We, COAL INDUSTRY (PATENTS) LIMITED

of Hobart House, Grosvenor Place,
LONDON SW1X 7AE, ENGLAND.

hereby apply for the grant of a Patent for an invention
entitled:

"PURIFICATION SYSTEM"

which is described in the accompanying complete specification.

This application is a Convention application and is based on the
application(s) numbered: 26088/78

for a patent or similar protection made in UNITED KINGDOM

on 31st MAY, 1978.

Our address for service is C/o GRIFFITH HASSEL & FRAZER, Patent
Attorneys, 71 York Street, Sydney 2001, in the State of New
South Wales, Commonwealth of Australia.

DATED THIS 27th day of August, 1982.

[Signature]

GRIFFITH, HASSEL & FRAZER
Fellows, Institute of Patent
Attorneys of Australia

TO:
THE COMMISSIONER OF PATENTS
COMMONWEALTH OF AUSTRALIA

This invention relates to a system which is used to
produce gas substantially free of...
COMMONWEALTH OF AUSTRALIA

PATENTS ACT 1952-62

Declaration in support of an Application for a Patent

In support of the application made by Coal Industry (Patents) Limited for a patent for an invention entitled;

"PURIFICATION SYSTEM"

I, John Irwin Wood, of the Applicant's address, do solemnly and sincerely declare as follows:

1. I am authorised by the applicant for the patent to make this Declaration on its behalf.

2. Michael Jonathan COOKE
of 67 Bourne Side Road, Cheltenham, Gloucestershire, England,

and Graham Phillip REED
of 24 Croft Road, Charlton Kings, Cheltenham, Gloucestershire, England.

and

of

are the actual inventor(s) of the invention and the applicant is the assignee of the said inventor(s).

3. The basic application, as defined by Section 141 of the Act, was made in the United Kingdom on: 31 May 1978

by Coal Industry (Patents) Limited.

4. The basic application referred to in Paragraph 3 of this Declaration was the first application made in a Convention country in respect of the invention, the subject of the application.

Declared at London, England, 18th May 1979

[Signature]

WOOD
Claim 1. A method of producing a product gas substantially free from corrosive alkali-metal compounds, comprising feeding a mineral and a gas contaminated with a corrosive alkali-metal compound to a fluidised or spouting bed of non-sticky, non-degradable particles maintained at a temperature whereat the mineral reacts with the alkali-metal compound to form a non-corrosive material of low vapour pressure, and withdrawing the product gas from the bed.
TO BE COMPLETED BY APPLICANT

Name of Applicant: COAL INDUSTRY (PATENTS) LIMITED

Address of Applicant: Hobart House, GROSVENOR PLACE, LONDON SW1X 7AE. ENGLAND.

Actual Inventor: Michael Jonathan COOKE
Griffith, Hassel & Frazer,
Address for Service: 323 Castlereagh St., SYDNEY N.S.W. 2000 AUSTRALIA

Complete Specification for the invention entitled:
"PURIFICATION SYSTEM"

The following statement is a full description of this invention, with the best method of performing it known to me/us:
This invention relates to a system which is used to produce gases substantially free from contaminants.

It is envisaged that in a power plant, solid fuel, e.g. coal, will be used in various ways to produce gaseous products which will be passed to a gas turbine for expansion. For instance, the coal may be burned to produce combustion product gases, or may be gasified to produce a combustible fuel gas which is subsequently burned to produce combustion product gases. It is envisaged that in a large power plant there will be various parts each of which may burn or gasify the coal.

Combustion of coal may be carried out in a fixed or fluidised bed or in an entrained flow system. The combustion product gas normally contains proportions of carbon oxides, oxygen and nitrogen.

Gasification of coal may be carried out in a fixed or fluidised bed or in an entrained flow system. The fuel gas produced by the gasification normally contains proportions of carbon oxides, hydrogen, steam, methane and nitrogen, and preferably contains substantial proportions of carbon monoxide and hydrogen. The fuel gas may be burned to give heat and a combustion product gas similar to that obtained by the combustion of coal.
The combustion product gases and the fuel gas also entrain during their production contaminants, which may be solids, liquids or gases. The contaminants may be combustible, for instance solid fuel which has not been gasified or burned, coke particles, tar and hydrocarbons, or may be incombustible, for instance fly ash or alkali metal compounds. The liquid contaminants are usually present as aerosols. Most of the solid contaminants may be removed by a cyclone-type separator. However, in the case of combustion product gases, a significant proportion of the contaminants remains in the gas stream, and is introduced into the gas turbine with the combustion product gases. Also in the case of fuel gases, although a further proportion of the contaminants may be removed by being combusted in the burning stage, nonetheless a significant proportion of the contaminants is introduced into the gas turbine with the combustion product gases. This significant proportion of contaminants, especially if it contains ash particles or corrosive alkali-metal compounds can cause great damage to the gas turbine by fouling corrosion and erosion, particularly of the blading. Corrosive alkali-metal compounds present as sub-micron sized particles may not readily be removed in a gas clean-up device employing physical capture mechanisms.

It is therefore an object of the present invention to
provide a method whereby combustion product gases containing substantially no alkali metal compounds may be produced.

According to the present invention there is provided a method of producing a product gas substantially free from corrosive alkali-metal compounds, comprising feeding a mineral and a gas contaminated with a corrosive alkali-metal compound to a fluidised or spouting bed of non-sticky, non-degradable particles maintained at a temperature whereat the mineral reacts with the alkali-metal compound to form a non-corrosive material of low vapour pressure, and withdrawing the product gas from the bed.

Any of the gases referred to in this specification may be either a single component or a mixture of at least two components.

The contaminated gas may be a combustion product gas either from the combustion of a solid fuel or from the combustion of a solid fuel derived fuel gas. Alternatively the contaminated gas may be a solid fuel-derived fuel gas, and in this case the fuel gas may be burned in the collection medium, thereby to maintain it at the appropriate temperature, or may be burned in a subsequent combustion stage.
is preferably a fluidised or spouting bed of non-sticky, non-degradable particles. If the bed is a fluidised bed it may be of the stationary or rotating type. The bed of particles to be fluidised is preferably supported on a gas distributor plate of conventional type, and the contaminated gas is introduced through the plate to fluidise the particles, the pressure of the gas preferably being superatmospheric. The fluidising or spouting system should be designed to prevent or minimise fouling which could thereby prevent satisfactory bed movement.

The mineral may be for instance china clay which largely comprises kaolinite, a material with known ion exchange capability and which reacts with corrosive alkali-metal compounds to form alkali feldspars. Preferably the mineral is fed to the collection medium in hard granular form which will be retained in the collection medium. The mineral may be entrained in the contaminated gas before it is fed to the collection medium. However preferably the mineral is fed to the collection medium separately. This size of the mineral particles should not be so large as to affect adversely the operation of the fluidised or spouting bed system if this is used as the collection medium.

The collection medium may be maintained at a temperature of up to 1200°C, and conveniently at a temperature of from 700 to equilib
700 to 1000°C. In this temperature range the chemical equilibria favour the formation of alkali feldspars.

Preferably the contaminated gas is first passed through one or a series of cyclone separators, wherein larger particulate contaminants are removed, the exhausting fuel gas containing particulate contaminants at a level of about 1 g/m³ and corrosive alkali metal compounds at a level of about 1 ppm. The exhausting gas may in addition contain combustible particulate contaminants, aerosols of liquid contaminants and gaseous contaminants. The gas is then fed into the collection medium into which is also being fed the mineral. Aerosols of liquid contaminants will also be removed in the present method of adherence to the collection medium.

In a fluidised or spouting bed system the bed particles to which contaminants have adhered are increased in size and also are rendered sticky and so may agglomerate. To control the amount of agglomeration, and to remove the contaminants from the bed a proportion of the bed may be removed, either continuously or intermittently. The amount of the bed that is removed may be such that the size of the bed remains substantially constant, but preferably a weight of particles greater than the weight added to the bed by the contaminants and the mineral is removed from the bed. The bed is then topped up with fresh...
uncontaminated particles. This may be done continuously.

In a fluidised or spouting bed system the non-sticky, non-degradable particles must all be of such a size that under the fluidising conditions used, substantially none of them may leave the bed by entrainment in the product gas. They should therefore have a minimum particle size of about 100 μm, but preferably about 500 μm although this size will vary with the fluidising conditions used. The particles must have no substantial tendency to agglomerate. In addition the particles should not be of an easily abradable character. The preferred material from which the particles may be made is the mineral, although various washed sands and crushed refractory may also be included.

The contaminated gas may also contain gaseous contaminants, such as, in the case of combustion gases, sulphur dioxide, or, in the case of a fuel gas, hydrogen sulphide. These gaseous contaminants may be removed by providing a gas-absorbent collection medium. For a sulphur dioxide or hydrogen sulphide-containing gas the collection medium may comprise partly limestone or dolomite, and for hydrogen sulphide-containing gas, iron oxide may also be included.
Using the method of the present invention it is possible to remove from a contaminated gas at least 90% of the alkali metals and in many cases up to 99% of the alkali metals may be removed, to give a product gas containing substantially no corrosive components.

Although it is envisaged that the present invention will be particularly applicable to the decontamination of coal-derived fuel and combustion gases in order to feed them to a gas turbine, it is not limited to such applications, and may be used to decontaminate the combustion gases from burning for instance natural gas or a fuel gas derived from crude oil or peat, in which there are undesirable contaminants.

The invention will now be described, by way of example only, with reference to the accompanying drawing, in which there is shown schematically part of a coal processing plant, including an apparatus in which contaminated gases are decontaminated using a method according to the present invention.

Referring now to the drawing, a part of a coal processing plant comprises a fluidised bed reactor 1, cyclone separators 3, a particle collection bed 5 and a gas expansion turbine 7. The collection bed comprises a housing 9 having a particle outlet 12, a perforated plate 13, a system of spent plate 14 500 µm, 15.

In the operation, the fluidised bed apparatus mainly consists of its primary further carbon particles, entrained through the combustion still cold about 1200°C at a level 13.
13, a gas inlet 14 and outlet 15 and a solids feeding system 20 by which collector particles of mineral are added to the bed from store 21. Located on the perforated plate 13 is a bed 16 of particles having a minimum size of 500 μm. The particle outlet 12 is used for withdrawing spent mineral.

In the first example of use, coal is fed to the reactor 1 operating as a combustor, at a pressure of 15 bar and is fluidised by passing air into the apparatus 1. The apparatus produces a combustion gas which comprises mainly carbon dioxide, oxygen and nitrogen. The manner of its production is well known in the art and needs no further explanation. The gas has entrained in it ash, carbon particles and alkali-metal compounds and hydrocarbons as an aerosol. The combustion gas is then passed through the cyclone separators 3 wherein the larger of the entrained particulate contaminants are removed. The combustion gas that exits from the cyclone separators 3 still contains some particulate matter, but no more than about 1 g/m³ in total, and corrosive alkali metal compounds at a level of about 1 ppm.

The combustion gas then is passed into the particle collection bed 5 via gas inlet 14. The combustion gas is introduced through the perforated plate 13 at a rate of 7.0 m³/s this case.

This fluidisation a depth of

While the granulate kaolinite the bed.

The corrosion from the

While the granulate bed with the following contaminants vaporised consumed, adhered to material or may adhere for instance.
7.0 m³/s per square meter of the perforated plate 13. In this case, the area of the plate 13 is one square meter. This fluidises the bed 16 of particles, imparting a fluidising velocity of 2.0 m/s to the bed. The bed has a depth of 0.15 m and has a weight of 150 kg.

While the combustion gas is being fed into the bed, granulated china clay at a rate of typically 0.1 g/sec of kaolinite is fed through the solids feeding system 20 into the bed. The corrosive alkali metal compounds react in the bed with the kaolinite to form alkali metal feldspars. The corrosive alkali metal compounds are thereby removed from the contaminated gas.

While the corrosive alkali metal compounds are reacting with the mineral in the particle collection bed 5 the following events may also occur. Combustible contaminants, such as coal and coke dust, tar and vaporised hydrocarbons are substantially completely consumed, either while flowing freely in the bed or while adhered to the bed particles by the agency of molten material deposited thereon. The combustible contaminants may adhere to the bed due to their inherent stickiness, for instance, in the case of tars.

The temperature of 900°C at which the bed is maintained is substantially the temperature at which the combustion gas enters the bed and the contaminants react with the bed material. Therefore, the bed temperature is maintained at 900°C. The weight of the bed material is in the range of 100 kg to 200 kg, depending on the size and type of the bed material.

In a second operation, the bed material is fluidised, and the flow of contaminants through the bed is controlled. The appurtenances of the bed structure comprise about 50% of its weight.
enters the bed. Once the alkali metal compounds have reacted with the bed particles, the contaminants are substantially removed from the combustion gas, and are eventually removed from the bed as described hereinafter. The gas product from the particle collection bed contains less than 0.04 ppm of corrosive alkali metal compounds. Therefore 96% of the alkali metal compounds have been removed by this process, which is operated according to the present invention.

The weight of the bed will be increasing due to the alkali metal compounds and the mineral by approximately 0.4 kg in every hour. Therefore a proportion of the particles is removed from the bed through particle outlet 12. By controlling the amounts of particles that are removed and replaced it is possible to maintain the bed at a constant size and having constant properties with regard to both the fluidisation and contaminant removal.

In a second example of use, coal is fed to the reactor 1 operating as a gasifier at a pressure of 15 bar and is fluidised by passing air and steam into the apparatus 1. The apparatus 1 may comprise two or more fluidised beds. The apparatus produces a fuel gas having a calorific value of about 4.0 MJ/m³, the combustible constituents of which comprise mainly carbon monoxide and hydrogen. The manner of its production is well known in the art and needs no further explanation.

The fuel bed 5 via the cyclone 9 exits from the apparatus 1 and contains particulate ash, carb aero...
further explanation. The fuel gas has entrained in it ash, carbon particles and tar, and hydrocarbons as an aerosol. The fuel gas is then passed through the cyclone separators 3 wherein the larger of the entrained particulate contaminants are removed. The fuel gas that exits from the cyclone separators 3 still contains some particulate matter, but no more than about 1 g/m³ in total, and corrosive alkali metal compounds at a level of about 1 ppm.

The fuel gas is then passed into the particle collection bed 5 via gas inlet 14. The fuel gas is introduced through the perforated plate 9 at a rate of 7.0 m³/s per square meter of the perforated plate 9. In this case the area of the plate 9 is one square meter. This fluidises the bed 16 of particles imparting a fluidising velocity of 2.0 m/s to the bed. The bed has a depth of 0.15 m and has a weight of 150 kg.

While the fuel gas is being fed into the bed, granulated china clay at a rate of typically 0.1 g/s of kaolinite is fed through the solids feeding system 20 into the bed. The corrosive alkali metal compounds react with the kaolinite to form alkali metal feldspars. The corrosive alkali-metall compounds are thereby removed from the contaminated gases. A similar sequence of following events to that described above also occurs in the bed. Once the contaminant...
contaminants are adhered to the bed particles, the contaminants are substantially removed from the fuel gas and are eventually removed from the bed as described hereinafter. The temperature of 900°C at which the bed is maintained is substantially the temperature at which the fuel gas enters the bed. The gas product from the particle collection bed contains less than 0.04 ppm of corrosive alkali metal compounds. Therefore 96% of the contaminants have been removed by this process, which is operated according to the present invention.

The weight of the bed will be increasing due to collected alkali metal compounds and the mineral by approximately 0.4 kg in every hour. Therefore a proportion of the particles is removed from the bed through particle outlet 12.

By controlling the amounts of particles that are removed and replaced it is possible to maintain the bed at a constant size and having constant properties with regard to both the fluidisation and contaminant removal.

In a third example of use, coal is fed to the reactor 1 operating as a gasifier at a pressure of 15 bar and is fluidised by passing air and steam into the apparatus 1. The apparatus 1 may comprise two or more fluidised beds. The apparatus produces a fuel gas having a calorific value of about 4.0 MJm⁻³, the combustible constituents of
which comprise mainly carbon monoxide and hydrogen. The manner of its production is well known in the art and needs no further explanation. The fuel gas has entrained in its ash, carbon particles and tar, and hydrocarbons as an aerosol. The fuel gas is then passed through the cyclone separators 3 wherein the larger of the entrained particulate contaminants are removed. The fuel gas that exits from the cyclone separator 3 still contains some particulate matter, but no more than about 1g/m^3 in total, and corrosive alkali metal compounds at a level of about 1 ppm.

The fuel gas then is passed into the collection bed 5 via gas inlet 14 to be burned. At this stage oxygen or air may be mixed with the fuel gas and passed into the bed 5. The fuel gas and air are introduced through the perforated plate 9 at a rate of 1.4 and 4.6 m^3/s per square meter of the perforated plate 9 respectively. In this case the area of the plate 9 is one square meter. This fluidises the bed 16 of particles, imparting a fluidising velocity of 2.0 m/s to the bed. The bed has a depth of 0.15 m and has a weight of 150 kg. In a continuous process the fuel gas is ignited by the heat of the bed, which is maintained at a temperature of 1100°C by the combustion of the fuel gas.

While the fuel gas is being fed into the bed, granulated china clay at a rate of typically 0.1 g/s of kaolinite is
fed through the solids feeding system 20 into the bed. The corrosive alkali-metal compounds react with the kaolinite to form alkali metal feldspars. The corrosive alkali-metal compounds are thereby removed from the contaminated gas.

While the fuel gas is being burned in the bed 5 and the reaction between the alkali-metal contaminants and the kaolinite is occurring the following events also occur. Combustible contaminants, such as coal and coke dust, tar and vapourised hydrocarbons are substantially completely burned, either while flowing freely in the bed or while adhered to the bed particles. The combustible contaminates adhere to the bed due to their inherent stickiness, for instance, in the case of tars. The temperature at which the bed is maintained is a temperature at which the fuel gas burns to give the desired temperature of product gas to be expanded through the gas turbine 7.

The coal or coke dust which is burned may also comprise a proportion of ash, and this will suffer the same fate as the free ash as soon as the carbonaceous material has been burned. Once the incombustible contaminants are adhered to the bed particles, the contaminants are substantially removed from the fuel gas, and are eventually removed from the bed as described hereinafter.
Product gas, comprising mainly steam, carbon dioxide and nitrogen, is removed from above the bed 16 at a rate of 5.8 m$^3$/s and is used to drive the gas turbine 7. The product contains less than 0.01 ppm of corrosive alkali metal compounds. Therefore 96% of the contaminants have been removed by this process, which is operated according to the present invention.

The weight of the bed will be increasing due to the collected alkali metal compounds and the mineral by approximately 0.4 kg in every hour. Therefore a proportion of the particles is removed from the bed through particle outlet 12. By controlling the amounts of particles that are removed and replaced it is possible to maintain the bed at a constant size and having constant properties with regard to both the fluidisation and contaminant removal.

Thus by use of the present invention it is possible to decontaminate a fuel gas to give a substantially uncontaminated product gas which may be used to drive a gas turbine.
The claims defining the invention are as follows:-

1. A method of producing a product gas substantially free from corrosive alkali-metal compounds, comprising feeding a mineral and a gas contaminated with a corrosive alkali-metal compound to a fluidised or spouting bed of non-sticky, non-degradable particles maintained at a temperature whereat the mineral reacts with the alkali-metal compound to form a non-corrosive material of low vapour pressure, and withdrawing the product gas from the bed.

2. A method according to claim 1, wherein the gas is a solid fuel-derived fuel gas.

3. A method according to claim 1, wherein the gas is a solid fuel-derived combustion product gas.

4. A method according to claim 1, 2 or 3, wherein the fluidised bed is either of the stationary or rotating type.

5. A method according to any one of the preceding claims, wherein the mineral is china clay.

6. A method according to claim 5, wherein the china clay largely comprises kaolinite.

7. A method according to any one of the preceding claims, wherein the collection medium is maintained at a temperature of up to 1200°C.

8. A method according to claim 7, wherein the collection medium is maintained at a temperature of from 700°C to 1000°C.
9. A method of producing a product gas substantially free from corrosive alkali-metal compounds, substantially as hereinbefore described with reference to the drawing.

Dated this 27th day of August, 1982.

COAL INDUSTRY (PATENTS) LIMITED
By their Patent Attorneys,
GRiffith HassEL & FraZer