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5 **Description**

[0001] The invention relates to a Method for drying and purifying hydrogen-containing gases that arise during electrolytic water splitting with electric current in the form of an oxygen-rich gas and a hydrogen-rich gas, which contain residues of the other gas, 10 the oxygen-rich gas is discharged into the atmosphere or to a consumer, the hydrogen-rich gas is heated in a heater and subjected to an exothermic reaction in a reactor in which the residual oxygen and the hydrogen are converted into water and a 15 hot, moist process gas is formed, then the water from this process gas is removed under excess pressure by adsorption of the water on an adsorbent in one of at least two adsorbers connected through connecting pipelines and switching valves until the adsorbent is loaded with water in the respective adsorber, after leaving the 20 respective adsorber the dried process gas is diverted to the consumer via a filter as high-purity hydrogen clean gas in a clean gas pipeline and the untreated process gas is transferred to the unloaded adsorber for continuing of the loading, and at the same time the loaded adsorbent is regenerated by a partial quantity of 25 the clean gas as regeneration gas which is heated by an electric heater and the heated gas is fed in a regeneration gas pipeline counter to the direction of the flow of the respective adsorber that is currently being loaded, wherein a control unit switches the adsorber into the adsorption phase and regeneration phase or 30 vice versa depending on the loading of the adsorbent and all electrical users are supplied with electricity from the connected power supply via a power line.

[0002] Furthermore, the invention relates to a device for drying and purifying hydrogen-containing gases that arise during electrolytic water splitting with electric current in the form of an oxygen-rich gas and a hydrogen-rich gas, which contain residues of the other gas, with an electric power line connected to the feed power line for supplying all consumers of the device with electricity, a discharge pipeline for the oxygen-rich gas into the atmosphere or to a consumer and a feed pipeline for the hydrogen-rich gas, with a heater for preheating the hydrogen-rich gas, a reactor for converting residual oxygen and hydrogen with formation of water on a catalyst to form a hot process gas, at least two adsorbers filled with adsorbent, which are arranged switchable under excess pressure into the adsorption and regeneration phase or vice versa by the control unit via connecting pipelines and switching valves and to form two independent circuits, wherein the adsorbers are connected to the reactor via a process gas pipeline which carries the process gas into the adsorber for adsorption of the water, and the adsorber are connected to the consumer via a filter and a top-side clean gas pipeline that can be shut off with a switching valve discharging the dried process gas as high-purity clean hydrogen gas to the consumer, and the adsorbers are connected at the top with a regeneration gas pipeline branching off from the clean gas pipeline downstream the filter for taking a partial quantity of the clean gas as regeneration gas for heating in an electric heater and at the bottom with a desorption gas pipeline for discharging the desorption gas loaded with water opposite to the direction of flow of the process gas of the adsorber switched to adsorption.

State of the art

[0003] Electrolysis for generating hydrogen, i.e. water splitting,

is a state of the art that has been known for a long time.

In this process, water is dissociated into its components oxygen
5 and hydrogen in an electrolyzer using an electric current.

The generated hydrogen gas is then subjected to a purification,
for examples an electrical purification by a second electrolysis
unit (DE 10 2015 201 802 A1) or by adsorption (DE 10 2016 208 889
B4).

10 For the production of hydrogen gas, electricity from renewable
primary energy such as solar energy, wind or waterpower is
increasingly being used. Due to the weather, solar energy and wind
power are not available without interruption or can only be used
to a sufficient extent for electrolysis if other consumers in the
15 network do not use the electricity generated from renewable
sources.

The disadvantage of this prior art is that the electrolyzer has to
be switched off to generate hydrogen. As a result, the
regeneration of the adsorber that is not in adsorption mode must
20 also be interrupted, which causes energetic losses. In addition,
the non-regenerated adsorber is not available for the adsorptive
drying process after the electrolysis is switched on again and
must first be regenerated as soon as the regenerative generated
electricity is available again. During this time, the hydrogen
25 generated in the electrolysis cannot be dried. The electrolysis
plant can therefore not be used to generate hydrogen for several
hours until the regeneration of the adsorber has ended.

[0004] A device for adsorbing water from moist air with two
30 chambers, each containing a molecular sieve, is known from DE 22
14 663 C2, the feed pipes and discharge pipes of which are
connected to valves for intermittently reversing the chambers from

drying to regeneration and vice versa.

5 A partial flow of the dried air is fed back by a fan to regenerate the water-laden adsorber.

[0005] The prior art also includes a method for removing steam from a supplied compressed gas by feeding the gas into a chamber filled with adsorbent for the steam of an arrangement of at least two chambers, the other chamber being previously used for adsorbing steam from the gas and after a certain adsorption time the chambers are exchanged in order to reactivate the chamber previously used for adsorption and subsequent cooling by fresh air before switching over again, and a hot gas flow being fed in countercurrent to the adsorption device during the reaction period of the respective chamber by a blower operating in pressure mode (DE 37 20 915 C2). At the end of the reaction period, a fan is switched on for suction operation and the cooling flow is directed as suction flow through the chamber into the adsorption device. Ambient air is used as gas flow for the pressure and suction operation. Switching units forms the individual circuits for reactivation and adsorption. The reactivation circuit has a blower arrangement for suction and pressure operation, in which a heater is additionally switched on during the pressure operation.

[0006] Furthermore, DE 42 03 634 A1 describes a method for separating organic components from gas mixtures, in which the primary gas mixture to be treated is passed to a membrane separation stage in which the gas mixture to be separated into a permeate enriched with organic compounds, which is fed back into the primary gas mixture, and a retentate depleted with organic

compounds. The organic compounds are subsequently removed from the retentate via an adsorption process and the retentate gas stream purified in this way is released into the environment, at least a part of the purified retentate gas being passed as regeneration gas for vacuum-operated desorption onto the loaded adsorber device. The regeneration gas enriched with organic compounds is fed to the primary gas mixture.

[0007] Furthermore, a device for adsorptive separation of a gas with at least one adsorption container filled with an adsorbent and with feed and discharge pipes is known from DE 10 2008 057 763 A1, through which the gas flow to be separated is conducted into the adsorbent in an adsorption phase of the adsorption container and a part of the separated gas stream is passed through the adsorbent to regenerate the adsorbent in a regeneration phase of the adsorption container. Before the separation, the gas stream to be separated is passed into at least one guide channel running along the adsorbent in order to heat it. It concerns the drying of moist compressed air. The dried compressed air is branched off via a throttle element.

[0008] DE 10 2012 112 040 B4 and DE 10 2014 108 977 A1 disclose devices for drying gases, in particular for drying methane or natural gas, which have a gas inlet, a gas outlet, at least two adsorption chambers for receiving desiccant, a cooler, which is arranged in the flow direction between the gas inlet and the adsorption chambers, a condensate outlet which is arranged in flow direction between the adsorption chambers and the gas outlet, wherein the adsorption chambers are connected to the gas inlet and to the gas outlet. A blower is provided which is arranged in the flow direction between the gas inlet and the adsorption chambers, and a

connected to a suction pipe and a pipe for sucking in precooled gas and a suction pipe and a pipe for sucking in dry gas for regeneration.

[0009] Another known solution (DE 20 2010 017 546 U1) provides a device for adsorptive drying of purified biogas (bio methane) with a methane content of at least 90% by volume and regeneration of loaded adsorbent, consisting of at least one first heat exchanger for cooling and reducing the water content in the biogas. The device has at least two adsorbers, whereby one adsorber for drying and the other adsorber for regeneration can be switched alternatively, and the adsorbers are connected to a pipe for supplying cooled biogas and a pipe for discharging dried biogas. In the pipe discharging the biogas, a shut-off branch pipe connected to at least two heat exchangers is integrated to divert a partial flow of dried biogas, whereby one heat exchanger is intended for heating and the other heat exchanger for cooling the dried biogas. The heated or cooled biogas can be fed to the adsorber to be regenerated via another pipe.

[0010] EP 2 544 794 B1 proposes a process for the adsorptive drying of purified biogas (bio methane) und the regeneration of loaded adsorbents using at least two adsorbers containing solid adsorbents as loose bed, which are alternatively loaded and regenerated by means of a heated gas stream. The drying and the regeneration are carried out as a closed biogas cycle whereby separated layers based on silica gel and molecular sieves are used as adsorbents and the biogas to be dried is flowing first through the silica gel layer. Only heated, dried bio methane with a temperature of up to 150 °C is used for regeneration, which is returned to the initial stream of purified bio methane after

contact with adsorbent and, after regeneration, cooled, dried bio methane is brought into contact with the adsorbent, whereby
5 methane-rich water produced during the drying and regeneration is fed back into the generation and/or purification of biogas.

[0011] In addition, a method for removing a component of a base gas, for example air, by means of adsorption is known from EP 2
10 628 520A1, in which the base gas is passed through at least one of at least two chambers each containing an adsorbent, whereby at least one of the chambers in which the adsorptions process was carried out is then reactivated. For reactivation, a desorption gas is first passed through the corresponding chamber to
15 regenerate the adsorbent contained therein and then a cooling gas is passed through this chamber, whereby the desorption gas flow has the same direction as the flow direction in the adsorption process, and the desorption gas flow and the cooling gas flow are carried out by means of an alternating current operated compressor unit. The output of the compressor unit is controlled at least for
20 one of the gas flows via the frequency of the alternating current and the desorption gas is heated by means of a heating device before it enters the associated chamber and the temperature of the desorption gas measured in the direction of flow behind the heating device is regulated via the volume flow of the desorption
25 gas, whereby the AC frequency applied to the compressor is used as regulating variable.

[0012] All of these known solutions cannot eliminate the
30 disadvantage of an abrupt termination of the subsequent processes in the event of a sudden shutdown of the electrical power supply.

Task

[0013] In this prior art, the invention is based on the object of
5 maintaining the gas flow in the device through an
internal/external power source when the electrolysis is switched
off due to the loss of the electrical power supply or a black-out
until the regeneration of the water-laden adsorber properly is
completed and at the same time to improve the economic viability
10 of drying and purification hydrogen-containing gases by reducing
gas losses and emissions by returning a partial quantity of clean
gas as desorption gas to the process gas.

[0014] This object is achieved by a method with the features of
15 claim 1 and a device with the features of claim 13.

[0015] Advantageous embodiments of the method according to the
invention and the device according to the invention can be found
in the sub claims.

20
[0016] The solution of the task is achieved in that a gas-booster
with frequency converter, which is connected to the regeneration
gas pipeline sucks in the partial quantity of the clean gas as
regeneration gas and a flow transmitter with an integrated flow
25 computer adjusts the volume flow of the partial quantity by
determining a current rotational speed value of the gas-booster as
an actual value or a fixed value via the control unit, which, if
the power supply fails, triggers by a switching device a
switchover of all electrical power consumer units such as gas-
30 booster, electrical heater, control unit, switching valves and if
necessary the pump, to an internal/external power source for
temporary electrical energy supply via the power line, wherein

until the properly end of the regeneration the gas-booster generates a suction flow circulation of the residual gas that is present when the device switched off on the adsorber forming clean and desorption gas, through an internal flow path that passes through the gas pipelines, the adsorbers, the electric heater, the heat exchanger, separator and filter.

[0017] According to an advantageous embodiment of the method to the invention, a dry-running, hermetically sealed peripheral impeller pump with a magnetically coupled drive or a dry-running rotary vane compressor or a rotary piston compressor is used as gas-booster. This ensures that the hydrogen, despite its high diffusion speed and small molecule size, cannot escape from the working space and a contamination of the hydrogen by oil is also avoided. Instead of the peripheral pump, a dry-running rotary vane compressor or a rotary piston compressor can also be used if larger volume flows, for example volume flows of over 10.000 m³/h, are used.

[0018] According to a further preferred embodiment of the method of the invention, an eddy current meter with an integrated flow computer or variable area meter is used as flow transmitter, whereby the volume flow of regeneration gas is measured by the flow transmitter and a current speed value of the gas-booster is determined by the flow computer integrated in the flow transmitter as an actual value from the measured volume flow, which is transmitted to the control unit, which specifies this actual value as a control variable for the frequency converter of the gas-booster.

A variable area meter can also be used without departing from the invention.

[0019] The particular importance of the method according to the invention is that a fuel cell unit and/or UPS source and/or an emergency power unit and/or a landline connection can be used as an internal/external source. The fuel cell unit is expediently operated with previously generated pure hydrogen gas stored in a buffer until the regeneration is completed, but it can also be fed with hydrogen from an external, separate hydrogen storage unit.

[0020] In a further advantageous embodiment of the method according to the invention, the temperature of the regeneration gas is adjusted by an electronic circuit arranged in the electric heater and connected to the control unit to a target temperature which corresponds to the desorption temperature as a function of an actual temperature measured in the regeneration gas pipeline downstream of the gas-booster by a temperature sensor.

[0021] A further advantageous embodiment of the method according to the invention provides that the flow transmitter detects the presence of the regeneration gas and the flow computer converts this information into an on or off switch command for the electric heater.

[0022] In a further embodiment of the method according to the invention, the process gas/desorption gas is cooled in a heat exchanger downstream of the reactor and the water that condenses out during cooling is separated in a separator and is discharged with a pump or is temporarily stored in the separator.

[0023] Another embodiment of the method according to the invention is characterized in that the flow path is formed by an turnoff the clean gas pipeline with the switching valve to the consumer and

keeping open the process gas pipeline, the clean gas pipeline into the regeneration gas pipeline via the electric heater, the adsorber switched to adsorption by the switching valves via the connecting pipelines, the adsorber switched to regeneration by the switching valves via the connecting pipelines and the desorption gas pipeline which leads back into the process gas pipeline, so that an inner, self-contained circulation path is created for the gas remaining in the device when the electrical power supply ceases.

[0024] According to a further embodiment of the method according to the invention, the suction flow circuit comprises following steps:

I switching on the internal/external electric power source, for example a fuel cell unit, and continue operating of the electrical consumers, such as gas-booster, electric heating element, pump, switching valves and control unit,

II turn off the clean pipeline to the consumer by the switching valve and forming the flow path,

Iii continuing of the drying/regeneration by conveying the clean and desorption gas generated by the adsorbers from the residual gas with the gas-booster in the suction flow circuit, whereby the clean/desorption gas is circulated in the circuit until the regeneration is complete,

IV branching off a partial quantity of the clean gas via the clean gas pipeline as regeneration gas and adjusting this partial rational speed value of the gas-booster as an actual or a fixed speed value from the measured volume flow with the flow computer integrated in the flow transmitter, transmitting of the determined quantity by measuring its volume flow, determining a current value to the control unit, which specifies this value as a control

variable for the frequency converter of the gas booster,

V heating up the branched-off regeneration gas according to
5 step IV by regulating the temperature to a target temperature
corresponding to the desorption temperature, which is specified by
an electronic circuit in the electric heater via the control unit
as a function of an actual temperature measured by a temperature
sensor in flow direction behind the electric heater,

10 VI returning of the desorption gas leaving the adsorber which
is switched to regeneration via the desorption gas pipeline in the
flow direction upstream of the heat exchanger into the process gas
pipeline,

VII cooling of the desorption gas in the cooler, separating of
15 the condensed water and pumping out the water into the conveying
pipeline of the electrolyzer or in a separate storage or
intermediate storage of the water in the separator with subsequent
discharge the water,

VIII feeding of the quantity of desorption gas leaving the
20 separator for adsorption of the water still present in the
adsorber switched to adsorption, feeding of the dried gas as clean
gas via the filter to the gas-booster for the purpose of renewal
taking of the partial quantity of clean gas as regeneration gas,

IX continue steps 1 to VIII until the regeneration is
25 complete.

[0025] The object is achieved with the device according to the
invention in that a gas-booster with frequency converter is
connected to the regeneration gas pipeline for suction and
30 compressing the partial quantity of the clean gas and the gas-
booster is connected to a flow emitter with an integrated flow
computer for determining a current speed value of the gas-booster

as an actual value or a speed value as a fixed value for the volume flow of the regeneration gas and the electric heater is connected behind the gas-booster as the regeneration gas heater, wherein a temperature sensor is arranged in flow direction behind the electric heater for measuring the actual temperature of the regeneration gas and electronic circuit is included in the electric heater for adjusting to a target temperature corresponding to the desorption temperature, and that the flow emitter with frequency converter and the electronic circuit are connected to the control unit, which, if the power supply fails, triggers by a switching device a switchover of all electric power consumer, such gas-booster, electric heater, control unit, switching valves and, if necessary pump to an internal/external power source for temporary electrical power supply via the power line, wherein until the properly end of the regeneration the gas-booster maintains a suction flow circulation of the residual gas that is present in the adsorbers, when the device is switched off for forming clean and desorption gas on a flow path that passes through the gas pipelines, the adsorbers, the electric heater, the heat exchanger, the separator and filter.

[0026] The further embodiment of the device according to the invention provides that the gas-booster is a dry-running, hermetically sealed peripheral impeller pump with a magnetically coupled drive or a dry-running rotary vane compressor or a rotary piston compressor. This ensures that the hydrogen, despite its high diffusion speed and small molecule size, cannot escape from the working space and contamination of the hydrogen by oil is avoided.

[0027] According to a further advantageous embodiment of the

device according to the invention, the flow emitter is an eddy
current meter with an integrated flow computer or variable area
meter.

[0028] In a further embodiment of the device according to the
invention, the internal power source is a fuel cell unit and/or
UPS source. The power source can, without departing from the
invention, only be an external emergency power generator that is
able to maintain the power supply for the period up to the
completion of the regeneration. A landline connection can also
serve as an external power source if such a connection is
available.

[0029] In a further advantageous embodiment of the invention, a
buffer for storing previously generated clean gas is provided,
which is connected on the one hand to a branch pipeline that can
be brought into the open and closed position via a switching
valve, and on the other hand to the fuel cell unit, which is
connected to a feed pipeline that can be opened and closed by a
switching valve, for feeding the stored clean gas into the fuel
cell unit.

The invention also includes a separate hydrogen storage device,
which is connected to the fuel cell unit via the feed pipeline
which is brought into the opened or closed position by the
switching valve for feeding the hydrogen into the fuel cell unit.

[0030] The further embodiment of the device according to the
invention provides that the fuel cell unit has an internal control
member, which is connected to the control unit and to a switching
device that disconnects or connects the fuel cell unit from the
feed line of the power supply.

[0031] The alternating current consuming units of the device according to the invention, preferably the gas-booster and the pump, are expediently connected electrically to the fuel cell unit via an inverter. The switching valves and the control unit can also be connected to the inverter, as required or can be supplied by the current generated by the fuel cell unit. A UPS source or an emergency power supply can also take over the power supply of the units without leaving the invention. It is also possible to ensure the power supply of the units through a landline connection. It is clear that an inverter is provided if a UPS source is used as the power source.

[0032] According to a further feature of the invention, the flow computer of the flow transmitter acts as a switching element for the electric heater, which switches off the electric heater in the absence of regeneration gas or prevents it from being switched on.

[0033] In a particularly advantageous embodiment of the device according to the invention, a heat exchanger for cooling the process gas or desorption gas and a separator for separating the condensed water are arranged behind each other in the direction of the process gas, whereby the separator is connected via a pump for conveying the condensed water via a conveying pipeline opening into the electrolyzer or, in the event of a power failure, the separator temporarily stores the condensed water until the regeneration is complete.

[0034] It is especially beneficial that the desorption gas pipeline is integrated into the process gas pipeline in flow direction of the process gas downstream of the reactor, so that

the process gas pipeline via the heat exchanger, the separator and the adsorber switched to adsorption by the switching valves, the open clean gas pipeline which is closed to the consumer but opened to the regeneration gas pipeline, the regeneration gas pipeline, via the adsorber switched to regeneration by the valves with the desorption gas pipeline leading back to the process gas pipeline can form the inner flow path, in which the clean gas and desorption gas formed from the residual gas remaining in the device is conveyed in the suction flow circuit by the gas-booster until the regeneration is complete. By returning the partial quantity of clean gas as regeneration gas to the process gas, there are no gas losses and emissions, which improves the environmental compatibility and economic efficiency of the device according to the invention.

Furthermore, it is provided according to the invention that a switching valve is integrated into the feed pipeline for the fuel cell unit, which receives the control command from the control unit to switch on the internal/external power source in the moment that the electrical power supply is switched off and to switch off the internal/external power source when the electrical power supply is switched on via the switching device. If the electrical energy supply fails, the operation of the regeneration can be continued until it is completed, because the gas-booster, the electric heater, the pump, the switching valves and the control unit due to their relatively low consumption of electrical energy can be powered via the fuel cell unit or a UPS-source. The gas-booster conveys the existing gas until the regeneration is completed in the suction stream from the clean gas pipeline to an inner flow path that is formed from the process gas pipeline via the gas pipeline, the regeneration gas pipeline via the adsorber switched to regeneration by switching valves and the desorption

adsorber switched to adsorption by switching valves, the clean gas pipeline opened into the process gas pipeline.

5

[0035] In a further advantageous embodiment of the device according to the invention, the power line for the power supply of the gas-booster, the electric heater, the pump, switching valves and control unit can be switched on or off from the internal/external power source by the fuel cell unit or UPS source via the switching device as required.

10

[0036] According to a preferred embodiment of the invention, the adsorbers are filled with silica gel, molecular sieves or aluminum oxide gel as adsorbents for water.

15

[0037] Further advantages and details can be found in the following description with reference to the accompanying drawings.

20

Example

[0038] The invention will be explained in more detail using an example.

[0039] From the drawings show:

25

FIG. 1 a schematic representation of the structure of the device according to the invention with a gas-booster and an electric heater for heating the regeneration gas with regenerative power supply,

30

FIG. 2 a schematic view of the device according to the

invention during operation of the electrolytic splitting of water, showing the flowrate during adsorption and regeneration, and

FIG. 3 a schematic representation of the regeneration in the suction flow circuit of the residual gas remaining in the device when the water splitting is switched off.

[0040] FIG. 1 shows the basis structure of the device according to the invention.

In an electrolyzer 1 supplied with electricity from regenerative solar energy and/or wind power, water is electrolytic broken down into an oxygen-rich gas A and a hydrogen-rich gas B. The oxygen-rich gas A contains oxygen as its main component, residues of hydrogen and water, the hydrogen-rich gas B, residues of oxygen and water. Such electrolyzers consume considerable amounts of electrical energy, for example in the two to three-digit MW range.

The fluctuating nature of the regenerative power sources means that the electrolyzer cannot be continuously supplied with power and must be switched off when the regenerative power supply fails if other power sources are not available. The subsequent drying and purification of the hydrogen-rich gas B is thus also effected.

The generated oxygen-rich gas A passes through a discharge pipeline 2 into the atmosphere or to a consumer not described further, and the hydrogen-rich gas B passes through the feed pipeline 3 into the device according to the invention. The device according to the invention essentially comprises a heater 4 for preheating the hydrogen-rich gas B, a reactor 5 for the catalytic exothermic reaction between hydrogen and oxygen to form a hot process gas C containing water, a liquid-gas heat exchanger 6 for

cooling the process gas C with water, a separator 7 for separating the water that has condensed out during cooling, a pump 8 for discharging the separated water into the conveying pipeline 15 of the electrolyzer 1, at least two adsorbers 9 and 10 arranged in parallel, filled with adsorbent, a filter 11 for the dried clean gas D, which leaves the adsorber 9 or 10, a gas-booster 12 for withdrawing a partial quantity T_R from the clean gas D as regeneration gas E, an electric heater 13 and an internal power source, for example in form of a fuel cell unit 40 for heating the regeneration gas E to desorption temperature.

These structural units or assemblies are connected by pipelines and valves, which are described in more detail below. A control unit 21 controls the valves and thus the switching of the adsorbers into the adsorption or regeneration mode and vice versa, the withdrawing of the partial quantity T_R of clean gas D as regeneration gas E and the activation or deactivation of the fuel cell unit 40.

[0041] The hydrogen-rich gas B flows through a feed pipeline 3 in the heater 4 in which the gas is heated for example by 10 to 20 °C in order to avoid a blocking of the catalyst, in the reactor 5, in which the hydrogen-rich gas B and the residual oxygen contained in it is converted into a hot process gas C and water by an exothermic reaction.

[0042] The process gas pipeline 14 leads in the flow direction of the process gas C into the liquid-gas heat exchanger (cooler) 6, with which the hot process gas C is cooled to about 10°C to 30°C. The condensed water is discharged with the separator 7 downstream of the cooler 6 in the direction of flow, and the discharged water is returned by the pump 8 via a conveying pipeline 15 to the water

supply pipeline for the electrolyzer 1 or into a separate storage or temporarily stored in the separator 7.

5 As can be seen from FIG. 2, the cooled process gas C then flows on the bottom side into the adsorber 9 switched to adsorption, in which the process gas C is dried on the adsorbent. The dried process gas C leaves the adsorber 9 at the top as clean gas D and is discharged through the open clean gas pipeline 16 via the filter
10 11 to the consumer.

The regeneration gas pipeline 18 leads at the top into the adsorber 10, so that the heated regeneration gas E flows through the adsorbent in the adsorber 10 in countercurrent to the direction of flow of the adsorption in the adsorber 9 and leaves
15 the adsorber 10 at the bottom through the desorption gas pipeline 19 as desorption gas F. The desorption gas pipeline 19 is integrated into the process gas pipeline 14 in the flow direction of the process gas C after the reactor 5 but before the liquid-gas-heat exchanger 14.

20 Silica gel, molecular sieves or aluminum oxide gel are used as adsorbents.

[0043] Reference is now made to the scheme of circuitry of the adsorber 9 and 10.

25 In FIG. 2, the adsorber 9 is in the adsorption phase and the adsorber 10 is in the regeneration phase.

The process gas pipeline 14 open integrated into the bottom of the adsorber 9 and the desorption gas pipeline 19 leading out from the bottom of the adsorber 10 are meshed with one another by two
30 connecting pipelines 23 and 24, which are arranged in parallel and each of the pipelines 23 and 24 can be brought in the opened or closed position with two pressure-controlled switching valves 23, 26 or 27, 28, so that the adsorbers 9 and 10 can be switched

alternately from the adsorption phase to the regeneration phase
5 and vice versa.

The clean gas pipeline 16 leading from the adsorber 9 at the top
and the regeneration gas pipeline 18 leading into the adsorber 10
at the top are also meshed by two connecting pipelines 29 and 30
arranged in parallel, and each of the pipelines 29 and 30 can be
10 opened and closed with two pressure-controlled switching valves
31, 32 und 33, 34.

The switching valves 25,26, 27,28 and the switching valves 31, 32,
33, 34 are connected via the control line 22 to the control unit
21, which controls the switching valves 25 to 26 and 31 to 34
15 depending on the adsorption and regeneration process.

In the event that the adsorber 9 is in adsorption mode and the
adsorber 10 is in regeneration mode, the switching valve 25 at the
bottom and switching valve 33 at the top of the adsorber 9 are in
the open position, the switching valves 26 and 27 at the bottom
20 and switching valves 31 and 34 at the top of the adsorber 9 are in
closed position, while the switching valve 32 at the top and the
switching valve 28 of the adsorber are open.

[0044] In FIG. 2, the direction of flow of gases A, B, C, D, E and
25 F is indicated by arrows.

The partial quantity T_R of clean gas D is sucked in as regeneration
gas E by the gas-booster 12 with frequency converter and a flow
transmitter 35 with an integrated flow computer determines a
current speed value as an actual value or a speed value as a fixed
30 value for the volume flow. These values are forwarded a regulating
variable to the control unit 21 for setting the speeds of the gas-
booster. The regeneration gas E is heated in an electric heater 13

downstream of the gas-booster 12 by regulating the temperature of the regeneration gas to a target temperature corresponding to the desorption temperature, which is set by the control unit 21 via an electronic circuit 20 in the electric heater 13 as a function of an actual temperature, which is measured by a temperature sensor 17 in direction of flow behind the electric heater 13.

The electric heater 13 is integrated into the regeneration gas pipeline 18 as a tube through which the partial quantity T_R of regeneration gas E flows along heating rods (not shown) for heating and the partial quantity T_R is led at the top into the adsorber 10, which is switched to regeneration. The absent of a flow of regeneration gas E is detected with the electronic circuit 20 arranged in the electric heater 13 and communicated via the control line 22 to the control unit 21, which switches the electric heater 13 on or off.

The gas-booster 12, which is provided in the regeneration gas pipeline 18 in the direction of flow of the partial quantity T_R of the clean gas D as regeneration gas E, draws or sucks the partial quantity T_R of the clean gas D as regeneration gas and conveys the partial quantity T_R of the regeneration gas E through the regeneration gas pipeline 18 via the electric heater 13 into the top of the adsorber 9 or 10, whereby the partial quantity T_R of the regeneration gas E is heated to the desorption temperature.

The gas-booster 12 is a dry-running, i.e. oil-free, hermetically sealed peripheral pump with a magnetically coupled motor with a frequency converter.

Instead of the gas-booster 12, a dry-running rotary impeller compressor or a rotary piston compressor is also suitable. Eddy current meters or variable area meters have proven to be suitable as the flow transmitter 35.

[0045] FIG. 3 shows the representation of the continued operation of the regeneration when the regenerative power supply fails.

5 An electronic switching device 37 integrated into the feed line 36 for the regenerative power supply comprises a switch 38 for switching on and off the regenerative power supply and a switch 39 for switching on or off the internal power source 40, for example a fuel cell unit. The electronic switching device 37 detects the
10 absence or the restart of the regenerative power supply and forwards this information via the control line 22 to the control unit 21, which initiates the corresponding switching action at the switches 38 and 39 to switch on or off the internal power source 40 and ensures the connection to the power line 48 of the
15 consumer.

A fuel cell unit 40, for example, is used as an internal power source, which is supplied with clean gas D (hydrogen) as the reaction gas filled in the buffer 41, and with oxygen from the air. The buffer 41 is preferably connected to the clean gas
20 pipeline 16 via a branch pipeline 42 and stores a sufficient amount of the clean gas D generated by the device.

Of course, a separate storage device filled with hydrogen can also supply the fuel cell unit 40 with hydrogen.

The fuel cell unit 40 has a control member 46, which is connected
25 to the control unit 21 via the control line 22.

A pressure-controlled switching valve 43 is integrated into the branch pipeline 42, which leads from the clean gas pipeline 16 to the buffer 41. A feed pipeline 44, into which a pressure-controlled switching valve 45 is integrated for opening or closing
30 the hydrogen supply to the fuel cell unit 40, leads from the buffer 41 to the fuel cell unit 40. The power connection of the fuel cell unit 40 is connected via an inverter 47 to the switching

device 37, which, depending on the requirements at the instigation of the control unit 21, switches on or off the power supply to the consumers such as the gas-booster 12, the electric heater 13, the pump 8, the control unit 21 and the switching valves 25 to 28 or 31 to 34, 43, 45 and 49.

The switching action at the switching valves 43 and 45 to open the branch pipeline 42 and the feed pipeline 44 for supplying the fuel cell unit 40 with hydrogen takes place in connection with the control member 46 via the control line 22 by the control unit 21.

The inverter 47 converts the current generated by the fuel cell unit 40 into alternating current for the electric heater 13, the pump 8 and the gas-booster 12.

The fuel cell unit 40 is designed in terms of the output so that it is able to supply the assemblies of the device with power until the regeneration can be ended properly even if the regenerative power supply fails. The fuel cell unit 40 delivers about 3 to 100 kW.

[0046] The conveying of the residual gas G from hydrogen-rich gas, process gas, clean gas, regeneration gas and desorption gas which has remained in the device according to the invention, will now be described in the circulation suction operation when the regenerative power supply is no longer available.

The process gas pipeline 14, the regeneration gas pipeline 18 and the desorption gas pipeline 19 form together a flow path K for the clean gas D generated at the adsorbers 9 and 10, the regeneration gas E branched off from the clean gas D and the desorption gas F, whereby the flow path is passes through the adsorber 9 switched to adsorption by the open switching valves 25 or 33 switched to adsorption by the opened switching valves 25 or 33 and the closed

switching valves 27 or 34, and the adsorber 10 switched to regeneration by the open switching valves 28 or 32 and the closed switching valves 31, 34, 26 respectively 27. The clean gas D is sucked in by the gas-booster 12 in a partial quantity T_R via the clean gas pipeline 16 when the switching valve 49 is closed and the partial quantity T_R is adjusted so that the volume flow is measured with the flow computer of the flow transmitter 35, a current speed value as the actual value or a speed value is determined as a fixed value from the measured volume flow and this value is transmitted to the control unit 21, which specifies this value to the frequency converter of the gas-booster 12.

The temperature of the regeneration gas E is adjusted to a target temperature corresponding, which is specified by an electronic circuit 20 in the electric heater 13 via the control unit 21, as a function of an actual temperature measured by a temperature sensor 17 downstream of the electric heater 13.

[0047] With the method according to the invention, the drying and purifying of the process gas in the event of a failure of the electrical power supply is ensured in that the partial quantity T_R of the clean gas D is sucked in by a gas-booster 12 with a frequency converter connected to the regeneration gas pipeline 18 as regeneration gas E and a flow transmitter 35 with an integrated flow computer adjusts the volume flow of the partial quantity T_R by determining a current speed value of the gas-booster 12 or a speed value of the gas-booster 12 as a fixed value via the control unit 21, which, if the power supply fails, triggers by a switching device 37 a switchover of the power line 48 of all electrical power consumer units, such as gas-booster 12, electric heater 13, control unit 21, switching valves 25, 26, 27, 28, 31, 32, 33, 34,

43, 45, 49 and pump 8 to an internal/external power source 40 for temporary electrical energy supply, whereby until the end of the regeneration the gas-booster 12 maintains a suction flow circulation of the residual gas D that is present when the device is switched off on the adsorber 9 or 10 forming clean and desorption gas D and F, through an internal flow path K that passes through the gas pipelines 14, 16, 18, 19, 23, 24, 29 and 30, the adsorber 9, 10 and the electric heater 13.

[0048] The flow path K is closed to the consumer by shutting off the clean gas pipeline 16 with the switching valve 49 in flow direction behind the branch of the regeneration gas pipeline 18, which is kept open, so that the flow path K is formed by the regeneration gas pipeline 18 via the gas-booster 12 and the electric heater 13, the adsorber 9 or 10 switched to regeneration by the switching valves 25, 26, 27 and 28 via the connecting pipelines 23 and 24, the desorption gas pipeline 19 openly integrated into the process gas pipeline 14, the opened process gas pipeline 14, the clean gas pipeline 16 into the regeneration gas pipeline 18 via the electric heater 13, the adsorber 9 or 10 switched to adsorption by the switching valves 25, 26, 27 and 28 via the connecting pipelines 23 and 24, the desorption gas pipeline 19 leading back into the process gas pipeline 14, the process gas pipeline 14 with the heat exchanger 6 and separator 7.

[0049] The following steps are carried out if the power fails:

I switching on the power supply by the internal/external power source 40, for instance a fuel cell unit, and continue operating of the electrical consumers, such as gas-booster 12, electric heater 13, pump 8, switching valves 25 to 28,

31 to 34, 43, 45, and 48 and control unit 21,

- 5 II shutting off the clean gas pipeline 16 to the consumer by the
switching valve 49 and form the flow path K,
- 10 III continuation of the drying/regeneration by conveying the
clean gas D and the desorption gas F generated by the
adsorber 9 or 10 from the residual gas with the gas-booster
12 in the suction flow circuit through the flow path K,
whereby the clean gas D and the desorption gas F is
circulated in circuit until the regeneration is completed,
- 15 IV branching off a partial quantity T_R of the clean gas D via
the clean gas pipeline 16 as regeneration gas E and adjusting
this partial quantity by measuring its volume flow,
determining a current rotational speed value of the
gas-booster 12 as an actual or a fixed speed value from the
20 measured volume flow with flow computer integrated into the
flow transmitter 35, transmitting of the determined value to
the control unit 21, which specifies this value as a control
variable for the frequency converter of the gas-booster 12,
- 25 V heating up the branched-off regeneration gas E according to
step IV by regulating the temperature to a target temperature
corresponding to the desorption temperature, which is
specified by an electronic circuit 20 in the electric
heater 13 via the control unit 21 as a function of an actual
30 temperature measured by a temperature sensor 17 in flow
direction behind the electric heater 13,

VI returning of the desorption gas F leaving the adsorber 9 or
10 which is switched to regeneration via the desorption gas
5 pipeline 19 in the flow direction upstream of the heat
exchanger 6 into the process gas pipeline line 14,

VII cooling of the desorption gas F in the cooler 6, separating
of the condensed water and pumping out the water into the
10 conveying pipeline 15 of the electrolyzer 1 or in a separate
storage or intermediate storage of the water in the separator
7 with subsequent discharge the water,

VIII feeding of the quantity of desorption gas F leaving the
15 separator 7 for adsorption of the water still present in the
adsorber 9 or 10 switched to adsorption, feeding of the dried
gas as clean gas D via the filter 11 to the gas-booster
12 for the purpose of renewed taking of the partial quantity
 T_R of clean gas D as regeneration gas E,

20 IX continue steps 1I to IX until the regeneration is complete.

[0050] If the regenerative electrical energy supply is no
available, the operation of the regeneration can be continued
25 until it is completed, because the electrical heater, the gas-
booster, the pump, the switching valves and the control unit due
to their relatively low consumption of electrical energy can be
powered by the fuel cell unit 40 or the UPS source.

The gas-booster 12 conveys the gas present in suction flow circuit
30 on the flow path K formed by the gas pipelines and the adsorbers
until the regeneration is complete.

The consumption of electrical energy up to the end of the

regeneration is around 10-300 kWh, which can easily be made by a fuel cell unit 40.

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[0051] The drying and purification of the process gas C is explained in more details below using an example.

A volume flow of 10.000 Nm³ of hydrogen-rich gas B is to be treated at an overpressure of 35 bar in such a way that the clean gas D has a residual content of <10ppm V and a residual water content of <5 ppm V.

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The partial quantity T_R of regeneration gas E should be around 1.000 Nm³/h of clean gas D and the regeneration should be carried out at a temperature of at least 150 °C with silica gel as adsorbent.

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The following operation data are based on:

1. feeding hydrogen-rich gas B

volume flow:	approx.	10.000	Nm ³
pressure:	approx.	35	barü
temperature:	approx.	55	°C
oxygen content:	approx.	5.000	ppm V (maximum)
water content:	approx.	35	kg/h (saturated)

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2. output at the heater 4

volume flow gas B:	approx.	10.000	Nm ³ /h
pressure:		35	barü
temperature:	approx.	65	°C
oxygen content:	approx.	5.000	ppm V
water content:	approx.	35	kg/h

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3. output at the reactor 5

volume flow gas B:	approx.	9.900	Nm ³ /h
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	temperature: until about	160	°C
	oxygen content:	<10	ppm V
5	water content: approx.	115	kg/h
4.	desorption gas flow (partial quantity of clean gas D)		
	volume flow gas B: approx.	1.000	Nm ³ /h
	pressure: approx.	35	barü
10	temperature: approx.	25-150	°C
	oxygen content:	<10	ppm V
	water content: approx.	0-25	kg/h
5.	output cooler 6		
15	volume flow: approx.	10.900	Nm ³ /h
	pressure: approx.	35	barü
	temperature: approx.	10	°C
	oxygen content:	<10	ppm V
	water content: approx.	3	kg/h
20	6.	discharge condensate downstream of the separator 7	
	mass flow: approx.	115	kg/h
	pressure: approx.	34,8	barü
	temperature: approx.	11-20	°C
25	7.	output adsorber 9 (in adsorption mode)	
	volume flow: approx.	9.900	Nm ³ /h
	pressure: approx.	34,8	barü
	temperature: approx.	11-20	°C
30	oxygen content:	<10	ppm V
	water content: approx.	<5	ppm V
8.	partial quantity of regeneration gas flow (inlet adsorber 10)		
	volume flow: approx.	1.000	Nm ³ /h

	pressure:	approx.	35	barü
	temperature:	approx.	20-150	°C
5	oxygen content:		<10	ppm V
	water content:		<5	ppm V.

The resulting clean gas D is a high-purity hydrogen gas that fully meets the requirements for industrial use as gas in petrochemicals and refineries or fuel cells. It has an oxygen content <10 ppm V and a water content <5 ppm V. For other applications, for instance in the semiconductor industry, more intensive purification is carried out to an oxygen content < 1 ppm V and a water content < 1 ppm V as well.

15

List of drawing references

	electrolyzer	1
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20	feed pipeline for hydrogen-rich gas B	3
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	reactor	5
	liquid-gas-heat exchanger (cooler)	6
	separator	7
25	pump	8
	adsorber	9, 10
	filter	11
	gas-booster	12
	electric heater	13
30	process gas pipeline	14
	conveying pipeline	15
	clean gas pipeline	16
	temperature sensor	17

	regeneration gas pipeline	18
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5	circuit	20
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10	at the bottom	25, 26, 27, 28
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20	internal/external power source/fuel cell unit	40
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25	switching valve in 44	45
	control member of 40	46
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	power line for consumer	48
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30	oxygen-rich gas	A
	hydrogen-rich gas	B
	adsorption circuit	AK

	process gas	C
5	clean gas	D
	regeneration gas	E
	desorption gas	F
	residual gas from C,D,E and F	G
	flow path	K
10	regeneration circuit	R _K
	partial quantity of clean gas D for	T _R
	regeneration gas E	

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Krav:

1. Fremgangsmåde til tørring og rensning af hydrogenholdige gasser, som opstår ved den elektrolytiske vandspaltning med elektrisk strøm i form af en oxygenrig gas (A) og en hydrogenrig gas (B), som hver indeholder rester af den anden gas, hvori den oxygenrige gas (A) udledes til atmosfæren eller til en forbruger, den hydrogenrige gas (B) opvarmes i et varmeapparat (4), den opvarmede gas (B) udsættes for en eksoterm reaktion i en reaktor (5), i hvilken restoxygenet omsættes med hydrogenet til en varm fugtig procesgas (C), derefter fjernes vandet fra denne procesgas (C) under overtryk ved adsorption af vandet på et adsorptionsmiddel i én af mindst to med forbindelsesrør (23,24;29,30) og pilotventiler (25,26,27,28;31,32,33,34) forbundne adsorbere (9,10), indtil adsorptionsmidlet i den pågældende adsorber (9,10) er fyldt med vand, hvori den tørrede procesgas (C), efter at have forladt den pågældende adsorber (9,10), afledes til forbrugeren i et rengas-rør (16) via et filter (11) som ren hydrogengas (D) med høj renhed, og den ubehandlede procesgas (C) omdirigeres til den ikke-fyldte adsorber (9,10) til fortsættelse af fyldningsprocessen, samtidig regenereres den pågældende adsorbers (9,10) fyldte adsorptionsmiddel med en modsat strømningsretningen for den pågældende adsorber (9,10) i et regenereringsgasrør (18) tilført delmængde (T_R) af ren gas (D) som regenereringsgas (E), som opvarmes af et elektrisk varmelegeme (13), hvori en styreenhed (21) omskifter adsorberne (9,10) til adsorptions- eller regenereringsfasen afhængigt af adsorptionsmiddelbelastningen, og alle elektriske forbrugere forsynes fra den tilsluttede elektriske strømforsyning via en strømledning (48), **kendetegnet ved** at delmængden (T_R) af ren gas (D) suges ind som regenereringsgas (E) ved hjælp af en til

regenereringsgasrøret (18) forbundet gasbooster (12) med frekvensomformer, og en flowtransmitter (35) med integreret flowcomputer justerer delmængdens (T_R) volumenflow ved bestemmelse af en aktuel rotationshastighedsværdi for gasboosteren (12) eller en rotationshastighedsværdi for gasboosteren (12) som fast værdi via styreenheden (21), som ved hjælp af en omskifterindretning (37), ved svigt af strømforsyningen, udløser en omskiftning af alle strømforbrugende enheder, såsom gasbooster (12), elektrisk varmelegeme (13), styreenhed (21), pilotventiler (25, 26, 27, 28; 31, 32, 33, 34; 43; 45; 49) og om nødvendigt pumpe (8), til en intern/ekstern strømkilde (40) til midlertidig elektrisk energiforsyning via strømledningen (48), hvori gasboosteren (12), indtil reglementeret afbrydning af regenereringen, genererer et sugestrømskredsløb gennem en strømningsvej (K), som passerer gennem gasrørene (14, 16, 18, 19, 23, 24, 29, 30), adsorberne (9, 10), det elektriske varmelegeme (13), varmeveksler (6), separator (7) og filter (11) af ren gas og desorptionsgas (D, F), som er dannet af den ved slukning af strømforsyningen eksisterende restgas (G) på adsorberne (9, 10).

2. Fremgangsmåde ifølge krav 1, **kendetegnet ved** at en tørløbende, hermetisk forseglede, periferipumpe med magnetisk koblet drev, en tørløbende lamelkompressor eller en rotationsstempelkompressor anvendes som gasbooster (12).
3. Fremgangsmåde ifølge krav 1, **kendetegnet ved** at en hvirvelstrømsmåler med integreret flowcomputer eller et rotameter anvendes som flowtransmitter (35).
4. Fremgangsmåde ifølge krav 1, **kendetegnet ved** at en brændselscelleenhed, og/eller UPS-kilde, og/eller en nødstrømsenhed anvendes som intern/ekstern strømkilde (40).

5. Fremgangsmåde ifølge krav 4, **kendetegnet ved** at brændselscelleenheden drives med tidligere genereret ren hydrogengas (D) lagret i en buffer (41), indtil regenereringen er afsluttet.
6. Fremgangsmåde ifølge krav 4, **kendetegnet ved** at brændselscelleenheden drives med hydrogen fra et separat hydrogenlager, indtil regenereringen er afsluttet.
7. Fremgangsmåde ifølge krav 1, **kendetegnet ved** at i afhængighed af en faktisk temperatur målt af en temperatursensor (17) i regenereringsgasrøret (18) efter gasboosteren (12) justeres regenereringsgassens (E) temperatur af et elektronisk kredsløb (20), som er anbragt i det elektriske varmelegeme (13) kommunikerende med styreenheden (21), til en referencetemperatur svarende til desorptionstemperaturen.
8. Fremgangsmåde ifølge krav 1, **kendetegnet ved** at flowtransmitteren (35) detekterer tilstedeværelsen eller fraværet af regenereringsgassen (E), og flowcomputeren omdanner denne information til en kommando til tænding eller slukning af det elektriske varmelegeme (13).
9. Fremgangsmåde ifølge krav 1, **kendetegnet ved** at procesgassen (C)/desorptionsgassen (F) afkøles i en varmeveksler (6) nedstrøms for reaktoren (5), og at vandet, som kondenserer ud under afkølingen, separeres i en separator (7) og udledes med en pumpe (8) eller opbevares midlertidigt i separatoren (7).
10. Fremgangsmåde ifølge krav 1, **kendetegnet ved** at strømningsvejen (K) dannes ved med pilotventilen (49) at

nedlukke for rengas-røret (16) til forbrugeren, og at holde procesgasrøret (14) åbent, holde rengas-røret (16) i regenereringsgasrøret (18) åbent via det elektriske varmelegeme (13), holde adsorberer (9, 10), som ved hjælp af pilotventilerne (25, 26, 27, 28) og via forbindelsesrørene (29, 30) er skiftet til adsorption, åben, holde adsorberer (10, 9), som ved hjælp af pilotventilerne (31, 32, 33, 34) og via forbindelsesrørene (29, 30) er skiftet til regenerering, åben, og at holde desorptionsgasrøret (19), som fører tilbage til procesgasrøret (14), åbent.

11. Fremgangsmåde ifølge krav 1, **kendetegnet ved** at sugestrømskredsløbet omfatter følgende trin:

I at tænde for den interne/eksterne strømkilde (40), for eksempel en brændselscelleenhed, og fortsætte driften af de elektriske forbrugere, såsom gasbooster (12), elektrisk varmelegeme (13), pumpe (8), pilotventiler (25 til 28; 31 til 34, 43, 45 og 49) og styreenhed (21),

II at afspærre rengas-røret (16) til forbrugeren ved hjælp af pilotventilen (49), og at danne strømningsvejen (K),

III at fortsætte tørringen/regenereringen ved med gasboosteren (12) i sugestrømskredsløbet at transportere den rene gas og desorptionsgassen (D, F), som er genererede af adsorberne (9 og 10) fra den tilbageværende restgas, gennem strømningsvejen (K), hvori den rene gas/desorptionsgassen (D og F), som forlader adsorberne (9 eller 10), cirkuleres i kredsløbet, indtil regenereringen afsluttes,

- IV at forgrene delmængden (T_R) af ren gas (D) til rengasrøret (16) som regenereringsgas (E), og justere denne delmængde ved at måle dens volumenflow, bestemme en
5 som aktuel værdi eller en rotationshastighedsværdi som fast værdi ud fra det målte volumenflow med den i flowtransmitteren (35) integrerede flowcomputer, at overføre den bestemte værdi til styreenheden (21), som angiver denne værdi som en styrevariabel for
10 gasboosterens (12) frekvensomformer,
- V at opvarme den forgrenede regenereringsgas (E) ifølge trin IV ved at justere temperaturen til en temperatur svarende til desorptionstemperaturen, som er
15 forudbestemt af et elektronisk kredsløb (20) i elektrisk varmelegeme (13) via styreenheden (21) i afhængighed af en, af en temperatursensor (17) i strømretningen nedstrøms det elektriske varmelegeme (13), målt faktisk temperatur,
20
- VI via desorptionsgasrøret (19) før varmeveksleren (6) i procesgasrøret (14) set i strømningsretningen at returnere desorptionsgassen (F), som forlader
25 adsorbereren (9 eller 10), som er skiftet til regenerering,
- VII at afkøle desorptionsgassen (F) i køler (6), udskille det kondenserede vand, og bortpumpe vandet i transportrøret (15) til elektrolysatoren (1) eller i
30 et til vandet separat lager eller mellemlager i separatoren (7) med efterfølgende udledning af vandet,
- VIII at tilføre mængden af desorptionsgas (F), som forlader separatoren (7), til adsorption af vandet som stadig

er til stede i adsorberen (9 eller 10), som er skiftet til adsorption, at tilføre den tørrede gas som ren gas (D) via filteret (11) til gasboosteren (12) med henblik på fornyet optagelse af delmængden (T_R) af ren gas (D) som regenereringsgas (E),

IX at fortsætte trin I til VIII indtil regenereringen er afsluttet.

- 10 12. Fremgangsmåde ifølge krav 1, **kendetegnet ved** at silikagel, molekylsigter eller aluminiumoxid anvendes som adsorptionsmiddel.
- 15 13. Indretning til tørring og rensning af hydrogenholdige gasser, som opstår ved elektrolytisk vandspaltning i form af en oxygenrig gas (A) og en hydrogenrig gas (B), som hver indeholder rester af den respektive anden gas, med en til forsyningsrøret (36) tilsluttet strømledning (48) til forsyning af alle forbrugere af indretningen med strøm, et udledningsrør (2) til den oxygenrige gas (A) til atmosfæren
- 20 eller til forbrugeren, og et tilførselsrør (3) til den hydrogenrige gas (B), med et varmeapparat (4) til forvarmning af den hydrogenrige gas (B), en reaktor (5) til omdannelse af restoxygen og hydrogen under dannelse af vand på en katalysator til en varm procesgas (C), mindst to med
- 25 adsorptionsmiddel fyldte adsorbere (9, 10), som via en styreenhed (21) er omskifteligt anbragt i forhold til hinanden via forbindelsesrør (23, 24; 29, 30) og pilotventiler (25, 26, 27, 31, 32, 33, 34) under overtryk i
- 30 adsorptions- og regenereringstilstanden og omvendt, og som danner de to indbyrdes uafhængige adsorptionskredsløb (AK, RK), hvori adsorberne (9, 10) står i forbindelse med reaktoren (5) via et procesgasrør (14), som fører procesgassen (C) ind i adsorberne (9, 10) til adsorption af

vandet, og adsorberne (9, 10) er forbundne til forbrugeren via et filter (11) og et mod toppen vendende placeret rengas-rør (16), som kan afspærres med en pilotventil (49), til afledning af den tørrede procesgas som ren hydrogengas (D) med høj renhed, og adsorberne (9, 10) er ved toppen forbundne med et regenereringsgasrør (18), som nedstrøms for filteret (11) afgrener sig fra rengas-røret (16), til tilførsel af en delmængde (T_R) af den rene gas (D) som regenereringsgas (E) til opvarmning i et elektrisk varmelegeme (13), og vendende mod bunden forbundne med et desorptionsgasrør (19) til ledning af den med vand fyldte desorptionsgas (F) imod procesgassens (C) strømningsretning i adsorberen (9, 10), som er skiftet til adsorption, **kendetegnet ved** at til regenereringsgasrøret (18) er sluttet til en gasbooster (12) med frekvensomformer til sugning og komprimering af delmængden (T_R) af den rene gas (D), og til en flowtransmitter (35) med integreret flowcomputer til bestemmelse af en aktuel rotationshastighedsværdi for gasboosteren (12) som en faktisk værdi, eller en rotationshastighedsværdi som fast værdi, for volumenflowet af regenereringsgas (E), og nedstrøms for gasboosteren (12) er det elektriske varmelegeme (13) tilsluttet som regenereringsgasopvarmer, hvori der i strømretningen nedstrøms for det elektriske varmelegeme (13) er anbragte en temperatursensor (17) til måling af regenereringsgassens (E) faktiske temperatur og et i det elektriske varmelegeme (13) elektronisk kredsløb (20) til justering af en til desorptionstemperaturen modsvarende referencetemperatur, og at flowtransmitteren (35) står i forbindelse med frekvensomformeren, og at kredsløbet (20) står i forbindelse med styreenheden (21), ved svigt af strømforsyningen skifter alle de strømforbrugende indretninger, såsom gasbooster (12), elektrisk varmelegeme (13), styreenhed (21), pilotventiler

- (25, 26, 27, 28; 31, 32, 33, 34; 43; 45; 49), og om nødvendigt pumpe (8), ved hjælp af en omskifterindretning (37), til en intern/ekstern strømkilde (40) til midlertidig elektrisk energiforsyning via strømledningen (48), hvori
- 5 gasboosteren (12) opretholder en kredsløbssugestrøm af den, ved adsorberne (9, 10) og ud fra den ved slukning af strømforsyningen tilstedeværende restgas (G) i indretningen, dannede rene gas og desorptionsgas (D, F) i en gennem gasrørene (14, 16, 18, 19, 23, 24, 29, 30),
- 10 adsorberne (9, 10), det elektriske varmelegeme (13), varmeveksleren (6), separator (7) og filter (11) førende strømningsvej (K), indtil den reglementerede slukning af regenereringen.
- 15 14. Indretning ifølge krav 13, **kendetegnet ved** at gasboosteren (12) er en tørløbende, hermetisk forseglet periferipumpe med magnetisk koblet drev, en lamelkompressor eller en rotationsstempelkompressor.
- 20 15. Indretning ifølge krav 13, **kendetegnet ved** at flowtransmitteren (35) er en hvirvelstrømsmåler med integreret flowcomputer eller et rotameter.
- 25 16. Indretning ifølge krav 13, **kendetegnet ved** at den interne/eksterne strømkilde (40) er en brændselscelleenhed, og/eller UPS-kilde, og/eller en nødstrømsenhed.
- 30 17. Indretning ifølge krav 13, **kendetegnet ved** at der til lagring af tidligere genereret ren gas (D) er tilvejebragt en buffer (41), som på den ene side er forbundet med rengas-røret (16) via et forgreningsrør (42), som via en pilotventil (43) kan bringes i den åbne eller lukkede position, og på den anden side står i forbindelse med brændselscelleenheden (40) via et tilførselsrør (44), som

via en pilotventil (45) kan åbnes eller lukkes, til tilførsel af den lagrede rene gas (D) ind i brændselscelleenheden (40).

5 18. Indretning ifølge krav 13, **kendetegnet ved** at et separat hydrogenlager er tilvejebragt, som står i forbindelse med brændselscelleenheden (40) via tilførselsrøret (44), som
10 via pilotventilen (45) bringes i den åbne eller lukkede position, til tilførsel af hydrogen ind i brændselscelleenheden (40).

19. Indretning ifølge krav 13, **kendetegnet ved** at brændselscelleenheden (40) har et internt styreelement (46), som er forbundet med styreenheden (21) og forbundet
15 med en omskifterindretning (37), som afbryder brændselscelleenheden (40) fra strømforsyningen eller forbinder med denne.

20. Indretning ifølge krav 13, **kendetegnet ved** at flowtransmitterens (35) flowcomputer slukker for det
20 elektriske varmelegeme (13), eller forhindrer det i at blive tændt, ved en mangel på regenereringsgas.

21. Indretning ifølge krav 13, **kendetegnet ved** at det
25 elektriske varmelegeme (13) er elektrisk forbundet med brændselscelleenheden (40) via en vekselretter (47).

22. Indretning ifølge krav 13, **kendetegnet ved** at i procesgasrøret (14) er varmeveksleren (6) til afkøling af
30 procesgassen (C)/desorptionsgassen (F) og separatoren (7) til separationen af det kondenserede vand anbragte efter hinanden set i procesgassens (C) strømretning, hvori separatoren (7), via en pumpe (8) til transporten af det

kondenserede vand, er tilsluttet et transportrør (15), som udmunder i elektrolysatoren.

23. Indretning ifølge krav 13, **kendetegnet ved** at
5 procesgasrøret (14) via varmeveksleren (6), separator (7),
og den ved hjælp af pilotventilerne (25, 26, 27, 28) til
adsorption skiftede adsorber (9), det til forbrugeren
afspærrede, men til regenereringsgasrøret (18) åbne,
10 rengasrør (16), regenereringsgasrøret (18) danner, ved
hjælp af ventilerne (31, 32, 33, 34) via den til
regeneration skiftede adsorber (10), sammen med det i
procesgasrøret (14) tilbageførende desorptionsgasrør (19),
strømningsvejen (K), i hvilken den fra i indretningen
eksisterende restgas (G) dannede rene gas (D) og
15 desorptionsgas (F) transporteres i sugestrømskredsløbet af
gasboosteren (12) indtil regenereringen er afsluttet.

24. Indretning ifølge krav 13, **kendetegnet ved** at
desorptionsgasrøret (19) er integreret i procesgasrøret
20 (14) nedstrøms for reaktoren (5) set i procesgassens (C)
strømningsretning.

25. Indretning ifølge krav 13, **kendetegnet ved** at pumpen (8),
gasboosteren (12), det elektriske varmelegeme (13),
25 pilotventilerne (25 til 28, 31 til 34, 43, 45, 49) og
styreenheden (21) via omskifterindretningen (37) er
forbundet med brændselscelleenheden (40) eller UPS-kilden
til forsyning af strøm på en måde, hvor der kan tændes
eller slukkes.

30

26. Indretning ifølge krav 13, **kendetegnet ved** at adsorberne
(9, 10) er fyldte med silicagel, molekylsigter eller
aluminiumoxidgel som adsorptionsmiddel til vand.

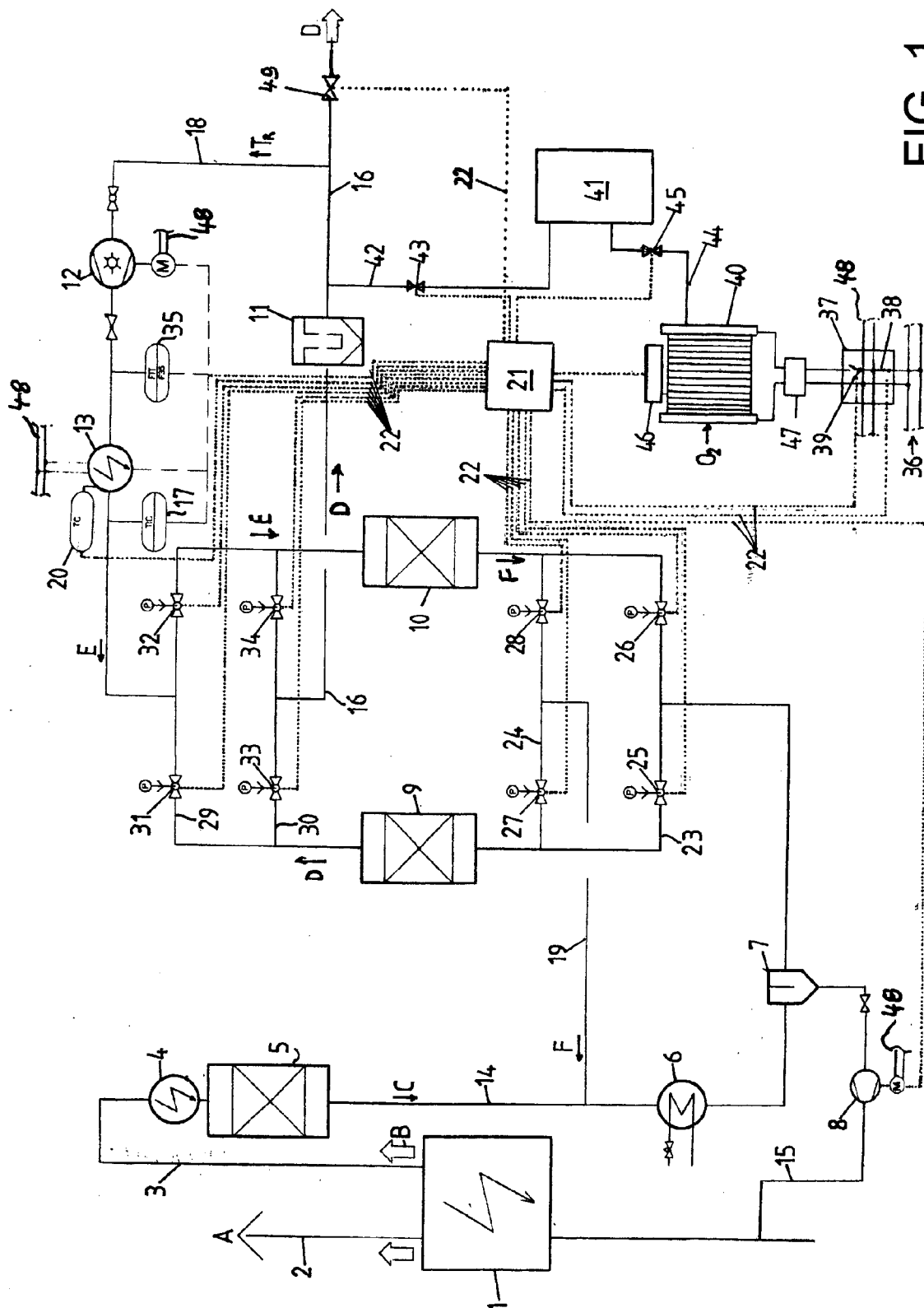


FIG. 1

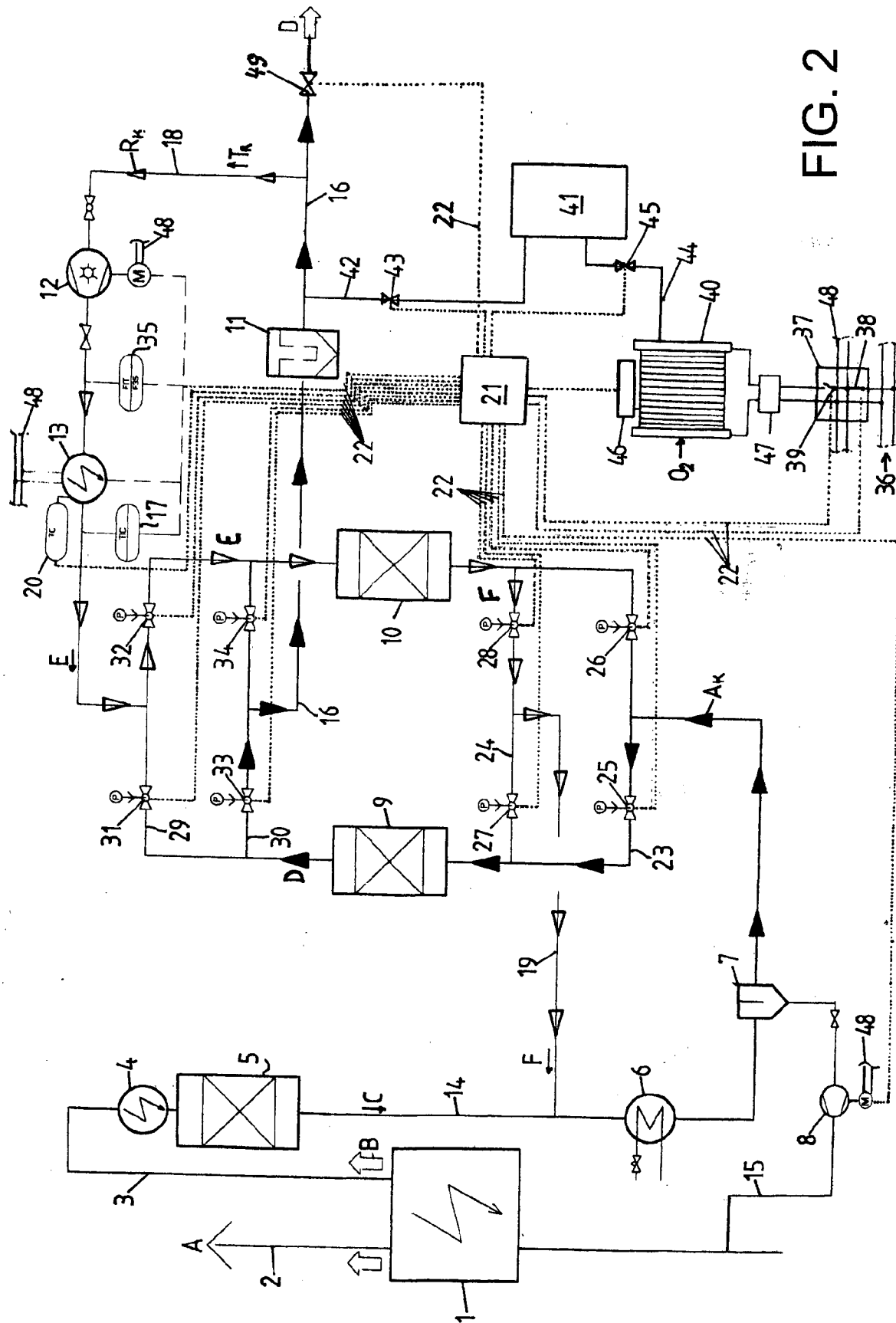


FIG. 2

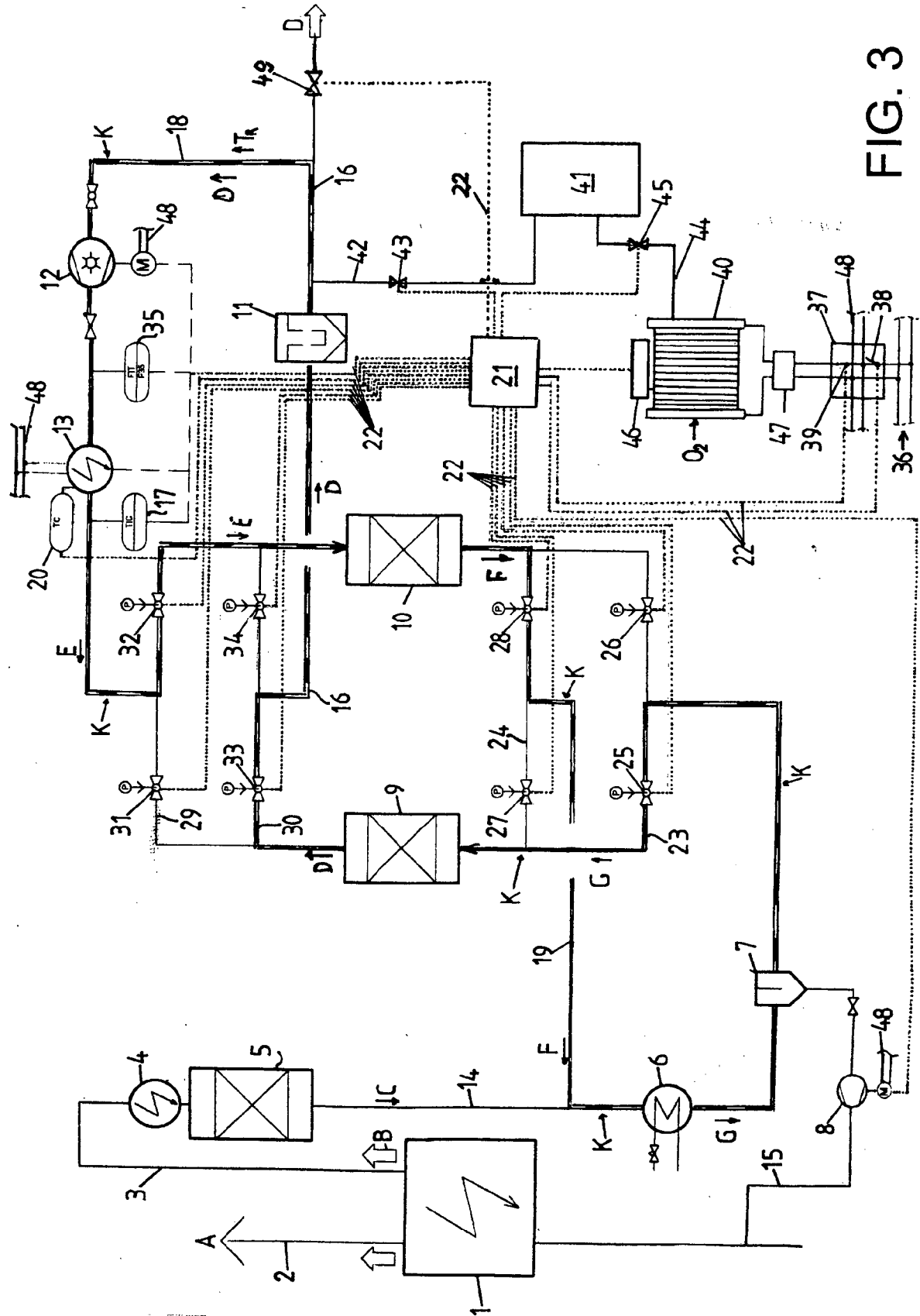


FIG. 3