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(54) ELECTROLYSIS ARRANGEMENT AND METHOD

(57) Electrolysis arrangement (1) comprising
- an electrolysis stack (2),
- a feed installation (3) for supplying an electrolysis medium to the electrolysis stack (2),
- a first heat transfer medium path (4) including a heat sink (6) and including a first heat exchanger (8) that is integrated into the feed installation (3),
- a second heat transfer medium path (5) including a heat source (7) and including the first heat exchanger (8) or a second heat exchanger (9) that is integrated into the feed installation (3).

Due to the separation into the first heat transfer medium path (4) and the second heat transfer medium path (5) the electrolysis arrangement (1) can be switched particularly quickly between the heating mode and the cooling mode. This is because only part of the heat transfer medium has to be heated up when switching into the heating mode.

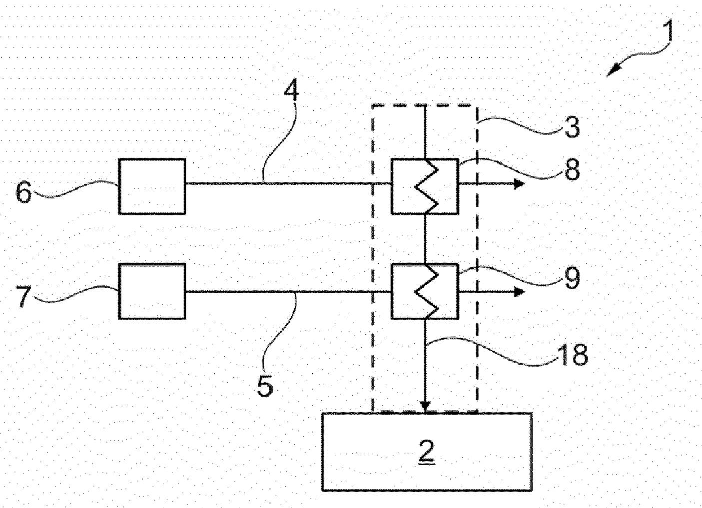

Fig. 1

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Description

[0001] The invention is directed to an electrolysis arrangement and to an electrolysis method, in particular for hydrogen production on an industrial scale.

[0002] In known systems for the electrolysis of water, stacks of electrolysis cells are used that are supposed to be operated at a particular temperature. If the actual temperature deviates significantly from the desired temperature, the efficiency is reduced or the stacks may be damaged, in particular due to cell voltage peaks. Hence, if operated at a high load, cooling of the stacks may be required to compensate for heat generated by the cells of the stacks themselves. If operated at a low load, however, heating may be required. For cooling and heating, known electrolysis systems comprise a heat exchanger flown through by the water that is supplied to the cells/stacks. Therein, heat can be exchanged between the water and a heat transfer medium. The water can be cooled if the heat transfer medium has a lower temperature and the water can be heated if the heat transfer medium has a higher temperature. However, in case of an immediate change in the load of the stacks, the temperature of the heat transfer medium cannot be adjusted immediately. That is, the known systems have a slow dynamic response. Additionally, the dynamic response can be different depending on the electrolysis medium and the specific heat capacity. For example, the temperature in PEM electrolysis cells usually rises faster than in alkaline electrolysis cells.

[0003] The object of the invention is to improve the prior art so that the temperature of an electrolysis stack can be controlled more reliably, in particular in case of a change in the load of the electrolysis stack.

[0004] The object is solved with the electrolysis arrangement and method according to the independent claims. Advantageous refinements are presented in the dependent claims. The features described in the claims and in the description can be combined with each other in any technologically reasonable manner.

[0005] According to the invention an electrolysis arrangement is presented. The electrolysis arrangement comprises:

- an electrolysis stack,
- a feed installation for supplying an electrolysis medium to the electrolysis stack,
- a first heat transfer medium path including a heat sink and including a first heat exchanger that is integrated into the feed installation,
- a second heat transfer medium path including a heat source and including the first heat exchanger or a second heat exchanger that is integrated into the feed installation.

[0006] The electrolysis arrangement can be used for electrolysis of a medium. Preferably, the medium is liquid, in particular water. In particular, the electrolysis medium can be water only. Alternatively, the medium may be water that contains dissolved salts such as KOH for alkaline electrolysis or electrolysis using anion exchange membrane cells. The electrolysis products are preferably gaseous. In the case of water, hydrogen and oxygen can be obtained as the electrolysis products. The electrolysis arrangement is intended to be used for an industrial scale electrolysis. For example, it is preferred that at least one of the electrolysis products is obtained at a rate of 250 to 1500 Nm^3 per hour per electrolysis stack. This applies, in particular, to the production of hydrogen in the case of water electrolysis. The electrolysis is preferably performed in an automated way.

[0007] The electrolysis arrangement comprises one electrolysis stack. That is, it is possible that the electrolysis arrangement has more than one electrolysis stack. Preferably, the electrolysis stacks each have a maximum rated DC power consumption in the range of 1 to 20 MW, in particular in the range of 3 to 10 MW. The described electrolysis arrangement is preferably used for industrial scale electrolysis. In particular, this is to be understood in contrast to experimental setups on a laboratory scale. The industrial scale can be quantified in terms of the maximum rated DC power consumption of the electrolysis stacks. The maximum rated DC power consumption is what is commonly used to describe the electrolysis stacks. For example, a "5 MW electrolysis stack" has a maximum rated DC power consumption of 5 MW.

[0008] The electrolysis stack is preferably configured to be operated at a temperature in the range of 50 to 120°C, in particular at 90 °C. Hence, it is desirable to provide the electrolysis medium at a respective temperature to the electrolysis stack.

[0009] The electrolysis medium can be supplied to the electrolysis stack via a feed installation. In one preferred embodiment the feed installation is configured as a single feed line. Alternatively, the feed installation can comprise multiple independent feed lines. Also, it is preferred that the feed installation comprises one or more separators. The feed installation can be part of a circuit, via which the electrolysis medium can be circulated. For example, the electrolysis medium together with an anode product of the electrolysis can be guided from the anode of the electrolysis stack to an anode separator, where the anode product can be separated from the electrolysis medium. The electrolysis medium together with a cathode product of the electrolysis can be guided from the cathode of the electrolysis stack to a cathode separator, where the cathode product can be separated from the electrolysis medium. From the separators the electrolysis medium can be guided back to the electrolysis stack via a feed line that, together with the separators, is part of the feed installation. In a further preferred embodiment the feed installation is configured as a feed line that has two branches, one of which being connected to the anode space and the other one being connected to the cathode space. It is also possible that the feed installation comprises multiple feed line branches that merge into a single feed line. For example, a first of these branches can be connected to the anode separator and a second of these branches can be connected to the cathode separator. Downstream of where the branches merge the feed line can be connected to the electrolysis stack as a single line or as two branches.

[0010] Into the feed installation a first heat exchanger and, optionally, also a second heat exchanger are integrated. That means that the electrolysis medium flowing through the feed installation passes the heat exchanger(s) such that heat can be exchanged between the electrolysis medium and a heat exchange medium supplied to the heat exchanger(s). It is preferred that the heat exchanger(s) is/are integrated into a feed line that is part of the feed installation. In particular, it is preferred that the heat exchanger(s) is/are integrated into a feed line that extends from an anode separator and/or from a cathode separator to the electrolysis stack. That is, the heat exchanger(s) are preferably arranged between the anode separator and/or the cathode separator on the one hand and the electrolysis stack on the other hand. Alternatively, it is preferred that the heat exchanger(s) is/are arranged within the anode separator and/or the cathode separator.

[0011] In a first embodiment the electrolysis arrangement comprises

- an electrolysis stack,
- a feed installation for supplying an electrolysis medium to the electrolysis stack,
- a first heat transfer medium path including a heat sink and including a heat exchanger that is integrated into the feed installation,
- a second heat transfer medium path including a heat source and including the heat exchanger.

[0012] In the first embodiment there is at least one heat exchanger. This heat exchanger is what has been referred to as the "first heat exchanger" above. However, since here the same heat exchanger is part of both the first heat transfer medium path and the second heat transfer medium path, there is no need for a numbering of heat exchangers. In view of the costs it is preferred in the first embodiment to have exactly one heat exchanger. This heat exchanger is preferably integrated into a feed line of the feed installation. In particular, it is preferred that the heat exchanger is integrated into a feed line that extends from an anode separator and/or from a cathode separator to the electrolysis stack. It is also possible that multiple heat exchangers are provided that are each part of both the first heat transfer medium path and the second heat transfer medium path. In the wording used above, multiple first heat exchangers are provided in such a case. In order to avoid confusion with the below described second embodiment, these multiple heat exchangers are not referred to as a first, second, ... heat exchanger. For example, in the first embodiment one heat exchanger can be integrated into the anode separator and one heat exchanger can be integrated into the cathode separator, wherein both these heat exchangers are part of both the first heat transfer medium path and the second heat transfer medium path.

[0013] The electrolysis arrangement comprises two paths for a heat transfer medium. Both heat transfer medium paths are supposed to be used with the same heat transfer medium. The heat transfer medium is preferably water. The first heat transfer medium path extends at least between the heat sink and the heat exchanger. The second heat transfer medium path extends at least between the heat source and the heat exchanger. It is possible that a section of the first heat transfer medium path and a section of the second heat transfer medium path share a conduit such as a pipe. That is, it is not necessary that the first heat transfer medium path and the second heat transfer medium path can be distinguished from each other at every point. It is sufficient that the first heat transfer medium path and the second heat transfer medium path are not completely identical. That is, a single path that includes both the heat sink and the heat source cannot qualify as both the first heat transfer medium path and the second heat transfer medium path merely because it could be assumed that the first heat transfer medium path and the second heat transfer medium path would run in parallel through a shared conduit at every point. The first heat transfer medium path includes at least one section exclusive to the first heat transfer medium and the second heat transfer medium path includes at least one section exclusive to the second heat transfer medium path.

[0014] The first heat transfer medium path can be used to supply the heat transfer medium from the heat sink to the heat exchanger. Thereby, the electrolysis medium can be cooled. This can be used in a cooling mode. In the cooling mode, preferably a flow rate of the heat transfer medium flowing through the first heat transfer medium path is higher than a flow rate of the heat transfer medium flowing through the second heat transfer medium path. In particular, it is preferred that only the first heat transfer medium path is used. It is thereby sufficient for the heat sink to be active. The heat source can be inactive. The second heat transfer medium path can be used to supply the heat transfer medium from the heat source to the heat exchanger. Thereby, the electrolysis medium can be heated. This can be used in a heating mode. In the heating mode, preferably a flow rate of the heat transfer medium flowing through the first heat transfer medium path is lower than a flow rate of the heat transfer medium flowing through the second heat transfer medium path. In particular, it is preferred that only the second heat transfer medium path is used. It is thereby sufficient for the heat source to be active. The heat sink can thereby be inactive. In between the cooling mode and the heating mode there can be an intermediate mode. In the intermediate mode the first heat transfer medium path and the second heat transfer medium path can be used simultaneously. Thereby, a particularly smooth transition between the cooling mode and the heating mode can be obtained.

[0015] In a second embodiment the electrolysis arrangement comprises

- an electrolysis stack,
- a feed installation for supplying an electrolysis medium to the electrolysis stack,
- a first heat transfer medium path including a heat sink and including a first heat exchanger that is integrated into the feed installation,
- a second heat transfer medium path including a heat source and including a second heat exchanger that is integrated into the feed installation.

[0016] The electrolysis arrangement comprises two paths for a heat transfer medium. The first heat transfer medium path and the second heat transfer medium path can be entirely separated from each other. Hence, it is possible, that the first heat transfer medium path is used with a first heat transfer medium and that the second heat transfer medium path is used with a second heat transfer medium, which is different from the first heat transfer medium. However, it is also possible that both heat transfer medium paths are used with the same heat transfer medium, preferably water. The first heat transfer medium path extends at least between the heat sink and the first heat exchanger. The second heat transfer medium path extends at least between the heat source and the second heat exchanger. Analogously to what has been described with respect to the first embodiment, it is possible that a section of the first heat transfer medium path and a section of the second heat transfer medium path share a conduit such as a pipe. Also, the operation with a cooling mode, a heating mode and an intermediate mode is analogous to the first embodiment.

[0017] In the second embodiment there is at least one first heat exchanger and at least one second heat exchanger. In order to reduce the costs, it is preferred that there is exactly one first heat exchanger and exactly one second heat exchanger. In this case the first heat exchanger and the second heat exchanger are preferably integrated into a feed line of the feed installation. In particular, it is preferred that the first heat exchanger and the second heat exchanger are integrated into a feed line that extends from an anode separator and/or from a cathode separator to the electrolysis stack. It is also possible that multiple first heat exchangers are provided that are each part of the first heat transfer medium path and/or that multiple second heat exchangers are provided that are each part of the second heat transfer medium path. For example, in the second embodiment one heat exchanger can be integrated into the anode separator and one heat exchanger can be integrated into the cathode separator, wherein both these heat exchangers are part of the first heat transfer medium path. These two heat exchangers constitute two first heat exchangers. Additionally, one heat exchanger can be integrated into the anode separator and one heat exchanger can be integrated into the cathode separator, wherein both these heat exchangers are part of the second heat transfer medium path. These two heat exchangers constitute two second heat exchangers. In this example, there is a total of four heat exchangers.

[0018] The difference between the first embodiment and the second embodiment is that in the first embodiment at least one heat exchanger is provided that is part of both the first heat transfer medium path and the second heat transfer medium path. In the second embodiment, in contrast, there are at least two heat exchangers, which his more expensive.

[0019] The heat sink is preferably an active heat sink, in particular an air cooler. The heat sink preferably can be switched on and off such that the heat transfer medium that passes the heat sink is cooled only in case the heat sink is active. The heat source is preferably an active heat source, in particular an electric heater. The heat source preferably can be switched on and off such that the heat transfer medium that passes the heat source is heated only in case the heat source is active.

[0020] In a preferred embodiment of the electrolysis arrangement the first heat transfer medium path is configured as a circuit and/or the second heat transfer medium path is configured as a circuit. The "and" case is preferred.

[0021] A circuit is a closed loop. That is, the heat transfer medium can be circulated through the respective heat transfer medium path. To that end the heat transfer medium can be reused, which reduces the consumption of the heat transfer medium.

[0022] As an alternative to a first heat transfer medium path configured as a circuit, the first heat transfer medium path could, for example, extend from a river to the (first) heat exchanger. Water as the (first) heat transfer medium could thereby be taken from the river and supplied to the (first) heat exchanger. From the (first) heat exchanger the first heat transfer medium path could lead to a drain, for example of a public waste water network.

[0023] As an alternative to a second heat transfer medium path configured as a circuit, the second heat transfer medium path could, for example, extend from a steam source to the (second) heat exchanger. The steam source can be configured for a process such as methanol synthesis. Steam as the (second) heat transfer medium could thereby be taken from the steam source and supplied to the (second) heat exchanger. From the (second) heat exchanger the steam could be exhausted to the environment.

[0024] The following preferred embodiments are each particularly preferred as a refinement of the above described "first embodiment" having only one heat exchanger.

[0025] In a preferred embodiment of the electrolysis arrangement the first heat transfer medium path and the second heat transfer medium path partly overlap such that the heat source is also part of the first heat transfer medium path.

[0026] In this embodiment the first heat transfer medium path comprises the heat sink and the heat source, whereas the second heat transfer medium path comprises the heat source, but not the heat sink. That is, the heat sink is arranged in a part of the first heat transfer medium path that is exclusive to the first heat transfer medium path. The overlap of the first heat transfer medium path with the second heat transfer medium path reduces the required amount of piping. If the heat source is switched off, the heat transfer medium flowing through the first heat transfer medium path can pass the heat source without being affected. Hence, the first heat transfer medium path can be used for cooling, despite the fact that the first heat transfer medium path includes also the heat source.

[0027] In a further preferred embodiment of the electrolysis arrangement the first heat transfer medium path and the second heat transfer medium path partly overlap such that a pump unit is part of both the first heat transfer medium path and the second heat transfer medium path.

[0028] In this embodiment a single pump unit is sufficient for both heat transfer medium paths. This reduces the costs of the electrolysis arrangement. It is sufficient that the pump unit comprises a single pump.

[0029] In a further preferred embodiment of the electrolysis arrangement the first heat transfer medium path and the second heat transfer medium path partly overlap, wherein a three-way control valve is provided where the first heat transfer medium path and the second heat transfer medium path separate from each other and/or where the first heat transfer medium path and the second heat transfer medium path merge. It is preferred that only one three-way control valve is provided.

[0030] The three-way control valve can be used to switch between usage of the first heat transfer medium path and the second heat transfer medium path. This can be done in a gradual manner. That is, depending on the setting of the three-way control valve the heat transfer medium can flow through the first heat transfer medium path only, through both the first heat transfer medium path and the second heat transfer medium path or through the second heat transfer medium path only. The fraction of the heat transfer medium flowing through the two heat transfer medium paths can be selected freely by gradually adjusting the three-way control valve. Alternatively, the three-way control valve can be configured such that the entire heat transfer medium can only flow through one of the two heat transfer medium paths.

[0031] In the cooling mode the three-way control valve is set such that the entire heat transfer medium flows through the first heat transfer medium path. Thereby, the heat transfer medium flows through the second heat transfer medium path only to the extent that the first heat transfer medium path and the second heat transfer medium path overlap. In the heating mode the three-way control valve is set such that the entire heat transfer medium flows through the second heat transfer medium path. Thereby, the heat transfer medium flows through the first heat transfer medium path only to the extent that the first heat transfer medium path and the second heat transfer medium path overlap. In between the cooling mode and the heating mode there can be a transition mode in which the three-way control valve is set such that a part of the heat transfer medium flows through the first heat transfer medium path and the other part of the heat transfer medium flows through the second heat transfer medium path.

[0032] In a further preferred embodiment of the electrolysis arrangement the first heat transfer medium path further comprises a storage vessel.

[0033] The storage vessel can be used to store the heat transfer medium. Thereby, a reserve of the heat transfer medium is provided within the first heat transfer medium path. After switching out of the cooling mode, the heat sink can remain active for a period of time. Thereby, a reserve of cooled heat transfer medium can be obtained that can be stored in the storage vessel.

[0034] Additionally or alternatively, the first heat transfer medium path can comprises an expansion vessel. A single vessel can be used as a storage and expansion vessel.

[0035] In a further preferred embodiment of the electrolysis arrangement the first heat transfer medium path is longer than the second heat transfer medium path.

[0036] In case the electrolysis arrangement is switched into the heating mode, only the heat transfer medium in the shorter second heat transfer medium path requires heating up. This can be achieved particularly quickly. This is due to a particularly low heat capacity of the second heat transfer medium path.

[0037] The present embodiment can be realized by the first heat transfer medium path being configured as a circuit and the second heat transfer medium path being configured as a circuit, wherein the first heat transfer medium path comprises a section shared with the second heat transfer medium path and a bypass of the heat sink. The heat source is preferably arranged in the section shared by the first heat transfer medium path and the second heat transfer medium path.

[0038] According to a further aspect of the invention a method is provided for performing an electrolysis of an electrolysis medium in an electrolysis stack, wherein in a cooling mode the electrolysis medium is cooled prior to the electrolysis by a first heat transfer medium provided in a first heat transfer medium path that includes a heat sink, and wherein in a heating mode the electrolysis medium is heated prior to the electrolysis by the first heat transfer medium provided in a second heat transfer medium path, which further includes a heat source, or by a second heat transfer medium provided in a second heat transfer medium path that includes a heat source.

[0039] The advantages and features of the described electrolysis arrangement are transferrable to the method, and vice versa. The electrolysis arrangement is preferably configured to be used according to the method. In a preferred embodiment of the method the electrolysis is performed using an electrolysis arrangement configured as described.

[0040] In the first embodiment of the electrolysis arrangement the method can be performed as follows: In a cooling mode the electrolysis medium is cooled prior to the electrolysis by a heat transfer medium provided in the first heat transfer medium path that includes the heat sink. In a heating mode the electrolysis medium is heated prior to the electrolysis by the heat transfer medium provided in the second heat transfer medium path, which further includes the heat source. Here, only one heat transfer medium is used. Hence, there is no need for a numbering of heat transfer media. Both the cooling and the heating can be achieved using the same heat exchanger.

[0041] In the second embodiment of the electrolysis arrangement the method can be performed as follows: In a cooling mode the electrolysis medium is cooled prior to the electrolysis by a first heat transfer medium provided in the first heat transfer medium path that includes the heat sink. In a heating mode the electrolysis medium is heated prior to the electrolysis by a second heat transfer medium provided in a second heat transfer medium path that includes a heat source. The cooling can be achieved using the first heat exchanger, the heating can be achieved using the second heat exchanger.

[0042] In a further preferred embodiment of the method the heating mode is used for a startup of the electrolysis stack.

[0043] By means of the startup the operation of the electrolysis stack can be started. This applies to a first time use of a new electrolysis stack as well as to a case in which an electrolysis stack had been out of service, for example for maintenance purposes. Before the electrolysis is started, the electrolysis stack is brought to its operation temperature. In the present embodiment, this is done using the heating mode. Thus, there is no need for equipment designated to the startup only.

[0044] Additionally or alternatively, the heating mode can be used in order to tighten bolts that are used to hold the electrolysis cells of the electrolysis stack together. At an elevated temperature the bolts can be tightened particularly securely.

[0045] Additionally or alternatively, in case of low environmental temperatures the heating mode can be used to avoid freezing of the first heat transfer medium path and/or of the electrolysis stack if the electrolysis arrangement is shut down. The first heat transfer medium path can be protected using the heating mode by directing a small amount of the heat transfer medium from the heat source through the first heat transfer medium path.

[0046] In a further preferred embodiment of the method in the cooling mode the first heat transfer medium has a temperature in the range of 40 to 80 °C when being used for cooling the electrolysis medium
and/or
in the heating mode the first heat transfer medium or the second heat transfer medium, respectively, has a temperature in the range of 50 to 110 °C when being used for heating the electrolysis medium.

[0047] The "and" case is preferred.

[0048] In the first embodiment, the temperatures provided for the cooling mode and heating mode refer to the temperature of the one heat transfer medium used in both modes. In the second embodiment, the temperature provided for the cooling mode refers to the first heat transfer medium and the temperature provided for the heating mode refers to the second heat transfer medium.

[0049] In the cooling mode the (first) heat transfer medium has a comparatively high temperature. Nevertheless, it is preferred that after having been used for cooling, the (first) heat transfer medium has a temperature below 100 °C. This refers to the temperature at the outlet of the (first) heat exchanger. In the heating mode the (first or second) heat transfer medium has a comparatively low temperature. This reduces the time to switch between the cooling mode and the heating mode.

[0050] In a further preferred embodiment of the method the first heat transfer medium enters the first heat exchanger at a temperature that differs by less than 15 °C from a temperature at which the first heat transfer medium leaves the first heat exchanger,
and/or
the second heat transfer medium enters the second heat exchanger at a temperature that differs by less than 15 °C from a temperature at which the second heat transfer medium leaves the second heat exchanger.

[0051] In the first embodiment of the electrolysis arrangement only the first alternative is applicable, according to which the (first) heat transfer medium enters the (first) heat exchanger at a temperature that differs by less than 15 °C from a temperature at which the (first) heat transfer medium leaves the (first) heat exchanger. In the second embodiment of the electrolysis arrangement, both alternatives are applicable. Therein, the "and" case is preferred.

[0052] In this embodiment the heat exchanger(s) is/are configured for only a comparatively small change in temperature. This is in line with the previously described embodiment, according to which the heat transfer medium/media has/have a comparatively high temperature in the cooling mode and a comparatively low temperature in the heating mode. Hence, also in the present embodiment the time to switch between the cooling mode and the heating mode is particularly short.

[0053] In a further preferred embodiment of the method the cooling mode is used if a temperature of the electrolysis medium prior to the electrolysis is detected to be above a first temperature threshold value and/or wherein the heating mode is used if the temperature of the electrolysis medium prior to the electrolysis is detected to be below a second temperature threshold value. The "and" case is preferred.

[0054] In this embodiment the decision whether the cooling mode or the heating mode is used is made in view of the temperature of the electrolysis medium. The electrolysis stack is supposed to be operated at an operation temperature. For example, this can be 90 °C. In order to operate the electrolysis stack as close as possible to the optimal temperature, a set point for the temperature of the electrolysis medium prior to the electrolysis is chosen. In view of this set point the cooling mode or the heating mode are used. For example, the first temperature threshold and the second temperature threshold can both be equal to the set point. In that case, if the measured temperature of the electrolysis medium is higher than the set point, the cooling mode is applied in order to reduce the temperature of the electrolysis medium. In case the measured temperature of the electrolysis medium is lower than the set point, the heating mode is applied in order to increase the temperature of the electrolysis medium.

[0055] However, it is not necessary to switch from the cooling mode directly to the heating mode. To this end, the first temperature threshold value can be higher than the set point and the second temperature threshold value can be lower than the set point. For example, if extensive cooling is required, the three-way control valve can be set such that the entire flow of the heat transfer medium is directed through the first heat transfer medium path comprising the heat sink, which is active. Once less extensive cooling is required, the cooling power generated by the heat sink can be reduced, for example by reducing the fan speed of an air cooler used as the heat sink. Once a fan speed of zero has been reached and in case the temperature of the electrolysis medium is still lower than desired, it can be switched from the cooling mode to an intermediate mode. Therein, the three-way control valve can be gradually opened such that part of the heat transfer medium is guided through the second heat transfer medium path so as to bypass the heat sink. The more the three-way control valve is opened in this way, the less will the electrolysis medium be cooled. Once the entire heat transfer medium flows through the second heat transfer path, the heating mode is reached. Therein, the heat source is activated. The higher the heating power of the heat source is set, the more will the electrolysis medium be heated.

[0056] In a further preferred embodiment of the method the cooling mode is used if a load of the electrolysis stack is detected to be above a first threshold value and/or wherein the heating mode is used if the load of the electrolysis stack is detected to be below a second threshold value. The "and" case is preferred.

[0057] In this embodiment the decision whether the cooling mode or the heating mode is used is made in view of the load of the electrolysis stack. Therein, it is assumed that at high loads a cooling is required and that at low loads a heating is required. The first threshold and the second threshold can be equal to each other.

[0058] In a further preferred embodiment of the method in the cooling mode the temperature of the electrolysis medium prior to the electrolysis is controlled by adjusting a cooling power of the heat sink and/or wherein in the heating mode the temperature of the electrolysis medium prior to the electrolysis is controlled by adjusting a hating power of the heat source. The "and" case is preferred.

[0059] In this embodiment the temperature of the electrolysis medium is controlled based on a measurement of the temperature of the electrolysis medium. In the cooling mode the temperature of the electrolysis medium can be controlled by adjusting a fan speed of an air cooler used as the heat sink. If the fan speed approaches zero, it can be assumed that the heat loss of the electrolysis stack is approximately equal to the heat generation of the electrolysis stack. In the heating mode the temperature of the electrolysis medium can be controlled by adjusting an electrical current flowing through an electric heater used as the heat sink.

[0060] In the following the invention will be described with respect to the figures. The figures show a preferred embodiment, to which the invention is not limited. The figures and the dimensions shown therein are only schematic. The figures show:

Fig. 1: a first embodiment of an electrolysis arrangement according to the invention,

Fig. 2: a second embodiment of an electrolysis arrangement according to the invention,

Fig. 3 a third embodiment of an electrolysis arrangement according to the invention,

Fig. 4 a fourth embodiment of an electrolysis arrangement according to the invention,

Fig. 5 a fifth embodiment of an electrolysis arrangement according to the invention,

Fig. 6 a sixth embodiment of an electrolysis arrangement according to the invention,

Fig. 7: a seventh embodiment of an electrolysis arrangement according to the invention when operated in a cooling mode, and

Fig. 8: the electrolysis arrangement of Fig. 7 when operated in a heating mode.

[0061] Fig. 1 shows an electrolysis arrangement 1 comprising an electrolysis stack 2 and a feed installation 3 for supplying an electrolysis medium to the electrolysis stack 2. The feed installation 3 is configured as a feed line 18. Further, the electrolysis arrangement 1 comprises a first heat transfer medium path 4 for providing a first heat transfer medium from a heat sink 6 to a first heat exchanger 8 integrated into the feed line 18 of the feed installation 3. Using the first heat transfer medium path 4, the electrolysis medium in the feed line 18 of the feed installation 3 can be cooled. Further, the electrolysis arrangement 1 comprises a second heat transfer medium path 5 for providing a second heat transfer medium from a heat source 7 to a second heat exchanger 9 integrated into the feed line 18 of the feed installation 3. Using the second heat transfer medium path 5, the electrolysis medium in the feed installation 3 can be heated. In a cooing mode only the first heat transfer medium path 4 is active. In a heating mode only the second heat transfer medium path 5 is active.

[0062] Fig. 2 shows an electrolysis arrangement 1 similar to the one shown in Fig. 1. However, in the embodiment of Fig. 2 the feed line 18 downstream of the second heat exchanger 9 splits into a first branch 19 and a second branch 20. The first branch 19 can be connected to an anode space of the electrolysis stack 2 and the second branch 20 can be connected to a cathode space of the electrolysis stack 2.

[0063] Fig. 3 shows an electrolysis arrangement 1 comprising an electrolysis stack 2 and a feed installation 3 for supplying an electrolysis medium to the electrolysis stack 2. The feed installation 3 is configured as a feed line 18. Further, the electrolysis arrangement 1 comprises a first heat transfer medium path 4 for providing a heat transfer medium from a heat sink 6 to a heat exchanger 8 integrated into the feed line 18 of the feed installation 3. The first heat transfer medium path 4 extends from the heat sink 6 to the heat exchanger 8. Using the first heat transfer medium path 4, the electrolysis medium in the feed line 18 of the feed installation 3 can be cooled. Further, the electrolysis arrangement 1 comprises a second heat transfer medium path 5 for providing the heat transfer medium (i.e. the same medium that is also used in the first heat transfer medium path 4) from a heat source 7 to the heat exchanger 8 integrated into the feed line 18 of the feed installation 3. The second heat transfer medium path 5 extends from a point outside the first heat transfer medium path 4 via the heat source 7 to the heat exchanger 8. Between the heat source 7 and the heat exchanger 8 the two heat transfer medium paths 4,5 overlap. Using the second heat transfer medium path 5, the electrolysis medium in the feed installation 3 can be heated. In a cooling mode only the heat sink 6 is active. In a heating mode only the heat source 7 is active.

[0064] Fig. 4 shows an electrolysis arrangement 1 similar to the one shown in Fig. 3. However, in the embodiment of Fig. 4 the feed line 18 downstream of the heat exchanger 8 splits into a first branch 19 and a second branch 20. The first branch 19 can be connected to an anode space of the electrolysis stack 2 and the second branch 20 can be connected to a cathode space of the electrolysis stack 2.

[0065] Fig. 5 shows a further embodiment of an electrolysis arrangement 1 that is similar to the ones shown in Fig. 1 and 2. However, in Fig. 5 the feed installation 3 comprises an anode separator 13, a cathode separator besides the feed line 18. The feed line 18 comprises a first branch 19 connected to the anode separator 13 and a second branch 20 connected to the cathode separator 20. Downstream of the separators 13,14 the branches 19,20 merge such that a the feed line 18 is connected to the electrolysis stack 2 as a single line. A respective first heat exchanger 8 is integrated into the anode separator 13 and into the cathode separator 14. A respective second heat exchanger 9 is integrated into the anode separator 13 and into the cathode separator 14. That is, in total four heat exchangers 8,9 are provided.

[0066] Fig. 6 shows a further embodiment of an electrolysis arrangement 1 that is similar to the ones shown in Fig. 3 and 4. However, in Fig. 6 the feed installation 3 comprises an anode separator 13, a cathode separator besides the feed line 18. The feed line 18 comprises a first branch 19 connected to the anode separator 13 and a second branch 20 connected to the cathode separator 20. Downstream of the separators 13,14 the branches 19,20 merge such that a the feed line 18 is connected to the electrolysis stack 2 as a single line. A respective heat exchanger 8 is integrated into the anode separator 13 and into the cathode separator 14. That is, in total two heat exchangers 8 are provided. In order to avoid confusion with the other embodiments, however, these two heat exchangers 8 are not referred to as a first and second heat exchanger.

[0067] Both the embodiments according to Fig. 5 and 6 can be altered in particular in the following two ways (not shown in the figures). First, the feedline 18 could split again downstream of where the first branch 19 and the second branch 20 merge. This way, the anode space and the cathode space of the electrolysis stack 2 can be connected separately to the feed line 18. Second, instead of merging, the first branch 19 and the second branch 20 could be connected directly to the (the anode and cathode space of) the electrolysis stack. In this case the two branches 19, 20 could be considered separate feed lines.

[0068] Fig. 7 shows a further embodiment of an electrolysis arrangement 1. The electrolysis arrangement 1 comprises an electrolysis stack 2 connected to a feed installation 3 for supplying an electrolysis medium to the electrolysis stack 2. After having been processed in the electrolysis stack 2, the electrolysis medium can be transferred together with the electrolysis products to an anode separator 13 and a cathode separator 14. Therein, the anode and cathode products of the electrolysis can be separated from the electrolysis medium. In the case of water electrolysis, for example, oxygen can be extracted at an oxygen outlet 15 of the anode separator 13 and hydrogen at a hydrogen outlet 16 of the cathode separator 14. In order to compensate for the consumption of the electrolysis medium, new electrolysis medium can be supplied into the electrolysis arrangement 1 via an inlet 17.

[0069] Into the feed installation 3 a heat exchanger 8 is integrated. Similar to Fig. 2, the heat exchanger 8 is part of a first heat transfer medium path 4 and a second heat transfer medium path 5 that partly overlap. The first heat transfer medium path 4 and the second heat transfer medium path 5 are configured as a respective circuit such that a heat transfer medium can be circulated through the first heat transfer medium path 4 or the second heat transfer medium path 5, respectively. The first heat transfer medium path 4 comprises an air cooler as a heat sink 6, a storage vessel 12 for storing the heat transfer medium, a pump unit 10 and an electric heater as a heat source 7. The pump unit 10 and the heat source 7 are also part of the second heat transfer medium path 5. A three-way control valve 11 is provided where the first heat transfer medium path 4 and the second heat transfer medium path 5 separate from each other. The first heat transfer medium path 4 is longer than the second heat transfer medium path 5.

[0070] In a cooling mode the electrolysis medium in the feed installation 3 can be cooled. This is shown in Fig. 7. Thereby, the heat sink 6 is active and the heat source 7 is inactive. The three-way control valve 11 is set such that the heat transfer medium flows through the first heat transfer medium path 4. The second heat transfer medium path 5 is flown through by the heat transfer medium only to the extent that the first heat transfer medium path 4 and the second heat transfer medium path 5 overlap. By a dotted line it is indicated that the part of the second heat transfer medium path 5 that is exclusive to the second heat transfer medium path 5 is closed. The heat transfer medium has a temperature in the range of 40 to 80 °C when being used for cooling the electrolysis medium, that is when entering the heat exchanger 8. The heat transfer medium enters the heat exchanger 8 at a temperature that is less than 15 °C lower than a temperature at which the heat transfer medium leaves the heat exchanger 8.

[0071] Fig. 8 shows the electrolysis arrangement 1 of Fig. 7 in a heating mode. Therein, the electrolysis medium in the feed installation 3 can be heated. In the heating mode the heat sink 6 is inactive and the heat source 7 is active. The three-way control valve 11 is set such that the heat transfer medium flows through the second heat transfer medium path 5. The first heat transfer medium path 4 is flown through by the heat transfer medium only to the extent that the first heat transfer medium path 4 and the second heat transfer medium path 5 overlap. By a dotted line it is indicated that the part of the first heat transfer medium path 4 that is exclusive to the first heat transfer medium path 4 is closed. The heat transfer medium has a temperature in the range of 50 to 1 10 °C when being used for heating the electrolysis medium, that is when entering the heat exchanger 8. The heat transfer medium enters the heat exchanger 8 at a temperature that is less than 15 °C higher than a temperature at which the heat transfer medium leaves the heat exchanger 8. The heating mode can be used, in particular, for a startup of the electrolysis stack 2.

[0072] The cooling mode illustrated in Fig. 7 can be used if a temperature of the electrolysis medium prior to the electrolysis is detected to be above a first temperature threshold value and the heating mode illustrated in Fig. 8 can used if the temperature of the electrolysis medium prior to the electrolysis is detected to be below a second temperature threshold value.

[0073] Alternatively, the cooling mode illustrated in Fig. 7 can be used if a load of the electrolysis stack 2 is detected to be above a first load threshold value and the heating mode illustrated in Fig. 8 can be used if the load of the electrolysis stack 2 is detected to be below a second load threshold value.

[0074] In the cooling mode the temperature of the electrolysis medium prior to the electrolysis can be controlled by adjusting a cooling power of the heat sink 6 and in the heating mode the temperature of the electrolysis medium prior to the electrolysis can be controlled by adjusting a hating power of the heat source 7.

[0075] Due to the separation into the first heat transfer medium path 4 and the second heat transfer medium path 5 the electrolysis arrangement 1 can be switched particularly quickly between the heating mode and the cooling mode. This is because only part of the heat transfer medium has to be heated up when switching into the heating mode.

List of reference numerals

[0076]

1	electrolysis arrangement
2	electrolysis stack
3	feed installation
4	first heat transfer medium path
5	second heat transfer medium path
6	heat sink
7	heat source
8	(first) heat exchanger
9	second heat exchanger
10	pump unit
11	three-way control valve
12	storage vessel
13	anode separator
14	cathode separator
15	oxygen outlet
16	hydrogen outlet
17	inlet
18	feed line
19	first branch
20	second branch

Claims

1. Electrolysis arrangement (1) comprising

- an electrolysis stack (2),
- a feed installation (3) for supplying an electrolysis medium to the electrolysis stack (2),
- a first heat transfer medium path (4) including a heat sink (6) and including a first heat exchanger (8) that is integrated into the feed installation

(3),
- a second heat transfer medium path (5) including a heat source (7) and including the first heat exchanger (8) or a second heat exchanger (9) that is integrated into the feed installation (3).

2. Electrolysis arrangement (1) according to claim 1, wherein the first heat transfer medium path (4) is configured as a circuit and/or wherein the second heat transfer medium path (5) is configured as a circuit.

3. Electrolysis arrangement (1) according to any of the preceding claims, wherein the first heat transfer medium path (4) and the second heat transfer medium path (5) partly overlap such that the heat source (7) is also part of the first heat transfer medium path (4).

4. Electrolysis arrangement (1) according to any of the preceding claims, wherein the first heat transfer medium path (4) and the second heat transfer medium path (5) partly overlap such that a pump unit (10) is part of both the first heat transfer medium path (4) and the second heat transfer medium path (5).

5. Electrolysis arrangement (1) according to any of the preceding claims, wherein the first heat transfer medium path (4) and the second heat transfer medium path (5) partly overlap, and wherein a three-way control valve (11) is provided where the first heat transfer medium path (4) and the second heat transfer medium path (5) separate from each other and/or where the first heat transfer medium path (4) and the second heat transfer medium path (5) merge.

6. Electrolysis arrangement (1) according to any of the preceding claims, wherein the first heat transfer medium path (4) further comprises a storage vessel (12).

7. Electrolysis arrangement (1) according to any of the preceding claims, wherein the first heat transfer medium path (4) is longer than the second heat transfer medium path (5).

8. Method for performing an electrolysis of an electrolysis medium in an electrolysis stack (2), wherein in a cooling mode the electrolysis medium is cooled prior to the electrolysis by a first heat transfer medium provided in a first heat transfer medium path (4) that includes a heat sink (6), and wherein in a heating mode the electrolysis medium is heated prior to the electrolysis by the first heat transfer medium provided in a second heat transfer medium path (5), which further includes a heat source (7), or by a second heat transfer medium provided in a second heat transfer medium path (5) that includes a heat source (7).

9. Method according to claim 8, wherein the electrolysis is performed using an electrolysis arrangement (1) according to one of the claims 1 to 7.

10. Method according to claim 8 or 9, wherein the heating mode is used for a startup of the electrolysis stack (2).

11. Method according to one of claim 8 to 10,
wherein in the cooling mode the first heat transfer medium has a temperature in the range of 40 to 80 °C when being used for cooling the electrolysis medium and/or
wherein in the heating mode the first heat transfer medium or the second heat transfer medium, respectively, has a temperature in the range of 50 to 110 °C when being used for heating the electrolysis medium.

12. Method according to one of claims 9 to 11,
wherein the first heat transfer medium enters the first heat exchanger (8) at a temperature that differs by less than 15 °C from a temperature at which the first heat transfer medium leaves the first heat exchanger (8),
and/or
wherein the second heat transfer medium enters the second heat exchanger (9) at a temperature that differs by less than 15 °C from a temperature at which the second heat transfer medium leaves the second heat exchanger (9).

13. Method according to one of claims 8 to 12, wherein the cooling mode is used if a temperature of the electrolysis medium prior to the electrolysis is detected to be above a first temperature threshold value and/or wherein the heating mode is used if the temperature of the electrolysis medium prior to the electrolysis is detected to be below a second temperature threshold value.

14. Method according to one of claims 8 to 12, wherein the cooling mode is used if a load of the electrolysis stack (2) is detected to be above a first load threshold value and/or wherein the heating mode is used if the load of the electrolysis stack (2) is detected to be below a second load threshold value.

15. Method according to one of the claims 8 to 14, wherein in the cooling mode the temperature of the electrolysis medium prior to the electrolysis is controlled by adjusting a cooling power of the heat sink (6) and/or wherein in the heating mode the temperature of the electrolysis medium prior to the electrolysis is controlled by adjusting a heating power of the heat source (7).

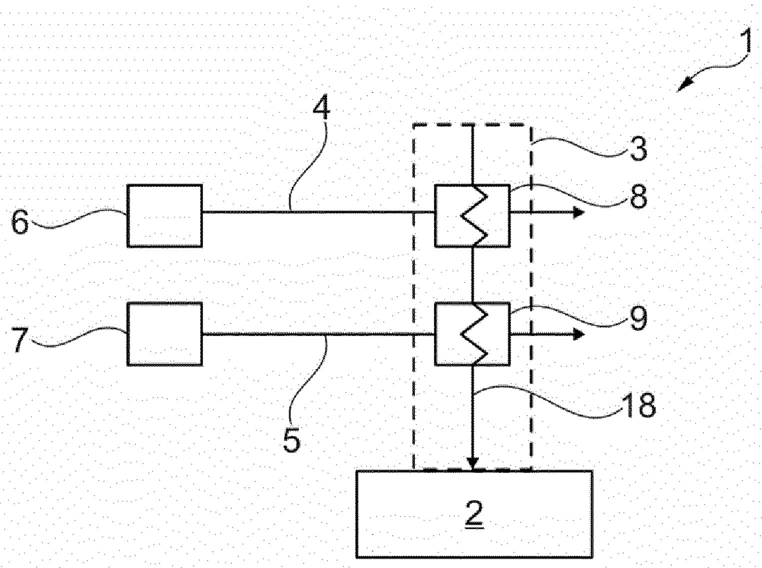

Fig. 1

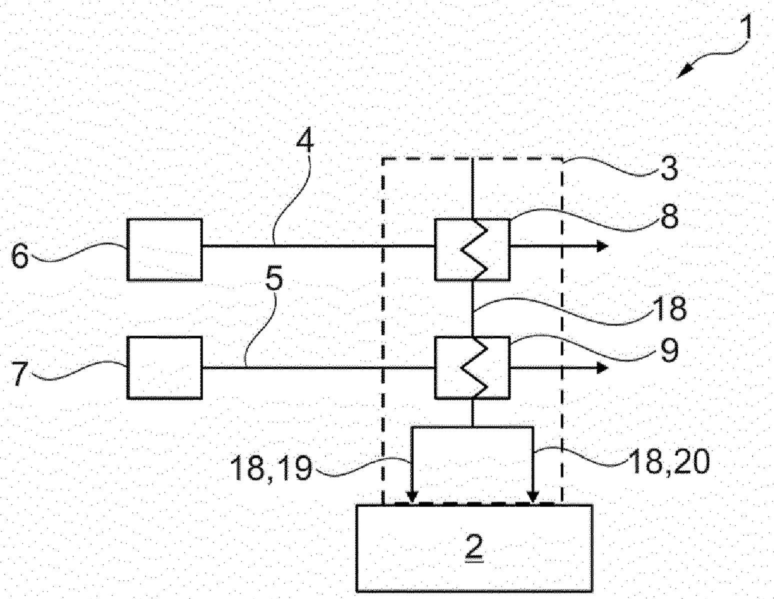

Fig. 2

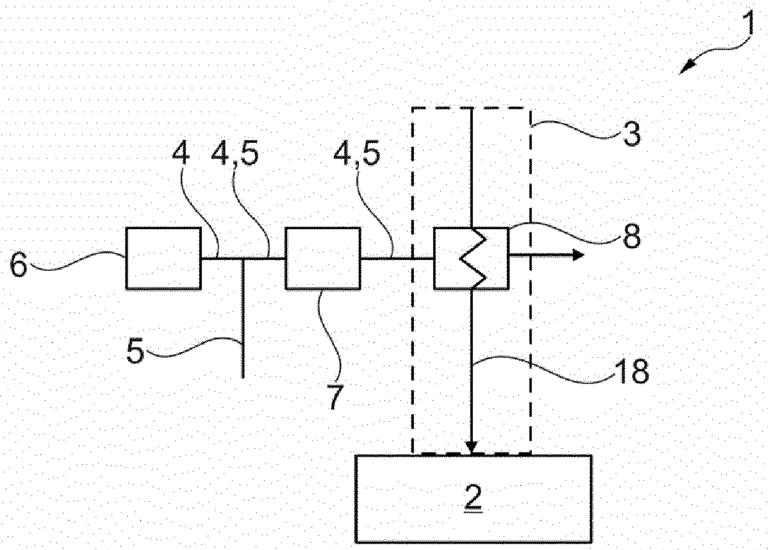

Fig. 3

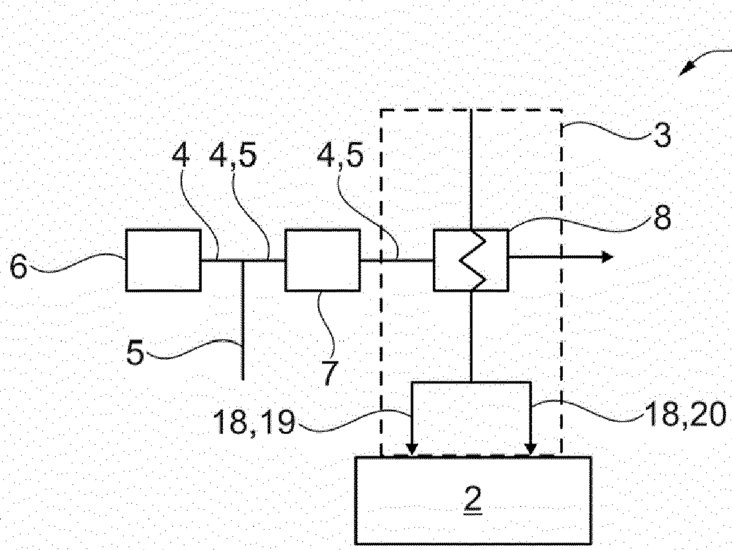

Fig. 4

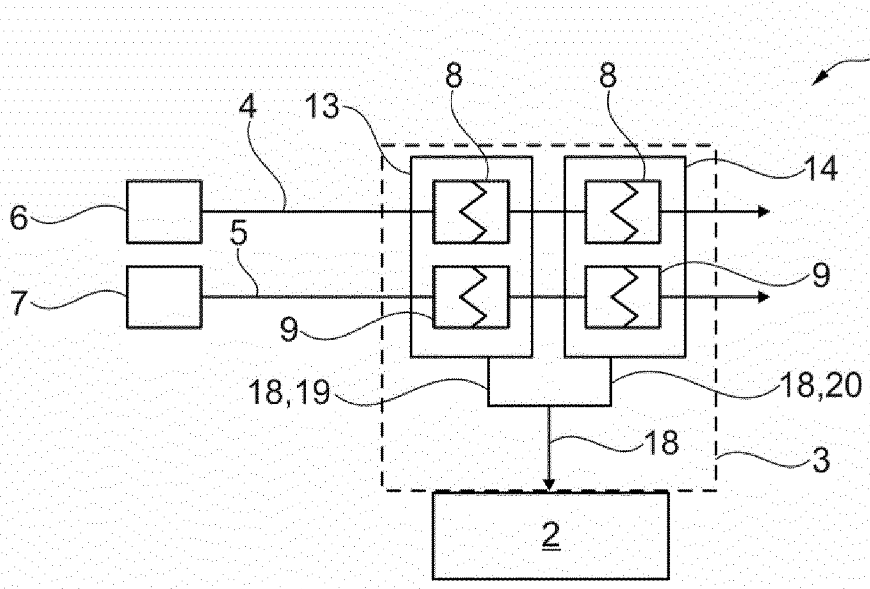
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Fig. 5

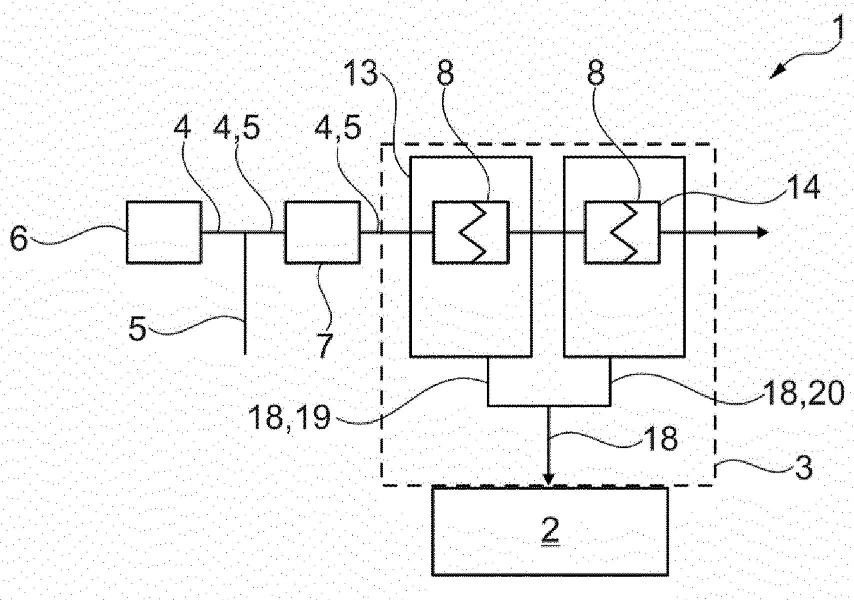
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Fig. 6

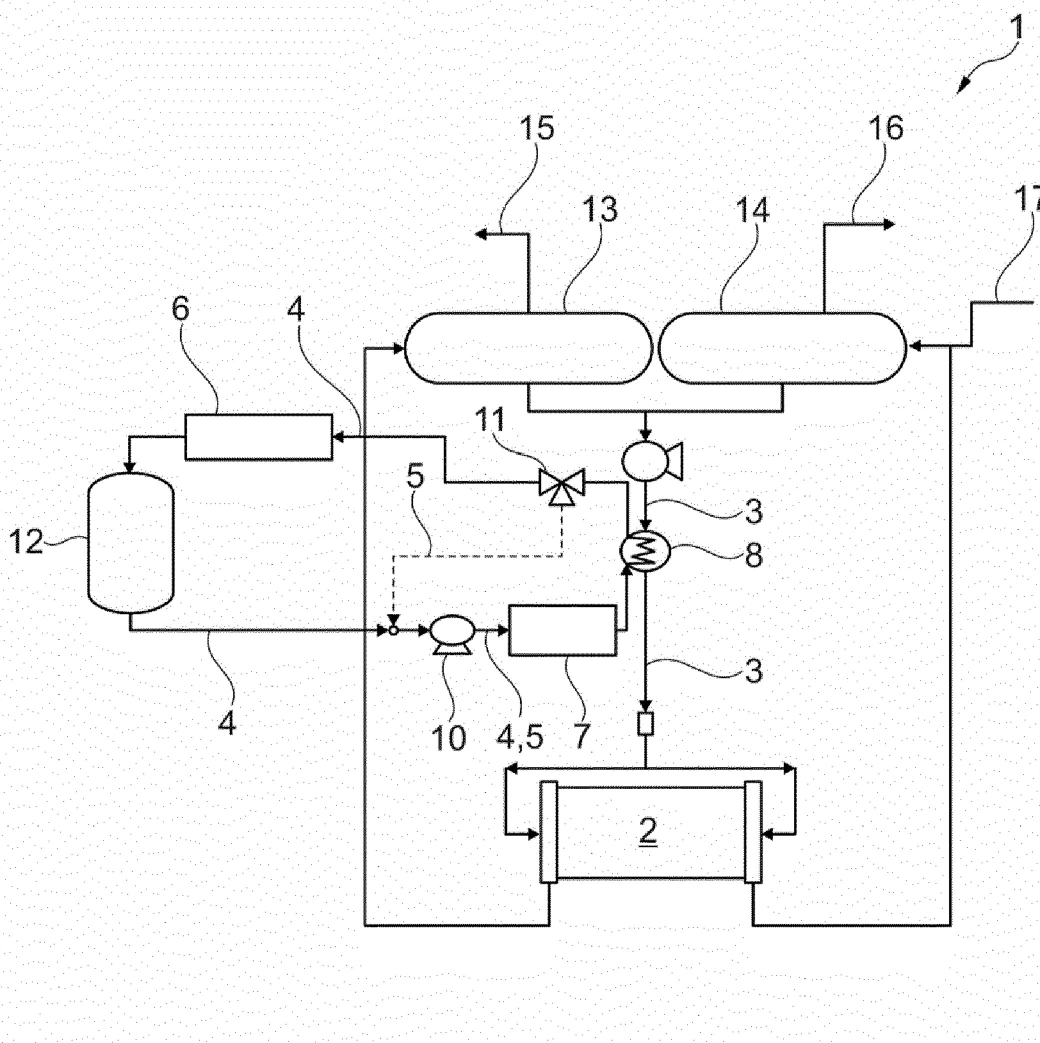

Fig. 7

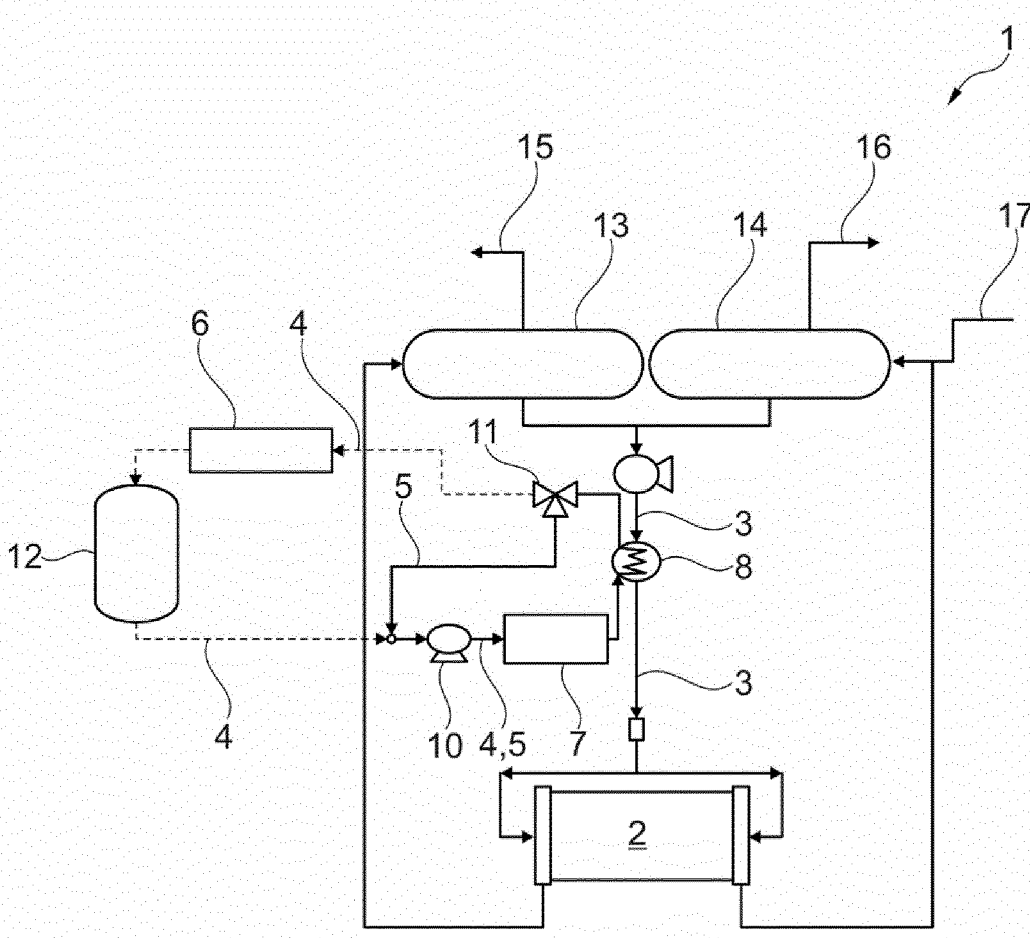

Fig. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 21 15 3497

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2

Place of search	Date of completion of the search	Examiner
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