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(54) **Title:** METHOD AND DEVICE FOR TREATING A GAS FLOW COMPRISING CARBON DIOXIDE FROM A LARGE
COMBUSTION PLANT

(54) **Bezeichnung :** VERFAHREN UND VORRICHTUNG ZUR BEHANDLUNG EINES KOHLENDIOXIDHALTIGEN
GASSTROMS AUS EINER GROSSFEUERUNGSANLAGE

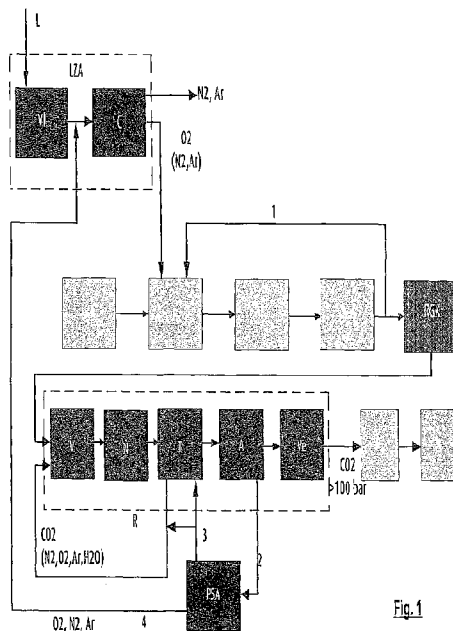


Fig. 1

(57) **Abstract:** The invention relates to a method and to a device for treating a gas flow comprising carbon dioxide from a large combustion plant, particularly a power plant. The gas flow is separated in a carbon dioxide scrubbing stage R into a partial gas flow having increased carbon dioxide content and a partial gas flow having reduced carbon dioxide content. The partial gas flow having increased carbon dioxide content is fed into a further processing and/or storage unit S. In particular, by compressing the carbon dioxide in the bedrock, the emission of climate-damaging gases can be reduced. In order to increase the proportion of compressible CO₂, the invention proposes that the partial gas flow having reduced carbon dioxide content is fed into a pressure swing adsorption stage PSA, wherein a fraction rich in carbon dioxide and a fraction having low carbon dioxide content are generated. The fraction rich in carbon dioxide is fed back into the carbon dioxide scrubbing stage R, or fed directly into the further processing and/or storage unit S.

(57) **Zusammenfassung:** Die Erfindung betrifft ein Verfahren und eine Vorrichtung zur Behandlung eines kohlendioxidhaltigen Gasstroms aus einer Großfeuerungsanlage, insbesondere eines Kraftwerks. Der Gasstrom wird in einer Kohlendioxidreinigungsstufe R in einen Teilgasstrom mit erhöhtem Kohlendioxidgehalt

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und einen Teilgasstrom mit vermindertem Kohlendioxidgehalt aufgetrennt. Der Teilgasstrom mit erhöhtem Kohlendioxidgehalt wird einer Weiterverwertung und/oder Speicherung S zugeführt. Insbesondere kann durch Verpressung des Kohlendioxids im Untergrund die Emission klimaschädlicher Gase vermindert werden. Zur Erhöhung des verpressbaren CO₂- Anteils wird vorgeschlagen, dass der Teilgasstrom mit vermindertem Kohlendioxidgehalt einer Druckwechseladsorptionsstufe PSA zugeführt wird, in der eine kohlendioxidreiche und eine kohlendioxidarme Fraktion erzeugt werden. Die kohlendioxidreiche Fraktion wird zur Kohlendioxidreinigungsstufe R zurückgeführt oder direkt der Weiterverwertung und/oder Speicherung S zugeführt.

Description

5 Process and apparatus for the treatment of a carbon
 dioxide-containing gas stream from a large-scale
 combustion plant

10 The invention relates to a process for the treatment of
 a carbon dioxide-containing gas stream from a large-
 scale combustion plant, in particular of a power
 station, where the gas stream is separated in a carbon
 dioxide purification stage into a gas substream having
15 an increased carbon dioxide content and a gas substream
 having a reduced carbon dioxide content and the gas
 substream having an increased carbon dioxide content is
 passed to further use and/or storage, and also an
 apparatus for carrying out the process.

20 Carbon dioxide-containing gas streams are obtained in
 all large-scale combustion plants which are operated
 using fossil fuels such as coal, petroleum or natural
 gas. These include power stations in particular, but
 also industrial furnaces, steam boilers and similar
25 large-scale thermal plants for power and/or heat
 generation. Owing to the adverse effect of carbon
 dioxide gas on the climate, there is a search for
 solutions which enable emissions of carbon dioxide-
 containing offgases into the atmosphere to be reduced.

30 New power station concepts in which the fossil fuel,
 e.g. coal, is burnt using an oxygen-rich combustion
 gas, in particular technical-grade oxygen or oxygen-
 enriched air, (oxygen combustion gas process) have
 recently been proposed. The oxygen content of this
35 combustion gas is, for example, from 95 to 99.9% by
 volume. The offgas formed which is also referred to as
 flue gas, contains mainly carbon dioxide (CO₂) in a
 proportion of about 70-85% by volume. The aim of these

new concepts is to compress the carbon dioxide which is formed in the combustion of the fossil fuels and is present in a high concentration in the flue gas in suitable underground formations, in particular in certain rock strata or strata conducting salt water and thus to limit carbon dioxide emission into the atmosphere. The climate-damaging effect of greenhouse gases such as carbon dioxide are to be reduced as a result. Such power stations are referred to in technical speech as "oxyfuel" power stations.

In the concepts known hitherto, dust removal, removal of nitrogen oxides and desulphurization of the flue gas are carried out in successive steps. Subsequent to this flue gas purification, the carbon dioxide-rich offgas which has been treated in this way is compressed and fed to a carbon dioxide purification stage. A gas substream having a reduced carbon dioxide content and another gas substream having an increased carbon dioxide content are typically produced there by means of a cryogenic separation process. The gas substream having an increased carbon dioxide content represents the desired carbon dioxide product stream which is obtained with a carbon dioxide content of, for example, more than 95% by volume and is intended for further utilization, in particular for transport to storage reservoirs. The gas substream having a reduced carbon dioxide content is obtained as secondary stream (known as vent gas) at from 15 to 30 bar, preferably 18-25 bar, and contains predominantly the constituents not intended for compressed storage, in particular inert gases such as nitrogen (N_2) and argon (Ar) and also oxygen (O_2). However, proportions of carbon dioxide are also still present in this gas substream in a concentration of about 25-35% by volume. This vent gas is at present released into the atmosphere. This reduces the degree of possible utilization and

compressed storage of the carbon dioxide. This degree of CO₂ utilization is also referred to as CO₂ recovery ratio. The recovery ratio r is defined as the ratio of purified CO₂ obtained to the CO₂ formed in the combustion process, multiplied by the factor 100:

$$r = \frac{\text{CO}_2 \text{ (recovered and purified)}}{\text{CO}_2 \text{ (formed)}} \times 100$$

The introduction of the oxyfuel technology has the objective of achieving very high CO₂ recovery ratios, i.e. to produce as much CO₂ as possible in the required quality for compressed storage and at the same time reduce the amount of environmentally damaging CO₂ (greenhouse gas) as emission into the atmosphere. Efforts at present assume that the CO₂ recovery ratio should be at least 90%.

This recovery ratio can be influenced by the CO₂ content of the flue gas, by the type of process and by the energy consumption.

Apart from CO₂ in a concentration of about 75-90% by volume (preferably from 75 to 85% by volume), the following further components are found in the raw gas: nitrogen, oxygen, argon and traces of carbon monoxide, sulphur oxide and nitrogen oxide. Since the CO₂ product should have a CO₂ content of > 95% by volume, the inert constituents have to be reduced. This leads to part of the CO₂ also being lost together with the inerts which are separated off in the cryogenic purification. This means that the desire for CO₂-free power stations has hitherto not been able to be fulfilled, but at best low-CO₂ power stations have been able to be realised.

In the paper presented at "Purification of Oxyfuel-Derived CO₂; IEAGHG International Oxy-Combustion

Network, Yokohama, Japan, 5/6 March 2008; Vince White (Air Products PLC, UK)", it was proposed that the oxygen be recovered from the vent gas by means of a membrane unit and recirculated to the oxyfuel power station and mixed into the combustion gas. The remaining gas with the remaining amounts of CO₂ is released into the atmosphere.

Any discussion of the prior art throughout the specification should in no way be considered as an admission that such prior art is widely known or forms part of common general knowledge in the field.

It is an object of the present invention to overcome or ameliorate at least one of the disadvantages of the prior art, or to provide a useful alternative.

It is an object of preferred forms of the present invention to provide a process of the type mentioned at the outset.

It is an object of preferred forms of the present invention to provide an apparatus for carrying out the process so as to increase the CO₂ recovery ratio.

This object is provided in terms of a process by the gas substream having a reduced carbon dioxide content being fed to a pressure swing adsorption stage in which a fraction which is rich in carbon dioxide and a fraction which is low in carbon dioxide are produced.

According to a first aspect, the present invention provides a process for the treatment of a carbon dioxide-containing gas stream from a large-scale combustion plant, said process comprising:

separating said carbon dioxide-containing gas stream in a carbon dioxide purification stage into a gas substream having an increased carbon dioxide content and a gas substream having a reduced carbon dioxide content,

passing the gas substream having an increased carbon dioxide content from said carbon dioxide purification stage to further use and/or storage,

feeding the gas substream having a reduced carbon dioxide content to a pressure swing adsorption stage in which a fraction which is rich in carbon dioxide and a fraction which is low in carbon dioxide are produced, and

5 recirculating the fraction which is rich in carbon dioxide to the carbon dioxide purification stage,

wherein the gas stream is a carbon dioxide-containing offgas stream produced from a large-scale combustion plant in which fossil fuels are burnt by a combustion gas which is produced in an air fractionation plant and which has an oxygen content higher than that of air, and

wherein the fraction which is low in carbon dioxide from the pressure swing adsorption plant is recirculated to the air fractionation plant.

5 According to a second aspect, the present invention provides a process for the treatment of a carbon dioxide-containing gas stream from a large-scale combustion plant, in particular of a power station, said process comprising:

0 separating said carbon dioxide-containing gas stream in a carbon dioxide purification stage into a gas substream having an increased carbon dioxide content and a gas substream having a reduced carbon dioxide content,

25 passing the gas substream having an increased carbon dioxide content from said carbon dioxide purification stage to further use and/or storage,

30 feeding the gas substream having a reduced carbon dioxide content to a pressure swing adsorption stage in which a fraction which is rich in carbon dioxide and a fraction which is low in carbon dioxide are produced, and

increasing the pressure of the fraction which is rich in carbon dioxide and then passing the pressurized fraction rich in carbon dioxide to further use and/or storage, and

35 wherein the gas stream is a carbon dioxide-containing offgas stream produced from a large-scale combustion plant in which fossil fuels are burnt by a combustion gas which is produced in an air

fractionation plant and which has an oxygen content higher than that of air, and

wherein the fraction which is low in carbon dioxide from the pressure swing adsorption plant is recirculated to the air fractionation plant.

According to a third aspect, the present invention provides an apparatus for the treatment of a carbon dioxide-containing gas stream from a large-scale combustion plant, said apparatus comprising:

a carbon dioxide purification facility to which the carbon dioxide-containing gas stream is supplied,

a discharge line for discharging a gas substream having an increased carbon dioxide content from said carbon dioxide purification facility,

a discharge line for discharging a gas substream having as reduced carbon dioxide content from said carbon dioxide purification facility,

said discharge line for the gas substream having an increased carbon dioxide content is connected to a utilization facility and/or a storage reservoir, and

said discharge line for the gas substream having a reduced carbon dioxide content is connected to a pressure swing adsorption plant which has a discharge line for a fraction which is rich in carbon dioxide and a discharge line for a fraction which is low in carbon dioxide,

wherein the discharge line for a fraction which is rich in carbon dioxide is connected to the carbon dioxide purification facility, and

wherein carbon dioxide-containing gas stream is provided by a carbon dioxide-containing an off-gas line from a large-scale combustion plant in which fossil fuels are burnt by a combustion gas which is produced in an air fractionation plant and which has an oxygen content higher than that of air, and

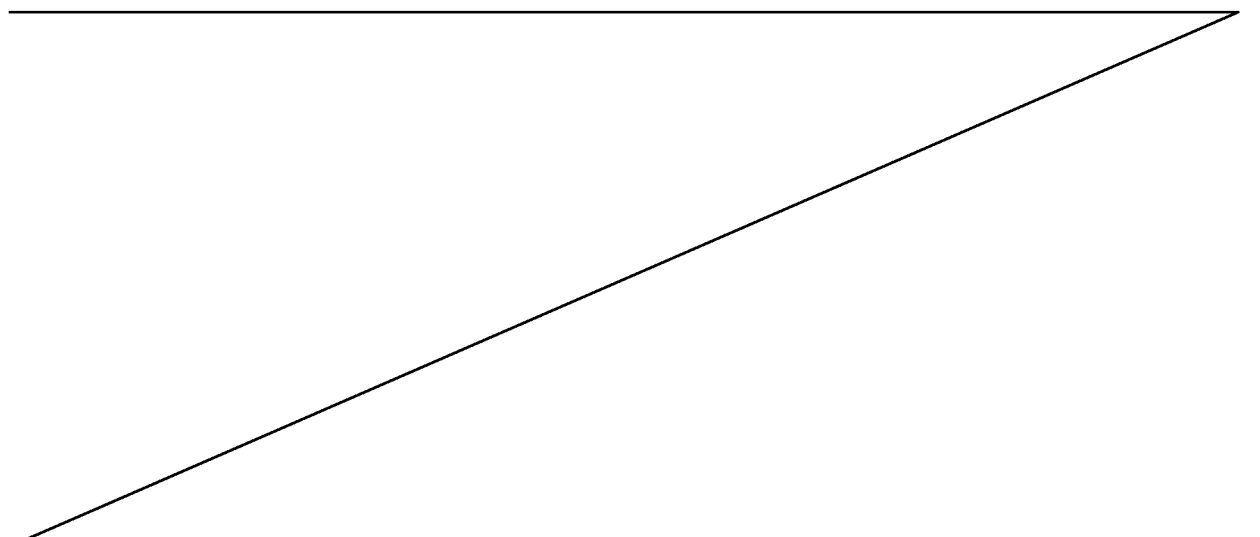
wherein said discharge line for a fraction which is low in carbon dioxide is connected to the air fractionation plant.

According to a fourth aspect, the present invention provides a treated carbon dioxide-containing gas when produced by the process according to the first aspect.

5 Unless the context clearly requires otherwise, throughout the description and the claims, the words "comprise", "comprising", and the like are to be construed in an inclusive sense as opposed to an exclusive or exhaustive sense; that is to say, in the sense of "including, but not limited to".

0 The fraction which is rich in carbon dioxide can be recirculated to the carbon dioxide purification stage or be passed directly to further use and/or storage.

5 The carbon dioxide purification stage which is used for producing a usable or storable, in particular compressible, CO₂ product and is configured, for example, as a cryogenic carbon dioxide liquefaction plant is thus extended by a pressure swing adsorption stage (pressure swing adsorption plant or PSA). In the pressure swing adsorption
0 stage, the vent gas which is normally released into the atmosphere is worked up to form a fraction which is rich in carbon dioxide and a fraction which is low in carbon dioxide (in particular containing about 500 ppmv of CO₂). The fraction which is rich in carbon dioxide has a CO₂ content of, in particular, more than 85% by volume and is
25 recirculated to the carbon dioxide purification plant as additional



feed gas. This makes it possible to achieve a significant increase in the recovery ratio compared to conventional processes which operate without a pressure swing adsorption stage. It is in this way possible to
5 achieve CO₂ recovery ratios of as much as 99% in large-scale combustion plants which are operated as oxyfuel plants.

The carbon dioxide purification stage typically
10 comprises compression of the gas stream so that a precompressed gas substream having a reduced carbon dioxide content (vent gas) is obtained under a pressure of preferably 15-30 bar, particularly preferably
15 18-25 bar, is obtained and can be fed to the pressure swing adsorption stage. This makes it possible to employ a pressure swing adsorption stage without further compression.

An air fractionation plant is usually used for
20 providing the combustion gas having an increased oxygen content which is required for oxyfuel plants. In this case, the gas stream is formed by a carbon dioxide-containing offgas stream from a large-scale combustion plant in which fossil fuels are burnt using a
25 combustion gas which is produced in an air fractionation plant and has an oxygen content higher than that of air. In a particularly preferred embodiment of the invention, the fraction which is low in carbon dioxide from the pressure swing adsorption
30 stage is in this case recirculated to the air fractionation plant. In this way, the fraction which is low in carbon dioxide and consists essentially of nitrogen, oxygen and argon can be reused in the overall power station process. This fraction contains oxygen
35 (in particular about 12-25% by volume) and is preferably already compressed so that this gas mixture can be integrated into the process of the air

fractionation plant. In particular, this fraction can be introduced into a previously compressed feed gas stream to the air fractionation plant. This reduces the proportion of recirculated oxygen in the compression of
5 air for the air fractionation plant and enables compression energy to be saved.

The carbon dioxide purification stage advantageously comprises a drying stage, in particular an adsorptive
10 drying stage, for drying the gas stream. In this case, preference is given to at least part of the fraction which is rich in carbon dioxide and/or that which is low in carbon dioxide from the pressure swing adsorption stage being used as regeneration gas for the
15 drying stage. Here, the required pressure can be provided by the pressure swing adsorption stage.

Any temperature fluctuations resulting from use of the gas fraction as regeneration gas (e.g. during heating
20 and cooling of the adsorbers) can be evened out by recirculating part of the gas stream flowing out from the drying stage to a raw gas cooling stage (in particular flue gas condensation) preceding the carbon dioxide purification stage or feeding it back into the
25 gas stream upstream of the gas stream compression and thus contributing to mixing of the CO₂ raw gas stream and making it uniform.

Particularly when the fraction which is low in carbon
30 dioxide is used as regeneration gas for the drying stage before it is introduced into the air fractionation plant, any temperature fluctuations resulting from the use as regeneration gas are preferably evened out by feeding part of the gas stream
35 flowing out from the drying stage into a direct cooling stage of the air fractionation plant.

The carbon dioxide purification stage advantageously encompasses a multistage gas stream compression. In this case, the fraction which is rich in carbon dioxide from the pressure swing adsorption stage is preferably
5 fed into the gas stream upstream of the first stage of the gas stream compression. At an increased delivery pressure from the pressure swing adsorption stage, this fraction can also be fed at a pressure of more than 2 bar, in particular from 2 to 4 bar, into the gas
10 stream downstream of the first stage of the gas stream compression. In the case of introduction downstream of the first compressor stage, the compression energy for CO₂ recirculation can be reduced.

15 The invention further provides an apparatus for the treatment of a carbon dioxide-containing gas stream from a large-scale combustion plant, in particular a power station, having a carbon dioxide purification facility supplied with the gas stream, a discharge line
20 for a gas substream having an increased carbon dioxide content and a discharge line for a gas substream having a reduced carbon dioxide content, wherein the discharge line for the gas substream having an increased carbon dioxide content is connected to a utilization facility
25 and/or a storage reservoir.

In terms of the apparatus, the stated object is achieved by the discharge line for the gas substream having a reduced carbon dioxide content being connected
30 to a pressure swing adsorption plant which has a discharge line for a fraction which is rich in carbon dioxide and a discharge line for a fraction which is low in carbon dioxide, wherein the discharge line for the fraction which is rich in carbon dioxide is
35 connected to the carbon dioxide purification facility. In oxyfuel plants, the large-scale combustion plant is usually connected to an air fractionation plant for

producing a combustion gas having an oxygen content which is higher than that of air. In this case, it is proposed that the discharge line of the pressure swing adsorption plant for the fraction which is low in carbon dioxide be connected to the air fractionation plant.

In addition, the carbon dioxide purification facility preferably comprises a gas stream compression facility.

Furthermore, the discharge line of the pressure swing adsorption plant for the fraction which is low in carbon dioxide is advantageously connected to a discharge line of a compressor of the air fractionation plant.

The carbon dioxide purification facility typically comprises a drying facility, in particular a drying facility having an adsorber, for drying the gas stream. In this case, it is proposed that the drying facility be connected directly via a line to the pressure swing adsorption plant. The drying facility can also be connected directly via a line to a gas stream feed line of a compressor of the carbon dioxide purification facility located upstream of the drying facility. Another variant provides for the drying facility to be connected directly via a line to a raw gas cooling facility located upstream of the carbon dioxide purification facility.

According to a further development of the inventive concept, the carbon dioxide purification facility comprises a plurality of compressors or compressor stages and the discharge line of the pressure swing adsorption plant for the fraction which is rich in carbon dioxide is connected to a gas stream feed line to the first compressor or compressor stage or to a gas

stream transfer line from the first compressor or from the first compressor stage to the second compressor or to the second compressor stage.

- 5 The invention provides the possibility of significantly increasing the CO₂ recovery ratio in large-scale combustion plants, in particular power stations, which operate, for example, according to the oxyfuel technology. As a result, a larger proportion of carbon
- 10 dioxide can be compressed in rock strata or underground strata which conduct salt water, so that less carbon dioxide is emitted into the atmosphere. A significant contribution to reducing the greenhouse effect can be achieved in this way. At the same time, there is the
- 15 possibility of likewise integrating a previously compressed gas stream having an oxygen content of about 12-25% by volume into the overall process in order to reduce the compressor energy in the air fractionation plant by an amount corresponding to the amount of
- 20 oxygen in the gas stream.

The invention is suitable for all conceivable large-scale combustion plants in which carbon dioxide-containing gas streams are obtained. These include, for

25 example, power stations operated using fossil fuels, industrial furnaces, steam boilers and similar large-scale thermal plants for power and/or heat generation. The invention can be used particularly advantageously in large-scale combustion plants which are supplied

30 with technical-grade oxygen or oxygen-enriched air as combustion gas and in which off gas streams having high carbon dioxide concentrations are accordingly obtained. The invention is particularly suitable for low-CO₂ coal-fired power stations which are operated using oxygen as

35 combustion gas ("oxyfuel" power stations) and in which the carbon dioxide present in high concentration in the

offgas is separated off and compressed underground ("CO₂ capture technology").

The invention and further embodiments of the invention
5 are illustrated below with the aid of the examples
presented schematically in the figures.

In the figures:

- 10 Figure 1 shows a block flow diagram of integration of
a pressure swing adsorption plant into an
oxyfuel power station with dryer regeneration
by means of the CO₂-rich fraction
- 15 Figure 2 shows a block flow diagram of integration of
a pressure swing adsorption plant into an
oxyfuel power station with dryer regeneration
by means of the low-CO₂ fraction
- 20 Figure 3 shows a block flow diagram of integration of
a pressure swing adsorption plant into an
oxyfuel power station with direct supply of
the CO₂-rich fraction to the storage
- 25 The present example relates to a coal-fired power
station which is operated using a combustion gas having
an oxygen content of about 95% by volume and in which
an offgas stream enriched with carbon dioxide is
treated for compression underground. In Figure 1, a
30 combustion chamber K of the coal-fired power station is
supplied with coal from a coal drying facility KT. In
the combustion chamber K, the coal is burnt by means of
a combustion gas which has an oxygen content of about
95% by volume and also contains proportions of
35 nitrogen, oxygen and argon (about 5% by volume). The
combustion gas is generated from the ambient air L in
an air fractionation plant LZA which comprises an air

compressor VI and a precooling stage, an adsorber station and a coldbox C. The offgas (flue gas) from the combustion chamber K is conveyed via a filter F and purified in a downstream flue gas desulphurization plant REA. Part of the gas stream which has been purified in this way is recirculated via a CO₂ return line 1 to the combustion chamber K. The remaining gas stream goes into a flue gas cooling stage RGK. The cooled gas stream is fed to a carbon dioxide purification stage R which comprises a precompression V, a DeNO_x N and drying T and also a separation A and final compression Ve. In the separation A, a gas substream having an increased carbon dioxide content and a gas substream having a reduced carbon dioxide content are obtained. The gas substream having an increased carbon dioxide content is the desired CO₂ product stream which is finally fed at a pressure of above 100 bar into a pipeline P and transported to a storage S. As storage S, it is possible to use, for example, an underground stratum which conducts salt water or an underground rock stratum. The gas substream having a reduced carbon dioxide content (vent gas) which is obtained as secondary stream is fed at a pressure of about 15 bar via line 2 to the pressure swing adsorption plant PSA. In the pressure swing adsorption plant PSA, a fraction which is rich in carbon dioxide and a fraction which is low in carbon dioxide are produced. The fraction 3 which is rich in carbon dioxide is recirculated at a pressure of more than 2 bara to the carbon dioxide purification stage R, as a result of which the proportion of CO₂ in the CO₂ product stream to the pipeline P and thus the CO₂ recovery ratio are ultimately increased. The fraction 3 which is rich in carbon dioxide can firstly also be used as regeneration gas for the drying stage T, which comprises an adsorber station, present in the carbon dioxide purification stage R. For this purpose, a

substream of the fraction 3 which is rich in carbon dioxide is fed directly to the adsorber station of the drying stage T. Another substream having a CO₂ content of about 90% by volume and containing proportions of N₂, O₂ and Ar is recirculated at atmospheric pressure to the precompression V. The fraction 4 which is low in carbon dioxide obtained in the pressure swing adsorption plant PSA, which has a CO₂ content of about 500 ppm and contains proportions of O₂, N₂ and Ar, is recirculated at a pressure of more than 6.5 bara to the air fractionation plant LZA and, after the air compression LV, fed into the feed gas stream to the air fractionation plant.

The variant depicted in Figure 2 differs from that shown in Figure 1 in that the fraction 4 which is low in carbon dioxide from the pressure swing adsorption plant PSA is used for regenerating the adsorbers of the drying stage T before being recirculated to the air fractionation plant LZA, while the CO₂-rich fraction 3 is recirculated directly to the precompression V.

Finally, Figure 3 shows a variant in which the fraction 3 which is rich in carbon dioxide from the pressure swing adsorption plant is, after a pressure increase stage D, fed directly to the final compressor Ve for supply to the storage S. The fraction 4 which is low in carbon dioxide is used for regenerating the adsorbers of the drying stage T. This variant is particularly suitable when a purity of the CO₂-rich fraction which corresponds to the requirements for the CO₂ product is achieved, e.g. by use of a vacuum pressure swing adsorption plant (VPSA). In this case, the CO₂-rich fraction can be brought directly by a pressure increase stage to the inlet-side pressure level of the final compression Ve, so that recirculation via the CO₂ purification steps V, N, T and

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- 13 -

A can be omitted. In this way, the load on these purification steps can be decreased.

CLAIMS

1. A process for the treatment of a carbon dioxide-containing gas stream from a large-scale combustion plant, said process comprising:

5 separating said carbon dioxide-containing gas stream in a carbon dioxide purification stage into a gas substream having an increased carbon dioxide content and a gas substream having a reduced carbon dioxide content,

0 passing the gas substream having an increased carbon dioxide content from said carbon dioxide purification stage to further use and/or storage,

5 feeding the gas substream having a reduced carbon dioxide content to a pressure swing adsorption stage in which a fraction which is rich in carbon dioxide and a fraction which is low in carbon dioxide are produced, and

recirculating the fraction which is rich in carbon dioxide to the carbon dioxide purification stage,

0 wherein the gas stream is a carbon dioxide-containing offgas stream produced from a large-scale combustion plant in which fossil fuels are burnt by a combustion gas which is produced in an air fractionation plant and which has an oxygen content higher than that of air, and

25 wherein the fraction which is low in carbon dioxide from the pressure swing adsorption plant is recirculated to the air fractionation plant.

2. The process according to claim 1, wherein the gas substream having an increased carbon dioxide content is passed from said carbon dioxide purification stage to further use and/or storage.

3. The process according to claim 1 or claim 2, wherein the carbon dioxide purification stage comprises a gas stream compression so that a precompressed gas substream having a reduced carbon dioxide content is fed to the pressure swing adsorption stage.

4. The process according to any one of claims 1-3, wherein the fraction which is low in carbon dioxide from the pressure swing

adsorption stage is introduced into a previously compressed feed gas stream to the air fractionation plant.

5 5. The process according to any one of claims 1-4, wherein the carbon dioxide purification stage comprises a drying stage, for drying the gas stream, and at least part of the fraction which is rich in carbon dioxide and/or the fraction which is low in carbon dioxide from the pressure swing adsorption stage is used as regeneration gas for the drying stage.

0 6. The process according to claim 5, wherein the carbon dioxide purification stage comprises a gas stream compression so that a precompressed gas substream having a reduced carbon dioxide content is fed to the pressure swing adsorption stage, and a portion of the regeneration gas stream flowing out from the drying stage of the carbon dioxide purification stage is fed back into the gas stream
5 upstream of the gas stream compression.

7. The process according to claim 5, wherein a portion of the regeneration gas stream flowing out from the drying stage of the carbon dioxide purification stage is recirculated to a raw gas cooling stage upstream of the carbon dioxide purification stage.

0 8. The process according to claim 5, wherein a portion of the regeneration gas stream flowing out from the drying stage of the carbon dioxide purification stage is recirculated to a direct cooling stage of the air fractionation plant.

25 9. The process according to any one of claims 1-8, wherein the carbon dioxide purification stage comprises a multistage gas stream compression and the fraction which is rich in carbon dioxide from the pressure swing adsorption stage is either a) fed into the gas stream upstream of the first stage of the multistage gas stream compression; or b) fed at a pressure of more than 2 bar into the gas stream
30 downstream of the first stage of the multistage gas stream compression.

10. The process according to any one of claims 1-9, wherein the fraction has a carbon dioxide content of about 500 ppmv.

11. The process according to any one of claims 5-8, wherein the drying stage is an adsorptive drying stage.

12. A process for the treatment of a carbon dioxide-containing gas stream from a large-scale combustion plant, in particular of a power station, said process comprising:

separating said carbon dioxide-containing gas stream in a carbon dioxide purification stage into a gas substream having an increased carbon dioxide content and a gas substream having a reduced carbon dioxide content,

passing the gas substream having an increased carbon dioxide content from said carbon dioxide purification stage to further use and/or storage,

feeding the gas substream having a reduced carbon dioxide content to a pressure swing adsorption stage in which a fraction which is rich in carbon dioxide and a fraction which is low in carbon dioxide are produced, and

increasing the pressure of the fraction which is rich in carbon dioxide and then passing the pressurized fraction rich in carbon dioxide to further use and/or storage, and

wherein the gas stream is a carbon dioxide-containing offgas stream produced from a large-scale combustion plant in which fossil fuels are burnt by a combustion gas which is produced in an air fractionation plant and which has an oxygen content higher than that of air, and

wherein the fraction which is low in carbon dioxide from the pressure swing adsorption plant is recirculated to the air fractionation plant.

13. A process according to any one of claims 1-12 wherein said large-scale combustion plant is a power station.

14. An apparatus for the treatment of a carbon dioxide-containing gas stream from a large-scale combustion plant, said apparatus comprising:

a carbon dioxide purification facility to which the carbon dioxide-containing gas stream is supplied,

a discharge line for discharging a gas substream having an increased carbon dioxide content from said carbon dioxide purification facility,

a discharge line for discharging a gas substream having as reduced carbon dioxide content from said carbon dioxide purification facility,

said discharge line for the gas substream having an increased carbon dioxide content is connected to a utilization facility and/or a storage reservoir, and

said discharge line for the gas substream having a reduced carbon dioxide content is connected to a pressure swing adsorption plant which has a discharge line for a fraction which is rich in carbon dioxide and a discharge line for a fraction which is low in carbon dioxide,

wherein the discharge line for a fraction which is rich in carbon dioxide is connected to the carbon dioxide purification facility, and

wherein carbon dioxide-containing gas stream is provided by a carbon dioxide-containing an off-gas line from a large-scale combustion plant in which fossil fuels are burnt by a combustion gas which is produced in an air fractionation plant and which has an oxygen content higher than that of air, and

wherein said discharge line for a fraction which is low in carbon dioxide is connected to the air fractionation plant.

15. The apparatus according to claim 14, wherein the carbon dioxide purification stage comprises a gas stream compression facility and wherein the discharge line for the fraction which is rich in carbon dioxide is connected to the carbon dioxide purification facility upstream of the gas stream compression facility.

16. The apparatus according to claim 14, wherein the carbon dioxide purification stage comprises a gas stream compression facility and a final gas stream compression downstream of the gas stream compression facility, and wherein the discharge line for the fraction which is

rich in carbon dioxide is connected to the carbon dioxide purification stage at a point upstream of the gas stream compression facility and upstream of the final gas stream compression.

17. The apparatus according to any one of claims 14-16, wherein the fractionation plant comprises an air compressor and the discharge line for the fraction which is low in carbon dioxide is connected to the air fractionation plant downstream of the air compressor.

18. The apparatus according to any one of claims 14-17, wherein the carbon dioxide purification facility comprises a gas stream compression facility.

19. The apparatus according to any one of claims 14-18, wherein the air fractionation plant comprises an air compressor, and the discharge line of for the fraction which is low in carbon dioxide is connected to a discharge line of said air compressor of the air fractionation plant.

20. The apparatus according to any one of claims 14-19, wherein the carbon dioxide purification facility comprises a drying facility for drying the gas stream, and the drying facility is connected directly via a line to the pressure swing adsorption plant.

21. The apparatus of claim 20, wherein the drying facility is connected directly via a line to either a) a gas stream feed line of a compressor of the carbon dioxide purification facility upstream of the drying facility; or b) a raw gas cooling facility upstream of the carbon dioxide purification facility.

22. The apparatus according to any one of claims 14-21, wherein the carbon dioxide purification facility comprises a plurality of compressors and the discharge line for the fraction which is rich in carbon dioxide is connected to a gas stream feed line to the first compressor of said plurality of compressors or to a gas stream transfer line from the first compressor of said plurality of compressors to the second compressor of said plurality of compressors.

23. The apparatus according to claim 20 or claim 21, wherein the drying facility comprises adsorbers.

24. A treated carbon dioxide-containing gas when produced by the process according to any one of claims 1-13.

5 25. A process for the treatment of a carbon dioxide-containing gas stream from a large-scale combustion plant; an apparatus for the treatment of a carbon dioxide-containing gas stream from a large-scale combustion plant; or a treated carbon dioxide-containing gas substantially as herein described with reference to any one of the
0 embodiments of the invention illustrated in the accompanying drawings and/or examples.

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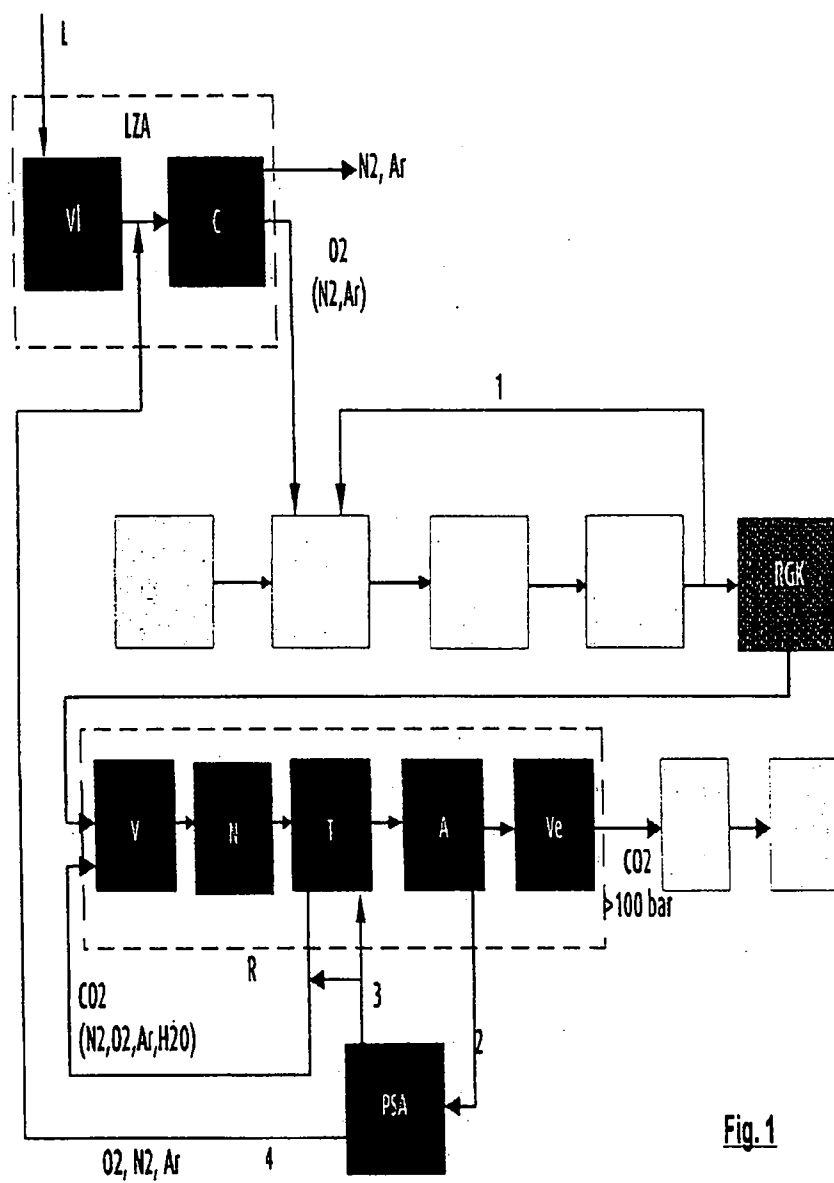


Fig. 1

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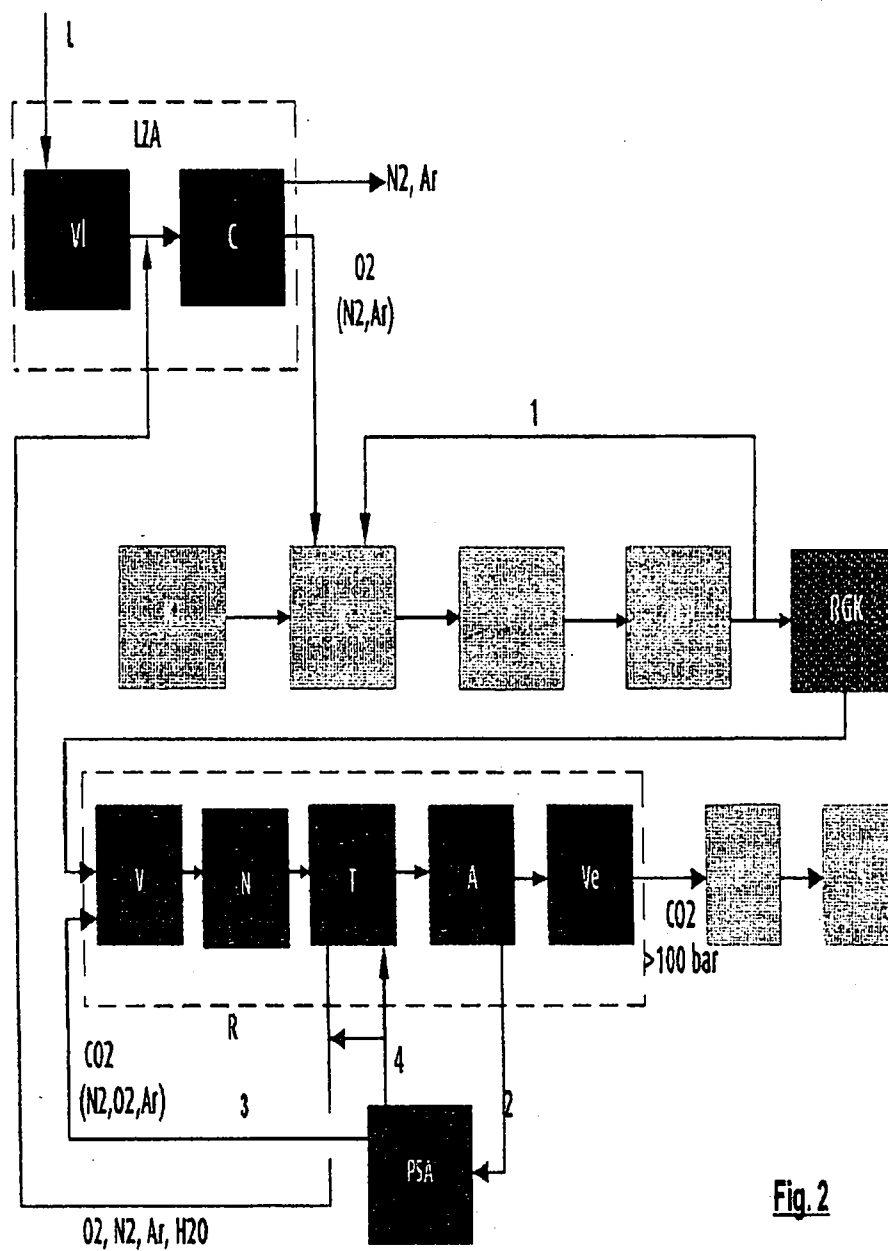


Fig. 2

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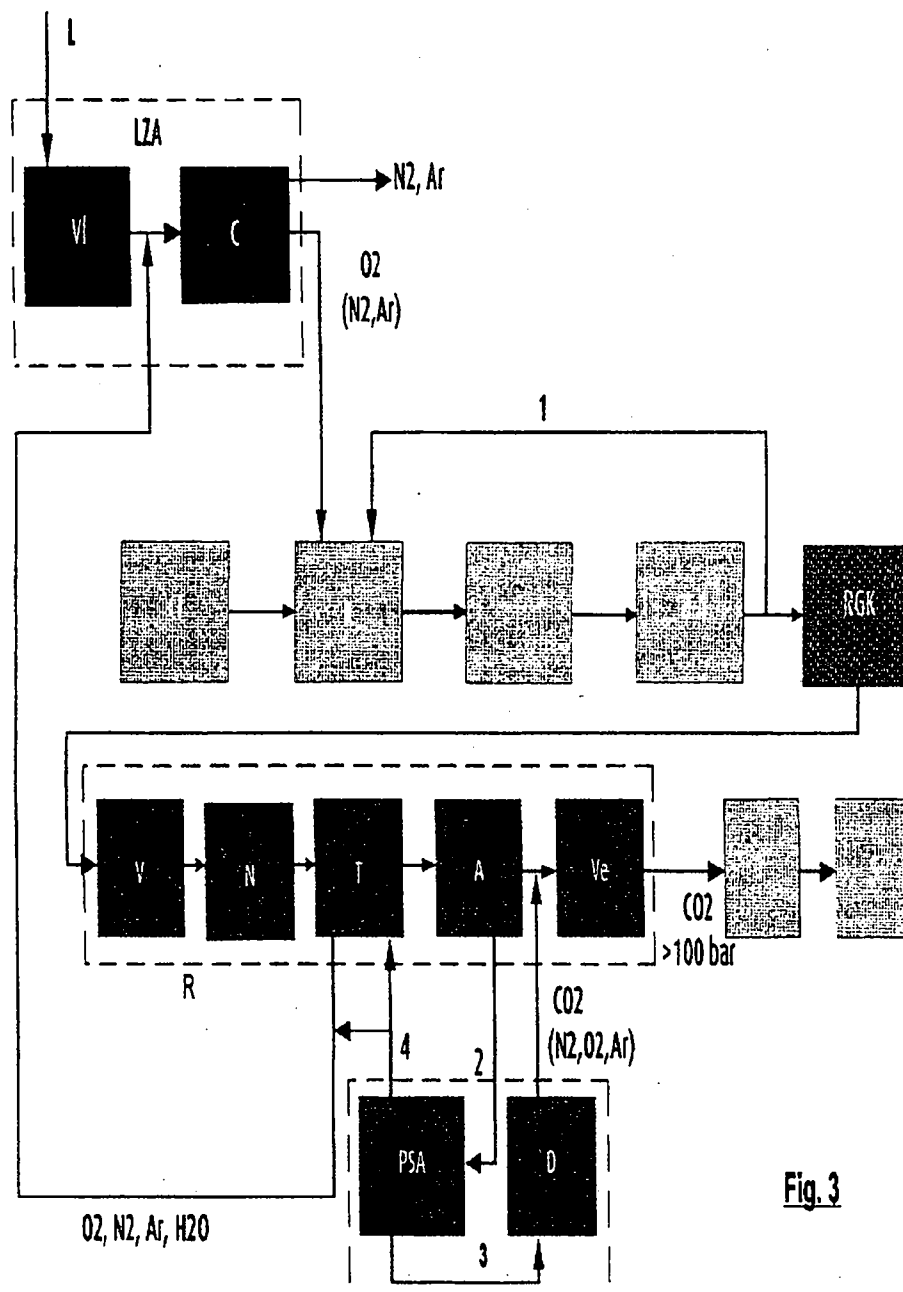


Fig. 3