein the fluid injection device is arranged to receive preheated first fluid from the economizer and discharged liquid from the liquid-vapor separator and to inject the received preheated first fluid together with the received discharged liquid into the evaporator such that the second fluid to be heated by the evaporator comprises preheated first fluid provided by the economizer and liquid discharged by the liquid-vapor separator. For example, the fluid injection device may be a header device as described in EP15170495.4.

[0040] In embodiments, the evaporator comprises a heat transfer arrangement in the form of an evaporator tube arrangement arranged to receive and convey the second fluid to be heated as discussed above and the fluid injection device is a header device comprising a header, wherein the header comprises an inlet portion and an outlet portion communicating with each other, wherein the inlet portion comprises a header inlet for liquid discharged by the liquid-vapor separator, wherein the outlet portion comprises a wall surrounding an inner space, wherein the outlet portion comprises a header outlet, which extends through the wall and is connected to the evaporator tube arrangement, wherein the header is configured to permit liquid discharged by the liquid-vapor separator to enter the inner space via the header inlet, and to flow from the inner space to the evaporator tube arrangement via the header outlet, wherein the header device comprises an injector pipe connected to the header and arranged to inject preheated first fluid provided by the economizer into the header to force liquid discharged by the liquid-vapor separator through the

header outlet and into the evaporator tube arrangement together with preheated first fluid provided by the economizer.

[0041] By means of such a header device, the preheated first fluid will operate to force the liquid discharged by the liquid-vapor separator into the evaporator tube arrangement by means of an ejector action. Consequently, it may be dispensed with a circulation pump for the liquid discharged from the separator. Furthermore, there is no need for a long down comer, which means that the separator may be positioned relatively closely to the evaporator.

[0042] In embodiments, the header outlet comprises a number of openings through the wall of the outlet portion, wherein each opening is configured to be connected to a respective one of the tubes of the evaporator tube arrangement. The number of openings through the wall of the outlet portion may, or may not, be the same as the number of tubes of the evaporator tube arrangement. Thus, one or more of the openings may be connectable to a single one of the tubes and vice versa.

[0043] In embodiments, a first portion of the injector pipe comprises an injector outlet and extends inside the inner space of the header. The injector pipe with the injector outlet in the inner space may further increase the circulation of the second fluid to be heated in the evaporator tube arrangement.

[0044] In embodiments, the injector outlet comprises a number of holes through a wall of the injector pipe. The number of holes may be one single hole or a plurality of holes. The holes of the injector outlet may have different areas, or equal areas. By selecting the area and position of each hole, it may be possible to control the flow to each tube of the evaporator tube arrangement, and to even out the flow distribution to the different tubes. This may be advantageous since the length, and thus the flow resistance, of the tubes may be different.

[0045] In embodiments, the number of holes through the wall of the injector pipe differs from the number of openings through the wall of the outlet portion. In embodiments, the holes of the injector outlet face the openings of the outlet portion. Center axes of the holes and the openings may, or may not, coincide.

[0046] In embodiments, the first portion of the injector pipe is arranged separated from the wall of the inner space. Thus, there is then a radial distance between the injector outlet and the header outlet. Especially, there may be a radial distance between the holes through the wall of the first portion of the injector pipe and the openings through the wall of the outlet portion. The radial distance may provide a free flow for the liquid discharged by the separator from the header inlet to the evaporator tube arrangement.

[0047] In embodiments, the header outlet has a first flow area and the injector outlet has a second flow area, wherein the first flow area is larger than the second flow area.

[0048] In embodiments, a longitudinal center axis of

the first portion of the injector pipe extends in parallel to a longitudinal center axis of the outlet portion of the header. The two parallel axes may permit holes and the openings to be aligned with each other.

[0049] In embodiments, the inlet portion extends to a first end of the header and the outlet portion extends to a second end of the header, wherein the second end is closed. The fluid entering the header thus has to pass through the header outlet, i.e. through any one of the openings through the wall of the outlet portion.

[0050] In embodiments, the injector pipe extends through the inlet portion into the inner space.

[0051] In embodiments, the injector pipe extends through a wall of the inlet portion. The wall of the inlet portion may have the same transversal shape as, and be concentric with, the wall of the outlet portion. In alternative embodiments, the inlet extends through the first end.

[0052] In embodiments, the injector pipe has a bottom end in the inner space, wherein the bottom end is closed.

[0053] In embodiments of the first aspect of the invention, the liquid-vapor separator is further arranged to receive preheated first fluid from the economizer, wherein the evaporator is arranged to receive liquid discharged by the liquid-vapor separator, and wherein the second fluid to be heated by the evaporator comprises liquid discharged by the liquid-vapor separator. Thus, in these embodiments the economizer may be connected to the liquid-vapor separator (e.g. via an economizer outlet conduit) and the liquid-vapor separator may be connected to the evaporator via the first separator outlet (and e.g. via a first separator outlet conduit). Accordingly, in these embodiments the evaporator and the liquid-vapor separator are part of a circulation circuit. For example, one or more circulation pumps and/or one or more downcomers may be part of means for recirculation of liquid discharged by the separator in the circulation circuit in these embodiments.

[0054] In embodiments of the first aspect of the invention, the economizer is arranged to receive liquid discharged by the liquid-vapor separator, wherein the first fluid to be preheated by the economizer comprises liquid discharged by the liquid-vapor separator, wherein the evaporator is arranged to receive preheated first fluid from the economizer, and wherein the second fluid to be heated by the evaporator comprises preheated first fluid provided by the economizer. Thus, in these embodiments the liquid-vapor separator may be connected to the economizer via the first separator outlet (and e.g. via a first separator outlet conduit) and the economizer may be connected to the evaporator (e.g. via an economizer outlet conduit). In these embodiments, the first fluid to be preheated may further comprise a feedfluid. Accordingly, in these embodiments the economizer, the evaporator and the liquid-vapor separator are part of a circulation circuit. For example, one or more circulation pumps and/or one or more downcomers may be part of means for recirculation of liquid discharged by the liquid-vapor

separator in the circulation circuit in these embodiments.

[0055] In embodiments of the first aspect of the invention, the vapor generation system comprises further a feedfluid pre-treatment system, wherein the first fluid to be preheated by the economizer comprises feedfluid provided from the feedfluid pre-treatment system. Thus, the economizer inlet may be connected to the feedfluid pre-treatment system.

[0056] The feedfluid pre-treatment system may comprise a storage tank/container for feedfluid and/or a cleaning device for cleaning the feedfluid and/or a softening device. The cleaning device may be arranged to remove impurities in the feedfluid and may, for example, comprise a reverse osmosis unit. The softening device may be included in the feedfluid pre-treatment system if the feedfluid is feedwater. The softening device is arranged to soften water by addition of a softening agent.

[0057] In embodiments of the first aspect of the invention, the vapor generation system comprises further the source of the high temperature fluid.

[0058] In embodiments of the first aspect of the invention, the vapor generation system comprises further a second heating device, which is arranged to further heat superheated vapor provided by the superheater. The second heating device may be arranged to receive superheated vapor from the superheater via the superheater outlet. The second heating device may comprise any suitable heating device for further heating the superheated vapor. For example, the second heating device may be an electric heating device or a heat exchanger, e.g. a shell and tube heat exchanger.

[0059] Any of the above described embodiments of the vapor generation system according to the first aspect of the invention may be a steam generation system in accordance with the above. Any embodiment of the vapor generation system according to the first aspect of the invention being a steam generation system may be comprised in a deodorization system.

[0060] Deodorization may be a part of the refining process for edible oils and/or fats as well as oils and/or fats for non-edible use. In addition, a number of different pre-treatment processes performed before the deodorization may also be part of the refining process, e.g. pre-treatment processes such as degumming, neutralization and bleaching (treatment with a solid adsorbent, e.g. acid activated clay).

[0061] Deodorization is a high-temperature, high-vacuum process carried out in order to remove undesirable volatile components, i.e. volatile impurities, that may affect, for example, flavour, odour, colour and/or stability of the oils and/or fats. Primarily, the deodorization is a distillation process. The removal of volatile impurities is facilitated by addition of a deodorization gas to the oils and/or fats.

[0062] In more detail, the deodorization process may comprise a stripping process, during which undesirable volatile components that have a higher vapor pressure than the main product are stripped off by the use of a

deodorization gas. Thus, during the stripping process treated oils and/or fats are brought into contact with a deodorization gas (e.g. a deodorization gas may be passed through the oils and/or fats) and undesirable volatile components are removed from the treated oils and/or fats.

[0063] Any inert gas can be utilized as deodorization gas, but steam is commonly utilized since it has the advantage of being readily available and is readily condensed. Thus, the stripping performed during the deodorization process is commonly denoted as steam stripping. Preferably, clean superheated steam is utilized as deodorization gas.

[0064] Volatile components removed during the stripping process may include free fatty acids (FFAs) as well as various flavour and odour compounds classified largely as aldehydes, ketones, alcohols and hydrocarbons, and other compounds formed by heat decomposition of peroxides and pigments.

[0065] The deodorization process may also comprise a heat bleaching process, i.e. a heat treatment process during which for example undesirable pigments of the treated oils and/or fats may be decomposed and volatile decomposition products thereof may be volatilized and removed from the treated oils and/or fats by means of a deodorization gas. During the heat bleaching process the treated oils and/or fats are thermally treated for a certain amount of time. The heat bleaching process may be performed before, during or after a stripping process. However, the refining process for oils and fats for non-edible use does normally not include the heat bleaching process. One example of deodorization conducted by steam stripping in combination with heat bleaching is disclosed by WO 98/00484.

[0066] In a second aspect of the invention, there is provided a deodorization system for deodorization of oils and/or fats, wherein the deodorization system comprises a deodorization vessel comprising:

- a vacuum connection arranged to be connected to a vacuum system;
- an inlet for introduction of oils and/or fats into the deodorization vessel;
- an outlet for discharge of oils and/or fats from the deodorization vessel;
- at least one steam inlet for introduction of superheated steam into the deodorization vessel, and
- at least one treatment section arranged to receive oils and/or fats introduced into the deodorization vessel and superheated steam introduced into the deodorization vessel and arranged to bring received oils and/or fats in contact with received superheated steam during a treatment,

wherein the deodorization system further comprises a steam generation system according to any embodiment of the first aspect of the invention discussed above, and wherein the at least one steam inlet is arranged to receive

superheated steam from the steam generation system via the superheater outlet of the steam generation system.

[0067] Thus, the steam generation system according to any embodiment of the first aspect of the invention included in the deodorization system according to the second aspect of the invention is arranged to generate superheated steam, which is to be introduced into the deodorization vessel through the one or more steam inlets and to be utilized in the one or more treatment sections.

[0068] The deodorization vessel may be a deodorization column. However, the deodorization vessel may alternatively be a heat exchanger in which deodorization is performed. The deodorization vessel may further comprise means for bringing oils and/or fats introduced into the vessel into contact with superheated steam introduced into the vessel in the at least one treatment section, such as e.g. means for supply/distribution of superheated steam and means for holding/distributing oils and/or fats.

[0069] Accordingly, each treatment section is arranged to receive oils and/or fats as well as superheated steam that have been introduced into the deodorization vessel and to bring received oils and/or fats into contact with received superheated steam during a treatment. For example, each treatment section may be arranged to bring received superheated steam to pass through the received oils and/or fats. Thus, each treatment section may be arranged to subject received oils and/or fats to a treatment which involves bringing received oils and/or fats into contact with received superheated steam. Each treatment section may be arranged to receive superheated steam introduced via one or more steam inlets.

[0070] The one or more steam inlets may be connected to the superheater outlet of the steam generation system via one or more conduits. For example, the one or more steam inlets may be connected to the superheater outlet via a superheater outlet conduit or via a superheater outlet conduit and one or more steam inlet conduits (e.g. one steam inlet conduit for each steam inlet).

[0071] In embodiments of the second aspect of the invention, at least one of the at least one treatment section is a stripping section for a stripping process. The stripping section is arranged to receive oils and/or fats as well as superheated steam introduced into the deodorization vessel and to bring received oils and/or fats into contact with received superheated steam during a stripping process. Accordingly, the stripping section is arranged to subject received oils and/or fats to a treatment comprising a stripping process. The temperature of the oils and/or fats exposed to a stripping process of the stripping section may be 160-275°C and the stripping process may be carried out under 1-20 mbar absolute pressure.

[0072] The oils and/or fats received in a stripping section may have been treated in one or more previous treatment sections in the deodorization vessel, e.g. in one or more previous stripping sections.

[0073] The stripping section may be any suitable type

of stripping section. For example, the stripping section may be a stripping section comprising a structured packing, through which received oils and/or fats are brought to flow under influence of gravity or under pressure and to meet a flow of superheated steam, i.e. stripping steam, in counter current. The stripping section may then further comprise a distributor for distributing received oils and/or fats over the structured packing and/or a receiver tray for collecting oils and/or fats from the structured packing and/or a feed buffer tray for collecting received oils and/or fats before being fed to the structured packing. Furthermore, if the stripping section comprises a distributor, it may further comprise a liquid flow regulating means for regulating the flow of oils and/or fats to the distributor. In addition, the stripping section may comprise a steam distributor for distributing the superheated steam to meet the oils and/or fats in the structured packing in counter current.

[0074] Alternatively, the stripping section may be a stripping section comprising a plurality of vertically stacked treatment trays and optionally means for transferring oils and/or fats from tray to tray. This stripping section may be arranged to bring oils and/or fats in each treatment tray into contact with superheated steam, i.e. to subject the oils and/or fats to a sub-step of stripping in each tray. In the bottom of each treatment tray there may be means for providing a flow of superheated steam through the oils and/or fats. Alternatively, each tray may comprise a Mammoth pump or other liquid/gas contacting device for bringing the received oils and/or fats in the tray in contact with superheated steam. In alternatives, the stripping section may comprise only one treatment tray.

[0075] Still alternatively, the stripping section may be a stripping section comprising a structured packing and one or more treatment trays.

[0076] The stripping section may further be arranged to subject received oils and/or fats to a heat bleaching process simultaneously with the stripping process.

[0077] In embodiments of the second aspect of the invention, at least one of the at least one treatment section is a retention section for a heat bleaching process. The retention section is arranged to receive oils and/or fats as well as superheated steam introduced into the deodorization vessel and to bring received oils and/or fats into contact with superheated steam during a heat bleaching process. Accordingly, the retention section is arranged to subject received oils and/or fats to a treatment comprising a heat bleaching process. The oils and/or fats received in a retention section may have been treated in one or more previous treatment sections in the deodorization vessel, e.g. in one or more previous stripping sections.

[0078] In embodiments, the deodorization vessel comprises one or more stripping sections and one or more retention sections.

[0079] In embodiments of the second aspect of the invention, the deodorization system comprises further one

or more devices from the group of:

- a deaerator arranged to remove air from the oils and/or fats before introduction into the deodorization vessel;
- at least one heating device arranged to heat the oils and/or fats before introduction into the deodorization vessel, and
- a scrubber arranged to receive volatiles removed from the oils and/or fats, condense received volatiles and discharge condensed volatiles.

[0080] The deodorization system may comprise heating devices in the form of at least one preheating device and a final heating device. The preheating device may be arranged to preheat the oils and/or fats to a first temperature and the final heating device may be arranged to heat the preheated oil or fat to a final temperature (e.g. a temperature required for deodorization) before introduction into the deodorization vessel. For example, one of the at least one preheating device may be an economizer unit which is arranged to preheat oils and/or fats by heat exchange with oils and/or fats discharged from the deodorization vessel. The final heating device may be a heat exchanger connected to a steam boiler, wherein the heating is performed by heat exchange with a heating medium in the form of steam received from the steam boiler. The one or more heating devices may further be arranged to receive superheated steam from the steam generation system and to deodorize the oils and/or fats by means of the superheated steam.

[0081] In embodiments of the second aspect of the invention, the steam generation system (which is comprised in the deodorization system) comprises the source of the high temperature fluid. As discussed above, the source may be a burner, boiler, turbine, engine or other suitable device generating a high temperature fluid from which heat may be extracted/recovered by the heat exchange devices in the channel of the steam generation system. In these embodiments, the source included in the steam generation system, and thus in the deodorization system, may be utilized as a source of the high temperature fluid for the steam generation system but also for other purposes in the deodorization system. As an example, the source may be a steam boiler which also is utilized for generating steam for use as heating medium in a heating device, e.g. a final heating device or a preheating device, of the deodorization system. Thus, exhaust gas from the steam boiler utilized for other purposes in the deodorization system may then be utilized for generation of superheated steam in the steam generation system, which generated superheated steam is to be utilized for treatment in the deodorization vessel. Accordingly, the efficiency of the steam boiler is thereby increased since energy in the exhaust gas is efficiently recovered and reused.

[0082] Consequently, in embodiments of the second aspect of the invention the steam generation system

comprises further the source of the high temperature fluid and the deodorization system comprises a heating device in the form of a heat exchanger for heating the oil or fat before introduction into the deodorization vessel, wherein the source of the high temperature fluid is a steam boiler arranged to generate steam to be utilized as a heating medium in said heat exchanger, and wherein the steam boiler is arranged to generate exhaust gas to be utilized as the high temperature fluid in the steam generation system.

[0083] Fats and oils that may be deodorized in the deodorization system according to the second aspect may be any vegetable oils or fats or animal oils or fats and may, for example, be selected from the non-limiting group of palm oil, palm kernel oil, coconut oil, tallow, lard, soybean oil, canola or rapeseed oil, cottonseed oil, corn or maize oil, sunflower oil, safflower oil, rice bran oil, olive oil, cocoa butter, sal fats, illipe butter, shea butter, milk butter, fish oils, groundnut oil, camelia oil, various types of exotic fats and oils, and oil-derivatives such as alkane esters, ethyl or methyl esters.

[0084] In embodiments of the second aspect of the invention, the deodorization system comprises two or more of the above described deodorization columns.

[0085] Another object of the present invention is to provide an improved method for generation of vapor, by which method the generation of vapor may be boosted.

[0086] As a third aspect of the invention there is provided a method for generation of vapor, wherein the method comprises:

- providing a vapor generation system according to any embodiment of the first aspect of the invention as discussed above;
- conveying a high temperature fluid through the channel;
- providing the economizer with a first fluid via the economizer inlet;
- preheating the first fluid in the economizer by heat exchange with the high temperature fluid;
- providing the evaporator with a second fluid to be heated, wherein the second fluid to be heated by the evaporator comprises preheated first fluid provided by the economizer and/or liquid discharged by the liquid-vapor separator;
- heating the second fluid to be heated in the evaporator by heat exchange with the high temperature fluid;
- providing the liquid-vapor separator with heated second fluid from the evaporator;
- optionally providing the liquid-vapor separator with preheated first fluid from the economizer;
- separating liquid and vapor of the heated second fluid in the liquid-vapor separator;
- providing the superheater with a vapor fluid comprising vapor discharged by the liquid-vapor separator;
- heating the vapor fluid in the superheater by heat exchange with the high temperature fluid so as to

- provide superheated vapor;
- discharging superheated vapor from the superheater via the superheater outlet, and
- heating liquid in the liquid-vapor separator by means of the first heating device so as to convert liquid to vapor.

[0087] The terms and definitions used in relation to the third aspect are as discussed under the first aspect of the invention above.

[0088] The method according to the third aspect may be a method for generation of steam, wherein the provided vapor generation system is a steam generation system.

[0089] In embodiments of the third aspect of the invention, the method comprises further a step of regulating the amount of heat released by the first heating device. The regulation may be performed by means of a control unit.

[0090] Regulating may comprise turning on the first heating device and/or increasing the amount of heat released by the first heating device. Regulating may further comprise decreasing the amount of heat released by the first heating device and/or turning off the first heating device.

[0091] Embodiments of the third aspect of the invention comprising a step of regulating the amount of heat released by the first heating device may further comprise a step of detecting at least one parameter related to the amount of superheated vapor generated by the vapor generation system. The detecting may be performed by means of at least one sensing device, wherein each sensing device is configured to detect a respective parameter. These embodiments may comprise regulating the amount of heat released by the first heating device based on at least one of the detected at least one parameter. In these embodiments, regulating may comprise turning on the first heating device and/or increasing the amount of heat released by the first heating device, for example if one or more of the detected at least one parameter is above/below a threshold value. Regulating may further comprise decreasing the amount of heat released by the first heating device and/or turning off the first heating device, for example if one or more of the detected at least one parameter is above/below a threshold value. Furthermore, in these embodiments regulating may comprise using a regulation loop to keep the amount of vapor generated by the system at a constant level, i.e. at a certain level, or within a certain range.

[0092] As mentioned above, one of the at least one parameter may be a parameter related to the amount of liquid in the liquid-vapor separator. Thus, one parameter may be the liquid level in the liquid-vapor separator.

[0093] The method of the third aspect may further comprise a step of generating the high temperature fluid by a source of the high temperature fluid.

[0094] In addition, the method of the third aspect may further comprise a step of further heating superheated

vapor discharged by the superheater. The further heating may be performed by a second heating device.

[0095] As a fourth aspect of the invention there is provided a method for deodorization of oils and/or fats, the method comprising the steps of:

- providing a deodorization system according to the any embodiment of the second aspect of the invention as discussed above;
- connecting the vacuum connection of the deodorization vessel to a vacuum system;
- introducing oils and/or fats into the deodorization vessel through the inlet;
- generating superheated steam by means of the steam generation system comprised in the deodorization system;
- introducing generated superheated steam into the deodorization vessel through the at least one steam inlet;
- providing at least one of the at least one treatment section with oils and/or fats introduced into the deodorization vessel and superheated steam introduced into the deodorization vessel;
- bringing the provided oils and/or fats into contact with provided superheated steam in said at least one treatment section during a treatment;
- discharging steam from the deodorization vessel through the vacuum connection, and
- discharging oils and/or fats from the deodorization vessel through the outlet.

[0096] The terms and definitions used in relation to the fourth aspect are as discussed under the second and third aspects above.

[0097] In embodiments of the deodorization method according to the fourth aspect of the invention, at least one of the at least one treatment section is a stripping section and oils and/or fats provided in each stripping section are brought into contact with provided superheated steam during a stripping process.

[0098] Still other objects and features of the present disclosure will become apparent from the following detailed description considered in conjunction with the accompanying drawings. It is to be understood, however, that the drawings are designed solely for purposes of illustration and not as a definition of the limits of the invention, for which reference should be made to the appended claims. It should further be understood that the drawings are not drawn to scale and that they are merely intended to conceptually illustrate the structures described herein.

Brief Description of the Drawings

[0099] In the drawings, wherein like reference characters denote similar elements throughout the several views:

Figs. 1a-d show schematic views of different embodiments of a vapor generation system according to the present disclosure;

Fig. 2 shows a schematic view of an embodiment of an economizer of a vapor generation system according to the present disclosure;

Fig. 3a shows schematically a view from above of a first embodiment of a fluid injection device;

Fig. 3b shows schematically an end view of the fluid injection device in Fig. 3a;

Fig. 3c shows schematically a longitudinal section along the lines V-V in Fig. 3a;

Fig. 3d shows schematically a view from above of a second embodiment of a fluid injection device;

Fig. 3e shows schematically an end view of the fluid injection device in Fig. 3d;

Fig. 3f shows schematically a longitudinal section along the lines IIIV-IIIIV in Fig. 3d, and

Figs. 4a-b show schematic views of different embodiments of a deodorization system according to the present disclosure.

Detailed Description

[0100] The vapor generation system and method for generation of vapor according to the present disclosure will be further illustrated by the following description of some embodiments with reference to the accompanying drawings. In the following description, the vapor generation system and the method for generation of vapor will be described as a steam generation system and a method for generation of steam. However, as above described the vapor generation system and method for generation of vapor may likewise be utilized for generation of other vapor than steam, such as e.g. toluene vapor.

[0101] Fig. 1a shows an embodiment of a steam generation system 1 for generation of superheated steam from feedwater. The system 1 comprises a vessel 2 with a channel 3 for a high temperature fluid. The channel 3 is connectable to a source 4 of the high temperature fluid and is in Fig. 1a connected to the source 4. The source 4 of the high temperature fluid may be a boiler, burner, turbine, engine or other suitable device generating a high temperature fluid from which heat may be extracted/recovered.

[0102] The vessel 2 comprises an inlet 5 for the high temperature fluid into the channel 3 and an outlet 6 for the high temperature fluid out of the channel 3. The channel 3 for the high temperature fluid is arranged to convey the high temperature fluid through the channel 3 from the inlet 5 to the outlet 6 of the vessel 2. The channel 3 is thus arranged to convey the high temperature fluid in a flow direction from the inlet 5 to the outlet 6. The channel 3 has a longitudinal centre axis X which extends through the inlet 5 and the outlet 6.

[0103] The system 1 comprises further an economizer 7, an evaporator 8 and a superheater 9 arranged in the channel 3. In addition, the system 1 comprises a water-

steam separator 10 arranged external of the channel 3.

[0104] The economizer 7 is arranged to receive a first fluid constituted by feedwater to be preheated via an economizer inlet 7a. More specifically, the system 1 of Fig. 1a comprises further an economizer inlet conduit 11 and a first fluid pre-treatment system (i.e. a feedwater pre-treatment system) 12. The economizer inlet conduit 11 is connected with the feedwater pre-treatment system 12 and the economizer inlet 7a and is arranged to convey feedwater. A feedwater pump 13 is arranged to feed feedwater from the pre-treatment system 12 via the economizer inlet conduit 11 and the economizer inlet 7a into the economizer 7.

[0105] The feedwater pre-treatment system 12 shown in Fig. 1a comprises a feedwater storage tank 14, a cleaning device 15 and a softening device 16. The softening device 16 is arranged to receive water to be treated and to soften received water by addition of a softening agent. The cleaning device 15 is connected to the softening device 16 and is arranged to receive softened water from the softening device 16. Furthermore, the cleaning device 15 is arranged to clean received softened water so as to remove impurities. The storage tank 14 is connected to the cleaning device 15 and is arranged to receive cleaned water from the cleaning device 15. Water stored in the storage tank 14 constitutes feedwater to be supplied to the economizer 7. The storage tank 14 is connected to the economizer inlet conduit 11.

[0106] Thus, the economizer 7 is arranged to receive feedwater from the storage tank 14 via the economizer inlet conduit 11 and the economizer inlet 7a. Furthermore, the economizer 7 is arranged to preheat the received feedwater by heat exchange with the high temperature fluid in the channel 3 so as to provide preheated feedwater and discharge preheated feedwater through an economizer outlet 7b. More specifically, the economizer 7 shown in Fig. 1a comprises an economizer tube arrangement 7c arranged to receive and convey the feedwater. The high temperature fluid in the channel 3 is in heat exchanging relation with the feedwater in the economizer tube arrangement 7c, wherein the feedwater is preheated when conveyed in the economizer tube arrangement 7c. The economizer tube arrangement 7c is illustrated schematically in Fig. 2.

[0107] As can be seen in Fig. 2, the economizer tube arrangement 7c comprises a number of tubes, i.e. four tubes 7d-g, configured to convey the feedwater to be preheated and extending between the economizer inlet 7a and the economizer outlet 7b. The tubes 7d-g may optionally be provided with fins or other surface enlarging elements (not shown).

[0108] Each tube 7d-g comprises or is formed as a helical coil having a plurality of turns. The helical coils of the tubes 7d-g are concentric with the longitudinal centre axis X. The tubes 7d-g are arranged one within the other as can be seen in Fig. 2.

[0109] The system 1 shown in Fig. 1a comprises further an economizer outlet conduit 17 connected with the

economizer outlet 7b and a water injection device 8d. The water injection device 8d will be further described below. The economizer outlet conduit 17 is arranged to convey preheated feedwater from the economizer outlet 7b to the water injection device 8d.

[0110] The evaporator 8 is arranged to receive a second fluid to be heated via an evaporator inlet 8a. The evaporator 8 is arranged to heat (evaporate) the received second fluid by heat exchange with the high temperature fluid in the channel 3 so as to provide a heated second fluid, which may consist of a mixture comprising water and steam, and discharge heated second fluid through an evaporator outlet 8b. More specifically, the evaporator 8 shown in Fig. 1 a comprises an evaporator tube arrangement 8c arranged to receive and convey the second fluid to be heated. The high temperature fluid in the channel 3 is in heat exchanging relation with the second fluid in the evaporator tube arrangement 8c, wherein the second fluid is heated when conveyed in the evaporator tube arrangement 8c. The evaporator tube arrangement 8c is not shown in further detail, but has a similar construction as the economizer tube arrangement 7c shown in Fig. 2. Thus, the evaporator tube arrangement 8c comprises a number of tubes, i.e. four tubes, configured to convey the second fluid to be heated and extending between the evaporator inlet 8a and the evaporator outlet 8b. Each of the tubes comprises or is formed as a helical coil having a plurality of turns. The helical coils of the tubes are concentric with the longitudinal centre axis X. The tubes are arranged one within the other.

[0111] The system 1 shown in Fig. 1 a comprises further an evaporator outlet conduit 18 connected with the evaporator outlet 8b and a first separator inlet 10a. The evaporator outlet conduit 18 is arranged to convey heated second fluid from the evaporator outlet 8b to the first separator inlet 10a.

[0112] The water-steam separator 10 is arranged to receive heated second fluid from the evaporator 8 via the first separator inlet 10a and to separate water and steam of the received heated second fluid. In the embodiment shown in Fig. 1 a the water-steam separator 10 is a steam drum, wherein steam is collected in an upper part of the steam drum 10 and water is collected in a lower part of the steam drum 10. The steam drum 10 is arranged to discharge water through a first separator outlet 10c and steam through a second separator outlet 10d.

[0113] The system 1 shown in Fig. 1 a comprises further a first separator outlet conduit 19 connected with the first separator outlet 10c and the water injection device 8d and a second separator outlet conduit 20 connected with the second separator outlet 10d and a superheater inlet 9a. The first separator outlet conduit 19 is arranged to convey liquid discharged by the separator 10 and the second separator outlet conduit 20 is arranged to convey vapor discharged by the separator 10. Thus, the water-steam separator 10 and the evaporator 8 are part of a circulation circuit 21.

[0114] The water injection device 8d is arranged to re-

ceive preheated feedwater from the economizer 7 (via the economizer outlet 7b and the economizer outlet conduit 17) and water discharged by the separator 10 (via the first separator outlet 10c and the first separator outlet conduit 17) and is further arranged to inject the received preheated feedwater together with the received discharged water into the evaporator 8 (via the evaporator inlet 8a). Thereby, the second fluid to be heated by the evaporator 8 comprises preheated feedwater provided by the economizer 7 and water discharged by the separator 10.

[0115] In the system 1 of Fig. 1 a the water injection device 8d is part of means for recirculation of water discharged by the separator 10 in the circulation circuit 21.

[0116] The superheater 9 is arranged to receive steam discharged by the water-steam separator 10 via the second separator outlet 10d, the second separator outlet conduit 20 and the superheater inlet 9a. The superheater 9 is further arranged to heat the received steam by heat exchange with the high temperature fluid in the channel 3 so as to provide superheated steam and is arranged to discharge the superheated steam through a superheater outlet 9b connected to a superheater outlet conduit 22. The superheater outlet conduit 22 is arranged to convey superheated steam discharged by the superheater 9. More specifically, the superheater 9 shown in Fig. 1 a comprises a superheater tube arrangement 9c arranged to receive and convey the steam to be heated. The high temperature fluid in the channel 3 is in heat exchanging relation with the steam in the superheater tube arrangement 9c, wherein the steam is heated when conveyed in the superheater tube arrangement 9c. The superheater tube arrangement 9c is not shown in further detail, but has a similar construction as the economizer tube arrangement 7c shown in Fig. 2. Thus the superheater tube arrangement 9c comprises a number of tubes, i.e. four tubes, configured to convey the steam to be heated and extending between the superheater inlet 9a and the superheater outlet 9b. Each of the tubes comprises or is formed as a helical coil having a plurality of turns. The helical coils of the tubes are concentric with the longitudinal centre axis X. The tubes are arranged one within the other.

[0117] The system 1 comprises further a first heating device 23. In the embodiment of Fig. 1 a the first heating device 23 is arranged in the lower part of the separator 10 in which separated water is collected. The first heating device 23 is arranged to heat water in the separator 10 so as to convert water to steam. In the embodiment shown in Fig. 1 a the first heating device 23 is an electrical heating device.

[0118] The system 1 shown in Fig. 1 a comprises further a control unit 24 configured to regulate the amount of heat released by the first heating device 23 and a sensing device 25 configured to detect a parameter related to the amount of superheated steam generated by the system 1. The control unit 24 is arranged as a separate unit in Fig. 1a. The control unit 24 is connected via con-

nection 25a with the sensing device 25 and is configured to receive information concerning the detected parameter from the sensing device 25. The control unit 24 is further connected with the first heating device 23 via connection 23a and is arranged to regulate the amount of heat released by the first heating device 23 based on the information concerning the detected parameter. More specifically, the control unit 24 in Fig. 1 a is configured to receive an input signal related to the detected parameter from the sensing device 25 and to generate an output signal to regulate the amount of heat released by the first heating device 23 based on the received input signal.

[0119] The control unit 24 may comprise an input/output interface (i.e. a communication interface such as a transmitter/receiver) 24a for receiving information about the detected parameter from the sensing device 25 and for communicating with the first heating device 23. The control unit 24 is further configured to carry out a method for regulating the amount of heat released by the first heating device 23. For this purpose the control unit 24 may comprise a processor 24b, which is configured to execute computer code instructions which for instance may be stored on a memory 24c. The memory 24c may thus form a (non-transitory) computer-readable medium for storing such computer code instructions. The processor 24b may alternatively be in the form of a hardware component, such as an application specific integrated circuit, a field-programmable gate array or the like.

[0120] In the embodiment of Fig. 1 a the detected parameter is the water level in the water-steam separator 10 and the sensing device 25 is a water level meter.

[0121] Thus, during operation of the system 1 shown in Fig. 1 a the control unit 24 may receive information regarding the water level from the sensing device 25 and regulate the amount of heat released by the first heating device 23 based on the received information. For example, the control unit 24 may turn on the first heating device 23 and/or increase the amount of heat released by the first heating device 23 if the signal from the sensing device 25 indicates that the water level in the separator 10 is above a certain threshold. Furthermore, the control unit 24 may decrease the amount of heat released by the first heating device 23 and/or turn off the first heating device 23 if the signal from the sensing device 25 indicates that the water level in the separator 10 is below a certain threshold. Regulation may also comprise using a regulation loop to keep the amount of superheated steam generated by the system 1 at a constant level, i.e. at a certain level, or within a certain range.

[0122] A first embodiment of the water injection device 8d of Fig. 1 a is shown in Figs. 3a-c. In the first embodiment the fluid injection device 8d is a header device. The header device 8d comprises a header 130 comprising an inlet portion 131 and an outlet portion 132. The inlet portion 131 and the outlet portion 132 are separated by a dashed line in Fig. 3a. The inlet portion 131 comprises a header inlet 133 for water discharged by the water-steam separator 10 via the second separator outlet 10c

and the second separator outlet conduit 19, see Fig. 1 a. The outlet portion 132 comprises a wall 134 surrounding an inner space 135. The outlet portion 132 has a longitudinal center axis C and an inner diameter D.

[0123] In the first embodiment, the outlet portion 132 is circular cylindrical and the wall 134 of the outlet portion 132 continues into the inlet portion 131, and forms a wall 136 of the inlet portion 131. Thus the walls 134 and 136 may be formed by one cylinder.

[0124] The inlet portion 131 extends to a first end 130a of the header 130. The outlet portion 132 extends to a second end 130b of the header 130. The second end 130b is closed by means of an end element 137.

[0125] The outlet portion 132 comprises a header outlet 116, which extends through the wall 134 of the outlet portion 132 and is connected to the evaporator tube arrangement 8c via the evaporator inlet 8a.

[0126] As mentioned above, the evaporator tube arrangement 8c of Fig. 1a comprises four tubes for the second fluid to be heated. The header outlet 116 may comprise a corresponding number of openings 138 extending through the wall 134 of the outlet portion 132, each opening 138 being connected to a respective one of the tubes. It should be noted that in Figs. 3a-3c, only three openings 138 are disclosed. However, it is clear that the header outlet 116 of the header 130 also may comprise four openings 138 arranged along a row as indicated in Figs. 3a and 3c.

[0127] It is also to be noted that the evaporator tube arrangement 8c may comprise any number of tubes, for instance only one tube, or 2, 3, 4, 5, 6, 7, 8 or even more tubes. In any case, the header 130 comprises a header outlet 116 with a corresponding number of openings 138 for being connected to a respective one of the tubes of the evaporator tube arrangement 8c.

[0128] The header inlet 133 is connected to the second separator outlet conduit 19, see Fig. 1a. The header 130 is thus configured to permit the water discharged by the water-steam separator 10 to enter the inner space 135 via the header inlet 133 and to flow from the inner space 135 to the evaporator tube arrangement 8c via the header outlet 116, i.e. via the openings 138 of the header outlet 116.

[0129] The header device 8d also comprises an injector pipe 140, connected to the header 130, for preheated feedwater conveyed from the economizer 7 through the economizer outlet conduit 17, see Fig. 1 a. A first portion 140' of the injector pipe 140 extends into the inner space 135 as can be clearly seen in Fig. 3c. The injector pipe 140 is configured to permit the supply of preheated feedwater to the inner space 135 in such a manner that the water discharged by the water-steam separator 10 and the preheated feedwater together are ejected into the evaporator tube arrangement 8c via the header outlet 116, i.e. via the openings 138. More particularly, when preheated feedwater is ejected from the injector pipe 140, liquid discharged by the separator 10 is forced through the header outlet 116 and into the evaporator tube ar-

rangement 8c together with preheated feedwater. The second fluid to be heated in the evaporator tube arrangement 8c thus comprises the preheated feedwater provided by the economizer 7 and liquid discharged by the separator 10.

[0130] To that end the first portion 140' of the injector pipe 140 comprises an injector outlet 117, which permits the supply of preheated feedwater to the inner space 135. The injector outlet 117 comprises a number of holes 141 extending through a wall 142 of the injector pipe 140. The injector pipe 140, at least in the area of the injector outlet 117 has a cylindrical, especially a circular cylindrical shape defining a longitudinal center axis c. The first portion 140' of the injector pipe 140 has an outer diameter d.

[0131] As can be seen in Fig. 3c, the first portion 140' of the injector pipe 140 is positioned in the inner space 135 in such a way that there is a radial distance between the number of holes 141 and the number of openings 138. More specifically, the inner diameter D is greater than the outer diameter d, wherein the first portion 140' of the injector pipe 140 along its complete length is provided at a radial distance from an inner side of the wall 134 of the outlet portion 132.

[0132] The injector pipe 140 extends through the inlet portion 131 into the inner space 135. In the first embodiment, the injector pipe 140 extends through the wall 136 of the inlet portion 131 as can be seen in Figs. 3a-3c.

[0133] The injector pipe 140 has a bottom end 143 provided in the inner space 135. The bottom end 143 is closed. In the first embodiment, the bottom end 143 is arranged adjacent to the closed second end 130b of the header 130.

[0134] The header outlet 116 has a first flow area, which may be the total area of all openings 138. The injector outlet 117 has a second flow area, which may be the total area of all holes 141. The first flow area is larger than the second flow area. Especially, the area of each opening 138 may be larger than the area of each hole 141. The area of the holes 141 may be equal or different for the different holes 141.

[0135] The header outlet 116 is provided within an elongated area 144 of the wall 134 of the outlet portion 132. The elongated area 144 extends in parallel with the longitudinal center axis C. In the first embodiment, the long sides of the area 144 are tangent to the edges of the openings 138.

[0136] The elongated area 144 has a width α , see Fig. 3a, i.e. an angular distance between the long sides. The width α is less than 60° with respect to the longitudinal center axis C, preferably less than 50° with respect to the longitudinal center axis C, more preferably less than 40° with respect to the longitudinal center axis C and most preferably less than 30° with respect to the longitudinal center axis C.

[0137] As can be seen in Fig. 3a, all of the openings 138 are positioned within the elongated area 144. The injector outlet 117 faces the elongated area 144. Conse-

quently, all of the holes 141 of the injector outlet 117 face the elongated area 144 and thus the openings 138.

[0138] In the first embodiment each of the holes 141 is positioned opposite to an opening 138 as can be clearly seen in Fig. 3a. However, as mentioned above, the number of holes 141 may be less than the number of openings 138.

[0139] Moreover, in the first embodiment, the openings 138 are positioned along a line being parallel with the longitudinal center axis C. Also the holes 141 are positioned along this line being parallel with the longitudinal center axis C. In particular, it should be mentioned that the holes 141 may be displaced in relation to the openings 138 along this line, especially such that the openings 138 and the holes 141 are not pairwise aligned with each other.

[0140] During operation of the steam generation system 1, preheated feedwater from the economizer 7 will thus be fed into the injector pipe 140 by means of the feedwater pump 13, see Fig. 1 a. The feedwater pump 13 raises the pressure of the preheated feedwater from the economizer 7, thereby forcing the preheated feedwater out of the holes 141 of the injector outlet 117. The preheated feedwater ejected from the holes 141 will then bring water discharged from the water-steam separator 10 to be ejected through the openings 138 together with the preheated feedwater from the holes 141. In such a way, circulation of the fluid between the separator 10 and the economizer 7 and the evaporator tube arrangement 8c will be maintained only by means of the power delivered to the feedwater pump 13.

[0141] A second embodiment of the header device 8d is disclosed in Figs. 3d-3f. The same reference signs are used for elements having the same or corresponding functions in the embodiments disclosed. The header device 8d of the second embodiment differs from the header device 8d of the first embodiment in that the inlet portion 131 is curved, more particularly bent 90 degrees, whereas the injector pipe 140 is straight and extends in parallel with the longitudinal center axis C, although the longitudinal center axis c of the injector pipe 140 is displaced with respect to the longitudinal center axis C of the outlet portion 132 as in the first embodiment. In the first embodiment the injector pipe 140 was curved, more particularly bent 90 degrees, while the inlet portion 131 was straight.

[0142] As can be seen in Figs 3c and 3f, the longitudinal center axis c of the first portion 140' of the injector pipe 140 is parallel with the longitudinal center axis C of the outlet portion 132. In the first and second embodiments, the longitudinal center axis c of the first portion 140' of the injector pipe 140 is displaced in a radial direction with respect to the longitudinal center axis C of the outlet portion 132. It should be noted, that the longitudinal center axis c of the first portion 140' of the injector pipe 140 may coincide with the longitudinal center axis C of the outlet portion 132.

[0143] Fig. 1b shows a further embodiment of the

steam generation system 1, which corresponds to the system 1 of Fig. 1 a but with the differences that the system 1 of Fig. 1b does not comprise the water injection device 8d and that the economizer outlet conduit 17 is connected to a second separator inlet 10b instead of to the water injection device 8d.

[0144] Thus, in the system 1 of Fig. 1b the economizer 7 is connected to the separator 10 via the economizer outlet 7b, the economizer outlet conduit 17 and the second separator inlet 10b, wherein the separator 10 is arranged to receive preheated feedwater from the economizer 7. The preheated feedwater received by the separator 10 is collected in the lower part of the separator 10 together with the separated water. In the embodiment of Fig. 1b, the first separator outlet conduit 19 is connected to the evaporator inlet 8a. Thus, the evaporator 8 is arranged to receive discharged liquid from the separator 10 via the first separator outlet 10c, the first separator outlet conduit 19 and the evaporator inlet 8a, wherein the second fluid to be heated by the evaporator 8 comprises water discharged by the separator 10. Furthermore, the system 1 of Fig. 1b comprises a pump 26 for feeding the discharged water from the separator 10 to the evaporator 8. Thus, in the system 1 of Fig. 1b the recirculation means comprises the pump 26.

[0145] Fig. 1c shows a further embodiment of the steam generation system 1, which corresponds to the system 1 of Fig. 1 a but with the differences that the circulation circuit 21 further comprises the economizer 7, that the system 1 does not comprise the water injection device 8d, that the first separator outlet 10c is connected to the economizer inlet conduit 11 via the first separator outlet conduit 19 instead of to the water injection device 8d and that the economizer 7 is connected to the evaporator 8 via the economizer outlet 7b, the economizer outlet conduit 17 and the evaporator inlet 8a.

[0146] In the embodiment of Fig. 1c the economizer inlet conduit 11 is arranged to receive water discharged by the separator 10 so that the received discharged water is added to the feedwater conveyed from the feedwater pre-treatment system 12 to the economizer 7. Thus, in this embodiment the first fluid to be heated by the economizer 7 comprises feedwater and water discharged by the separator 10. Furthermore, the evaporator 8 is arranged to receive preheated feedwater from the economizer 7, wherein the second fluid to be heated by the evaporator 8 comprises preheated feedwater provided by the economizer 8.

[0147] The embodiment of Fig. 1c comprises a pump 26 for feeding the discharged water from the separator 10 to the economizer inlet conduit 11. Thus, in the system of Fig. 1c the recirculation means comprises the pump 26.

[0148] Fig. 1d shows a further embodiment of the steam generation system 1, which corresponds to the system 1 of Fig. 1 a but with the difference that the system 1 further comprises a second heating device 27. The second heating device 27 is arranged to receive superheated vapor from the superheater 9 via the superheater outlet

9b and is thus connected to the superheater 9 via the superheater outlet 9b and the superheater outlet conduit 22. In the embodiment shown in Fig. 1d the second heating device 27 is an electrical heating device.

[0149] Fig. 4a shows one embodiment of a deodorization system 28 for deodorization of oils and/or fats, wherein the deodorization system 28 comprises a steam generation system 1 according to the embodiment shown in Fig. 1a and a deodorization vessel 29 in the form of a deodorization column. The steam generation system 1 is only shown highly schematically in Fig. 4a except for the source 4 and the superheater outlet conduit 22. For further details, see Fig. 1a. In the embodiment of Fig. 4a the source 4 is a steam boiler.

[0150] The deodorization column 29 comprises a vacuum connection 30a and is in Fig. 4a connected to a vacuum system 30. Furthermore, the column 29 comprises an inlet 31 for introduction of oils and/or fats into the column 29 and an outlet 32 for discharge of oils and/or fats from the column 29. The column 29 comprises also a steam inlet 33a for introduction of superheated steam into the column 29. The superheater outlet conduit 22 of the steam generation system 1 is connected to the steam inlet 33a. Furthermore, the deodorization column 29 comprises one treatment section 35a in the form of a stripping section, in which oils and/or fats introduced into the column 29 are to be contacted with superheated steam introduced into the column 29 through the steam inlet 33a.

[0151] More specifically, the stripping section 35a of the column 29 of Fig. 4a comprises a structured packing (not shown) which is arranged to receive introduced oils and/or fats. The oils and/or fats are brought to flow through the structured packing under influence by gravity and are brought to meet a flow of superheated steam introduced into the column 29 through the steam inlet 33a in counter current. The column 29 may further comprise means for supplying and/or distributing superheated steam (not shown) in counter current through the structured packing. Furthermore, the deodorization system 28 comprises a scrubber 37 arranged in the column 29. The scrubber 37 is arranged to receive steam and removed volatiles, to condense volatiles and discharge condensed volatiles. In the system of Fig. 4a the discharged volatiles are collected in a tank 34. The scrubber 37 may alternatively be arranged as a separate unit, i.e. external of the column 29.

[0152] During use of the system 28, oils and/or fats to be deodorized are conveyed into the column 29 through the inlet 31. The introduced oils and/or fats are brought to flow through the structured packing under influence by gravity and are brought to meet a flow of superheated steam in counter current in the packing. In the packing volatile components are removed from the oils and/or fats under influence of the flow of superheated steam. The flow of steam and removed volatiles enters the scrubber 37 in which volatiles are condensed. Steam enters the vacuum system 30 through the vacuum connection

30a. The vacuum system 30 may comprise one or more condensers (not shown) for steam condensation. A stripping action is performed in the stripping section 35a. A heat bleaching action may also be performed in the stripping section 35a.

[0153] The deodorization system 28 of Fig. 4a comprises further a deaerator 36 arranged to remove air from the oils and/or fats before introduction into the deodorization column 29. In addition, the deodorization system 28 comprises a preheating device 38 arranged to preheat oils and/or fats to a first temperature and a final heating device 39 arranged to heat the preheated oils and/or fats to a final temperature (e.g. a temperature required for deodorization) before introduction into the column 29. The preheating device 38 is a heat exchanger arranged to receive treated oils and/or fats from the column 29 via the outlet 32. The untreated oils and/or fats are heated by heat exchange with the treated oils and/or fats in the preheating device 38. Chilled treated oils and/or fats are provided from the preheating device 38. The final heating device 39 is a heat exchanger connected to the steam boiler 4, wherein the heating in the final heating device 39 is performed by heat exchange with steam received from the steam boiler 4.

[0154] Thus, the steam boiler 4 constitutes the source of the high temperature fluid for the steam generation system 1, i.e. the exhaust gases from the steam boiler 4 is utilized as high temperature fluid in the channel 3 of the steam generation system 1. Accordingly, the steam boiler 4 is arranged to generate steam to be utilized in the deodorization system 28 as heating medium in the final heating device 39 and to generate exhaust gas to be utilized as the high temperature fluid in the steam generation system 1. Accordingly, the energy in the exhaust gas of the steam boiler 4 is efficiently recovered and re-used.

[0155] Fig. 4b shows another embodiment of a system 28 for deodorization of oils and/or fats. The system 28 of Fig. 4b differs from the system 28 of Fig. 4a only in that the column 29 further comprises a further steam inlet 33b and a further treatment section 35b in the form of a retention section. The retention section 35b is arranged to receive oils and/or fats that have been treated in the stripping section 35a and superheated steam introduced through the steam inlet 33b. The retention section 35b is further arranged to hold received oils and/or fats for a certain amount of time and bring received oils and/or fats into contact with received superheated steam during a heat bleaching process. In an alternative of the embodiment of Fig. 4b, steam inlet 33a may be omitted.

[0156] While the invention has been described in connection with various exemplary embodiments, it is to be understood that the invention is not to be limited to the disclosed exemplary embodiments, on the contrary, it is intended to cover various modifications and equivalent arrangements within the appended claims. Furthermore, it should be recognized that any disclosed form or embodiment of the invention may be incorporated in any

other disclosed or described or suggested form or embodiment as a general matter of design choice. It is the intention, therefor, to be limited only as indicated by the scope of the claims.

5

Claims

1. A vapor generation system (1) comprising:

10

- a channel (3) for a high temperature fluid;
- an economizer (7) arranged in the channel (3), wherein the economizer (7) is arranged to receive a first fluid to be preheated via an economizer inlet (7a) and to preheat the received first fluid by heat exchange with the high temperature fluid;
- an evaporator (8) arranged in the channel (3), wherein the evaporator (8) is arranged to receive a second fluid to be heated and to heat the received second fluid by heat exchange with the high temperature fluid;
- a liquid-vapor separator (10) arranged to receive heated second fluid from the evaporator (8) and optionally preheated first fluid from the economizer (7), wherein the liquid-vapor separator (10) is arranged to separate liquid and vapor of the received heated second fluid and to discharge liquid through a first separator outlet (10c) and vapor through a second separator outlet (10d), and
- a superheater (9) arranged in the channel (3), wherein the superheater (9) is arranged to receive a vapor fluid comprising vapor discharged by the liquid-vapor separator (10), to heat the received vapor fluid by heat exchange with the high temperature fluid so as to provide superheated vapor and to discharge superheated vapor through a superheater outlet (9b);

15

20

25

30

35

40

45

50

55

wherein the second fluid to be heated by the evaporator (8) comprises preheated first fluid provided by the economizer (7) and/or liquid discharged by the liquid-vapor separator (10), and wherein the vapor generation system (1) further comprises a first heating device (23) arranged to heat liquid in the liquid-vapor separator (10) so as to convert liquid to vapor.

2. The vapor generation system (1) according to claim 1, wherein the vapor generation system (1) further comprises a control unit (24) configured to regulate the amount of heat released by the first heating device (23).

3. The vapor generation system (1) according to claim 1 or 2, wherein the vapor generation system (1) further comprises at least one sensing device (25) configured to detect a respective parameter related to

the amount of superheated vapor generated by the vapor generation system (1).

4. The vapor generation system (1) according to claim 2 and 3, wherein the control unit (24) is configured to regulate the amount of heat released by the first heating device (23) based on said respective parameter detected by the at least one sensing device.
5. The vapor generation system (1) according to claim 3 or 4, wherein the respective parameter detected by at least one of said at least one sensing device (25) is the liquid level in the liquid-vapor separator (10).
6. The vapor generation system (1) according to any one of claims 1-5, wherein the first heating device (23) is an electrical heating device or a heat exchanger.
7. The vapor generation system (1) according to any one of claims 1-6, wherein the liquid-vapor separator (10) is a vapor drum or a vapor cyclone.
8. The vapor generation system (1) according to any one of claims 1-7, wherein the evaporator (8) is arranged to receive preheated first fluid provided by the economizer (7) and liquid discharged by the liquid-vapor separator (10), wherein the second fluid to be heated by the evaporator (8) comprises preheated first fluid provided by the economizer (7) and liquid discharged by the liquid-vapor separator (10).
9. The vapor generation system (1) according to claim 8, wherein the vapor generation system (1) further comprises a fluid injection device (8d) connected to the evaporator (8), wherein the fluid injection device (8d) is arranged to receive preheated first fluid from the economizer (7) and discharged liquid from the liquid-vapor separator (10) and to inject the received preheated first fluid together with the received discharged liquid into the evaporator (8) such that the second fluid to be heated by the evaporator (8) comprises preheated first fluid provided by the economizer (7) and liquid discharged by the liquid-vapor separator (10).
10. The vapor generation system (1) according to claim 9, wherein the evaporator (8) comprises an evaporator tube arrangement (8c) arranged to receive and convey the second fluid to be heated, wherein the fluid injection device (8d) is a header device comprising a header (130), wherein the header (130) comprises an inlet portion (131) and an outlet portion (132) communicating with each other, wherein the inlet portion (131) comprises a header inlet (133) for liquid discharged by the liquid-vapor separator (10), wherein the outlet portion (132) comprises a wall

(134) surrounding an inner space (135), wherein the outlet portion (132) comprises a header outlet (116), which extends through the wall (134) and is connected to the evaporator tube arrangement (8c), wherein the header (130) is configured to permit liquid discharged by the liquid-vapor separator (10) to enter the inner space (135) via the header inlet (133), and to flow from the inner space (135) to the evaporator tube arrangement (8c) via the header outlet (116), wherein the header device (8d) comprises an injector pipe (140) connected to the header (130) and arranged to inject preheated first fluid provided by the economizer (7) into the header (130) to force liquid discharged by the liquid-vapor separator (10) through the header outlet (116) and into the evaporator tube arrangement (8c) together with preheated first fluid provided by the economizer (7).

11. The vapor generation system (1) according to any one of claims 1-7, wherein the liquid-vapor separator (10) is further arranged to receive preheated first fluid from the economizer (7), wherein the evaporator (8) is arranged to receive liquid discharged by the liquid-vapor separator (10), and wherein the second fluid to be heated by the evaporator (8) comprises liquid discharged by the liquid-vapor separator (10).
12. The vapor generation system (1) according to any one of claims 1-7, wherein the economizer (7) is arranged to receive liquid discharged by the liquid-vapor separator (10), wherein the first fluid to be preheated by the economizer comprises liquid discharged by the liquid-vapor separator (10), wherein the evaporator (8) is arranged to receive preheated first fluid from the economizer (7), and wherein the second fluid to be heated by the evaporator (8) comprises preheated first fluid provided by the economizer (7).
13. The vapor generation system (1) according to any one of the preceding claims, wherein the vapor generation system (1) further comprises a feedfluid pre-treatment system (12), wherein the first fluid to be preheated by the economizer (7) comprises feedfluid provided from the feedfluid pre-treatment system (12).
14. The vapor generation system (1) according to any one of the preceding claims, wherein the vapor generation system (1) further comprises a source (4) of the high temperature fluid.
15. The vapor generation system (1) according to any one of the preceding claims, wherein the vapor generation system (1) further comprises a second heating device (27), which is arranged to further heat superheated vapor provided by the superheater (9).

16. The vapor generation system (1) according to any one of the preceding claims, wherein the vapor generation system (1) is a steam generation system, wherein the liquid-vapor separator (10) is a water-steam separator, wherein the first fluid to be preheated by the economizer (7) comprises water, wherein the second fluid to be heated by the evaporator comprises preheated first fluid and/or water discharged by the water-steam separator, wherein the vapor fluid is a steam fluid comprising steam discharged by the water-steam separator and wherein the superheated vapor provided and discharged by the superheater is superheated steam.

17. A deodorization system (28) for deodorization of oils and/or fats, wherein the deodorization system (28) comprises a deodorization vessel (29) comprising:

- a vacuum connection (30a) arranged to be connected to a vacuum system (30);
- an inlet (31) for introduction of oils and/or fats into the deodorization vessel (29);
- an outlet (32) for discharge of oils and/or fats from the deodorization vessel (29);
- at least one steam inlet (33a, 33b) for introduction of superheated steam into the deodorization vessel (29), and
- at least one treatment section (35a, 35b) arranged to receive oils and/or fats introduced into the deodorization vessel (29) and superheated steam introduced into the deodorization vessel (29) and arranged to bring received oils and/or fats in contact with received superheated steam during a treatment,

wherein the deodorization system (28) further comprises a steam generation system (1) according to claim 16, and wherein said at least one steam inlet (33) is arranged to receive superheated steam from the steam generation system (1) via the superheater outlet (9a) of the steam generation system (1).

18. The deodorization system (28) according to claim 17, wherein at least one of the at least one treatment section is a stripping section (35a).

19. The deodorization system (28) according to claim 17 or 18, wherein the steam generation system (1) further comprises the source of the high temperature fluid and the deodorization system (28) further comprises a heat exchanger (39) for heating the oils and/or fats before introduction into the deodorization vessel (29), wherein the source of the high temperature fluid (4) is a steam boiler arranged to generate steam to be utilized as a heating medium in said heat exchanger (39), and wherein the steam boiler (4) is arranged to generate exhaust gas to be utilized as the high temperature fluid in the steam generation

system (1).

20. A method for generation of vapor, wherein the method comprises:

- providing a vapor generation system (1) according to any one of claims 1-16;
- conveying a high temperature fluid through the channel (3);
- providing the economizer (7) with a first fluid via the economizer inlet (7a);
- preheating the first fluid in the economizer (7) by heat exchange with the high temperature fluid;
- providing the evaporator (8) with a second fluid to be heated, wherein the second fluid to be heated by the evaporator (8) comprises preheated first fluid provided by the economizer (7) and/or liquid discharged by the liquid-vapor separator (10);
- heating the second fluid to be heated in the evaporator by heat exchange with the high temperature fluid;
- providing the liquid-vapor separator (10) with heated second fluid from the evaporator (8);
- optionally providing the liquid-vapor separator (10) with preheated first fluid from the economizer (7);
- separating liquid and vapor of the heated second fluid in the liquid-vapor separator (10);
- providing the superheater (9) with a vapor fluid comprising vapor discharged by the liquid-vapor separator (10);
- heating the vapor fluid in the superheater (9) by heat exchange with the high temperature fluid so as to provide superheated vapor;
- discharging superheated vapor from the superheater (9) via the superheater outlet (9b), and
- heating liquid in the liquid-vapor separator (10) by means of the first heating device (23) so as to convert liquid to vapor.

21. A method for deodorization of oils and/or fats, the method comprising the steps of:

- providing a deodorization system (28) according to any one of claims 17-19;
- connecting the vacuum connection (30a) of the deodorization vessel (29) to a vacuum system (30);
- introducing oils and/or fats into the deodorization vessel (29) through the inlet (31);
- generating superheated steam by means of the steam generation system (1) comprised in the deodorization system (28);
- introducing generated superheated steam into the deodorization vessel (29) through the at least one steam inlet (33a, 33b);

- providing at least one of the at least one treatment section (35a, 35b) with oils and/or fats introduced into the deodorization vessel (29) and superheated steam introduced into the deodorization vessel (29); 5
- bringing the provided oils and/or fats into contact with provided superheated steam in said at least one treatment section (35a, 35b) during a treatment; 10
- discharging steam from the deodorization vessel (29) through the vacuum connection (30a), and
- discharging oils and/or fats from the deodorization vessel (29) through the outlet (32). 15

20

25

30

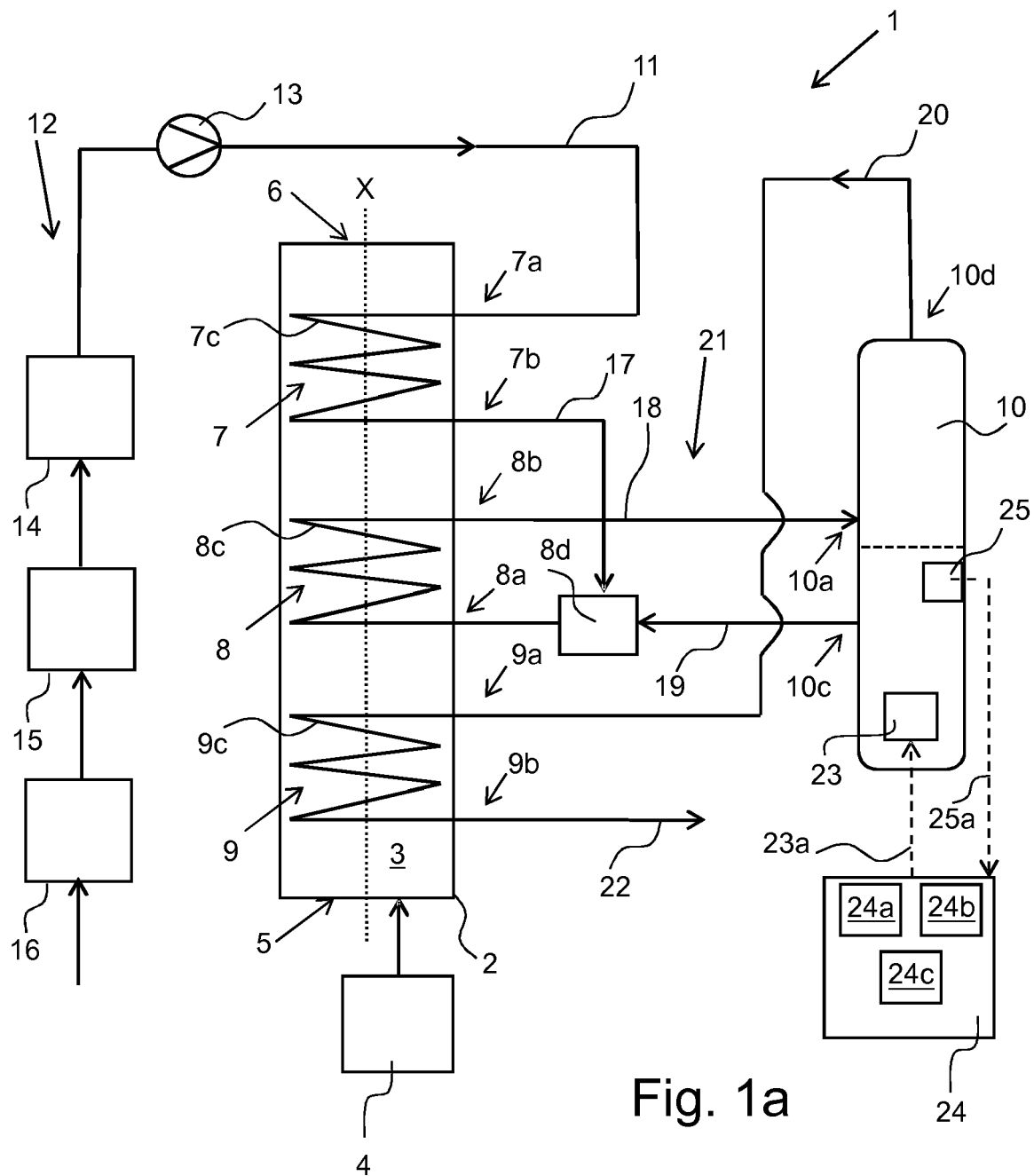
35

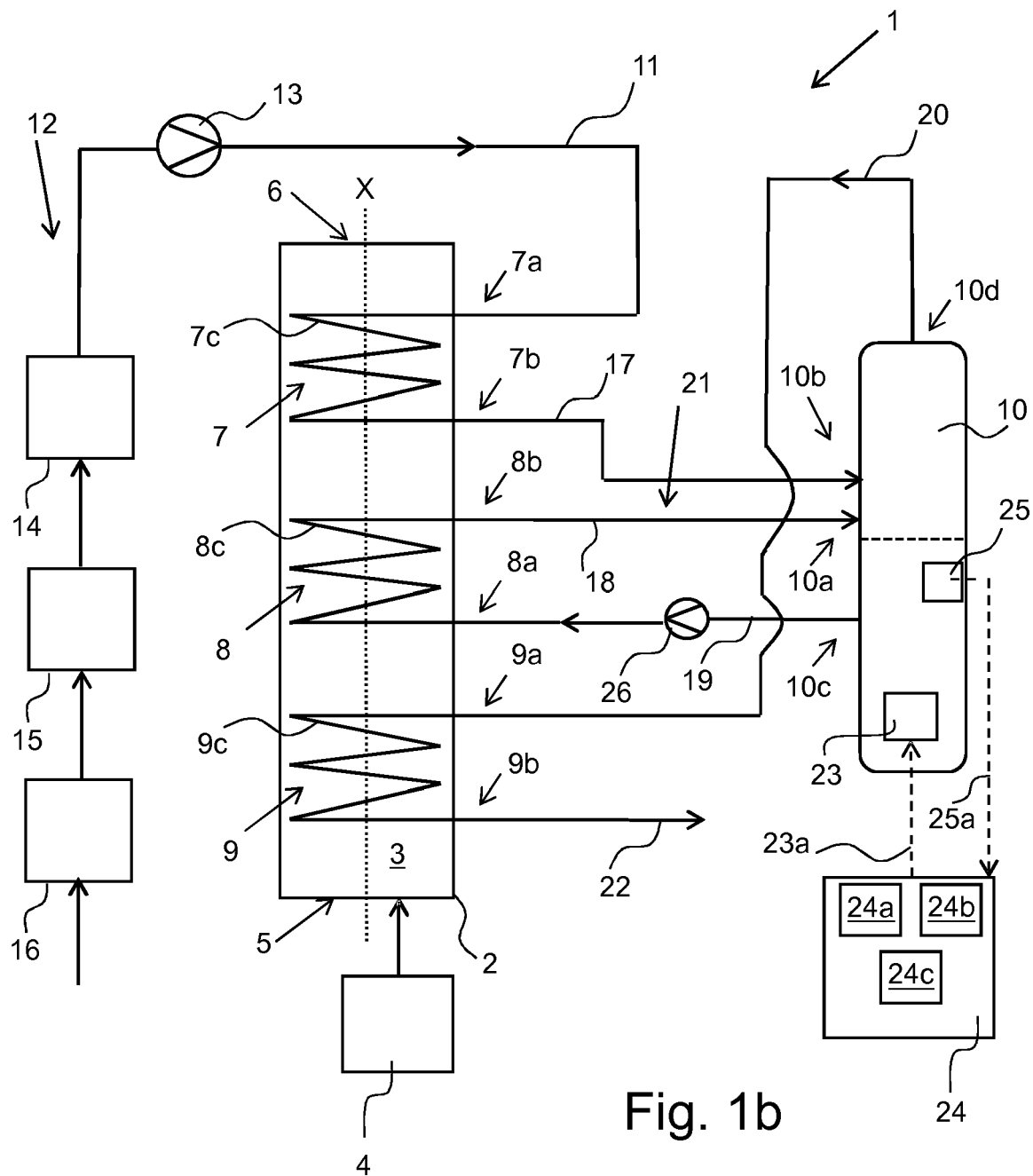
40

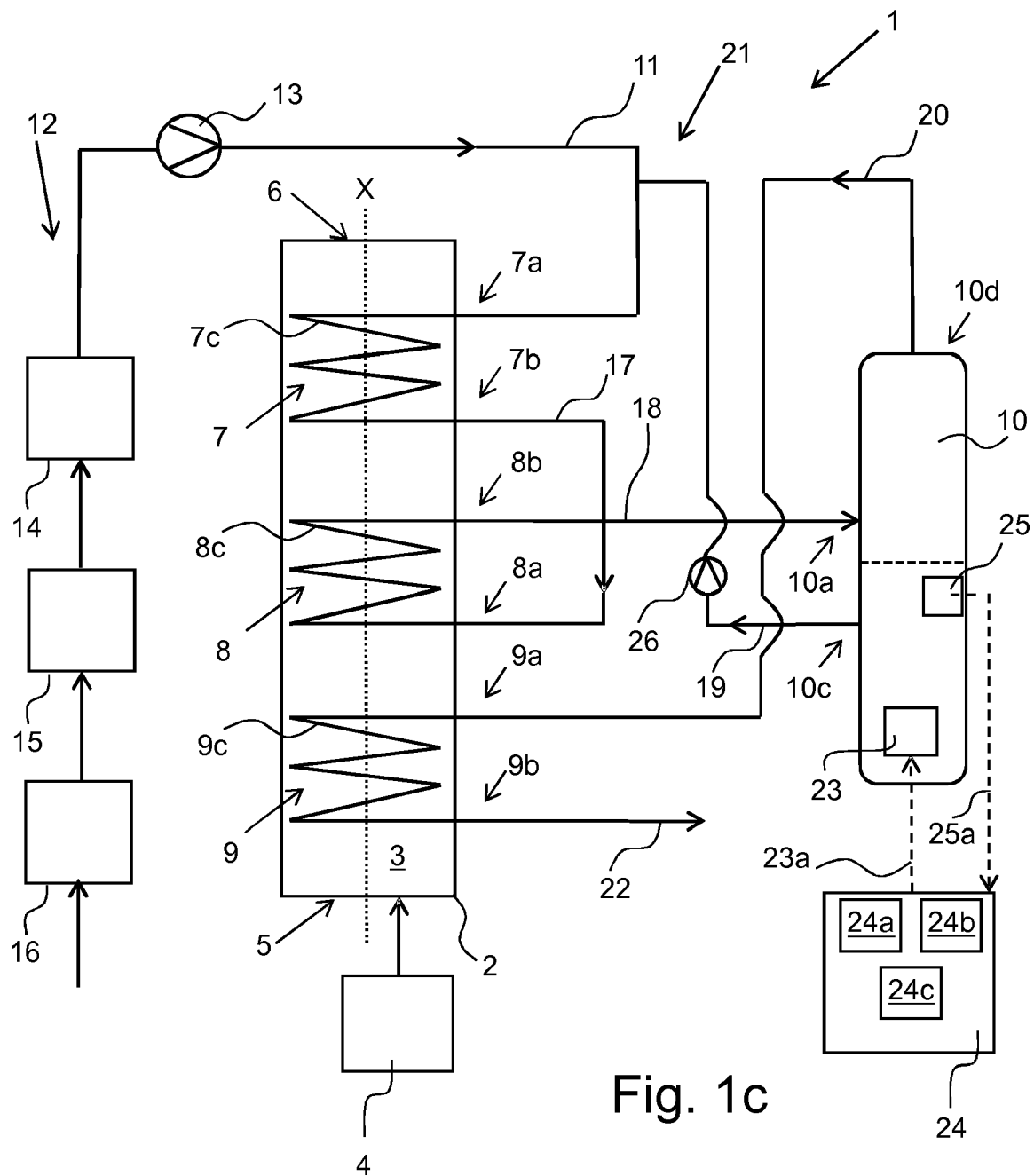
45

50

55







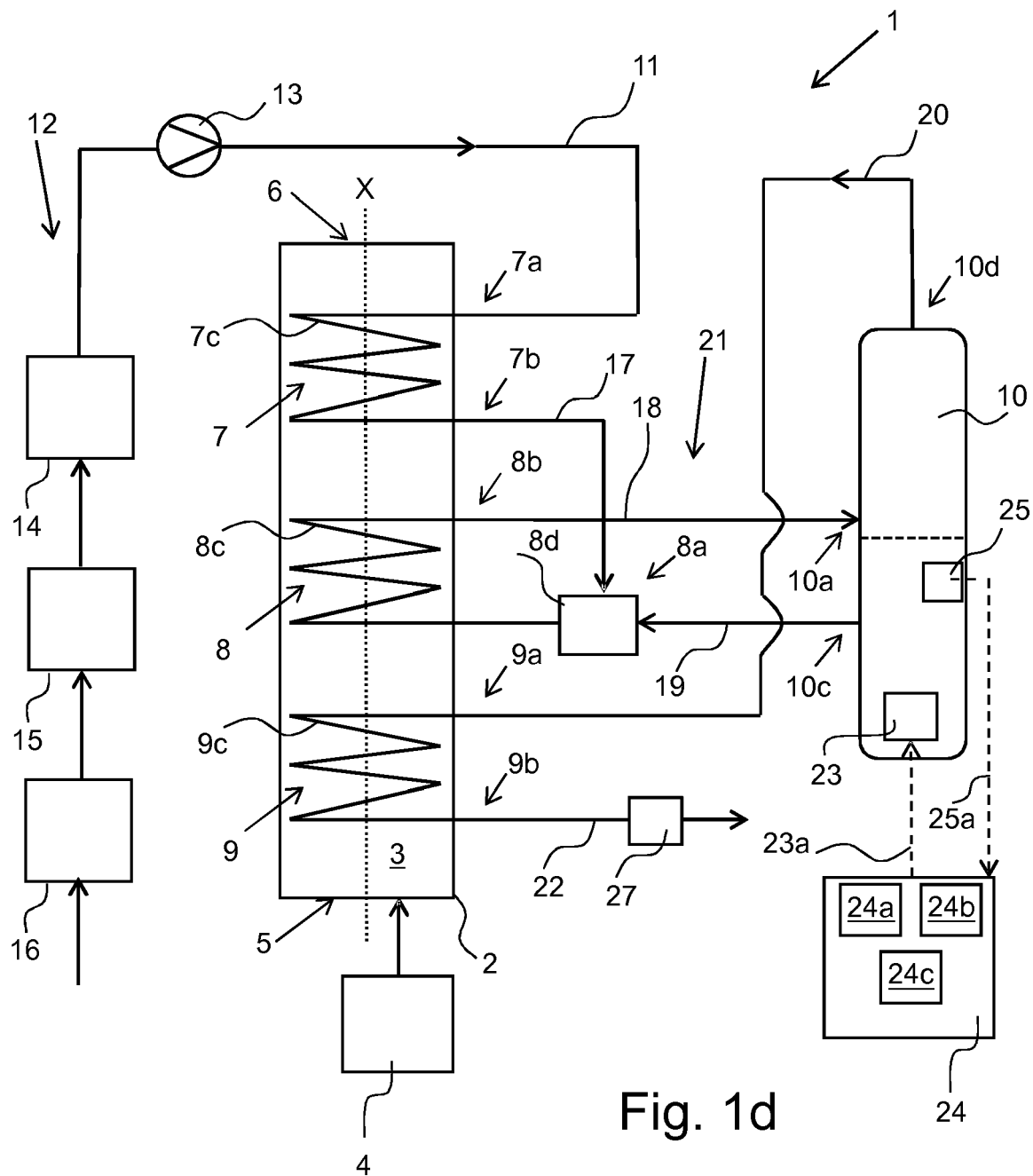


Fig. 1d

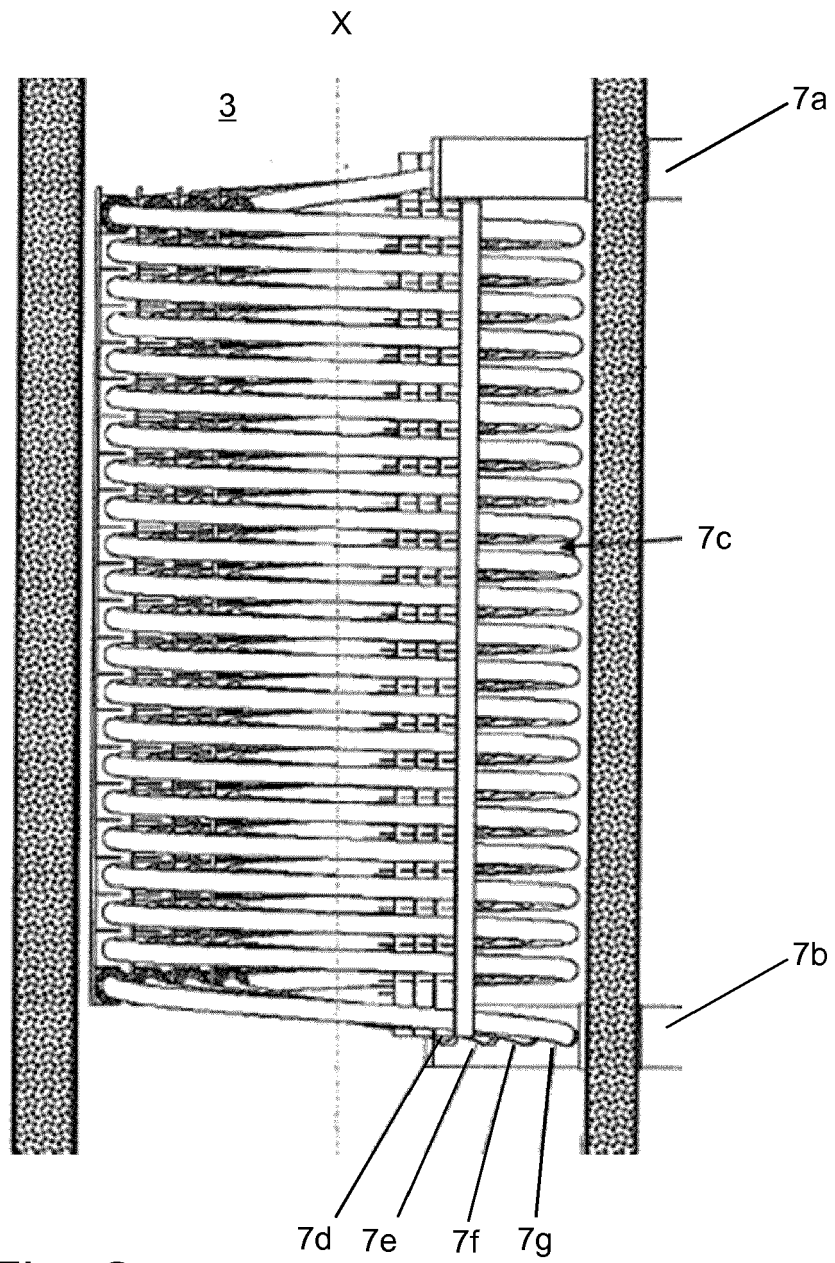


Fig. 2

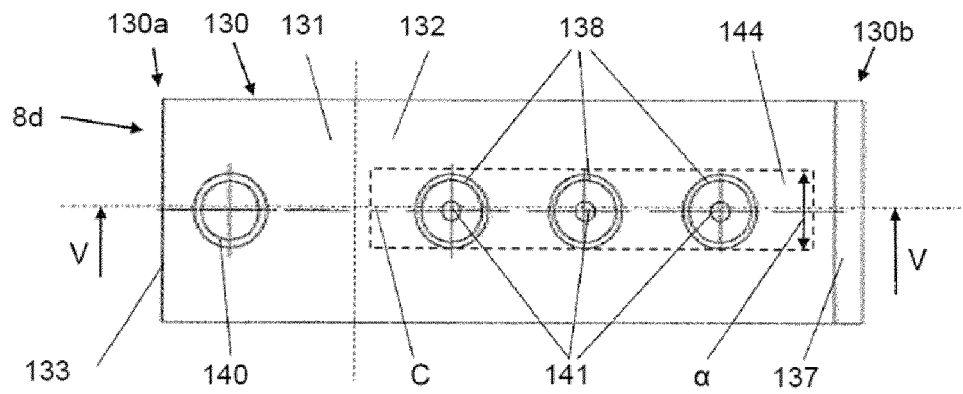


Fig. 3a

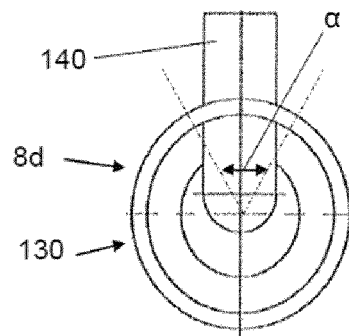


Fig. 3b

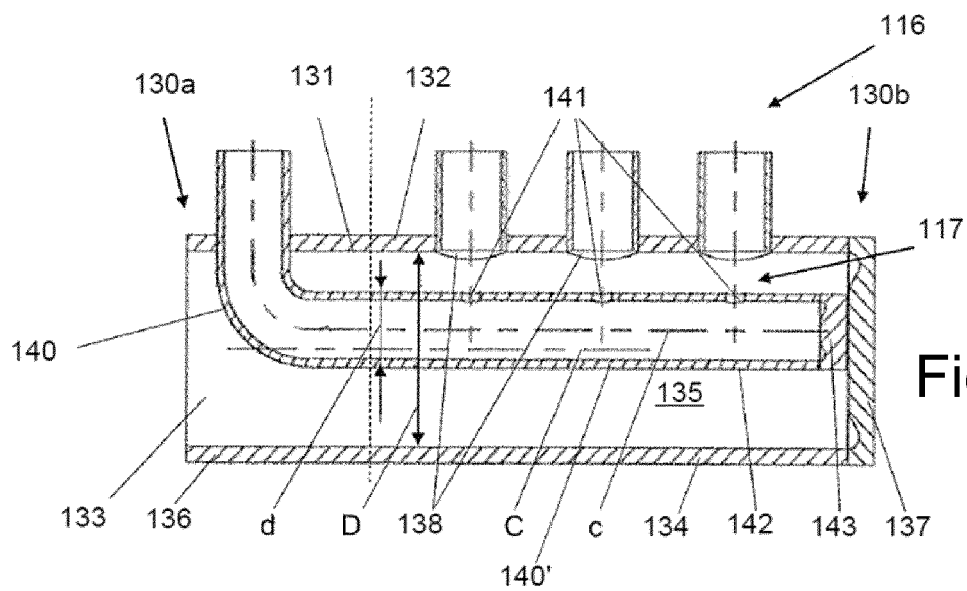


Fig. 3c

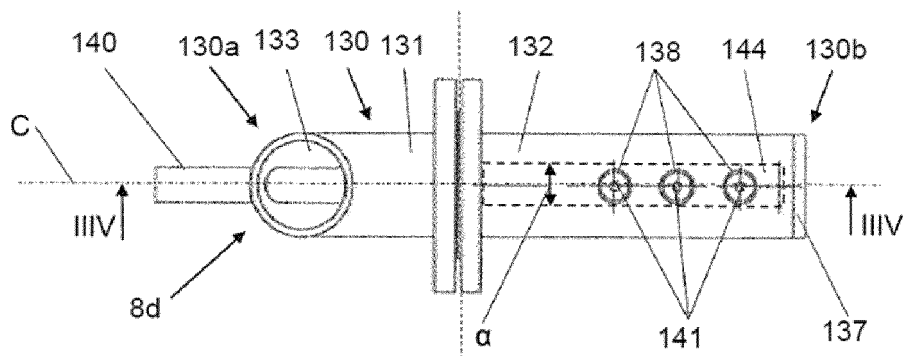


Fig. 3d

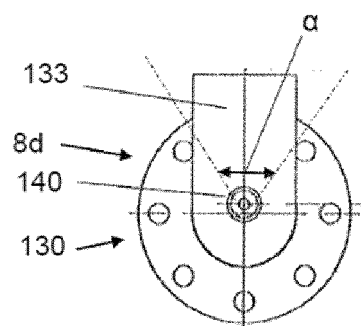


Fig. 3e

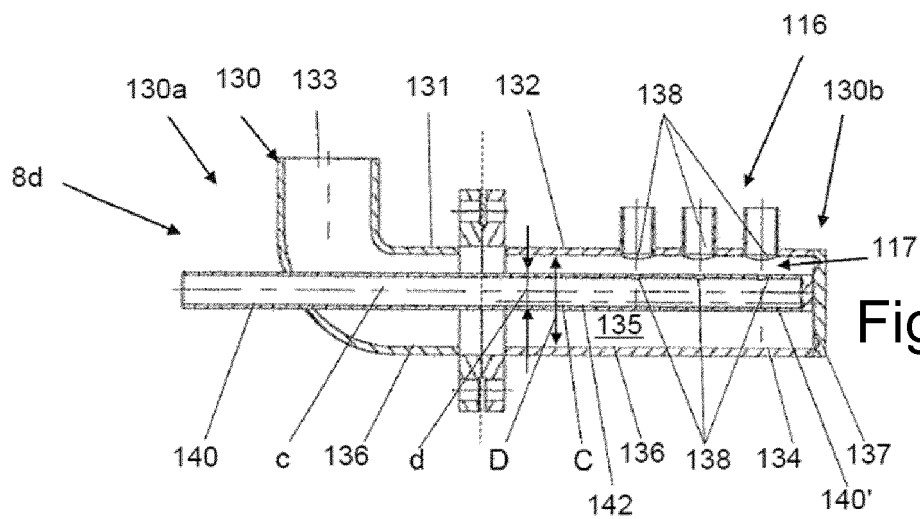


Fig. 3f

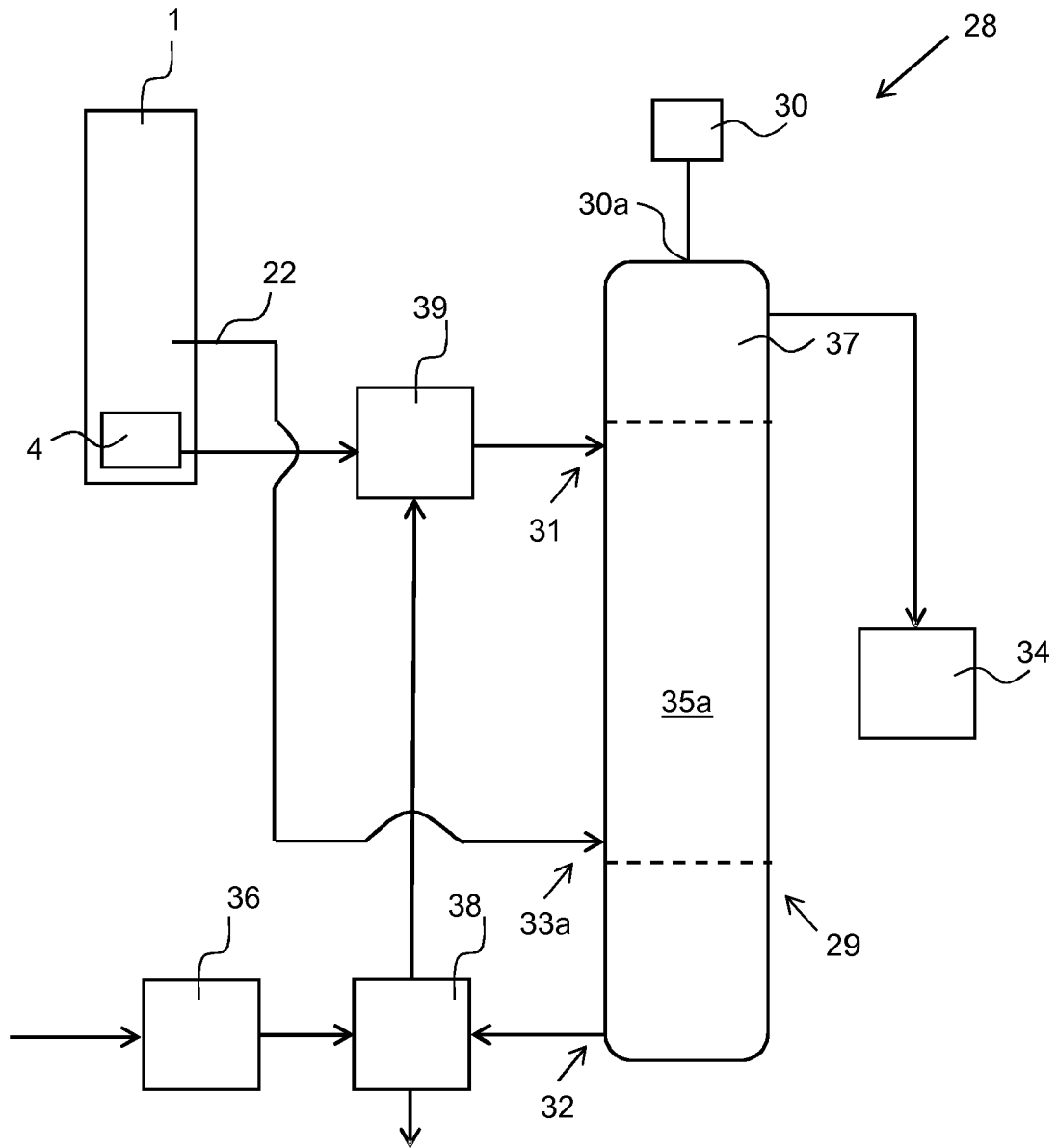


Fig. 4a

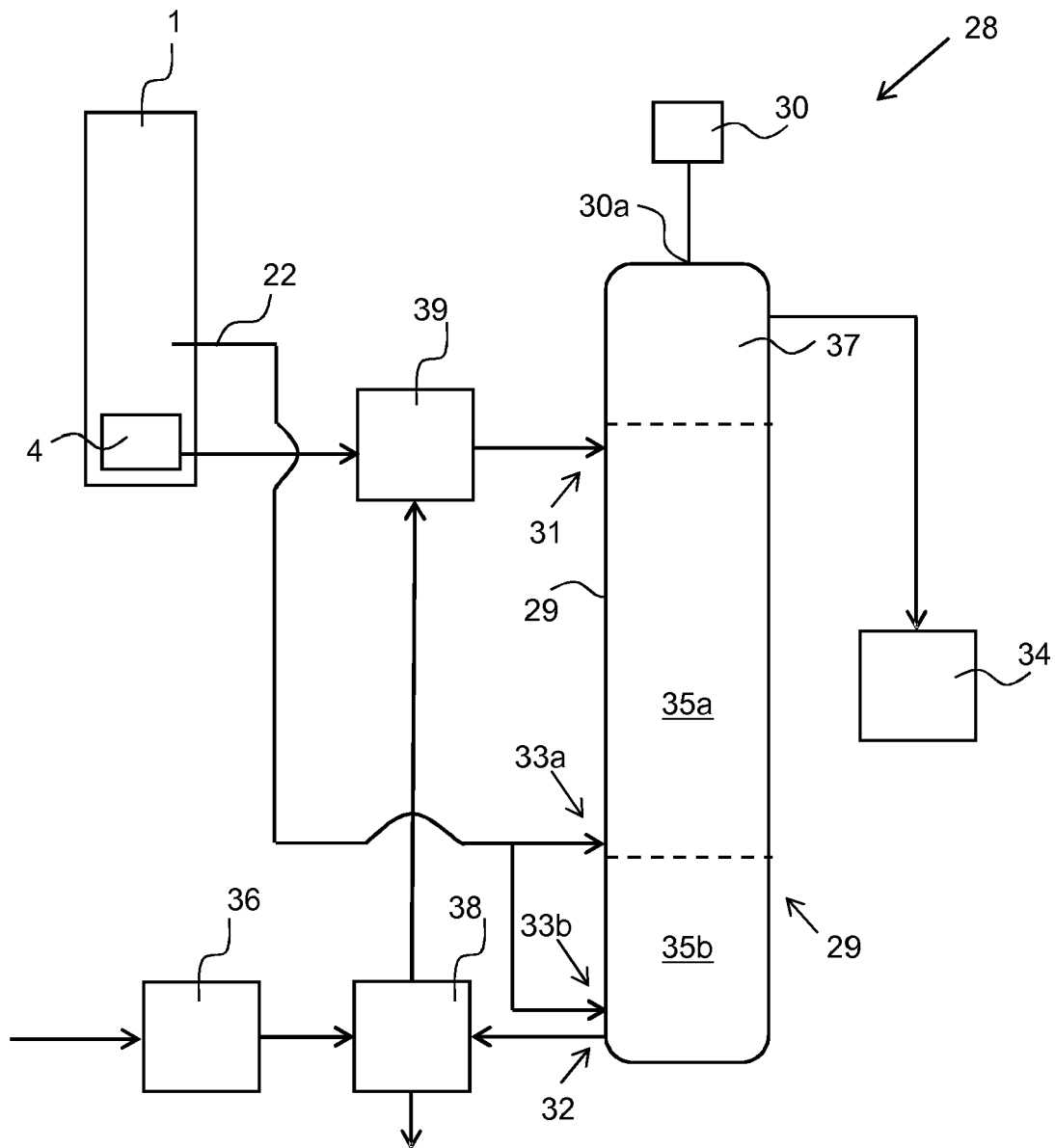


Fig. 4b



EUROPEAN SEARCH REPORT

 Application Number
 EP 16 20 1980

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 6 173 679 B1 (BRUECKNER HERMANN [DE] ET AL) 16 January 2001 (2001-01-16) * abstract; figure 1 * * column 5, line 34 - column 7, line 67 * -----	1-21	INV. F22B21/26 F22B37/22 C11B3/14
A	US 2008/289313 A1 (BATSCHA DANY [IL] ET AL) 27 November 2008 (2008-11-27) * abstract; figure 1 * * paragraphs [0024] - [0027], [0040], [0041] * -----	1-21	
A	US 6 001 220 A (HILLSTROEM ANDERS [SE] ET AL) 14 December 1999 (1999-12-14) * abstract; figure 1 * * column 2, line 64 - column 4, line 20 * -----	1-21	
			TECHNICAL FIELDS SEARCHED (IPC)
			F22B C11B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 22 June 2017	Examiner Varelas, Dimitrios
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

EPO FORM 1503 03.02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 16 20 1980

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

22-06-2017

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6173679 B1	16-01-2001	CA 2294710 A1	14-01-1999
		CN 1260034 A	12-07-2000
		EP 0993581 A1	19-04-2000
		ES 2174461 T3	01-11-2002
		ID 23378 A	20-04-2000
		JP 4540719 B2	08-09-2010
		JP 2002507272 A	05-03-2002
		JP 2008151503 A	03-07-2008
		KR 100439080 B1	05-07-2004
		RU 2193726 C2	27-11-2002
		US 6173679 B1	16-01-2001
		WO 9901697 A1	14-01-1999

US 2008289313 A1	27-11-2008	CA 2718367 A1	17-09-2009
		IL 207986 A	29-01-2015
		RU 2010141554 A	20-04-2012
		US 2008289313 A1	27-11-2008
		WO 2009112916 A2	17-09-2009

US 6001220 A	14-12-1999	AR 007708 A1	10-11-1999
		AT 207949 T	15-11-2001
		AU 719080 B2	04-05-2000
		BR 9706552 A	20-07-1999
		CA 2228555 A1	08-01-1998
		CN 1199418 A	18-11-1998
		CN 1495251 A	12-05-2004
		DE 69707832 D1	06-12-2001
		DE 69707832 T2	04-04-2002
		DK 0866843 T3	19-11-2001
		EP 0866843 A1	30-09-1998
		ES 2167007 T3	01-05-2002
		ID 19115 A	18-06-1998
		IN 192925 B	12-06-2004
		JP 3461511 B2	27-10-2003
		JP H11512144 A	19-10-1999
		KR 100454378 B1	17-12-2004
		MY 118130 A	30-09-2004
		PE 18099 A1	12-03-1999
		PT 866843 E	29-04-2002
		TW 450995 B	21-08-2001
		US 6001220 A	14-12-1999
		WO 9800484 A1	08-01-1998
		ZA 9705940 B	02-02-1998

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 7243618 B [0006]
- US 5588400 A [0006]
- EP 15170495 A [0039]
- WO 9800484 A [0065]