CLAIMS

What is claimed is:

1. A method of reducing the pollutant content in a pollutant-containing gas, the method comprising:

obtaining or providing an activated carbon sorbent comprising activated carbon sorbent particles comprising nitrogen in a surface layer of the sorbent particles;

contacting a pollutant-containing gas with the activated carbon sorbent, to form a pollutant-sorbent composition; and

separating at least some of the pollutant-sorbent composition from the pollutant-containing gas, to give a separated gas.

2. The method of claim 1, wherein the pollutant comprises mercury, and the pollutant-containing gas is a mercury-containing gas.

3. The method of any one of claims 1-2, wherein the concentration of nitrogen in the surface layer of the sorbent particles is higher than the concentration of nitrogen in a core of the sorbent particles.

4. The method of any one of claims 2-3, wherein the activated carbon sorbent combines with at least about 70 wt% of the mercury present in the mercury-containing gas.

5. The method of any one of claims 2-4, wherein the mercury-containing gas further comprises a concentration of sulfur(VI) and the concentration of sulfur(VI) in the mercury-containing gas is greater than about 3 ppm by mole and the activated carbon sorbent forms a mercury-sorbent composition at a higher absorption rate relative to a corresponding activated carbon sorbent comprising at least one of a) less or substantially no nitrogen in a corresponding particle surface layer, b) less or substantially no halide- or halogen-promotion, wherein the activated carbon sorbent comprising the activated carbon sorbent particles is halide- or halogen-promoted, and c) less or substantially no inorganic

matrix support, wherein the activated carbon sorbent comprising the activated sorbent particles is inorganic matrix-supported.

6. The method of any one of claims 1-5, wherein the pollutant-containing gas further comprises a concentration of sulfur(VI) and the concentration of sulfur(VI) in the pollutant-containing gas is about 3 ppm - 2000 ppm.

7. The method of any one of claims 1-6, wherein the nitrogen is substantially homogenously distributed in the core of the activated carbon sorbent particles.

8. The method of any one of claims 1-7, wherein the nitrogen in the surface layer decreases neutralization of carbocations in the activated carbon by at least one of SO_3^{2-} and HSO_3^{1-}, as compared to a corresponding activated carbon sorbent comprising less or substantially no nitrogen in a corresponding particle surface layer.

9. The method of any one of claims 1-8, wherein the nitrogen in the surface layer at least partially blocks carbocations in the activated carbon from at least one of SO_3^{2-} and HSO_3^{1-}, as compared to a corresponding activated carbon sorbent comprising less or substantially no nitrogen in a corresponding particle surface layer.

10. The method of any one of claims 1-9, further comprising: obtaining or providing an unpromoted carbon sorbent; obtaining or providing a promoter; and promoting at least a portion of the unpromoted sorbent by contacting the portion of the unpromoted sorbent with the promoter to form the activated carbon sorbent.

11. The method of claim 10, wherein the promoter comprises a halogen or halide promoter.

12. The method of any one of claims 10-11, wherein the promoter comprises at least one of a halogen, a Group V halide, a Group VI halide, a hydrogen halide, an ammonium halide, an alkali earth metal halide, and an alkaline earth metal halide.

13. The method of any one of claims 10-12, wherein the promoter comprises at least one of HI, IBr, ICl NH_4Br, NaBr, $CaBr_2$, HBr, NaCl, $CaCl_2$, and HCl.

14. The method of any one of claims 10-13, wherein the promoter is in a form comprising at least one of a vapor form, in a solvent, as a liquid, as a solid, and a combination thereof.

15. The method of any one of claims 10-14, wherein the promoting occurs in an aqueous scrubber, wherein the scrubber comprises an aqueous slurry that comprises the promotor.

16. The method of any one of claims 1-15, wherein contacting the pollutant-containing gas with the activated carbon sorbent comprises adding the activated carbon sorbent into the pollutant-containing gas.

17. The method of any one of claims 1-16, wherein the activated carbon sorbent is at least one of in a fixed bed, in a moving bed, in a scrubber, in a filter, or suspended in the pollutant-containing gas.

18. The method of any one of claims 1-17, wherein the core of the activated carbon sorbent particles comprise about 0 wt% - about 99 wt% nitrogen.

19. The method of any one of claims 1-18, wherein the core of the activated carbon sorbent particles comprise about 1 wt% - about 6 wt% nitrogen.

20. The method of any one of claims 1-19, wherein the surface layer of the activated carbon sorbent particles comprises about 0.001 wt% - about 99 wt% nitrogen.

21. The method of any one of claims 1-20, wherein the surface layer of the activated carbon sorbent particles comprises about 5 wt% - about 80 wt% nitrogen.

22. The method of any one of claims 1-21, wherein the surface layer of the activated carbon sorbent comprises a layer at the surface of the particle having a thickness of about 0.001% to about 99% of the radius of the particles.

23. The method of any one of claims 1-22, wherein the surface layer of the activated carbon sorbent particles comprises a layer at the surface of the particles having a thickness of about 0.001% to about 50% of the radius of the particles.

24. The method of any one of claims 1-23, wherein the activated carbon sorbent particles have an average diameter of about 0.1 μm to about 1000 μm.

25. The method of any one of claims 1-24, wherein the surface layer of the sorbent particles is a continuous surface layer.

26. The method of any one of claims 1-25, wherein obtaining or providing the activated carbon sorbent comprises:

obtaining or providing a carbon precursor comprising nitrogen; and

processing the carbon precursor with at least one of heating, microwaving, and irradiating, to provide the activated carbon sorbent.

27. The method of claim 26, wherein the carbon precursor comprises a carbonaceous material comprising carbon and a nitrogenous material comprising nitrogen.

28. The method of claim 27, wherein the carbonaceous material comprises at least one of brown sugar, barley sugar, caramel, cane sugar, corn syrup, starch, molasses, a glucan, a galactan, a xylan, and a sugar waste product.

29. The method of any one of claims 27-28, wherein the nitrogenous material comprises a nitrogen-containing organic or inorganic compound.

30. The method of any one of claims 27-29, wherein the nitrogenous material comprises a nitrogen heterocycle, a nitrogen-containing polymer or copolymer, a nitrile, a carbamate, an amino acid, nitrobenzene, hydroxylamine, urea, hydrazine, sulfamic acid, or a combination thereof.

31. The method of any one of claims 26-30, further comprising:

obtaining or providing a substrate material;

contacting the carbon precursor and the substrate material, to provide a sorbent starting material; and

processing the sorbent starting material with at least one of heating, microwaving, and irradiating, to provide the activated carbon sorbent.

32. The method of claim 31, wherein heating the sorbent starting material provides a second sorbent starting material, further comprising reacting the second sorbent starting material with an acidic or basic material, to provide the activated carbon sorbent.

33. The method of any one of claims 31-32, wherein the substrate comprises at least one of diatomaceous earth, a clay, a zeolite, or a mineral.

34. The method of any one of claims 31-33, wherein heating the sorbent starting material comprises heating to about 100 °C – about 1200 °C.

35. The method of any one of claims 31-34 wherein the activated carbon sorbent comprises a carbon nanocomposite sorbent.

36. The method of any one of claims 1-35, wherein the activated carbon sorbent comprises one or more binding sites.

37. The method of claim 36, wherein at least a portion of the binding sites in the activated carbon sorbent react with at least one of the pollutant and the oxidized species of the pollutant, to form the pollutant-sorbent composition.

38. The method of any one of claims 1-37, wherein the separating at least some of the pollutant-sorbent composition from the pollutant containing gas comprises separating in a particulate separator.

39. The method of claim 38, wherein the particulate separator comprises an electrostatic precipitator (ESP), a baghouse, a wet scrubber, a filter, cyclone, fabric separator, or any combination thereof.

40. The method of any one of claims 10-39, wherein a promoter precursor transforms into the halogen or halide promoter which then reacts with the activated carbon sorbent to give the activated carbon material.

41. The method of claim 40, wherein the promoter precursor is at least one of on the unpromoted sorbent and added with the unpromoted sorbent.

42. The method of any one of claims 1-41, further comprising at least one of during and prior to the contacting adding an alkaline component into the pollutant-containing gas.

43. The method of claim 42, wherein the alkaline component comprises at least one of an oxide, hydroxide, carbonate, or phosphate of an alkali element, an alkali or alkaline-earth element, and a compound or material including the same.

44. The method of any one of claims 1-43, wherein the activated carbon sorbent comprises a stabilizing agent comprising at least one of S, Se, or mixtures thereof.

45. The method of any one of claims 1-44, wherein the activated carbon sorbent comprises a stabilizing agent comprising at least one of H_2S, SO_2, H_2Se, SeO_2, CS_2, P_2S_5, or mixtures thereof.

46. The method of any one of claims 1-45, further comprising regenerating the pollutant-sorbent composition to give a regenerated activated carbon sorbent.

47. The method of any one of claims 1-46, wherein the activated carbon sorbent is a regenerated activated carbon sorbent.

48. The method of any one of claims 1-47, wherein at least one of the contacting and the separating occurs in an aqueous scrubber.

49. The method of claim 48, wherein the scrubber comprises an aqueous slurry that comprises the activated carbon sorbent.

50. A method for reducing the mercury content of a mercury-containing gas, the method comprising:

obtaining or providing a carbon precursor comprising nitrogen;

obtaining or providing a substrate material;

contacting the carbon precursor and the substrate material, to provide an inorganic matrix-supported sorbent starting material;

heating the inorganic matrix-supported sorbent starting material, to provide an unpromoted sorbent;

promoting at least a portion of the unpromoted sorbent by chemically reacting the portion of the unpromoted sorbent with a promoter to form a promoted inorganic matrix-supported activated carbon sorbent comprising activated carbon sorbent particles comprising nitrogen in a surface layer of the sorbent particles;

contacting a mercury-containing gas with the activated carbon sorbent, to form a mercury-sorbent composition; and separating at least some of the mercury-sorbent composition from the mercury-containing gas, to give a separated gas;

wherein the mercury-containing gas has a concentration of sulfur(VI) of about 3 - 2000 ppm by mole and a first quantity the activated carbon sorbent forms a mercury-sorbent composition at a first mercury adsorption rate, wherein the first adsorption rate is higher than a mercury absorption rate of the first quantity of a corresponding activated carbon sorbent comprising at least one of a) less or substantially no nitrogen in a corresponding particle surface layer, b) less or substantially no halide- or halogen-promotion, and c) less or substantially no inorganic matrix support.

51. A method of making an activated carbon sorbent, comprising:

obtaining or providing an unpromoted carbon sorbent comprising nitrogen;

promoting at least a portion of the unpromoted sorbent by contacting the portion of the unpromoted sorbent with a promoter to form an activated carbon sorbent comprising activated carbon sorbent particles comprising nitrogen, wherein the concentration of nitrogen in a surface layer of the sorbent particles is higher than the concentration of nitrogen in a core of the sorbent particles.

52. The method of claim 51, further comprising:

obtaining or providing a carbon precursor comprising nitrogen;

obtaining or providing a substrate material; contacting the carbon precursor and the substrate material, to provide a sorbent starting material; and

processing the sorbent starting material, to provide the unpromoted carbon sorbent comprising nitrogen.

53. The method of claim 52, wherein obtaining or providing the carbon precursor comprising nitrogen comprises:

obtaining or providing a carbonaceous material comprising carbon and a nitrogenous material comprising nitrogen; and

contacting and heating the carbonaceous material and the nitrogenous material, to provide the carbon precursor comprising nitrogen.

54. A method of making an activated carbon sorbent, comprising:

contacting a carbonaceous material and a nitrogenous material, to provide an unpromoted carbon sorbent comprising nitrogen; and

promoting at least a portion of the unpromoted sorbent by contacting the portion of the unpromoted sorbent with a promoter to form an activated carbon sorbent comprising activated carbon sorbent particles comprising nitrogen, wherein the concentration of nitrogen in the sorbent particles is higher than the concentration of nitrogen in the carbonaceous material.

55. An activated carbon sorbent made by the method of any one of claims 51-54.

56. An activated carbon sorbent, comprising: a halogen- or halide-promoted activated carbon, the activated carbon comprising activated carbon sorbent particles comprising nitrogen in a surface layer of the sorbent particles.

57. The activated carbon sorbent of claim 56, wherein the concentration of nitrogen in the surface layer of the sorbent particles is higher than the concentration of nitrogen in a core of the sorbent particles.

58. The activated carbon sorbent of any one of claims 56-57, wherein the activated carbon sorbent particles have an average diameter of about 0.1 μm to about 1000 μm.

59. The activated carbon sorbent of any one of claims 56-58, wherein the activated carbon is at least one of halogen-promoted, Group V halide-promoted, Group VI halide-promoted, hydrogen halide-promoted, ammonium halide-promoted, alkali earth metal halide-promoted, and alkaline earth metal halide-promoted.

60. The activated carbon sorbent of any one of claims 56-59, wherein the activated carbon sorbent is inorganic matrix-supported, the inorganic matrix support comprising at least one of diatomaceous earth, a clay, a zeolite, or a mineral.

61. The activated carbon sorbent of any one of claims 56-60, wherein the nitrogen is substantially homogenously distributed in the core of the activated carbon sorbent particles.

62. The activated carbon sorbent of any one of claims 56-61, wherein the nitrogen in the surface layer of the particles at least partially decreases neutralization by HSO_3^{1-} or SO_3^{2-} of carbocations in the activated carbon sorbent, as compared to a corresponding activated carbon sorbent comprising less or substantially no nitrogen in a corresponding particle surface layer under substantially similar conditions.

63. The activated carbon sorbent of any one of claims 56-62, wherein the nitrogen in the surface layer of the particles at least partially blocks carbocations in the activated carbon from forming ionic bonds with HSO_3^{1-} or SO_3^{2-}, as compared to a corresponding activated carbon sorbent comprising less or substantially no nitrogen in a corresponding particle surface layer under substantially similar conditions.

64. The activated carbon sorbent of any one of claims 56-63, wherein a first quantity of the activated carbon sorbent forms a mercury-sorbent composition at a first mercury adsorption rate in a gas composition comprising mercury wherein the concentration of sulfur(VI) in the gas composition is about 3 - 2000 ppm by mole, and wherein the first adsorption rate is higher than a mercury absorption rate of the first quantity of a corresponding activated carbon sorbent comprising at least one of a) less or substantially no nitrogen in a corresponding particle surface layer, b) less or substantially no halide- or halogen-promotion, and c) less or substantially no inorganic matrix support, wherein the activated carbon sorbent is inorganic-matrix supported.

65. The activated carbon sorbent of any one of claims 56-64, wherein the nitrogen is derived from a nitrogen-containing organic or inorganic compound.

66. The activated carbon sorbent of any one of claims 56-65, wherein the nitrogen is derived from indole, quinoxaline, carbazole, isoquinoline, nitrobenzene, urea, sulfamic acid, polyvinylpyrrolidone, vinylpyrrolidone-vinyl acetate copolymer, vinylpyrrolidone-acrylic acid copolymer, vinylpyrrolidone-maleic acid copolymer, polyethylenimine, alanine, piperazine, quinolone, quinoxaline, diazabicyclooctane, an amino acid, an ammonium salt, or a combination thereof.

67. An activated carbon sorbent for use in mercury removal from a mercury-containing gas, the sorbent comprising:

a halogen- or halide-promoted activated carbon comprising activated carbon particles, the particles comprising nitrogen in a surface layer, the nitrogen in the surface layer at sufficient concentration to at least one of a) decrease neutralization by HSO_3^{1-} or SO_3^{2-} of carbocations in the activated carbon sorbent, as compared to a corresponding activated carbon sorbent comprising less or substantially no nitrogen in a corresponding particle surface layer under substantially similar conditions, and b) at least partially block carbocations in the activated carbon from forming ionic bonds with HSO_3^{1-} or SO_3^{2-}, as compared to a corresponding activated carbon sorbent comprising less or substantially no nitrogen in a corresponding particle surface layer under substantially similar conditions.

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s):
Olson et al.

Application No.: 10/554,018

Filed: October 21, 2005

Title: PROCESS FOR REGENERATING A SPENT SORBENT

Attorney Docket No.: EER.P0018

Group Art Unit:
1793

Examiner:
JOHNSON, EDWARD M.

AMENDMENT

Commissioner for Patents
PO Box 1450
Alexandria, VA 22313-1450

In response to the Office Action dated April 27, 2010, please amend the application as follows.

IN THE CLAIMS

1. (currently amended) A method of regenerating a used activated carbon sorbent comprising:

creating an ~~a~~ activated carbon sorbent mixture containing used regenerated activated carbon sorbent and unused activated carbon sorbent;

exposing the ~~used~~ activated carbon sorbent mixture to a solution to remove contaminants collected on at least the used activated carbon sorbent to restore mercury sorption effectiveness to the used activated carbon sorbent, ~~wherein~~ the solution including ~~includes~~ a ~~halide~~ salt~~-salt,~~ containing an associated cation;

dewatering the activated carbon sorbent mixture to remove used activated carbon sorbent ~~particles~~ and at least some contaminants from the solution forming used regenerated activated carbon sorbent and a liquid; ~~and~~

drying the dewatered regenerated activated carbon sorbent from the used regenerated activated carbon sorbent mixture;

treating at least some of the liquid to remove at least some compounds therefrom; and

mixing at least some of the liquid with at least one of used regenerated activated carbon sorbent and unused activated carbon sorbent.

2. (currently amended) The method of claim 1, further comprising separating at least some ~~wherein~~ ash ~~is separated~~ from the used activated carbon sorbent mixture prior to exposure of the used activated carbon sorbent mixture to the solution.

Claims 3–4 (canceled)

5. (original) The method of claim 1, wherein the solution is a salt solution.

Claims 6–8 (canceled)

9. (original) The method of claim 1, wherein the solution includes an organic salt solution.

10. (original) The method of claim 9, wherein the organic salt solution includes:

at least one anion from at least one of citric acid, tartaric acid, oxalic acid, malonic acid, maleic acid, formic acid, and acetic acid; and

at least one associated cation, such as ammonium, sodium, potassium, iron, aluminum, boron, zinc, manganese, magnesium, or calcium.

Claim 11 (canceled)

12. (currently amended) The method of claim 1, wherein the used activated carbon sorbent mixture contains constituents derived from a flue gas stream.

13. (canceled)

14. (original) The method of claim 1, wherein the contaminant includes sulfuric acid.

15. (currently amended) The method of claim 1, wherein the mercury sorption effectiveness ~~effictiveness~~ of the used activated carbon sorbent is restored by removing anions collected on the used activated carbon sorbent.

16. (currently amended) The method of claim 1, wherein the mercury sorption effectiveness of the used activated carbon sorbent is restored by removing sulfuric acid from the used activated carbon sorbent.

17. (currently amended) The method of claim 1, further comprising agitating the used activated carbon sorbent mixture and the solution.

18. (currently amended) The method of claim 1, further comprising mixing an additive with the regenerated activated carbon sorbent prior to injecting the regenerated activated carbon sorbent into the flue gas stream.

19. (original) The method of claim 18, wherein the additive neutralizes acids.

20. (original) The method of claim 18, wherein the additive is a calcium-based additive.

21. (currently amended) A method of regenerating a used activated carbon sorbent comprising:

exposing the used activated carbon sorbent to a solution to remove contaminants collected on the used activated carbon sorbent to restore mercury sorption effectiveness to the used activated carbon sorbent;

dewatering the used activated carbon sorbent to remove used activated carbon sorbent ~~particles~~ and contaminants from the solution forming a liquid having contaminants;

adding a promoter comprising at least one of bromine, a bromine compound, and combinations thereof to the activated carbon sorbent ~~a hydrohalide, halogen, or one or more halogens combined with a Group V or Group VI element~~; ~~and~~

drying the dewatered used activated carbon sorbent ~~mixture~~ forming a regenerated used activated carbon sorbent; and

treating at least some of the liquid to remove at least some contaminants therefrom.

Claims 22–26 (canceled)

27. (currently amended) A method of regenerating a used sorbent and enhancing unused sorbent comprising:

creating ~~a~~ an activated carbon sorbent mixture containing used activated carbon sorbent and unused activated carbon sorbent, the activated carbon sorbent and unused carbon sorbent comprising at least one composition of granulated form and fibrous form;

regenerating the used activated carbon sorbent by exposing the activated carbon sorbent mixture to a solution to remove contaminants collected on the used activated carbon sorbent to restore mercury sorption effectiveness to the activated carbon sorbent, ~~wherein~~ the solution including ~~includes~~ a compound made up of at least one of bromine, bromine compounds, and combinations thereof ~~a hydrohalide~~ for low-ash and fiber sorbent regeneration; and

exposing the regenerated used activated carbon sorbent to a flue gas stream.

28. (currently amended) The method of claim 27, wherein the regenerated activated carbon sorbent is exposed to the flue gas stream by injecting the regenerated sorbent into the flue gas stream.

29. (currently amended) The method of claim 27, wherein the regenerated activated carbon sorbent is exposed to the flue gas stream using a fixed sorbent bed.

30. (currently amended) The method of claim 27, wherein the regenerated activated carbon sorbent is exposed to the flue gas stream using a traveling sorbent bed.

31. (currently amended) The method of claim 27, wherein the regenerated activated carbon sorbent is exposed to the flue gas stream using a traveling fiber filter.

Claims 32–36 (canceled)

37. (currently amended) A method of enhancing the effectiveness of ~~a~~ an activated carbon sorbent for capturing mercury comprising:

exposing the activated carbon sorbent to at least one of bromine, bromine compounds, and combinations thereof ~~a promoter selected from the group consisting of hydrohalides, metalhalides, halogens, and combinations thereof~~; and

modifying the carbon edge structure of the activated carbon sorbent to form carbocations so that the activated carbon sorbent accepts electrons from neutral mercury atoms of the mercury.

Claim 38 (canceled)

39. (currently amended) The method of claim 37, wherein the at least one of bromine, bromine compounds, and combinations thereof promoting the modification of the structure of the activated carbon solution comprises ~~is~~ a salt solution, the salt solution having an associated cation, such as ammonium, aluminum, boron, zinc, and iron.

Claim 40 (canceled)

41. (currently amended) The method of claim 37, wherein the salt solution includes an organic acid salt solution.

Claim 42 (canceled)

43. (currently amended) A method of enhancing the effectiveness of ~~a~~ an activated carbon sorbent by modifying the structure of the activated carbon sorbent in a mixture of ash and activated carbon sorbent comprising:

enhancing the activated carbon sorbent by exposing the activated carbon sorbent in a mixture of ash and activated carbon sorbent to one of an aqueous ~~a~~ solution and a nonaqueous solution that increases sorbent effectiveness, ~~wherein~~ the solution including ~~includes~~ one or more of bromine, bromine compounds, and combinations thereof, ~~thionyl bromide, sulfuryl bromide, phosphorus tribromide, phosphorus oxybromide, hypobromous acid, and bromine in nonaqueous solutions~~ for the mixture of ash and ~~ash-containing~~ activated carbon sorbent for the regeneration thereof; and

exposing the regenerated enhanced activated carbon sorbent to a flue gas stream.

44. (currently amended) The method of claim 43, wherein the enhanced activated carbon sorbent is exposed to the flue gas stream by injecting the enhanced activated carbon sorbent into the flue gas stream.

45. (currently amended) The method of claim 43, wherein the enhanced activated carbon sorbent is exposed to the flue gas stream using a fixed sorbent bed.

46. (currently amended) The method of claim 43, wherein the enhanced activated carbon sorbent is exposed to the flue gas stream using a traveling sorbent bed.

47. (currently amended) The method of claim 43, wherein the enhanced activated carbon sorbent is exposed to the flue gas stream using a traveling fiber filter.

48. (original) The method of claim 43, wherein the solution includes an inorganic acid solution.

Claim 49 (canceled)

50. (original) The method of claim 43, wherein the solution includes an organic acid.

Claims 51–55 (canceled)

56. (currently amended) A method of removing mercury or other pollutants in a flue gas stream during the burning of fossil fuels, comprising:

exposing an activated carbon ~~the~~ sorbent mixture to the flue gas stream to remove at least mercury as a contaminant ~~contaminants~~ from the flue gas stream forming a used activated carbon sorbent;

mixing the used activated carbon sorbent with fresh activated carbon sorbent and exposing the mixture of used activated carbon sorbent and fresh activated carbon sorbent to a solution including bromine, bromine compounds, and combinations thereof to remove contaminants collected on the used activated carbon sorbent to restore mercury sorption effectiveness to the used activated carbon sorbent and enhance sorption effectiveness of the fresh active carbon sorbent, ~~wherein~~ the solution including ~~includes a halide salt, containing~~ an associated cation, such as ammonium, aluminum, boron, zinc, and iron;

dewatering the solution ~~mixture~~ to remove used activated carbon sorbent and any fresh activated carbon sorbent ~~particles~~ and contaminants from the solution;

drying the used activated carbon and unused activated carbon sorbent particles; and

exposing the dried used activated carbon sorbent and the fresh activated carbon sorbent ~~particles~~ to the flue gas stream to remove additional contaminants from the flue gas stream.

Claim 57–58 (canceled)

59. (original) The method of claim 56, wherein the solution is a salt solution.

Claim 60 (canceled)

61. (original) The method of claim 56, wherein the solution includes an organic salt solution.

Claims 62-69 (canceled)

REMARKS

Claims 1-2, 5, 9-10, 12, 13-21, 27-31, 37, 39, 41-48, 50, 56, 59 and 61 are pending in the present application. Claims 1-21, 26-31, 36-37, 39, 41-42, 49-50, 55-57, 59 and 61 have been rejected under § 103 as being unpatentable over Pahlman et al. (US 6,579,507) (Pahlman) in view of deJong et al. (US 4,196,173) (deJong). Claims 43-48 have been rejected under § 103 as being unpatentable over Pahlman in view of deJong and Harmer et al. (US 6,001,762) (Harmer). Claims 43-48 have also been rejected under § 103 as being unpatentable over Leppin et al. (US 6,475,451) (Leppin) in view Harmer.

Dependent claims 13, 26, 36, 55, and 57 have been canceled. Various claims have been amended. The status of non-elected claims 62-69 has been added.

Independent claims 1, 21, 27, 37, and 56 have been rejected under § 103 as being unpatentable over Pahlman in view of deJong. Applicants assert that Pahlman in view of deJong does not teach or suggest the amended claims.

Pahlman discloses the use of an acid-washing step in the regeneration of a metal oxide sorbent for the purpose of dissolving contaminant salts collected on the sorbent. Halide acids are not specified in Pahlman. The Office Action relies on deJong as disclosing inorganic acids, including HCl, to allege that it would have been obvious to one of ordinary skill in the art to use the inorganic acid of deJong in the sorbent regeneration method of Pahlman.

Amended claim 1 recites a method of regenerating a used activated carbon sorbent comprising "creating an activated carbon sorbent mixture containing used regenerated activated carbon sorbent and unused activated carbon sorbent," "exposing the activated carbon sorbent mixture to a solution to remove contaminants collected on at least the used activated carbon sorbent to restore mercury sorption effectiveness to the used activated carbon sorbent, the solution including a salt containing an associated cation," "dewatering the activated carbon sorbent mixture to remove used activated carbon sorbent and at least some contaminants from the solution forming used regenerated activated carbon sorbent and a liquid," "drying the dewatered regenerated activated carbon sorbent from the used regenerated activated carbon sorbent mixture," "treating at least some of the liquid to remove at least some compounds therefrom," and "mixing at least some of the liquid with at least one of used regenerated activated carbon sorbent and unused activated carbon sorbent."

Applicants assert that Pahlman in view of deJong does not teach or suggest amended claim 1. For example, Pahlman in view of deJong does not disclose, among other things, the dewatering, drying, treating, and mixing elements, as they are recited in amended claim 1.

For at least these reasons, applicants assert that amended claim 1 is allowable over the cited prior art. Since dependent claims 2, 5, 9, 10, 12, and 14-20 depend from amended claim 1, it is also believed that these claims are allowable over the cited prior art.

Amended claim 21 recites a method of regenerating a used activated carbon sorbent comprising "exposing the used activated carbon sorbent to a solution to remove contaminants collected on the used activated carbon sorbent to restore mercury sorption effectiveness to the used activated carbon sorbent," "dewatering the used activated carbon sorbent to remove used activated carbon sorbent and contaminants from the solution forming a liquid having contaminants," "adding a promoter comprising at least one of bromine, a bromine compound, and combinations thereof to the activated carbon sorbent," "drying the dewatered used activated carbon sorbent forming a regenerated used activated carbon sorbent," and "treating at least some of the liquid to remove at least some contaminants therefrom."

Applicants assert that Pahlman in view of deJong do not teach or suggest amended claim 21. For example, Pahlman in view of deJong does not disclose, among other things, the dewatering, adding a promoter, drying, and treating elements, as they are recited in amended claim 21.

For at least these reasons, applicants assert that amended claim 21 is allowable over the cited prior art.

Amended claim 27 recites a method of regenerating a used sorbent and enhancing unused sorbent comprising "creating an activated carbon sorbent mixture containing used activated carbon sorbent and unused activated carbon sorbent, the activated carbon sorbent and unused carbon sorbent comprising at least one composition of granulated form and fibrous form," "regenerating the used activated carbon sorbent by exposing the activated carbon sorbent mixture to a solution to remove contaminants collected on the used activated carbon sorbent to restore mercury sorption effectiveness to the activated carbon sorbent, the solution including a compound made up of at least one of bromine, bromine compounds, and combinations thereof for low-ash and fiber sorbent regeneration," and "exposing the regenerated used activated carbon sorbent to a flue gas stream."

Applicants assert that Pahlman in view of deJong do not teach or suggest amended claim 27. For example, Pahlman in view of deJong does not disclose, among other things, the creating, regenerating, and exposing elements, as they are recited in amended claim 27.

For at least these reasons, applicants assert that amended claim 27 is allowable over the cited prior art. Since dependent claims 28-31 depend from amended claim 27, it is also believed that these claims are allowable over the cited prior art.

Amended claim 37 recites a method of enhancing the effectiveness of an activated carbon sorbent for capturing mercury comprising "exposing the activated carbon sorbent to at least one of bromine, bromine compounds, and combinations thereof," and "modifying the carbon edge structure of the activated carbon sorbent to form carbocations so that the activated carbon sorbent accepts electrons from neutral mercury atoms of the mercury."

Applicants assert that Pahlman in view of deJong do not teach or suggest amended claim 37. For example, Pahlman in view of deJong does not disclose, among other things, the exposing and modifying elements, as they are recited in amended claim 37.

For at least these reasons, applicants assert that amended claim 37 is allowable over the cited prior art. Since dependent claims 39, 41 and 42 depend from amended claim 37, it is also believed that these claims are allowable over the cited prior art.

Amended claim 56 recites a method of removing mercury or other pollutants in a flue gas stream during the burning of fossil fuels, comprising "exposing an activated carbon sorbent mixture to the flue gas stream to remove at least mercury as a contaminant from the flue gas stream forming a used activated carbon sorbent," "mixing the used activated carbon sorbent with fresh activated carbon sorbent and exposing the mixture of used activated carbon sorbent and fresh activated carbon sorbent to a solution including bromine, bromine compounds, and combinations thereof to remove contaminants collected on the used activated carbon sorbent to restore mercury sorption effectiveness to the used activated carbon sorbent and enhance sorption effectiveness of the fresh active carbon sorbent, the solution including an associated cation, such as ammonium, aluminum, boron, zinc, and iron," "dewatering the solution to remove used activated carbon sorbent and any fresh activated carbon sorbent and contaminants from the solution," "drying the used activated carbon and unused activated carbon sorbent particles," and "exposing the dried used activated carbon sorbent and the fresh activated carbon sorbent to the flue gas stream to remove additional contaminants from the flue gas stream."

Applicants assert that Pahlman in view of deJong do not teach or suggest amended claim 56. For example, Pahlman in view of deJong does not disclose, among other things, the exposing, mixing, dewatering, and drying elements, as they are recited in amended claim 56.

For at least these reasons, applicants assert that amended claim 56 is allowable over the cited prior art. Since dependent claims 59 and 61 depend from amended claim 56, it is also believed that these claims are allowable over the cited prior art.

Independent claim 43 has been rejected under § 103 as being unpatentable over Pahlman in view of deJong and Harmer, and over Leppin in view Harmer.

The Office Action relies on Pahlman as disclosing a method for regenerating a sorbent comprising removing used sorbent in a multi-stage manner, exposing it to a dilute acid solution, and recovering the sorbent by removing and drying. The Office Action relies on Harmer as disclosing bromine, to allege that it would have been obvious to one of ordinary skill in the art to use the bromine of Harmer in the regeneration process of Pahlman.

The Office Action relies on Leppin as disclosing a method for regenerating a sorbent comprising injecting sorbent into a gas stream, removing in stages, and exposing it to an acid solution. The Office Action relies on Harmer as disclosing bromine, to allege that it would have been obvious to one of ordinary skill in the art to use the bromine of Harmer in the regeneration process of Leppin.

Amended claim 43 recites a method of enhancing the effectiveness of an activated carbon sorbent by modifying the structure of the activated carbon sorbent in a mixture of ash and activated carbon sorbent comprising "enhancing the activated carbon sorbent by exposing the activated carbon sorbent in a mixture of ash and activated carbon sorbent to one of an aqueous solution and a nonaqueous solution that increases sorbent effectiveness, the solution including one or more of bromine, bromine compounds, and combinations thereof, for the mixture of ash and activated carbon sorbent for the regeneration thereof," and "exposing the regenerated enhanced activated carbon sorbent to a flue gas stream."

Applicants assert that neither Pahlman in view of deJong and Harmer, nor Leppin in view Harmer teach or suggest amended claim 43. For example, the combinations of cited references do not disclose, among other things, modifiying the structrure of the activated carbon sorbent in a mixture of ash and activated carbon sorbent by exposing an activated carbon sorbent, as recited in amended claim 43.

For at least these reasons, applicants assert that amended claim 43 is allowable over the cited prior art. Since dependent claims 44-48 and 50 depend from amended claim 43, it is also believed that these claims are allowable over the cited prior art.

It is respectfully submitted that all claims are patentable over the cited prior art. It is furthermore respectfully submitted that all other matters have been addressed and remedied and that the application is in form for allowance. Should there remain unresolved issues that require adverse action, it is respectfully requested that the Examiner telephone Bruce A. Johnson, Applicants Attorney at 512-301-9900 so that such issues may be resolved as expeditiously as possible. Charge any additional fee(s) or underpayments of fee(s) under 37 CFR 1.16 and 1.17 to deposit account number 50-3864 (Johnson & Associates).

Respectfully Submitted,

10/27/10
Date

Bruce A. Johnson
Reg. No. 37361
Attorney for Applicant(s)

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Date: ______________

Document Code: IMIS

Office of Patent Application Process
Office of Initial Processing Division

Original Application Number: 10/554018

Name of Contact: Bruce Johnson

Phone Number: 512-301-9900/9915

No ~~Per~~ telephone conversation with the applicant on 11/3/10

The following instructions have been given:

CREDIT CARD DECLINED, SO I CONTACTED THE CC CO FOR APPROVAL CODE ON

11/3/10 AT 7:55AM, DUE TO DENIAL OR INSUFFICIENT

FUNDS. IF DEPOSIT ACCOUNT IS PRESENT CHARGE 50-3864

AND IF DEPOSIT ACCOUNT HAS INSUFFICIENT FUNDS ON 11/3/10

IN THE AMOUNT OF 37,00.

Cynthia Streater

(Please print name)

Office of Initial Processing Division

Electronic Acknowledgement Receipt

EFS ID:	32660200
Application Number:	15978760
International Application Number:	
Confirmation Number:	6432
Title of Invention:	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
First Named Inventor/Applicant Name:	Edwin S. Olson
Customer Number:	21186
Filer:	Jordan Rivard Golomb/Jamie Johnson
Filer Authorized By:	Jordan Rivard Golomb
Attorney Docket Number:	4820.007US4
Receipt Date:	18-MAY-2018
Filing Date:	
Time Stamp:	10:54:59
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
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	Miscellaneous Incoming Letter		2	3	
	Transmittal Letter		4	5	
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This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s): Edwin S. Olson et al.
Title: SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY

Docket No.: 4820.007US4
Filed: May 14, 2018
Examiner: Unknown
Customer No.: 21186

Serial No.: 15/978,760
Due Date: N/A
Group Art Unit: Unknown
Confirmation No.: 6432

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

We are transmitting herewith the following attached items (as indicated with an "X"):

X Communication Concerning Prior and Copending Applications (2 pgs.)
X Information Disclosure Statement (2 pgs.), Form 1449 (19 pgs.) Copies of Cited References (326).

If not provided for in a separate paper filed herewith, please consider this a PETITION FOR EXTENSION OF TIME for sufficient number of months to enter these papers and please charge any additional fees or credit overpayment to Deposit Account No. 19-0743. If applicable, any papers or fees supplied herewith are considered to be timely filed pursuant to 37 C.F.R. § 1.7(a), the response period falling on a Federal Holiday, Saturday or Sunday being extended to the next succeeding business day.

SCHWEGMAN LUNDBERG & WOESSNER, P.A.
Customer No.: 21186

By /Nicholas P. Lanzatella/
Nicholas P. Lanzatella
Reg. No. 63,803

S/N 15/978,760 **PATENT**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s): Edwin S. Olson et al. Examiner: Unknown
Serial No.: 15/978,760 Group Art Unit: Unknown
Filed: May 14, 2018 Docket: 4820.007US4
Customer No.: 21186 Confirmation No.: 6432
Title: SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY

COMMUNICATION CONCERNING PRIOR OR COPENDING APPLICATION(S)

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Pursuant to the guidance of MPEP §§ 2001.06(b) and 2004(9), Applicant would like to bring the following additional application(s) to the Examiner's attention. The identification of these applications is not intended to suggest that the subject matter claimed in any listed application is, or has been, substantially similar to any claim or claims in the present application.

Serial No./ Patent No.	Filing Date	Attorney Docket	Title
11/209,163 7,435,286	August 22, 2005	4820.001US1	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
12/201,595	August 29, 2008	4820.001US2	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
12/419,219 8,168,147	April 6, 2009	4820.001US3	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
13/427,665 8,512,655	March 22, 2012	4820.001US4	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
13/966,768 8,821,819	August 14, 2013	4820.001US5	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
14/318,270 9,757,689	June 27, 2014	4820.001US6	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
14/712,558	May 14, 2015	4820.001US7	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
15/951,970	April 12, 2018	4820.001US8	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY

14/195,360 9,669,355	March 3, 2014	4820.003US1	ACTIVATED CARBON SORBENT INCLUDING NITROGEN AND METHODS OF USING THE SAME
15/974,343	May 8, 2018	4820.001US9	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
15/589,359	May 8, 2017	4820.003US2	ACTIVATED CARBON SORBENT INCLUDING NITROGEN AND METHODS OF USING THE SAME
15/382,114	December 16, 2016	4820.004US1	PROMOTED AMMONIUM SALT-PROTECTED ACTIVATED CARBON SORBENT PARTICLES FOR REMOVAL OF MERCURY FROM GAS STREAMS
15/449,112	March 3, 2017	4820.005US1	SORBENT COMPRISING CARBON AND NITROGEN AND METHODS OF USING THE SAME
12/429,058 8,652,235	April 23, 2009	4820.007US1	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
14/102,896 9,468,886	December 11, 2013	4820.007US2	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
15/295,594	October 17, 2016	4820.007US3	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
15/853,029	December 22, 2017	4820.018US1	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY

Respectfully submitted,

SCHWEGMAN LUNDBERG & WOESSNER, P.A.
P.O. Box 2938
Minneapolis, MN 55402
(612) 349-9580

Date 5-17-2018 By / Nicholas P. Lanzatella /
Nicholas P. Lanzatella
Reg. No. 63,803

S/N 15/978,760 **PATENT**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s):	Edwin S. Olson et al.	Examiner:	Unknown
Serial No.:	15/978,760	Group Art Unit:	Unknown
Filed:	May 14, 2018	Docket:	4820.007US4
Customer No.:	21186	Confirmation No.:	6432
Title:	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY		

INFORMATION DISCLOSURE STATEMENT

MS Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

In compliance with the duty imposed by 37 C.F.R. § 1.56, and in accordance with 37 C.F.R. §§ 1.97 *et. seq*., the enclosed materials are brought to the attention of the Examiner for consideration in connection with the above-identified patent application. Applicant respectfully requests that this Information Disclosure Statement be entered and the documents listed on the attached PTO 1449 Form be considered by the Examiner and made of record. Pursuant to the provisions of MPEP 609, Applicant requests that a copy of the PTO 1449 Form, initialed as being considered by the Examiner, be returned to the Applicant with the next official communication.

Pursuant to 37 C.F.R. § 1.97(b), it is believed that no fee or statement is required with the Information Disclosure Statement. However, if an Office Action on the merits has been mailed after filing of the application or after the filing of the most recent RCE, the Commissioner is hereby authorized to charge the required fees to Deposit Account No. 19-0743 in order to have this Information Disclosure Statement considered.

Pursuant to 37 C.F.R. § 1.98(a)(2), copies of cited U.S. Patents and Published Applications, and Non-Published Applications identifiable by USPTO Serial Number, are no longer required to be provided to the Office. Applicant acknowledges the requirement to submit copies of foreign patent documents and non-patent literature in accordance with 37 C.F.R § 1.98(a)(2).

The Examiner is invited to contact the undersigned at the telephone number indicated if there are any questions regarding this communication.

Respectfully submitted,

SCHWEGMAN LUNDBERG & WOESSNER, P.A.
P.O. Box 2938
Minneapolis, MN 55402
(612) 349-9580

Date 5-17-2018 By

Nicholas P. Lanzatella
Reg. No. 63,803

NPL:jj

Electronic Acknowledgement Receipt

EFS ID:	32660400
Application Number:	15978760
International Application Number:	
Confirmation Number:	6432
Title of Invention:	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
First Named Inventor/Applicant Name:	Edwin S. Olson
Customer Number:	21186
Filer:	Jordan Rivard Golomb/Jamie Johnson
Filer Authorized By:	Jordan Rivard Golomb
Attorney Docket Number:	4820.007US4
Receipt Date:	18-MAY-2018
Filing Date:	
Time Stamp:	11:06:36
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
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4	Non Patent Literature	0065_3338005us1_rrr_070907.pdf	120258 9d42f953d79e3ed0b59cf62d24ab00d6ab491789	no	2
Warnings:					
Information:					
5	Non Patent Literature	0066_3338005us1_aarn_111307.pdf	2255877 944f599810aa5d71e099f6904bffc74e78da18eb	no	19
Warnings:					
Information:					
6	Non Patent Literature	0067_3338005us1_rerr_060707.pdf	622880 863642dab189fb3b955f3ac4da36ac6437120538	no	6
Warnings:					
Information:					
7	Non Patent Literature	0068_3338002us1exir4511.pdf	386116 3eefdbfb75553475460c0a5f79f30c3a072ca17e	no	3
Warnings:					
Information:					
8	Non Patent Literature	0069_3338002us1_foar_051111.pdf	1752774 d7f563380b32dc8f53d2145386b3f588caf8b5bd	no	15
Warnings:					
Information:					

9	Non Patent Literature	0070_3338002us1_oarn_011911.pdf	1489183 72947579512c108ccd0babcb603881bfced90e00	no	14
Warnings:					
Information:					
10	Non Patent Literature	0071_3338002us1_aarn_040711.pdf	355854 96f37ccf5ebcc2e39b3408846eca9faf74053def	no	12
Warnings:					
Information:					
11	Non Patent Literature	0072_3338002us1_aarf_070811.pdf	95664 aa4173b908a69a1d47fcff3626a6ead178c79d51	no	11
Warnings:					
Information:					
12	Non Patent Literature	0073_final_oa_03_10_10.pdf	3671215 a97ff713957724993fd0ec8a820b58ec3be1bb2c	no	13
Warnings:					
Information:					
13	Non Patent Literature	0074_nonfinal_oa_04_16_2009.pdf	6039014 664439dc613973c9ea51e6a6f746e84417ac58b9	no	21
Warnings:					
Information:					
14	Non Patent Literature	0075_3338005us2_aarn_101609.pdf	2599100 a12264671892e09536834be37112440af790bff7	no	18
Warnings:					
Information:					
15	Non Patent Literature	0076_final_oa_10_14_10.pdf	5153942 3202d57f1b88b008fbc0be0e5f53c83b060ff500	no	17
Warnings:					
Information:					

16	Non Patent Literature	0077_non_final_oa_1_15_10.pdf	3870503 c66ec12dceb80afb02c99bc432c2ecb800e19325	no	13
Warnings:					
Information:					
17	Non Patent Literature	0078_non_final_oa_2_23_11.pdf	4995701 3df75049db4dc84e3798f970d247bc75907a1b1e	no	17
Warnings:					
Information:					
18	Non Patent Literature	0079_non_final_oa_8_4_11.pdf	4803990 cf756ffffd042e5651e71f00adb86d4cec7621a3	no	16
Warnings:					
Information:					
19	Non Patent Literature	0080_12419219__noar_011012.pdf	935300 89d49694d3f26193c83958bfb6396dd71b268250	no	7
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Information:					
20	Non Patent Literature	0081_3338005us3_pamd_040609.pdf	585228 5849185d5d41db8ce6defad4f0e1b79f311ed4d3	no	7
Warnings:					
Information:					
21	Non Patent Literature	0082_response_02_14_11.pdf	3929643 b1c680957a1ab2845952271c7d24d77f8e0b47f5	no	19
Warnings:					
Information:					
22	Non Patent Literature	0083_response_05_20_11.pdf	132358 7b7dcb391fa3d4f7f08da9812f9eb5ae6df16f69	no	14
Warnings:					
Information:					

23	Non Patent Literature	0084_3338005us3_aarn_071510.pdf	3249302 912a6b8581f4ae63bfcfcdea0c24510c095fec05	no	22
Warnings:					
Information:					
24	Non Patent Literature	0085_3338005us3_aarn_102711.pdf	126688 15e22070df3d91399499df55870a980609d0a853	no	12
Warnings:					
Information:					
25	Non Patent Literature	0086_5_4820007us1_adar_052912.pdf	408765 c44268b7b589052573cde0bc98ac0840fd7f28e7	no	3
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Information:					
26	Non Patent Literature	0087_11_4820007us1_xpqa_021413.pdf	604722 359d528ac342b8f5220b6c585ac51525e49be974	no	7
Warnings:					
Information:					
27	Non Patent Literature	0088_9_4820007us1_exir_122812.pdf	443804 da57e4fb1f8fc11ad1fae130597d08d2c9ee21ea	no	4
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Information:					
28	Non Patent Literature	0089_8_4820007us1_foar_103112.pdf	1986747 b15d0ff78303269084479cfb21de66ce24deea08	no	21
Warnings:					
Information:					
29	Non Patent Literature	0090_3_4820007us1_foar_122011.pdf	1928967 fe1707f56c7029c579975e4cbbdf573df7ca10f9	no	21
Warnings:					
Information:					

30	Non Patent Literature	0091_6_4820007us1_oarn_061112.pdf	1756454 dfd8a87296a739ec57543f40dbcfcd98e553abd3	no	18
Warnings:					
Information:					
31	Non Patent Literature	0092_1_4820007us1_oarn_071911.pdf	1915188 e81fe6336a1d4e1ce4e092e630c0f89f83cba21d	no	20
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Information:					
32	Non Patent Literature	0093_14_4820007us1_noar_011614.pdf	473567 f7f13ae391f70ce567b7563b7ef10ac5f8c65c62	no	5
Warnings:					
Information:					
33	Non Patent Literature	0094_13_4820007us1_noar_091113.pdf	1189971 1e93de589744be680c88312907e59b2f00f7dd3e	no	11
Warnings:					
Information:					
34	Non Patent Literature	0095_10_4820007us1_aarf_013113.pdf	2446056 bcc02d79a59437536126bee3421c07cc3c3fd158	no	19
Warnings:					
Information:					
35	Non Patent Literature	0096_12_4820007us1_xpqre_030713.pdf	738332 a9550bb593dc26e2530f8c25152e72ec6a8d3260	no	7
Warnings:					
Information:					
36	Non Patent Literature	0097_4_4820007us1_aarf_051112.pdf	1285857 bdb41e8a16fb0a9982e0149cb4cb7fb9382472cc	no	11
Warnings:					
Information:					

37	Non Patent Literature	0098_7_4820007us1_aarn_091112.pdf	2061960 4f8b65b325f9fc241f8cc6bcef9cbc5f34b12f7c	no	16
Warnings:					
Information:					
38	Non Patent Literature	0099_2_4820007us1_aarn_101811.pdf	2134584 c1e6c10ae083dc54531682d5ba0fd7189c362c72	no	17
Warnings:					
Information:					
39	Non Patent Literature	0100_non_final_oa_01_04_13.pdf	8931366 3755ede4827de0c9ee051b8aa972876a307bbc92	no	23
Warnings:					
Information:					
40	Non Patent Literature	0101_final_oa_08_03_12.pdf	3382371 59f4558f473296f0c6a4575a552e674020f1f513	no	12
Warnings:					
Information:					
41	Non Patent Literature	0102_3338005us4_noar_041613.pdf	936793 f19cf85a7c515931e0cfc4dc75539316467c96fb	no	8
Warnings:					
Information:					
42	Non Patent Literature	0103_3338005us4_aarn_032113.pdf	167958 b1dc38c7219f7c5e30bbbbd8bb4ecb589aea9cd2	no	20
Warnings:					
Information:					
43	Non Patent Literature	0104_response_10_10_12.pdf	109408 f1f8ee05c661282dece58ae05347ceff116631ea	no	15
Warnings:					
Information:					

44	Non Patent Literature	0105_03338005us4_pamd_032212.pdf	165681 b58a0d194aac05573aba409e0ba9493f0831d993	no	3
Warnings:					
Information:					
45	Non Patent Literature	0106_advisory_action.pdf	944995 288d24d53535e66c877f64bb1a2d54ae1574e289	no	3
Warnings:					
Information:					
46	Non Patent Literature	0107_final_oa_10_16_2014.pdf	1118523 770f102f797437e95dde936203c64f7aeac5b4e7	no	4
Warnings:					
Information:					
47	Non Patent Literature	0108_nonfinal_oa_05_30_14.pdf	2006359 29ee49cabf8b1e9a933918f640e299772649e924	no	6
Warnings:					
Information:					
48	Non Patent Literature	0109_noa_01_05_15.pdf	2591843 88707251ab0cd00c4eee9ce74ce883db46410e48	no	5
Warnings:					
Information:					
49	Non Patent Literature	0110_response_9_2_2014.pdf	131827 1f722e7268b4f6fe4a5d1a87f6090ead163fdc7a	no	13
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Information:					
50	Non Patent Literature	0111_amend_response_110614.pdf	82370 764f735f40665edc9105f675e80be6aa99155d73	no	7
Warnings:					
Information:					

51	Non Patent Literature	0112_response_12_9_2014.pdf	75611 4d2897306ec8c0fbd41f792214fb4f8627514479	no	6
Warnings:					
Information:					
52	Non Patent Literature	0113_nonfinal_oa_12_06_13.pdf	2944086 de667e20b3e14c5b1140a8faaaea50f0708e686a	no	7
Warnings:					
Information:					
53	Non Patent Literature	0114_noa_08_01_2014.pdf	2727722 14336818e06337b7ed0ad4a894a6110aecd0cd0a	no	6
Warnings:					
Information:					
54	Non Patent Literature	0115_noa_4_18_2014.pdf	2843974 69ffc5cef21a6e4a4ba12dba4e5da8840414dcdd	no	7
Warnings:					
Information:					
55	Non Patent Literature	0116_prel_amend_08_14_13.pdf	427085 de5fc4f17f3326f3cff726605eaed1113df298a0	no	3
Warnings:					
Information:					
56	Non Patent Literature	0117_response_3_6_2014.pdf	62917 306e39c708b29c05b4f2207c121d3e5ce7835084	no	6
Warnings:					
Information:					
57	Non Patent Literature	0118_supp_prel_amend_08_15_13.pdf	977857 b1f4b619e297fa563701f20d9f3470421f1fe06a	no	6
Warnings:					
Information:					

58	Non Patent Literature	0119_4820007us2_adar_121615.pdf	349056 e8fe35cdd5551b399ace9095f7833f41d0b24653	no	3
Warnings:					
Information:					
59	Non Patent Literature	0120_4820007us2_foar_082615.pdf	1154157 b1b5dc8fa893f8e90b464110adac77a2baa2c45d	no	12
Warnings:					
Information:					
60	Non Patent Literature	0121_4820007us2_oarn_032315.pdf	1210847 3dd21efa4a90a20cf799429c61ce807529618b1d	no	13
Warnings:					
Information:					
			Total Files Size (in bytes):	112868214	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US04/12828

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : B01J 20/34, 38/48, 38/60, 38/62
US CL : 502/22, 27, 28

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 502/22, 27, 28

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Please See Continuation Sheet

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X, P	US 6,579,507 B2 (PAHLMAN et al) 17 June 2003 (17.06.2003), column 10, lines 39-67; column 40, lines 32-67.	1-3,11-14,17-22,26-32,36-38,42-48,55-58, and 62-69
---		---
Y,P		4-10,15,16,23-25,33-35,39-41,49-51, and 59-61
X	US 6,475,451 B1 (LEPPIN et al) 05 November 2002 (05.11.2002), see abstract.	43-48
A	US 5,827,352 (ALTMAN et al) 27 October 1998 (27.10.1998), see abstract and entire patent.	1-69
Y	US 5,480,619 (JOHNSON et al) 02 January 1996 (02.01.1996), see abstract, col . 4, lines 30-35.	7-10, 15,16,23-25,33-35,39-41,49-51 and 59-61
Y	US 4,196,173 (deJong et al.) 01 April 1980 (01.04.1980), see abstract.	4-6

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
22 September 2004 (22.09.2004)

Date of mailing of the international search report
22 OCT 2004

Name and mailing address of the ISA/US
Mail Stop PCT, Attn: ISA/US
Commissioner of Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
Facsimile No. (703) 305-3230

Authorized officer
Jonas N. Strickland
Telephone No. 571-272-1700

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

PCT/US04/12828

Continuation of B. FIELDS SEARCHED Item 3:
EAST, WEST search terms: sorbent, regeneration, mercury, acid, water, solvent, solution, liquid, reactivation

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING TRANSMITTAL OF COPY OF INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY (CHAPTER I OF THE PATENT COOPERATION TREATY)

(PCT Rule 44bis.1(c))

To:

MADDEN, Robert B.
Schwegman, Lundberg & Woessner, P.A.
P.O. Box 2938
Minneapolis, Minnesota 55402
ETATS-UNIS D'AMERIQUE

Schwegman Lundberg
Woessner PA
SEP 21 2015

Date of mailing *(day/month/year)* 17 September 2015 (17.09.2015)	
Applicant's or agent's file reference 3338021WO1	**IMPORTANT NOTICE**

International application No. PCT/US2014/019916	International filing date *(day/month/year)* 03 March 2014 (03.03.2014)	Priority date *(day/month/year)* 06 March 2013 (06.03.2013)

Applicant

ENERGY & ENVIRONMENTAL RESEARCH CENTER FOUNDATION

The International Bureau transmits herewith a copy of the international preliminary report on patentability (Chapter I of the Patent Cooperation Treaty)

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer Philippe Bécamel
Facsimile No. +41 22 338 82 70	e-mail: pt03.pct@wipo.int

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter I of the Patent Cooperation Treaty)

(PCT Rule 44*bis*)

Applicant's or agent's file reference 3338021WO1	**FOR FURTHER ACTION**	See item 4 below
International application No. PCT/US2014/019916	International filing date *(day/month/year)* 03 March 2014 (03.03.2014)	Priority date *(day/month/year)* 06 March 2013 (06.03.2013)
International Patent Classification (8th edition unless older edition indicated) See relevant information in Form PCT/ISA/237		
Applicant ENERGY & ENVIRONMENTAL RESEARCH CENTER FOUNDATION		

1. This international preliminary report on patentability (Chapter I) is issued by the International Bureau on behalf of the International Searching Authority under Rule 44 *bis*.1(a).

2. This REPORT consists of a total of 13 sheets, including this cover sheet.

   In the attached sheets, any reference to the written opinion of the International Searching Authority should be read as a reference to the international preliminary report on patentability (Chapter I) instead.

3. This report contains indications relating to the following items:

☒	Box No. I	Basis of the report
☐	Box No. II	Priority
☒	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☒	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☒	Box No. VII	Certain defects in the international application
☒	Box No. VIII	Certain observations on the international application

4. The International Bureau will communicate this report to designated Offices in accordance with Rules 44*bis*.3(c) and 93*bis*.1 but not, except where the applicant makes an express request under Article 23(2), before the expiration of 30 months from the priority date (Rule 44*bis* .2).

	Date of issuance of this report 08 September 2015 (08.09.2015)
The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No. +41 22 338 82 70	Authorized officer Philippe Bécamel e-mail: pt03.pct@wipo.int

Form PCT/IB/373 (January 2004)

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:

see form PCT/ISA/220

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing
(day/month/year) see form PCT/ISA/210 (second sheet)

Applicant's or agent's file reference
see form PCT/ISA/220

FOR FURTHER ACTION
See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2014/019916	03.03.2014	06.03.2013

International Patent Classification (IPC) or both national classification and IPC
INV. B01J20/20 B01D53/02 B01D53/10 B01J20/32 C01B31/08

Applicant
ENERGY & ENVIRONMENTAL RESEARCH CENTER FOUNDATION

1. This opinion contains indications relating to the following items:

☒ Box No. I Basis of the opinion
☐ Box No. II Priority
☒ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☒ Box No. IV Lack of unity of invention
☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
☐ Box No. VI Certain documents cited
☒ Box No. VII Certain defects in the international application
☒ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notifed the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA:	Date of completion of this opinion	Authorized Officer
European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Fax: +49 89 2399 - 4465	see form PCT/ISA/210	Pöhlmann, Robert Telephone No. +49 89 2399-2059

Form PCT/ISA/237 (Cover Sheet) (July 2009)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2014/019916

Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed

   ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1 (b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43bis.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing filed or furnished:

   a. (means)

   ☐ on paper

   ☐ in electronic form

   b. (time)

   ☐ in the international application as filed

   ☐ together with the international application in electronic form

   ☐ subsequently to this Authority for the purposes of search

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non obvious), or to be industrially applicable have not been examined in respect of

☐ the entire international application

☒ claims Nos. 50-67(completely); 1-49(partially)

because:

☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international search *(specify)*:

☐ the description, claims or drawings *(indicate particular elements below)* or said claims Nos. are so unclear that no meaningful opinion could be formed *(specify)*:

☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed *(specify)*:

☒ no international search report has been established for the whole application or for said claims Nos. 50-67(completely); 1-49(partially)

☐ a meaningful opinion could not be formed without the sequence listing; the applicant did not, within the prescribed time limit:

- ☐ furnish a sequence listing on paper complying with the standard provided for in Annex C of the Administrative Instructions, and such listing was not available to the International Searching Authority in a form and manner acceptable to it.
- ☐ furnish a sequence listing in electronic form complying with the standard provided for in Annex C of the Administrative Instructions, and such listing was not available to the International Searching Authority in a form and manner acceptable to it.
- ☐ pay the required late furnishing fee for the furnishing of a sequence listing in response to an invitation under Rules 13*ter*.1(a) or (b).

☐ See Supplemental Box for further details

Box No. IV Lack of unity of invention

1. ☒ In response to the invitation (Form PCT/ISA/206) to pay additional fees, the applicant has, within the applicable time limit:

   ☐ paid additional fees

   ☐ paid additional fees under protest and, where applicable, the protest fee

   ☐ paid additional fees under protest but the applicable protest fee was not paid

   ☒ not paid additional fees

2. ☐ This Authority found that the requirement of unity of invention is not complied with and chose not to invite the applicant to pay additional fees.

3. This Authority considers that the requirement of unity of invention in accordance with Rule 13.1, 13.2 and 13.3 is

   ☐ complied with

   ☒ not complied with for the following reasons:

   see separate sheet

4. Consequently, this report has been established in respect of the following parts of the international application:

   ☐ all parts.

   ☒ the parts relating to claims Nos. 1-49(partially)

Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	5-49(partially)
	No:	Claims	1-4(partially)
Inventive step (IS)	Yes:	Claims	10-15, 26-37, 40-47(all partially)
	No:	Claims	1-9, 16-25, 38, 39, 48, 49(all partially)
Industrial applicability (IA)	Yes:	Claims	1-49(partially)
	No:	Claims	

2. Citations and explanations

   see separate sheet

Box No. VII Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

Re Item VIII

Certain observations on the international application

1 Clarity, Article 6 PCT)

1.1 General

The terms "about" (used in claims 4-6, 18-24, 34, 50, 58, 64), "substantially" (used in claims 5, 7-9, 50, 61-64, 67) and "core" (used in claims 3, 7, 18, 19, 51, 56, 61) are vague and unclear and leave the reader in doubt as to the meaning of the technical features to which they refer, thereby rendering the definition of the subject-matter of said claims unclear, Art. 6 PCT.

1.2 Claim 4

Claim 4 does not meet the requirements of Article 6 PCT because the matter for which protection is sought is not clearly defined. The claim attempts to define the subject-matter in terms of the result to be achieved (combines with at least 70 wt%), which merely amounts to a statement of the underlying problem, without providing the technical features necessary for achieving this result (like but not limited to volume flows, distribution of sorbent, injection of sorbent, contact times, temperatures, other components in the mercury-containing gas).

1.3 Claim 7

It is unclear (Art. 6 PCT) how the nitrogen can be homogeneously distributed in the core of the particles and how at the same time there can be a concentration profile from the surface to the core (when referring to claim 3).

1.4 Claims 8, 9

Claims 8 and 9 do not meet the requirements of Art. 6 PCT because the matter for which protection is sought is not clearly defined. The claims attempt to define the subject-matter in terms of the result to be achieved, which merely amounts to a statement of the underlying problem, without providing the technical features necessary for achieving this result.

1.5 Claim 18

It is unclear in claim 18 how a core of an activated carbon sorbent particle can comprise 99 wt% nitrogen (Art. 6 PCT). The core practically would consist of nitrogen only in this case.

1.6 Claim 20

It is unclear in claim 20 how a surface layer of an activated carbon sorbent particle can comprise 99 wt% nitrogen (Art. 6 PCT). The surface would consist of nitrogen only in this cas. Also it is unclear if the technical effect related to nitrogen being present at 0.001 wt% in the surface layer is still existing (Art.6 PCT).

1.7 Claim 22

The definition of the surface layer is unclear as a thickness of 99% of the radius of the particles is in fact the complete particle and not only a "surface layer" (Art. 6 PCT).

Re Item IV

2 **Lack of unity of invention**

Notwithstanding the objections under Article 6 PCT above, the application lacks unity within the meaning of Rule 13.1 PCT.

2.1 Reference is made to the following document:

D1 YUANJING ZHENG ET AL: "Review of technologies for mercury removal from flue gas from cement production processes",PROGRESS IN ENERGY AND COMBUSTION SCIENCE, ELSEVIER SCIENCE PUBLISHERS, AMSTERDAM, NL,vol. 38, no. 5, 26 April 2012 (2012-04-26), pages 599-629, XP028415255,ISSN: 0360-1285, DOI: 10.1016/J.PECS.2012.05.001[retrieved on 2012-05-25]

D2 DE 20 2012 003747 U1 (BLUECHER GMBH [DE]) 15 November 2012 (2012-11-15)

2.2 **There are several groups of claims:**

- Group 1: Claims 1-49 (partially), in particular claims 2-9, 16-25, 38, 39, 48, 49
- Group 2: Claims 1-49 (partially), in particular claims 10-15, 26-37, 40, 41, 44, 45, claims 50-67 (completely)
- Group 3: Claims 1-49 (partially), in particular claims 42, 43
- Group 4: Claims 1-49 (partially), in particular claims claims 46, 47

2.3 **The common concept linking together the groups is the subject-matter of claim 1**. This common concept is not new over D1.

2.3.1 D1 discloses a method of reducing the mercury content in a mercury-containing gas (see page 600, para. 1.), the method comprising obtaining or providing an activated carbon sorbent comprising activated carbon sorbent particles comprising nitrogen in a surface layer of the sorbent particles (see page 615, para. 4.2.5.1 and page 616, left column, "...by impregnation of nitrogen-containing polymers or pitches ..."), contacting a pollutant-containing gas with the activated carbon sorbent to form a pollutant-sorbent composition (implicitly disclosed as for a sorbent based removal process the pollutant has to be contacted with the sorbent, the pollutant thereby always forms a pollutant-sorbent composition), and separating at least some of the pollutant-sorbent composition from the pollutant-containing gas, to give a separated gas (see page 622, figure 20).

Hence, D1 discloses all the features of claim 1.

2.3.2 D1 further discloses

- claim 3: the concentration of nitrogen in the surface layer of the sorbent particles to be higher than in a core of the particles (see page 615, right column, lines 1-4, nitrogenated function introduced on carbon surface, therefrom following a lower nitrogenous concentration in the core of the particles)

- claim 5, 6: the mercury-containing gas to comprise a sulfur(VI) concentration, like SO_3 (see page 616, right column, 2nd paragraph)

2.4 **The differentiating features are**

- Group 1: applying the method for gases with a sulfur(VI) concentration of more than 3 ppm by mole
- Group 2: obtaining or providing the activated carbon sorbent comprises promoting an unpromoted carbon sorbent and/or providing or obtaining the unpromoted carbon sorbent from a carbon precursor comprising nitrogen and/or the activated carbon sorbent comprising a stabilizing agent
- Group 3: adding an alkaline component into the pollutant containing gas
- Group 4: regenerating the activated carbon sorbent

2.5 **with following resulting technical effects:**

- Group 1: no surprising and unexpected technical effect distinguishable

- Group 2: further enhancement of the mercury sorption efficiency of the activated carbon sorbent comprising nitrogen
- Group 3: reduction of sulfuric compounds in the pollutant containing gas
- Group 4: saving financial means for sorbent

2.6 **Thus the problems solved may be regarded as**

- Group 1: finding an alternative mercury containing gas for which the method can be applied.
- Group 2: how to modify the method of D1 in order to further enhance the mercury sorption efficiency of the activated carbon sorbent comprising nitrogen
- Group 3: how to modify the method of D1 in order to reduce the sulfuric compounds in the pollutant containing gas
- Group 4: how to modify the method of D1 in order to save financial means for sorbent

2.7 **The special technical features (R. 13.2 PCT) are**

- Group 1: **no** special technical feature A as the alternative gas is considered to be obvious for the skilled person.
- Group 2: differentiating feature = special technical feature B as the feature is neither disclosed nor rendered obvious by D1 and therefore is considered to make a contribution over D1.
- Group 3: differentiating feature = special technical feature C as the feature is neither disclosed nor rendered obvious by D1 and therefore is considered to make a contribution over D1.
- Group 4: **no** special technical feature D as the regeneration and reuse of the sorbent is disclosed by D1 (see page 612, left column, paragraph before 4.2.2.3).

2.8 **Groups of (alleged) inventions**

The groups of technical features do not solve any common technical problem. Thus the groups of claims are neither linked by the same nor by corresponding special technical features and define different inventions not linked by a single general inventive concept (Rule 13.1 and 13.2 PCT) and therefore **the requirement for unity of invention referred to in Rule 13 PCT is not fulfilled.**

2.9 **Consequence**

A search has been performed for the invention first mentioned in the claims, here the subject-matter of the claims forming group 1. Correspondingly, in the following this written opinion is restricted to group 1.

Group 1 : Claims 1-9, 16-25, 38, 39, 48, 49 (partially)

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

3 Novelty Claim 1

3.1 As already shown under point 2.3.1 above the subject-matter of claim 1 is not new (Article 33(2) PCT).

4 Inventive Step Claim 1

Besides D1, which is considered to be the closest prior art to the subject-matter of claim 1, also D2 could be regarded as the closest prior art the subject-matter of claim 1.

4.1.1 D2 discloses

A method of reducing the pollutant content in a pollutant-containing gas (see §0142 and 0143), the method comprising:

obtaining or providing an activated carbon sorbent comprising activated carbon sorbent particles comprising nitrogen in a surface layer of the sorbent particles (see claim 1);

4.1.2 The subject-matter of claim 1 therefore differs from this known D2 in that

a pollutant-containing gas is contacted with the activated carbon sorbent, to form a pollutant-sorbent composition; and in that at least some of the pollutant-sorbent composition is separated from the pollutant-containing gas, to give a separated gas.

4.1.3 There is no unexpected technical effect related to that difference.

4.1.4 The problem to be solved by the present invention may therefore be regarded as how to to apply the method of D2 for reducing the pollutant content in a pollutant-containing gas.

4.1.5 The solution proposed in claim 1 of the present application cannot be considered to involve an inventive step (Article 33(3) PCT) for the following reasons:

It is common general knowledge for the skilled person to contact the sorbent with the gas to form a pollutant-sorbent composition and to separate the pollutant-sorbent composition from the gas to give a separated gas. Also, amongst many other documents he finds in D1 an indication (see cited passages) with which he would contact the sorbent with the gas, thereby forming a pollutant sorbent composition and separate this composition from the gas to give a separated gas, thereby arriving at the subject-matter of claim 1 without being inventive.

5 Dependent claims

Dependent claims 2-9, 16-25, 38, 39, 48, 49 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty and/or inventive step.

5.1 Claims 2, 3

The subject-matter of said claims is neither new (see points 2.3.1 and 2.3.2 above), nor inventive (see D2, claim 1 and §0143, mercury being an obvious toxic substance whose removal from gas streams with activated carbon is widely known in industry).

5.2 Claims 5, 6

D1 discloses a sulfur(VI) concentration in the mercury-containing gas (see 2.3.2 above) and the claimed ranges for said concentration are considered to be merely an arbitrary selection out of a variety of possible mercury containing gases without showing an unexpected technical effect. The properties of the activated carbon sorbent of D1 are considered to achieve the results claimed in claim 5 with regard to corresponding activated carbon sorbents.

5.3 Claims 16, 17, 38, 39, 48, 49

It is well-known in the art to add the sorbent into the mercury-containing gas and to remove it after a certain distance by various means like bag houses, electrostatic precipitators, cyclones or the like. As well, it is common general knowledge to contact the gas with the sorbent in a fixed bed, a dry or aqueous scrubber, a filter or a moving bed.

Claim 19, 21

D2 discloses a wide variety of possible nitrogen concentrations of the activated carbon (see claim 25), which is also considered to be applicable either to the surface and/or to the core of carbon particles. Therefore, the claimed ranges are not inventive.

Claim 24, 25

The claimed range of particle diameters is considered an arbitrary selection and activated carbon particles in this range are known to the skilled person (see for reference D2, §0106). Furthermore, every surface is considered to be continuous and therefore also a surface layer.

Re Item VII

Certain defects in the international application

6 The requirements of Rule 6.3(b) PCT (two-part form of independent claims) and Rule 5.1(a)(ii) and (ii) PCT (acknowledgement of prior art D1) are not met.

Electronic Acknowledgement Receipt

EFS ID:	32660545
Application Number:	15978760
International Application Number:	
Confirmation Number:	6432
Title of Invention:	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
First Named Inventor/Applicant Name:	Edwin S. Olson
Customer Number:	21186
Filer:	Jordan Rivard Golomb/Jamie Johnson
Filer Authorized By:	Jordan Rivard Golomb
Attorney Docket Number:	4820.007US4
Receipt Date:	18-MAY-2018
Filing Date:	
Time Stamp:	11:14:15
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Non Patent Literature	0122_4820007us2_noar_061016.pdf	952724 0f1c2ff74fa3bbcfafc7b8ec400873d40a15ea48	no	7

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5	Non Patent Literature	0126_3338021us1_cnoa_022717.pdf	273812 c3c410f78345a6a07e75e770646c24b9452cf36a	no	2
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			Total Files Size (in bytes):	44398274	

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<u>New Applications Under 35 U.S.C. 111</u>

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Electronic Acknowledgement Receipt

EFS ID:	32660695
Application Number:	15978760
International Application Number:	
Confirmation Number:	6432
Title of Invention:	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
First Named Inventor/Applicant Name:	Edwin S. Olson
Customer Number:	21186
Filer:	Jordan Rivard Golomb/Jamie Johnson
Filer Authorized By:	Jordan Rivard Golomb
Attorney Docket Number:	4820.007US4
Receipt Date:	18-MAY-2018
Filing Date:	
Time Stamp:	11:23:36
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
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7	Non Patent Literature	0187_4820007ca1_aarmisc_060616.pdf	1387087 4ef21b6253ce4ad19dfe19ebc86380ee5ebfd7b0	no	13
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8	Non Patent Literature	0188_4820007ca1_vamd_013015.pdf	3118481 6b6b1f1c193b99d75e1a56e974e2c892cda8d155	no	27
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9	Non Patent Literature	0189_ca_response_02_26_16.pdf	602552 a5cbc269a0e806ff0f8a58a5c67a7ca09950cb03	no	13
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11	Non Patent Literature	0191_4820006ca1_oarmisc_04242018.pdf	358499 ac02f210c0c75176bf94d31ebeb2cca75f23d46c	no	4
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42	Non Patent Literature	0222_ep_response_04_18_08.pdf	2807308 da5e2004a2d4ce38e9f3da471e0330da4345bd4e	no	7
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47	Non Patent Literature	0227_third_party_comment_12_04_07.pdf	1423804 868ee8c4089dbaf8f3b3ebfa6b24f922da14f7b0	no	5
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50	Non Patent Literature	0230_4820007ep1_e2000c_031714.pdf	7019807 1eaeebad8903d34f6d571915da898bdb18568fb8	no	44
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51	Non Patent Literature	0231_4820007ep1_e2000c_093013.pdf	6729745 eda4a87ba101d2c4528b9a2575279ce352ceae21	no	44
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52	Non Patent Literature	0232_4820007ep1_aarmisc_020314.pdf	1209441 b33a315eaed3418e17a75812a4958e69468276a1	no	11
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54	Non Patent Literature	0234_3_4820001ep3_e2001_112612.pdf	325585 00325f93cefaac2c6087ac81ffc8d14471449802	no	4
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			Total Files Size (in bytes):	86650121	

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Electronic Acknowledgement Receipt

EFS ID:	32660992
Application Number:	15978760
International Application Number:	
Confirmation Number:	6432
Title of Invention:	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
First Named Inventor/Applicant Name:	Edwin S. Olson
Customer Number:	21186
Filer:	Jordan Rivard Golomb/Jamie Johnson
Filer Authorized By:	Jordan Rivard Golomb
Attorney Docket Number:	4820.007US4
Receipt Date:	18-MAY-2018
Filing Date:	
Time Stamp:	11:39:20
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Non Patent Literature	0241_4820001ep2_e2001_010913.pdf	351104 e109e2649f5744ec5d07dc53660d14370e0478da	no	4

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National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
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If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Espacenet

Bibliographic data: DE3816600 (A1) — 1989-11-23

Process for the regeneration of arsenic-contaminated catalysts and sorbents

Inventor(s):	KAIZIK ALFRED DR [DE]; HOEG HANS-ULRICH DR [DE] ±	
Applicant(s):	HUELS CHEMISCHE WERKE AG [DE] ±	
Classification:	**- international:**	***B01D53/86; B01J21/20; B01J23/92; B01J38/60;*** (IPC1-7): B01D53/34; B01J21/06; B01J21/20; B01J23/18
	- European:	B01D53/86F2C; B01J21/20; B01J23/92; B01J38/60
Application number:	DE19883816600 19880514	
Priority number(s):	DE19883816600 19880514	
Also published as:	DE3816600 (C2)	

Abstract of DE3816600 (A1)

In the selective catalytic removal of nitrogen oxides from flue gases of slag-tap-fired furnaces, in particular those having ash recirculation, the problem occurs that the catalysts based on titanium oxide are rapidly deactivated by arsenic compounds. The catalysts damaged in this way have previously had to be replaced by new ones. On the other hand, there is the possibility of removing the arsenic compounds from the flue gas in advance by a sorbent based on titanium oxide upstream of the catalyst. It is desirable in this case to find a process for the regeneration of arsenic-contaminated catalysts and arsenic-laden sorbents. Arsenic-contaminated catalysts and arsenic-laden sorbents can be regnerated by washing with an inorganic or organic acid. Regeneration of arsenic-contaminated catalysts and arsenic-laden sorbents.

Last updated: 14.03.2012 Worldwide Database 5.7.38; 92p

⑲ BUNDESREPUBLIK
DEUTSCHLAND

DEUTSCHES
PATENTAMT

⑫ **Offenlegungsschrift**
⑪ **DE 3816600 A1**

(51) Int. Cl. 4:
B 01 J 21/20
B 01 J 21/06
B 01 J 23/18
B 01 D 53/34
// B01J 23/30,23/20

㉑ Aktenzeichen: P 38 16 600.3
㉒ Anmeldetag: 14. 5. 88
(43) Offenlegungstag: 23. 11. 89

DE 3816600 A1

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(72) Erfinder:
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Prüfungsantrag gem. § 44 PatG ist gestellt

(54) Verfahren zur Regeneration arsenkontaminierter Katalysatoren und Sorbentien

Bei der selektiven katalytischen Stickoxidentfernung aus Rauchgasen von Schmelzkammerfeuerungen, insbesondere von solchen mit Ascherückführung, trat das Problem auf, daß die Katalysatoren auf Basis Titanoxid durch Arsenverbindungen rasch desaktiviert wurden. Die so geschädigten Katalysatoren mußten bisher durch neue ersetzt werden. Zum anderen besteht die Möglichkeit, die Arsenverbindungen aus dem Rauchgas durch ein dem Katalysator vorgeschaltetes Sorbens auf Basis Titanoxid vorher zu entfernen. Wünschenswert ist es somit, ein Verfahren zur Regeneration von arsenkontaminierten Katalysatoren und von arsenbeladenen Sorbentien zu finden.
Arsenkontaminierte Katalysatoren und arsenbeladene Sorbentien lassen sich durch Waschen mit einer anorganischen oder organischen Säure regenerieren.
Regeneration arsenkontaminierter Katalysatoren und arsenbeladener Sorbentien.

DE 3816600 A1

BUNDESDRUCKEREI 10. 89 908 847/392 10/70

Beschreibung

Die Erfindung betrifft ein Verfahren zur Regeneration arsenkontaminierter Katalysatoren und Sorbentien auf Basis Titanoxid.

Vorzugsweise betrifft die Erfindung ein Verfahren zur Regeneration arsenkontaminierter Katalysatoren auf Basis Titanoxid zur Entfernung von Stickoxiden aus Abgasen und Sorbentien auf Basis Titanoxid zur Entfernung von Arsenverbindungen aus Abgasen.

Die derzeit wichtigste, im großtechnischen Maßstab genutzte Methode zur Minderung des Stickoxidausstoßes von Feuerungsanlagen ist die selektive katalytische Reduktion von Stickoxiden mit Ammoniak, wobei überwiegend Katalysatoren auf Basis von Titandioxid eingesetzt werden. Dieses Verfahren wurde ursprünglich für gas- oder ölbefeuerte Anlagen und für Kohlefeuerungen mit trockenem Ascheabzug entwickelt. Bei der Übertragung auf Schmelzkammerfeuerungen, insbesondere solche mit Ascherückführung, trat das Problem in Erscheinung, daß Spuren von Arsenverbindungen in der Kohle sich im Rauchgas zu einer solchen stationären Konzentration anreichern, daß die Katalysatoren eine rasche Desaktivierung erleiden. Eine Lösung für dieses Problem ist noch unbekannt (Energie Spektrum, November 1986, S. 16).

Ein allgemeines Verfahren zur Entfernung störender Kontaminanten ist die Wäsche mit einem geeigneten Agens. Bislang hat man sich jedoch ausschließlich mit der Entfernung anderer Verunreinigungen als Arsenverbindungen befaßt.

Es sind Verfahren zur Regeneration von Katalysatoren zur Stickoxidminderung in Abgasen von Feuerungsanlagen bekannt, und zwar füe Entfernung der folgenden Kontaminanten, wie

Alkalisalze

durch Wäsche mit Wasser und anschließender Imprägnierung mit einer oxidischen Schwefelverbindung gemäß EP-A 159 959, mit Wasserstoffperoxid gemäß JP-OS 59 127 650 und Chemical Abstracts, Vol. 101, 176, 792 und mit Natriumsulfat- oder Ammoniumsulfat-Lösung gemäß Chem. Letters 1983, S. 515—518, wobei zugleich festgestellt wird, daß früher beschriebene Säurewäschen den Katalysatoren zerstören;

Calciumsulfat

durch Wäsche mit organischen oder anorganischen Säuren gemäß JP-OS 59-0 98 739 und Derwent Sect. E 84-17 90 86/29;

Flugstaub

das heißt anhaftendem Staub, dessen Gehalt an Schwermetallen die unerwünschte SO_2-Oxidation fördert und dessen Gehalt an Natrium- und Kaliumsalzen die NO_x-Minderung beeinträchtigt; durch Wäsche mit einer Oxalsäure-Lösung gemäß EP-A 161 206 und anschließendem Ersatz des herausgelösten Katalysatorbestandteils Wolframoxid durch Nachimprägnierung.

In keiner dieser Veröffentlichungen wird eine Desaktivierung durch Arsenverbindungen als Problem erwähnt, geschweige denn ein Verfahren zur Regeneration von durch Arsenverbindungen desaktivierten Katalysatoren vorgeschlagen.

Zum anderen kann man gemäß Patentanmeldung ... eine Desaktivierung von Katalysatoren durch Arsenverbindungen verhindern, indem dem Katalysator ein Sorbens vorgeschaltet wird, das die Arsenverbindungen aus dem Abgas entfernt. Besonders geeignet für die Entfernung von Arsenverbindungen aus Rauchgasen sind Sorbentien auf Basis Titanoxid, da dieselben auch im Bereich höherer Temperaturen von ca. 300 bis 450°C eingesetzt werden können. Ein Verfahren zur Regeneration von mit Arsenverbindungen beladenen Sorbentien auf Basis Titanoxid ist ebenfalls bisher nicht bekannt.

Somit liegt der Erfindung die Aufgabe zugrunde, ein Verfahren zur Regeneration von Katalysatoren und Sorbentien auf Basis Titanoxid zu finden, die durch Arsenverbindungen desaktiviert bzw. mit denselben beladen sind.

Es wurde nun überraschenderweise gefunden, daß arsenkontaminierte Katalysatoren und mit Arsenverbindungen beladene Sorbentien durch eine Wäsche mit anorganischen oder organischen Säuren ihre ursprüngliche Aktivität wiedererlangen.

Gegenstand der vorliegenden Erfindung ist daher ein Verfahren zur Regeneration arsenkontaminierter Katalysatoren und Sorbentien auf Basis Titanoxid, welches dadurch gekennzeichnet ist, daß die arsenkontaminierten Katalysatoren und mit Arsenverbindungen beladenen Sorbentien mit einer anorganischen oder organischen Säure gewaschen werden.

Vorzugsweise werden die Katalysatoren auf Basis Titanoxid zur Entfernung von Stickoxiden aus Abgasen und die Sorbentien auf Basis Titanoxid zur Entfernung von Arsenverbindungen aus Abgasen eingesetzt.

Insbesondere betrifft die Erfindung bezüglich der Regeneration von Katalysatoren solche auf Basis von Titanoxid, die außerdem zusätzliche katalytisch aktive Komponenten, vorzugsweise Oxide des Vanadiums und/oder Molybdäns und/oder Wolframs enthalten. Des weiteren können noch andere Komponenten, wie z. B. SiO_2, ZrO_2, Al_2O_3 Alumosilikate und Tone im Katalysator vorhanden sein. Beispielhaft sei hierzu auf die DE-PS 24 58 888 verwiesen.

Im Zuge der Entwicklung des erfindungsgemäßen Verfahrens ist bei den Untersuchungen zur Desaktivierung von Katalysatoren zur Stickoxidminderung durch Arsenverbindungen festgestellt worden, daß die schädliche Einwirkung der Arsenverbindungen überwiegend aus der Gasphase erfolgt und beispielsweise durch Arsen-III-Oxid als Spezies herrührt.

Die Form des Katalysators oder Sorbens ist für den Erfolg des Verfahrens unwesentlich. Die Wäsche kann durchgeführt werden mit Waben, Platten, Pellets, Strängen, Tabletten und Pulvern, wobei im letztgenannten Fall die Abtrennung von der Waschlösung durch Filtration oder Zentrifugieren erfolgt.

Beispiele für zum Waschen eingesetzte anorganische Säuren sind Salpetersäure, Salzsäure und Schwefelsäure, für organische Säuren Essigsäure. Komplexierende organische Säuren wie Oxalsäure, Malonsäure oder Zitronensäure sind nicht geeignet zur Katalysatorregenerierung, da sie zu einer weiteren Verringerung der Aktivität führen. Dagegen eignen sie sich aber zur Regeneration von Sorbentien zur Arsenentfernung, sofern diese keine komplexierbaren Schwermetallkomponenten enthalten. Vorzugsweise werden die mit Arsenverbindungen beladenen Sorbentien mit Oxalsäure gewaschen.

Die Konzentration der zum Waschen verwendeten Säure beträgt vorzugsweise 1 bis 25 Gew.-% in der wäßrigen Lösung, besonders vorzugsweise 8 bis 15 Gew.-%. Konzentrationen außerhalb dieses Bereiches sind ebenfalls anwendbar, doch bedingen kleinere Werte eine unvorteilhafte lange Behandlungsdauer und große Volumina, während höhere Konzentrationen keine Verbesserung mehr mit sich bringen und die Handhabung erschweren. Im Fall der Verwendung von Schwefelsäure zum Waschen ist es vorteilhaft, derselben Wasserstoffperoxid zuzusetzen, so daß der Gehalt an Wasserstoffperoxid, bezogen auf die gesamte Säurelösung, 0,1 bis 2 Gew.-% beträgt.

Die Regeneration geschieht bevorzugt durch Tauchen des Katalysators oder Sorbens in der Säure. Vorteilhaft erfolgt die Behandlung, d. h. die Wäsche mit Säuren, bei erhöhten Temperaturen von 50 bis 90°C und unter Bewegung des Säurebades, beispielsweise durch Umpumpen oder Durchblasen von Luft. Typische Behandlungsdauern liegen zwischen 5 Minuten und 5 Stunden. Anschließend wird mehrfach mit Wasser gewaschen, vorzugsweise auch hier bei erhöhter Temperatur, bei 100 bis 200°C getrocknet und ggf. bei 350 bis 500°C getempert.

Die Erfindung wird durch die folgenden Beispiele näher erläutert:

Beispiel 1

Regeneration von Katalysatoren

Für die Versuche wurden drei handelsübliche Typen von Wabenkatalysatoren für die Stickoxidminderung verwendet, die nach dem Einsatz in kohlebefeuerten Kraftwerken in ihrer Aktivität stark gemindert waren und einen deutlichen Gehalt an Arsen aufwiesen.

Die Katalysatoren bestanden überwiegend, d. h. zu mehr als 80 Gew.-%, aus Titanoxid.

Hierbei enthielt der Katalysator K1 Vom Typ KW 33 221 zusätzlich noch 7 Gew.-% WO_3, der Katalysator K2 von Typ KW 22 120 zusätzlich 7 Gew.-% WO_3 und 0,35 Gew.-% V_2O_5 und der Katalysator K3 vom Typ KW 32 221 zusätzlich 8 Gew.-% WO_3 und 0,7 Gew.-% V_2O_5. Alles sind Katalysatoren der Hüls AG.

Die arsenkontaminierten Katalysatoren wurden nun wie folgt mit einer Säure gewaschen:

Aus den desaktivierten Katalysatorwaben wurden zuerst Stücke von 100 mm Länge und 16.2 mm Kantenlänge mit 2mal 2 Kanälen herausgeschnitten. Anschließend stellte man diese Stücke in ein Glasrohr mit poröser Bodenplatte, in welchem sich 100 ml Säure mit einer Temperatur von 80°C befanden. Unter Durchleiten von Luft wurde zwei Stunden lang behandelt, d. h. mit Säure gewaschen. Anschließend entnahm man die Katalysatorstücke dem Säurebad und tauchte sie dreimal für jeweils zwei Minuten in 50 ml Wasser mit einer Temperatur von 80°C. Nach dem Abtropfen wurde 2 h bei 120°C getrocknet und 16 h bei 450°C getempert.

Die einzelnen Katalysatoren wurden jeweils mit den nachfolgend aufgeführten Säuren der folgenden Konzentrationen gewaschen:

Katalysator K1	mit jeweils 2, 5 und 10gew.-%iger Salzsäure (siehe **Abb.** 1),
Katalysator K2	mit 10gew.-%iger Salzsäure (siehe **Abb.** 2), 10gew.-%iger Salpetersäure (siehe **Abb.** 3), 2gew.-%iger Schwefelsäure, die zusätzlich 0,35 Gew.-% H_2O_2, bezogen auf die gesamte Säurelösung, enthielt (siehe **Abb.** 4), 10gew.-%er Essigsäure (siehe **Abb.** 5) und mit 10gew.-%iger Oxalsäure (siehe **Abb.** 6) und
Katalysator K3	mit 10gew.-%iger Salzsäure und mit 2gew.-%iger Schwefelsäure, die zusätzlich 0,35 Gew.-% H_2O_2, bezogen auf die gesamte Säurelösung, enthielt (siehe **Abb.** 7).

Bei Katalysator K3 betrug die Waschdauer mit der Säure nur 30 Minuten.

Der Katalysator K1 enthielt vor der Regeneration 0,15 Gew.-% Arsen, berechnet als As, K2 0,26 Gew.-% und K3 0,36 Gew.-%. Nach der Wäsche mit Säure verblieben im Katalysator K1 noch 0,01 Gew.-% Arsen. Aus den Katalysatoren K2 und K3 wurden durch die Säurewäsche, ausgenommen mit Oxalsäure, 20 bis 40% des Arsens sowie bis zu 0,6% des WO_3 und bis zu 3% des V_2O_5, bezogen auf die Ausgangsgehalte, entfernt. Da die Reaktivierung trotz Verbleibs eines großen Teils des Arsens im Katalysator gelang, wird vermutet, daß gezielt die für die Stickoxidminderung verantwortlichen, katalytisch aktiven Zentren von ihrer Blockade durch Arsen befreit wurden. Mit Oxalsäure wurden zwar 50% des Arsens, jedoch auch 23% des WO_3 und 4% des V_2O_5 herausgewaschen, so daß in der Bilanz eine nicht vertretbare Schädigung des Katalysators eintrat.

Aktivitätstestung

Die Katalysatoren K1, K2 und K3 wurden in einem elektrisch beheizten Rohrreaktor bezüglich ihrer Aktivität für die Stickoxidreduktion getestet, und zwar in allen Fällen in jeweils frischem, desaktivierten und regenerierten Zustand. Hierbei leitete man durch ein Wabenstück von 100 mm Länge und 16,6 mm Kantenlänge mit 2×2 Kanälen 290 Normliter pro Stunde eines vorgemischten Testgases, das

5 Vol.-%O_2,
1000 Vol.-ppm NO_x mit mehr als 95% NO,
1000 Vol.-ppm SO_2
1000 Vol.-ppm NH_3 und
94,7 Vol.-ppm N_2

enthielt. und registrierte im Temperaturbereich zwischen 200 und 450°C die verbliebene Stickoxidkonzentration im abströmenden Gas mittels Stickoxid-Analysator. Um für die Dauereigenschaften der Katalysatoren ein uncharakteristisches Anfangsverhalten auszuschließen, wurde mit den Messungen erst nach 16stündigem Durchleiten des Testgases bei 350°C begonnen.

Die Versuchsergebnisse werden als prozentualer Stickoxid-Umsatz (NO_x-Umsatz) in Abhängigkeit von der Temperatur in den Abbildungen 1 bis 7 zusammenfassend dargestellt:

—**Abb.** 1 zeigt am Beispiel der Regeneration des Katalysators K1 durch Waschen mit

2gew.-%iger,
5gew.-%iger und
10gew.-%iger Salzsäure

den Einfluß der Säurekonzentration auf das Ausmaß der Regeneration. Überraschenderweise verlieh die Säurewäsche mit 10gew.-%iger Säure dem regenerierten Katalysator K1 eine höhere Aktivität als im frischen Zustand. Vermutlich werden durch die Wäsche neue Brönstedt-Säurezentren geschaffen, die als förderlich für die Stickoxidreduktion angesehen werden.

Legende zur **Abb.** 1:
○ Frischkatalysator
● desaktivierter Katalysator
□ Regenerierung mit 2%iger Salzsäure
■ Regenerierung mit 5%iger Salzsäure
△ Regenerierung mit 10%iger Salzsäure

—**Abb.** 2 bis 5 zeigen den Erfolg der Regeneration des Katalysators K2 durch Wäsche mit 10gew.-%iger Salzsäure (**Abb.** 2), 10gew.-%iger Salpetersäure (**Abb.** 3), 2gew.-%iger Schwefelsäure, die zusätzlich 0,35 Gew.-% H_2O_2, bezogen auf die gesamte Säurelösung, enthält (**Abb.** 4), und mit 10gew.-%iger Essigsäure (**Abb.** 5). Hier ist in allen Fällen die Aktivität des regenerierten Katalysators, vor allem bei höheren Temperaturen, etwas geringer als die des frischen. Ursache dafür ist das Herauslösen eines kleinen Teils des Schwermetallgehaltes. Dieser Effekt kann bei Bedarf in bekannter Weise durch Nachimprägnieren mit Vanadyloxalat- oder Ammoniumvanadat-Lösung rückgängig gemacht werden, ist jedoch im allgemeinen zu dulden.

Legende zu den **Abb.** 2 bis5:
○○ Katalysator frisch
●● Katalysator desaktiviert
△△ Katalysator reaktiviert

—**Abb.** 6 zeigt am Beispiel des Katalysators K2, daß eine Wäsche mit 10gew.-%iger Oxalsäurelösung zu einer deutlichen, weiteren Verschlechterung der Aktivität des Katalysators führt. Ursache dafür ist das Herauslösen erheblicher Teile der Schwermetallkomponenten. Hier wäre ein Nachimprägnieren ebenfalls möglich, jedoch unwirtschaftlich.

Legende zu den **Abb.** 6:
○○ Katalysator frisch
●● Katalysator desaktiviert
△△ Regenerationsversuch

—**Abb.** 7 zeigt die Regeneration des Katalysators K3 mit 10gew.-%iger Salzsäure und mit 2gew.-%iger Schwefelsäure, die zusätzlich 0,35 Gew.-% H_2O_2, bezogen auf die gesamte Säurelösung, enthält. Das Erscheinungsbild entspricht dem bei der Regeneration des Katalysators K2.

Legende zu den **Abb.** 7:
○○ Katalysator frisch
●● Katalysator desaktiviert
△△ Katalysator mit 2gew.-%iger H_2SO_4 mit 0,35 Gew.-% H_2O_2 regeneriert
▲▲ Katalysator mit 10gew.-%iger HCl regeneriert

Beispiel 2

Regeneration eines Sorbens

Kalzinierte Strangpreßlinge aus VKR-611, einer sprühgetrockneten Metatitansäure mit ca. 6 Gew.-% Sulfatgehalt der Firma Sachtleben Chemie, deren Sulfatgehalt vor dem Kalzinieren durch Wäsche mit Ammoniakwasser entfernt worden war und die nach dem Kalzinieren eine BET-Oberfläche von 71 m^2/g besaßen, wurden durch Kontaktieren mit einem Arsen-III-Oxid enthaltenden Gasstrom mit 3,8 Gew.-% Arsen beladen. 15 g der mit Arsen beladenen Strangpreßlinge wusch man auf die gleiche Weise, wie in Beispiel 1 beschrieben, zwei Stunden lang mit 10gew.-%iger Oxalsäure und dann mit Wasser. Anschließend wurden sie für zwei Stunden bei 120°C und für 1 Stunde bei 450°C getrocknet. 50% der Arsenbeladung wurden auf diese Weise entfernt. Bei erneutem Einsatz zur Arsenentfernung aus einem Gasstrom zeigte das Sorbens den entsprechenden Teil seiner früheren Aufnahmekapazität.

Patentansprüche

1. Verfahren zur Regeneration arsenkontaminierter Katalysatoren und Sorbentien auf Basis Titanoxid, **dadurch gekennzeichnet,** daß die arsenkontaminierten Katalysatoren und mit Arsenverbindungen beladenen Sorbentien mit einer anorganischen oder organischen Säure gewaschen werden.
2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die Katalysatoren auf Basis Titanoxid zur Entfernung von Stickoxiden aus Abgasen und die Sorbentien auf Basis Titanoxid zur Entfernung von Arsenverbindungen aus Abgasen eingesetzt werden.
3. Verfahren nach den Ansprüchen 1 und 2, dadurch gekennzeichnet, daß zum Waschen Salpetersäure, Salzsäure, Schwefelsäure oder Essigsäure eingesetzt werden.
4. Verfahren nach den Ansprüchen 1 und 2, dadurch gekennzeichnet, daß die mit Arsenverbindungen beladenen Sorbentien mit Oxalsäure gewaschen werden.
5. Verfahren nach den Ansprüchen 1 und 4, dadurch gekennzeichnet, daß die Konzentration der zum Waschen verwendeten Säure 1 bis 25 Gew.-% in der wäßrigen Lösung beträgt.
6. Verfahren nach Anspruch 5, dadurch gekennzeichnet, daß die Konzentration der zum Waschen verwendeten Säure 8 bis 15 Gew.-% in der wäßrigen Lösung beträgt.
7. Verfahren nach den Ansprüchen 1, 2, 3, 5 und 6, dadurch gekennzeichnet, daß die zum Waschen verwendete Schwefelsäure zusätzlich 0,1 bis 2 Gew.-% Wasserstoffperoxid, bezogen auf die gesamte Säurelösung, enthält.
8. Verfahren nach den Ansprüchen 1 und 7, dadurch gekennzeichnet, daß die Wäsche mit Säuren bei Temperaturen von 50 bis 90°C erfolgt.
9. Verfahren nach den Ansprüchen 1 und 8, dadurch gekennzeichnet, daß nach der Wäsche mit Säuren die Katalysatoren und Sorbentien mit Wasser gewaschen, getrocknet ggf. getempert werden.
10. Verfahren nach den Ansprüchen 1, 2, 3 und 5 bis 9, dadurch gekennzeichnet, daß die zu regenerierenden Katalysatoren auf Basis Titanoxid außerdem zusätzlich katalytisch aktive Komponenten enthalten.
11. Verfahren nach Anspruch 10, dadurch gekennzeichnet, daß die zu regenerierenden Katalysatoren auf Basis Titanoxid als zusätzlich katalytisch aktive Komponenten Oxide des Vanadiums und/oder Molybdäns und/oder Wolframs enthalten.

Nummer: 38 16 600
Int. Cl.^{4}: B 01 J 21/20
Anmeldetag: 14. Mai 1988
Offenlegungstag: 23. November 1989

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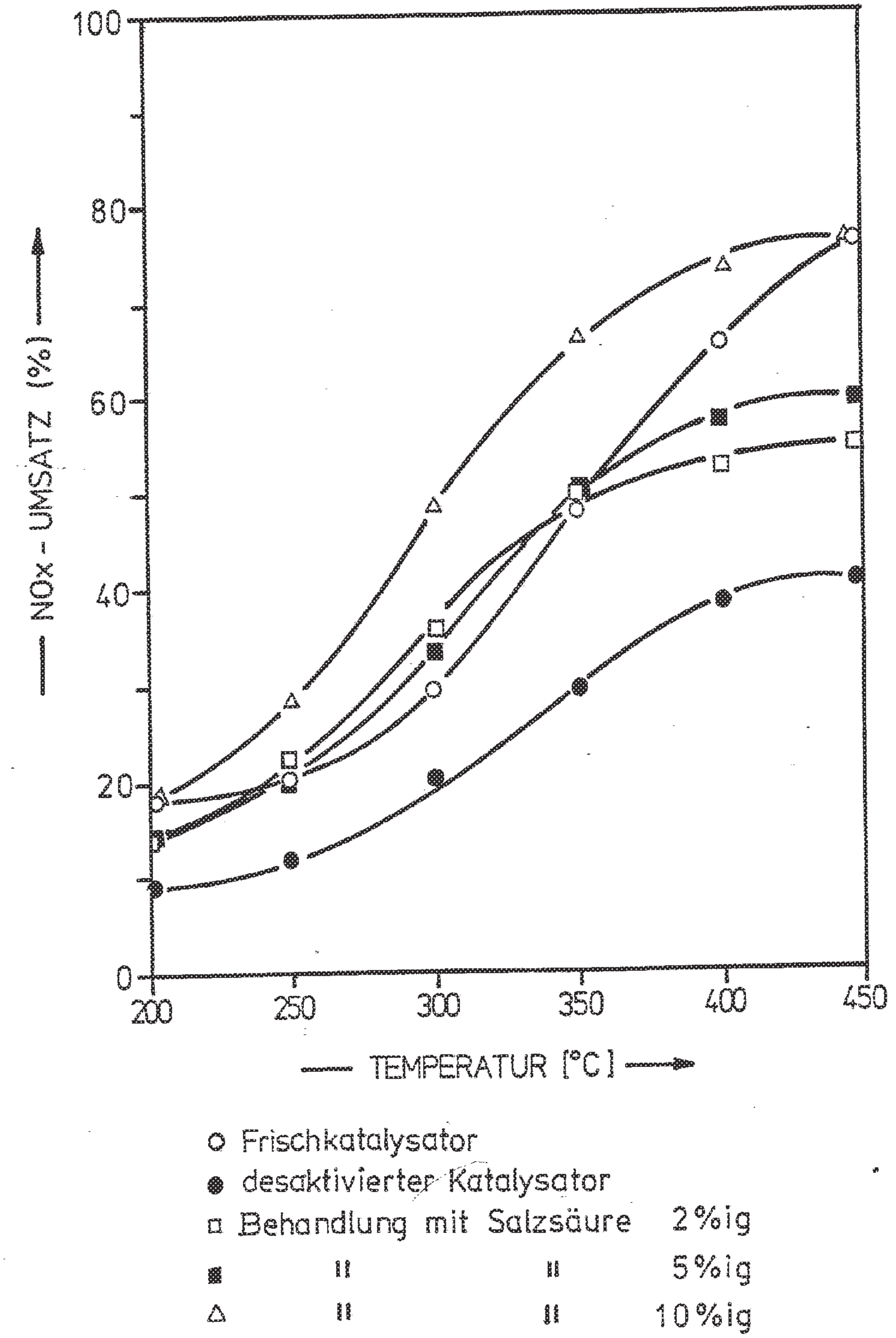
REGENERATION DES KATALYSATORS K 1

EINFLUSS DER SÄUREKONZENTRATION

Abb. 1



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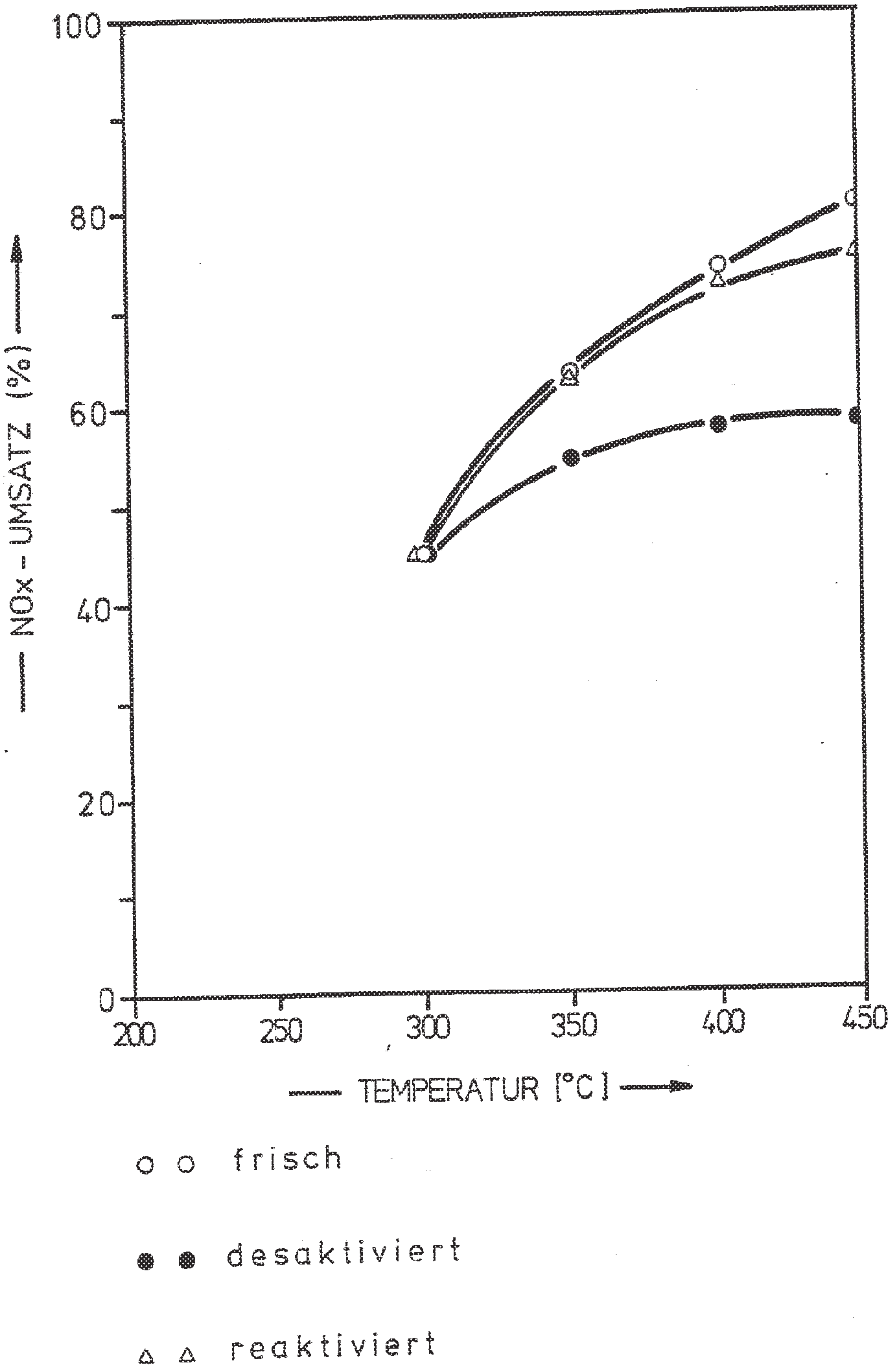
KATALYSATOR K 2

REGENERATION MIT 10%iger SALZSÄURE

Abb. 2



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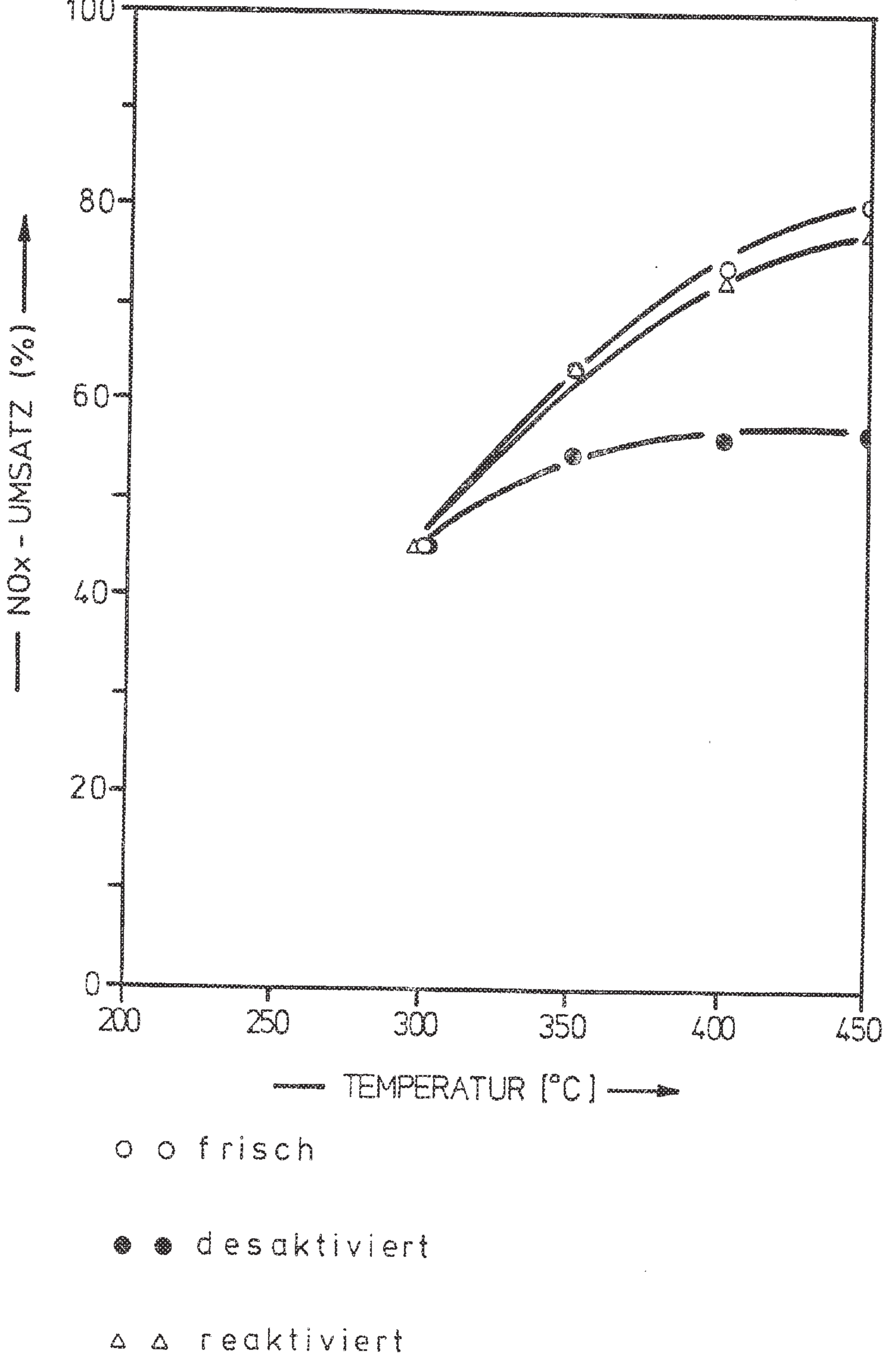
KATALYSATOR K 2

REGENERATION MIT 10 gew.%iger SALPETERSÄURE

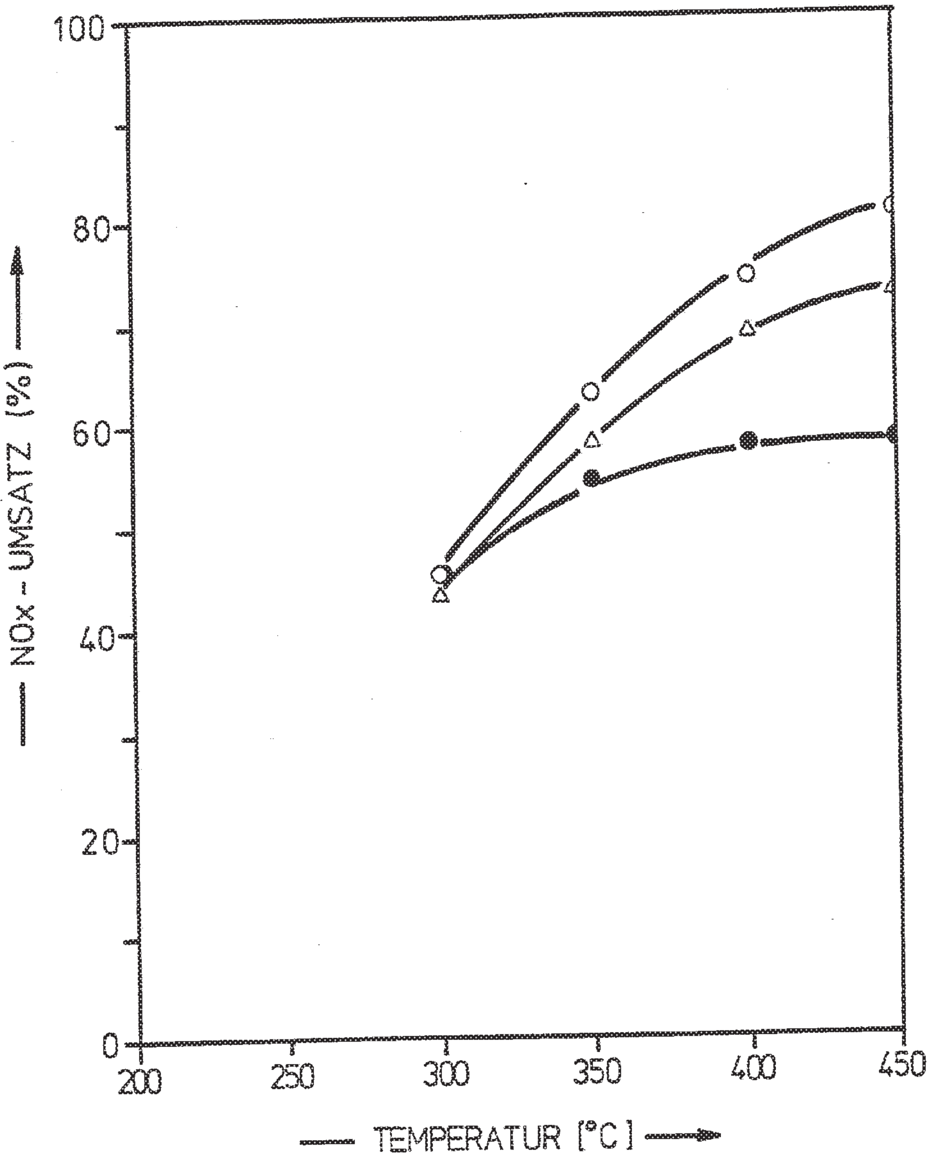
Abb. 3



KATALYSATOR K 2

REGENERATION MIT 2 gew.%iger SCHWEFELSÄURE
MIT 0,35 Gew.% H_2O_2

Abb. 4



○ ○ frisch

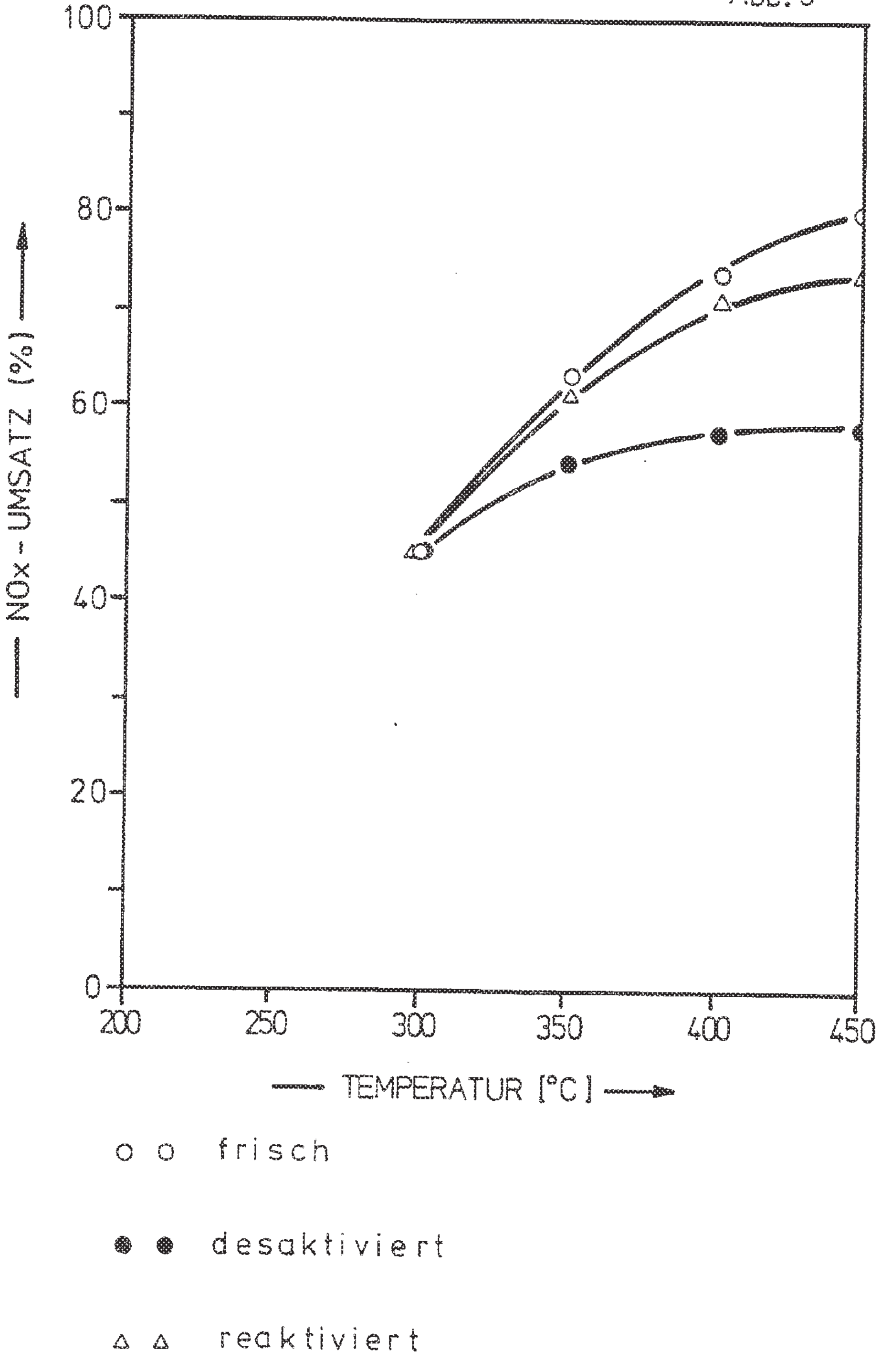
● ● desaktiviert

△ △ reaktiviert

KATALYSATOR K 2

REGENERATION MIT 10gew.%iger ESSIGSÄURE

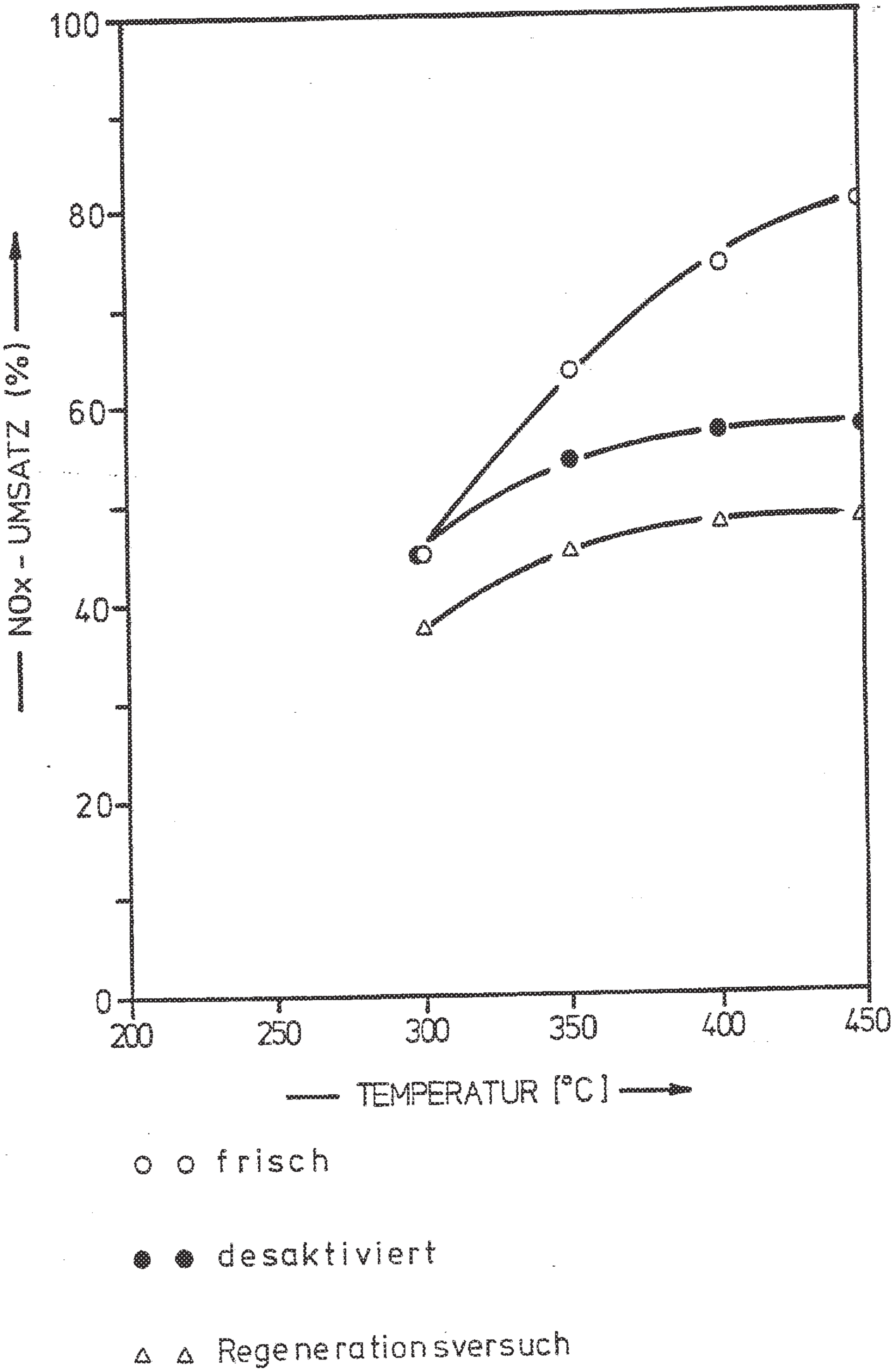
Abb. 5



KATALYSATOR K2

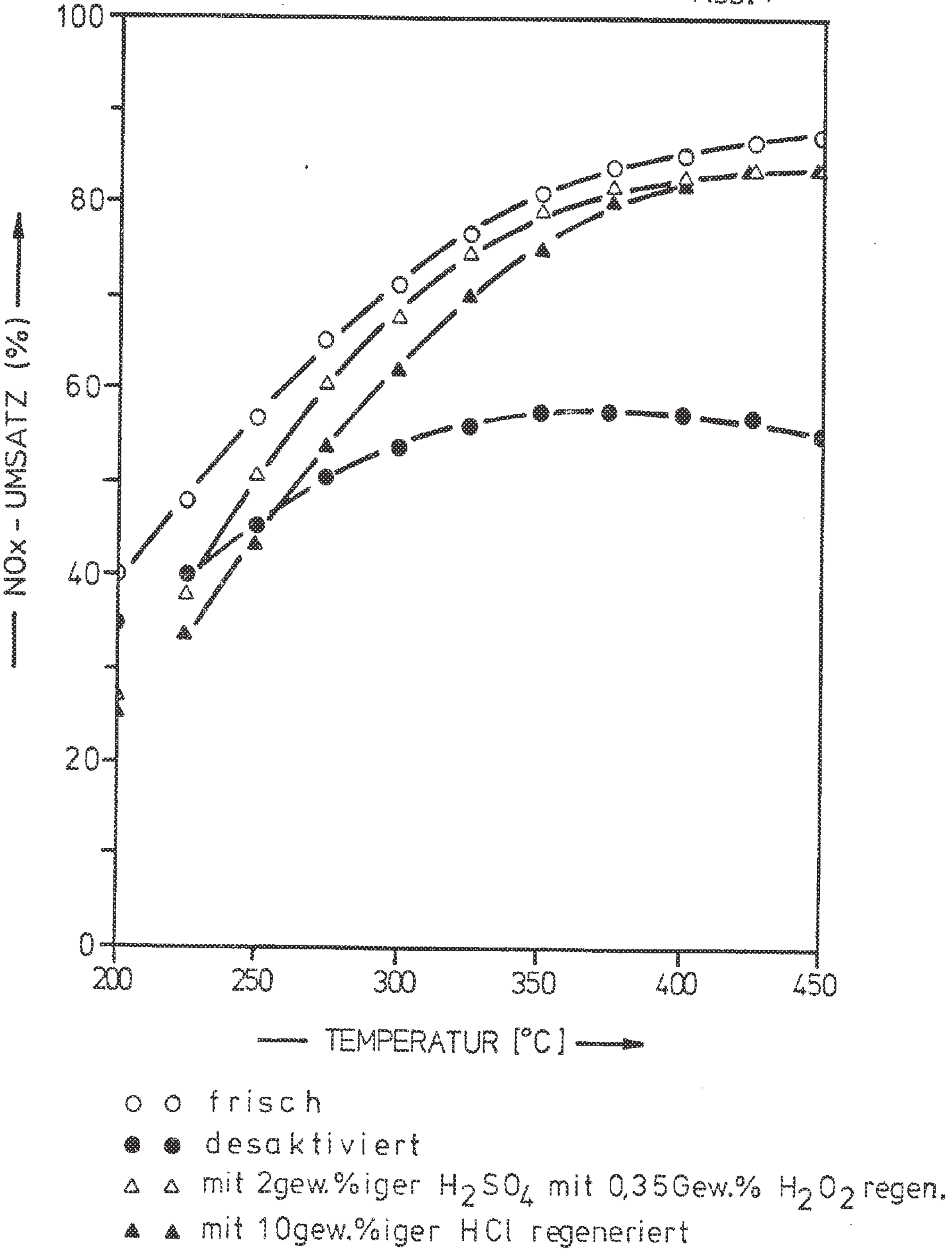
REGENERATIONSVERSUCH
MIT 10gew.%iger OXALSÄURE

Abb. 6



REGENERATION DES KATALYSATORS K3

Abb. 7



(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 208 490**
A1

(12)
EUROPEAN PATENT APPLICATION

(21) Application number: 86305054.8

(22) Date of filing: 27.06.86

(51) Int.Cl.⁴: **B 01 D 53/34**

(30) Priority: 01.07.85 DK 2984/85

(43) Date of publication of application:
14.01.87 Bulletin 87/3

(84) Designated Contracting States:
AT CH DE LI SE

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(54) A process for removal of mercury vapor and vapor of chlorodibenzodioxins and -furans from a stream of hot flue gas.

(57) Mercury vapor and/or vapor of chlorodibenzodioxins and/or vapor of chlorodibenzofurans are removed from a stream of hot flue gas together with acidic components of the flue gas in a spray absorption process. The absorbent used in said process is an aqueous liquid which besides alkaline components contains suspended activated carbon.

Croydon Printing Company Ltd.

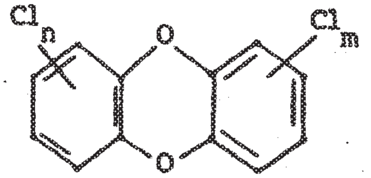
A process for removal of mercury vapor and vapor of chlorodibenzo-dioxins and -furans from a stream of hot flue gas.

FIELD OF THE INVENTION.

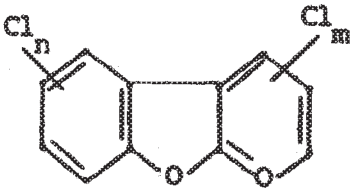
It is a well recognized fact that flue gases often contain mercury vapor in such amounts that their release into the atmosphere is regarded as being hazardous. This especially applies to flue gases from incineration plants where domestic refuse is incinerated but also flue gas formed by combustion of certain coals may contain mercury vapor in such amounts that it is highly desirable to remove a substantial part of said mercury vapor before releasing the flue gas into the atmosphere.

In the present specification and the attached claims the term mercury vapor means elementary mercury as well as mercury-containing chemical compounds in the vapor phase.

In recent years a growing concern has arisen as to the presence in flue gases of the toxic polychlorodibenzodioxines (PCDD) and polychlorodibenzofurans (PCDF). Said two series of compounds may be represented by the following formulae



PCDD



PCDF

wherein n and m each independently is an integer from 0 through 4 provided that n + m is at least 2.

PCDD and PCDF are present in flue gases from incineration plants and in minor proportion also in the flue gases from power plants. In flue gases these compounds are primarily present in vapor phase and in the present specification the above abbreviations denote the compounds as vapors.

The extremely high toxicity of certain of these compounds makes it desirable to avoid their release into the atmosphere.

DESCRIPTION OF PRIOR ART.

Numerous methods have been suggested for removing or recovering mercury from gases. However, the majority of the prior art processes have been created with the purpose of removing mercury from relative small amounts of gas having high mercury concentration. These processes are not suitable for cleaning flue gas since costs of chemicals would be prohibitive or operation would be impracticable in connection with large volumes of flue gas.

Processes for removing mercury from air of relatively low mercury content have also been suggested. Such a process is disclosed in published European Patent Application No. 1.456. (Akzo N.V.). Said process which is described as particularly suitable for the removal of mercury from air which is vented from buildings, is based on the principle that mercury vapor is absorbed as mercury chloride when passing a bed of activated carbon having a specific chlorine content. According to the specification to said European application high moisture content of the gas from which mercury is to be removed, should be avoided since the effectiveness of the activated carbon is reduced thereby. From said specification it also appears that activated carbon used in a stationary bed without chlorine is unsatisfactory as absorbent for mercury and has a very low capacity for that purpose.

The process of said European application seems unsuitable for treating flue gas since it would require the total amount of flue gas to be passed through a bed of activated carbon to which gaseous chlorine is added, which obviously involves the risk that a surplus of chlorine may be entrained with the flue gas to the atmosphere.

A process for removing mercury vapor from a hot hydrogene chloride-containing flue gas is disclosed in published European patent application no. 13.567, (Svenska Fläktfabriken). According to said process the gas which contains hydrogen chloride and minor amounts of mercury vapor, is contacted with powdered calcium hydroxide, preferably in a fluidized bed. The hydrogen chloride in the gas reacts with the calcium hydroxide to form calcium chloride which apparently is essential to the removal of mercury. Said process is restricted to gases having a substantial contents of hydrogen chloride. This condition will often be fulfilled by the flue gas from a waste incineration plant while flue gasses from other sources may be deficient in that respect.

US patent specification 4.273.747 (Rasmussen) discloses removal of mercury from hot waste gasses by atomizing an aqueous liquid into the waste gasses in the presence of fly ash suspended in the gas and subsequently separating the fly ash together with a substantial part of the mercury originally present as vapor. It is essential that by said treatment the gas stream is cooled from a temperature of at least 200°C to a temperature below 160°C. The aqueous liquid may be just water or it may be an aqueous solution or suspension of an alkaline compound, preferably calcium hydroxide.

Obviously said method will not be suitable in case it is not acceptable to cool the gas to the extent required or if the amount of fly ash is insufficient due to the use of a preceding fly ash separation. Even when the conditions as to fly ash contents of the flue gas and cooling are satisfied it would in certain applications be desired to increase the efficiency of the removal of mercury vapor in said process.

Efforts to reduce the PCDD and PCDF levels in flue gas have hitherto mainly concentrated on thermal destruction. A reliable thermal destruction is, however, difficult to establish, since a very high temperature is required to ensure a complete destruction.

According to a paper of A.J. Teller and J. D. Lauber : "Control of Dioxin Emissions from Incineration" presented at the 76th annual meeting of the Air Pollution Control Association, Atlanta, Georgia, June 19 - 24, 1983, dioxin theoretic estimations indicate that emission may be reduced by condensing the dioxin thereof. However, A. Nottrodt et al: "Emissionen von polychlorierten Dibenzodioxinen und polychlorierten Dibenzofuranen aus Abfallverbrennungsanlagen", Müll und Abfall 11/84, p. 313-327 (Erich Schmidt Verlag GmbH Berlin, Bielefeld, München) state results showing high vapor phase concentrations after several wet scrubbings with flue gas temperatures lower than those obtained in the theoretic estimations made in said paper by Teller and Lauber.

Consequently a need excists for efficient measures for removing not only mercury vapor but also PCDD and PDCF vapors from flue gases.

SUMMARY OF THE INVENTION.

The present invention is directed to a novel process for efficient removal of mercury vapor and PCDD and PCDF from a stream of hot flue gas, which process provides a simultaneous removal of acidic components of the flue gas.

It has turned out that incorporation of a relatively small amount of activated carbon in an alkaline feed suspension to be spraydried in a spray absorption process enables a surprising improvement of the ability of the process to remove mercury, PCDD and PCDF.

Consequently the process according to the invention is characterized in that an aqueous liquid which besides alkaline components comprises suspended activated carbon is spray dried in the flue gas which subsequently is freed from the resulting particulate material.

The amount of activated carbon to be used depends on the amount of mercury vapor as well as PCDD and PCDF in the flue gas, on the limits for emission which it is intended to meet, on the extent to which cooling of the gas is permissible, on the proportion of fly ash and the character thereof, etc.

Usually the amount of activated carbon will correspond to at least 5 mg per Nm^3 flue gas to be treated. For economic reasons the amount will usually not exceed 500 mg per Nm^3 flue gas, peferrably not 200 mg per Nm^3.

Since the prior art describes activated carbon as not being very suitable for absorption of mercury vapor when no chlorine is present and since high moisture conditions are described as harmful to mercury sorption by means of activated carbon together with chlorine it could not be predicted that a very efficient mercury removal is obtained by the very simple measures prescribed by the present process. It is also surprising that the rather small additions of activatet carbon to the aqueous liquid to be atomized, which come into consideration by the present process, enables a reduction of PCDD and PCDF levels to extremely low values.

The preferred alkaline component for the simultaneous removal of acidic components of the gas is calcium hydroxide which by chemical reaction absorbs e.g. sulphur oxides and hydrogen chloride. However, it is to be observed that by the process of the invention presence of hydrogen chloride and consequently production of calcium chloride is not necessary to achieve an efficient removal of mercury vapor.

The fact that in the present process the activated carbon is initially present in aqueous suspension in the atomized droplets and subsequently is embedded in the particulate material comprising the reaction products of e.g. calcium hydroxide and the acidic components of the gas, apparently does not have any substantial adverse influence on the absorption ability of the activated carbon, as would have been expected.

The process of the present invention may be performed using those measures which are conventional in spray absorption processes for desulfurization of flue gases, e.g. as described in US patent 4,279,873 (Felsvang et al), incorporated herein by reference.

In the typical embodiment the process of the invention is performed on a stream of flue gas the fly ash of which has previously been removed in a particle collector, e.g. an electrostatic precipitator. However, the absorption of mercury vapor by activated carbon may be used as a supplement to the absorption by means of fly ash as described in the above cited US specification 4,273,747, in which case at least a portion of the fly ash present in the flue gas stream remains in said stream during the spray absorption process and is recovered together with the particulate material formed by the spray absorption process.

It is also possible to add fly ash to the liquid to be atomized, thereby utilizing the sorption ability of the fly ash to reduce the requirement for activated carbon.

Also other absorbents such as silicates may be added to the liquid to be atomized to minimize the requirement as to activated carbon.

As indicated above the amount of activated carbon necessary to achieve a substantial reduction of the concentration of mercury vapor and PCDD and PCDF in the flue gas is surprisingly small. The actual amounts to be used in each individual case may easily be fixed by a person skilled in the art on the basis of a few tests.

It is an important feature of the invention that by very simple measures a very flexible process is obtained since even flue gases with substantially varying levels of Hg, PCDD and PCDF may be coped with just by changing the amount of activate carbon added to the liquid to be atomized.

The particulate material formed in the spray absorption process and typically comprising calcium sulfite, calcium sulfate, calcium hydroxide and activated carbon and possibly fly ash is preferably separated from the flue gas in a baghouse which enables a prolonged contact between the particulate material and the flue gas.

In the following the process according to the invention will be further illustrated by means of examples.

In these examples analysis was performed on flue gas withdrawn by means of a heated probe with glass lining and equipped with a glass wool filter. The mercury was collected in two impinger flasks in series containing an aqueous 5% potassium permanganate - nitric acid solution. Mercury was analyzed by flameless atomic absorption using $NaBH_4$ as a reductant (MHS-20, Mercury/ Hydride System by Perkin Elmer, ref. 338 - A2-M 294/ 12.79).

It is to be observed that methods previously used for determination of Hg in flue gases have not always been accurate and have often indicated values lower than the actual ones. Consequently the reults obtained as to removal of Hg vapor in the following examples may not be comparable with prior art results determined by means of less accurate methods of analysis.

EXAMPLE 1

Eight test runs were performed using a partial stream of the flue gas from an incineration plant wherein domestic waste was incinerated.

The spray absorption process was performed in a spray absorber the chamber of which comprised a cylindrical portion having a diameter of 1.2 m and a hight of 0.8 m, and a conical bottom portion the cone angle of which was 60°. The spray absorber was provided with a rotary atomizer. Downstream of the spray absorber particle separation was performed using a baghouse.

An aqueous suspension of slaked lime or an aqueous solution of sodium carbonate (solids content of the suspension or solution app. 5%) was used as feed for the atomizer.

The temperature of the flue gas when led to the spray absorber was 225-300°C and the amount of fly ash therein was 0.5-1.0 g/Nm^3 in run nos. 1-5 whereas run nos. 6-8 were performed using flue gas with substantially no fly ash. The flue gas was supplied in an amount of 300 kg/h.

The concentration of mercury vapor was measured upstream of the spray absorber, between the spray absorber and the baghouse filter and downstream of the baghouse filter.

Run nos. 1 and 7 were performed for comparison and no activated carbon was added to the feed suspension of slaked lime or feed solution of sodium carbonate. In runs 2 through 6 and in run 8 activated carbon was added to said feed solution in an amount of app. 2% by weight of the solids content, corresponding to 0,04-0,05 g/Nm^3 of flue gas.

The following results were obtained:

	Run no.							
	1	2	3	4	5	6	7	8
<u>Upstream of spray absorber</u>								
Hg vapor, $\mu g/Nm^3$	241	290	725	517	314	423	213	405
Absorbent	Slaked lime	Slaked lime + activated carbon	slaked lime + activated carbon	slaked lime + activated carbon	slaked lime + activated carbon	slaked lime + activated carbon	Na_2CO_3	Na_2CO_3 + activated carbon
<u>Between spray absorber and baghouse</u>								
Gas temperature, °C	130	130	100	160	175	165	130	130
Hg vapor, $\mu g/Nm^3$	77	46	not analysed	not analysed	not analysed	not analysed	not analysed	not analysed
<u>Downstream the baghouse</u>								
Hg vapor, $\mu g/Nm^3$	30	20	11	42	63	80	96	47
% removal	87.6	93	98.9	92.9	79.9	81.1	54.9	88.4

The above results clearly indicate that activated carbon acts as a very efficient absorbent for mercury vapor when utilized in the process of the present invention.

EXAMPLE 2

Two further test runs was made in the same plant and under similar conditions as described in example 1, except that the flue gas temperature varied between 280 and 300°C.

The results obtained are listed in the following table:

	Run No.	
	9	10
<u>Upstream of spray absorber</u>		
PCDD[1] +PCDF, μg/Nm³	0.38	0.53
Absorbent	slaked lime	slaked lime + activated carbon
<u>Between spray absorber and baghouse</u>		
Gas temperature, °C	150	150
PCDD[1] +PCDF, μg/Nm³	not analysed	0.28
<u>Downstream the baghouse</u>		
PCDD[1] +PCDF, μg/Nm³	0.047	0.01
% removal	87.8	98.1

[1] The PCDD contents were approximately 35-45% of the total contents of PCDD and PCDF.

CLAIMS

1. A process for removal of mercury vapor and/or vapor of chlorodibenzodioxins and/or vapor of chlorodibenzofurans from a stream of hot flue gas combined with a simultaneous removal of acidic components of the flue gas, characterized in that an aqueous liquid, which besides alkaline components comprises suspended activated carbon is spray dried in the flue gas which subsequently is freed from the resulting particulate material.

2. The process of claim 1, wherein the amount of activated carbon in said aqueous liquid amounts to 5-500 mg per Nm^3 flue gas being treated.

3. The process of claim 1, wherein the amount of activated carbon in said aqueous liquid amounts to 5-200 mg per Nm^3 flue gas being treated.

4. The process of claim 1, wherein said alkaline components comprise calcium hydroxide in a quantity at least sufficient to neutralize a substantial part of the acidic components, such as sulfuroxides and hydrogen chloride, of the flue gas.

5. The process of claim 1, wherein said particulate material is recovered in a baghouse.

6. The process of claim 1, wherein at least a portion of any fly ash present in the flue gas stream remains in said stream during the spray absorption process and is recovered together with the particulate material formed by the spray absorption process.

7. The process of claim 1, wherein at least a portion of any fly ash present in the flue gas stream is collected from said stream before said aqueous liquid is spray dried therein, and at least a part of the collected fly ash is suspended in said aqueous liquid before spraying thereof.

European Patent Office

EUROPEAN SEARCH REPORT

Application number

0208490

EP 86 30 5054

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	US-A-4 049 399 (TELLER ENVIRONMENTAL SYSTEMS) ---		B 01 D 53/34
A	US-A-2 886 131 (J.R. CONLISK) ---		
D,A	US-A-4 273 747 (E. RASMUSSEN) ---		
A	US-A-4 246 242 (C.H.S. BUTLER) ---		
A	CHEMICAL ABSTRACTS, vol. 88, no. 2, 9th January 1978, page 125, abstract no. 9181j, Columbus, Ohio, US; T. HALMOE: "Micropollutants from an incineration plant lower than expected", & FAST AVFALL 1977, (1), 29-31 -----		TECHNICAL FIELDS SEARCHED (Int. Cl.4) B 01 D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	26-08-1986	PYFFEROEN K.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document
T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
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EPO Form 1503 03 82

Espacenet

Bibliographic data: EP1386655 (A1) — 2004-02-04

Process for removing mercury from flue gases

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Classification:	**- international:** ***B01D53/34; B01D53/64; B01D53/86; B01J27/06;*** (IPC1-7): B01D53/64 **- cooperative:** **B01D53/64**
Application number:	EP20030016026 20030715 Global Dossier
Priority number(s):	DE2002133173 20020722
Also published as:	EP1386655 (B1) AT383193 (T) AU2003220713 (A1) AU2003220713 (B2) AU2003220713 (B8) more

Abstract of EP1386655 (A1)

Mercury is removed from flue gases of high-temperature plants by feeding bromine and/or a bromine compound to a multi-stage furnace and/or to the flue gas, and subjecting the flue gas to a multi-stage clean-up. The combustion takes place in the presence of a sulfur compound, particularly sulfur dioxide, with or without the addition of sulfur and/or a sulfur compound and/or a mixture of various sulfur compounds. The removal of mercury from flue gases of high-temperature plants, comprises feeding bromine and/or a bromine compound and/or a mixture of various bromine compounds to a multi-stage furnace and/or to the flue gas in a plant section downstream of the furnace, the temperature during the contact of the bromine compound with the flue gas being >= 500[deg]C, preferably >= 800[deg]C. The combustion takes place in the presence of a sulfur compound, particularly sulfur dioxide, with or without the addition

of sulfur and/or a sulfur compound and/or a mixture of various sulfur compounds. The flue gas is subjected to a multi-stage clean-up comprising a wet scrubber and/or a dry clean-up.

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 386 655 A1

(12) EUROPÄISCHE PATENTANMELDUNG

(43) Veröffentlichungstag:
04.02.2004 Patentblatt 2004/06

(51) Int Cl.7: **B01D 53/64**

(21) Anmeldenummer: **03016026.1**

(22) Anmeldetag: **15.07.2003**

(84) Benannte Vertragsstaaten:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LI LU MC NL PT RO SE SI SK TR
Benannte Erstreckungsstaaten:
AL LT LV MK

(30) Priorität: **22.07.2002 DE 10233173**

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(54) Verfahren zur Abscheidung von Quecksilber aus Rauchgasen

(57) Die Erfindung beschreibt ein Verfahren zur Abscheidung von Quecksilber aus Rauchgasen von Hochtemperaturanlagen, insbesondere von Kraftwerken und Abfallverbrennungsanlagen, bei dem der, gegebenenfalls mehrstufigen, Feuerung und/oder dem Rauchgas in einem der Feuerung nachgeschalteten Anlagenteil eine bromhaltige Verbindung zugeführt wird, wobei die Temperatur beim Kontakt der bromhaltigen Verbindung mit dem Rauchgas mindestens 500°C, vorzugsweise mindestens 800°C, beträgt. Die Verbrennung erfolgt in Gegenwart einer schwefelhaltigen Verbindung, insbesondere Schwefeldioxid. Im Anschluss an die Feuerung wird das Rauchgas einer, gegebenenfalls mehrstufigen, Reinigung zur Abtrennung von Quecksilber aus dem Rauchgas unterzogen, welche eine Nasswäsche und/oder eine Trockenreinigung umfasst.

Printed by Jouve, 75001 PARIS (FR)

Beschreibung

[0001] Die Erfindung betrifft ein Verfahren zur Abscheidung von Quecksilber aus Rauchgasen von Hochtemperaturanlagen, insbesondere von Kraftwerken und Abfallverbrennungsanlagen.

[0002] Aufgrund der hohen Toxizität von Quecksilber, insbesondere von organisch gebundenem Quecksilber, das direkt oder indirekt über die Nahrungskette auch vom Menschen aufgenommen wird, existieren strenge Grenzwerte für die gesetzlich zulässige Emission von Quecksilber z.B. aus Verbrennungsanlagen und Kraftwerken. Trotz der heute bereits niedrigen Quecksilber-Reingaskonzentrationen - der derzeit in Deutschland zulässige Halbstundenmittelwert für Quecksilberemissionen aus Abfallverbrennungsanlagen beträgt 30 $\mu g/m^3$ i. N. tr. (i. N. tr.: im Normalzustand trocken) - werden aufgrund großer Volumenströme, beispielsweise aus Großkraftwerken, beachtliche Quecksilberfrachten erzielt, so dass eine weitere Minderung der derzeit zulässigen Grenzwerte angestrebt wird.

[0003] Diverse Verfahren zur Minderung von Quecksilberemissionen aus Kraftwerken, Abfallverbrennungsanlagen oder dgl. sind aus der Literatur bekannt. Welches der Verfahren für eine bestimmte Anwendung zweckmäßig ist, hängt stark von der eingebrachten Fracht und vom Chlorgehalt des Feuerungsgutes ab. Bei hohem Chlorgehalt ist der Anteil an ionischem Quecksilber im Rauchgas hoch. Ionisches Quecksilber lässt sich gut in Wäschern abscheiden. Das quasi-wasserunlösliche metallische Quecksilber kann beispielsweise durch den Zusatz von Oxidationsmitteln, wie Peroxide, Ozon oder Natriumchlorit, im Kesselrohgas vor der Rauchgasreinigung oder im entstaubten Kesselrohgas in ionisches Quecksilber überführt und anschließend in Wäschern abgeschieden werden. Weitere Verfahren zur Abscheidung des Quecksilbers sind: der Zusatz von Reaktionsmitteln, wie Natriumtetrasulfit, zur Bindung des Quecksilbers mittels Schwefel im Kesselrohgas vor Rauchgasreinigung oder im teilgereinigten Reingas; die verbesserte Auswaschung von ionischem Quecksilber durch pH- bzw. pCl-Absenkung in der sauren Wäsche oder durch Beaufschlagung mit 1,3,5-Triazin-2,4,6-trithiol (Trimercapto-S-triazin, TMT) in der schwach sauren oder schwach alkalischen Wäsche; die sorptive Abscheidung von ionischem und metallischem Quecksilber unter Zusatz von pulvrigen Sorbentien oder zerstäubten Suspensionen.

[0004] Bisherige Techniken zur Minderung sind nicht ausreichend effektiv und sind aufgrund ihrer z.T. hohen Zusatzinvestitionen und dem zusätzlichen Betriebsmittelverbrauch relativ teuer.

[0005] Aufgabe der Erfindung ist es, ein Verfahren zur Abscheidung von Quecksilber, insbesondere zur weitgehend vollständigen Abscheidung von Quecksilber (Hg), aus Rauchgasen von Hochtemperaturprozessen bereitzustellen. Das Verfahren soll breitestmögliche Anwendung finden, wie im Falle von im Wesentlichen konstanten niedrigen Hg-Konzentrationen, z.B. in Kohlekraftwerken, aber auch im Falle von relativ hohen Hg-Konzentrationen, z.B. in der Klärschlammverbrennung, oder sehr hohen Hg-Konzentrationen z.B. in der Hausmüll- oder Sondermüllverbrennung. Des Weiteren sollte das Verfahren keiner umfangreichen Nachrüstung der Hochtemperaturanlagen bedürfen sowie möglichst geringer zusätzlicher Betriebsmittel, so dass das Verfahren kostengünstig implementiert und betrieben werden kann.

[0006] Gegenstand der Erfindung ist ein Verfahren zur Abscheidung von Quecksilber aus Rauchgasen von Hochtemperaturanlagen, insbesondere von Kraftwerken und Abfallverbrennungsanlagen, welches darin besteht, dass der, gegebenenfalls mehrstufigen, Feuerung und/oder dem Rauchgas in einem der Feuerung nachgeschalteten Anlagenteil Brom und/oder eine bromhaltige Verbindung und/oder eine Mischung verschiedener bromhaltiger Verbindungen zugeführt wird, wobei die Temperatur beim Kontakt der bromhaltigen Verbindung mit dem Rauchgas mindestens 500°C, vorzugsweise mindestens 800°C, beträgt, die Verbrennung in Gegenwart einer schwefelhaltigen Verbindung, insbesondere Schwefeldioxid, gegebenenfalls unter Zusatz von Schwefel und/oder einer schwefelhaltigen Verbindung und/oder einer Mischung verschiedener schwefelhaltiger Verbindungen erfolgt und anschließend das Rauchgas einer, gegebenenfalls mehrstufigen, Reinigung zur Abtrennung von Quecksilber aus dem Rauchgas unterzogen wird, welche eine Nasswäsche und/oder eine Trockenreinigung umfasst.

[0007] Die Abscheidung von Quecksilber aus Rauchgasen in einer der Verbrennung oder einem ähnlichen Hochtemperaturprozess nachgeschalteten Rauchgasreinigung hängt entscheidend davon ab, in welcher Speziesform das Quecksilber vor Eintritt in die Rauchgasreinigung vorliegt. Ein möglichst hoher Anteil an ionischem Quecksilber ist von Vorteil, da das ionische Quecksilber gut wasserlöslich, also auswaschbar, sowie an diversen Adsorbentien gut adsorbierbar ist. Der Zusatz von Brom bzw. bromhaltigen Verbindungen zur Feuerung bewirkt unter den gegebenen Bedingungen eines Hochtemperaturprozesses oder dgl. in Gegenwart einer schwefelhaltigen Verbindung, insbesondere in Gegenwart von Schwefeldioxid, eine weitgehende, im Wesentlichen vollständige, Oxidation des Quecksilbers und erlaubt daher eine starke Abscheidung des Quecksilbers aus Rauchgasen.

[0008] Unter Hochtemperaturanlagen werden im Sinne der vorliegenden Erfindung insbesondere Abfallverbrennungsanlagen, beispielsweise Hausmüll-, Sondermüll- und Klärschlammverbrennungsanlagen, sowie Kraftwerke, beispielsweise Steinkohleoder Braunkohlekraftwerke, aber auch sonstige Anlagen für Prozesse hoher Temperatur, wie z.B. das Zementbrennen, sowie Abfall mitverbrennende Hochtemperaturanlagen oder kombinierte (mehrstufige) Hochtemperaturanlagen, wie z.B. Kraftwerke oder Zementdrehrohröfen mit vorgeschalteter Abfallpyrolyse oder Abfallvergasung, verstanden. Die Dimension der Hochtemperaturanlage spielt für das erfindungsgemäße Verfahren keine Rolle.

Vorteilhaft an dem erfindungsgemäßen Verfahren ist gerade, dass es auf unterschiedliche Typen von Hochtemperaturanlagen und auf Hochtemperaturanlagen von unterschiedlicher Größenordnung anwendbar ist. Dies schließt Anlagen mit einem Rauchgasvolumenstrom von nur $15 \cdot 10^3$ m^3 i. N. tr./h, beispielsweise zur Klärschlammverbrennung, oder von $50 \cdot 10^3$ m^3 i. N. tr./h, z.B. in Sondermüllverbrennungsanlagen, oder von $150 \cdot 10^3$ m^3 i. N. tr./h, z.B. in der Hausmüllverbrennung, ebenso ein wie Großkraftwerke mit z.B. $2\text{-}3 \cdot 10^6$ m^3 i. N. tr./h.

[0009] Für das erfindungsgemäße Verfahren ist es unerheblich, in welcher Form das zugeführte Brom vorliegt. Es ist möglich, freies oder organisch gebundenes oder anorganisch gebundenes Brom einzusetzen. Das Brom oder die bromhaltigen Verbindungen können einzeln oder im Gemisch zugeführt werden. Besonders bevorzugt wird eine wässrige Lösung von Bromwasserstoff oder ein Alkalibromid, insbesondere Natriumbromid, oder eine wässrige Lösung des Alkalibromids verwendet. Durch diese Ausführungsform ist das Verfahren wirtschaftlich besonders interessant, da die Kosten für zusätzliche Betriebsmittel niedrig gehalten werden können. Weiterhin bevorzugt ist eine Ausführungsform, in der die bromhaltige Verbindung bzw. das Gemisch verschiedener bromhaltiger Verbindungen aus bromreichen Abfallstoffen, wie z.B. niedrig- oder hochhalogenierte Flüssigabfälle, bestehen, welche Teil des Verbrennungsguts sind oder dem Verbrennungsgut, beispielsweise Sondermüll, beigemengt werden.

[0010] Das erfindungsgemäße Verfahren findet in Gegenwart einer schwefelhaltigen Verbindung statt. Die Zugabe einer bromhaltigen Verbindung nach dem erfindungsgemäßen Verfahren führt zu einer Gasphasenreaktion zwischen Quecksilber und Brom in Gegenwart von Schwefeldioxid. Da bei den im Sinne dieser Erfindung üblichen Verbrennungs- und sonstigen Hochtemperaturprozessen in der Regel Schwefeldioxid entsteht, ist für das erfindungsgemäße Verfahren in der Regel ein ausreichendes Angebot einer schwefelhaltigen Verbindung vorhanden. Ein ausreichendes Angebot im Sinne dieser Erfindung liegt vor, wenn unter Zugabe einer bromhaltigen Verbindung zu der Feuerung der Gehalt an Schwefeldioxid im Rauchgas vor der Rauchgasreinigung deutlich größer als Null ist. Wird bei einem Verbrennungsprozess jedoch kein oder nicht ausreichend Schwefeldioxid gebildet, muss dem Prozess eine schwefelhaltige Verbindung zugeführt werden. Dies kann in Form von freiem oder gebundenem Schwefel, beispielsweise Schwefelgranulat, Abfallschwefelsäure oder andere schwefelreiche Abfallstoffe, erfolgen. Darüber hinaus kann insbesondere auch zur Minderung eines zu hohen Gehalts an freien Halogenen im Rauchgas eine schwefelhaltige Verbindung zugesetzt werden, wenn z.B. mehr bromhaltige Verbindung zugeführt worden ist, als zur Oxidation des vorliegenden Quecksilbers notwendig ist. Die Zudosierung einer schwefelhaltigen Verbindung kann z.B. nach dem in der bisher unveröffentlichten Patentanmeldung DE 10131464 beschriebenen Verfahren zur korrosions- und emissionsarmen Mitverbrennung hochhalogenierter Abfälle in Abfallverbrennungsanlagen erfolgen. Nach diesem Verfahren wird in den primären und/oder sekundären Feuerraum Schwefel oder ein entsprechender Schwefelträger geregelt zudosiert. Die Regelung der Schwefelmenge erfolgt im Wesentlichen proportional zur mit den Abfällen eingetragenen aktuellen Halogengesamtfracht im Kesselrauchgas. Der zudosierte Schwefel verbrennt im Feuerraum zu Schwefeldioxid, was kesselintern zu einer weitgehenden Unterdrückung zwischenzeitlich gebildeter freier Halogene im Kesselrauchgas sowie nachfolgend zur stabilen Halogeneinbindung in der alkalischen Wäsche führt. Die Zudosierung von Schwefel wird so geregelt, dass der Soll-Schwefeldioxidgehalt im Rauchgas am Kesseleingang oder der Soll-Schwefeldioxidrestgehalt am Kesselende, d.h. im Kesselrohgas vor einer beispielsweise nassen Rauchgasreinigung, im stationären Betriebszustand über einen einfachen primären Regelkreis eingehalten werden.

[0011] Wird speziell Natriumbromid der Feuerung zugesetzt, so ist ein Mehrverbrauch an Schwefeldioxid zu beobachten, welcher auf die Sulfatierung des Natriumbromids im Hochtemperaturbereich zurückzuführen ist.

[0012] Andererseits stellt ein relativ hoher Gehalt einer schwefelhaltigen Verbindung, insbesondere an Schwefeldioxid, im Rauchgas keinen Nachteil für das erfindungsgemäße Verfahren dar. Ein hoher Gehalt an Schwefeldioxid kann beispielsweise bei der Verbrennung von Steinkohlen auftreten, welche üblicherweise zwischen 0,5 und 1 Gew.-% Schwefel enthalten, oder bei einer geregelten Zudosierung einer schwefelhaltigen Verbindung, welche zur Unterdrükkung zwischenzeitlich gebildeter freier Halogene (s.o.) zugesetzt wird. Unter den gegebenen Bedingungen eines Hochtemperaturprozesses findet auch in Gegenwart von überschüssigem Schwefeldioxid die Oxidation des Quecksilbers statt, welche nach dem erfindungsgemäßen Verfahren durch den Zusatz einer oder mehrerer bromhaltiger Verbindungen erzielt wird. Darin liegt ein besonderer Vorteil des vorliegenden Verfahrens, denn die Oxidation des Quecksilbers durch den Zusatz von bromhaltigen Verbindungen zeigt sich - anders als durch den Zusatz von chlorhaltigen Verbindungen - weitgehend unempfindlich gegenüber einem Überschuss an Schwefeldioxid.

[0013] Die Zugabe einer bromhaltigen Verbindung sowie gegebenenfalls einer schwefelhaltigen Verbindung erfolgt erfindungsgemäß zur Feuerung und/oder zum Rauchgas in einem der Feuerung nachgeschalteten Anlagenteil, wobei die Temperatur beim Kontakt der bromhaltigen Verbindung mit dem Rauchgas mindestens 500°C, vorzugsweise mindestens 800°C, beträgt. Die bromhaltige Verbindung, z.B. Natriumbromid, kann entweder in fester, z.B. als Salz, oder flüssiger Form, z.B. als wässrige Lösung, dem zu verfeuernden Abfallgemisch, der Kohle oder dgl. vor der Feuerung beigemengt werden. Die Zugabe kann auch in einen der Feuerung vorgeschalteten Anlagenteil erfolgen, beispielsweise einer Pyrolysetrommel, welche z.B. dem thermischen Aufschluss mitverbrannter Abfallstoffe dient, oder einer Kohlemühle. Die Verbindung kann ebenso während des Verbrennungsprozesses zugeführt werden. Umfasst die Feuerung mehrere Stufen, z.B. eine primäre und eine sekundäre Feuerung, kann die bromhaltige Verbindung in eine oder beide Brennkammern, beispielsweise in den Drehrohrofen und/oder die Nachbrennkammer, ebenfalls in fester oder flüssiger Form eingeführt werden. Vorzugsweise wird eine wässrige Lösung der Verbindung in einer der Brennkammern eingedüst. Ferner kann die Zugabe auch nach der Verbrennung, z.B. in einem nachgeschalteten Abhitzekessel, erfolgen, sofern die Temperatur des Rauchgases ausreichend hoch ist, d.h. mindestens 500°C, insbesondere mindestens 800°C, beträgt. In anderen Hochtemperaturprozessen, wie z.B. dem Zementbrennen, wird beispielsweise der heiße Ofenkopf des Zementdrehrohrofens und/oder die befeuerte Entsäuerungsstufe des nachgeschalteten Zementrohmehlvorwärmers mit der bromhaltigen Verbindung bestückt.

[0014] In einer weiteren Ausführungsform des erfindungsgemäßen Verfahrens ist es auch möglich, die bromhaltige Verbindung, beispielsweise eine wässrige Lösung von Bromwasserstoff oder von Natriumbromid, fein dispergiert der Verbrennungsluft und/oder gegebenenfalls einem rückgeführten Teilstrom, insbesondere rückgeführtem Rauchgas, rückgeführter Asche und rückgeführten Flugstäuben, zuzuführen.

[0015] Um eine möglichst vollständige, insbesondere 100%ige, Oxidation des Quecksilbers durch die Zugabe einer bromhaltigen Verbindung zu erzielen, wird die bromhaltige Verbindung bevorzugt in einem Massenverhältnis von Brom zu Quecksilber im Bereich von 10^2 bis 10^4 zugegeben. Wird die bromhaltige Verbindung in großem Überschuss zugefügt, wirkt sich dies nicht nachteilig auf das erfindungsgemäße Verfahren aus. Ein zu großer Überschuss muss jedoch vermieden werden, nicht zuletzt aus Kostengründen. Gegebenenfalls müssen zwischenzeitlich gebildete freie Halogene, wie z.B. freies Brom, durch die Zugabe einer schwefelhaltigen Verbindung unterdrückt bzw. stabil eingebunden werden (s.o.), da auch Bromemissionen in der Regel gesetzlich festgelegten Grenzwerten unterliegen.

[0016] Die Oxidation von Quecksilber kann prinzipiell auch durch chlorhaltige oder jodhaltige Verbindungen erfolgen. Es zeigt sich jedoch, dass bromhaltige Verbindungen Quecksilber unter den gegebenen Bedingungen von Hochtemperaturprozessen, wie der Temperatur, und insbesondere auch bei einem hohen Gehalt an Schwefeldioxid (s.o.) wirksamer oxidieren als chlorhaltige Verbindungen. Jodhaltige Verbindungen oxidieren im Vergleich zu bromhaltigen Verbindungen Quecksilber wirksamer. Aus wirtschaftlichen Gesichtspunkten werden in dem erfindungsgemäßen Verfahren allerdings bromhaltige Verbindungen bevorzugt eingesetzt. Gegebenenfalls in den Abfallstoffen, z.B. in Sondermüll, vorliegende chlor- oder jodhaltige Verbindungen tragen demnach zur Oxidation des Quecksilbers bei. In einer bevorzugten Ausführungsform erfolgt das erfindungsgemäße Verfahren zusätzlich zu den bromhaltigen Verbindungen in Gegenwart von Chlor und/oder Jod und/oder einer chlorhaltigen Verbindung und/oder einer jodhaltigen Verbindung und/oder einem Gemisch solcher Verbindungen. Die chlorhaltige und/oder jodhaltige Verbindung kann beispielsweise in Form von chlor- oder jodreichen Abfallstoffen in Ergänzung zu oder unter teilweisem Ersatz der zugesetzten bromhaltigen Verbindung zugeführt werden.

[0017] Nach dem erfindungsgemäßen Verfahren folgt nach der Verbrennung oder einem ähnlichen Hochtemperaturprozess unter Zusatz einer bromhaltigen Verbindung eine Reinigung des Rauchgases, wodurch das oxidierte Quecksilber möglichst weitgehend aus dem Rauchgas abgeschieden wird. Verschiedene Rauchgasreinigungsverfahren zur Abscheidung von u.a. ionischem Quecksilber sind aus dem Stand der Technik bekannt. Sie basieren entweder auf einer Nasswäsche oder einer Trockenreinigung oder einer Kombination beider und kann ggf. mehrstufig sein. Die Nasswäsche umfasst z.B. eine saure Wäsche, welche beispielsweise in einer mit Kreislaufwaschwasser bedüsten Quenche, einem Druckdüsen- oder Rotationszerstäuberwäscher oder einem Füllkörperwäscher erfolgt. Eine Wäsche kann aber ggf. auch nur schwachsauer oder alkalisch ausgeführt sein, beispielsweise im Fall niedriger Chlorwasserstofffrachten, aber hoher Schwefeldioxidfrachten.

[0018] In einer bevorzugten Ausführungsform umfasst die Rauchgasreinigung eine mehrstufige nasse Rauchgaswäsche mit mindestens einer stark sauren (pH kleiner 1) und/oder mindestens einer schwach sauren (pH 3-4) und/oder mindestens einer alkalischen Waschstufe.

[0019] Die Rauchgasreinigung kann auch eine auf der Adsorption von ionischen Quecksilberverbindungen basierende Trockenreinigung umfassen. Eine solche Reinigung kann beispielsweise durch quasitrockene Entschwefelung in einem Sprühtrockner durchgeführt werden, welcher mit einer Kalkmilch-Kohle-Suspension beaufschlagt ist, oder mit Hilfe von Festbettadsorbern, z.B. auf Basis von körniger Aktivkohle oder von Herdofenkoks oder von Mischungen derartiger Adsorbentien mit gekörntem Kalk, oder mit Hilfe von Flugstromadsorbern, z.B. elektrostatischen Gasreinigungsfiltern (EGR-Filter), oder mit Hilfe von Gewebefiltern, welche mit einem eingeblasenen feinpulvrigen Kalkhydrat-Aktivkohle- oder Kalkhydrat-Herdofenkoks-Gemisch beaufschlagt sind. Auch Zeolithe eignen sich zur Abscheidung von quecksilberhaltigen Verbindungen. Im Bezug auf die trockene Rauchgasreinigung zeigt sich ein weiterer Vorteil des erfindungsgemäßen Verfahrens. Die Anwendung des Verfahrens ist insbesondere auch für jene Hochtemperaturanlagen interessant, welche über keine nasse Rauchgasreinigung, sondern ausschließlich über eine trockene Reinigung mit einer Quecksilbersorptionsstufe verfügen. Quecksilberbromid $HgBr_2$ adsorbiert stärker an Trockensorbentien als Quecksilberchlorid $HgCl_2$. Beispielsweise verstärkt sich die Adsorption von Quecksilber am Flugstaub von EGR-Filtern.

[0020] In einer bevorzugten Ausführungsform umfasst die Rauchgasreinigung daher mindestens eine trockene oder quasitrockene, auf Adsorption basierende Reinigungsstufe, insbesondere unter Verwendung von elektrostatischen oder filternden Staubabscheidern.

[0021] Des weiteren werden die mit Quecksilber beladenen Flugstäube aus gegebenenfalls vorhandenen Staubabscheidern zwecks Quecksilberentfrachtung vorzugsweise thermisch nachbehandelt, insbesondere in einer auf Temperaturen von mindestens 200°C beheizten Drehtrommel.

[0022] Bevorzugt wird in dem erfindungsgemäßen Verfahren der Quecksilbergehalt des Rauchgases, insbesondere der Gehalt an metallischem Quecksilber, nach der Rauchgasreinigung kontinuierlich gemessen und anhand des gemessenen Quecksilbergehalts die Menge an zugeführtem Brom und/oder bromhaltigen Verbindungen und/oder der Mischung bromhaltiger Verbindungen sowie gegebenenfalls Schwefel und/oder schwefelhaltigen Substanzen und/oder der Mischung schwefelhaltiger Substanzen geregelt. Ein relativ hoher Gehalt an metallischem Quecksilber im Rauchgas ist ein Indikator dafür, dass die Oxidation des Quecksilbers unvollständig verläuft und damit das Quecksilber in der Rauchgasreinigung unvollständig abgetrennt wird. Um Quecksilber möglichst vollständig zu oxidieren, muss in einem solchen Fall mehr bromhaltige Verbindung zugeführt werden. Zusätzlich kann der Gehalt an ionischem Quecksilber nach der Rauchgasreinigung gemessen werden und daraus der Abscheidegrad des ionischen Quecksilbers in der Rauchgasreinigung bestimmt werden. Der Gehalt an metallischem Quecksilber und ggf. an Quecksilber insgesamt im Kesselrohgas kann nach entsprechender Gasaufbereitung beispielsweise mit Hilfe eines Differenz-Absorptionsphotometers gemessen werden. Die kontinuierliche Messung von metallischem Quecksilber und ggf. auch von Quecksilber insgesamt im Reingas nach der nassen und/oder trockenen Rauchgasreinigung erfolgt vorzugsweise vor einer gegebenenfalls vorhandenen, nachgeschalteten SCR-Entstickungsanlage (SCR: selective catalytic reduction), da der metalloxidreiche Festbettkatalysator erhebliche Mengen an metallischem Quecksilber adsorbiert.

[0023] Nachfolgend wird die Erfindung anhand der Beispiele unter Bezugnahme auf die anliegenden Figuren näher erläutert. Es zeigen:

Figur 1	ein Schema einer Sondermüllverbrennungsanlage
Figur 2	ein Diagramm, welches den Gehalt von metallischem Quecksilber (Hg_{met}) im gewaschenen Kesselrauchgas, d.h. im Reingas, nach der Nasswäsche in µg/m^3 i. N. tr. (Kurve 21, linke Ordinate) sowie den Gesamtgehalt von Brom (Br_{ges}) im Kesselrauchgas in mg/m^3 i. N. tr. (Kurve 22, rechte Ordinate) in Abhängigkeit von der Zeit darstellt,
Figur 3	ein Diagramm, welches den Gesamtgehalt von Quecksilber (Hg_{ges}) im Kesselrauchgas, d.h. zugleich im Kesselrohgas, vor der Nasswäsche in µg/m^3 i. N. tr. (Kurve 31, linke Ordinate) sowie den Gehalt von metallischem Quecksilber (Hg_{met}) im Reingas nach der Nasswäsche in µg/m^3 i. N. tr. (Kurve 32, rechte Ordinate) in Abhängigkeit von der Zeit darstellt,
Figur 4	ein Diagramm, welches den Gesamtgehalt von Brom (Br_{ges}) im Kesselrauchgas, d.h. zugleich im Kesselrohgas, vor der Nasswäsche in mg/m^3 i. N. tr. (Kurve 41, linke Ordinate) sowie den Gehalt von metallischem Quecksilber (Hg_{met}) im Reingas nach der Nasswäsche in µg/m^3 i. N. tr. (Kurve 42, rechte Ordinate) als Funktion der Zeit darstellt,
Figur 5	ein Diagramm, welches das Massenverhältnis von Brom zu Quecksilber im Kesselrauchgas (Kurve 51, linke Ordinate) sowie den erzielten Gesamtabscheidegrad von Quecksilber in der mehrstufigen Nasswäsche in % (Kurve 52, rechte Ordinate) als Funktion der Zeit darstellt,
Figur 6	ein Diagramm, welches das Gewichtsverhältnis von metallischem Quecksilber zur Summe aus metallischem und ionischem Quecksilber (Hg_{met}/Hg_{ges}), d.h. den Hg_{met}-Speziesanteil im Kesselrohgas, in Gew.-% als Funktion des Gesamtgehaltes an Chlor (Kurve 61) bzw. an Brom (Kurve 62) im Kesselrohgas in mg/m^3 i. N. tr. darstellt,
Figur 7	ein Diagramm, welches den Gesamtgehalt an Quecksilber (Hg_{ges}) im entstaubten Rohgas nach der elektrostatischen Gasreinigung (Kurve 71, linke Ordinate) bzw. den Gehalt an metallischem Quecksilber (Hg_{met}) nach der elektrostatischen Gasreinigung (Kurve 72, linke Ordinate) sowie die durch Quecksilberzudosierung herbeigeführte Anhebung des Gesamtgehalts an Quecksilber (Hg_{ges}) im Kesselrauchgas (Kurve 73, rechte Ordinate) als Funktion der Zeit darstellt,
Figur 8	ein Diagramm, welches das Gewichtsverhältnis von metallischem Quecksilber (Hg_{met}) zu der Summe aus metallischem und ionischem Quecksilber (Hg_{ges}), d.h. den Hg_{met}-Speziesanteil (Hg_{met}/Hg_{ges}), im entstaubten Kesselrohgas nach der elektrostatischen Gasreinigung in Gew.-% (Kurve 82) sowie den Gesamtgehalt an Brom (Br_{ges}) im Kesselrauchgas in mg/m^3 i. N. tr. (Kurve 81) als Funktion der Zeit darstellt.

Figur 9 ein Schema eines Industriekraftwerks mit zwei Schmelzkammerkesseln.

Beispiele

[0024] Die Beispiele 1-4 wurden in einer dem Schema in Figur 1 entsprechenden Sondermüllverbrennungsanlage der Bayer AG in Leverkusen durchgeführt. Der Drehrohrofen 3 als primärer Feuerraum wird mit Feststoffabfällen aus dem Bunker 1 über einen Krangreifer 2, mit Flüssigabfällen aus einem Flüssigabfalltank sowie mit Abfallgebinden über eine Gebindeaufgabe befeuert. Auch die Nachbrennkammer 4 als sekundärer Feuerraum wird mit Flüssigabfällen befeuert. Das Rauchgas wird über den Abhitzekessel 5 abgekühlt und anschließend, als sogenanntes Kesselrohgas, der nassen Rauchgasreinigung (mehrstufige Wäsche) zugeführt, welche eine Quenche 6, einen sauren Rotationszerstäuberwäscher 7, einen alkalischen Rotationszerstäuberwäscher 8 und eine elektrostatische Gasreinigung mit Wasserdampf-Teilkondensation 9 (KEGR) umfasst. Über Saugzüge 10 gelangt das gewaschene Rauchgas, als sogenanntes Reingas, in die nachgeschaltete katalytische Entstickungsanlage 11 (selektive katalytische Entstickung des Reingases mittels Ammoniak) und wird von dort über den Kamin 12 emittiert. Der Gehalt an metallischem Quecksilber (Hg_{met}) sowie gegebenenfalls der Gesamtgehalt an Quecksilber (Hg_{ges}) im gewaschenen Reingas nach KEGR wurde - nach entsprechender Aufbereitung - an der Messstelle 16 mit Hilfe eines Differenz-Absorptionsphotometers kontinuierlich bestimmt. Der Gehalt an Quecksilber insgesamt (Hg_{ges}) im emittierten Reingas wurde an der Messstelle 17, d. h. in einer Kaminhöhe von 22 m, quasikontinuierlich bestimmt durch Amalgamierung an einer periodisch ausgeheizten Goldfolie mit nachfolgendem Differenz-Absorptionsphotometer.

[0025] Beispiel 5 beschreibt die Anwendung des erfindungsgemäßen Verfahrens in einem Kohlekraftwerk der Bayer AG in Uerdingen, welches im Wesentlichen einen Schmelzkammerkessel und eine kraftwerkstypische Rauchgasreinigung, bestehend aus einer trockenen elektrostatischen Gasreinigung (EGR), einem schwachsauren, auf Kalkstein basierten Nasswäscher zur Rauchgasentschwefelung sowie einer SCR-Entstickungsanlage (SCR: selective catalytic reduction), umfasst.

Beispiel 1

[0026] Über einen Zeitraum von 116 Minuten wurde dem sekundären Feuerraum (Nachbrennkammer 4) über die Schauluke 15 eine Serie von Proben von metallischem Quecksilber in Kunststoffkapseln zugeführt (in Summe 3400 g, siehe Tabelle 1). Die Zugabe erfolgte in Abständen von ca. 5-10 Minuten mit zunehmender Quecksilbermenge. Das eingeworfene Quecksilber verdampft innerhalb von ca. 2-4 Minuten; demzufolge können die im Kesselrauchgas mit einem Volumenstrom von ca. $45 \cdot 10^3$ m^3 i. N. tr./h aufgetretenen momentanen Spitzenkonzentrationen an Quecksilber abgeschätzt werden. Die Abschätzung liefert zum Versuchsende hin Spitzenkonzentrationen von mehr als $130 \cdot 10^3$ $\mu g/m^3$ i. N. tr.

Tabelle 1:

Zugabe der Hg-Proben			
Uhrzeit	**Hg-Menge [g]**	**Uhrzeit**	**Hg-Menge [g]**
9:24	5	10:32	180
9:32	10	10:37	200
9:38	15	10:43	220
9:49	20	10:48	240
9:54	40	10:53	260
9:59	60	10:58	280
10:04	80	11:03	300
10:09	100	11:08	310
10:15	120	11:13	320
10:20	140	11:20	340
10:26	160		
Versuchsdauer [min]		**Hg-Gesamtmenge [g]**	
116		**3400**	

[0027] Während des Versuchszeitraums wurde durch Mitverbrennung eines hochbromierten Flüssigabfalls (Zugabe zum Drehrohrofenkopf) im Kesselrauchgas von $45 \cdot 10^3$ m^3 i.N. tr./h ein Bromgehalt von ca. $4 \cdot 10^3$ mg/m^3 i. N. tr. aufrechterhalten, wie die Kurve 22 (rechte Ordinate) in Figur 2 zeigt (Bestimmung anhand des Durchsatzes und Bromgehaltes des hochbromierten Flüssigabfalls). Der Rest-SO_2-Gehalt im Kesselrohgas vor der Quenche war dabei mittels Zudosierung von Schwefelgranulat zum Drehrohrofenkopf auf $5{,}5 \cdot 10^3$ mg/Nm^3 i. N. tr. ungewöhnlich hoch eingestellt (direkte SO_2-Messung im Kesselrohgas vor der Quenche). Damit war sichergestellt, dass für das erfindungsgemäße Verfahren ein ausreichendes Angebot an Schwefeldioxid vorhanden war. Das sonstige Verbrennungsgut bestand aus Festabfällen und schwachchlorierten Lösemitteln. Vor, während und nach der Quecksilberzugabe wurde an der Messstelle 16, d.h. nach der Rauchgasreinigung, der Gehalt an Quecksilber im Rauchgas gemessen. Wie die Kurve 21 (linke Ordinate) in Figur 2 zeigt, steigt trotz der Zugabe von erheblichen Quecksilbermengen der Gehalt an metallischem Quecksilber, welches durch die Wäsche durchschlägt, praktisch nicht an.

[0028] Darüber hinaus sind in Tabelle 2 die momentanen Austragungsströme von Quecksilber um 11:30 Uhr, d.h. kurz nach der Zugabe der letzten Quecksilberprobe und damit zum Zeitpunkt der höchsten Quecksilberkonzentration, aufgeführt, welche mit den Wäscherabwässern der nassen Rauchgasreinigung ausgetragen wurden. Umfangreiche abwasserseitige Messungen belegen, dass ca. 99,93 % des insgesamt ausgetragenen Quecksilbers als ionisches Quecksilber mit dem Abwasser der stark sauren Quenche (pH-Wert kleiner 1) und ca. 0,066 % mit dem Abwasser des alkalischen Rotationszerstäuberwäschers (pH-Wert ca. 7,5) ausgetragen wurden. Der geringe, nicht ausgewaschene Rest von nur 0,004 % des insgesamt ausgetragenen Quecksilbers wurde mit dem gewaschenen Reingas als metallisches Quecksilber ausgetragen. Nachweislich war im gewaschenen Reingas praktisch kein Hg_{ion} zu finden (Hg_{ion} = Null, d.h. vollständige Auswaschung des ionischen Quecksilbers und Somit $Hg_{ges} = Hg_{met}$).

Tabelle 2:

Momentane Quecksilber-Austragungsströme [g/h] um 11:30 Uhr	
Quenche (einschließlich dem sauren Rotationszerstäuberwäscher)	1931
(Saurer Rotationszerstäuberwäscher, dessen Abwasser zur Quenche rückgeführt wird)	(468)
Alkalischer Rotationszerstäuberwäscher	1,32
Gewaschenes Reingas nach KEGR	0,069

Beispiel 2

[0029] Über einen Zeitraum von 130 Minuten wurde dem sekundären Feuerraum (Nachbrennkammer 4) über eine Düse in der Nachbrennkammerdecke kontinuierlich eine wässrige $HgCl_2$-Lösung zugeführt. Dabei wurde die zudosierte Menge in Zeitschritten von etwa 5 Minuten angehoben. Figur 3 zeigt den so herbeigeführten Anstieg der Konzentration von Quecksilber im Kesselrauchgas in der Zeit zwischen ca. 10:45 und 13:00 Uhr. Das eindosierte Quecksilber wird in der Nachbrennkammer unverzüglich als metallisches Quecksilber Hg_{met} freigesetzt. Die Gesamtkonzentration von Quecksilber im Kesselrauchgas stieg auf diese Weise bis auf Werte von $18 \cdot 10^3$ µg/m^3 i. N. tr. an (Kurve 31 und linke Ordinate). Die Hg-Konzentration im Kesselrauchgas wurde aus dem zugegebenen Quecksilbermengenstrom und dem betrieblich gemessenen Rauchgasvolumenstrom berechnet. Während des Versuchszeitraums wurde durch Mitverbrennung eines hochbromierten Flüssigabfalls (Zugabe über einen Brenner am Drehrohrofenkopf) im Kesselrauchgas von $45 \cdot 10^3$ m^3 i.N. tr./h ein Bromgehalt von ca. $9 \cdot 10^3$ mg/m^3 i. N. tr. aufrechterhalten (Bestimmung anhand des Durchsatzes und Bromgehalt des mitverbrannten hochbromierten Flüssigabfalls). Der Rest-SO_2-Gehalt im Kesselrohgas vor Quenche war dabei mittels Zudosierung von Schwefelgranulat zum Drehrohrofenkopf auf ca. $4 \cdot 10^3$ mg/Nm^3 i. N. tr. eingestellt (direkte SO_2-Messung im Kesselrohgas vor der Quenche).

[0030] Im Zeitraum zwischen ca. 11:00 und 13:00 Uhr wurde im gewaschenen Reingas nach der KEGR eine Konzentration von metallischem Quecksilber von weniger als 10 µg/m^3 i. N. tr. beobachtet. Nachweislich war im gewaschenen Reingas auch hier praktisch kein Hg_{ion} zu finden (Hg_{ion} = Null, d.h. vollständige Auswaschung des ionischen Quecksilbers und somit $Hg_{ges} = Hg_{met}$). Bei einem kurzzeitigen Ausfall der Bromzugabe gegen 13:05 Uhr stieg die Konzentration von Hg_{met} sprunghaft auf ca. 800 µg/m^3 i. N. tr. an und kehrte aber unverzüglich auf ihren niedrigen Ausgangswert von weniger als 10 µg/m^3 i. N. tr. zurück, als die Bromzugabe wieder einsetzte (Kurve 32 und rechte Ordinate).

Beispiel 3

[0031] In der Zeit zwischen ca. 8:30 und 14:45 Uhr, d.h. über einen Zeitraum von 675 Minuten, wurde dem sekundären Feuerraum (Nachbrennkammer 4) über eine Düse in der Nachbrennkammerdecke kontinuierlich eine wässrige

$HgCl_2$-Lösung zugerührt. Dabei wurde nunmehr aber der zudosierte Hg-Mengenstrom konstant gehalten, entsprechend einer Konzentration von Quecksilber im Kesselrauchgas von ca. $9{,}6 \cdot 10^3$ µg/m³ i. N. tr.

[0032] In diesem Versuchszeitraum (vgl. Fig. 4 bzw. Fig. 5) wurde Brom in Form eines hochbromierten Flüssigabfalls über einen Brenner am Drehrohrofenkopf zugegeben, jedoch wurde die zugegebene Brommenge schrittweise verringert, womit der Bromgehalt im Kesselrauchgas stufenweise von ca. $9 \cdot 10^3$ auf ca. $3 \cdot 10^3$ mg/m³ i. N. tr. abgesenkt wurde (Kurve 41 in Fig. 4 und linke Ordinate). Der mittels Zudosierung von Schwefelgranulat herbeigeführte Rest-SO_2-Gehalt im Kesselrohgas war mit ca. $4{,}3 \cdot 10^3$ mg/m³ i. N. tr in diesem Versuchszeitraum wiederum sehr hoch gewählt worden. Neben dem hochbromierten Flüssigabfall wurde auch ein chlorierter Flüssigabfall mitverbrannt.

[0033] Wie Figur 4 bzw. Figur 5 zu entnehmen ist, war der Gehalt an metallischem Quecksilber im gewaschenen Reingas nach KEGR deutlich kleiner als 2 µg/m³ i. N. tr. (Kurve 42 in Fig. 4 und rechte Ordinate). Nachweislich war im gewaschenen Reingas auch hier praktisch kein Hg_{ion} zu finden (Hg_{ion} = Null, d.h. vollständige Auswaschung des ionischen Quecksilbers und somit $Hg_{ges} = Hg_{met}$). Entsprechend war der Abscheidegrad von Quecksilber in der Nasswäsche deutlich größer als 99,98 % (Kurve 52 in Fig. 5 und rechte Ordinate), solange der Bromgehalt größer als $3 \cdot 10^3$ mg/m³ i. N. tr. (Kurve 41 und linke Ordinate) bzw. das Brom-Quecksilber-Massenverhältnis größer als 500 µg Brom/µg Quecksilber betrug (Kurve 51 in Fig.5 und linke Ordinate). Gegen 13:30 Uhr sinkt der Bromgehalt im Rauchgas auf $3 \cdot 10^3$ mg/m³ i. N. tr. bzw. das Brom-Quecksilber-Massenverhältnis auf ca. 335 µg Brom/µg Quecksilber. Dabei steigt die Konzentration von metallischem Quecksilber nach der Nasswäsche auf bis zu 20 µg/m³ i. N. tr. (Kurve 42 in Fig. 4 und linke Ordinate) bzw. nimmt der Hg-Abscheidegrad auf 99,8 % ab (Kurve 52 in Fig. 5 und rechte Ordinate). Darüber hinaus führt eine kurzzeitige Unterbrechung der Chlor-Zugabe kurz nach 14:30 Uhr zu einer Spitzenkonzentration von metallischem Quecksilber nach der Wäsche von ca. 117 µg/m³ i. N. tr. (Kurve 42 in Fig. 4 und linke Ordinate) bzw. zu einem kurzzeitigen Abfall des Abscheidegrades auf ca. 98,4 % (Kurve 51 in Fig. 5 und rechte Ordinate). Hieran wird die gegenüber Brom vergleichsweise geringe Wirkung von Chlor deutlich.

Beispiel 4

[0034] Figur 6 illustriert einen Versuch zum Vergleich der Wirkung von Brom und Chlor auf die Oxidation von Quecksilber im Kesselrauchgas der oben beschriebenen Sondermüllverbrennungsanlage. Dabei lagen ein durch Zudosierung von $HgCl_2$ eingestellter Hg_{ges}-Gehalt von 130 µg/m³ i. N. tr. bei einem durch Mitverbrennung chlorarmer Lösemittel eingestellten Chlorgehalt (Cl_{ges}) im Kesselrauchgas von $1{,}35 \cdot 10^3$ mg/m³ i. N. tr. sowie einem durch Zudosierung von Schwefelgranulat eingestellten Restgehalt an Schwefeldioxid im Kesselrohgas von $1{,}5 \cdot 10^3$ mg/m³ i. N. tr. vor. Der Messpunkt 63 zeigt den zunächst ohne Bromzusatz, d.h. allein durch Chlor, erzielten Hg_{met}-Speziesanteil von ca. 63 Gew.-% im Kesselrohgas vor der Nasswäsche. Die anlagenspezifische Kurve 61, welche auf ca. 20 Betriebsversuchen an einer Sondermüllverbrennungsanlage mit Verbrennung hochchlorierter Flüssigabfälle basiert, zeigt, wie der Hg_{met}-Speziesanteil (Hg_{met}/Hg_{ges}) mit wachsendem Chlorgehalt Cl_{ges} im Kesselrauchgas zurückgeht.

[0035] Ausgehend von einem Hg_{met}-Speziesanteil von ca. 63 Gew.-% im Kesselrohgas vor der Nasswäsche (Messpunkt 63 mit Cl_{ges}-Gehalt als Abszisse bzw. Messpunkt 63' mit Br_{ges}-Gehalt als Abszisse) wurde dann in drei Schritten eine zunehmende Menge einer bromhaltigen Verbindung zudosiert (vgl. Pfeil 64, der den Übergang von der Darstellung des Hg_{met}-Speziesanteil in Abhängigkeit von dem Cl_{ges}-Gehalt zu der Darstellung in Abhängigkeit von dem Br_{ges}-Gehalt markiert). Dabei wurde der Bromgehalt im Kesselrauchgas von zunächst 0 mg/m³ i. N. tr. (Messpunkt 63' mit Brges-Gehalt als Abszisse) durch Zudosierung von wässriger Bromwasserstofflösung bzw. von wässriger Natriumbromidlösung (Eindüsung an der Nachbrennkammerdecke 14, Fig. 1) in drei Schritten auf 50, 100 und 120 mg/m³ i. N. tr. (Messpunkte 62 mit Br_{ges}-Gehalt als Abszisse) angehoben. Dabei ging der Hg_{met}-Speziesanteil (Hg_{met}/Hg_{ges}) im Kesselrohgas vor der Nasswäsche - ausgehend von ca. 63 Gew.-%-bis auf 30 Gew.-% zurück.

[0036] Der Vergleich weist die deutlich effektivere Oxidation des Quecksilbers durch bromhaltige Verbindungen im Vergleich zu chlorhaltigen Verbindungen am Beispiel einer Sondermüllverbrennungsanlage nach. Um allein mittels Chlor einen Hgmet-Speziesanteil von nur 30 Gew.-% zu erreichen, müsste man den Cl_{ges}-Gehalt gemäß der Chlorierungskurve 61 auf $4 \cdot 10^3$ mg/m³ i. N. tr. erhöhen. Statt dessen erreicht man dies mit nur 120 mg/m³ i. N. tr. an Brom. Brom erscheint daher etwa 25-fach wirksamer als Chlor. Die Hg-Bromierungskurve 65 (Br_{ges}-Gehalt als Abszisse) entspricht unter Berücksichtigung dieses Faktors der vollständig vermessenen Hg-Chlorierungskurve 61 (Cl_{ges}-Gehalt als Abszisse). Gleiches gilt für im Fall von Kraftwerksrauchgasen, wo allerdings die anlagenspezifische Hg-Chlorierungskurve und die entsprechende Hg-Bromierungskurve 65 zu wesentlich niedrigeren Halogengehalten hin verschoben sind.

Beispiel 5

[0037] Figur 7 und Figur 8 illustrieren Versuche zum Nachweis der Wirkung von Brom auf die Quecksilberabscheidung in einem Kohlekraftwerk der Bayer AG in Uerdingen (vgl. Fig. 9). In dem Kohlekraftwerk erfolgte ein Versuch mit Zudosierung von wässriger $HgCl_2$-Lösung und von wässriger NaBr-Lösung in den Feuerraum zum Nachweis der Wirkung von Brom auf die Hg-Oxidation. Das Kraftwerk umfasst zwei parallele Schmelzkammerkessel 91, 91' mit Temperaturen im Feuerraum um 1450°C. Die Schmelzkammerkesssel 91, 91' werden mit Kohle 92, 92' bestückt. Über die jeweiligen Luftvorwärmer 93, 93' wird den Schmelzkammerkesseln 91, 91' Frischluft 94, 94' zugeführt. Das Kesselrohgas 95, 95' wird über elektrostatische Gasreiniger (EGR) 96, 96' dem gemeinsamen schwachsauren (pH = 5,3) Nasswäscher als Rauchgasentschwefelungsanlage (REA-Wäscher) 97 zugeführt. Das gewaschene Kesselrauchgas (Reingas) wird anschließend in zwei parallele katalytisch wirkende Entstickungsanlagen (SCR-Entstickungsanlage) 98, 98' überführt, bevor es über Kamine 100, 100' emittiert wird. Der in den EGR abgeschiedene Flugstaub 99, 99' wird zu 100 % in die Feuerung des jeweiligen Schmelzkammerkessels zurückgeführt. An der Messstelle 101 nach der EGR 96 wurden die Gehalte an Hg_{met} und Hg_{ges} im entstaubten Kesselrohgas kontinuierlich erfasst.

[0038] Es wurde kein Schwefel zudosiert. Der Gehalt an Schwefeldioxid im Kesselrauchgas von $1{,}3 \cdot 10^3$ i. N. tr. resultierte ausschließlich aus dem verbrannten Kohleschwefel selbst. Der Gesamtquecksilbergehalt im entstaubten Rohgas nach der EGR, d.h. vor der Nasswäsche, betrug zu Beginn bei reiner Kohleverbrennung (polnische Steinkohle) im Mittel nur 22,5 $\mu g/m^3$ i. N. tr., vgl. Fig. 7, Kurve 71 (Gesamtgehalt an Quecksilber Hg_{ges}) um 8:30 Uhr, der Gehalt an metallischem Quecksilber im Mittel nur 8,8 $\mu g/m^3$ i. N. tr., vgl. Fig. 7, Kurve 72 (Gehalt an metallischem Quecksilber Hg_{met}) um 8:30 Uhr. Die Zahnung beider Kurven 71, 72 im 10-Minuten-Takt beruht auf der regelmäßigen Abklopfung der EGR; wodurch unmittelbar nach Abreinigung der Staubschichten im entstaubten Kesselrohgas hinter der EGR höhere Gehalte auftreten. Um 9:15 Uhr wurde mit der Zudosierung von Quecksilber (als wässrige $HgCl_2$-Löung) und um 10:30 dann auch mit der Zudosierung von Brom (als wässrige NaBr-Lösung) in den Feuerraum begonnen. Die Kurve 73 (Figur 7, rechte Ordinate) stellt die durch Zudosierung von Quecksilber herbeigeführte Erhöhung des Hg_{ges}-Gehalts im Kesselrauchgas dar. Zwischen ca. 9:30 und 13:00 Uhr betrug die mittels $HgCl_2$-Zudosierung herbeigeführte Anhebung des Gesamtgehalts an Quecksilber im Rauchgas vor der EGR mindestens ca. 220 $\mu g/m^3$ i. N. tr. (Kurve 73, rechte Ordinate). Die Kurve 81 in Fig. 8 stellt die durch Zudosierung von wässriger NaBr-Lösung herbeigeführte Erhöhung des Br-Gehalts im Kesselrauchgas dar. Um 10:30 Uhr wurde der Bromgehalt im Rauchgas vor der EGR zunächst um mindestens 75 mg/m^3 i. N. tr. angehoben und schrittweise wieder abgesenkt. Um 16:10 Uhr erfolgte eine neuerliche Anhebung des Bromgehalts um ca. 43 mg/m^3 i. N. tr. Wegen der Rückführung der Flugasche in die Schmelzkammerfeuerung und somit auch der Rückführung von an der Flugasche sorbiertem Quecksilber bzw. Brom handelt es sich hierbei um Mindestanhebungen, wie sie sich aus den zudosierten Mengenströmen und dem Rauchgasvolumenstrom (ca. $110 \cdot 10^3$ m^3 i. N. tr./h) ergeben. Die tatsächlichen Hg- und Br-Gehalte im Rohgas vor der EGR liegen demzufolge (Kreislauf zwischen Schmelzkammerfeuerung und EGR) etwas höher.

[0039] Die Kurven 71 bzw. 72 (linke Ordinate) in Figur 7 zeigen, wie mit dem Zusatz der bromhaltigen Verbindung der Gehalt an Quecksilber im Rauchgas deutlich zurückgeht. Dies gilt einerseits für das ionische Quecksilber (Differenz zwischen Hg_{ges} und Hg_{met}), welches in Anwesenheit der bromhaltigen Verbindung vermehrt gebildet und offensichtlich am rückgeführten Flugstaub adsorbiert wird, und gilt andererseits aber stärker noch für das metallische Quecksilber, dessen Gehalt im entstaubten Rohgas nach EGR trotz des Zusatzes von Quecksilber annähernd auf den Ausgangsgehalt vor der Quecksilberzugabe zurückkehrt. Von 10:30 Uhr bis 13:00 Uhr (Ende der Br-Zudosierung) und weit darüber hinaus betrug der Gehalt an Hg_{met} weniger als 10 $\mu g/m^3$ i. N. tr. Erst mit dem Ende der neuerlichen Zugabe der Natriumbromidlösung gegen 19:00 Uhr steigt der Gehalt von Hg_{ges} deutlich an. Weiterhin zeigt die Kurve 82 in Figur 8 den zunächst schlagartigen Rückgang des Speziesanteils an metallischem Quecksilber mit der Zugabe von Brom (Absenkung von ca. 40 Gew.-% auf ca. 10 Gew.-% gegen 10:30 Uhr). Entsprechendes zeigt sich nach ca. 17:00 Uhr bei der neuerlichen Quecksilber- und Bromzugabe an dem allmählichen Rückgang des Hg_{met}-Speziesanteils bis auf nur ca. 5 Gew.-% gegen 20:45 Uhr. Infolge der Hg-Zudosierung und der verstärkten Hg-Adsorption stieg der Hg-Gehalt im zur Schmelzkammer rückgeführten EGR-Flugstaub von anfänglich ca. 2-5 mg/kg im Laufe des Versuchs auf 55 mg/kg an.

Patentansprüche

1. Verfahren zur Abscheidung von Quecksilber aus Rauchgasen von Hochtemperaturanlagen, insbesondere von Kraftwerken und Abfallverbrennungsanlagen, **dadurch gekennzeichnet, dass**

   - der, gegebenenfalls mehrstufigen, Feuerung und/oder dem Rauchgas in einem der Feuerung nachgeschalteten Anlagenteil Brom und/oder eine bromhaltige Verbindung und/oder eine Mischung verschiedener bromhaltiger Verbindungen zugeführt wird, wobei die Temperatur beim Kontakt der bromhaltigen Verbindung mit dem Rauchgas mindestens 500°C, vorzugsweise mindestens 800°C, beträgt,

   - die Verbrennung in Gegenwart einer schwefelhaltigen Verbindung, insbesondere Schwefeldioxid, gegebenenfalls unter Zusatz von Schwefel und/oder einer schwefelhaltigen Verbindung und/oder einer Mischung verschiedener schwefelhaltiger Verbindungen erfolgt

- und anschließend das Rauchgas einer, gegebenenfalls mehrstufigen, Reinigung zur Abtrennung von Quecksilber aus dem Rauchgas unterzogen wird, welche eine Nasswäsche und/oder eine Trockenreinigung umfasst.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** die bromhaltige Verbindung eine wässrige Lösung von Bromwasserstoff und/oder ein Alkalibromid, insbesondere Natriumbromid, und/oder eine wässrige Lösung von Alkalibromid ist.

3. Verfahren nach einem der Ansprüche 1 bis 2, **dadurch gekennzeichnet, dass** die bromhaltige Verbindung und/oder die Mischung bromhaltiger Verbindungen flüssige und/oder feste bromreiche Abfallstoffe sind.

4. Verfahren nach einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** das Brom und/oder die bromhaltige Verbindung und/oder die Mischung bromhaltiger Verbindungen der Verbrennungsluft und/oder gegebenenfalls einem rückgeführten Teilstrom, insbesondere dem rückgeführtem Rauchgas und den rückgeführten Flugstäuben, zugesetzt wird.

5. Verfahren nach einem der Ansprüche 1 bis 4, **dadurch gekennzeichnet, dass** das Massenverhältnis von Brom zu Quecksilber im Bereich von 10^2 bis 10^4 liegt.

6. Verfahren nach einem der Ansprüche 1 bis 5, **dadurch gekennzeichnet, dass** die Verbrennung zusätzlich in Gegenwart von Chlor und/oder einer chlorhaltigen Verbindung und/oder einer Mischung verschiedener chlorhaltiger Verbindungen und/oder Jod und/oder einer jodhaltigen Verbindung und/oder einer Mischung verschiedener jodhaltiger Verbindungen durchgeführt wird.

7. Verfahren nach einem der Ansprüche 1 bis 6, **dadurch gekennzeichnet, dass** die Rauchgasreinigung eine mehrstufige nasse Rauchgaswäsche mit mindestens einer stark sauren und/oder mindestens einer schwach sauren und/oder alkalischen Waschstufe umfasst.

8. Verfahren nach einem der Ansprüche 1 bis 7, **dadurch gekennzeichnet, dass** die Rauchgasreinigung mindestens eine trockene oder quasitrockene, auf Adsorption basierende Reinigungsstufe umfasst, insbesondere unter Verwendung von elektrostatischen oder filternden Staubabscheidern.

9. Verfahren nach Anspruch 8, **dadurch gekennzeichnet, dass** die mit Quecksilber beladenen Flugstäube aus gegebenenfalls vorhandenen Staubabscheidern zwecks Quecksilberentfrachtung thermisch nachbehandelt wird, insbesondere in einer auf Temperaturen von mindestens 200°C beheizten Drehtrommel.

10. Verfahren nach einem der Ansprüche 1 bis 9, **dadurch gekennzeichnet, dass** der Quecksilbergehalt des Rauchgases, insbesondere der Gehalt an metallischem Quecksilber, nach der Rauchgasreinigung kontinuierlich gemessen wird und anhand des gemessenen Quecksilbergehalts die Menge an zugeführtem Brom und/oder bromhaltigen Verbindungen sowie gegebenenfalls Schwefel und/oder schwefelhaltigen Verbindungen geregelt wird.

Fig. 1

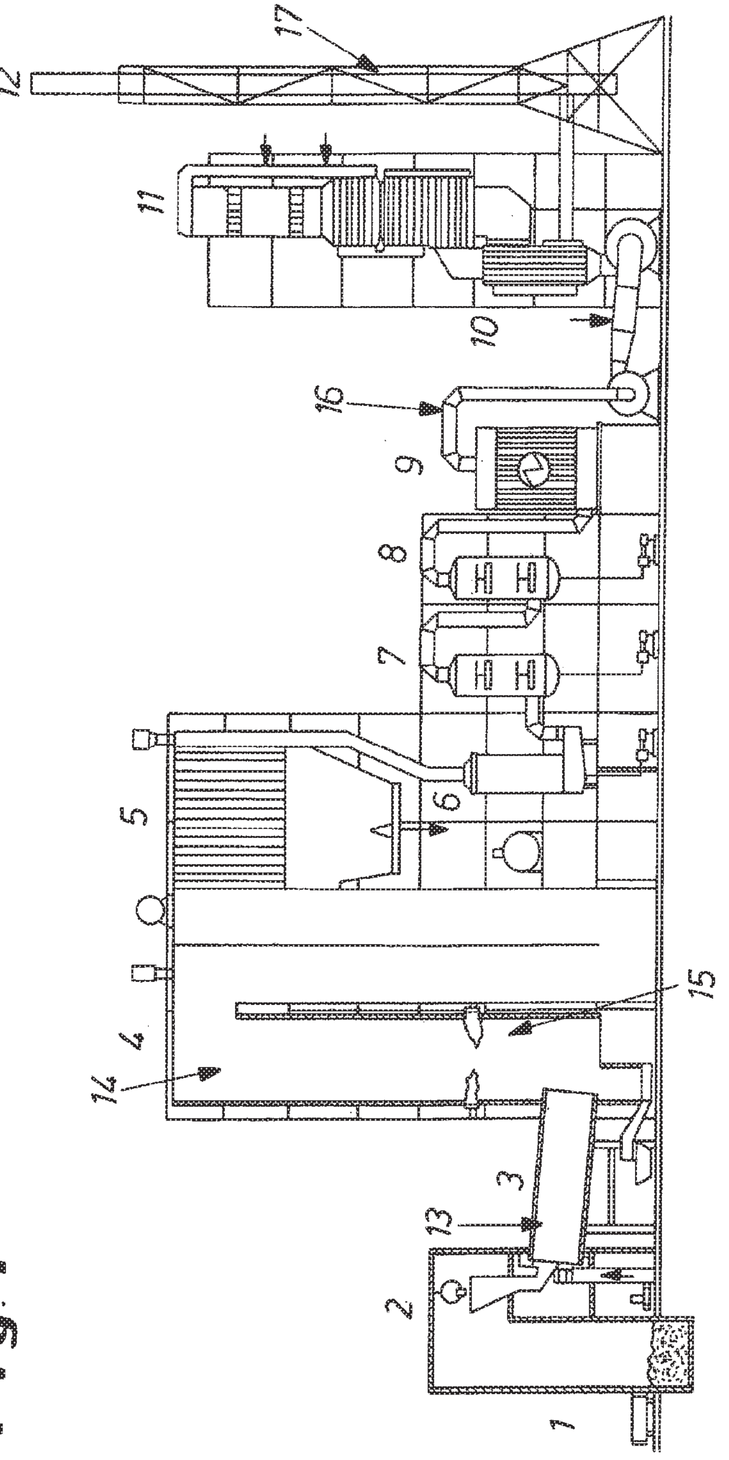


Fig. 2

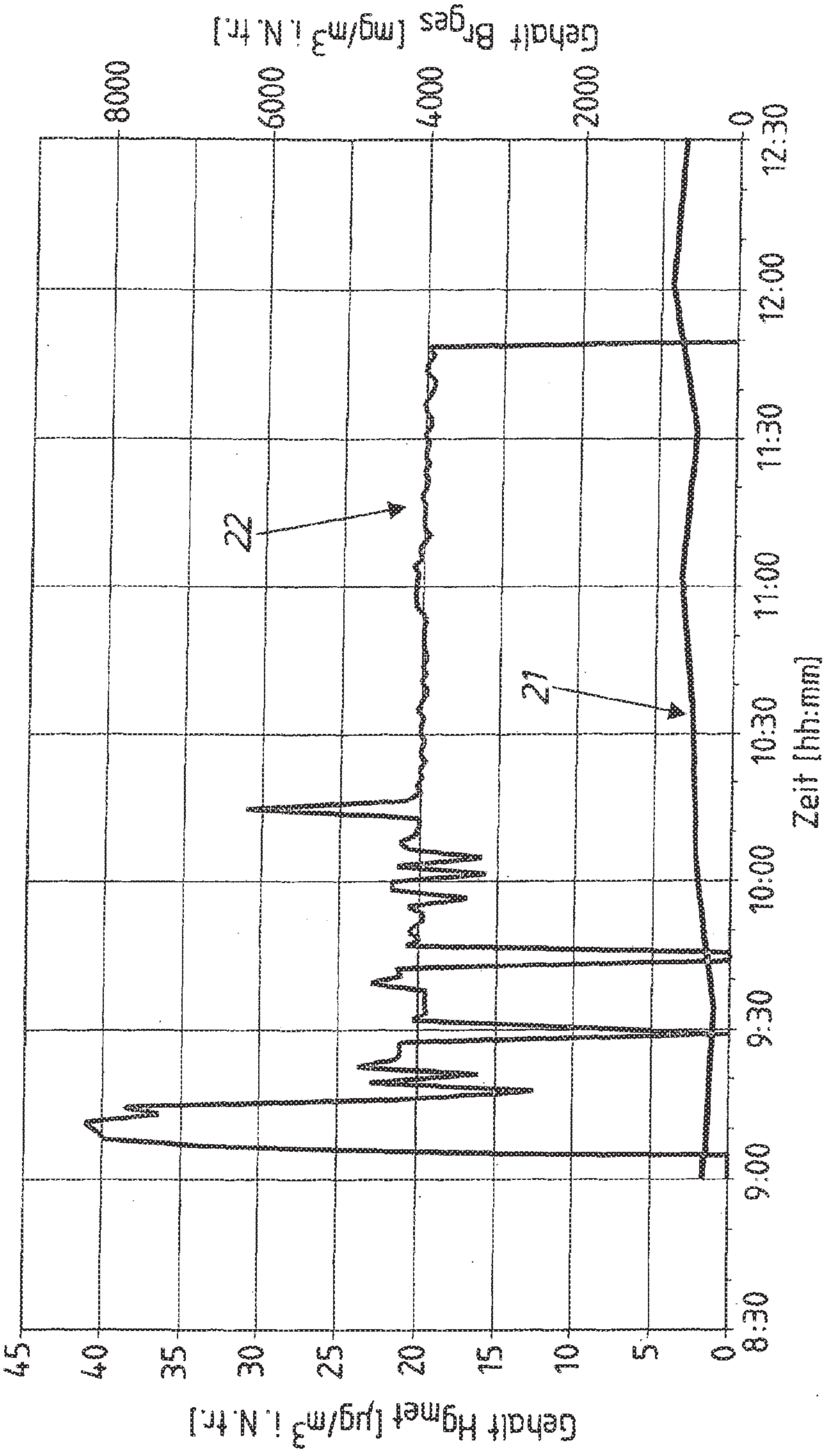

Gehalt Hgmet [µg/m³ i.N.tr.]
45
40
35
30
25
20
15
10
5
0
Gehalt Brges [mg/m³ i.N.tr.]
8000
6000
4000
2000
0
8:30
9:00
9:30
10:00
10:30
11:00
11:30
12:00
12:30
Zeit [hh:mm]
21
22

Fig. 3

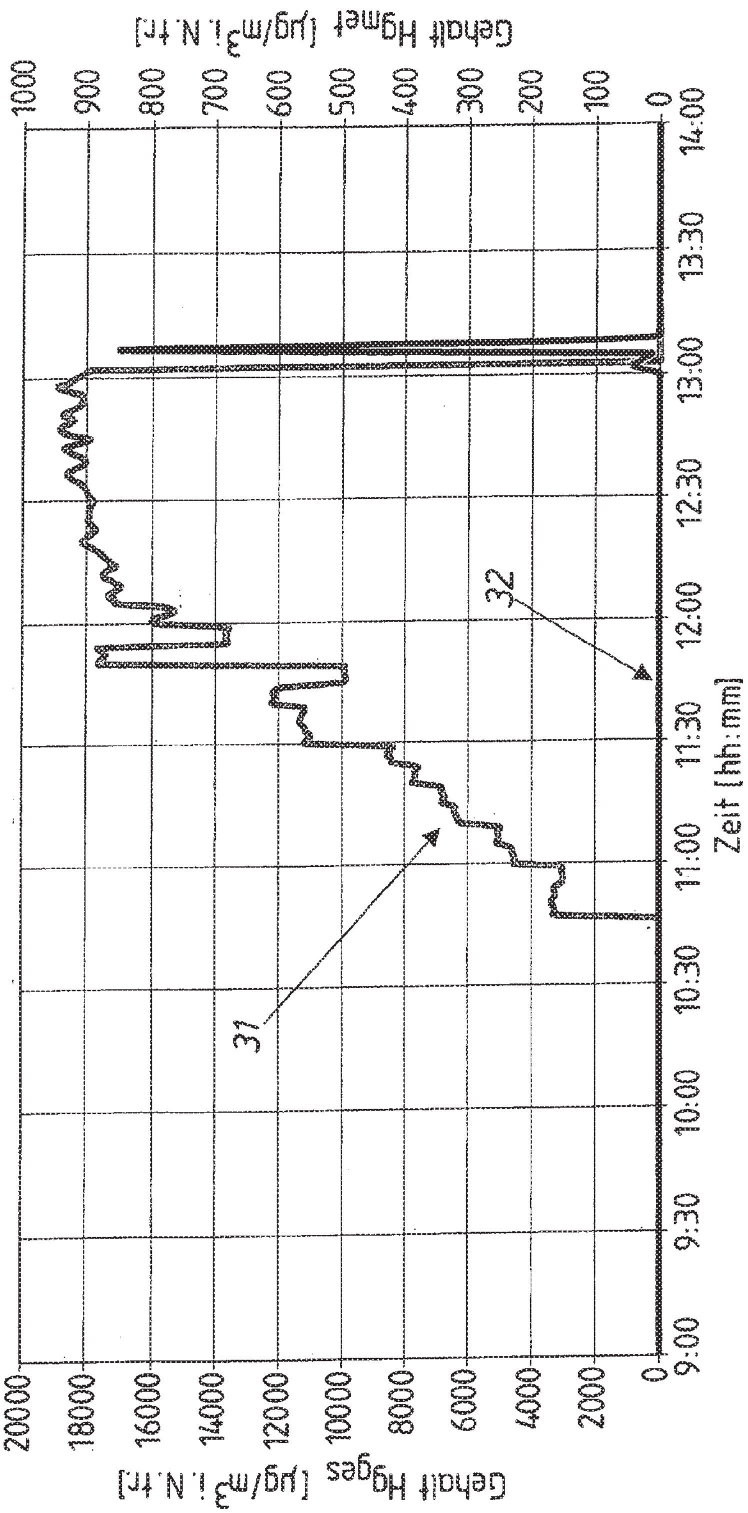

Gehalt Hg$_{ges}$ [µg/m^3 i.N.tr]
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
Gehalt Hg$_{met}$ [µg/m^3 i.N.tr]
0
100
200
300
400
500
600
700
800
900
1000
9:00
9:30
10:00
10:30
11:00
11:30
12:00
12:30
13:00
13:30
14:00
Zeit [hh:mm]
31
32

Fig. 4

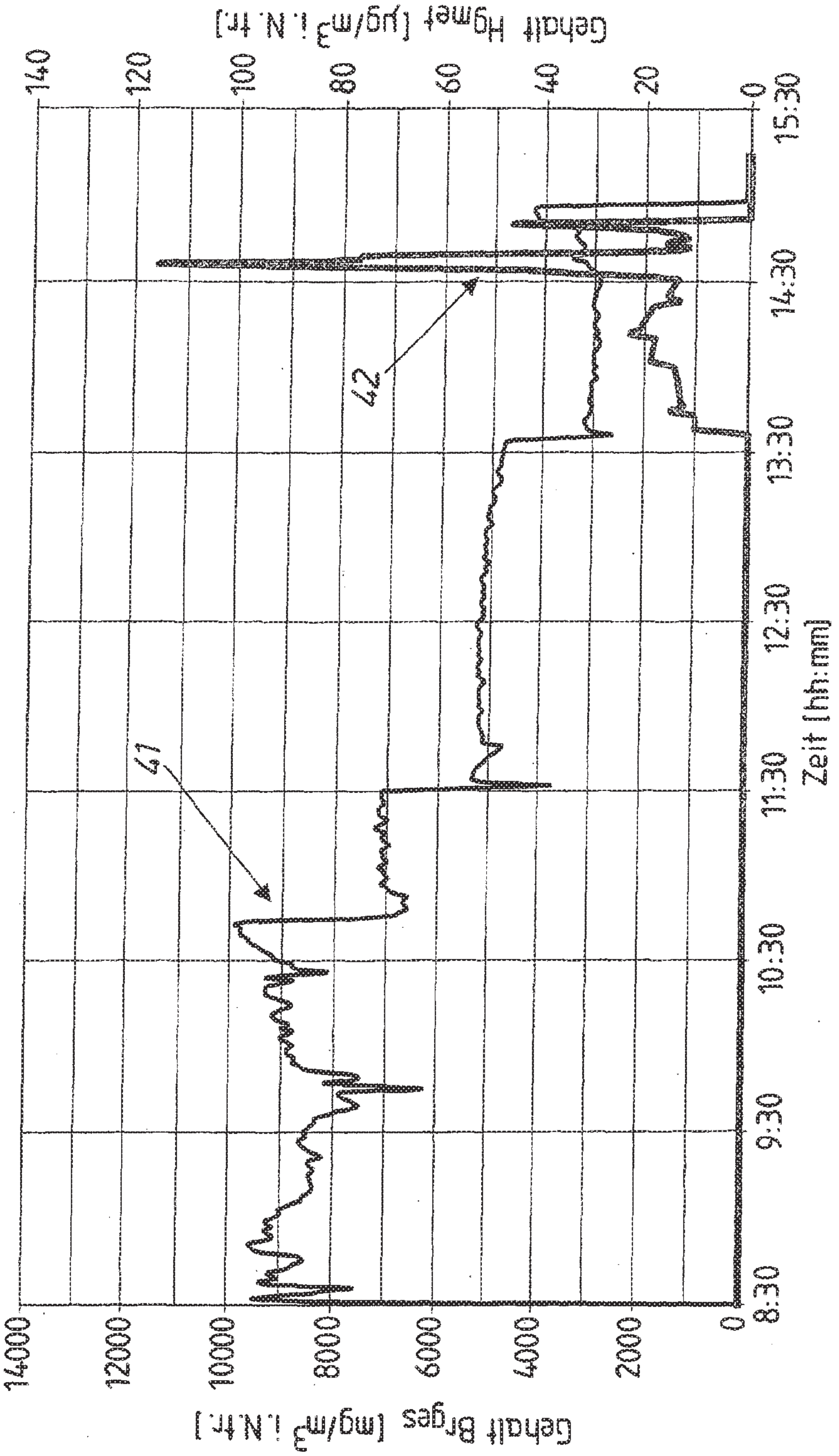

Gehalt Hgmet [µg/m3 i.N.tr.]
0
20
40
60
80
100
120
140
Gehalt Brges [mg/m3 i.N.tr.]
0
2000
4000
6000
8000
10000
12000
14000
8:30
9:30
10:30
11:30
12:30
13:30
14:30
15:30
Zeit [hh:mm]
41
42

Fig. 5

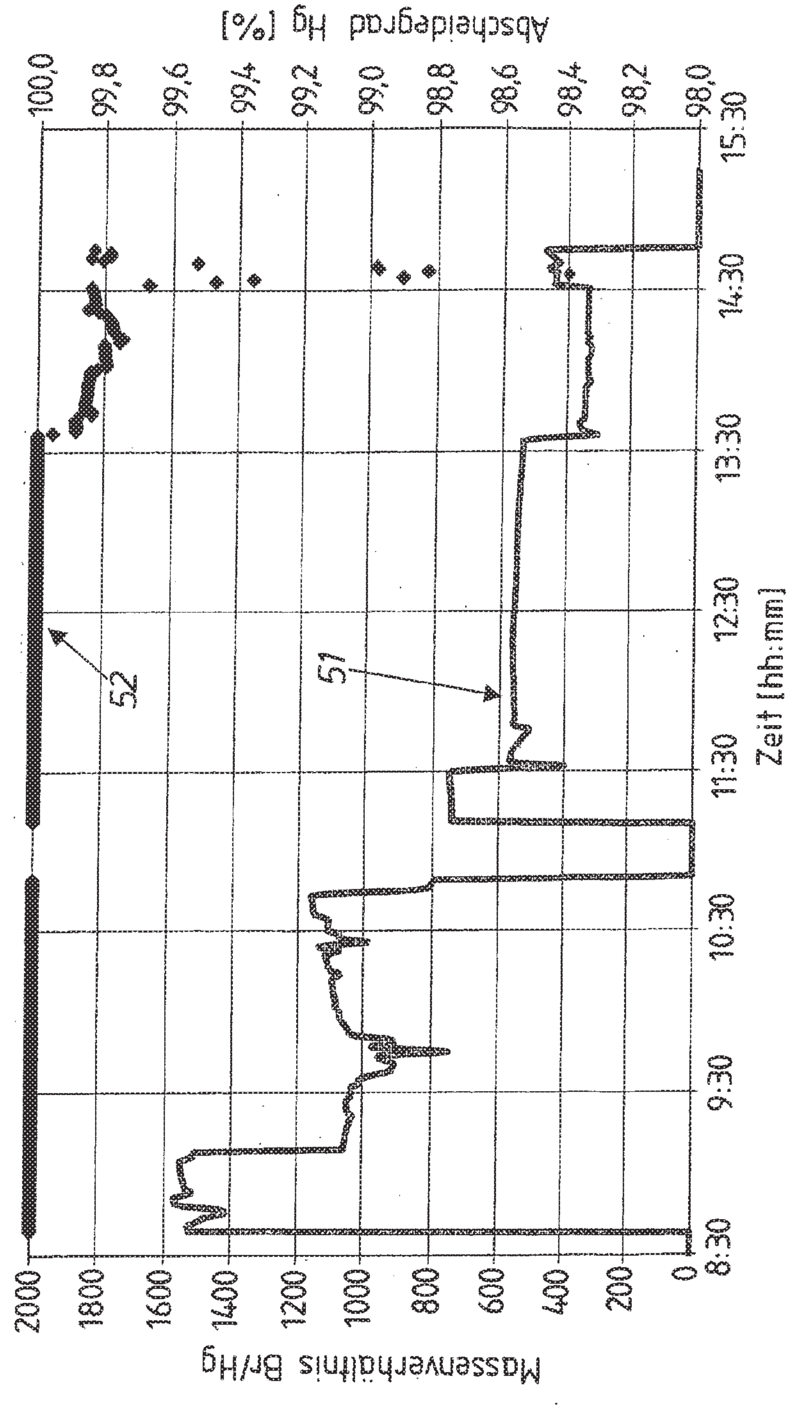

Abscheidegrad Hg [%]
100,0
99,8
99,6
99,4
99,2
99,0
98,8
98,6
98,4
98,2
98,0
Massenverhältnis Br/Hg
2000
1800
1600
1400
1200
1000
800
600
400
200
0
8:30
9:30
10:30
11:30
12:30
13:30
14:30
15:30
Zeit [hh:mm]
51
52

Fig. 6

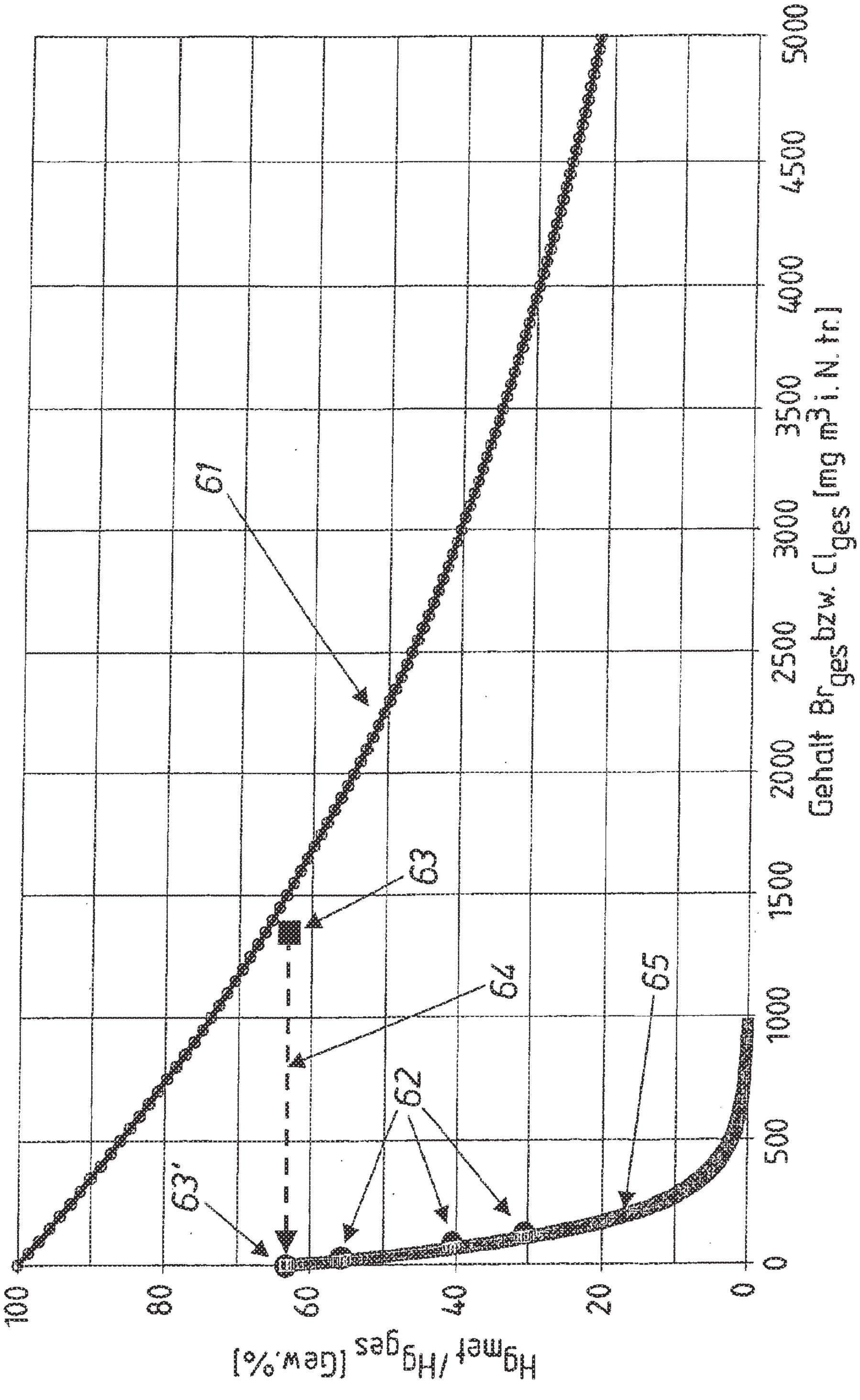

61
62
63
63'
64
65
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Gehalt Br$_{ges}$ bzw. Cl$_{ges}$ [mg m^3 i. N. tr.]
100
80
60
40
20
0
Hg$_{met}$/Hg$_{ges}$ [Gew.%]

Fig. 7

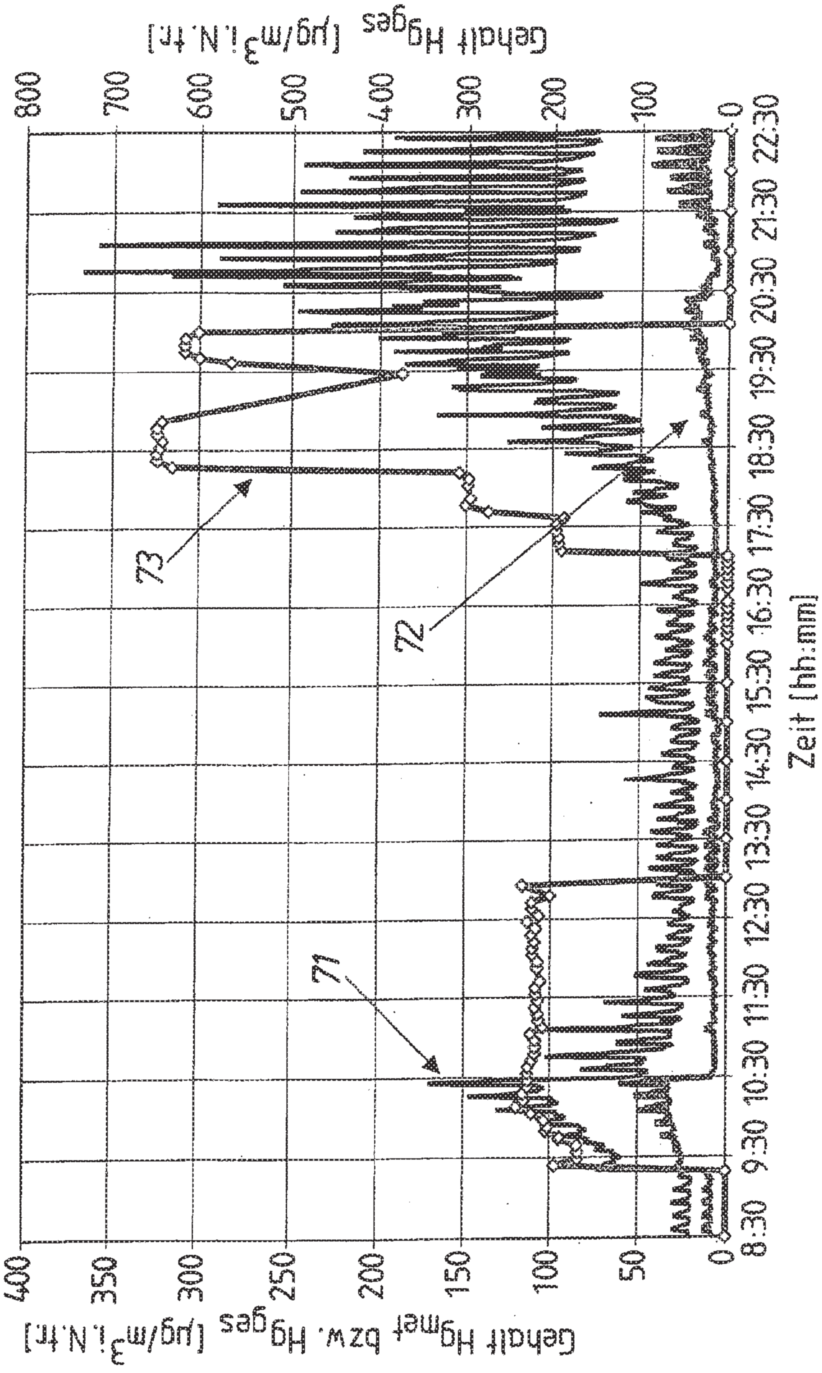

Gehalt Hg_ges [µg/m³ i.N.tr.]
800
700
600
500
400
300
200
100
0
Gehalt Hg_met bzw. Hg_ges [µg/m³ i.N.tr.]
400
350
300
250
200
150
100
50
0
8:30
9:30
10:30
11:30
12:30
13:30
14:30
15:30
16:30
17:30
18:30
19:30
20:30
21:30
22:30
Zeit [hh:mm]
71
72
73

Fig. 8

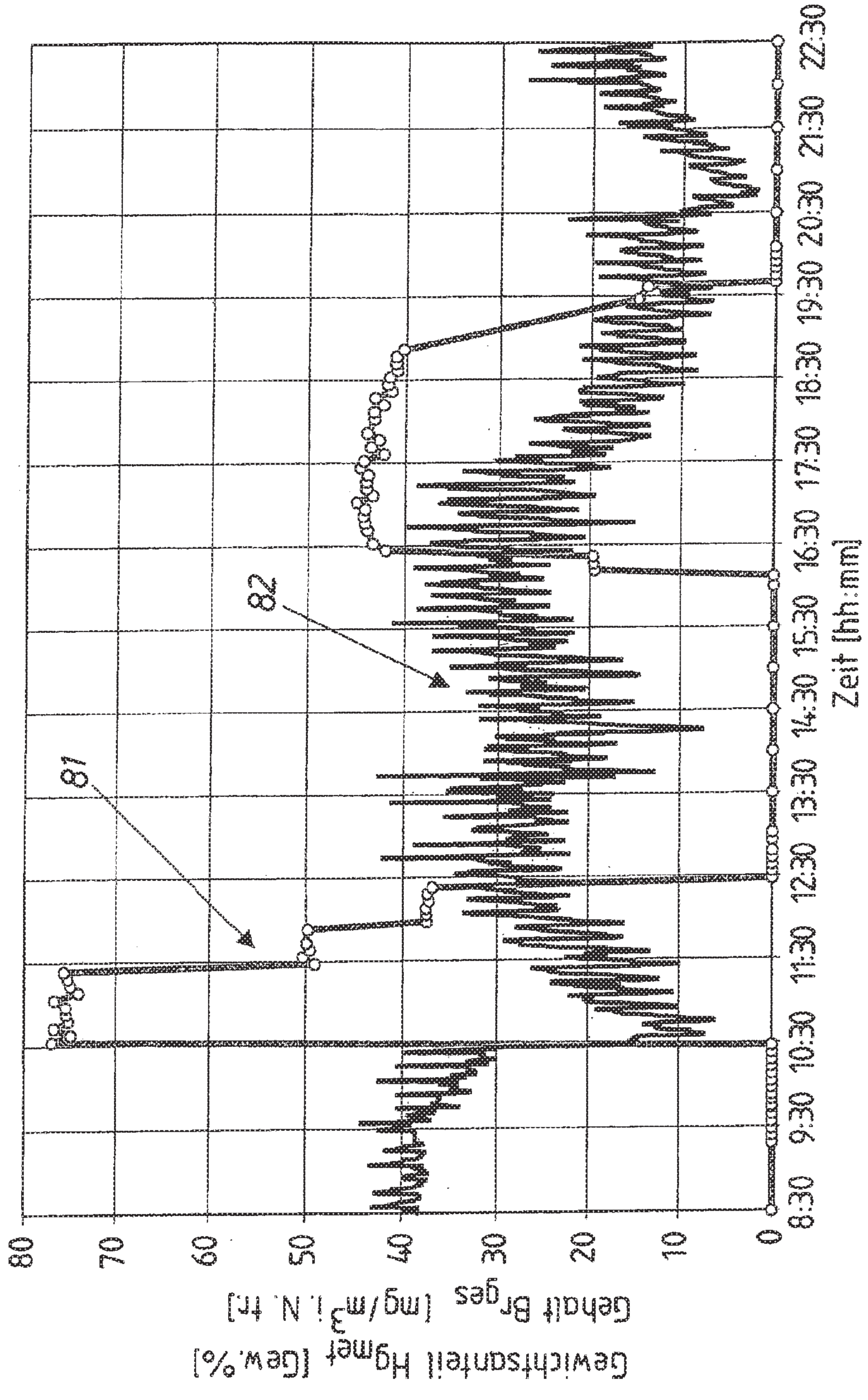
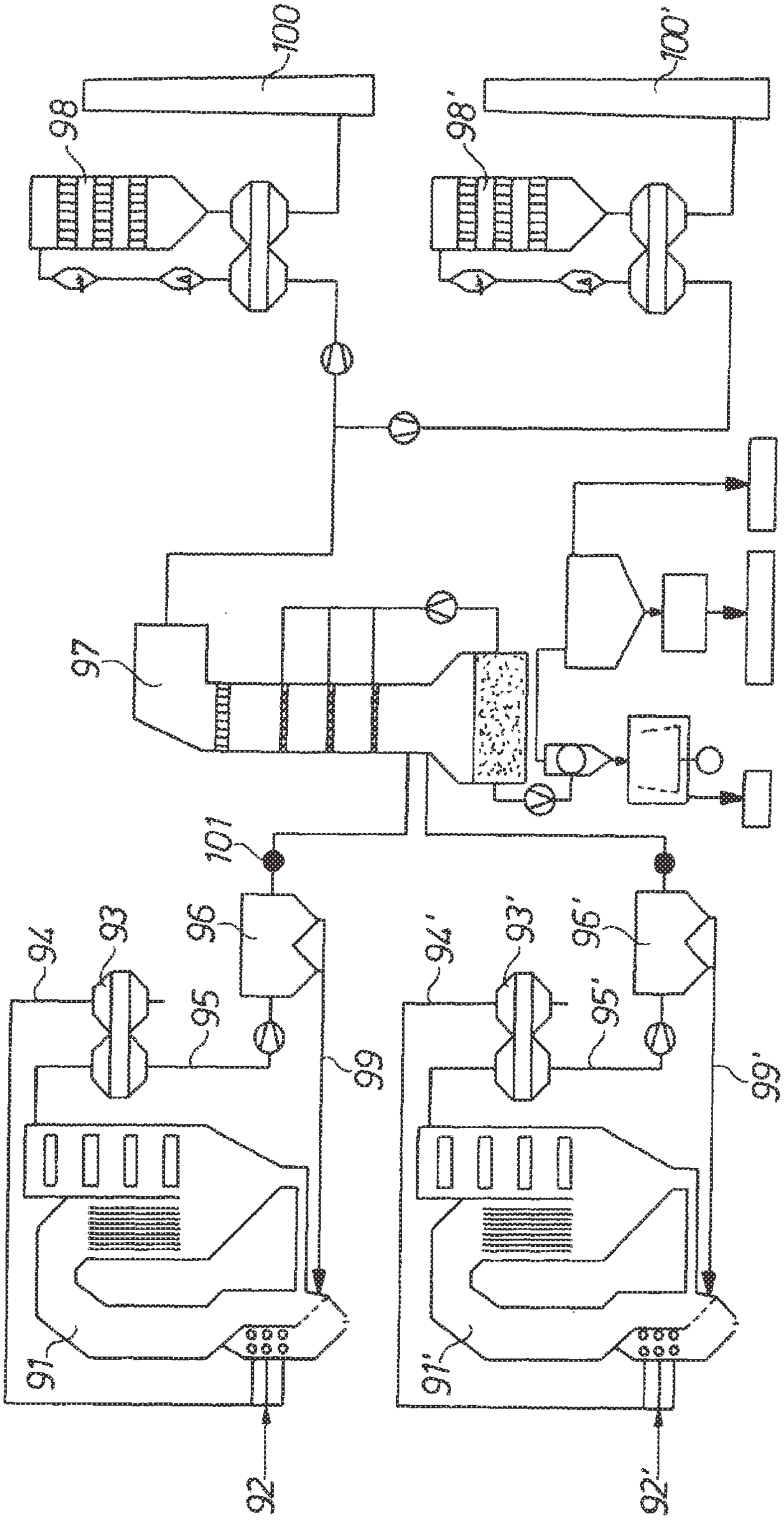

Gewichtsanteil Hg_{met} [Gew.%]
Gehalt Br_{ges} [mg/m³ i. N. tr.]
80
70
60
50
40
30
20
10
0
8:30
9:30
10:30
11:30
12:30
13:30
14:30
15:30
16:30
17:30
18:30
19:30
20:30
21:30
22:30
Zeit [hh:mm]
81
82

Fig.9



Europäisches Patentamt

EUROPÄISCHER RECHERCHENBERICHT

Nummer der Anmeldung
EP 03 01 6026

EINSCHLÄGIGE DOKUMENTE

Kategorie	Kennzeichnung des Dokuments mit Angabe, soweit erforderlich, der maßgeblichen Teile	Betrifft Anspruch	KLASSIFIKATION DER ANMELDUNG (Int.Cl.7)
A	DE 198 50 054 A (KARLSRUHE FORSCHZENT) 4. Mai 2000 (2000-05-04) * Seite 1, Zeile 46 - Zeile 47; Ansprüche 1,2; Beispiel 1 * ---	1	B01D53/64
A	US 5 900 042 A (MENDELSOHN MARSHALL H ET AL) 4. Mai 1999 (1999-05-04) * Anspruch 1 * ---	1	
A	DE 44 22 661 A (PATRA PATENT TREUHAND) 4. Januar 1996 (1996-01-04) * Seite 1, Zeile 55 - Zeile 66 * ---	1	
A	PATENT ABSTRACTS OF JAPAN vol. 2000, no. 10, 17. November 2000 (2000-11-17) & JP 2000 197811 A (KAWASAKI HEAVY IND LTD), 18. Juli 2000 (2000-07-18) * Zusammenfassung * -----	1	
			RECHERCHIERTE SACHGEBIETE (Int.Cl.7)
			B01D

Der vorliegende Recherchenbericht wurde für alle Patentansprüche erstellt

Recherchenort	Abschlußdatum der Recherche	Prüfer
BERLIN	4. November 2003	Clement, J-P

KATEGORIE DER GENANNTEN DOKUMENTE

X : von besonderer Bedeutung allein betrachtet
Y : von besonderer Bedeutung in Verbindung mit einer anderen Veröffentlichung derselben Kategorie
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O : nichtschriftliche Offenbarung
P : Zwischenliteratur

T : der Erfindung zugrunde liegende Theorien oder Grundsätze
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L : aus anderen Gründen angeführtes Dokument

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EPO FORM 1503 03.82 (P04C03)

ANHANG ZUM EUROPÄISCHEN RECHERCHENBERICHT ÜBER DIE EUROPÄISCHE PATENTANMELDUNG NR.

EP 03 01 6026

In diesem Anhang sind die Mitglieder der Patentfamilien der im obengenannten europäischen Recherchenbericht angeführten Patentdokumente angegeben.
Die Angaben über die Familienmitglieder entsprechen dem Stand der Datei des Europäischen Patentamts am
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04-11-2003

Im Recherchenbericht angeführtes Patentdokument		Datum der Veröffentlichung	Mitglied(er) der Patentfamilie		Datum der Veröffentlichung
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EPO FORM P0461

Für nähere Einzelheiten zu diesem Anhang : siehe Amtsblatt des Europäischen Patentamts, Nr.12/82

Espacenet

Description: EP1458474 (A1) — 2004-09-22

PRETREATMENT AND REGENERATION OF OXIDES OF MANGANESE

Description not available for EP1458474 (A1)
Description of corresponding document: WO03072241 (A1)

A high quality text as facsimile in your desired language may be available amongst the following family members:

CN1620334 (A) MXPA04005896 (A) US2003219368 (A1) WO03072241 (A1)

PRETREATMENT AND REGENERATION
OF OXIDES OF MANGANESE Related Applications
This application claims priority to US Provisional Application No. 60/342, 587 filed December 21,2001, which is incorporated herein by reference.

Field of the Invention
The invention relates to systems and processes for treating oxides of manganese that may be utilized as a sorbent for capture and removal of target pollutants from industrial and other gas streams. Further, the invention relates to pollution removal systems incorporating such methods and apparatus and to oxides of manganese, oxides of manganese sorbent particles, and oxides of manganese filter cake formed by the processes of the invention.

Background of the Invention
The element manganese (Mn) may exist in six different valence (oxidation) states. Of particular interest and usefulness in the PahlmanTM systems and processes are those oxides of manganese having valence states of +2, +3, and +4, which correspond to the oxides MnO, Mon203, and Mn02. The oxide Mn04 is probably a solid-solution of both the +2 and +3 states.

A characteristic of most oxides of manganese species is non-stoichiometry; that is, most oxides of manganese molecules or Mn02 species typically contain on average less than the theoretical number of 2 oxygen atoms, with numbers more typically ranging between 1.5 to 2.0. The non-stoichiometry characteristic is thought to result from solid-solution mixtures of two or more oxide species, and exists in all but the beta (ss), or pyrolusite, form of manganese dioxide. Oxides of manganese having the formula MnOX where X is about 1.5 to about 2.0 are particularly suitable for dry removal of target pollutants from gas streams.

However, the most active types of oxides of manganese for use as a sorbent for target pollutant removal usually have the formula MnOl. 7 to 1. 95, which translates into manganese valence states of +3. 4 to +3.9, as opposed to the theoretical +4.0 state. It is unusual for average valence states above about 3.9 to exist in most forms of oxides of manganese. The

formula Mn02, as used herein, symbolically represents all varieties of manganese dioxide including those with valence states ranging from +3 to +4, or MnOl. s 2. o.

Oxides of manganese are known to exhibit several identifiable crystal structures, which result from different assembly combinations of their basic molecular structural units.

These basic structural"building block"units are Mn06 octahedra, which consist of one manganese atom at the geometric center, and one oxygen atom at each of the six apex positions of an octahedral geometrical shape. The octahedra may be joined together along their edges and/or corners, to form"chain"patterns, with void spaces ("tunnels"). Regular (and sometimes irregular) three-dimensional patterns consist of layers of such"chains"and "tunnels"of joined octahedra. These crystalline geometries are identified by characteristic x- ray diffraction (XRD) patterns. Most oxides of manganese are classifiable into one or more of the six fundamental crystal structures, which are called alpha (a), beta ( ), gamma (y), delta (8), epsilon (s), and ramsdellite. Certain older literature also included rho (p) and lambda (X) structures, which are now thought obsolete, due partly to improvements in XRD technique. Some (amorphous) forms of MnO2 exhibit no crystalline structure.

Certain characteristics of oxides of manganese probably arise from the size and shape of voids within these crystalline patterns and from certain elements, and compounds, which may occupy the voids and appear to help prevent collapse of certain structures. Applicants believe that these characteristics in addition to the oxidation state may have and affect upon the loading capacity of oxides of manganese sorbent. Further, many oxides of manganese are hydrous, and include structurally bound water. This bound water may also contribute to chemical reactivity and possibly catalytic behavior of the species.

Some oxides of manganese have the ability to absorb oxygen from gas. Manganous oxide (MnO) will oxidize to MnO2 in the presence of air, for example. Additionally, the dioxides are themselves oxidizers, they readily exchange oxygen in chemical reactions, and they are known to have catalytic properties. This oxygen exchange ability may be related to proton mobility and lattice defects common within most MnO2 crystal structures. The oxidizing potential of Mn02 is advantageously utilized in target pollutant removal in the PahlmanTM and other systems and processes. Target pollutants, such as NOx and SO2 gases, mercury (Hg) and other pollutants, require oxidation of the species prior to reaction with MnO2 sorbent to form reaction products, such as manganese sulfates and nitrates, mercury compounds, and other corresponding reaction products, in order for them to be captured and removed from gas stream.

Manganese compounds are soluble in water in the +2 valence state, but not in the +4 state. Therefore Mn+2 compounds, including MnO are readily soluble in aqueous solutions, as opposed to MnO2. During the formation of reaction products such as manganese nitrates and sulfates, the manganese is reduced from about the +4 state to the +2 state. This property allows the reaction products formed on the surface of oxides of manganese sorbent particles to be readily dissolved and removed from the sorbent particles in aqueous solutions by disassociation into sulfate, nitrate, and Mn+2 ions.

Manganese dioxides are divided into three origin-based categories, which are: 1) natural (mineral) manganese dioxide (NMD), 2) chemical manganese dioxide (CMD), and 3) electrolytic manganese dioxide (EMD). As implied, NMD occurs naturally as various minerals, which may be purified by mechanical or chemical means. The most common form of NMD is pyrolusite (ss-MnO2), which is inexpensive, but has rather low chemical activity and therefore low pollutant loading capacity. CMD and EMD varieties are synthetic. EMD is produced primarily for the battery industry, which requires relatively high bulk density (which often results from relatively large, compact particles), relatively high purity, and good electrochemical activity. Though useful as a sorbent, characteristics such as low surface area and large compact particle size make EMD somewhat inferior to CMD for gas removal applications, despite its good electrochemical activity. Chemically synthesized oxides of manganese of all kinds falls into the CMD category and includes chemically treated oxides of manganese. In chemical synthesis, a great deal of control is possible over characteristics such as particle size and shape, porosity, composition, surface area, and bulk density in addition to electrochemical or oxidation potential. It is believed that these characteristic contribute the loading capacity of some oxides of manganese.

EnviroScrub Technologies Corporation has developed pollutant removal systems and processes utilizing dry and wet removal techniques and combinations thereof, incorporating the use of oxides of manganese as a sorbent. These systems and processes, commonly known as PahlmanTM systems and processes are the subject of co-pending U. S. Patent Application Numbers 09/919,600, 09/951,697, 10/044,089 and 10/025,270, the disclosures of which are incorporated herein. High target pollutant removal efficiencies have been obtained utilizing the Pahlmanrm systems and processes with oxides of manganese as the sorbent. Due to pollutant loading during the removal process, the Pahlman system or some of its system components must be periodically taken off-line so that sorbent may be removed for regeneration and recovery of useful by-products. The frequency of such disruptions and

related downtime could be decreased if it were possible to increase the loading capacity of the sorbent. It would therefore be desirable to enhance the loading capacities of the oxides of manganese in order to extend the period of sorbent use and its loading capacity. Applicants have developed methods of treating virgin oxides of manganese and of recycle processing of loaded oxides of manganese with oxidants or oxidizers that result in treated oxides of manganese having enhanced or increased loading capacity.

Brief Description of the Drawings

Figure 1 is a block flow diagram depicting an embodiment of a treatment system and method of the invention.

Figure 2 is a block flow diagram depicting an embodiment of a treatment system and method of the invention.

Figure 3 is a sorbent loading graph.

Figure 4 is a sorbent loading graph.

Figure 5 is a sorbent loading graph.

Figure 6 is a sorbent loading graph.

Figure 7 is a block flow diagram of a treatment system and method of the invention incorporating a controller.

Figure 8 is a block flow diagram of a embodiment of a treatment system and method of the invention incorporating a controller.

Figure 9 is a Pourbaix diagram for an aqueous solution of 1 mole/liter manganese ion concentration.

Figure 10 is a Pourbaix diagram for an aqueous solution of 10-6 mole/liter manganese ion concentration.

Summary of the Invention
The invention relates to systems and processes for treatment of oxides of manganese that may be utilized as a sorbent for removal of target pollutants from a gas stream.

An embodiment of a process for pretreatment of virgin oxides of manganese for use as a sorbent to remove target pollutants from a gas stream comprises the steps of washing virgin oxides of manganese in wash unit with an aqueous oxidizing solution, the solution having Eh and pH values within the Mn02 stability area; and filtering the washed oxides of manganese to form a filtrate and a pretreated oxides of manganese filter cake, the oxides of

manganese of the filter cake having a pollutant loading capacity greater than the pollutant loading capacity of the virgin oxides of manganese.

Another embodiment of a process for pretreatment of virgin oxides of manganese for use as a sorbent to remove target pollutants from a gas stream comprises the steps of washing virgin oxides of manganese in a wash unit with an aqueous oxidizing solution, the solution having Eh and pH values within the MnO2 stability area; monitoring and adjusting the pH and/or the Eh values of the solution so as to maintain the Eh and pH values of the solution within the MnO2 stability area; and filtering the washed oxides of manganese to form a filtrate and a pretreated oxides of manganese filter cake, the oxides of manganese of the filter cake having a pollutant loading capacity greater than the pollutant loading capacity of the virgin oxides of manganese. The monitoring and adjusting step may be carried out by a controller capable of individually or simultaneously monitoring and adjusting system operational parameters, the controller providing integrated control of within the wash unit of the temperature, Eh values, and pH values in order to maintain conditions of the aqueous oxidizing solution within the Mn02 stability area.

An embodiment of a process for pretreatment of virgin oxides of manganese for use as a sorbent to remove target pollutants from a gas stream comprises the steps of washing virgin oxides of manganese in a rapid filtration wash unit with an aqueous oxidizing solution to form a filtrate and a pretreated oxides of manganese filter cake, the solution having Eh and pH values within the MnO2 stability area; and removing the pretreated oxides of manganese filter cake from the rapid filtration unit, the oxides of manganese of the filter cake having a pollutant loading capacity greater that the pollutant loading capacity of the virgin oxides of manganese.

An embodiment of a process for regeneration of loaded oxides of manganese formed through reaction between unreacted oxides of a manganese and target pollutants in a gas stream comprises the steps of washing loaded oxides of manganese in a rapid filtration wash unit with an aqueous oxidizing solution having Eh and pH values within the MnO2 stability area to form a filtrate and a regenerated oxides of manganese filter cake; and removing the regenerated oxides of manganese filter cake from the rapid filtration unit, the oxides of manganese of the filter cake having a pollutant loading capacity equal to or greater than the pollutant loading capacity of the unreacted oxides of manganese from which the loaded oxides of manganese are formed.

An embodiment of a process for regeneration of loaded oxides of manganese sorbent particles bearing a reaction product layer of the surface thereof formed during reaction between unreacted oxides of manganese sorbent particles and target pollutants in a gas stream in a pollution removal system comprises the steps of rapidly washing and filtering the loaded oxides of manganese sorbent particles in a rapid filtration wash unit with an aqueous oxidizing solution to dissolve the reaction product layer from the surface of the loaded oxides of manganese sorbent particles into the solution to form a filtrate and a regenerated oxides of manganese filter cake, the solution having Eh and pH values within the Mn02 stability area; and removing the regenerated oxides of manganese filter cake from the rapid filtration unit, the oxides of manganese of the filter cake having a pollutant loading capacity equal to or greater than the pollutant loading capacity of the unreacted oxides of manganese sorbent particles from which the loaded oxides of manganese sorbent particles are formed.

The above processes may further comprise the steps of drying the filter cake ; and comminuting and sizing the dried filter cake to provide oxides of manganese particles. The may alternative further comprise the steps of drying the filter cake ; and comminuting and sizing the dried filter cake to provide oxides of manganese particles for introduction into a feeder or reaction chamber of a dry pollution removal system. In a further alternative, they processes may further comprise the steps of drying the filter cake; comminuting and sizing the dried filter cake to provide oxides of manganese particles for introduction into a feeder or reaction chamber of a dry pollution removal system; and introducing the comminuted and sized oxides of manganese particles into the feeder or reaction chamber. In yet a further alternative, the above described processes may further comprise the step of conveying the filter cake to a dryer configured to inject the a wet filter cake or a slurry of oxides of manganese sorbent into the flow of a gas stream prior to introduction into a reaction chamber of a pollutant removal system. In yet another further alternative, the above-described processes may further comprise the steps of conveying the filter cake to a dryer configured to inject the a wet filter cake or a slurry of oxides of manganese sorbent into the flow of a gas stream prior to introduction into a reaction chamber of a pollutant removal system; and injecting the wet filter cake or the slurry into the reaction chamber.

In the above-described processes the aqueous oxidizing solution contains an oxidizer.

The oxidizer may be selected from the group consisting of hypochlorites, perchlolates, permanganates, oxygen (ou), air, ozone, peroxides, persulfates, and combinations thereof.

13 An embodiment of a system for pretreatment of virgin oxides of manganese comprising a wash unit configured to hold and agitate a slurry of virgin oxides of manganese in an aqueous oxidizing solution, the solution have Eh and pH values within the Mn02 stability area, the wash unit being optionally equipped with a pH probe, an Eh probe, and a temperature probe, the wash unit being further configured to receive the slurry of virgin oxides of manganese or to individually receive virgin oxides of manganese and the aqueous oxidizing solution; a filtration unit configured to receive the slurry from the wash unit and to filter the slurry to form a filtrate and a pretreated

oxides of manganese filter cake; an aqueous oxidizing solution vessel containing a supply of aqueous oxidizing solution, the solution having Eh and pH values within the Mn02 stability area, the vessel having a feeder configured to feed aqueous oxidizing solution to the wash unit and being optionally equipped with an Eh probe; an oxides of manganese vessel containing a supply of virgin oxides of manganese, the vessel having a feeder configured to feed oxides of manganese directly to the wash unit or, in conjunction with the aqueous oxidizing solution feeder to feed a slurry of virgin oxides of manganese to the wash unit; and a pH adjust vessel having a supply of acid or base or separate supplies of acid and base, the pH adjust vessel having a feeder configured to feed acid and/or base to the wash unit. The system of this embodiment may further comprise a controller capable of individually or simultaneously monitoring and adjusting system operational parameters, the controller providing integrated control within the wash unit of the temperature, Eh values, and pH values in order to maintain conditions of the aqueous oxidizing solution within the Mn02 stability area.

This embodiment of a system for treatment of virgin or loaded oxides of manganese may further comprise a dryer for drying the filter cake ; a device for comminuting and sizing the dried filter cake to form oxides of manganese particles; and a reaction chamber of a pollutant removal system into which the oxides of manganese particles are introduced to capture target pollutants from a gas, the reaction chamber being equipped with at least one target pollutant concentration reader for measuring target pollutant concentration of the gas as it exits the reaction chamber, the reader being in electronic communication with the controller for checking the loading performance of the oxides of manganese particles and signaling need for adjustment of operational parameters within the wash unit.

14 Another embodiment of a system for treatment of virgin or loaded oxides of manganese comprising a rapid filtration wash unit, the wash unit being configured to individually receive oxides of manganese and an aqueous oxidizing solution having a Eh and

pH values within the Mn02 stability area, the wash unit being further configured to rapidly remove the aqueous oxidizing solution from contact with the oxides of manganese forming a filtrate and a treated oxides of manganese filter cake; an aqueous oxidizing solution vessel containing a supply of aqueous oxidizing solution, the solution having Eh and pH values within the Mn02 stability area, the vessel having a feeder configured to feed aqueous oxidizing solution to the wash unit and being optionally equipped with a probe selected from the group consisting of an Eh probe, a pH probe, a temperature probe, or any combination thereof; an oxides of manganese vessel containing a supply of virgin of loaded oxides of manganese, the vessel having a feeder configured to feed oxides of manganese to the wash unit ; optionally, a oxidizer vessel containing a supply of oxidizer, the oxidizer vessel having feeder configured to feed oxidizer to the aqueous oxidizing solution vessel; and optionally, a pH adjust vessel having a supply of acid or base or separate supplies of acid and base, the pH adjust vessel having a feeder configured to feed acid and/or base to the aqueous oxidizing solution vessel. The system of this embodiment may further comprise a controller capable of individually or simultaneously monitoring and adjusting system operational parameters, the controller providing integrated control of the temperature, Eh values, and pH values within the aqueous oxidizing solution vessel in order to maintain conditions of the aqueous oxidizing solution within the mon02 stability area.

This embodiment of a system for treatment of virgin or loaded oxides of manganese may further comprise a dryer for drying the filter cake; a device for comminuting and sizing the dried filter cake to form oxides of manganese particles; and a reaction chamber of a pollutant removal system into which the oxides of manganese particles are introduced to capture target pollutants from a gas, the reaction chamber being equipped with at least one target pollutant concentration reader for measuring target pollutant concentration of the gas as it exits the reaction chamber, the reader being in electronic communication with the controller for checking the loading performance of the oxides of manganese particles and signaling need for adjustment of operational parameters within the aqueous oxidizing solution vessel.

Another embodiment of a system for pretreatment of virgin oxides of manganese comprises a wash unit configured to hold and agitate a slurry of virgin oxides of manganese in an aqueous oxidizing solution, the solution have Eh and pH values within the Mn02 stability area, the wash unit being equipped with a pH probe, an Eh probe, and a temperature probe, the wash unit being further configured to receive the slurry of virgin oxides of manganese or to individually receive virgin oxides of manganese and the aqueous oxidizing

solution; a filtration unit configured to receive the slurry from the wash unit and to filter the slurry to form a filtrate and a pretreated oxides of manganese filter cake ; an aqueous oxidizing solution vessel containing a supply of aqueous oxidizing solution, the solution having Eh and pH values within the Mn02 stability area, the vessel having a feeder configured to feed aqueous oxidizing solution to the wash unit and being equipped with an Eh probe; an oxides of manganese vessel containing a supply of virgin oxides of manganese, the vessel having a feeder configured to feed oxides of manganese directly to the wash unit or, in conjunction with the aqueous oxidizing solution feeder to feed a slurry of virgin oxides of manganese to the wash unit; a pH adjust vessel having a supply of acid or base or separate supplies of acid and base, the pH adjust vessel having a feeder configured to feed acid and/or base to the wash unit; and a controller capable of individually or simultaneously monitoring and adjusting system operational parameters, the controller providing integrated control within the wash unit of the temperature, Eh values, and pH values in order to maintain conditions of the aqueous oxidizing solution within the MnOz stability area, the controller being electronic communication with the probes and feeders of the system.

This embodiment of a for pretreatment of virgin oxides of manganese may further comprise a dryer for drying the filter cake; a device for comminuting and sizing the dried filter cake to form oxides of manganese particles; and a reaction chamber of a pollutant removal system into which the oxides of manganese particles are introduced to capture target pollutants from a gas, the reaction chamber being equipped with at least one target pollutant concentration reader for measuring target pollutant concentration of the gas as it exits the reaction chamber, the reader being in electronic communication with the controller for checking the loading performance of the oxides of manganese particles and signaling need for adjustment of operational parameters within the wash unit.

18 Another embodiment of a system for treatment of virgin or loaded oxides of manganese comprises a rapid filtration wash unit, the wash unit being configured to individually receive oxides of manganese and an aqueous oxidizing solution having a Eh and pH values within the MnO2 stability area, the wash unit being further configured to rapidly remove the aqueous oxidizing solution from contact with the oxides of manganese forming a filtrate and a treated oxides of manganese filter cake ; an aqueous oxidizing solution vessel containing a supply of aqueous oxidizing solution, the solution having Eh and pH values within the Mn02 stability area, the vessel having a feeder configured to feed aqueous oxidizing solution to the wash unit and being

equipped with a probe selected from the group

consisting of an Eh probe, a pH probe, a temperature probe, or any combination thereof; an oxides of manganese vessel containing a supply of virgin of loaded oxides of manganese, the vessel having a feeder configured to feed oxides of manganese to the wash unit; a oxidizer vessel containing a supply of oxidizer, the oxidizer vessel having feeder configured to feed oxidizer to the aqueous oxidizing solution vessel; a pH adjust vessel having a supply of acid or base or separate supplies of acid and base, the pH adjust vessel having a feeder configured to feed acid and/or base to the aqueous oxidizing solution vessel; and a controller capable of individually or simultaneously monitoring and adjusting system operational parameters, the controller providing integrated control of the temperature, Eh values, and pH values within the aqueous oxidizing solution vessel in order to maintain conditions of the aqueous oxidizing solution within the Mn02 stability area, the controller being in electronic communication with the probes and feeders of the system.

This embodiment of a system for treatment of virgin or loaded oxides of manganese may further comprise a dryer for drying the filter cake ; a device for comminuting and sizing the dried filter cake to form oxides of manganese particles; and a reaction chamber of a pollutant removal system into which the oxides of manganese particles are introduced to capture target pollutants from a gas, the reaction chamber being equipped with at least one target pollutant concentration reader for measuring target pollutant concentration of the gas as it exits the reaction chamber, the reader being in electronic communication with the controller for checking the loading performance of the oxides of manganese particles and signaling need for adjustment of operational parameters within the aqueous oxidizing solution vessel.

In the above-described systems the aqueous oxidizing solution contains an oxidizer.

The oxidizer may be selected from the group consisting of hypochlorites, perchlolates, permanganates, oxygen (O_2), air, ozone, peroxides, persulfates, and combinations thereof.

The invention also relates to oxides of manganese, oxides of manganese particles, and oxides of manganese filter cakes formed by the above-described processes.

Oxides of manganese particles may be formed by a process for pretreatment of virgin oxides of manganese for use as a sorbent to remove target pollutants from a gas stream comprising the steps of washing virgin oxides of manganese in wash unit with an aqueous oxidizing solution, the solution having Eh and pH values within the Mn02 stability area; filtering the washed oxides of manganese to form a filtrate and a pretreated oxides of manganese filter cake, the oxides of manganese of the filter cake having a pollutant loading capacity greater than the pollutant loading capacity of the virgin oxides of manganese; drying

the filter cake; and comminuting and sizing the dried filter cake to form oxides of manganese particles.

Oxides of manganese particles may be formed by a process for pretreatment of virgin oxides of manganese for use as a sorbent to remove target pollutants from a gas stream, comprising the steps of washing virgin oxides of manganese in a wash unit with an aqueous oxidizing solution, the solution having Eh and pH values within the MnO_2 stability area; monitoring and adjusting the pH and/or the Eh values of the solution so as to maintain the Eh and pH values of the solution within the MnO_2

stability area; filtering the washed oxides of manganese to form a filtrate and a pretreated oxides of manganese filter cake, the oxides of manganese of the filter cake having a pollutant loading capacity greater than the pollutant loading capacity of the virgin oxides of manganese; drying the filter cake; and comminuting and sizing the dried filter cake to form oxides of manganese particles.

Oxides of manganese particles may be formed by a process for pretreatment of virgin oxides of manganese for use as a sorbent to remove target pollutants from a gas stream comprising the steps of washing virgin oxides of manganese in a rapid filtration wash unit with an aqueous oxidizing solution to form a filtrate and a pretreated oxides of manganese filter cake, the solution having Eh and pH values within the Mn02 stability area; removing the pretreated oxides of manganese filter cake from the rapid filtration unit, the oxides of manganese of the filter cake having a pollutant loading capacity greater that the pollutant loading capacity of the virgin oxides of manganese; drying the filter cake ; and comminuting and sizing the dried filter cake to form oxides of manganese particles.

Oxides of manganese particles may formed by a process for regeneration of loaded oxides of manganese formed through reaction between unreacted oxides of a manganese and target pollutants in a gas stream comprising the steps of washing loaded oxides of manganese in a rapid filtration wash unit with an aqueous oxidizing solution having Eh and pH values within the MnO2 stability area to form a filtrate and a regenerated oxides of manganese filter cake; removing the regenerated oxides of manganese filter cake from the rapid filtration unit, the oxides of manganese of the filter cake having a pollutant loading capacity equal to or greater than the pollutant loading capacity of the unreacted oxides of manganese from which the loaded oxides of manganese are formed; drying the filter cake; and comminuting and sizing the dried filter cake to form oxides of manganese particles.

Oxides of manganese sorbent particles may formed by a process for regeneration of loaded oxides of manganese sorbent particles bearing a reaction product layer of the surface

thereof formed during reaction between unreacted oxides of manganese sorbent particles and target pollutants in a gas stream in a pollution removal system, comprising the steps of rapidly washing and filtering the loaded oxides of manganese sorbent particles in a rapid filtration wash unit with an aqueous oxidizing solution to dissolve the reaction product layer from the surface of the loaded oxides of manganese sorbent particles into the solution to form a filtrate and a regenerated oxides of manganese filter cake, the solution having Eh and pH values within the Mn02 stability area; removing the regenerated oxides of manganese filter cake from the rapid filtration unit, the oxides of manganese of the filter cake having a pollutant loading capacity equal to or greater than the pollutant loading capacity of the unreacted oxides of manganese sorbent particles from which the loaded oxides of manganese sorbent particles are formed; drying the filter cake ; and comminuting and sizing the dried filter cake to form oxides of manganese particles.

Oxides of manganese filter cakes particles may be formed by a process for pretreatment of virgin oxides of manganese for use as a sorbent to remove target pollutants from a gas stream, comprising the steps of washing virgin oxides of manganese in a wash unit with an aqueous oxidizing solution, the solution having Eh and pH values within the MnO2 stability area; monitoring and adjusting the pH and/or the Eh values of the solution so as to maintain the Eh and pH values of the solution within the MnO2 stability area; and filtering the washed oxides of manganese to form a filtrate and a pretreated oxides of manganese filter cake, the oxides of manganese of the filter cake having a pollutant loading capacity greater than the pollutant loading capacity of the virgin oxides of manganese.

Oxides of manganese filter cake may be formed by a process for pretreatment of virgin oxides of manganese for use as a sorbent to remove target pollutants from a gas stream, comprising the step of washing virgin oxides of manganese in a rapid filtration wash unit with an aqueous oxidizing solution to form a filtrate and a pretreated oxides of manganese filter cake, the solution having Eh and pH values within the Mn02 stability area; wherein the oxides of manganese of the pretreated oxides of manganese filter cake have a pollutant loading capacity greater that the pollutant loading capacity of the virgin oxides of manganese.

Oxides of manganese filter cake formed by a process for regeneration of loaded oxides of manganese formed through reaction between unreacted oxides of a manganese and target pollutants in a gas stream comprising the step of washing loaded oxides of manganese in a rapid filtration wash unit with an aqueous oxidizing solution having Eh and pH values

within the MnO2 stability area to form a filtrate and a regenerated oxides of manganese filter cake; wherein the oxides of manganese of the regenerated oxides of manganese filter cake have a pollutant loading capacity equal to or greater than the pollutant loading capacity of the unreacted oxides of manganese from which the loaded oxides of manganese are formed.

Oxides of manganese filter cake may be formed by a process for regeneration of loaded oxides of manganese sorbent particles bearing a reaction product layer of the surface thereof formed during reaction between unreacted oxides of manganese sorbent particles and target pollutants in a gas stream in a pollution removal system comprising the step of rapidly washing and filtering the loaded oxides of manganese sorbent particles in a rapid filtration wash unit with an aqueous oxidizing solution to dissolve the reaction product layer from the surface of the loaded oxides of manganese sorbent particles into the solution to form a filtrate and a regenerated oxides of manganese filter cake, the solution having Eh and pH values within the Mn02 stability area; wherein the oxides of manganese in the regenerated oxides of manganese filter cake have a pollutant loading capacity equal to or greater than the pollutant loading capacity of the unreacted oxides of manganese sorbent particles from which the loaded oxides of manganese sorbent particles are formed.

In the processes for formation of the above-described oxides of manganese particles and oxides of manganese filter cakes, the aqueous oxidizing solution contains an oxidizer.

The oxidizer may be selected from the group consisting of hypochlorites, perchlolates, permanganates, oxygen (02), air, ozone, peroxides, persulfates, and combinations thereof.

Detailed Description of Preferred Embodiments

The following definitions will be useful in understanding the invention disclosed herein: "Reacted"or"loaded,"as used interchangeably herein, refers in conjunction with "oxides of manganese"and/or"sorbent"to oxides of manganese or sorbent that has interacted with one or more target pollutants in a gas whether by chemical reaction, adsorption or absorption. The term does not mean that all reactive or active sites of the sorbent have been utilized as all such sites may not actually be utilized.

"Unreacted"or"virgin, "as used interchangeably herein, refers in conjunction with "oxides of manganese"and/or"sorbent"to oxides of manganese or sorbent that has not interacted with target pollutants in a gas or gas stream.

"Nitrates of manganese, "as used herein, refers to and includes the various forms of manganese nitrate, regardless of chemical formula, that may be formed through the chemical reaction between NOx and the sorbent and includes hydrated forms as well.

"Sulfates of manganese, "as used herein, refers to and includes the various forms of manganese sulfate, regardless of chemical formula that may be formed through the chemical reaction between SOx and the sorbent and includes hydrated forms as well.

"Target pollutant, "as used herein, refers to the pollutant or pollutants that are or are to be captured and removed from a gas stream.

"Mn02 stability area, "as used herein, refers to the region of thermodynamic stability for manganese dioxide delineated by Eh and pH values for aqueous solutions. More specifically, it refers to the region of thermodynamic stability for manganese dioxide delineated by Eh and pH values for aqueous solutions in an electrochemical stability diagram, such as presented by Pourbaix diagrams.

Oxides of manganese may be utilized for various applications. one such application is in the use as a sorbent for removal of target pollutants in gas streams. Examples of target pollutants that may be removed with an oxide of manganese sorbent, include but are not limited to, NOx, SOx,, mercury (Hg) and some mercury compounds, H2S and other totally reduced sulfides (TRS), and oxides of carbon. As previously noted above, certain target pollutant removal systems and processes methods utilizing oxide of manganese sorbents and referred to as Pahlman systems and Pahlman processes are described and disclosed in co-pending U. S. patent application numbers 09/919,600, 09/951,697, 10/044,089 and 10/025,270, all assigned to EnviroScrub Technologies Corporation, the assignee of this application. The disclosures of these four patent applications are incorporated herein by reference.

Oxides of manganese sorbents are introduced into these and other pollution removal systems and interact with the target pollutants in gas streams routed through the systems as a catalyst, a reactant, an absorbent or an adsorbent.

During such interaction in the process of pollutant removal, the oxidation (or valence) state of the oxides of manganese sorbent is reduced from its original state during reaction with the target pollutants. For example, where the target pollutants are NOx or SOx, possibly through overall reactions such as the following:

SO2+MnO2 9 MnSO4 Reaction (1) 2NO + 02+Mn02 Mn (N03) 2 Reaction (2) In both of the reactions above, manganese (Mn) is reduced from the +4 valence state to +2 valence state during formation of the reaction products shown. It should be noted that the actual reactions may include other steps not shown, and that indicating Reactions 1 and 2 is not in any way intended to limit the scope of the invention, but is used only to illustrate the process.

Additionally, it is believed that reaction products, such as the salts of Reaction (1) and Reaction (2) above, form on the surfaces of the sorbent particles of oxides of manganese.

These reactions may extend to some depth inside the sorbent particles. Applicants believe that formation of such reactions products occurs on the surfaces of the oxides of manganese particles, resulting in a layer or coating, which effectively isolates the covered portion of the particle surface and thereby prevents continued rapid reaction with additional target pollutants. Further, the oxidation state and thus the loading capacity of the oxides of manganese below the surface of the reaction product coating may be reduced during the pollutant removal, thus diminishing the loading capacity of sorbent even after the reaction product have been removed or disassociated into an aqueous solution.

Following reaction with the target pollutants, it is desirable for economic reasons to re-use the unreacted portions of the sorbent for subsequent cycles of pollutant gas removal.

These unreacted portions may exhibit decreased loading capacity. In order to render reacted oxides of manganese effective for subsequent re-use as a gas sorbent with high removal efficiency, it is necessary to: (1) remove reaction products, such as salts from the sorbent particle surfaces and (2) restore or increase the target pollutant loading capacity of the oxides of manganese sorbent. Applicants have found that washing the loaded oxides of manganese in an aqueous oxidizing solution that has been adjusted to within the Mn02 stability area can accomplish these requirements. Further, Applicants have found that loading capacity of virgin or unreacted sorbent can be increased by washing with aqueous oxidizing solutions.

Without being bound by theory, Applicants believe that the processing of oxides of manganese according to the invention in aqueous oxidizing solution systems maintained with the Mn02 stability window may beneficially affect a number of sorbent characteristics. Such characteristics may include particle size and shape, crystalline structure or morphology,

porosity, composition, surface area, bulk density, electrochemical or oxidation potential or manganese valence states.

Regardless, the increased loading capacity is achieved with aqueous oxidizing solutions. Hypochlorites, such as sodium hypochlorite (NaOCl), have been found to be a suitable oxidizers for use in the aqueous oxidizing solutions, although many other oxidizers may also be suitable for this purpose. Other suitable oxidizers include, but are not limited to chlorates, such as sodium chlorate (NaCl03), perchlorates such as sodium perchlorate (Na2C104), permanganates, such as potassium permanganate (KMn04), oxygen (02) or air, ozone (03), peroxides, such as H202, and persulfates, such as sodium peroxidisulfate (Na2S208). The electrochemical potential of the aqueous oxidizing solution, and therefore the effectiveness of the treatment methods of the invention, depends, in part, upon the strength of the oxidizer and/or the concentration of the oxidizer in the solution.

In the treatment methods and systems disclosed herein, the oxidizer used to prepare the aqueous oxidizing solution, must be able to provide the required electrochemical (oxidizing) potential (Eh), within the specified pH range, to provide an Eh-pH combination to achieve stable solution equilibrium, as defined by the Mn02 stability area as delineated in a Pourbaix diagram, such as those depicted in Figures 9 and 10. In a Pourbaix diagram, the Mn02 stability area is defined by the thermodynamically stable ranges or boundaries of pH- Eh combinations that promote the existence and formation Mn02 (having valence state of +4) as the most thermodynamically stable form of manganese in an aqueous solution system.

The domain of Mn02 stability for an aqueous solution varies based upon the various components of the system. For example, changes in dissolved manganese ion concentration, solution temperature, and competing dissolved ions will affect the boundaries of stability for Mn02. The effects of such changes upon the boundaries of the Mn02 stability area on a Pourbaix Eh-pH diagram can be determined either by empirical data derived from experimentation or with computer software programs known to those skilled in the art, such as HSC Chemistry distributed by Outokumpu Oy of Finland. Software may also be written to determine the Mn02 stability area as defined by other diagrams, such as the Latimer Diagram or the Frost Diagram.

In Figure 9, ranges of pH and Eh values for thermodynamically stable aqueous solutions of various manganese compounds are illustrated in graph form for aqueous solution systems at 25 C and a lmole/liter manganese ion concentration. Figure 10 similarly illustrates ranges of pH and Eh values for aqueous solution systems at 25 C but with a 1.0 x

10-6 mole/liter manganese ion concentration. The Pourbaix Window diagrams depicted in Figures 9 and 10 were derived from the diagram presented in Atlas Of Electrochemical Equilibria in Aqueous Solutions,"Marcel Pourbaix, pages 286-293, National Association of Corrosion Engineers, Houston, Texas.

The Eh and pH values as plotted on the graphs delineate the boundaries of the Mn02 stability area for each of the two aqueous solution systems, emphasized with shading in Figures 9 and 10. A comparison of the boundaries of the two shaded areas on Figures 9 and 10 is illustrative of the different stability areas that exist under different system conditions.

Regardless of the specific system conditions, under the thermodynamically stable conditions for Mn02 at a given pH and corresponding Eh range within the MnO2 stability area or the given system conditions, the desired manganese valence state (theoretically +4) will exist. Thus, there is no propensity for Mn compounds in the +4 valence state to degrade to +3 or +2 valence states. Applicants have found that oxides of manganese treated in oxidizing solutions maintained within the MnO2 stability area will exhibit a Mn valence state of close to +4, resulting in a Mn02 with target pollutant loading capacities equal to and/or greater than (increased) the loading capacities of virgin or loaded oxides of manganese.

From the graph presented in Figure 9 or 10, the thermodynamically stable ranges or boundaries of pH-Eh combinations for the particular aqueous system that will promote the existence and formation of MnO2 can be identified. Through their understanding of the relationships between these system parameters of the MnO2 stability area of a Pourbaix Window diagram and application thereof to conditions of a given aqueous system, Applicants are able to treat both virgin and loaded oxides of manganese sorbents so as to yield a treated sorbent, both pretreated and recycled, having equal or increased loading capacity when compared to the untreated sorbent.

Oxidizing solutions having the desired pH-Eh combination can be prepared, maintained or adjusted by increasing or decreasing oxidizer, acid, or base concentrations and/or temperature adjustment, as appropriate, so that the conditions are adjusted to remain within the MnO2 stability area. With monitoring of Eh and pH data, an operator can make necessary adjustments in order to maintain or return the oxidizing solution to conditions within the MnO2 stability area. Monitoring and adjusting can also be automated utilizing electronic sensors and controllers.

Virgin (unreacted) oxides of manganese sorbent particles may be treated or pretreated to increase the oxidation state and/or target pollution loading capacity. This can be

accomplished by washing virgin (unreacted) sorbent with a wash solution of volume-to-sample weight ratio (liquid-to-solids ratio) of 2: 1 or greater. However, effective treatment can also be accomplished with both lower and higher liquid-to-solids ratios as well. The sorbent powder is added to an aqueous oxidizing solution, for example a hypochlorite solution, stirred or agitated for a time sufficient to achieve an increased oxidation state and/or target pollution loading capacity. The then treated sorbent is separated by filtering, and the wet particles dried, which prepares the sorbent for target pollutant removal.

This method of virgin sorbent treatment may be better understood with reference to Figure 1. Turning to Figure 1 a virgin sorbent pretreatment system 10 is illustrated. The pretreatment system includes a washing unit 12, optionally equipped with pH probe 14 and Eh probe 16. As explained later in the specification, these probes may be utilized to provide information on aqueous solution conditions that may be utilized to provided manual or electronically controlled adjustments to relative to providing and maintaining the desire pH- Eh combination and other operating conditions. For example, temperature probe (not shown) may also optionally be provided. Virgin sorbent from virgin sorbent storage 18 is introduced into wash unit 12 along with an aqueous oxidizing solution prepared to have the desired pH- Eh combination within the Mn02 stability area. Optionally, adjustments to the slurry pH and Eh can be made using appropriate oxidants for Eh adjustment and mineral acids and bases for pH adjustments.

The solid-liquid mixture or slurry is agitated or stirred and maintained at the desire operating conditions so as to increase the loading capacity and/or the Mn oxidation state.

Optionally, adjustments to the slurry pH and Eh can be made using appropriate oxidants for Eh adjustment and mineral acids or bases for pH adjustment, so that the pH/Eh combination of the slurry is maintained within the window of Mn02 stability for the specific system.

A filtration unit 22 configured for solid-liquid separation is next provided. Suitable filtration units known and readily identified by those skilled in the art may be utilized for filtration unit 22. The slurry from wash unit 12 is conveyed to filtration unit 22 where the treated sorbent is separated from the solution, with the wash solution or filtrate being routed for re-use, other processing or disposal. Since the filtrate may yet contain useful residual oxidizer, it may not be economic or desirable to dispose of the solution after a single use.

However, after multiple uses, the solution may contain an accumulation of undesired constituents, such as contaminants and debris, that may be present in a load of virgin sorbent.

Such undesired constituents may impact the efficiency or continued usefulness of the filtrate

for subsequent sorbent pretreatment. At that juncture the filtrate may be disposed of or otherwise processed to recover useful values.

In any event, the treated sorbent that has been separated from the slurry is in the form of a wet sorbent cake and may be dried prior to use in a pollutant removal system such as the Pahlman system if the sorbent is to be fed dry into the removal system. In some removal systems the sorbent may be fed as a slurry or even as a wet sorbent cake and for such removal systems a drying step would not be required. However, where drying is required or desired prior to introduction into a pollution removal system, the wet sorbent cake is routed to a dryer 24. A variety of dryers known to those skilled in the art may be utilized for this purpose, such as a rotary kiln, heat exchanger, oven, or other suitable dryers. After drying the treated sorbent may require comminution and possible sieving to reduce the sorbent particles to the desired size. Further, the sorbent dryer 24 may be a standard cake or slurry drying system known to those skilled in the art of drying, which could include a fluidized bed dryer or a spray dryer, configured or designed to inject the wet cake or slurry of oxides of manganese sorbent into the flow of a gas stream prior to introduction into a reaction chamber of a pollutant removal system. Whether dried and comminuted or routed to a cake or slurry drying system, the resulting sorbent having increased loading capacity is ready for use in a pollution removal system

Loaded (reacted) sorbent requires a different treatment in order to prepare it for reuse for target pollutant removal. Specifically, applicants have found it advantageous to rapidly remove the aqueous oxidizing solution from contact with the loaded sorbent being treated during washing once dissolved reaction products, such as soluble salts, have disassociated into solution. Applicants believe that such rapid removal of soluble salts is necessary in order to prevent possible re-deposition of a reaction product coating or layer, through precipitation of reaction products, e. g. , sulfate and nitrate compounds or their derivatives, upon the washed oxides of manganese sorbent particles. Such coatings are believed to be detrimental to target pollutant removal efficiency of the sorbent. In order to prevent re-deposition of such coatings or layer, the washing or rinsing equipment is configured to prevent buildup of high dissolved salt concentrations and avoids prolonged sorbent contact with the wash solutions used.

Prolonged sorbent-solution contact should be avoided for another reason. As the reaction products are dissolved into solution, the acidity of the wash solution has been observed to increase, perhaps having a pH as low as 2.0-4. 0, as a result of sulfate and nitrate salts, for example, combining with wash solution to form weak acids. Such pH shifts during

washing can and oxidizing of loaded sorbent can take the oxidizing solution outside of the MnO2 stability area At the lower pH ranges, as illustrated in the Pourbaix Window diagram of Figure 9, an upward, sometimes significant, Eh adjustment would be required to remain within the MnO2 stability area. Base could also be added to accomplish the desired adjustment; however, this will be ineffective if the oxidizer has been depleted, requiring oxidizer addition. As some oxidizers or oxidants are inexpensive, such Eh adjustment can be uneconomic. However, if not otherwise made, a treated sorbent with a lower valance state and/or loading capacity would result. Through avoidance of prolonged contact potentially, costly Eh adjustments and pH adjustments can be avoided or minimized and a treated sorbent with increased loading capacity can be obtained.

Rapid filtration can be accomplished by various methods such as vacuum or pressure filtration. On the laboratory scale, rapid filtration can be accomplished by placing the loaded oxides of manganese sorbent to be washed on a filter media, using an apparatus such as a Beuchner funnel, and maintaining a vacuum to the filter while applying the wash solution onto the loaded oxides of manganese sorbent. This results in rapid filtration of wash solutions through the sorbent, accompanied by rapid transport of dissolved salts away from the washed sorbent.

Loaded oxides of manganese sorbent samples are washed with an oxidizing wash solution of volume-to-sample weight ratio (liquid-to-solids ratio) of between 2: 1 and 50: 1 or greater, preferably 25: 1 to 35: 1. Within these liquid-to-solid ratios and with rapid filtration, effective dissolution and rapid removal of reaction products can be achieved, resulting in a treated or recycle processed (sometimes referred to as regenerated) sorbent having an increased oxidation state and/or target pollution loading capacity.

The system and method of recycle processing of loaded sorbent can be understood with reference to Figure 2. Turning to Figure 2 a loaded sorbent treatment or recycle processing system 30 is illustrated. The system 30 includes a combination rapid filtration wash unit 32. The wash unit 32 is configured to receive loaded sorbent from loaded sorbent storage 34 and to aqueous oxidizing solution. The wash unit 32 is further configured and operated so as to avoid and pooling of oxidizing solution or creation of a liquefied slurry or other conditions that would lead to prolonged solid-liquid contact such that the solution no longer remains within the Mn02 stability area. Devices such as moving belt filters presses, filter presses, and filter drum presses or pressurized or vacuum filters or other such devices

known to those skilled in the art for rapid filtration washing can be used for rapid filtration wash unit 32.

Loaded sorbent is introduced into rapid-wash filtration unit 32 from loaded sorbent storage 34. An aqueous oxidizing solution prepared to have the desired pH-Eh combination within the Mn02 stability area is then passed over and through the loaded sorbent with rapid filtration. The aqueous oxidizing solution may be monitored and adjusted prior to application to the loaded sorbent and the Eh and pH of the filtrate may be monitored. However, monitoring is not really required as long as there is no pooling so as to cause undesirable prolonged solid-liquid contact. Once the load sorbent had been washed for a time sufficient to restore or increase the loading capacity and/or Mn oxidation state, solution is no longer applied and the wet sorbent cake is routed to dryer 36. The same types and variety of dryers suitable as dryer 24 in the virgin sorbent pretreatment system 10 are suitable for use as dryer 36 in the loaded sorbent treatment system 30. And similarly, the selection will depend upon whether the recycle processed sorbent is to be introduced into a pollutant removal system dry or as a wet sorbent cake. If to be introduced dry, with comminution and possibly sieving, as necessary, the treated or recycle processed loaded sorbent is ready for re-introduction into a pollutant removal system.

It should be noted that the embodiment of the system of the invention in Figure 2 may be utilized for treatment of virgin oxides of manganese as well, even though prolonged liquid-solid contact need not be avoided for pretreatment. Thus, virgin sorbent may be treated in the system depicted in either Figure 1 or Figure 2 and by the same method as loaded sorbent.

Respectively, Figures 7 and 8 illustrate embodiments of the invention incorporating electronic controller to provide integrated simultaneous monitoring and adjustment of operational parameters for treatment of oxides of manganese with option feed back loop for checking the loading capacity of the treated sorbent.

With reference to Figure 7, the pretreatment system 40, illustrated in block flow, has a wash unit 42, a filtration unit 44, and a dryer 46. Wash unit 42 is equipped with temperature probe 47A, pH probe 47B and Eh probe 47C which are in electronic communication with a controller 50. A vessel 52 containing oxidizing solution is configured to feed oxidizing solution to wash unit 42. Virgin sorbent vessel 53 containing virgin sorbent is configured to feed virgin sorbent to wash unit 42. Acid and/or base vessel 54 is configured to feed acid and or base to wash unit 42. The feeders (not shown) of vessels 52,53 and 54 are in electronic

communication with the controller 50. The controller is also in electronic communication with the Eh probe 55 with which the oxidizing solution vessel 53 is equipped. As illustrated treated sorbent from dryer 46 is routed to reaction chamber 56. Alternatively, sorbent from dryer 46 may be routed for storage or to a sorbent feeder prior to introduction to the reaction chamber 56. Reaction chamber 56 represents a pollution removal system or a reaction zone of a pollution removal system such as a Pahlman dry removal system described in co- pending U. S. patent application numbers 09/919, 600,09/951, 697,10/044, 089 and 10/025, 270 or any other pollution control system that utilizes oxides of manganese as a sorbent for removal of target pollutants from gas streams. Reaction chamber 56 is equipped with optional target pollutant concentration readers or continuous emission monitors (CEMS) for NOx and SOx readers 57A and 57B in electronic communication with controller 50.

The controller 50 interfaces with probes 47A-47C, readers 57A, 57B and the feeders of the vessels 52-54 for measurement and adjustment of operational parameters with in the pretreatment system. These parameters are important in determining the proper Eh of the aqueous oxidizing solution prior to addition to the washing unit 42 and the conditions in the washing unit 42 when the virgin sorbent is added. Eh probe 55 is in communication with controller 50 to adjust the Eh of oxidizing solution vessel 52. The controller 50 adds oxidant to vessel 52 until the desired Eh reading is abtained prior to addition to the wash unit 42. The temperature, pH, and Eh of the washing unit are monitored and adjusted so as to maintain conditions within the Mn02 stability area.

The controller 50 contains a programmable logic controller (PLC) and other hardware components necessary for the operation of the controller such as a power supply, input and output nodules that would communicate with the probes 47A-47C and/or readers 57A, 57B, and the feeders of the vessels 52-54. The controller 50 receives inputs from the various probes and readers and converts them into ladder logic language that would be used by an internal proportional integral derivative (PID) loop to individually and simultaneously monitor system operational parameters and to reconcile the inputs with predetermined or computer generated calculated set points for the operational parameters, such as temperature, and Eh and pH levels. As determined by computer logic, the controller 50 will send an output as necessary to any of the feeders of vessels 52-53 signaling a feeder to cycle on or to change feeder rate so as to maintain or adjust system operational parameters to within the Mn02 stability area. The controller 50 may also contain an Ethernet card or other component that allows onsite or offsite remote display and operator interface and control as needed.

The controller 50 would be given a start command and direct the feeders of vessels 52 and 53 to inject, respectively, a predetermined amounts of virgin sorbent and oxidizing solution into the washing unit 42. The controller would signal the feed of a predetermined amount of oxidant into the aqueous oxidizing solution vessel checking and or adjusting the Eh and/or pH of the solution prior to feeding into the washing unit. The Eh of the oxidizing solution in vessel 52 may be adjusted by addition of an oxidizer in sufficient quantity as to raise the Eh to the desired level from an oxidizer vessel, not shown in Figure 7, containing a supply of oxidizer. As determined by programmed controller logic, the controller 50 would also check, based on inputs received from the probes 47A-47C and/or adjust the conditions of the washing unit by adjusting the temperature utilizing a heater or heat exchanger (not shown in Figure 7) to increase or decrease solution temperature; the pH, if needed, by increasing or decreasing the rate of base or acid feed; and the Eh, if needed, by increasing or decreasing the oxidizer concentration of the aqueous oxidizing solution. An optional, final quality control loop may be provided utilizing the readers 57A, 57B checking the loading performance of the treated sorbent by sending, for example, SOx and NOx readings back to the controller 50. As determined by controller logic, the controller 50 would then adjust the washing unit parameters, if needed, to provide treated oxides of manganese having increased loading capacity as compared to the untreated virgin sorbent contained in vessel 53. The same controller may also be used to control the entire operation of both the reaction chamber 56 and the pretreatment system 40, or separate controllers may be provided.

With reference to Figure 8, a recycle processing or regeneration system 60, for treating loaded sorbent is illustrated as a block flow diagram. The regeneration system 60 has a rapid filtration wash unit 62 from which treated sorbent is routed to dryer 64. The filtrate from wash unit 62 is directed for disposal or for other processing to recover useful values therein. Loaded sorbent vessel 66 is configured to feed loaded sorbent to wash unit 62. An oxidizing solution vessel 68 containing oxidizing solution is configured to feed oxidizing solution to wash unit 62. The feeders (not shown) of vessels 66,68 are in electronic communication with the controller 70. Vessel 68 is equipped with an Eh probe 72A and pH probe 72B which are also in electronic communication with the controller 70. As illustrated, treated sorbent from the dryer 64 is routed to a reaction chamber 56. It being understood that, as in pretreatment system of Figure 7, the treated sorbent may be routed to a sorbent feeder or to a sorbent storage bin. Similarly, optional readers 57A, 57B are in electronic

communication with controller 70, providing a optional control loop to check loading performance of treated sorbent.

The controller 70 interfaces with the Eh probe 72A, pH probe 72B, temperature probe 72C, the readers 57A, 57B, and the feeders of the vessels 66,68 to monitor and adjust the operational parameters of pH, Eh and temperature within the regeneration system 60.

Additionally, the controller 70 interfaces with a vessel (not shown in Figure 8) and the feeder thereof to provide acid or base as necessary to the aqueous oxidizing solution. It is important to determine and adjust, as necessary, the operational parameters prior to introducing the oxidizing solution into wash unit 62 in order to assure that conditions of the oxidizing solution are within the Mn02 stability area.

The controller 70 contains a programmable logic controller (PLC) and other components that would be necessary for the operation of the controller such as a power supply, input and output modules that would communicate with the probes 72A, 72B, 72C, the readers 57A, 57B and the feeders that supply the loaded sorbent, the aqueous oxidizing solution, and acid or base. The controller 70 receives inputs from the various probes and readers and convert them into ladder logic language that would be used by the internal proportional integral derivative (PID) loop to individually or simultaneously monitor system operational parameters and to reconcile the inputs with predetermined or computer generated calculated set points for the operational parameters. The controller 70 may also contain an Etc-remet card or other component that allows onsite or offsite remote display and operator interface and control as needed. Such integrated control of the regeneration system allows a practical alternative to manual adjustments by an operator and lends itself to automation of the regeneration system even from remote locations.

The controller 70 would be given a start command and signal the feeders of the vessels 66,68, simultaneously or in desired sequence, to inject a predetermined amount of loaded sorbent and oxidizing solution into rapid filtration wash unit 62. In order to maintain conditions of the solution within the MnOa stability area, the controller 70 would, as necessary, signal feed of a predetermined amount of oxidizer, acid or base into the aqueous oxidizing solution in vessel 68, regularly monitoring and/or adjusting the Eh and/or pH of the solution prior to being fed into the washing unit. As determined by the controller logic, the controller 70 would also check, based on inputs received from the probes 72A, 72B, 72C, and/or adjust the conditions of the aqueous oxidizing solution in vessel 68 by adjusting the temperature utilizing a heater or heat exchanger (not shown in Figure 8) to increase or

decrease solution temperature; the pH, if needed, by increasing or decreasing the rate of base or acid feed; and the Eh, if needed, by increasing or decreasing the oxidizer concentration of the aqueous oxidizing solution.

As in the pretreatment system, an optional, final quality control loop may be provided utilizing the readers 57A, 57B, checking the loading performance of the treated sorbent by sending, for example, SOx and NOx readings back to the controller 70. As determined by controller logic, the controller 70 would then adjust oxidizing solution parameters, if needed, to provide treated oxides of manganese having increased loading capacity as compared to the untreated loaded sorbent contained in vessel 66. The same controller may also be used to control the entire operation of both the reaction chamber 56 and the treatment system 40, or separate controllers may be provided.

Applicants conducted a series of lab-scale tests utilizing a live slipstream of an actual exhaust gas from a coal-fired combustion source in order to demonstrate the increased loaded capacity achieved with the invention. A glass reactor designed to mimic the gas-solid interactions known to be present in the reaction zones of a Pahlman dry target pollutant removal system was utilized for the tests. The glass reactor was a vertically positioned Pyrex glass cylinder having an internal diameter of 2 inches and a length of approximately 18 inches. For each test run, 50.0 grams of oxides of manganese were suspended in the reactor using a permeable fritted glass filter positioned approximately 4 inches from the bottom of the reactor, allowing for flow of the gas stream through the reactor while keeping the oxides of manganese suspended. The test reactor was insulated and configured with thermocouples for temperature readings and heating elements for temperature control to maintain a temperature set point, which in the purposes of the conducted testes was 250 F.

A NOx and SOx laden gas stream was pumped into the bottom of the test reactor at a flow rate which provided adequate fluidization of the bed of sorbent to promote optimal gas/solids contact. The reactor was heated during the testing to 250 F and the gas flow rate was metered at a constant 6.5 liters per minute (lpm). The slipstream of actual exhaust gas was from a 570 MW tangentially-fired coal-burning boiler operating on Powder River Basin (PRB) western coal.

The composition of the exhaust gas was measured both on the inlet and outlet of the test reactor with appropriate gas analyzers, as one skilled in the art would employ and for the test run examples presented found to be within the following ranges: Oxygen (02) 6-7%, carbon dioxide (CO2) 10-12%, oxides of nitrogen (NOx) 190-250ppm, sulfur dioxide (S02)

400-500ppm. The composition of the inlet gas to the test reactor varied slightly from test to test, therefore the data was normalized and presented as pounds (lbs) of NOx or SO2 into and out of the test reactor. The extent of NOx and S02 loading was then calculated to determine the effectiveness of the aqueous oxidizing rinse. The slipstream was passed through the fluidized bed of oxides of manganese, where the flow carried a portion of the sorbent up onto the filter, thus creating a filter cake, which mimics a bag house reaction chamber of a Pahlman dry target pollutant removal system.

S02 and NOx concentrations were measured continuously alternating from the reactor inlet and outlet utilizing a continuous emissions monitoring system (CEMS). S02 concentrations were measured utilizing a Bovar Western Research model 921NMP spectrophotometric instrument and NOx concentrations were measured utilizing a Thermo Electron model 42H chemiluminescent instrument. In order to obtain accurate and reliable emission concentrations, sampling and reporting was conducted in accordance with US EPA Reference CFR 40, Part 60, Appendix A, Method 6C. Inlet gas temperature was 250 F, with a differential pressure across the permeable fritted glass filter was 2. 00" of WC. Figures 3 and 4 show the results of comparative test runs conducted utilizing 50g of each of virgin EMD type oxides of manganese sorbent, to provide a baseline, and treated virgin EMD type oxides of manganese sorbent prepared according to the invention. The treated virgin EMD type oxides of manganese sorbent sample was prepared by first treating with an aqueous oxidizing solution of 0.01% sodium hypochlorite (NaOCl). The measured pH and Eh values of the starting aqueous oxidizing solution of 0.01% sodium hypochlorite (NaOCl) were 8.5 and 900mV respectively, which provided a solution within the Mn02 stability area. A quantity of virgin EMD type oxides of manganese sorbent (75. 3g) was then added to a mixing beaker of 151g of the aqueous oxidizing solution of 0. 01% sodium hypochlorite (NaOCl). The slurry was then continually stirred for a period of 15 minutes while recording data on the changing pH and Eh of the solution. The starting pH of 8.5 quickly dropped to 6.2 within the first minute of mixing and after 15 minutes had dropped to 6.1. The Eh which started at 900mV rose to 1040mV within the first minute of mixing then started slowly dropping in about even increments to a finial value of 885mV after 15 minutes. The slurry was then placed in a paper filter to separate the solids from the filtrate. The now treated EMD type oxides of manganese sorbent was then placed in a drying oven and dried for 5 hrs at 185 F (85 C). The dried sorbent was then gently deagglomerated and 50g were then placed in the laboratory test reactor for subsequent target pollutant loading, the measured data points

are plotted and identified in Figures 3 and 4 as"Virgin Sorbent Following Treatment".

Along with the treated virgin EMD type sorbent loading rates, data points from untreated virgin EMD type oxides of manganese sorbent are alos plotted in Figure 3 and 4 as"Virgin Sorbent Baseline"to provide a baseline for loading capacity comparison.

Figure 3 shows the NOx loading curves. Looking at the virgin sorbent baseline, the virgin EMD type sorbent was at least achieving 90% NOx removal on a ppm basis for 24 minutes, during which time an accumulative total of 158 x 10-6 pounds of NOx entered into the laboratory test reactor with only 5. 6 x 10-6 pounds of NOx exiting the reactor, for a total of 152.4 x 10'"pounds of NOx being captured by the virgin EMD type oxides of manganese sorbent. The treated virgin EMD type sorbent is shown to exhibit substantially improved loading rates. NOx removal time at a NOx removal rate of at least 90% was increased to 47 minutes. For comparison, an accumulative total of 331 x

10'"pounds of NOx entered the laboratory test reactor with only 6.1 x 10-6 pounds of NOx exiting the reactor for a total of 324.9 x 10-6 pounds of NOx being captured by the treated virgin EMD type oxides of manganese sorbent
Figure 4 shows the SO2 loading curves. Looking at the virgin sorbent baseline, the virgin EMD type sorbent was at least achieving 99% S02 removal on a ppm basis for 24 minutes, during which time an accumulative total of 548 x 10-6 pounds of SO2 entered into the laboratory test reactor with only 1.9 x 10-6 pounds of SO2 exiting the reactor, for a total of 546. 1 x 10-6 pounds of S02 being captured by the virgin EMD type oxides of manganese sorbent. The treated virgin EMD type sorbent is shown to exhibit substantially improved loading rates. SO2 removal time a a removal rate of at least 99% was increased to 61 minutes. For comparison, an accumulative total of 1266 x 10-6 pounds of S02 entered the laboratory test reactor with only 0.9 x 10'"pounds of S02 exiting the reactor, for a total of 1265.1 x 10-6 pounds of S02 being captured by the treated virgin EMD type oxides of manganese sorbent.

Figures 5 and 6 show the results of comparative test runs conducted utilizing 50g of each of virgin EMD type oxides of manganese sorbent, to provide a baseline, and treated loaded EMD type oxides of manganese sorbent prepared according to the invention. The treated loaded EMD type sorbent sample was first treated with an aqueous oxidizing solution of 0. 01% sodium hypochlorite (NaOCl). The measured pH and Eh values of the starting aqueous oxidizing solution of 0. 01% sodium hypochlorite (NaOCl) were 8.9 and 900mV respectively, which provided a solution within the Mn02 stability area. A quantity of loaded

EMD type oxides of manganese sorbent (98.8g) was evenly distributed on moistened filter paper, which was placed in a Beuchner funnel. After applying vacuum, a first quantity of 1650 ml of aqueous oxidizing solution of 0.01% sodium hypochlorite (NaOCl) was evenly applied to the loaded EMD type sorbent surface at a rate such that no solution pooling was allowed to take place. The filtrate was then collected and the pH and Eh was measured to be 2.8 and 1070mV respectively. A second quantity of 1650 ml of an aqueous oxidizing solution of 0. 01% sodium hypochlorite (NaOCl) was again evenly applied to the loaded sorbent surface at a rate such that no solution pooling was allowed to take place. The second filtrate was then found to have a pH of 2.8 and an Eh of 1100mV. The now treated EMD type oxides of manganese sorbent was then placed in a drying oven and dried for 2 hrs at 185 F (85 C). The dried sorbent was then gently deagglomerated and 50g were then placed in the laboratory test reactor for subsequent target pollutant loading, the measured data points are plotted and identified in Figures 5 and 6 as"Loaded Sorbent Following Treatment."The data points from untreated virgin EMD type oxides of manganese sorbent are plotted in Figure 5 and 6 as"Virgin Sorbent Baseline"to provide a baseline for loading capacity comparison.

Figure 5 shows the NOx loading curves. Looking at the virgin sorbent baseline, the EMD type sorbent was at least achieving 90% NOx removal on a ppm basis for 24 minutes, during which time an accumulative total of 158 x 10-6 pounds of NOx entered into the laboratory test reactor with only 5.6 x 10-6 pounds of NOx exiting the reactor, for a total of 152.4 x 10-6 pounds of NOx being captured by the virgin EMD type oxides of manganese sorbent. The loaded EMD type sorbent following treatment is shown to exhibit substantially improved loading rates. NOx removal time at a removal rate of at least 90% was increased to 32 minutes. For comparison, an accumulative total of 222 x 10-6 pounds of NOx entered the laboratory test reactor with 8.4 x 10-6 pounds of NOx exiting the reactor, for a total of 213.6 x 10-6 pounds of NOx being captured by the treated loaded EMD type oxides of manganese sorbent.

Figure 6 shows the S02 loading curves. Looking at the virgin sorbent baseline, the EMD type sorbent was at least achieving 99% SO2 removal on a ppm basis for 24 minutes, during which time an accumulative total of 548 x 10-6 pounds of S02 entered into the laboratory test reactor with only 1.9 x 10-6 pounds of SO2 exiting the reactor, for a total of 546.1 x 10-6 pounds of S02 being captured by the virgin EMD type oxides of manganese sorbent. The treated loaded EMD type sorbent is shown to exhibit substantially improved

loading rates. S02 removal time at a rate of at least 99% was increased to 47 minutes. For comparison, an accumulative total of 901 x 10~6pounds of SO2 entered the laboratory test reactor with only 3.2 x 10-6 pounds of SO2 exiting the reactor, for a total of 897.8 x 10-6 pounds of SO2 being captured by the treated loaded EMD type oxides of manganese sorbent.

The data from the lab-scale tests presented in Figure 3-6 illustrate the increased loading capacity that is achievable with the invention.

While exemplary embodiments of this invention and methods of practicing the same have been illustrated and described, it should be understood that various changes, adaptations, and modifications might be made therein without departing from the spirit of the invention and the scope of the appended claims.

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 1 570 894 A1**

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
07.09.2005 Bulletin 2005/36

(51) Int Cl.⁷: **B01D 53/64**, B01D 53/10

(21) Application number: **04258064.7**

(22) Date of filing: **22.12.2004**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR LV MK YU

(30) Priority: **06.01.2004 US 751496**

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(54) Method and system for removal of mercury emissions from coal combustion

(57) A method to reduce emissions in flue gas due to combustion of coal in a combustion unit (12) including the steps of: combusting coal in a primary combustion zone (26) of the combustion unit; releasing elemental mercury from the combustion into the flue gas; injecting NH_4Cl, NH_4Br, or NH_4I (36) into the flue gas; oxidizing the elemental mercury with halogen from the additive; adsorbing the oxidized mercury generated by the combustion of the coal with an adsorbent in the flue gas, and collecting the adsorbent with the oxidized mercury in a combustion waste treatment system (32).

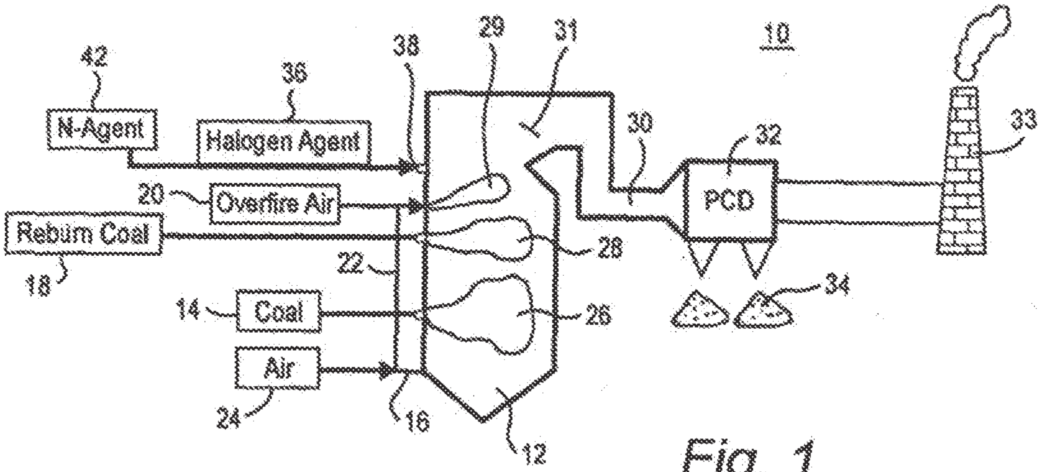

Fig. 1

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Printed by Jouve, 75001 PARIS (FR)

Description

[0001] This invention relates to the combustion of coal and in particular to the reduction of mercury (Hg) and nitrogen oxides (NOx) in flue gas generated during coal combustion.

[0002] Emissions from coal combustion can contain oxides of nitrogen (NOx) and volatile metals such as mercury (Hg). There is a long felt need to reduce Hg and NOx in gaseous emissions from coil-fired boilers and other industrial coal combustion systems.

[0003] As mercury volatizes during coal combustion, it enters the flue gas generated by combustion. Some of the volatized mercury can be captured by coal fly ash and removed via a particulate collection system. The volatized mercury that is not captured in the particulate collection system, or by some other control system, passes into the atmosphere with the stack gases from the coil boiler. It is desirable to capture as much of mercury in flue gas before the stack discharge.

[0004] Mercury volatizes as elemental mercury (Hg°) during coal combustion. Oxidized mercury (Hg^{+2}) is more easily collected by emission control devices than is elemental mercury. Oxidization of mercury is a known technique to capture mercury and remove it from flue gases. As flue gases cool, mercury is partially oxidized by chlorine which is present in coal and released during combustion. It is believed that most oxidized mercury (Hg^{+2}) in flue gas is present as mercury chloride ($HgCl_2$). Oxidation of mercury occurs in combustion gas-phase reactions and on the surface of fly ash. It is believed that mercury oxidation on the surface of fly ash is a predominant channel of mercury oxidation.

[0005] Oxidized mercury ($HgCl_2$ or Hg^{+2}) is water soluble and is easily adsorbed on high carbon fly ash or activated carbon. The oxidized mercury captured by fly ash may be collected with the ash and removed via a particulate collection system. Oxidized mercury is also easily removed by wet scrubbers that are used to control sulfur dioxide (SO_2) emissions. Mercury control is generally most effective when the mercury in flue gas is mostly oxidized.

[0006] Controlling mercury emissions is complicated because mercury is present in flue gases in several different forms, such as elemental mercury (Hg°) and oxidized mercury (Hg^{+2}). Mercury changes forms throughout the combustion process. To effectively control mercury emissions, a control system should take into account the form or speciation of the mercury present in the flue gases at the location of the control system in the flue gas stream. In addition, it would be beneficial if mercury emission controls reduced NOx in stack gases discharged by a power plant.

[0007] There is a special need to control mercury emission from boilers firing low-rank coals, such as coal from the Powder River Basin (hereinafter PRB) and lignite coals. These low-rank coals represent a significant portion of the coal energy market, especially in the U.S. These low-rank coals often have low sulfur content, which minimize SO_2 emissions. Mercury emissions from the burning of low-rank coals tends not to oxidize because of the low chlorine (Cl) content of the coal and the presence of other constituents in the coal that tend to suppress Hg oxidation. Chlorine assists in the oxidation of mercury in flue gas. The low chlorine levels in low rank coal results in relatively high levels of elemental mercury in the flue gas from low rank coal. There is a long felt need to reduce the levels of elemental mercury in flue gas in coal fired plants, especially when low-rank coals are fired.

[0008] The invention may be embodied as a method to reduce emissions in flue gas due to combustion of coal in a combustion unit including the steps of: combusting coal in a primary combustion zone of the combustion unit; releasing elemental mercury from the combustion into the flue gas; injecting NH_4Cl, NH_4Br, or NH_4I into the flue gas; oxidizing the elemental mercury with a halogen (chlorine, bromine, or iodine) from the injected additive; adsorbing the oxidized mercury generated by the combustion of the coal with an adsorbent in the flue gas, and collecting the adsorbent with the oxidized mercury in a combustion waste treatment system.

[0009] The invention may also be embodied as a method to reduce mercury in gas emissions from the combustion of coal in a combustion system, said method comprising: combusting the coal in a primary combustion zone of the combustion system, wherein elemental mercury (Hg°) is released in the flue gas produced by the combustion; staging combustion air supplied to the combustion system by adding a portion of the combustion air to the primary combustion zone and a second portion of the combustion air to an overfire air zone downstream of the combustion zone; maintaining a stoichiometric ratio in the primary combustion zone of no greater than 1.1 so as to form active carbon in the fly ash generated by the combustion of coal; oxidizing the elemental mercury by injection of NH_4Cl, NH_4Br or NH_4I in the flue gas to generate oxidized mercury (Hg^{+2}); adsorbing the oxidized mercury in the flue gas by the active carbon in the fly ash, and collecting the fly ash with adsorbed mercury in a combustion waste treatment system.

[0010] The invention may be further embodied as a system to treat mercury in flue gas emissions from a coal fired furnace comprising: a primary combustion zone receiving combustion air and having a downstream passage for flue gases and fly ash generated during combustion; a coal injector adapted to inject coal into the primary combustion zone; an air injector adapted to introduce combustion oxygen into the combustion zone, wherein an stoichiometric ratio in the zone is no greater than 1.1 so as to form active carbon in the fly ash generated by the combustion of coal; an overfire air burnout zone downstream of the combustion zone and included in the downstream passage, wherein combustion air is injected into the burnout zone; an NH_4Cl, NH_4Br or NH_4I

injector downstream of the primary combustion zone; a combustion treatment waste system coupled to the flue gas output and a discharge for captured particulate waste, and wherein said primary combustion zone burns the coal, and elemental mercury released in the flue gas reacts with injected additive to oxidize the mercury.

[0011] Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

FIGURE 1 is a schematic diagram of a coal fired power plant having a primary combustion zone with an additive injection system downstream of the primary combustion zone.

FIGURE 2 is a schematic diagram of coal fired power plant similar to the plant shown in Figure 1 wherein the additive injection is performed in cooperation with an overfire air (OFA) system.

FIGURE 3 is a schematic diagram of coal fired power plant similar to the plant shown in Figure 1 where the additive injector is in a conductive pass of the plant and the conductive pass also includes a Selective Catalytic Reduction (SCR) unit.

FIGURE 4 is a chart of the effects on mercury and NO_x emissions due to the injection of NH_4Cl at different flue gas temperatures.

FIGURE 5 is a chart of the effects on NOx and Hg emissions due to air staging and NH_4Cl injection.

FIGURE 6 is a schematic diagram of a computer model for predicting flue gas reactions due to the injection of NH_4Cl.

FIGURE 7 is a chart of predicted NOx reduction due to NH_4Cl injection.

FIGURE 8 is a chart of the predicted effects of NH_4Cl injection on, elemental an oxidized mercury in flue gas.

FIGURE 9 is a chart of the predicted effect of chlorine and bromine containing species on mercury oxidation.

[0012] Available mercury control technologies for coal-fired power plants tend to be more effective at removing oxidized mercury from flue gas than in removing elemental mercury. A technique has been developed to increase the fraction of oxidized mercury in flue gas by injecting an oxidizing a halogen additive, e.g., ammonium chloride (NH_4Cl), NH_4Br or NH_4I, into the flue gas. By increasing the fraction of oxidized mercury, the halogen additive increases the amount of mercury removal by activated carbon injection, wet scrubbers and other mercury control technologies. Simultaneously, the halogen additive injection decreases NOx emissions by reducing oxides of nitrogen to molecular nitrogen.

[0013] The presence of chlorine containing compounds in flue gas is an important factor in the oxidation of mercury. Chlorine is a halogen that oxidizes mercury. Low rank coals tend to have low chlorine content, e.g., less than 100 ppm, and a high content of alkali metals. These alkali metals tend to react with and remove the chlorine in the low-rank coal flue gas. Mercury oxidation is suppressed during combustion of low rank coals because of the lack of chlorine in the flue gas. Adding chlorine to flue gas of low rank coal should assist in the oxidation of elemental mercury.

[0014] Other halogens including bromine (Br) and iodine (I) oxidize mercury to form $HgBr_2$ and HgI_2, respectively. Because of very low bromine and iodine contents in coal, these halogens typically contribute very little if any to mercury oxidation in flue gas. However, adding bromine or iodine to flue gas of low rank coals should improve mercury oxidation.

[0015] It has been discovered that mercury removal can be significantly improved by injecting ammonium chloride (NH_4Cl), NH_4Br or NH_4I into flue gas, especially in the flue gas from low-rank coals. The hot flue gas causes the additive to thermally decompose to form HCl, HBr or HI which results in more significant mercury oxidation. The increase in mercury oxidation allows for improved efficiency of mercury removal by activated carbon (AC) injection, wet flue gas desulfurization (FGD) systems, and other mercury control technologies.

[0016] The injected additive also reduces NOx emissions in a selective catalytic reduction (SCR) and/or (SNCR) process, especially if the additive is injected with a nitrogen agent (N-agent) into NOx and O_2 containing flue gas at flue gas temperatures in a range of 1600°F (Fahrenheit) to 2300°F. Injection of additive can also oxidize elemental mercury and improve the performance of the SCR process especially if the additive is injected with N-agent before the SCR unit.

[0017] FIGURE 1 shows a coal-fired power plant 10 comprising a coal combustion furnace 12, e.g., a boiler, having a coal fuel injection system 14, primary air injectors 16, reburn coal injectors 18 and overfire air (OFA) injectors 20. An exterior air duct 22 may distribute air provided by an air source 24, e.g., ambient air, to the primary combustion air injectors 16 and overfire air injectors 20. The coal injection system 14 and combustion air injectors 16 may be included in a low NOx burner (LNB) system.

[0018] The hot gas path through the furnace 12 includes a primary combustion zone 26, a reburn zone 28, an overfire air zone 29, and a convective pass 30. The power plant 10 further includes a particulate control device (PCD) 32 and a fly ash collection unit 34. Most of the coal is burned in a primary combustion zone 26 of the boiler 12. The remaining coal (or fuel) is injected downstream into the reburn zone 28 through the reburn injectors 18 to provide fuel-rich combustion in the reburn zone 26. Overfire air (OFA) is injected into the OFA burnout zone 29 to complete combustion. The hot flue gases flow through the post-combustion zone 31 of the boiler and to a conductive pass 30. Gas emissions are ultimately discharged through a smoke stack 33.

[0019] A halogen additive, e.g., ammonium chloride (NH_4Cl), NH_4Br or NH_4I, is injected as an aqueous solution 36 by nozzles 38 into the flue gas. The halogen assists in the oxidation of elemental mercury in the flue gas. The injection is made downstream from the primary combustion zone 26 at flue gas temperatures of, for example, 1600°F to 2300°F. The halogen additive can be co-injected with air, recycled flue gas, nitrogen or another carrier gas to increase the penetration of the additive aqueous solution across the flue gas path and to improve mixing of the additive aqueous solution and flue gas. Optionally, the halogen additive can be added to ammonia, urea or other N-agent solution 42 (in a SNCR process) to increase the efficiency of NOx reduction. A SNCR process is a selective non-catalytic reduction process in which ammonia, urea or another N-agent solution is injected into flue gas to reduce NOx emissions.

[0020] FIGURE 2 schematically shows a second coal fired power plant 44. Common reference numbers are used to identify components of the second plant that are common to the first plant 10. In the second plant 44, a halogen containing additive agent, an NH_4Cl aqueous solution 36 is injected through nozzles 46 into the boiler along with the OFA 20 into the burnout zone 29. As with the first plant, the boiler 12 of the second plant 44 can be retrofitted with OFA 20 and/or a reburn system 18. The additive can be injected separately downstream of the primary combustion zone, such as with or downstream of the OFA unit. The halogen additive can also be added with ammonia, urea or other N-agent solution 42 (SNCR process) to increase efficiency of NOx reduction.

[0021] FIGURE 3 schematically shows a third coal fired power plant 48. Common reference numbers are used to identify components of the third plant that are common to the first plant 10. In the third plant 48, the halogen containing additive is an aqueous NH_4Cl solution 36 that is injected via nozzles 50 into the conductive pass 30 of the boiler and upstream of a selective catalytic reduction (SCR) unit 52. SCR units are conventionally used to minimize NOx emissions by injecting a nitrogenous reducing agent (hereinafter N-agent), such as ammonia or urea, on the surface of a catalyst exposed to flue gas. An SCR unit is typically positioned in the conductive pass 30 where the flue gas is at a temperature of about 700° F. An SCR can relatively easily achieve 80% NOx reduction. As with the first plant, the boiler 12 of the third plant 48 can be retrofitted with OFA 20 and a reburn system 18. The additive can be added with ammonia, urea or other N-agent solution (SNCR process) to increase efficiency of NOx reduction.

[0022] To evaluate the injection of a NH_4Cl (a halogen containing additive) downstream of a primary combustion zone of a boiler, tests were performed in a 1.0 MMBTU/hr Boiler Simulator Facility (hereinafter BSF) to determine effect of NH_4Cl injection on Hg oxidation and NOx removal. The BSF is described in U.S. Patent 6,280,695.

[0023] Tests were conducted with and without air staging, e.g., with and without OFA. In tests without air staging, the stoichiometric ratio in the primary combustion zone 26 (SR1) was 1.16 which corresponded to about 3% excess air in the flue gas at the BSF emission discharge. The stoichiometric ratio is defined as the ratio of the O_2 to fuel concentrations to the ratio of O_2 to the fuel concentration that results in complete consumption of O_2 and fuel. Combustion of coal without air staging generated about 880 parts-per-million (ppm) of NOx. In the BSF test, the NH_4Cl was injected as an aqueous solution at a nitrogen stoichiometric ratio (NSR) of 0.6. The nitrogen stoichiometric ratio is defined as the ratio of the NH_4Cl concentration to the NO concentration in the flue gas at the location of NH_4Cl injection.

[0024] FIGURE 4 is a chart showing the effect of the injection of a NH_4Cl additive on mercury oxidation and on NOx reduction. During the tests reported in Figure 4, the BSF plant had no air staging. The test results shown in Figure 4 are for: no NH_4Cl additive (56), an NH_4Cl additive added at a flue gas temperature of 1700° F (58), and the NH_4Cl additive added to flue gas at 1850° F (60). Figure 4 shows the percentage of elemental mercury of the total mercury in the flue gas, and the percentage reduction in NOx due to the NH_4Cl injection. Without NH_4Cl injection, the concentration of elemental mercury in flue gas was about 60% of total mercury. No NO_x reduction was observed without NH_4Cl injection. Injection of the NH_4Cl additive at a flue gas temperature of 1700° F resulted in about a 30% NOx reduction and a decrease in the concentration of elemental mercury (Hg^o) from 60% to about 30% of total mercury indicating that the additive oxidized some mercury. Injection of the NH_4Cl additive at 1850° F resulted in more significant mercury oxidation while NOx reduction slightly decreased.

[0025] FIGURE 5 is a chart showing test conducted while BSF plant operated with air staging. In these tests, the SR_1 was 0.7, and SR2 was 1.16. SR_1 is the stoichiometric ratio in the primary combustion zone. SR2 is the stoichiometric ratio at the overfire air injection zone. Overfire air was injected at a flue gas temperature of 2200°F. NH_4Cl was injected as an aqueous solution where the flue gas temperature was at 1800° F. The amount of chlorine in the flue gas provided by NH_4Cl was 120 ppm, and the NSR was 1.5. Figure 5 shows the effect of the NH_4Cl additive injection on NOx reduction and the reduction of the concentration of the elemental mercury. The test results 62,64 presented in Figure 5 demonstrate that staging reduces NOx emissions by about 80% in comparison to no staging of combustion air. Injection of the NH_4Cl additive 64 in conjunction with staging increased the efficiency of NOx reduction by an additional 7% (as compared to no NH4Cl-62) and decreased the percentage of elemental mercury (Hg°) of the total mercury in flue gas from about 40% to about 20%. The BSF test results show in Figures 4 and 5 demonstrate that the injection of NH_4Cl at flue gas temperatures of 1700° F to 1850° F reduces NOx emissions and decreases the concentration of elemental mercury in flue gas.

[0026] A computer simulation process model was developed to predict the effect of NH_4Cl on NOx reduction and Hg oxidation. This process model is described in U. S. Patent No. 6,280,695.

[0027] FIGURE 6 illustrates a computer model used to describe the mixing of reagents with flue gas to the stream of NH_4Cl (so-called inverse mixing). The model treated the injection of gases introduced to the reaction over a certain period of time (mixing time) rather than instantaneously. FIGURE 6 schematically shows a process model 70 that treats the reacting system as a series of two plug-flow reactors R1 (72) and R2 (74). Each reactor describes one of the physical and chemical processes occurring in a boiler: addition of NH_4Cl, NOx reduction by N-agent, and mercury oxidation by chlorine compounds. The first reactor R1 describes mixing of flue gas and NH_4Cl using the model of inverse mixing. The mixture entering R1 consisted of NH_4Cl.

[0028] The flue gas was added to NH_4Cl at a constant rate over period of 120 ms. The flue gas added to R1 corresponds to products coming out of the OFA zone in a typical boiler with OFA. The second reactor R2 describes reactions in the burnout zone.

[0029] The mixing time and temperature profile in the mixing region R1 of the model were estimated using a single jet in a cross flow model. The mixing time was determined by evaluating the entrainment rate of fluid from the crossflow into the jet. For the NH_4Cl jet, the mixing time was estimated to be 110 ms (millisecond) to 120 ms. Variation of mixing time within the range of 120 ms ± 20 ms showed little effect on modeling results. A mixing time of 120 ms was used for NH_4Cl injection in the modeling results shown in Figures 7 and 8.

[0030] The initial amount of NO in the modeled flue gas was 500 ppm. The concentration of NH_4Cl in flue gas after injection was 500 ppm, which corresponded to an NSR of 1.0. The temperature of the flue gas decreased at a linear rate of 550 degrees Fahrenheit per second (F/s). Variations in the temperature gradient within ±50° F showed little effect on modeling predictions.

[0031] FIGURE 7 is a chart of the results of modeling that show the predicted temperature effect of NH_4Cl injection on NOx reduction. Figure 7 shows that NH_4Cl injection in a temperature range of 1600° F to 2300° F reduces NOx emissions. An optimal range according to the modeling for NOx reduction is 1750° F to 1950° F. The maximum predicted NOx reduction is about 73% where NSR is 1.0.

[0032] FIGURE 8 shows a predicted effect of NH_4Cl injection on mercury in flue gas. The NH_4Cl shows the predicted effect of injecting a spray of 500 ppm NH_4Cl in flue gas on mercury speciation. Total mercury concentration of mercury in the flue gas was 10 ppbv. It was assumed that all mercury was present in elemental form (Hg°) prior to NH_4Cl injection. Modeling predicted that about 12% of the Hg° was oxidized by chlorine compounds in the gas phase due to NH_4Cl injection. Mercury oxidation during coal combustion can be catalyzed by minerals present in fly ash. Mechanism of that heterogeneous process is not well understood and was not considered in modeling. Accordingly, the amount of mercury oxidized in the flue gas may be substantially higher than that predicted by the model.

[0033] An equilibrium model was used to predict the effects of chlorine and bromine on mercury oxidation. Equilibrium modeling predicts the most stable composition of products at a specified temperature and pressure, thus indicating the dominant direction for the transformation of mercury-containing species.

[0034] FIGURE 9 shows a predicted effect of chlorine and bromine on concentration of oxidized mercury in flue gas resulting from combustion of a typical PRB coal. The concentration of oxidized mercury is shown as a percent of the total mercury in flue gas. Equilibrium modeling predicted that without additives all mercury is present in the elemental form at temperature higher than 700 °F. As temperature decreases, mercury is oxidized by chlorine or bromine released from coal into flue gas during coal combustion.

[0035] Modeling predicts that injection of chlorine or bromine in the amount of 3 ppm results in mercury oxidation at higher temperatures. Modeling also predicts that bromine is a more effective oxidizing agent than is chlorine. The model predicted that a presence of only 0.3 ppm of bromine in flue gas results almost in the same effect as 3 ppm of chlorine.

[0036] The equilibrium calculations predict that chlorine and bromine containing compounds are mercury oxidizing agents. Modeling also predicts that bromine containing compounds are stronger oxidizing agents than are chlorine containing compounds. It is believed that iodine containing compounds also should be strong mercury oxidizing additives.

[0037] For completeness, various aspects of the invention are set out in the following numbered clauses:

1. A method to reduce emissions in flue gas due to combustion of coal in a combustion unit (12), said method comprising:

   a. combusting coal in a primary combustion zone (26) of the combustion unit;
   b. releasing elemental mercury from the combustion into the flue gas;
   c. injecting a halogen-containing additive (36)

into the flue gas;

d. oxidizing the elemental mercury with a halogen from the halogen-containing additive;

e. adsorbing the oxidized mercury generated by the combustion of the coal with an adsorbent in the flue gas, and

f. collecting the adsorbent with the mercury in a combustion waste treatment system (32).

2. A method as in clause 1 wherein the halogen-containing additive (36) is selected from a group consisting of NH_4Cl, NH_4Br and NH_4I.

3. A method as in clause 1 wherein the coal comprises a coal having a low chlorine content.

4. A method as in clause 3 wherein the coal having the low chlorine content is a Powder River Basin coal or lignite coal.

5. A method as in clause 3 wherein the coal having the low chlorine content has less than 100 parts-per-million (ppm) of chlorine.

6. A method as in clause 1 wherein the combustion waste treatment system includes a particle control device (32).

7. A method as in clause 1 wherein the adsorbent is fly ash, and the oxidized mercury is adsorbed on the fly ash.

8. A method as in clause 1 wherein the adsorbent is activated carbon, and the oxidized mercury is adsorbed on the activated carbon.

9. A method as in clause 1 further comprising heating the halogen-containing additive (36) with flue gas to generate HCl, HBr or HI and oxidizing the elemental mercury with the HCl, HBr or HI.

10. A method as in clause 1 further comprising injecting overfire air (20) downstream of the primary combustion zone to generate excessive carbon fly ash and the adsorbent is the fly ash.

11. A method as in clause 10 wherein the stoichiometric ratio (SR1) in the primary combustion zone is less than 1.1, and the stoichiometric ratio (SR2) at an overfire air injection zone is above 1.0.

12. A method as in clause 11 wherein SR1 is no greater than 0.8 and SR2 is no less than 1.15.

13. A method as in clause 1 further comprising coal reburning downstream of the primary combustion zone to form carbon in fly ash generated during combustion, and the fly ash is the adsorbent.

14. A method as in clause 1 further comprising injecting a nitrogenous reducing agent into the flue gas.

15. A method as in clause 14 further comprising a catalytic surface for NOx and mercury oxidation.

16. A method as in clause 1 wherein the halogen containing additive is injected where the flue gas is in a temperature range of 1600° F to 2300° F.

17. A method as in clause 1 wherein the halogen containing additive is injected where the flue gas is in a temperature range of 1750° F to 1950° F.

18. A method as in clause 1 wherein an amount of halogen injected into the flue gas by the halogen containing additive is in the range of 1 to 200 parts per million.

19. A method as in clause 1 wherein the halogen containing additive is injected in an aqueous solution into the flue gas.

20. A method as in clause 19 wherein the halogen containing additive is injected in the solution further comprising NH_4OH.

21. A method as in clause 19 wherein the halogen containing additive is injected in the solution further comprising urea.

22. A method as in clause 1 wherein the mercury released from combustion is mostly elemental mercury (Hg^0) and further comprising oxidizing the elemental mercury as the flue gases cools.

23. A method as in clause 22 wherein the oxidized mercury is removed from flue gas in a scrubber.

24. A method as in clause 1 further comprising injecting an aqueous solution of the halogen containing additive with a carrier gas.

25. A method as in clause 24 wherein the carrier gas is at least one of air, recycled flue gas and nitrogen gas.

26. A method to reduce mercury in gas emissions from the combustion of coal in a combustion system, said method comprising:

a. combusting the coal in a primary combustion zone of the combustion system, wherein elemental mercury (Hg^0) is released in the flue gas produced by the combustion;

b. staging combustion air supplied to the combustion system by adding a portion of the com-

bustion air to the primary combustion zone and a second portion of the combustion air to an overfire air zone downstream of the combustion zone;
c. maintaining stoichiometric ratio in the primary combustion zone of no greater than 1.1 so as to form active carbon in the fly ash generated by the combustion of coal;
d. oxidizing the elemental mercury by injection of a halogen containing additive in the flue gas to generate oxidized mercury (Hg^{+2});
e. adsorbing the oxidized mercury in the flue gas by the active carbon in the fly ash, and
f. collecting the fly ash with adsorbed mercury in a combustion waste treatment system.

27. A method as in clause 26 wherein the halogen containing additive is selected from a group consisting of NH_4Cl, NH_4Br and NH_4I.

28. A method as in clause 26 wherein the combustion waste treatment system comprises a particle control device capturing the fly ash with adsorbed mercury and discharging the captured fly ash to a fly ash collection unit.

29. A method as in clause 26 wherein the combustion waste treatment system comprises a particle control device capturing the fly ash after the fly ash cools to a temperature no greater than 400 degrees Fahrenheit.

30. A method as in clause 26 further comprising coal reburning in the combustion system to form carbon in the fly ash generated during combustion.

31. A method as in clause 30 wherein an amount of reburning fuel used during the coal reburning is in a range of about 10 to about 30 percent of a total heat input of fuel used for the combustion.

32. A method as in clause 30 wherein an amount of reburning fuel used during the coal reburning is in a range of about 15 to about 25 percent of a total heat input of fuel used for the combustion.

33. A method as in clause 26 wherein combustion occurs in a low nitrogen oxide (NOx) burner.

34. A system to treat mercury in flue gas emissions from a coal fired furnace comprising:

a primary combustion zone receiving combustion air;
a coal injector adapted to inject coal into the primary combustion zone;
an air injector adapted to introduce combustion oxygen into the primary combustion zone;
a downstream passage of the primary combustion zone for flue gases and fly ash generated during combustion;
an injector in the downstream passage for injecting a halogen containing additive;
a combustion treatment waste system coupled to a flue gas output of the downstream passage and to a discharge for captured particulate waste, and
wherein said primary combustion zone burns the coal, and elemental mercury released in the flue gas reacts with the injected halogen containing additive to oxidize the mercury.

35. A system as in clause 33 wherein halogen containing additive is selected from a group consisting of NH_4Cl, NH_4Br and NH_4I.

36. A system as in clause 34 wherein the downstream passage comprises a duct downstream of the primary combustion zone to cool the flue gas and collect fly ash with the absorbed mercury.

37. A system as in clause 34 further comprising an overfire air burnout zone downstream of the combustion zone and included in the downstream passage, wherein combustion air is injected into the burnout zone.

38. A system as in clause 34 wherein the injector for the halogen containing additive further comprises a nozzle spraying an aqueous solution of halogen-containing additive in the flue gas.

Claims

1. A method to reduce emissions in flue gas due to combustion of coal in a combustion unit (12), said method comprising:

a. combusting coal in a primary combustion zone (26) of the combustion unit;
b. releasing elemental mercury from the combustion into the flue gas;
c. injecting a halogen-containing additive (36) into the flue gas;
d. oxidizing the elemental mercury with a halogen from the halogen-containing additive;
e. adsorbing the oxidized mercury generated by the combustion of the coal with an adsorbent in the flue gas, and
f. collecting the adsorbent with the mercury in a combustion waste treatment system (32).

2. A method as in claim 1 wherein the halogen-containing additive (36) is selected from a group consisting of NH_4Cl, NH_4Br and NH_4I.

3. A method as in claim 1 wherein the coal comprises a coal having a low chlorine content.

4. A method as in claim 1 wherein the combustion waste treatment system includes a particle control device (32).

5. A method as in claim 1 wherein the adsorbent is fly ash, and the oxidized mercury is adsorbed on the fly ash.

6. A method as in claim 1 wherein the adsorbent is activated carbon, and the oxidized mercury is adsorbed on the activated carbon.

7. A method as in claim 1 further comprising heating the halogen-containing additive (36) with flue gas to generate HCl, HBr or HI and oxidizing the elemental mercury with the HCl, HBr or HI.

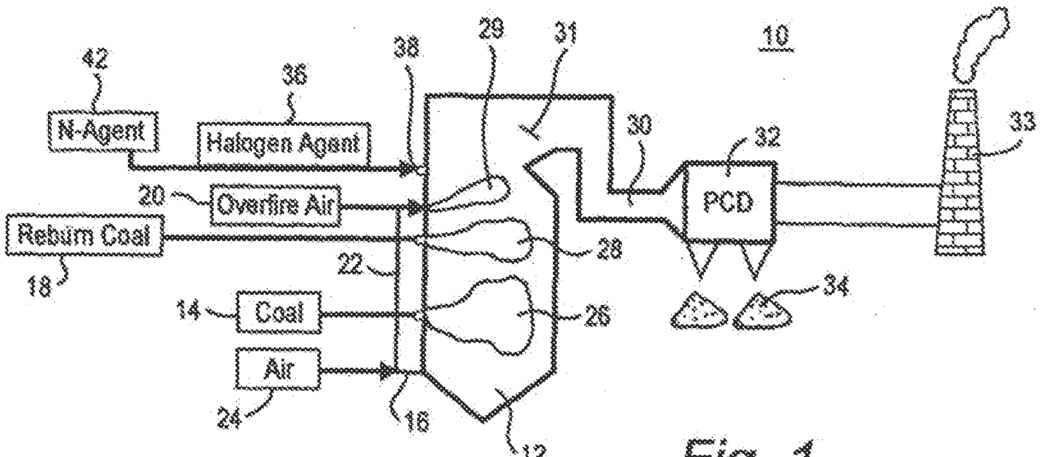
8. A method as in claim 1 further comprising injecting overfire air (20) downstream of the primary combustion zone to generate excessive carbon fly ash and the adsorbent is the fly ash.

9. A method to reduce mercury in gas emissions from the combustion of coal in a combustion system, said method comprising:

a. combusting the coal in a primary combustion zone of the combustion system, wherein elemental mercury (Hg^0) is released in the flue gas produced by the combustion;
b. staging combustion air supplied to the combustion system by adding a portion of the combustion air to the primary combustion zone and a second portion of the combustion air to an overfire air zone downstream of the combustion zone;
c. maintaining stoichiometric ratio in the primary combustion zone of no greater than 1.1 so as to form active carbon in the fly ash generated by the combustion of coal;
d. oxidizing the elemental mercury by injection of a halogen containing additive in the flue gas to generate oxidized mercury (Hg^{+2});
e. adsorbing the oxidized mercury in the flue gas by the active carbon in the fly ash, and
f. collecting the fly ash with adsorbed mercury in a combustion waste treatment system.

10. A system to treat mercury in flue gas emissions from a coal fired furnace comprising:

a primary combustion zone receiving combustion air;
a coal injector adapted to inject coal into the primary combustion zone;
an air injector adapted to introduce combustion oxygen into the primary combustion zone;
a downstream passage of the primary combustion zone for flue gases and fly ash generated during combustion;
an injector in the downstream passage for injecting a halogen containing additive;
a combustion treatment waste system coupled to a flue gas output of the downstream passage and to a discharge for captured particulate waste, and
wherein said primary combustion zone burns the coal, and elemental mercury released in the flue gas reacts with the injected halogen containing additive to oxidize the mercury.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Overfire Air
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Reburn Coal
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22
14
Coal
26
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Air
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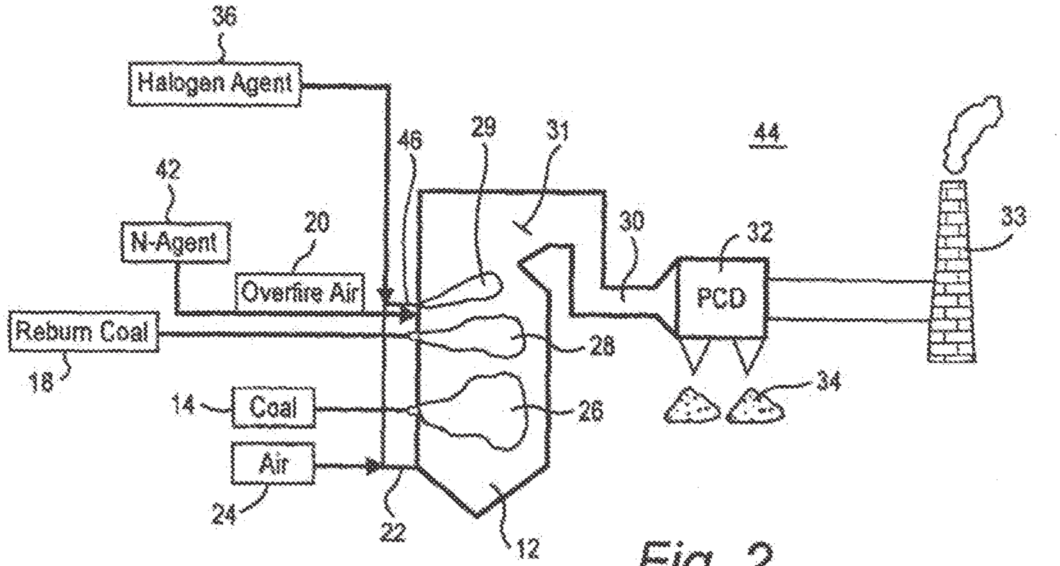
16
12

Fig. 1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Air
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22
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Fig. 2

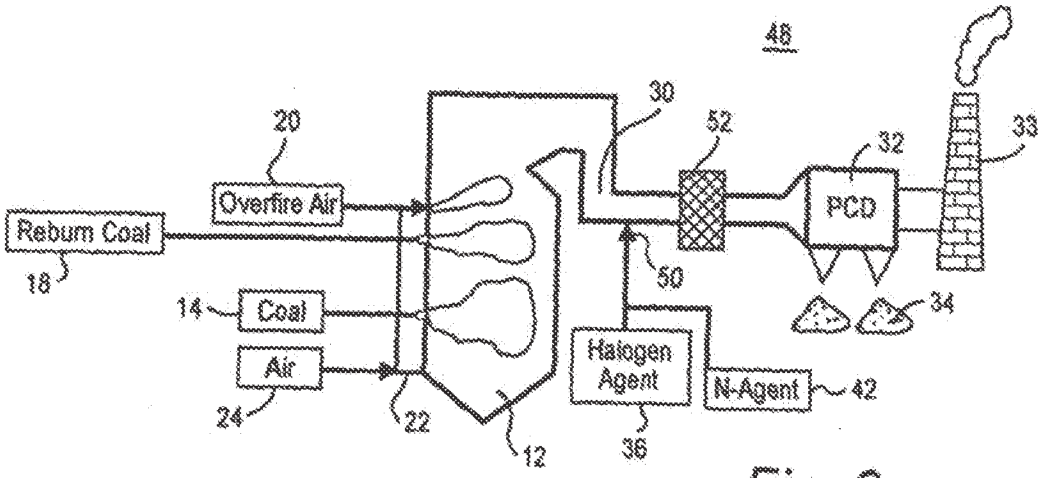

Fig. 3

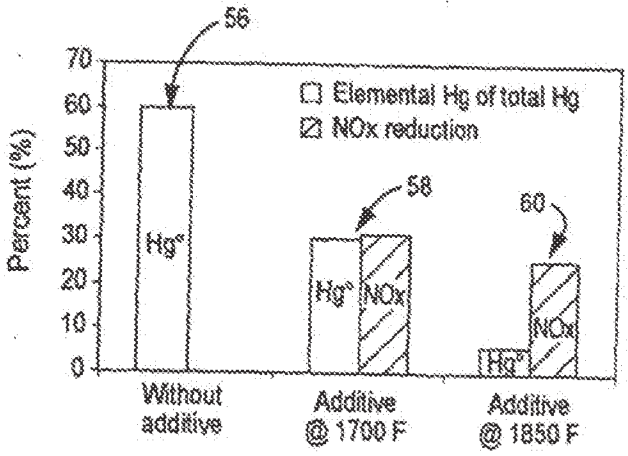

Fig. 4

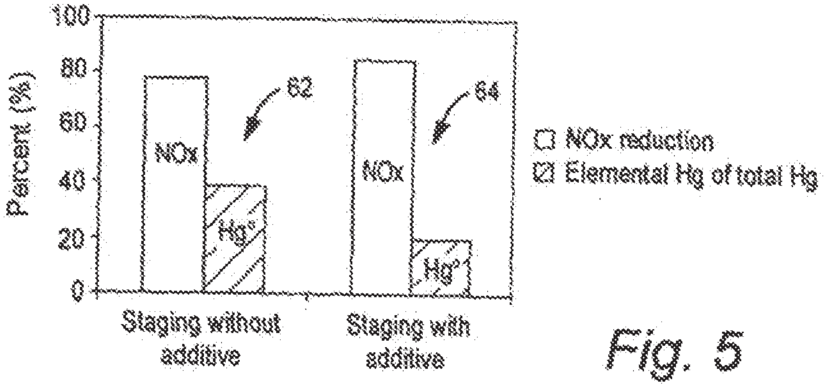

Fig. 5

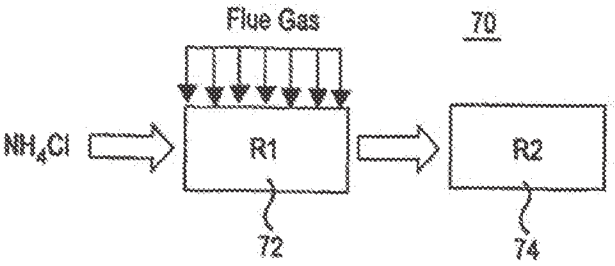

Fig. 6

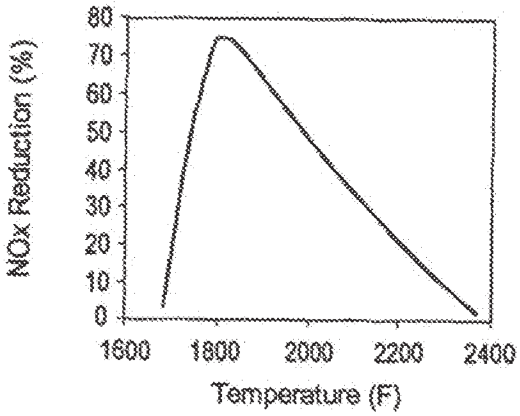

Fig. 7

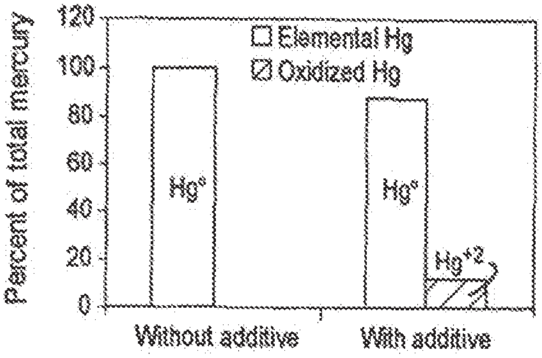

Fig. 8

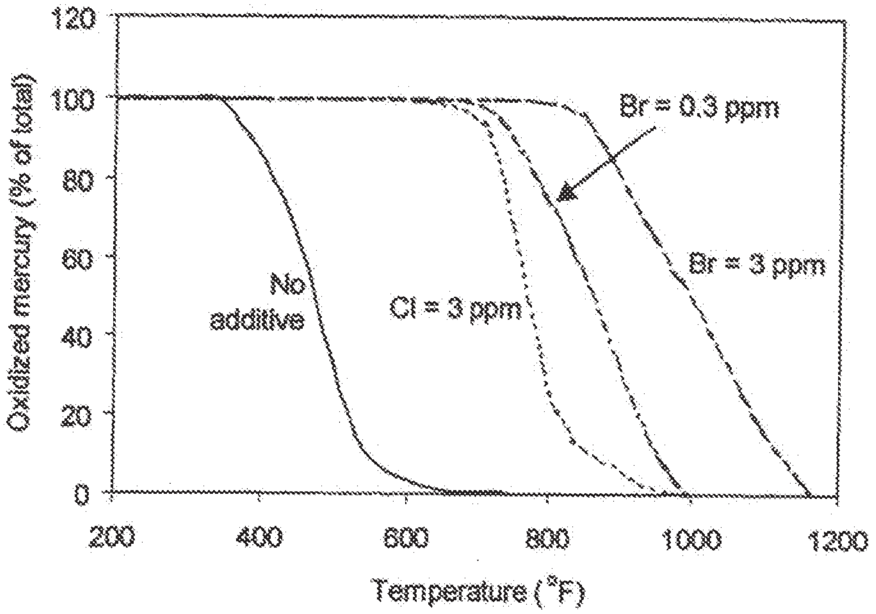
120
100
80
60
40
20
0
Oxidized mercury (% of total)
200
400
600
800
1000
1200
Temperature (°F)
Br = 0.3 ppm
Br = 3 ppm
No
additive
Cl = 3 ppm

Fig. 9

European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 04 25 8064

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
Y X	US 2003/143128 A1 (LANIER WILLIAM STEVEN ET AL) 31 July 2003 (2003-07-31) * paragraphs [0014], [0017] - [0021], [0029]; figure 1 * -----	1-9 10	B01D53/64 B01D53/10
Y	US 1 984 164 A (STOCK ALFRED) 11 December 1934 (1934-12-11) * the whole document * -----	1-9	
Y	B.HALL, O.LINDQVIST, E.LJUNGSTRÖM: "Mercury Chemistry in Simulated Flue Gases Related to Waste Incineration Conditions" ENVIRONMENTAL SCIENCE AND TECHNOLOGY, [Online] vol. 24, no. 1, 25 August 1989 (1989-08-25), - 1990 pages 108-111, XP002320099 USA * the whole document * -----	1-9	
Y	US 4 729 882 A (IDE ET AL) 8 March 1988 (1988-03-08) * abstract; claim 1 * * column 4, lines 17-40 * -----	1-9	TECHNICAL FIELDS SEARCHED (Int.Cl.7) B01D
Y	US 2002/117094 A1 (TELLER AARON J ET AL) 29 August 2002 (2002-08-29) * abstract * * paragraph [0027] * -----	1-9	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	4 March 2005	Degen, M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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

EP 04 25 8064

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The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

04-03-2005

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		EP 0208036 A1	14-01-1987
US 2002117094 A1	29-08-2002	US 6439138 B1	27-08-2002

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

Electronic Acknowledgement Receipt

EFS ID:	32661069
Application Number:	15978760
International Application Number:	
Confirmation Number:	6432
Title of Invention:	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
First Named Inventor/Applicant Name:	Edwin S. Olson
Customer Number:	21186
Filer:	Jordan Rivard Golomb/Jamie Johnson
Filer Authorized By:	Jordan Rivard Golomb
Attorney Docket Number:	4820.007US4
Receipt Date:	18-MAY-2018
Filing Date:	
Time Stamp:	11:43:36
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Foreign Reference	0021_de3816600a1.pdf	1520038 08c4e9768f01af753b356b43a8e42b521d817000	no	13

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2	Foreign Reference	0022_ep0208490a1.pdf	1758358 3f8c4eb52efb57b59b92e7bdd3cde13debff5a2c	no	14
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6	Non Patent Literature	0055_10554018_noar_011912.pdf	915937 329e79647885d5200b6bebeaa1171276f79de3fe	no	7
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7	Non Patent Literature	0056_3338013us1_aarn_020810.pdf	705845 be6d4b3f2ab04d8e0d89a6a9959ed5d91e6b4ef0	no	9
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11	Non Patent Literature	0060_final_oa_01_23_2008.pdf	5840947 d5093d25268d5e716d6c6fefccc2a3388197aa27	no	20
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12	Non Patent Literature	0061_non_final_oa_08_13_07.pdf	4408721 66ece423b3ce61788a176ef43dc0488b4105dcdc	no	14
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			Total Files Size (in bytes):	42107065	

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If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 15/978,760

APPLICATION AS FILED - PART I

	(Column 1)	(Column 2)	SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
FOR	NUMBER FILED	NUMBER EXTRA	RATE($)	FEE($)		RATE($)	FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	300
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	660
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	760
TOTAL CLAIMS (37 CFR 1.16(i))	20 minus 20 =	*			OR	x 100 =	0.00
INDEPENDENT CLAIMS (37 CFR 1.16(h))	2 minus 3 =	*				x 460 =	0.00
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0.00
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	1720

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)	SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
AMENDMENT A		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE($)	ADDITIONAL FEE($)		RATE($)	ADDITIONAL FEE($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1)		(Column 2)	(Column 3)					
AMENDMENT B		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE($)	ADDITIONAL FEE($)		RATE($)	ADDITIONAL FEE($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
15/978,760	05/14/2018	1776	1720	4820.007US4	20	2

CONFIRMATION NO. 6432

FILING RECEIPT

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SCHWEGMAN LUNDBERG & WOESSNER, P.A.
P.O. BOX 2938
MINNEAPOLIS, MN 55402

Date Mailed: 06/07/2018

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

Edwin S. Olson, Grand Forks, ND;
Michael J. Holmes, Thompson, ND;
John H. Pavlish, East Grand Forks, MN;

Applicant(s)

Midwest Energy Emissions Corp, Lewis Center, OH;

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a CIP of 15/295,594 10/17/2016
which is a CON of 14/102,896 12/11/2013 PAT 9468886
which is a CON of 12/429,058 04/23/2009 PAT 8652235
which is a CIP of 12/201,595 08/29/2008 ABN
which is a DIV of 11/209,163 08/22/2005 PAT 7435286
which claims benefit of 60/605,640 08/30/2004

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 06/05/2018

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 15/978,760**

Projected Publication Date: 09/13/2018

Non-Publication Request: No

Early Publication Request: No
Title

SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY

Preliminary Class

095

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

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Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

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Title 37, Code of Federal Regulations, 5.11 & 5.15

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The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

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The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/978,760	05/14/2018	Edwin S. Olson	4820.007US4	6432

21186 7590 06/13/2018
SCHWEGMAN LUNDBERG & WOESSNER, P.A.
P.O. BOX 2938
MINNEAPOLIS, MINNESOTA 55402
UNITED STATES OF AMERICA

EXAMINER	
ORLANDO, AMBER ROSE	

ART UNIT	PAPER NUMBER
1776	

NOTIFICATION DATE	DELIVERY MODE
06/13/2018	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

SLW@blackhillsip.com
uspto@slwip.com

PTOL-90A (Rev. 04/07)

Decision Granting Request for Prioritized Examination (Track I)	**Application No.** 15/978,760	**Applicant(s)** Olson et al.	
	Examiner JoAnne Burke	**Art Unit** OPET	**AIA (First Inventor to File) Status** No

1. THE REQUEST FILED 14 May 2018 IS **GRANTED** .

The above-identified application has met the requirements for prioritized examination
A. ☑ for an original nonprovisional application (Track I).
B. ☐ for an application undergoing continued examination (RCE).

2. **The above-identified application will undergo prioritized examination**. The application will be accorded special status throughout its entire course of prosecution until one of the following occurs:

A. filing a **petition for extension of time** to extend the time period for filing a reply;

B. filing an **amendment to amend the application to contain more than four independent claims, more than thirty total claims** , or a multiple dependent claim;

C. filing a **request for continued examination** ;

D. filing a notice of appeal;

E. filing a request for suspension of action;

F. mailing of a notice of allowance;

G. mailing of a final Office action;

H. completion of examination as defined in 37 CFR 41.102; or

I. abandonment of the application.

Telephone inquiries with regard to this decision should be directed to JoAnne Burke at (571)272-4584. In his/her absence, calls may be directed to Petition Help Desk at (571) 272-3282.

/JOANNE L BURKE/
Paralegal Specialist, OPET

U.S. Patent and Trademark Office
PTO-2298 (Rev. 02-2012)

UNITED STATES PATENT AND TRADEMARK OFFICE

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/978,760	05/14/2018	Edwin S. Olson	4820.007US4	6432

21186 7590 06/29/2018
SCHWEGMAN LUNDBERG & WOESSNER, P.A.
P.O. BOX 2938
MINNEAPOLIS, MINNESOTA 55402
UNITED STATES OF AMERICA

EXAMINER	
ORLANDO, AMBER ROSE	

ART UNIT	PAPER NUMBER
1776	

NOTIFICATION DATE	DELIVERY MODE
06/29/2018	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

SLW@blackhillsip.com
uspto@slwip.com

PTOL-90A (Rev. 04/07)

Office Action Summary	**Application No.** 15/978,760	**Applicant(s)** Olson et al.	
	Examiner AMBER R ORLANDO	**Art Unit** 1776	**AIA Status** No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☑ Responsive to communication(s) filed on 5/14/2018.
☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.
2a)☐ This action is **FINAL.** 2b) ☑ This action is non-final.
3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5) ☑ Claim(s) 2-21 is/are pending in the application.
5a) Of the above claim(s) _____ is/are withdrawn from consideration.
6) ☑ Claim(s) 2-19 is/are allowed.
7) ☑ Claim(s) 20-21 is/are rejected.
8) ☐ Claim(s) _____ is/are objected to.
9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

Application Papers

10)☐ The specification is objected to by the Examiner.
11)☑ The drawing(s) filed on 5/14/2018 is/are: a)☑ accepted or b)☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
Certified copies:
a)☐ All b)☐ Some** c)☐ None of the:
1.☐ Certified copies of the priority documents have been received.
2.☐ Certified copies of the priority documents have been received in Application No. _____.
3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☑ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b)
Paper No(s)/Mail Date ______.
3) ☑ Interview Summary (PTO-413)
Paper No(s)/Mail Date ______.
4) ☐ Other: ______.

DETAILED ACTION

Notice of Pre-AIA or AIA Status

The present application is being examined under the pre-AIA first to invent provisions.

Priority

Claim Rejections - 35 USC § 103

In the event the determination of the status of the application as subject to AIA 35 U.S.C. 102 and 103 (or as subject to pre-AIA 35 U.S.C. 102 and 103) is incorrect, any correction of the statutory basis for the rejection will not be considered a new ground of rejection if the prior art relied upon, and the rationale supporting the rejection, would be the same under either status.

The following is a quotation of pre-AIA 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

The factual inquiries set forth in *Graham v. John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under pre-AIA 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.

2. Ascertaining the differences between the prior art and the claims at issue.

3. Resolving the level of ordinary skill in the pertinent art.

4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

This application currently names joint inventors. In considering patentability of the claims under pre-AIA 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of pre-AIA 35 U.S.C. 103(c) and potential pre-AIA 35 U.S.C. 102(e), (f) or (g) prior art under pre-AIA 35 U.S.C. 103(a).

Claim(s) 20 are is/are rejected under pre-AIA 35 U.S.C. 102(b) as being anticipated by Nelson Jr. US 2004/00033716 in view of Vosteen et al. US 6,878,358.

For claim 20, the Nelson reference discloses a method for separating mercury from a mercury-containing gas, the method comprising: reacting mercury in a mercury-containing gas with an injected in-flight promoted activated carbon sorbent to form a mercury/sorbent composition, wherein the promoter comprises Br2, HBr, Br^-, or a combination thereof (paragraphs [0044], [0055] [0059] and [0060]); separating the mercury/sorbent composition from the mercury-containing gas (paragraph [0060]).

The Vosteen et al. reference discloses monitoring the mercury content of the cleaned gas; and controlling, in response to the monitored mercury content of the cleaned gas, an injection rate of injecting the sorbent into the mercury-containing gas, the sorbent composition, or a combination thereof (column 5, lines 47-63).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the Nelson reference to include monitoring the mercury content of the cleaned gas; and controlling, in response to the monitored mercury content of the cleaned gas, an injection rate of injecting the sorbent into the mercury-containing gas, the sorbent composition, or a combination thereof (Vosteen column 5, lines 47-63) to achieve a desired level of mercury removal. The Vosteen reference clearly shows that complete removal of the mercury in the mercury-containing gas (i.e. greater than 70% closer to 100% is desired) and is desired and obtainable by adding more absorbent.

Claim(s) 21 is/are rejected under pre-AIA 35 U.S.C. 102(b) as being anticipated by Nelson Jr. US 2004/00033716 and Vosteen et al. US 6,878,358 as applied in claim 20 and further in view of Comrie US 2007/0168213.

For claim 21, the Nelson reference discloses reacting the mercury in the mercury-containing gas with the promoted halogenated activated carbon sorbent to form the mercury/sorbent composition comprises reacting the mercury in the mercury-containing gas with the promoted halogenated activated carbon sorbent (as shown above)

The Comrie reference discloses reacting the mercury in the mercury-containing gas with a promoted halogenated non-carbon sorbent to form the mercury/sorbent composition (paragraph [0035]).

It would have been obvious to one having ordinary skill in the art before the invention was made to have modified the Nelson reference to include reacting the mercury in the mercury-containing gas with a promoted halogenated non-carbon sorbent to form the mercury/sorbent composition (Comrie paragraph [0035]) so as to further allow for the collection or removal of mercury and/or sulfur from coal burning.

Allowable Subject Matter

Claims 2-19 are allowed.

The following is an examiner's statement of reasons for allowance: for claim 2, the prior art does not disclose the mercury containing gas provided by the combusting coal in the combustion chamber including halogen or halide promoter and then subsequently injecting a sorbent material including activated carb into the mercury-containing gas, such that the activated carbon reacts with the halogen or halide promoter in the mercury-containing gas to form a promoted sorbent.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Double Patenting

The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on nonstatutory double patenting provided the reference application or patent either is shown to be commonly owned with the examined application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement. See MPEP § 717.02 for applications subject to examination under the first inventor to file provisions of the AIA as explained in MPEP § 2159. See MPEP §§ 706.02(l)(1) - 706.02(l)(3) for applications not subject to examination under the first inventor to file provisions of the AIA. A terminal disclaimer must be signed in compliance with 37 CFR 1.321(b).

The USPTO Internet website contains terminal disclaimer forms which may be used. Please visit www.uspto.gov/patent/patents-forms. The filing date of the application in which the form is filed determines what form (e.g., PTO/SB/25, PTO/SB/26, PTO/AIA/25, or PTO/AIA/26) should be used. A web-based eTerminal Disclaimer may be filled out completely online using web-screens. An eTerminal Disclaimer that meets all requirements is auto-processed and approved immediately upon submission. For more information about eTerminal Disclaimers, refer to www.uspto.gov/patents/process/file/efs/guidance/eTD-info-I.jsp.

Claims 20 and 21 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1 and 11 of U.S. Patent No. 8,652,235 ('235). Although the claims at issue are not identical, they are not patentably distinct from each other because:

Claim 20 of the current application corresponds to claim 1 of '235.

Claim 21 of the current application corresponds to claim 11 of '235.

Claims 20 is rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1 of U.S. Patent No. 7,435,286 ('286). Although the claims at issue are not identical, they are not patentably distinct from each other because:

Claim 20 of the current application corresponds to claim 1 of '286.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to AMBER ROSE ORLANDO whose telephone number is (571)270-3149. The examiner can normally be reached on Monday-Thursday 7:00-5:30.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Duane Smith can be reached on (571)272-1166. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

AMBER ROSE. ORLANDO
Primary Examiner
Art Unit 1776

/AMBER R ORLANDO/
Primary Examiner, Art Unit 1776

Examiner-Initiated Interview Summary	**Application No.** 15/978,760	**Applicant(s)** Olson et al.		
	Examiner AMBER R ORLANDO	**Art Unit** 1776	**AIA (First Inventor to File) Status** No	**Page** **1 of** 1

All participants (applicant, applicants representative, PTO personnel):

1. AMBER R ORLANDO (Primary Examiner); Telephonic 2. Nicholas Lansatella (Attorney); Telephonic

Date of Interview: 14 June 2018

Claims Discussed: 2-21

Issues Discussed:

Item(s) under 35 U.S.C. 112:
The examiner asked for clarification where exactly the new claims 2-21 have support within the originally filed application. The applicant pointed to figure 6. The examiner agreed.

/AMBER R ORLANDO/
Primary Examiner, Art Unit 1776

Applicant is reminded that a complete written statement as to the substance of the interview must be made of record in the application file. It is the applicants responsibility to provide the written statement, unless the interview was initiated by the Examiner and the Examiner has indicated that a written summary will be provided. See MPEP 713.04
Please further see:
MPEP 713.04
Title 37 Code of Federal Regulations (CFR) § 1.133 Interviews, paragraph (b)
37 CFR § 1.2 Business to be transacted in writing

Applicant recordation instructions: It is not necessary for applicant to provide a separate record of the substance of interview.

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

Search Notes	**Application/Control No.** 15/978,760	**Applicant(s)/Patent Under Reexamination** Olson et al.
	Examiner AMBER R ORLANDO	**Art Unit** 1776

CPC - Searched*		
Symbol	**Date**	**Examiner**

CPC Combination Sets - Searched*		
Symbol	**Date**	**Examiner**

US Classification - Searched*			
Class	**Subclass**	**Date**	**Examiner**

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	**Date**	**Examiner**
IDS Search (EAST and DAV)	06/24/2018	AO
Inventor Search (DAV)	06/24/2018	AO
EAST searched for inflight promotion of sorbents.	06/24/2018	AO

Interference Search			
US Class/CPC Symbol	**US Subclass/CPC Group**	**Date**	**Examiner**

Bibliographic Data

Application No: 15/978,760

Foreign Priority claimed: ○ Yes ● No

35 USC 119 (a-d) conditions met: ☐ Yes ☑ No | ☐ Met After Allowance

Verified and Acknowledged: /AMBER R ORLANDO/

Examiner's Signature | Initials

Title: SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
05/14/2018	095	1776	4820.007US4
RULE			

APPLICANTS

Midwest Energy Emissions Corp, Lewis Center, OH,

INVENTORS

Edwin S. Olson Grand Forks, ND, UNITED STATES

Michael J. Holmes Thompson, ND, UNITED STATES

John H. Pavlish East Grand Forks, MN, UNITED STATES

CONTINUING DATA

This application is a CIP of 15295594 10/17/2016

15295594 is a CON of 14102896 12/11/2013 PAT 9468886

14102896 is a CON of 12429058 04/23/2009 PAT 8652235

12429058 is a CIP of 12201595 08/29/2008

12201595 is a DIV of 11209163 08/22/2005 PAT 7435286

11209163 has PRO of 60605640 08/30/2004

FOREIGN APPLICATIONS

IF REQUIRED, FOREIGN LICENSE GRANTED**

06/05/2018

STATE OR COUNTRY

UNITED STATES

ADDRESS

SCHWEGMAN LUNDBERG & WOESSNER, P.A.
P.O. BOX 2938
MINNEAPOLIS, MN 55402
UNITED STATES

FILING FEE RECEIVED

$5,860

Substitute for form 1449A/PTO **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** (Use as many sheets as necessary)	*Complete if Known*	
	Application Number	15/978,760
	Filing Date	May 14, 2018
	First Named Inventor	Edwin S. Olson
	Group Art Unit	Unknown
	Examiner Name	Unknown
Sheet 1 of 19	Attorney Docket No: 4820.007US4	

US PATENT DOCUMENTS

Examiner Initial *	USP Document Number	Publication Date	Name of Patentee or Applicant of cited Document
	US-1,984,164	12/11/1934	Alfred, Stock
	US-20010002387A1	5/31/2001	Tsutsumi, Yoshio, et al.
	US-20010003116A1	6/7/2001	Neufert, Ronald
	US-2002/01505a1	10/17/2002	Pahlman, John E, et al.
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	US-20020043496A1	4/18/2002	Boddu, Veera M., et al.
	US-20020134242A1	9/26/2002	Yang, Ralph T, et al.
	US-20020150516A1	10/17/2002	Pahlman, John, et al.
	US-20030057293A1	3/27/2003	Boecking, Friedrich
	US-20030104937A1	6/5/2003	Sinha, R. K.
	US-20030136509A1	7/24/2003	Virtanen, Jorma
	US-20030206843A1	11/6/2003	Sidney Jr, Nelson G
	US-20030206846A1	11/6/2003	Jangbarwala, Juzer
	US-20040003716A1	1/8/2004	Nelson Jr, Sidney
	US-20040013589A1	1/22/2004	Vosteen, Bernhard, et al.
	US-20040076570A1	4/22/2004	Jia, Charles Q
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	US-20050074380A1	4/7/2005	Boren, Richard M, et al.
	US-20050147549A1	7/7/2005	Lissianski, Vitali Victor, et al.
	US-20050227146A1	10/13/2005	Ghantous, Dania, et al.
	US-20060048646A1	3/9/2006	Olson, Edwin S, et al.
	US-20060057044A1	3/16/2006	Chang, Shih-ger, et al.
	US-20060112823A1	6/1/2006	Avina, David Christopher
	US-20060191835A1	8/31/2006	Petrik, Viktor I, et al.
	US-20060204418A1	9/14/2006	Chao, Chien-chung, et al.
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	US-20070168213A1	7/19/2007	Comrie, Douglas C
	US-20070234902A1	10/11/2007	Fair, David L, et al.
	US-20070295347A1	12/27/2007	Paine III, John B, et al.
	US-20080090951A1	4/17/2008	Mao, Dongsheng, et al.
	US-20080107579A1	5/8/2008	Downs, William, et al.
	US-20080134888A1	6/12/2008	Chao, Chien-chung, et al.
	US-20080182747A1	7/31/2008	Sinha, R. K.
	US-20080207443A1	8/28/2008	Gadkaree, Kishor Purushottam, et al.
	US-20080292512A1	11/27/2008	Kang, Shin G.

EXAMINER /AMBER R ORLANDO/ **DATE CONSIDERED** 06/24/2018

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant is to place a check mark here if English language Translation is attached

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.R.O/

Modified form PTO/SB/08A(04-07) OMB 651-0031
US Patent & Trademark Office: U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 2 of 19

	Complete if Known
Application Number	15/978,760
Filing Date	May 14, 2018
First Named Inventor	Edwin S. Olson
Group Art Unit	Unknown
Examiner Name	Unknown

Attorney Docket No: 4820.007US4

US PATENT DOCUMENTS

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	Group Art Unit	Unknown
	Examiner Name	Unknown
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	"Application Serial No. 12/429,058, Response filed 05-11-12 to Final Office Action mailed 12-20-11", 11 pgs	
	"Application Serial No. 12/429,058, Response filed 09-11-12 to Non Final Office Action mailed 06-11-12", 16 pgs	
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Substitute for form 1449A/PTO **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** (Use as many sheets as necessary)	*Complete if Known*	
	Application Number	15/978,760
	Filing Date	May 14, 2018
	First Named Inventor	Edwin S. Olson
	Group Art Unit	Unknown
	Examiner Name	Unknown
Sheet 9 of 19	Attorney Docket No: 4820.007US4	

OTHER DOCUMENTS – NON PATENT LITERATURE DOCUMENTS

Examiner Initial *	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T 1
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	Examiner Name	Unknown
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	First Named Inventor	Edwin S. Olson
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	"Canadian Application Serial No. 2,871,422, Response filed 08-28-15 to Canadian Office Action mailed 04-02-15", 22 pgs	
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	"European Application Serial No. 05814011.2, Response filed 09-09-11 to European Search Report mailed 04-14-09 and Office Actioin mailed 11-05-09", 20 pgs.	
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	"European Application Serial No. 05814011.2, Decision to grant mailed 06-08-12", 2 pgs	
	"European Application Serial No. 05814011.2, Extended European Search Report mailed 04-14-09", 13 pgs	
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	"European Application Serial No. 05814011.2, Office Action mailed 01-31-12", 4 pgs	
	"European Application Serial No. 05814011.2, Office Action mailed 04-27-12", 6 pgs	
	"European Application Serial No. 05814011.2, Office Action mailed 11-05-09", 2 pgs.	
	"European Application Serial No. 05814011.2, Partial European Search Report mailed 04-14-09", 13 pgs.	
	"European Application Serial No. 05814011.2, Response filed 02-28-12 to Office Action mailed 01-31-12", 30 pgs	
	"European Application Serial No. 05814011.2, Response filed 04-18-08 to Office Action mailed 01-25-08 and Third Party Observations submitted 12-04-07", 7 pgs.	
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	"European Application Serial No. 11189252.7, Office Action mailed 12-11-13", 6 pgs	
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	"European Application Serial No. 13719338.9, Notification Regarding Rule 164 and Article 94(3) EPC mailed 04-24-17", 8 pgs	
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	"International Application Serial No. PCT/US2005/030018, International Search Report mailed 07-25-06", 2 pgs	
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	"International Application Serial No. PCT/US2010/022807, International Preliminary Report on Patentability mailed 11-03-11", 6 pgs	
	"International Application Serial No. PCT/US2010/022807, International Search Report mailed 09-13-10", 3 pgs	
	"International Application Serial No. PCT/US2010/022807, Written Opinion mailed 09-13-10", 4 pgs	
	"International Application Serial No. PCT/US2013/036964, International Preliminary Report on Patentability mailed 07-17-14", 11 pgs	
	"International Application Serial No. PCT/US2013/036964, International Search Report mailed 11-29-13", 7 pgs	
	"International Application Serial No. PCT/US2013/036964, Invitation to Pay Additional Fees and Partial Search Report mailed 08-02-13", 7 pgs	
	"International Application Serial No. PCT/US2013/036964, Written Opinion mailed 04-15-14", 10 pgs	
	"International Application Serial No. PCT/US2013/036964, Written Opinion mailed 11-29-13", 13 pgs	
	"International Application Serial No. PCT/US2014/019916, International Search Report mailed 10-13-14", 6 pgs.	
	"International Application Serial No. PCT/US2014/019916, Invitation to Pay Additional Fees and Partial Search Report mailed 05-30-14", 6 pgs	
	"International Application Serial No. PCT/US2014/019916, Written Opinion mailed 10-13-14", 13 pgs.	
	"Powdered Activated Carbon", Cabot Corp, [Online] retrieved from the internet: <http://www.cabotcorp.com/solutions/products-plus/activated-carbon/powdered>, (01/03/15), 3 pgs	

EXAMINER /AMBER R ORLANDO/ **DATE CONSIDERED** 06/24/2018

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	Application Number	15/978,760
	Filing Date	May 14, 2018
	First Named Inventor	Edwin S. Olson
	Group Art Unit	Unknown
	Examiner Name	Unknown
Sheet 16 of 19	Attorney Docket No: 4820.007US4	

OTHER DOCUMENTS – NON PATENT LITERATURE DOCUMENTS

Examiner Initial *	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T 1
	"Response filed 09-04-17 to Notification Regarding Rule 164 and Article 94(3) EPC mailed 04-24-17", 7 pgs	
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	First Named Inventor	Edwin S. Olson
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	Examiner Name	Unknown
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	GOMEZ-AVILES, A., et al., "Multifunctional materials based on graphene-like/sepiolite nanocomposites", Applied Clay Science, 47, (2010), 203-211	
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EAST Search History

EAST Search History (Prior Art)

<table>
<tr><th>Ref #</th><th>Hits</th><th>Search Query</th><th>DBs</th><th>Default Operator</th><th>Plurals</th><th>Time Stamp</th></tr>
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<tr><td>S2</td><td>0</td><td>(95/134.ccls. or 95/142.ccls. or 110/345.ccls. or 423/210.ccls.) and sorben and promoter and activated carbond and mercury</td><td>US-PGPUB; USPAT</td><td>ADJ</td><td>ON</td><td>2013/09/09 09:19</td></tr>
<tr><td>S3</td><td>0</td><td>(95/134.ccls. or 95/142.ccls. or 110/345.ccls. or 423/210.ccls.) and sorbent and promoter and activated carbond and mercury</td><td>US-PGPUB; USPAT</td><td>ADJ</td><td>ON</td><td>2013/09/09 09:20</td></tr>
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<tr><td>S11</td><td>0</td><td>(95/134.ccls. or 95/142.ccls. or 110/345.ccls. or 423/210.ccls.) and sorbent</td><td>US-PGPUB; USPAT</td><td>ADJ</td><td>ON</td><td>2015/03/17 13:50</td></tr>
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		and promoter and activated carbond and mercury				
S12	116	(95/134.ccls. or 95/142.ccls. or 110/345.ccls. or 423/210.ccls.) and (halogen or halide of HBr) with sorbent	US-PGPUB; USPAT	ADJ	ON	2015/03/17 13:50
S13	172	(B01D53/64, B01D2257/602, B01D2253/104, B01D2253/10, B01D53/10).cpc. and (halogen or halide of HBr) with sorbent	US-PGPUB; USPAT	ADJ	ON	2015/08/20 22:04
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S15	67	"6136749"	US-PGPUB; USPAT	ADJ	ON	2016/05/27 09:11
S16	20	"684374"	US-PGPUB; USPAT	ADJ	ON	2016/05/27 09:12
S17	1	"20040003716"	US-PGPUB; USPAT	ADJ	ON	2016/05/27 09:12
S18	68	"6848374"	US-PGPUB; USPAT	ADJ	ON	2016/05/27 09:12
S19	41	"7435286"	US-PGPUB; USPAT	ADJ	ON	2016/05/27 09:13
S20	13	"8168147"	US-PGPUB; USPAT	ADJ	ON	2016/05/27 09:13
S21	69	(95/134.ccls. or 95/142.ccls. or 110/345.ccls. or 423/210.ccls.) and activated carbon and promoter	US-PGPUB; USPAT	ADJ	ON	2016/06/07 09:06
S22	181	(B01D53/64, B01D2257/602, B01D2253/104, B01D2253/10, B01D53/10).cpc. and (halogen or halide of HBr) with sorbent	US-PGPUB; USPAT	ADJ	ON	2016/06/07 09:06
S25	28	"5266280"	US-PGPUB; USPAT	ADJ	ON	2016/06/07 13:41
S26	281	sorbent with mercury and (diameter or size) with ("30" or "40" or "50" or "60" or "70") with (sorbent or carbon)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/09/29 15:01
S27	148	sorbent with mercury and (diameter or size) with ("30" or "40" or "50" or "60" or "70") with (sorbent or carbon) and halogen	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/09/29 15:02
S28	159	sorbent with mercury and (diameter or size) with ("30" or "40" or "50" or "60" or "70") with (sorbent or carbon) and halogen$4	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/09/29 16:18
S29	206	(sorbent or activated carbon) with mercury and (diameter or size) with ("30" or "40" or "50" or "60" or "70") with (sorbent or carbon) and halogen$4 and activated	US-PGPUB; USPAT; USOCR; FPRS;	ADJ	ON	2016/09/29 16:22

		carbon	EPO; JPO; DERWENT; IBM_TDB			
S30	195	(B01D53/64, B01D2257/602, B01D2253/104, B01D2253/10, B01D53/10).cpc. and (halogen or halide of HBr) with sorbent	US-PGPUB; USPAT	ADJ	ON	2016/09/30 13:48
S33	6	"20040003719"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 10:56
S34	49	"2004003716"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 10:57
S35	81	"6848374"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 10:58
S36	56	"7435286"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:02
S37	7	olson.in. and ("40" microns).clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:04
S38	0	("40" microns and halocarbon sorbent).clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:05
S39	0	(halocarbon sorbent).clm. and "40" microns and olson.in.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:05
S40	65	"40" microns and olson.in.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO;	ADJ	ON	2016/11/16 11:06

			DERWENT; IBM_TDB			
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S42	29	("40" microns and sorbent).clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:06
S43	1	(halocarbon sorbent).clm. and olson.in.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:08
S44	36	(sorbent).clm. and olson.in.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:08
S45	0	(sorbent).clm. and olson.in. and "40" micron	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:08
S46	17	"11209163"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:09
S47	2	"20110233133"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:27
S48	7	"20110023427"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:28
S49	15	"2004025274"	US-PGPUB; USPAT; USOCR;	ADJ	ON	2016/11/16 11:32

			FPRS; EPO; JPO; DERWENT; IBM_TDB			
S50	11	"20040025274"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:32
S51	15	"2004025274"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:33
S52	40	"6312489"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:33
S53	30	("20030024872" | "20050045553" | "20050144916" | "4008060" | "4640779" | "4655921" | "4673503" | "4738778" | "4746432" | "4799944" | "5043000" | "5051118" | "5120296" | "5174896" | "5320657" | "5512075" | "5674302" | "6152979" | "6312489" | "6315130" | "6336946" | "6398836" | "6585793" | "6598749" | "7648546").PN. OR ("7931723").URPN.	US-PGPUB; USPAT; USOCR	ADJ	ON	2016/11/16 11:36
S54	33	("4200444" | "4640779" | "5968215" | "6059851").PN. OR ("6312489").URPN.	US-PGPUB; USPAT; USOCR	ADJ	ON	2016/11/16 11:40
S55	5	"8518142"	US-PGPUB; USPAT; USOCR	ADJ	ON	2016/11/16 11:54
S56	4	"8747505"	US-PGPUB; USPAT; USOCR	ADJ	ON	2016/11/16 11:57
S57	2	"14318270"	US-PGPUB; USPAT; USOCR	ADJ	ON	2016/11/16 12:06
S58	13	pac with size with sorbent	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 12:13
S59	197	(B01D53/64, B01D2257/602, B01D2253/104, B01D2253/10, B01D53/10).cpc. and (halogen or halide of HBr) with sorbent	US-PGPUB; USPAT	ADJ	ON	2016/11/16 15:23
S60	0	(B01D53/64, B01D2257/602, B01D2253/104, B01D2253/10,	US-PGPUB; USPAT	ADJ	ON	2016/11/17 12:39

		B01D53/10).cpc. and (halogen or halide of HBr) with sorbent "4198388"				
S61	10	"4198388"	US-PGPUB; USPAT	ADJ	ON	2016/11/17 12:39
S62	0	"2010083696"	US-PGPUB; USPAT	ADJ	ON	2016/11/17 13:32
S63	2	"20100083696"	US-PGPUB; USPAT	ADJ	ON	2016/11/17 13:32
S64	2	absorp$5 with mea with methanol with acid	US-PGPUB; USPAT	ADJ	ON	2016/11/17 13:36
S65	2	"20070283813"	US-PGPUB; USPAT	ADJ	ON	2016/11/17 13:39
S66	21	"4469596"	US-PGPUB; USPAT	ADJ	ON	2016/11/21 08:29
S67	4	"2003229245"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2017/05/10 10:36
S68	2	"20030229245"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2017/05/10 10:36
S69	45	"5,338,458"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2017/05/10 10:38
S70	45	"5338458"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2017/05/10 10:38
S71	213	(B01D53/64, B01D2257/602, B01D2253/104, B01D2253/10, B01D53/10).cpc. and (halogen or halide of HBr) with sorbent	US-PGPUB; USPAT	ADJ	ON	2017/05/10 11:02
S72	64	("1786483" | "1984164" | "2317857" | "20010002387" | "20010003116" | "20020134242" | "20020150516" | "20030136509" | "20040003716" | "20040013589" | "20050019240" | "20060048646" | "20060191835" | "20090062119" | "20100047146" | "20120183458" | "20140056787" | "3194629" | "3662523" | "3786619" | "3826618" | "3849267" | "4196173" | "4500327" | "4814152" | "4820318" | "4889698" | "4959162" | "5300137" | "5409522" | "5462908" | "5505766" | "5575982" | "5607496" | "5672323" |	US-PGPUB; USPAT	ADJ	ON	2017/05/10 11:20

		"5695726" | "5827352" | "5891324" | "6027551" | "6080281" | "6136072" | "6136749" | "6214304" | "6258334" | "6372187" | "6375909" | "6383981" | "6471936" | "6528030" | "6818043" | "6848374" | "6878358" | "6942840" | "6953494" | "7101631" | "7435286" | "7479263" | "7514052" | "7563311" | "7611564" | "8007749" | "8168147" | "8168149" | "8512655").PN.				
S73	3	("20090235848" | "20110076210" | "20150246315").PN.	US-PGPUB; USPAT	ADJ	ON	2017/05/10 11:31
S79	3	("20090235848" | "20110076210" | "20140224121").PN.	US-PGPUB; USPAT	ADJ	ON	2017/06/27 09:36
S80	96	("1984164" | "2317857" | "20010002387" | "20010003116" | "20020043496" | "20020134242" | "20020150516" | "20030104937" | "20030136509" | "20040003716" | "20040013589" | "20040076570" | "20050019240" | "20060048646" | "20060191835" | "20080182747" | "20080292512" | "20090062119" | "20090136401" | "20090320678" | "20100047146" | "20110168018" | "20120183458" | "20130280156" | "20140056787" | "20140255279" | "20140308188" | "20150098878" | "3194629" | "3662523" | "3786619" | "3826618" | "3849267" | "3876393" | "4094777" | "4101631" | "4196173" | "4338896" | "4500327" | "4708853" | "4786483" | "4814152" | "4820318" | "4889698" | "4956162" | "5300137" | "5336835" | "5409522" | "5462908" | "5505766" | "5575982" | "5607496" | "5672323" | "5695726" | "5827352" | "5891324" | "6027551" | "6080281" | "6136072" | "6136749" | "6214304" | "6258334" | "6372187" | "6375909" | "6383981" | "6471936" | "6528030" | "6638485" | "6808692" | "6818043" | "6848374" | "6878358" | "6942840" | "6953494" | "6960329" | "7081434" | "7211707" | "7435286" | "7479263" | "7514052" | "7521032" | "7544338" | "7563311" | "7611564" | "7622092" | "7722843" | "7767174" | "7780765" | "8007749" | "8168147" | "8168149" | "8216535" | "8512655" | "8652235" | "8821819" | "9011805").PN.	US-PGPUB; USPAT	ADJ	ON	2017/06/27 09:41
S81	593	honeycomb with plug$4 and plug$4 with length	US-PGPUB; USPAT	ADJ	ON	2017/06/27 14:45
S82	0	honeycomb with plug$4 and plug$4 with length with less than with "5"	US-PGPUB; USPAT	ADJ	ON	2017/06/27 14:45
S83	0	honeycomb with plug$4 and plug$4 with length with less than	US-PGPUB; USPAT	ADJ	ON	2017/06/27 14:45
S84	127	honeycomb with plug$4 and plug$4 with length with "5"	US-PGPUB; USPAT	ADJ	ON	2017/06/27 14:46
S85	241	honeycomb with plug$4 and plug$4 with length with mm	US-PGPUB; USPAT	ADJ	ON	2017/06/27 14:47
S86	41	honeycomb with plug$4 and plug$4 with	US-PGPUB;	ADJ	ON	2017/06/27

		length with "3 mm "	USPAT			14:49
S87	28	honeycomb with plug$4 and plug$4 with length with "3 mm " and plug$4 with porosity	US-PGPUB; USPAT	ADJ	ON	2017/06/27 14:52
S88	28	honeycomb and plug$4 with length with "3 mm " and plug$4 with porosity	US-PGPUB; USPAT	ADJ	ON	2017/06/27 14:53
S89	43	honeycomb and plug$4 with porosity with "100"	US-PGPUB; USPAT	ADJ	ON	2017/06/27 15:06
S90	20	honeycomb and plug$4 with pore (size or diameter) with "100"	US-PGPUB; USPAT	ADJ	ON	2017/06/27 15:07
S91	8	saw with honeycomb with filter	US-PGPUB; USPAT	ADJ	ON	2017/06/29 13:31
S92	230	(B01D53/64, B01D2257/602, B01D2253/104, B01D2253/10, B01D53/10).cpc. and (halogen or halide of HBr) with sorbent	US-PGPUB; USPAT	ADJ	ON	2017/12/01 14:36

6/24/2018 1:43:18 PM
C:\Users\amillerharris\Documents\EAST\Workspaces\12429058.wsp

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s):	Edwin S. Olson et al.	Examiner: AMBER ROSE ORLANDO
Application No.:	15/978,760	Group Art Unit: 1776
Filed:	May 14, 2018	Docket No.: 4820.007US4
Confirmation No.:	6432	
Title:	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY	

AMENDMENT & RESPONSE UNDER 37 C.F.R. § 1.111

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Applicant has received the Non-Final Office Action dated June 29, 2018. Please enter the following.

IN THE CLAIMS

Please amend the claims as follows:

1. (Canceled)

2. (Previously Presented) A method of separating mercury from a mercury-containing gas, the method comprising:

combusting coal in a combustion chamber, to provide the mercury-containing gas, wherein the mercury-containing gas comprises a halogen or halide promoter comprising Br_2, HBr, Br^-, or a combination thereof;

injecting a sorbent material comprising activated carbon into the mercury-containing gas downstream of the combustion chamber such that the activated carbon reacts with the halogen or halide promoter in the mercury-containing gas to form a promoted sorbent;

reacting mercury in the mercury-containing gas with the promoted sorbent, to form a mercury/sorbent composition;

separating the mercury/sorbent composition from the mercury-containing gas, to form a cleaned gas;

monitoring the mercury content of the cleaned gas; and

controlling, in response to the monitored mercury content of the cleaned gas, an injection rate of injecting the sorbent into the mercury-containing gas, the sorbent composition, or a combination thereof, so that the mercury content of the cleaned gas is maintained at or below a desired level.

3. (Previously Presented) The method of claim 2, comprising removing greater than 70 wt% of the mercury in the mercury-containing gas.

4. (Previously Presented) The method of claim 2, comprising removing greater than 70 wt% of the mercury in the mercury-containing gas on the sorbent.

5. (Previously Presented) The method of claim 2, wherein the promoted sorbent comprises about 1 g to about 30 g of the halogen or halide promoter per 100 g of the sorbent material.

6. (Previously Presented) The method of claim 2, wherein the combustion chamber comprises the halogen or halide promoter.

7. (Previously Presented) The method of claim 2, wherein a promoter precursor is on the coal, wherein the combusting of the coal forms the halogen or halide promoter in the mercury-containing gas.

8. (Previously Presented) The method of claim 2, wherein the promoter is reacted with the sorbent in vapor form, gaseous form, liquid form, or in an organic solvent.

9. (Previously Presented) The method of claim 2, further comprising injecting a secondary material into the mercury-containing gas downstream of the combustion chamber.

10. (Previously Presented) The method of claim 9, wherein the secondary material comprises a halogen, a compound derived from a halogen, a hydrohalide, a compound comprising a Group V or Group VI element and a molecular halogen, or a combination thereof.

11. (Previously Presented) The method of claim 2, wherein the sorbent material injected into the mercury-containing gas further comprises a non-carbon sorbent material.

12. (Previously Presented) The method of claim 11, wherein the non-carbon sorbent material comprises at least one of a porous felsic material, a vesicular felsic material, a porous basaltic material, a vesicular basaltic material, a clay-based compound, an alkaline compound, a calcium hydroxide compound, a sodium acetate compound, and a bicarbonate compound.

13. (Previously Presented) The method of claim 2, wherein the activated carbon comprises powdered activated carbon, granular activated carbon, or a combination thereof.

14. (Previously Presented) The method of claim 2, wherein the sorbent material injected into the mercury-containing gas is substantially free of halogen and halide promotion.

15. (Previously Presented) The method of claim 2, wherein the sorbent material is a product-promoted sorbent obtained by reaction of a base sorbent with another halogen or halide promoter.

16. (Previously Presented) The method of claim 2, wherein the combustion chamber comprises a boiler.

17. (Previously Presented) The method of claim 2, wherein the mercury-containing gas is a flue gas.

18. (Previously Presented) The method of claim 2, wherein the injection of the sorbent material into the mercury-containing gas occurs upstream of an air pre-heater.

19. (Previously Presented) The method of claim 2, wherein the injection of the sorbent material into the mercury-containing gas occurs upstream of a particulate separator or a scrubber.

20. (Canceled)

21. (Canceled)

REMARKS

This responds to the Non-Final Office Action dated June 29, 2018.

No claims are presently amended. Claims 20-21 are presently canceled, and claim 1 was canceled previously. No new claims are presently added. As a result, claims 2-19 are now pending in this application.

Allowed claims.

The Office Action states that claims 2-19 are allowed.

Applicant thanks the Examiner for indicating allowable subject matter.

The Rejection of Claims Under §102

I. The Office Action rejected claim 20 under pre-AIA 35 U.S.C. § 103(a) over U.S. patent publication no. 2004/0003716 ("Nelson") in view of U.S. Patent No. 6,878,358 ("Vosteen").

This rejection is respectfully traversed.

Applicant notes that the office action states that claim 20 is rejected under § 102(b); however, the surrounding text refers to a §103(a) rejection and a combination of references is applied, none of which are identified as describing or suggesting all of the claimed features. Therefore, it is believed that the Examiner intended a §103(a) rejection.

The Office Action states that "…the Nelson reference discloses … reacting mercury in a mercury-containing gas with an injected in-flight promoted activated carbon sorbent to form a mercury/sorbent composition…." Applicant respectfully disagrees. Nelson mentions treatment of activated carbon with a bromine-containing gas (Abstract). However, the present application describes "in-flight" promotion as promotion of an injected activated carbon in a flue gas stream or in a transport line leading into the flue gas stream; see, the present application as originally filed at paragraphs [0025], [0027], [0030], [0072], [0077], [0092], [0098]. Nelson fails to describe or suggest promotion of an injected activated carbon in a flue gas stream or in a transport line leading into the flue gas stream. Like Nelson, Vosteen also fails to describe or suggest promotion of an injected activated carbon sorbent in a flue gas stream or in a transport line leading into the flue gas stream. Nelson and Vosteen, alone or together, fail to describe all the features of independent claim 20; therefore, this claim is patentable over this combination of references.

However, merely to expedite prosecution, while traversing and still disagreeing with the rejection for at least the reasons above, claim 20 is canceled.

Applicant therefore respectfully requests reconsideration and withdrawal of the rejection of claim 20 under pre-AIA 35 U.S.C. § 103(a) over Nelson in view of Vosteen.

II. The Office Action rejected claim 21 under pre-AIA 35 U.S.C. § 103(a) over U.S. patent publication no. 2004/0003716 ("Nelson") in view of U.S. Patent No. 6,878,358 ("Vosteen") and U.S. patent publication no. 2007/0168213 ("Comrie").

This rejection is respectfully traversed.

Applicant notes that the office action states that claim 21 is rejected under § 102(b); however, the surrounding text refers to a §103(a) rejection and a combination of references is applied, none of which are identified as describing or suggesting all of the claimed features. Therefore, it is believed that the Examiner intended a §103(a) rejection.

As explained herein at **I**, Nelson and Vosteen fail to describe or suggest all the features of independent claim 20. Comrie fails to remedy the deficiencies of Nelson and Vosteen. Nelson, Vosteen, and Comrie fail to describe or suggest all the features of independent claim 20; therefore, this claim is patentable over Nelson, Vosteen, and Comrie.

Claim 21 is dependent on independent claim 20. As such, claim 21 incorporates all the features of independent claim 20. Accordingly, claim 21 is patentable for at least the reasons given herein for patentability of independent claim 1.

However, merely to expedite prosecution, while traversing and still disagreeing with the rejection for at least the reasons above, claim 21 is canceled.

Applicant therefore respectfully requests reconsideration and withdrawal of the rejection of claim 21 under pre-AIA 35 U.S.C. § 103(a) over Nelson in view of Vosteen and Comrie.

Double Patenting Rejection

III. The Office Action rejected claims 20 and 21 for nonstatutory double patenting over claims 1 and 11 of U.S. patent no. 8,652,235.

Applicant does not admit that the claims are obvious in view of claims 1 and 11 of U.S. Patent No. 8,652,235. However, merely to expedite prosecution, claims 20 and 21 are presently canceled.

Applicant therefore respectfully requests that the rejection of claims 20 and 21 for nonstatutory double patenting over claims 1 and 11 of U.S. patent no. 8,652,235 be withdrawn.

CONCLUSION

It is respectfully submitted that the claims are in condition for allowance, and notification to that effect is earnestly requested. The Examiner is invited to telephone the undersigned at (612) 349-9580 to facilitate prosecution of this application.

If necessary, please charge any additional fees or deficiencies, or credit any overpayments to Deposit Account No. 19-0743.

Respectfully submitted,

SCHWEGMAN LUNDBERG & WOESSNER, P.A.
P.O. Box 2938
Minneapolis, MN 55402-0938
(612) 373-6900

Date July 13, 2018

By ________________

Nicholas P. Lanzatella
Reg. No. 63,803

S/N 15/978,760 **PATENT**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s):	Edwin S. Olson et al.	Examiner:	Amber Orlando
Serial No.:	15/978,760	Group Art Unit:	1776
Filed:	May 14, 2018	Docket:	4820.007US4
Customer No.:	21186	Confirmation No.:	6432
Title:	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY		

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

MS Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

In compliance with the duty imposed by 37 C.F.R. § 1.56, and in accordance with 37 C.F.R. §§ 1.97 *et. seq.*, the enclosed materials are brought to the attention of the Examiner for consideration in connection with the above-identified patent application. Applicant respectfully requests that this Information Disclosure Statement be entered and the documents listed on the attached PTO 1449 Form be considered by the Examiner and made of record. Pursuant to the provisions of MPEP 609, Applicant requests that a copy of the PTO 1449 Form, initialed as being considered by the Examiner, be returned to the Applicant with the next official communication.

Pursuant to 37 C.F.R. § 1.97(c)(2), Applicant hereby authorizes the Commissioner to charge the fee of $240.00 as set forth in 37 C.F.R. § 1.17(p), to Deposit Account No. 19-0743. Please charge any additional fees or deficiencies, or credit any overpayment to Deposit Account No. 19-0743.

Pursuant to 37 C.F.R. § 1.98(a)(2), copies of cited U.S. Patents and Published Applications, and Non-Published Applications identifiable by USPTO Serial Number, are no longer required to be provided to the Office. Applicant acknowledges the requirement to submit copies of foreign patent documents and non-patent literature in accordance with 37 C.F.R § 1.98(a)(2).

The Examiner is invited to contact the undersigned at the telephone number indicated if there are any questions regarding this communication.

Respectfully submitted,

SCHWEGMAN LUNDBERG & WOESSNER, P.A.
P.O. Box 2938
Minneapolis, MN 55402
(612) 349-9580

Date July 13, 2018 By
Nicholas P. Lanzatella
Reg. No. 63,803

NPL:mlr1

Substitute for form 1449A/PTO **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** (Use as many sheets as necessary)	*Complete if Known*	
	Application Number	15/978,760
	Filing Date	May 14, 2018
	First Named Inventor	Edwin S. Olson
	Group Art Unit	1776
	Examiner Name	Amber Orlando
Sheet 1 of 1	Attorney Docket No: 4820.007US4	

US PATENT DOCUMENTS

Examiner Initial *	USP Document Number	Publication Date	Name of Patentee or Applicant of cited Document
	US-6,103,205	8/15/2000	Wojtowicz, Marek A, et al.
	US-6,284,199	9/4/2001	Downs, William, et al.
	US-20090297413A1	12/3/2009	Olson, Edwin S, et al.
	US-20180133646A1	5/17/2018	Pavlish, John H, et al.

FOREIGN PATENT DOCUMENTS

Examiner Initial *	Foreign Document Number	Publication Date	Name of Patentee or Applicant of cited Document	T 1

OTHER DOCUMENTS – NON PATENT LITERATURE DOCUMENTS

Examiner Initial *	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T 1
	"Application Serial No. 14/712,558, Non Final Office Action mailed 07-02-18", 16 pgs	
	"Application Serial No. 14/712,558, Supplemental Amendment filed 06-13-2018", 14 pgs.	
	"Application Serial No. 15//974,343 Preliminary Amendment Filed 5-15-2018", 7 pgs.	
	"Application Serial No. 15/295,594, Response filed 07-03-18 to Restriction Requirement mailed 05-22-18", 9 pgs.	
	"Application Serial No. 15/295,594, Restriction Requirement mailed 05-22-18", 6 pgs	
	"Application Serial No. 15/295,594, Restriction Requirement mailed 06-29-18", 5 pgs	
	"Application Serial No. 15/295,594, Supplemental Amendment Filed 5-15-2018", 10 pgs.	
	"Application Serial No. 15/589,359, Final Office Action mailed 06-04-18", 13 pgs	
	"Application Serial No. 15/589,359, Response filed 05-18-18 to Non Final Office Action mailed 02-21-18", 14 pgs.	
	"Supplementary European Search Report, dated December 6, 2012", 2 pgs	

EXAMINER **DATE CONSIDERED**

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant is to place a check mark here if English language Translation is attached

Electronic Patent Application Fee Transmittal

Application Number:	15978760
Filing Date:	14-May-2018
Title of Invention:	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
First Named Inventor/Applicant Name:	Edwin S. Olson
Filer:	Steven M. Reid/Megan Reed
Attorney Docket Number:	4820.007US4

Filed as Large Entity

Filing Fees for **Utility under 35 USC 111(a)**

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
SUBMISSION- INFORMATION DISCLOSURE STMT	1806	1	240	240
	Total in USD ($)			**240**

Electronic Acknowledgement Receipt

EFS ID:	33170603
Application Number:	15978760
International Application Number:	
Confirmation Number:	6432
Title of Invention:	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
First Named Inventor/Applicant Name:	Edwin S. Olson
Customer Number:	21186
Filer:	Steven M. Reid/Megan Reed
Filer Authorized By:	Steven M. Reid
Attorney Docket Number:	4820.007US4
Receipt Date:	13-JUL-2018
Filing Date:	14-MAY-2018
Time Stamp:	11:51:07
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	$240
RAM confirmation Number	071318INTEFSW00009235190743
Deposit Account	
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		SIGNED_4820_007US4_NFOAResponse_SIDS.pdf	207942 007bd3f955a5620132524e282433900a2ee07792	yes	12

Multipart Description/PDF files in .zip description

Document Description	Start	End
Transmittal Letter	1	1
Amendment/Req. Reconsideration-After Non-Final Reject	2	2
Claims	3	5
Applicant Arguments/Remarks Made in an Amendment	6	9
Transmittal Letter	10	11
Information Disclosure Statement (IDS) Form (SB08)	12	12

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
2	Non Patent Literature	4820001US7_Amend_20180613.pdf	147570 610b07480e7cd58352c4e20a1ff92328d8f5a355	no	14

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
3	Non Patent Literature	4820003US2_AARN_05_18_18.pdf	136334 df4f1c5a49148acc27bb28c1a7f299722313fc27	no	14

Warnings:

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Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
4	Non Patent Literature	4820003US2_FOAR_06042018.pdf	448582 5e3e919f99d15c3515b0f22cae8c575bb29df28c	no	13

Warnings:					
Information:					
5	Non Patent Literature	4820007US3_rspRR.pdf	138605 7690b8142f637529236cb30e3c32db3b38e5d35c	no	9
Warnings:					
Information:					
6	Non Patent Literature	15295594_Supplemental_pamd.pdf	123257 8e6de3bf1f47dd930d4e857019247aa0d128b6d2	no	10
Warnings:					
Information:					
7	Non Patent Literature	15974343_pamd.pdf	112273 1d634f082e56a9279a4abbf99efc1c5913a06678	no	7
Warnings:					
Information:					
8	Non Patent Literature	Supp_EU_Search_Rpt_1262012.pdf	71429 6be4fb2af74048d89e93afe9c44dd589a5f6bf96	no	2
Warnings:					
Information:					
9	Non Patent Literature	_4820001US7_OARN_07022018.pdf	1481651 5c033eec1083511b4041a3cba699121c0428ddb4	no	16
Warnings:					
Information:					
10	Non Patent Literature	_4820007US3_RERR_05222018.pdf	791713 8045cb88d988e0f5536f619bcfed4232eef119b4	no	6
Warnings:					
Information:					
11	Non Patent Literature	_4820007US3_RERR_06292018.pdf	732432 8b4ea2161349184cfc6efb0a044600bb7aed21f3	no	5
Warnings:					
Information:					

12	Fee Worksheet (SB06)	fee-info.pdf	30237 32607b8c859e6fbfd6fc9e3d9129237125db9d1f	no	2

Warnings:

Information:

Total Files Size (in bytes):	4422025

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s): Edwin S. Olson et al.
Title: SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY

Docket No.: 4820.007US4
Filed: May 14, 2018
Examiner: Amber Orlando
Customer No.: 21186

Serial No.: 15/978,760
Due Date: September 29, 2018
Group Art Unit: 1776
Confirmation No.: 6432

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

We are transmitting herewith the following attached items (as indicated with an "X"):

X Amendment and Response under 37 C.F.R. § 1.111 (8 pgs.)
X Supplemental Information Disclosure Statement (2 pgs.), Form 1449 (1 pg.) Copies of Cited References (10).
X Authorization to charge Deposit Account 19-0743 in the amount of $240.00 to cover the fee for consideration of Information Disclosure Statement under 37 C.F.R. § 1.97(c).

If not provided for in a separate paper filed herewith, please consider this a PETITION FOR EXTENSION OF TIME for sufficient number of months to enter these papers and please charge any additional fees or credit overpayment to Deposit Account No. 19-0743. If applicable, any papers or fees supplied herewith are considered to be timely filed pursuant to 37 C.F.R. § 1.7(a), the response period falling on a Federal Holiday, Saturday or Sunday being extended to the next succeeding business day.

SCHWEGMAN LUNDBERG & WOESSNER, P.A.
Customer No.: 21186

By: /Nicholas P. Lanzatella/
Nicholas P. Lanzatella
Reg. No. 63,803

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 15/978,760	Filing Date 05/14/2018	☐ To be Mailed

ENTITY: ☑ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $100 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $460 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	07/13/2018	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 18	Minus	** 20	= 0		x $100 =	0
	Independent (37 CFR 1.16(h))	* 1	Minus	*** 3	= 0		x $460 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	LIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	marsha R richards
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".	
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 1

Complete if Known	
Application Number	15/978,760
Filing Date	May 14, 2018
First Named Inventor	Edwin S. Olson
Group Art Unit	1776
Examiner Name	Amber Orlando

Attorney Docket No: 4820.007US4

US PATENT DOCUMENTS

Examiner Initial *	USP Document Number	Publication Date	Name of Patentee or Applicant of cited Document
	US-5,569,436	10/29/1996	Lerner, B. J.
	US-5,785,935	7/28/1998	Fristad, William E, et al.
	US-6,475,471	11/5/2002	Wehrli, Janet M
	US-20120244355A1	9/27/2012	Pollack, Nicholas R, et al.
	US-20180229182A1	8/16/2018	Olson, Edwin S., et al.

FOREIGN PATENT DOCUMENTS

Examiner Initial *	Foreign Document Number	Publication Date	Name of Patentee or Applicant of cited Document	T 1

OTHER DOCUMENTS – NON PATENT LITERATURE DOCUMENTS

Examiner Initial *	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T 1
	"Application Serial No. 15/295,594, Response filed 07-24-18 to Restriction Requirement mailed 06-29-18", 9 pgs.	
	"Application Serial No. 15/449,112, Notice of Allowance mailed 07-12-18", 8 pgs	
	"Application Serial No. 15/589,359, Response filed 07-26-18 to Non Final Office Action mailed 06-04-18", 14 pgs.	
	"Application Serial No. 15/974,343, Non Final Office Action mailed 07-27-18", 12 pgs	
	"Application Serial No. 15/997,091, Non Final Office Action mailed 07-27-18", 13 pgs	
	"Application Serial No. 15/997,091,Response filed 08-14-2018 to Non Final Office Action mailed 07-27-18", 10 pgs	
	"European Application Serial No. 14711106.6, Office Action mailed 06-05-18", 16 pgs	

EXAMINER **DATE CONSIDERED**

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant is to place a check mark here if English language Translation is attached

Electronic Patent Application Fee Transmittal

Application Number:	15978760
Filing Date:	14-May-2018
Title of Invention:	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
First Named Inventor/Applicant Name:	Edwin S. Olson
Filer:	Jordan Rivard Golomb/Jamie Johnson
Attorney Docket Number:	4820.007US4

Filed as Large Entity

Filing Fees for **Utility under 35 USC 111(a)**

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
SUBMISSION- INFORMATION DISCLOSURE STMT	1806	1	240	240
	Total in USD ($)			**240**

Electronic Acknowledgement Receipt

EFS ID:	33592616
Application Number:	15978760
International Application Number:	
Confirmation Number:	6432
Title of Invention:	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
First Named Inventor/Applicant Name:	Edwin S. Olson
Customer Number:	21186
Filer:	Jordan Rivard Golomb/Jamie Johnson
Filer Authorized By:	Jordan Rivard Golomb
Attorney Docket Number:	4820.007US4
Receipt Date:	30-AUG-2018
Filing Date:	14-MAY-2018
Time Stamp:	17:04:40
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	$240
RAM confirmation Number	083118INTEFSW00004127190743
Deposit Account	
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		15978760_SIDS_08-30-2018.pdf	302851 5fa0b56674886b14e5fae4df93b212ab7c2e8e0c	yes	5

Multipart Description/PDF files in .zip description

Document Description	Start	End
Miscellaneous Incoming Letter	1	1
Miscellaneous Incoming Letter	2	2
Transmittal Letter	3	4
Information Disclosure Statement (IDS) Form (SB08)	5	5

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
2	Non Patent Literature	0001_4820007us3_rrr1mo_072418.pdf	70585 f6031737cb6a686fb91372c85527fd87b6bfffad	no	9

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
3	Non Patent Literature	0002_4820005us1_noar_07122018.pdf	1263995 17877f3f2bd3e7c8f3135aac33d7b0327374b2c4	no	8

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4	Non Patent Literature	0003_4820003us2_aarn_072618.pdf	106699 dfd4aa1f5809c84f9cbc5d04c2cfbc139a98168f	no	14

Warnings:

Information:

5	Non Patent Literature	0004_4820001us9_oarn_07272018.pdf	1374025 727607f35a0d58bf905c628cbb62a783312584b3	no	12
Warnings:					
Information:					
6	Non Patent Literature	0005_4820001u10_oarnpe_07272018.pdf	1446593 98cc4c27651e714ad46e7ebd13c2d50980a2b938	no	13
Warnings:					
Information:					
7	Non Patent Literature	0006_4820001u10_rsp_20180814.pdf	89830 bff8f9e64b2dc6aa4f3477fe274976bc0a6e8385	no	10
Warnings:					
Information:					
8	Non Patent Literature	0007_4820003ep1_oarmisc_06052018.pdf	1691614 4c7bd04ea56eea29c4273688f078ddb97d378c15	no	16
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Information:					
9	Fee Worksheet (SB06)	fee-info.pdf	30665 288753479d80fd2f4c400f8d66c8118fda02b2b3	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	6376857		

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

<u>IN THE UNITED STATES PATENT AND TRADEMARK OFFICE</u>

Inventor(s): Edwin S. Olson et al.
Title: SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY

Docket No.:	4820.007US4	Serial No.:	15/978,760
Filed:	May 14, 2018	Due Date:	N/A
Examiner:	Amber Orlando	Group Art Unit:	1776
Customer No.:	21186	Confirmation No.:	6432

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

We are transmitting herewith the following attached items (as indicated with an "X"):

<u>X</u> Communication Concerning Prior and Copending Applications (1 pg.)
<u>X</u> Supplemental Information Disclosure Statement (2 pgs.), Form 1449 (1 pg.) Copies of Cited References (7).
<u>X</u> Authorization to charge Deposit Account 19-0743 in the amount of $240.00 to cover the fee for consideration of Information Disclosure Statement under 37 C.F.R. § 1.97(c).

If not provided for in a separate paper filed herewith, please consider this a PETITION FOR EXTENSION OF TIME for sufficient number of months to enter these papers and please charge any additional fees or credit overpayment to Deposit Account No. 19-0743. If applicable, any papers or fees supplied herewith are considered to be timely filed pursuant to 37 C.F.R. § 1.7(a), the response period falling on a Federal Holiday, Saturday or Sunday being extended to the next succeeding business day.

<u>SCHWEGMAN LUNDBERG & WOESSNER, P.A.</u>
Customer No.: 21186

By /Nicholas P. Lanzatella/
Nicholas P. Lanzatella
Reg. No. 63,803

S/N 15/978,760 **PATENT**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s):	Edwin S. Olson et al.	Examiner: Amber Orlando
Serial No.:	15/978,760	Group Art Unit: 1776
Filed:	May 14, 2018	Docket: 4820.007US4
Customer No.:	21186	Confirmation No.: 6432
Title:	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY	

COMMUNICATION CONCERNING PRIOR OR COPENDING APPLICATION(S)

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Pursuant to the guidance of MPEP §§ 2001.06(b) and 2004(9), Applicant would like to bring the following additional application(s) to the Examiner's attention. The identification of these applications is not intended to suggest that the subject matter claimed in any listed application is, or has been, substantially similar to any claim or claims in the present application.

Serial No./ Patent No.	Filing Date	Attorney Docket	Title
15/997,091	June 4, 2018	4820.001U10	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY

Respectfully submitted,

SCHWEGMAN LUNDBERG & WOESSNER, P.A.
P.O. Box 2938
Minneapolis, MN 55402
(612) 349-9580

Date 8/30/2018 By /Nicholas P. Lanzatella/
Nicholas P. Lanzatella
Reg. No. 63,803

S/N 15/978,760 **PATENT**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s):	Edwin S. Olson et al.	Examiner:	Amber Orlando
Serial No.:	15/978,760	Group Art Unit:	1776
Filed:	May 14, 2018	Docket:	4820.007US4
Customer No.:	21186	Confirmation No.:	6432
Title:	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY		

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

MS Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

In compliance with the duty imposed by 37 C.F.R. § 1.56, and in accordance with 37 C.F.R. §§ 1.97 *et. seq*., the enclosed materials are brought to the attention of the Examiner for consideration in connection with the above-identified patent application. Applicant respectfully requests that this Information Disclosure Statement be entered and the documents listed on the attached PTO 1449 Form be considered by the Examiner and made of record. Pursuant to the provisions of MPEP 609, Applicant requests that a copy of the PTO 1449 Form, initialed as being considered by the Examiner, be returned to the Applicant with the next official communication.

Pursuant to 37 C.F.R. § 1.97(c)(2), Applicant hereby authorizes the Commissioner to charge the fee of $240.00 as set forth in 37 C.F.R. § 1.17(p), to Deposit Account No. 19-0743. Please charge any additional fees or deficiencies, or credit any overpayment to Deposit Account No. 19-0743.

Pursuant to 37 C.F.R. § 1.98(a)(2), copies of cited U.S. Patents and Published Applications, and Non-Published Applications identifiable by USPTO Serial Number, are no longer required to be provided to the Office. Applicant acknowledges the requirement to submit copies of foreign patent documents and non-patent literature in accordance with 37 C.F.R § 1.98(a)(2).

The Examiner is invited to contact the undersigned at the telephone number indicated if there are any questions regarding this communication.

Respectfully submitted,

SCHWEGMAN LUNDBERG & WOESSNER, P.A.
P.O. Box 2938
Minneapolis, MN 55402
(612) 349-9580

Date 8/30/2018 By
Nicholas P. Lanzatella
Reg. No. 63,803

NPL:jj

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
15/978,760	05/14/2018	Edwin S. Olson	4820.007US4

CONFIRMATION NO. 6432

PUBLICATION NOTICE

OC000000102290774

21186
SCHWEGMAN LUNDBERG & WOESSNER, P.A.
P.O. BOX 2938
MINNEAPOLIS, MN 55402

Title:SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY

Publication No.US-2018-0257031-A1
Publication Date:09/13/2018

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Public Records Division. The Public Records Division can be reached by telephone at (571) 272-3150 or (800) 972-6382, by facsimile at (571) 273-3250, by mail addressed to the United States Patent and Trademark Office, Public Records Division, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently https://portal.uspto.gov/pair/PublicPair. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	15978760
Filing Date	2018-05-14
First Named Inventor	Edwin S. Olson
Art Unit	1776
Examiner Name	Amber Orlando
Attorney Docket Number	4820.007US4

U.S.PATENTS

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Examiner Initial*	Cite No	Patent Number	Kind Code1	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

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Examiner Initial*	Cite No	Publication Number	Kind Code1	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20180257030	A1	2018-09-13	Olson, Edwin S., et al.	

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	1							

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T5

INFORMATION DISCLOSURE STATEMENT BY APPLICANT **(Not for submission under 37 CFR 1.99)**	Application Number	15978760
	Filing Date	2018-05-14
	First Named Inventor	Edwin S. Olson
	Art Unit	1776
	Examiner Name	Amber Orlando
	Attorney Docket Number	4820.007US4

	1	"Application Serial No. 15 974,343, Response filed 08-14-18 to Non Final Office Action mailed 07-27-18", 11 pgs	
	2	"Application Serial No. 14 712,558, Response filed 08-14-18 to Non Final Office Action mailed 07-02-18", 11 pgs	
	3	"Application Serial No. 15 382,114, Restriction Requirement mailed 08-28-18", 9 pgs	
	4	"Application Serial No. 15 589,359, Final Office Action mailed 09-12-18", 14 pgs	
	5	"Application Serial No. 15 382,114, Response filed 09-12-18 to Restriction Requirement mailed 08-28-18", 8 pgs.	
	6	"Application Serial No. 15 589,359, Response filed 09-14-18 to Final Office Action mailed 09-12-18", 18 pgs.	

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(**Not for submission under 37 CFR 1.99)**

Application Number	15978760
Filing Date	2018-05-14
First Named Inventor	Edwin S. Olson
Art Unit	1776
Examiner Name	Amber Orlando
Attorney Docket Number	4820.007US4

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Nicholas P. Lanzatella/	Date (YYYY-MM-DD)	2018-09-24
Name/Print	Nicholas P. Lanzatella	Registration Number	63,803

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Patent Application Fee Transmittal

Application Number:	15978760
Filing Date:	14-May-2018
Title of Invention:	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
First Named Inventor/Applicant Name:	Edwin S. Olson
Filer:	Jordan Rivard Golomb/Jamie Johnson
Attorney Docket Number:	4820.007US4

Filed as Large Entity

Filing Fees for **Utility under 35 USC 111(a)**

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
SUBMISSION- INFORMATION DISCLOSURE STMT	1806	1	240	240
	Total in USD ($)			**240**

Electronic Acknowledgement Receipt

EFS ID:	33804030
Application Number:	15978760
International Application Number:	
Confirmation Number:	6432
Title of Invention:	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
First Named Inventor/Applicant Name:	Edwin S. Olson
Customer Number:	21186
Filer:	Jordan Rivard Golomb/Jamie Johnson
Filer Authorized By:	Jordan Rivard Golomb
Attorney Docket Number:	4820.007US4
Receipt Date:	24-SEP-2018
Filing Date:	14-MAY-2018
Time Stamp:	12:57:52
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	$240
RAM confirmation Number	092418INTEFSW00012001190743
Deposit Account	
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Non Patent Literature	0001_2_npl_4820003us2_aarf_091418_f.pdf	151483 03d3831aa44f067a20c9ffa8a0d74f544937c793	no	14
Warnings:					
Information:					
2	Non Patent Literature	0002_2_npl_4820003us2_foar_09122018_f.pdf	443891 433c384740413b091badeea2bd00923f26f57a1f	no	14
Warnings:					
Information:					
3	Non Patent Literature	0003_2_npl_4820004us1_rerr_08282018_f.pdf	321053 d1bc44448bbf43fe2e900164ff3d43ead4ef0ce0	no	9
Warnings:					
Information:					
4	Non Patent Literature	0004_2_npl_4820004us1_rrr1mo_091218_f.pdf	125678 265b452a0b28ead53d21ad50a979211f556e8c6f	no	8
Warnings:					
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5	Non Patent Literature	0005_2_npl_4820_001us7_aarn_08142018_f.pdf	139635 6bf45cc088a63344481ccc5498811985dbff53e9	no	11
Warnings:					
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6	Non Patent Literature	0006_2_npl_4820_001us9_aarn_08142018_f.pdf	136050 76907cd0fca26e09690273661f9c56805023bbad	no	11
Warnings:					
Information:					

7	Information Disclosure Statement (IDS) Form (SB08)	15978760_ids_09-24-2018.pdf	617267 96c68facc9135c8c5c34a329c779cfce3bdcee18	no	4
Warnings:					
Information:					
8	Fee Worksheet (SB06)	fee-info.pdf	30665 efef7051a700913a6fdf59b7b42baa24b3b2d3d3	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	1965722	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES DEPARTMENT OF COMMERCE
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/978,760	05/14/2018	Edwin S. Olson	4820.007US4	6432

21186 7590 10/10/2018
SCHWEGMAN LUNDBERG & WOESSNER, P.A.
P.O. BOX 2938
MINNEAPOLIS, MN 55402

EXAMINER	
ORLANDO, AMBER ROSE	

ART UNIT	PAPER NUMBER
1776	

NOTIFICATION DATE	DELIVERY MODE
10/10/2018	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

SLW@blackhillsip.com
uspto@slwip.com

PTOL-90A (Rev. 04/07)

Office Action Summary	Application No. 15/978,760	Applicant(s) Olson et al.	
	Examiner AMBER R ORLANDO	Art Unit 1776	AIA Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☑ Responsive to communication(s) filed on 07/13/2018.
☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.
2a)☐ This action is **FINAL**. 2b) ☑ This action is non-final.
3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5) ☑ Claim(s) 2-19 is/are pending in the application.
5a) Of the above claim(s) _____ is/are withdrawn from consideration.
6) ☐ Claim(s) _____ is/are allowed.
7) ☑ Claim(s) 2-19 is/are rejected.
8) ☐ Claim(s) _____ is/are objected to.
9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

Application Papers

10)☐ The specification is objected to by the Examiner.
11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
Certified copies:
a)☐ All b)☐ Some** c)☐ None of the:
1.☐ Certified copies of the priority documents have been received.
2.☐ Certified copies of the priority documents have been received in Application No. _____.
3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☑ Notice of References Cited (PTO-892)
2) ☑ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b)
Paper No(s)/Mail Date _____.
3) ☐ Interview Summary (PTO-413)
Paper No(s)/Mail Date _____.
4) ☐ Other: _____.

DETAILED ACTION

Notice of Pre-AIA or AIA Status

The present application is being examined under the pre-AIA first to invent provisions.

Claim Rejections - 35 USC § 112

The following is a quotation of the first paragraph of 35 U.S.C. 112(a):

> (a) IN GENERAL.—The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor or joint inventor of carrying out the invention.

The following is a quotation of the first paragraph of pre-AIA 35 U.S.C. 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor of carrying out his invention.

Claim 7 is rejected under 35 U.S.C. 112(a) or 35 U.S.C. 112 (pre-AIA), first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor or a joint inventor, or for pre-AIA the inventor(s), at the time the application was filed, had possession of the claimed invention. The combusting of the coal forming the halogen or halide promoter in the mercury-containing gas is not within the originally filed specification.

Claim Rejections - 35 USC § 103

In the event the determination of the status of the application as subject to AIA 35 U.S.C. 102 and 103 (or as subject to pre-AIA 35 U.S.C. 102 and 103) is incorrect, any correction of the statutory basis for the rejection will not be considered a new ground of rejection if the prior art relied upon, and the rationale supporting the rejection, would be the same under either status.

The following is a quotation of pre-AIA 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

The factual inquiries set forth in *Graham v. John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under pre-AIA 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.
2. Ascertaining the differences between the prior art and the claims at issue.
3. Resolving the level of ordinary skill in the pertinent art.
4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

This application currently names joint inventors. In considering patentability of the claims under pre-AIA 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of pre-AIA 35 U.S.C. 103(c) and potential pre-AIA 35 U.S.C. 102(e), (f) or (g) prior art under pre-AIA 35 U.S.C. 103(a).

Claims 2-19 is/are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Felsvang et al. US 5,435,980 in view of Nelson Jr. US 2004/0003716.

For claim 2, the Felsvang et al. reference discloses a method of separating mercury from a mercury-containing gas, the method comprising: combusting coal in a combustion chamber (column 5, lines 23-25), to provide the mercury-containing gas, wherein the mercury-containing gas comprises a halogen or halide promoter (column 5, lines 60-65 and column 4, lines 42-45) injecting a sorbent material comprising activated carbon into the mercury-containing gas downstream of the combustion chamber (column 6, lines 11-14 and column 6, lines 24-26) such that the activated carbon reacts with the halogen or halide promoter in the mercury-containing gas to form a promoted sorbent (column 3, line 66-column 4, line 3, the interaction between the activated carbon and chloride component would inherently react to form the promoted sorbent); reacting mercury in the mercury-containing gas with the promoted sorbent, to form a mercury/sorbent composition (column 6, lines 20-23); separating the mercury/sorbent composition from the mercury-containing gas, to form a cleaned gas (column 5, lines 45-50); monitoring the mercury content of the cleaned gas; and controlling, in response to the monitored mercury content of the cleaned gas, an injection rate of injecting the sorbent into the mercury-containing gas, the sorbent composition, or a combination thereof, so that the mercury content of the cleaned gas is maintained at or below a desired level (column 6, lines 42-47). The reference does not disclose the halogen or halide promoter comprising Br_2, HBr, Br^-, or a combination thereof.

The Nelson reference discloses the halogen or halide promoter comprising Br_2, HBr, Br^-, or a combination thereof can be used to promote activated carbon (Nelson paragraphs [0017] and [0041]).

It would have been obvious to one having ordinary skill before the invention was made to have modified the Felsvang et al. reference to either replace the Cl with or include in addition to the halogen or halide promoter comprising Br_2, HBr, Br^-, or a combination thereof to promote activated carbon (Nelson paragraphs [0017] and [0041]) so as to provide an effective carbon sorbent for mercury.

For claims 3 and 4, the Felsvang et al. reference discloses the method comprises removing greater than 70 wt% of the mercury in the mercury-containing gas (examples 1, 3 and 4), while the reference does not explicitly state the method comprises removing greater than 70 wt% of the mercury in the mercury-containing gas on the sorbent the reference only removes particulate (column 5, lies 50-55) so it would be apparent to one having ordinary skill in the art that the particulate would include the activated carbon reacted with the chloride having absorbed mercury (column 6, lines 26-28). Further claims 93 and 94 detail the result of the method steps. As the method steps are shown above, the result of performing said method steps of the reference would be similar or the same as that of the claimed results.

For claim 5, the Felsvang et al. reference does not explicitly state the promoted sorbent comprises about 1 g to about 30 g of the halogen or halide promoter per 100 g of the sorbent material. The reference does disclose optimizing the amount of Cl introduced (column 6, lines 42-46).

The Nelson reference discloses optimizing the amount so as to obtain a desired mercury reactivity (paragraph 0054]).

It would have been obvious to one having ordinary skill in the art before the invention was made to have modified the Felvang et al. reference to include the promoted sorbent comprises about 1 g to about 30 g of the halogen or halide promoter per 100 g of the sorbent material so as to adjust the about of halogen introduced based on the Hg content and to ensure optimum reaction between the halogen and the activated carbon (Nelson paragraph [0054]). Further the courts have held that where the general conditions of a claim are disclosed in the prior art, discovering the optimum or workable ranges involves only routine skill in the art. *In re Aller,* 105 USPQ 233.

For claim 6, the Felsvang et al. reference discloses the combustion chamber comprises the halogen or halide promoter (column 4, lines 42-44 and column 6, lines 29-34).

For claim 7, the Felsvang et al. reference discloses a promoter precursor is on the coal, wherein the combusting of the coal forms the halogen or halide promoter in the mercury-containing gas (column 4, lines 51-58 and column 3, lines 53-56).

For claim 8, the Felsvang et al. reference discloses the promoter is reacted with the sorbent in vapor form, gaseous form, liquid form, or in an organic solvent (column 3, lines 53-56 and column 4, lines 39-59).

For claim 9, the Felsvang et al. reference discloses further comprising injecting a secondary material into the mercury-containing gas downstream of the combustion chamber (column 4, lines 42-47 and column 6, lines 24-39).

For claim 10, the Felsvang et al. reference discloses the secondary material comprises a halogen, a compound derived from a halogen, a hydrohalide, a compound comprising a Group V or Group VI element and a molecular halogen, or a combination thereof (column 4, lines 42-47 and column 6, lines 24-39).

For claims 11 and 12, the Felsvang et al. reference discloses the sorbent material injected into the mercury-containing gas further comprises a non-carbon sorbent material (column 5, lines 45-49) and the non-carbon sorbent material comprises at least one of a porous felsic material, a vesicular felsic material, a porous basaltic material, a vesicular basaltic material, a clay-based compound, an alkaline compound, a calcium hydroxide compound, a sodium acetate compound, and a bicarbonate compound (column 5, lines 45-49, column 4, lines 25-28 and column 5, lines 26-32).

For claim 13, the Felsvang et al reference discloses the activated carbon comprises powdered activated carbon, granular activated carbon, or a combination thereof (column 4, lines 5-18).

For claim 14, the Felsvang et al. reference discloses the sorbent material injected into the mercury-containing gas is substantially free of halogen and halide promotion (column 6, lines 29-35).

For claim 15, the Felsvang et al. reference discloses the sorbent material is a product-promoted sorbent obtained by reaction of a base sorbent with another halogen or halide promoter (column 4, lines ,39-50 and column 6, lines 19-42).

For claim 16, the Felsvang et al. reference discloses the combustion chamber comprises a boiler (column 5, lines 33-36).

For 17, the Felsvang et al. reference discloses the mercury-containing gas is a flue gas (column 5, lines 33-36).

For claim 18, the Felsvang et al. reference does not disclose the injection of the sorbent material into the mercury-containing gas occurs upstream of an air pre-heater.

The Nelson reference discloses the injection of the sorbent material into the mercury-containing gas occurs upstream of a particulate separator or a scrubber (figure 4, objects 71, 64 and 22 and paragraph [0062]).

It would have been obvious to one having ordinary skill in the art before the invention was made to have modified the Felsvang et al. reference to include the injection of the sorbent material into the mercury-containing gas occurs upstream of a particulate separator or a scrubber (Nelson figure 4, objects 71, 64 and 22 and paragraph [0062]) so the process can be used in a plant which has "hot-side" ESP and still have effective mercury capture.

For claim 19, the Nelson Felsvang et al. reference discloses the injection of the sorbent material into the mercury-containing gas occurs upstream of a particulate separator or a scrubber (figure, objects 4, 12, 14, 1 and 2).

Double Patenting

The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on nonstatutory double patenting provided the reference application or patent either is shown to be commonly owned with the examined application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement. See MPEP § 717.02 for applications subject to examination under the first inventor to file provisions of the AIA as explained in MPEP § 2159. See MPEP §§ 706.02(l)(1) - 706.02(l)(3) for applications not subject to examination under the first inventor to file provisions of the AIA. A terminal disclaimer must be signed in compliance with 37 CFR 1.321(b).

The USPTO Internet website contains terminal disclaimer forms which may be used. Please visit www.uspto.gov/patent/patents-forms. The filing date of the application in which the form is filed determines what form (e.g., PTO/SB/25, PTO/SB/26, PTO/AIA/25, or PTO/AIA/26) should be used. A web-based eTerminal Disclaimer may be filled out completely online using web-screens. An eTerminal Disclaimer that meets all requirements is auto-processed and approved immediately upon submission. For more information about eTerminal Disclaimers, refer to www.uspto.gov/patents/process/file/efs/guidance/eTD-info-I.jsp.

Claims 2-19 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-30 of U.S. Patent No. US 7,435,286 (‘286) in view of Felsvang et al. US 5,435,980.

The current claim set corresponds to ‘286 expect for the mercury containing gas comprises a halogen or halide promoter.

Felsvang et al. discloses this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the '286 reference to include the mercury containing gas comprises a halogen or halide promoter (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the chlorine content of the system so as to increase the mercury sorption capability.

Claims 2-19 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-25 of U.S. Patent No. US 8,168,147 ('147) in view of Felsvang et al. US 5,435,980.

The current claim set corresponds to '147 expect for the mercury containing gas comprises a halogen or halide promoter.

Felsvang et al. discloses this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the '147 reference to include the mercury containing gas comprises a halogen or halide promoter (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the chlorine content of the system so as to increase the mercury sorption capability.

Claims 2-19 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-60 of U.S. Patent No. US 8,512,655 ('655) in view of Felsvang et al. US 5,435,980.

The current claim set corresponds to '655 expect for the mercury containing gas comprises a halogen or halide promoter.

Felsvang et al. discloses this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the '655 reference to include the mercury containing gas comprises a halogen or halide promoter (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the chlorine content of the system so as to increase the mercury sorption capability.

Claims 2-19 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-60 of U.S. Patent No. US 8,821,819 ('819) in view of Felsvang et al. US 5,435,980.

The current claim set corresponds to ‘819 expect for the mercury containing gas comprises a halogen or halide promoter.

Felsvang et al. discloses this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the ‘819 reference to include the mercury containing gas comprises a halogen or halide promoter (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the chlorine content of the system so as to increase the mercury sorption capability.

Claims 2-19 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-33 of U.S. Patent No. US 9,757,689 (‘689) in view of Felsvang et al. US 5,435,980.

The current claim set corresponds to ‘689 expect combusting a fossil fuel in a combustion chamber to provide a mercury-containing gas, wherein the mercury containing gas comprises a halogen or halide promoter.

Felsvang et al. discloses this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the ‘689 reference to include a fossil fuel in a combustion chamber to provide a mercury-containing gas, wherein the mercury containing gas comprises a halogen or halide promoter. (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the chlorine content of the system so as to increase the mercury sorption capability within a fossil fuel operation.

Claims 2-19 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-20 of U.S. Patent No. US 9,468,886 (‘886) in view of Felsvang et al. US 5,435,980.

The current claim set corresponds to ‘886 expect for the mercury containing gas comprises a halogen or halide promoter.

Felsvang et al. discloses this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the ‘886 reference to include the mercury containing gas comprises a halogen or halide promoter (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the chlorine content of the system so as to increase the mercury sorption capability.

Claims 2-19 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-30 of U.S. Patent No. 8,652,235 (‘235) in view of Felsvang et al. US 5,435,980.

The current claim set corresponds to ‘235 expect for the mercury containing gas comprises a halogen or halide promoter.

Felsvang et al. discloses this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the ‘235 reference to include the mercury containing gas comprises a halogen or halide promoter (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the chlorine content of the system so as to increase the mercury sorption capability.

Claims 2-19 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-16 of copending Application No. 15/295594 (‘594). Although the claims at issue are not identical, they are not patentably distinct from each other because while the current claim set includes different wording it the limitations correspond to ‘594.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Claims 2-19 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over claims 8-20 of copending Application No. 15/589359 (‘359) in view of Felsvang et al. US 5,435,980.

The current claim set corresponds to ‘359 expect for the mercury containing gas comprises a halogen or halide promoter.

Felsvang et al. discloses this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the '359 reference to include the mercury containing gas comprises a halogen or halide promoter (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the chlorine content of the system so as to increase the mercury sorption capability.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Claims 2-19 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-20 of copending Application No. 15/853029 ('029). Although the claims at issue are not identical, they are not patentably distinct from each other because while the current claim set includes different wording it the limitations correspond to '029.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Claims 2-19 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-20 of copending Application No. 14/712558 ('558) Although the claims at issue are not identical, they are not patentably distinct from each other because while the current claim set includes different wording it the limitations correspond to '760.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Claims 2-19 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-20 of copending Application No. 15/951970 ('970). Although the claims at issue are not identical, they are not patentably distinct from each other because while the current claim set includes different wording, the limitations correspond to '970.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Claims 2-19 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over 1-20 of copending Application No. 15/382114 ('114) in view of Felsvang et al. US 5,435,980.

The current claim set corresponds to '114 expect for the mercury containing gas comprises a halogen or halide promoter.

Felsvang et al. discloses this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the '114 reference to include the mercury containing gas comprises a halogen or halide promoter (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the chlorine content of the system so as to increase the mercury sorption capability.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Claims 2-19 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over 1-20 of copending Application No. 15/853029 ('029). Although the claims at issue are not identical, they are not patentably distinct from each other because while the current claim set includes different wording it the limitations correspond to '029.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Response to Arguments

Applicant's arguments with respect to claims 2-19 have been considered but are moot because the arguments do not apply to any of the references being used in the current rejection.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to AMBER ROSE ORLANDO whose telephone number is (571)270-3149. The examiner can normally be reached on Monday-Thursday 7:00-5:30.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Duane Smith can be reached on (571)272-1166. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

AMBER ROSE. ORLANDO
Primary Examiner
Art Unit 1776

/AMBER R ORLANDO/
Primary Examiner, Art Unit 1776

Notice of References Cited	Application/Control No. 15/978,760	Applicant(s)/Patent Under Reexamination	
	Examiner AMBER R ORLANDO	Art Unit 1776	Page 1 of 2

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*	B	US-5569436-A	10-1996	Lerner; Bernard J.	B01D53/64	110/235
*	C	US-6136749-A	10-2000	Gadkaree; Kishor P.	B01D53/8665	502/180
*	D	US-6372187-B1	04-2002	Madden; Deborah A.	B01D53/508	110/345
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*	G	US-6719828-B1	04-2004	Lovell; John S.	B01D53/02	423/210
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Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

U.S. Patent and Trademark Office
PTO-892 (Rev. 01-2001) **Notice of References Cited** Part of Paper No. 20181003

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	Examiner AMBER R ORLANDO	Art Unit 1776 — Page 2 of 2

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	V	
	W	
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Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Search Notes	**Application/Control No.** 15/978,760	**Applicant(s)/Patent Under Reexamination** Olson et al.
	Examiner AMBER R ORLANDO	**Art Unit** 1776

CPC - Searched*

Symbol	Date	Examiner

CPC Combination Sets - Searched*

Symbol	Date	Examiner

US Classification - Searched*

Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes

Search Notes	Date	Examiner
IDS Search (EAST and DAV)	06/24/2018	AO
Inventor Search (DAV)	06/24/2018	AO
EAST searched for inflight promotion of sorbents.	06/24/2018	AO
EAST searched for inflight promotion of sorbents.	10/04/2018	AO

Interference Search

US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	75	"7435286"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/04 07:59
S1	45	(95/134.ccls. or 95/142.ccls. or 110/345.ccls. or 423/210.ccls.) and activated carbon and promoter	US-PGPUB; USPAT	ADJ	ON	2013/09/09 09:19
S2	0	(95/134.ccls. or 95/142.ccls. or 110/345.ccls. or 423/210.ccls.) and sorben and promoter and activated carbond and mercury	US-PGPUB; USPAT	ADJ	ON	2013/09/09 09:19
S3	0	(95/134.ccls. or 95/142.ccls. or 110/345.ccls. or 423/210.ccls.) and sorbent and promoter and activated carbond and mercury	US-PGPUB; USPAT	ADJ	ON	2013/09/09 09:20
S7	73	("20020150516" | "4786483" | "5409522" | "5505766" | "6383981" | "6878358" | "20020033097" | "4530765" | "5346674" | "6080281" | "4708853" | "6027551" | "6136072" | "6258334" | "6818043" | "20060057044" | "20080207443" | "20010002387" | "3826618" | "4814152" | "4820318" | "4889698" | "5891324" | "6528030" | "20050227146" | "5419834" | "7942566" | "20080134888" | "3662523" | "3849267" | "4196173" | "4500327" | "6942840" | "20020134242" | "20030136509" | "20050147549" | "20060112823" | "20080134888" | "6471936" | "20010003116" | "20050019240" | "20060048646" | "4956162" | "5575982" | "6372187" | "6375909" | "7435286" | "7514052" | "20050074380" | "20090081092" | "5288306" | "1984164" | "4101631" | "5695726" | "6080281" | "6848374" | "20050000197" | "5300137" | "5607496" | "5672323" | "6214304" | "6953494" | "5245120" | "20070168213" | "7938571" | "20040003716" | "20040013589" | "3194629" | "3786619" | "5827352" | "20040109800" | "20070295347" | "5435980" | "6136749" | "20030206846").PN.	US-PGPUB; USPAT	ADJ	ON	2015/03/17 12:25
S8	13	"11209163"	US-PGPUB; USPAT	ADJ	ON	2015/03/17 12:28
S9	3	"11209163" and non carbon	US-PGPUB; USPAT	ADJ	ON	2015/03/17 12:28
S10	161	(B01D53/64, B01D2257/602,	US-PGPUB;	ADJ	ON	2015/03/17

		B01D2253/104, B01D2253/10, B01D53/10).cpc. and (halogen or halide of HBr) with sorbent	USPAT			13:49
S11	0	(95/134.ccls. or 95/142.ccls. or 110/345.ccls. or 423/210.ccls.) and sorbent and promoter and activated carbond and mercury	US-PGPUB; USPAT	ADJ	ON	2015/03/17 13:50
S12	116	(95/134.ccls. or 95/142.ccls. or 110/345.ccls. or 423/210.ccls.) and (halogen or halide of HBr) with sorbent	US-PGPUB; USPAT	ADJ	ON	2015/03/17 13:50
S13	172	(B01D53/64, B01D2257/602, B01D2253/104, B01D2253/10, B01D53/10).cpc. and (halogen or halide of HBr) with sorbent	US-PGPUB; USPAT	ADJ	ON	2015/08/20 22:04
S14	67	(95/134.ccls. or 95/142.ccls. or 110/345.ccls. or 423/210.ccls.) and activated carbon and promoter	US-PGPUB; USPAT	ADJ	ON	2015/08/20 22:04
S15	67	"6136749"	US-PGPUB; USPAT	ADJ	ON	2016/05/27 09:11
S16	20	"684374"	US-PGPUB; USPAT	ADJ	ON	2016/05/27 09:12
S17	1	"20040003716"	US-PGPUB; USPAT	ADJ	ON	2016/05/27 09:12
S18	68	"6848374"	US-PGPUB; USPAT	ADJ	ON	2016/05/27 09:12
S19	41	"7435286"	US-PGPUB; USPAT	ADJ	ON	2016/05/27 09:13
S20	13	"8168147"	US-PGPUB; USPAT	ADJ	ON	2016/05/27 09:13
S21	69	(95/134.ccls. or 95/142.ccls. or 110/345.ccls. or 423/210.ccls.) and activated carbon and promoter	US-PGPUB; USPAT	ADJ	ON	2016/06/07 09:06
S22	181	(B01D53/64, B01D2257/602, B01D2253/104, B01D2253/10, B01D53/10).cpc. and (halogen or halide of HBr) with sorbent	US-PGPUB; USPAT	ADJ	ON	2016/06/07 09:06
S25	28	"5266280"	US-PGPUB; USPAT	ADJ	ON	2016/06/07 13:41
S26	281	sorbent with mercury and (diameter or size) with ("30" or "40" or "50" or "60" or "70") with (sorbent or carbon)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/09/29 15:01
S27	148	sorbent with mercury and (diameter or size) with ("30" or "40" or "50" or "60" or "70") with (sorbent or carbon) and halogen	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/09/29 15:02
S28	159	sorbent with mercury and (diameter or size) with ("30" or "40" or "50" or "60" or "70") with (sorbent or carbon) and halogen$4	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT;	ADJ	ON	2016/09/29 16:18

			IBM_TDB			
S29	206	(sorbent or activated carbon) with mercury and (diameter or size) with ("30" or "40" or "50" or "60" or "70") with (sorbent or carbon) and halogen$4 and activated carbon	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/09/29 16:22
S30	195	(B01D53/64, B01D2257/602, B01D2253/104, B01D2253/10, B01D53/10).cpc. and (halogen or halide of HBr) with sorbent	US-PGPUB; USPAT	ADJ	ON	2016/09/30 13:48
S33	6	"20040003719"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 10:56
S34	49	"2004003716"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 10:57
S35	81	"6848374"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 10:58
S36	56	"7435286"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:02
S37	7	olson.in. and ("40" microns).clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:04
S38	0	("40" microns and halocarbon sorbent).clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:05
S39	0	(halocarbon sorbent).clm. and "40" microns and olson.in.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:05

S40	65	"40" microns and olson.in.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:06
S41	3907	("40" microns).clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:06
S42	29	("40" microns and sorbent).clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:06
S43	1	(halocarbon sorbent).clm. and olson.in.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:08
S44	36	(sorbent).clm. and olson.in.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:08
S45	0	(sorbent).clm. and olson.in. and "40" micron	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:08
S46	17	"11209163"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:09
S47	2	"20110233133"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:27
S48	7	"20110023427"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO;	ADJ	ON	2016/11/16 11:28

			DERWENT; IBM_TDB			
S49	15	"2004025274"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:32
S50	11	"20040025274"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:32
S51	15	"2004025274"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:33
S52	40	"6312489"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:33
S53	30	("20030024872" | "20050045553" | "20050144916" | "4008060" | "4640779" | "4655921" | "4673503" | "4738778" | "4746432" | "4799944" | "5043000" | "5051118" | "5120296" | "5174896" | "5320657" | "5512075" | "5674302" | "6152979" | "6312489" | "6315130" | "6336946" | "6398836" | "6585793" | "6598749" | "7648546").PN. OR ("7931723").URPN.	US-PGPUB; USPAT; USOCR	ADJ	ON	2016/11/16 11:36
S54	33	("4200444" | "4640779" | "5968215" | "6059851").PN. OR ("6312489").URPN.	US-PGPUB; USPAT; USOCR	ADJ	ON	2016/11/16 11:40
S55	5	"8518142"	US-PGPUB; USPAT; USOCR	ADJ	ON	2016/11/16 11:54
S56	4	"8747505"	US-PGPUB; USPAT; USOCR	ADJ	ON	2016/11/16 11:57
S57	2	"14318270"	US-PGPUB; USPAT; USOCR	ADJ	ON	2016/11/16 12:06
S58	13	pac with size with sorbent	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 12:13
S59	197	(B01D53/64, B01D2257/602,	US-PGPUB;	ADJ	ON	2016/11/16

		B01D2253/104, B01D2253/10, B01D53/10).cpc. and (halogen or halide of HBr) with sorbent	USPAT			15:23
S60	0	(B01D53/64, B01D2257/602, B01D2253/104, B01D2253/10, B01D53/10).cpc. and (halogen or halide of HBr) with sorbent "4198388"	US-PGPUB; USPAT	ADJ	ON	2016/11/17 12:39
S61	10	"4198388"	US-PGPUB; USPAT	ADJ	ON	2016/11/17 12:39
S62	0	"2010083696"	US-PGPUB; USPAT	ADJ	ON	2016/11/17 13:32
S63	2	"20100083696"	US-PGPUB; USPAT	ADJ	ON	2016/11/17 13:32
S64	2	absorp$5 with mea with methanol with acid	US-PGPUB; USPAT	ADJ	ON	2016/11/17 13:36
S65	2	"20070283813"	US-PGPUB; USPAT	ADJ	ON	2016/11/17 13:39
S66	21	"4469596"	US-PGPUB; USPAT	ADJ	ON	2016/11/21 08:29
S67	4	"2003229245"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2017/05/10 10:36
S68	2	"20030229245"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2017/05/10 10:36
S69	45	"5,338,458"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2017/05/10 10:38
S70	45	"5338458"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2017/05/10 10:38
S71	213	(B01D53/64, B01D2257/602, B01D2253/104, B01D2253/10, B01D53/10).cpc. and (halogen or halide of HBr) with sorbent	US-PGPUB; USPAT	ADJ	ON	2017/05/10 11:02
S72	64	("1786483" | "1984164" | "2317857" | "20010002387" | "20010003116" | "20020134242" | "20020150516" | "20030136509" | "20040003716" | "20040013589" | "20050019240" | "20060048646" | "20060191835" | "20090062119" | "20100047146" | "20120183458" | "20140056787" |	US-PGPUB; USPAT	ADJ	ON	2017/05/10 11:20

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<tr><td>S73</td><td>3</td><td>("20090235848" | "20110076210" | "20150246315").PN.</td><td>US-PGPUB; USPAT</td><td>ADJ</td><td>ON</td><td>2017/05/10 11:31</td></tr>
<tr><td>S79</td><td>3</td><td>("20090235848" | "20110076210" | "20140224121").PN.</td><td>US-PGPUB; USPAT</td><td>ADJ</td><td>ON</td><td>2017/06/27 09:36</td></tr>
<tr><td>S80</td><td>96</td><td>("1984164" | "2317857" | "20010002387" | "20010003116" | "20020043496" | "20020134242" | "20020150516" | "20030104937" | "20030136509" | "20040003716" | "20040013589" | "20040076570" | "20050019240" | "20060048646" | "20060191835" | "20080182747" | "20080292512" | "20090062119" | "20090136401" | "20090320678" | "20100047146" | "20110168018" | "20120183458" | "20130280156" | "20140056787" | "20140255279" | "20140308188" | "20150098878" | "3194629" | "3662523" | "3786619" | "3826618" | "3849267" | "3876393" | "4094777" | "4101631" | "4196173" | "4338896" | "4500327" | "4708853" | "4786483" | "4814152" | "4820318" | "4889698" | "4956162" | "5300137" | "5336835" | "5409522" | "5462908" | "5505766" | "5575982" | "5607496" | "5672323" | "5695726" | "5827352" | "5891324" | "6027551" | "6080281" | "6136072" | "6136749" | "6214304" | "6258334" | "6372187" | "6375909" | "6383981" | "6471936" | "6528030" | "6638485" | "6808692" | "6818043" | "6848374" | "6878358" | "6942840" | "6953494" | "6960329" | "7081434" | "7211707" | "7435286" | "7479263" | "7514052" | "7521032" | "7544338" | "7563311" | "7611564" | "7622092" | "7722843" | "7767174" | "7780765" | "8007749" | "8168147" | "8168149" | "8216535" | "8512655" | "8652235" | "8821819" | "9011805").PN.</td><td>US-PGPUB; USPAT</td><td>ADJ</td><td>ON</td><td>2017/06/27 09:41</td></tr>
<tr><td>S81</td><td>593</td><td>honeycomb with plug$4 and plug$4 with length</td><td>US-PGPUB; USPAT</td><td>ADJ</td><td>ON</td><td>2017/06/27 14:45</td></tr>
<tr><td>S82</td><td>0</td><td>honeycomb with plug$4 and plug$4 with length with less than with "5"</td><td>US-PGPUB; USPAT</td><td>ADJ</td><td>ON</td><td>2017/06/27 14:45</td></tr>
<tr><td>S83</td><td>0</td><td>honeycomb with plug$4 and plug$4 with length with less than</td><td>US-PGPUB; USPAT</td><td>ADJ</td><td>ON</td><td>2017/06/27 14:45</td></tr>
</table>

S84	127	honeycomb with plug$4 and plug$4 with length with "5"	US-PGPUB; USPAT	ADJ	ON	2017/06/27 14:46
S85	241	honeycomb with plug$4 and plug$4 with length with mm	US-PGPUB; USPAT	ADJ	ON	2017/06/27 14:47
S86	41	honeycomb with plug$4 and plug$4 with length with "3 mm "	US-PGPUB; USPAT	ADJ	ON	2017/06/27 14:49
S87	28	honeycomb with plug$4 and plug$4 with length with "3 mm " and plug$4 with porosity	US-PGPUB; USPAT	ADJ	ON	2017/06/27 14:52
S88	28	honeycomb and plug$4 with length with "3 mm " and plug$4 with porosity	US-PGPUB; USPAT	ADJ	ON	2017/06/27 14:53
S89	43	honeycomb and plug$4 with porosity with "100"	US-PGPUB; USPAT	ADJ	ON	2017/06/27 15:06
S90	20	honeycomb and plug$4 with pore (size or diameter) with "100"	US-PGPUB; USPAT	ADJ	ON	2017/06/27 15:07
S91	8	saw with honeycomb with filter	US-PGPUB; USPAT	ADJ	ON	2017/06/29 13:31
S92	230	(B01D53/64, B01D2257/602, B01D2253/104, B01D2253/10, B01D53/10).cpc. and (halogen or halide of HBr) with sorbent	US-PGPUB; USPAT	ADJ	ON	2017/12/01 14:36
S93	2	"20060260468"	US-PGPUB; USPAT	ADJ	ON	2018/07/03 10:34
S94	19	engine with air with inlet with filter$4 with cone	US-PGPUB; USPAT	ADJ	ON	2018/07/03 15:26
S95	36	engine with air with inlet with filter$4 with (cone or conical or (diameter with (increas$4 or decreas$4)))	US-PGPUB; USPAT	ADJ	ON	2018/07/03 15:27
S96	24	("3771638" | "3870495" | "3872012" | "4157902" | "4702754" | "5125940" | "5522909" | "5549724" | "5632793").PN. OR ("5888260").URPN.	US-PGPUB; USPAT; USOCR	ADJ	ON	2018/07/03 15:31
S97	41	("0153535" | "0439091" | "1398685" | "1530163" | "1887052" | "2087688" | "4003836" | "4018580" | "4032455" | "4039308" | "4065276" | "4261710" | "4410341" | "4414110" | "4699715" | "5106397" | "5178656" | "5522909" | "5549722" | "5549724" | "5888260" | "6397842" | "6508052" | "D401597" | "D401942" | "D403414" | "D403416").PN. OR ("6808552").URPN.	US-PGPUB; USPAT; USOCR	ADJ	ON	2018/07/03 15:31
S98	15	("D403416").URPN.	USPAT	ADJ	ON	2018/07/03 15:33
S99	0	"20030089233"	USPAT	ADJ	ON	2018/07/04 12:29
S100	3	"20030089233"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/07/04 12:29
S101	26	"6833023"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/07/04 12:29
S102	2	"20070168213"	US-PGPUB;	ADJ	ON	2018/07/09

			USPAT; USOCR; FPRS; EPO; JPO			13:08
S103	14	carbocations with sorbent with bromine	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/07/09 13:14
S104	0	a side forming a cross sectional shape of each of the first	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/07/09 13:47
S105	0	non of side forming	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/07/09 13:56
S106	0	none of side forming	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/07/09 13:56
S107	0	none of sides forming	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/07/09 13:56
S109	13	olson.in. and (alkali and promoter and earth).clm.	US-PGPUB; USPAT	ADJ	ON	2018/07/17 16:22
S110	0	olson.in. and (alkali and promoter and earth with vapor).clm.	US-PGPUB; USPAT	ADJ	ON	2018/07/17 16:22
S111	10	olson.in. and (alkali and promoter with vapor).clm.	US-PGPUB; USPAT	ADJ	ON	2018/07/17 16:22
S112	0	"2015008283"	US-PGPUB; USPAT	ADJ	ON	2018/07/23 06:26
S113	2	"20150082833"	US-PGPUB; USPAT	ADJ	ON	2018/07/23 06:26
S114	24	olson.in. and liquid.clm. and promoted	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/07/23 07:50
S115	75	remov$4 with mercury and (br or bromine) with liquid with carbon	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/07/23 07:54
S116	0	separating greater than "70" wt% of the mercury	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/07/23 09:17
S117	0	((separating greater) with (of the mercury)).clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/07/23 09:17

<table>
<tr><td>S118</td><td>20</td><td>"11209163"</td><td>US-PGPUB;
USPAT;
USOCR;
FPRS;
EPO; JPO</td><td>ADJ</td><td>ON</td><td>2018/07/23 09:43</td></tr>
<tr><td>S119</td><td>40</td><td>(during with after with mercury with sorbent)</td><td>US-PGPUB;
USPAT;
USOCR;
FPRS;
EPO; JPO</td><td>ADJ</td><td>ON</td><td>2018/10/01 17:38</td></tr>
<tr><td>S120</td><td>304</td><td>sorbent with mercury and sorbent with boiler</td><td>US-PGPUB;
USPAT;
USOCR;
FPRS;
EPO; JPO</td><td>ADJ</td><td>ON</td><td>2018/10/01 17:39</td></tr>
<tr><td>S121</td><td>2</td><td>"20070168213"</td><td>US-PGPUB;
USPAT;
USOCR;
FPRS;
EPO; JPO</td><td>ADJ</td><td>ON</td><td>2018/10/01 17:41</td></tr>
<tr><td>S122</td><td>18</td><td>before with burn$4 with coal with sorbent</td><td>US-PGPUB;
USPAT;
USOCR;
FPRS;
EPO; JPO</td><td>ADJ</td><td>ON</td><td>2018/10/01 17:42</td></tr>
<tr><td>S123</td><td>204</td><td>("0174348" | "0202092" | "0208011" | "0224649" | "0229159" | "0298727" | "0346765" | "0347078" | "0367014" | "0537926" | "0537998" | "0541025" | "0625754" | "0647622" | "0685719" | "0688782" | "0700888" | "0744908" | "0846338" | "0894110" | "0896876" | "0911960" | "0945331" | "0945846" | "1112547" | "1167471" | "1167472" | "1183445" | "1788466" | "1984164" | "20020065581" | "20020114749" | "20020184817" | "20030088370" | "20030103882" | "20040003716" | "20040013589" | "20040086439" | "20040219083" | "20050039598" | "20060047526" | "20060210463" | "2016821" | "2059388" | "2089599" | "2511288" | "3194629" | "3288576" | "3437476" | "3599610" | "3662523" | "3725530" | "3764496" | "3823676" | "3838190" | "3849267" | "3849537" | "3956458" | "3961020" | "3974254" | "4040802" | "4075282" | "4094777" | "4101631" | "4115518" | "4148613" | "4174373" | "4196173" | "4226601" | "4233274" | "4272250" | "4280817" | "4305726" | "4322218" | "4377599" | "4387653" | "4394354" | "4440100" | "4472278" | "4474896" | "4519807" | "4519995" | "4555392" | "4582936" | "4602918" | "4629721" | "4693731" | "4716137" | "4741278" | "4758418" | "4764219" | "4786483" | "4804521" | "4807542" | "4824441" | "4830829" | "4873930" | "4886519" | "4892567" | "4915818" | "4933158" | "4936047" | "4964889" | "5013358" | "5024171" |</td><td>US-PGPUB;
USPAT;
USOCR</td><td>ADJ</td><td>ON</td><td>2018/10/01 17:42</td></tr>
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S124	1	"15573128"	US-PGPUB; USPAT; USOCR	ADJ	ON	2018/10/02 12:07
S125	2	"20110207597"	US-PGPUB; USPAT; USOCR	ADJ	ON	2018/10/02 12:08
S126	2	"20070168213"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/02 17:30
S127	71	sorbent with before with coal and remov$4 with mercury	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/02 17:30
S128	234	"6953494"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/02 17:38
S129	121	"5435980"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/02 17:40
S130	35	promoter with sorbent and "30" g	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/02 22:19
S131	28	promoter with sorbent with mercury and "30" g	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/02 22:19
S132	4	promoter with sorbent with mercury and ("30" g).clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/02 22:20

S133	4	promot$4 with sorbent with mercury and ("30" g).clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/02 22:23
S134	4	promot$4 with sorbent with mercury and pre.clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/02 22:41
S135	2	promot$4 with sorbent with mercury and pre-heater	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/02 22:42
S136	2	promot$4 with sorbent with mercury and pre heater	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 08:36
S137	57	promot$4 with sorbent with mercury and pre	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 08:36
S138	24	sorbent with preheat$4 with coal	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 08:39
S139	121	"5435980"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 08:47
S140	23	"11209163"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 11:28
S141	5	"14102896"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 11:48
S142	7	"12429058"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 12:09
S143	4	"12202595"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 12:23
S144	20	"12201595"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 12:24

S145	3	"14564860"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 12:27
S146	1	"15978760"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 12:28
S147	1	"15589359"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 12:32
S148	1	"15853029"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 12:37
S149	8	"15997091"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 12:42
S150	6	"14712558"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 12:42
S151	2	"15951970"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 15:18
S152	4	"15382114"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 15:47
S153	1	"15853029"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 15:51
S154	2	"20070168213"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 18:18
S155	69	"4279873"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 18:42

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Modified form PTO/SB/08A(04-07) OMB 651-0031
US Patent & Trademark Office: U.S. DEPARTMENT OF COMMERCE

Substitute for form 1449A/PTO **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** (Use as many sheets as necessary)	*Complete if Known*	
	Application Number	15/978,760
	Filing Date	May 14, 2018
	First Named Inventor	Edwin S. Olson
	Group Art Unit	1776
	Examiner Name	Amber Orlando
Sheet 1 of 1	Attorney Docket No: 4820.007US4	

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Examiner Initial *	USP Document Number	Publication Date	Name of Patentee or Applicant of cited Document
	US-6,103,205	8/15/2000	Wojtowicz, Marek A, et al.
	US-6,284,199	9/4/2001	Downs, William, et al.
	US-20090297413A1	12/3/2009	Olson, Edwin S, et al.
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Examiner Initial *	Foreign Document Number	Publication Date	Name of Patentee or Applicant of cited Document	T 1

OTHER DOCUMENTS – NON PATENT LITERATURE DOCUMENTS

Examiner Initial *	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T 1
	"Application Serial No. 14/712,558, Non Final Office Action mailed 07-02-18", 16 pgs	
	"Application Serial No. 14/712,558, Supplemental Amendment filed 06-13-2018", 14 pgs.	
	"Application Serial No. 15//974,343 Preliminary Amendment Filed 5-15-2018", 7 pgs.	
	"Application Serial No. 15/295,594, Response filed 07-03-18 to Restriction Requirement mailed 05-22-18", 9 pgs.	
	"Application Serial No. 15/295,594, Restriction Requirement mailed 05-22-18", 6 pgs	
	"Application Serial No. 15/295,594, Restriction Requirement mailed 06-29-18", 5 pgs	
	"Application Serial No. 15/295,594, Supplemental Amendment Filed 5-15-2018", 10 pgs.	
	"Application Serial No. 15/589,359, Final Office Action mailed 06-04-18", 13 pgs	
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	"Supplementary European Search Report, dated December 6, 2012", 2 pgs	

EXAMINER /AMBER R ORLANDO/ DATE CONSIDERED 10/04/2018

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Substitute for form 1449A/PTO **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** (Use as many sheets as necessary)	*Complete if Known*	
	Application Number	15/978,760
	Filing Date	May 14, 2018
	First Named Inventor	Edwin S. Olson
	Group Art Unit	1776
	Examiner Name	Amber Orlando
Sheet 1 of 1	Attorney Docket No: 4820.007US4	

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Examiner Initial *	USP Document Number	Publication Date	Name of Patentee or Applicant of cited Document
	US-5,569,436	10/29/1996	Lerner, B. J.
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	US-6,475,471	11/5/2002	Wehrli, Janet M
	US-20120244355A1	9/27/2012	Pollack, Nicholas R, et al.
	US-20180229182A1	8/16/2018	Olson, Edwin S., et al.

FOREIGN PATENT DOCUMENTS

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	"Application Serial No. 15/295,594, Response filed 07-24-18 to Restriction Requirement mailed 06-29-18", 9 pgs.	
	"Application Serial No. 15/449,112, Notice of Allowance mailed 07-12-18", 8 pgs	
	"Application Serial No. 15/589,359, Response filed 07-26-18 to Non Final Office Action mailed 06-04-18", 14 pgs.	
	"Application Serial No. 15/974,343, Non Final Office Action mailed 07-27-18", 12 pgs	
	"Application Serial No. 15/997,091, Non Final Office Action mailed 07-27-18", 13 pgs	
	"Application Serial No. 15/997,091,Response filed 08-14-2018 to Non Final Office Action mailed 07-27-18", 10 pgs	
	"European Application Serial No. 14711106.6, Office Action mailed 06-05-18", 16 pgs	

EXAMINER /AMBER R ORLANDO/ **DATE CONSIDERED** 10/04/2018

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Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (01-10)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	15978760
Filing Date	2018-05-14
First Named Inventor	Edwin S. Olson
Art Unit	1776
Examiner Name	Amber Orlando
Attorney Docket Number	4820.007US4

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	1	20180257030	A1	2018-09-13	Olson, Edwin S., et al.	

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/AMBER R ORLANDO/

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT **(Not for submission under 37 CFR 1.99)**	Application Number	15978760
	Filing Date	2018-05-14
	First Named Inventor	Edwin S. Olson
	Art Unit	1776
	Examiner Name	Amber Orlando
	Attorney Docket Number	4820.007US4

	1	"Application Serial No. 15 974,343, Response filed 08-14-18 to Non Final Office Action mailed 07-27-18", 11 pgs	
	2	"Application Serial No. 14 712,558, Response filed 08-14-18 to Non Final Office Action mailed 07-02-18", 11 pgs	
	3	"Application Serial No. 15 382,114, Restriction Requirement mailed 08-28-18", 9 pgs	
	4	"Application Serial No. 15 589,359, Final Office Action mailed 09-12-18", 14 pgs	
	5	"Application Serial No. 15 382,114, Response filed 09-12-18 to Restriction Requirement mailed 08-28-18", 8 pgs.	
	6	"Application Serial No. 15 589,359, Response filed 09-14-18 to Final Office Action mailed 09-12-18", 18 pgs.	

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature	/AMBER R ORLANDO/	Date Considered	10/04/2018

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[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	15978760
Filing Date	2018-05-14
First Named Inventor	Edwin S. Olson
Art Unit	1776
Examiner Name	Amber Orlando
Attorney Docket Number	4820.007US4

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Nicholas P. Lanzatella/	Date (YYYY-MM-DD)	2018-09-24
Name/Print	Nicholas P. Lanzatella	Registration Number	63,803

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

/AMBER R ORLANDO/

10/04/2018

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The information provided by you in this form will be subject to the following routine uses:

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6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

/AMBER R ORLANDO/ 10/04/2018

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s): Edwin S. Olson et al.
Examiner: AMBER ROSE ORLANDO
Application No.: 15/978,760
Group Art Unit: 1776
Filed: May 14, 2018
Docket No.: 4820.007US4
Confirmation No.: 6432
Title: SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY

AMENDMENT & RESPONSE UNDER 37 C.F.R. § 1.111

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Applicant has received the Non-Final Office Action dated October 10, 2018. Please enter the following.

IN THE CLAIMS

Please amend the claims as follows:

1. (Canceled)

2. (Currently Amended) A method of separating mercury from a mercury-containing gas, the method comprising:

combusting coal in a combustion chamber, to provide the mercury-containing gas, wherein the mercury-containing gas comprises a halogen or halide promoter comprising [[Br_2,]]HBr, Br^-, or a combination thereof;

injecting a sorbent material comprising activated carbon into the mercury-containing gas downstream of the combustion chamber such that the activated carbon reacts with the halogen or halide promoter in the mercury-containing gas to form a promoted sorbent;

reacting mercury in the mercury-containing gas with the promoted sorbent, to form a mercury/sorbent composition;

separating the mercury/sorbent composition from the mercury-containing gas, to form a cleaned gas;

monitoring the mercury content of the cleaned gas; and

controlling, in response to the monitored mercury content of the cleaned gas, an injection rate of injecting the sorbent into the mercury-containing gas, the sorbent composition, or a combination thereof, so that the mercury content of the cleaned gas is maintained at or below a desired level.

3. (Previously Presented) The method of claim 2, comprising removing greater than 70 wt% of the mercury in the mercury-containing gas.

4. (Previously Presented) The method of claim 2, comprising removing greater than 70 wt% of the mercury in the mercury-containing gas on the sorbent.

5. (Previously Presented) The method of claim 2, wherein the promoted sorbent comprises about 1 g to about 30 g of the halogen or halide promoter per 100 g of the sorbent material.

6. (Previously Presented) The method of claim 2, wherein the combustion chamber comprises the halogen or halide promoter.

7. (Currently Amended) The method of claim 2, wherein ~~a promoter precursor is on~~ the coal comprises added Br_2, HBr, Br^-, or a combination thereof~~, wherein the combusting of the coal forms the halogen or halide promoter in the mercury-containing gas~~.

8. (Previously Presented) The method of claim 2, wherein the promoter is reacted with the sorbent in vapor form, gaseous form, liquid form, or in an organic solvent.

9. (Previously Presented) The method of claim 2, further comprising injecting a secondary material into the mercury-containing gas downstream of the combustion chamber.

10. (Previously Presented) The method of claim 9, wherein the secondary material comprises a halogen, a compound derived from a halogen, a hydrohalide, a compound comprising a Group V or Group VI element and a molecular halogen, or a combination thereof.

11. (Previously Presented) The method of claim 2, wherein the sorbent material injected into the mercury-containing gas further comprises a non-carbon sorbent material.

12. (Previously Presented) The method of claim 11, wherein the non-carbon sorbent material comprises at least one of a porous felsic material, a vesicular felsic material, a porous basaltic material, a vesicular basaltic material, a clay-based compound, an alkaline compound, a calcium hydroxide compound, a sodium acetate compound, and a bicarbonate compound.

13. (Previously Presented) The method of claim 2, wherein the activated carbon comprises powdered activated carbon, granular activated carbon, or a combination thereof.

14. (Previously Presented) The method of claim 2, wherein the sorbent material injected into the mercury-containing gas is substantially free of halogen and halide promotion.

15. (Previously Presented) The method of claim 2, wherein the sorbent material is a product-promoted sorbent obtained by reaction of a base sorbent with another halogen or halide promoter.

16. (Previously Presented) The method of claim 2, wherein the combustion chamber comprises a boiler.

17. (Previously Presented) The method of claim 2, wherein the mercury-containing gas is a flue gas.

18. (Previously Presented) The method of claim 2, wherein the injection of the sorbent material into the mercury-containing gas occurs upstream of an air pre-heater.

19. (Previously Presented) The method of claim 2, wherein the injection of the sorbent material into the mercury-containing gas occurs upstream of a particulate separator or a scrubber.

20.-21. (Canceled)

22. (New) The method of claim 2, wherein the coal comprises added halide sorbent enhancement additive.

REMARKS

This responds to the Non-Final Office Action dated October 10, 2018.

Claims 1 and 7 are presently amended. No claims are presently canceled, and claims 1 and 20-21 were canceled previously. New claim 22 is presently added. As a result, claims 2-19 and 22 are now pending in this application.

Claim 2 is presently amended to recite "…a halogen or halide promoter comprising [[Br_2,]]HBr, Br^-, or a combination thereof…"

Claim 7 is presently amended to recite "…wherein ~~a promoter precursor is on~~ the coal comprises added Br_2, HBr, Br^-, or a combination thereof…" Support can be found in the application as-filed at paragraphs [0050] (promoter can be bromide, Br^-), [0064] and [0088] (bromine, bromide, or HBr can be promoter), [0035] (promoter can be introduced upstream of the combustor), paragraphs [0098]-[0107] ("additive" can mean promoter), and FIG. 6 (the additive can be added to the coal).

New claim 22 recites "…wherein the coal comprises added halide sorbent enhancement additive." Support can be found at paragraphs [0098]-[0107] ("additive" can mean promoter), paragraph [0010] (the additives can be called "sorbent enhancement additives"), and FIG. 6 (the additive can be added to the coal).

No new matter is added via the amendments herein.

The Rejection of Claims Under §112

I. The Office Action rejected claim 7 under 35 U.S.C. § 112(a) or 35 U.S.C. § 112 (pre-AIA), first paragraph, as allegedly failing to comply with the written description requirement.

The Office Action states "…[t]he combusting of the coal forming the halogen or halide promotor in the mercury-containing gas is not within the originally filed specification."

This rejection is respectfully traversed.

Claim 7 is presently amended to recite "…wherein ~~a promoter precursor is on~~ the coal comprises added Br_2, HBr, Br^-, or a combination thereof…"

Applicant therefore respectfully requests reconsideration and withdrawal of the rejection of claim 7 under 35 U.S.C. § 112(a) or 35 U.S.C. § 112 (pre-AIA), first paragraph.

The Rejection of Claims Under §103

II. The Office Action rejected claims 2-19 under 35 U.S.C. § 103(a) over U.S. patent no. 5,435,980 ("Felsvang") in view of U.S. patent publication no. 2004/0003716 ("Nelson").

This rejection is respectfully traversed.

As explained herein at **II(A)**, there would be no motivation for a person of ordinary skill in the art to use Nelson's bromide additives in Felsvang's process. As explained herein at **II(B)(1)**, in-flight promotion with bromide promoters is more effective for mercury removal than treating the sorbent with bromide or bromine additives outside the mercury-containing gas, and as explained herein at **II(B)(2)**, there would be no way for a person of ordinary skill in the art to predict this advantage from the cited references. As explained herein at **II(C)(1)**, in-flight promotion with bromide promoters is more effective for mercury removal than in-flight promotion with chloride-promoters, and as explained herein at **II(C)(2)**, there would be no way for a person of ordinary skill in the art to predict this advantage from the cited references. As explained herein at **II(D)**, even if a person of ordinary skill in the art compared the mercury removal of Felsvang's activated carbons promoted with chloride in the flue gas to activated carbons treated with HCl outside of the flue gas, they would not determine that in-flight promotion provides the same or better mercury removal properties.

II(A). There would be no motivation for a person of ordinary skill in the art to use Nelson's bromide additives in Felsvang's process.

Claim 2 is presently amended to recite "…a halogen or halide promoter comprising [[Br_2,]]HBr, Br^-, or a combination thereof…"

The Office Action admits that Felsvang fails to describe or suggest a halogen or halide promoter that is Br_2, HBr, or Br^-. Nelson fails to describe or suggest in-flight promotion of activated carbon with a halide in the flue gas. The Office Action alleges that one of ordinary skill in the art would combine Nelson's additive with Felsvang's method to accomplish the presently claimed method, stating that such a modification of Felsvang would be made "…to promote activated carbon (Nelson paragraphs [0017] and [0041]) so as to provide an effective carbon sorbent for mercury." (Office Action, page 4, last sentence of last full paragraph). Applicant respectfully disagrees. As explained below, a person of ordinary skill in the art would not be motivated to use Nelson's bromide additives in Felsvang's process.

Felsvang is directed to adding chlorine (Cl_2) or chloride (Cl^-) materials to the coal or combustion products. Felsvang makes clear that addition of chlorine or chloride material increases the amount of chloride supplied to the flue gas, or to the drying-absorption zone, see, Abstract and col. 3, lines 40-44. When Felsvang mentions activated carbon, the interaction between activated carbon and chloride is the focus: "[i]t has been experienced that the increase of the Hg-removing effect of chloride addition to the drying-absorption zone in a process treating flue gases of low chloride content is especially remarkable when activated carbon is present…." Col. 3, line 67 bridging to col. 4, line 4. For a person of ordinary skill in the art to be motivated to replace Felsvang's chloride-treatment with treatment by another material to provide an effective carbon sorbent for mercury, that person would need to think that the material they are using to replace the chloride would result in the same or better mercury-removal efficiency. However, not only does Felsvang fail to describe or suggest that in-flight promotion of activated carbon with chloride provides better mercury removal than treatment of activated carbon outside the flue gas with chloride; further, as shown herein at **II(D)**, treatment of activated carbon outside the flue gas with chloride actually provides better mercury removal than in-flight promotion of activated carbon with chloride, which would lead one of ordinary skill in the art away from using in-flight promotion.

Nelson's Background paragraph [0017] states that "[t]he particular advantages of using bromine rather than iodine or iodides, or chlorine or chlorides, with activated carbons for mercury control have not been previously appreciated." The paragraph then goes on to describe various accomplishments in the prior art, stating that prior art processes fail to use bromine as a sequestration agent on carbon, and concludes with "[r]ather, it serves as a catalyst, taking part in a repeated series of desired chemical reactions, but not becoming permanently consumed by any of them. Perhaps it is understandable that the tenacity of carbon-bromine-mercury complexes could be overlooked." Importantly, paragraph [0017] states that bromine (Br_2) is superior to I_2 or I^-, or Cl_2 or Cl^-, with activated carbons for sequestration, and never states that the claimed promoters HBr or Br^- are more effective with activated carbons than chlorides.

Nelson's paragraph [0041] states:

> **[0041]** I have discovered that the simple act of exposing a carbonaceous material, preferably powdered activated carbon (PAC), to gaseous bromine, $Br_2(g)$, or to gaseous hydrogen bromide, $HBr(g)$, significantly increases the carbonaceous material's ability to remove mercury species when injected into high-temperature coal-fired flue-gas compositions. Surprisingly, gaseous bromine produces a much more effective and appropriate carbon sorbent for mercury in hot combustion gases than do iodine or iodide species, or chlorine or chloride species, in contrast to what has been taught in the prior art.

Paragraph [0041] begins by stating that bromine, defined as Br_2, or hydrogen bromide, defined as HBr, increases the mercury absorption capacity of activated carbon. Then, paragraph [0041] states specifically that bromine (Br_2) produces a more effective mercury-absorbing carbon sorbent than iodine (I_2), or iodide (I^-), or chlorine (Cl_2), or chloride (Cl^-). With the precise definitions given for bromine and hydrogen bromide, and then reference only to bromine, Nelson makes clear that the comparison of efficacy is only with respect to bromine and not hydrogen bromide. Like paragraph [0017], paragraph [0041] also fails to state that HBr or Br^- are more effective with activated carbons than chlorides.

The majority of Nelson's Examples (1-4 and 8) focus only on Br_2. Nelson's Examples 5-7 demonstrate the use of HBr-treated sorbent; however, none of these Examples or any other parts of Nelson compare the mercury-absorption performance of HBr-treated activated carbon to chloride-treated activated carbon such as HCl-treated activated carbon. Although figures 14 and 15 illustrate HBr-treated activated carbon and Cl_2-treated activated carbon, Cl_2-treated activated carbon is not chloride-treated carbon and these figures fail to show any examples of chloride-treated activated carbon.

Nelson's paragraph [0049] states:

> **[0049]** A critical element in the process is that a bromine-containing gas **3** is used to treat the carbonaceous substrate. Preferably this gas comprises elemental bromine, $Br_2(g)$, although other bromine-containing gases, such as hydrogen bromide, HBr, will also have the advantageous effect of the invention.

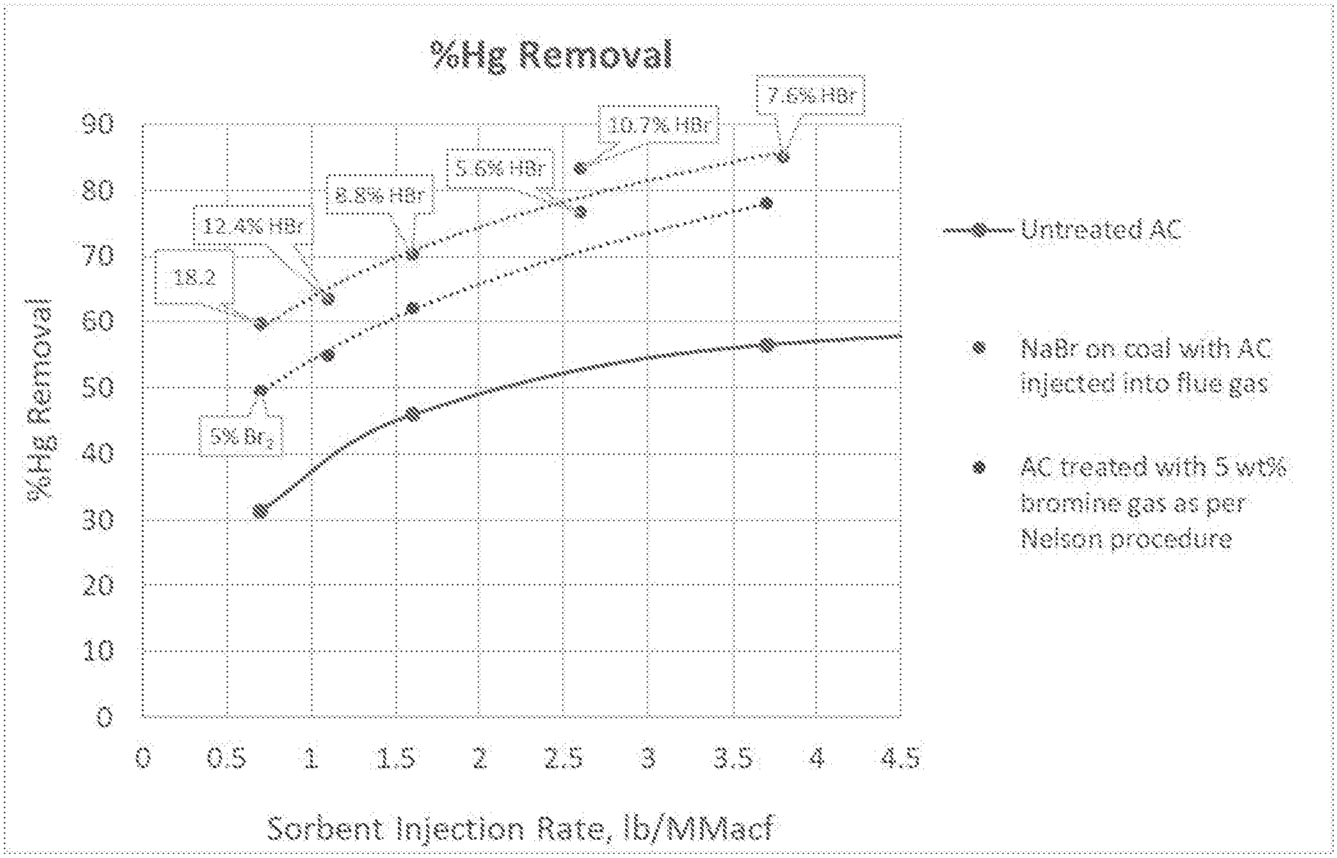
Paragraph [0049] says that using Br_2 is a critical element of the process. It states that HBr can also have the "advantageous effect of the invention"; however, it is not clear what advantage this is referring to. The very next paragraph, [0050], states "[i]n the liquid form at ambient temperatures, elemental bromine is dense and compact, with advantages in transport and storage." These statements also hold true for HBr in the form of a gas. No Example is given in Nelson comparing the mercury-absorption performance of activated carbons treated with bromides such as HBr to the mercury-absorption performance of chlorides such as HCl. In every statement comparing to other halogens or halides, Nelson states with great particularity, even giving the chemical formula, that bromine (Br_2) has advantageous effects over other halogens and halides but fails to mention bromides in these statements. One of ordinary skill in the art would not interpret paragraph [0049] or any other part of Nelson as describing or suggesting that bromides even have the same effectiveness for mercury sequestration when used to treat activated carbons as chlorides, let alone that bromides are more effective for mercury sequestration when used to treat activated carbons than chlorides or chlorine.

Nelson fails to describe or suggest that treatment of activated carbon with bromides such as HBr could provide any mercury-removal improvement, or even the same mercury-removal activity, compared to activated carbons treated with chlorides. Not only does Felsvang fail to describe or suggest that in-flight promotion of activated carbon with chloride provides better mercury removal than treatment of activated carbon outside the flue gas with chloride; further, as shown herein at **II(D)**, treatment of activated carbon outside the flue gas with chloride actually provides better mercury removal than in-flight promotion of activated carbon with chloride, which would lead one of ordinary skill in the art away from using in-flight promotion. A person of ordinary skill in the art would have no reason to modify Felsvang's chloride process with a different promoter to form an effective carbon sorbent for mercury if the resulting mercury-removal efficiency could not be reasonably predicted to be the same or greater as that of Felsvang's original process. Therefore, a person of ordinary skill in the art would not be motivated to combine Nelson's bromide additive with Felsvang's chloride method. Independent claim 2 is patentable for at least this reason.

II(B)(1). In-flight promotion with bromide promoters is more effective for mercury removal than treating the sorbent with bromide or bromine additives outside the mercury-containing gas.

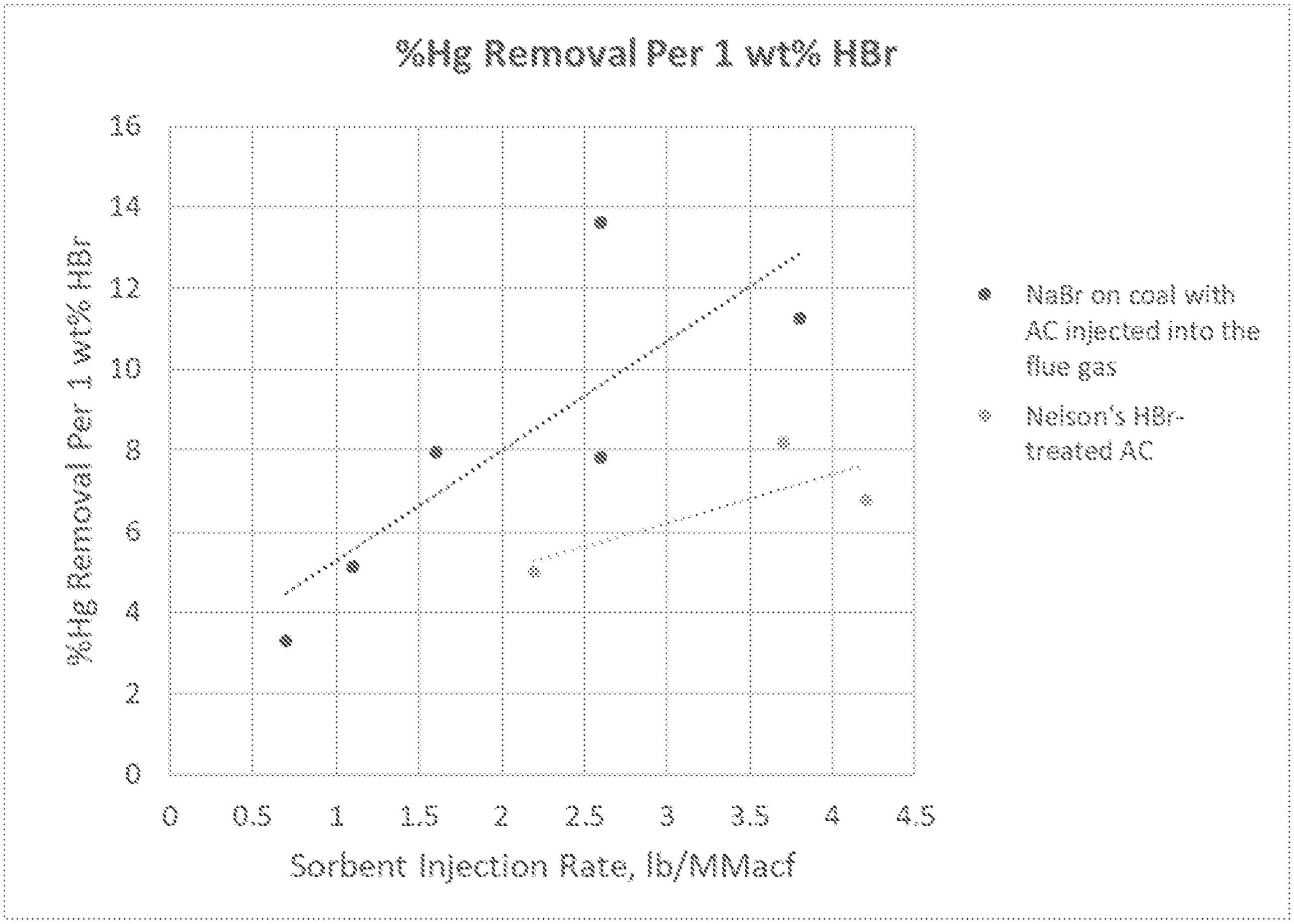
The inventors of the present application have discovered that by combusting coal in the presence of a bromide promoter, and by placing an activated carbon sorbent in the mercury-containing gas, as presently claimed, the activated carbon can be promoted by the promoter in-flight in the mercury-containing gas, and further, that in-flight bromide promotion of the activated carbon is more effective for mercury removal than use of an activated carbon that is treated with bromides or bromine outside the flue gas.

As explained in the 37 CFR § 1.132 declaration by John Pavlish filed herewith ("132 Declaration"), pilot-scale testing was performed with activated carbon alone (untreated) injected into the flue gas, the activated carbon treated with Br_2 outside the flue gas as per the Nelson procedure (see, 132 Declaration at item 6), and with NaBr added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas. The same activated carbon was used for each sample. See, the 132 Declaration at items 8-11. The plot given in the 132 Declaration at item 11 is reproduced below.



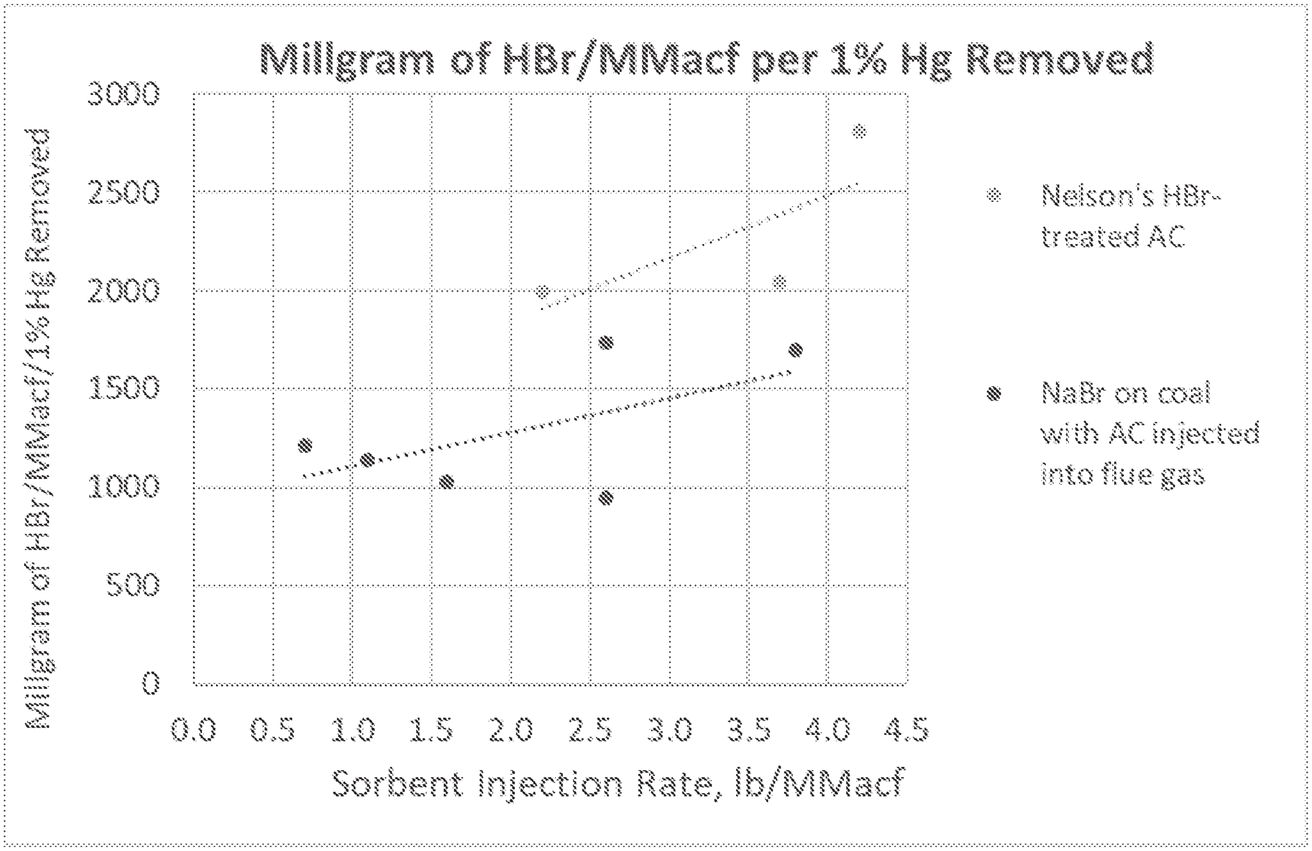
The data in the plot above from item 11 of the 132 Declaration show that the NaBr added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas (in-flight promotion with Br^-) provided a higher percent of mercury removal at all tested sorbent injection rates as compared to the activated carbon alone (untreated) and compared to the activated carbon treated with Br_2 outside the flue gas described herein at item 6 as per the Nelson procedure. With NaBr added to the coal and activated carbon injected into the flue gas, there was a significant reduction in the amount of sorbent required to acheive similar mercury removal compared to the activated carbon treated with Br_2 outside the flue gas. For example, to acheive 70% mercury removal, 2.5 lb/MMacf of Br_2-treated carbon was required, as compared to 1.6 lb/MMacf with NaBr added to the coal and activated carbon injected into the flue gas; an additional (2.5-1.6/1.6)*100% or 56% treated sorbent was required to achieve the same leval of mercury removal. See, 132 Declaration at items 2-5 and 12.

The percent mercury removal per 1 wt% HBr versus the sorbent injection rate was compared with NaBr added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas using the pilot-scale plant, and with Nelson's activated carbon treated with HBr outside the flue gas. The data for Nelson's activated carbon treated with HBr outside the flue gas was taken directly from Nelson. The first plot given in the 132 Declaration at item 13 is reproduced below, but only showing the bromide data.



The data in the plot above, derived from the first plot at item 13 of the 132 Declaration, show that the NaBr added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas provided a significantly higher (about 2x) percent mercury removal per 1 wt% HBr at all tested sorbent injection rates as compared to Nelson's activated carbon treated with HBr outside the flue gas. See, 132 Declaration at item 14.

The data from the pilot-scale plant was also plotted to show the milligrams of HBr/MMacf per 1% mercury removal versus the sorbent injection rate with NaBr added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas, and for Nelson's activated carbon treated with HBr outside the flue gas. The second plot given in the 132 Declaration at item 13 is reproduced below.



The data in the plot above, derived from the second plot at item 13 of the 132 Declaration, show that NaBr added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas provided a significantly lower milligrams of HBr/MMacf per 1% mercury removal at all tested sorbent injection rates as compared to Nelson's activated carbon treated with HBr outside the flue gas, indicating more efficient (approximately 2x) use of HBr for mercury removal during in-flight promotion of activated carbon than treatment of activated carbon outside the flue gas. See, 132 Declaration at item 14.

II(B)(2). There is no way a person of ordinary skill in the art could predict from the cited references that in-flight promotion of a sorbent with bromide promoters is more effective for mercury removal than use of a sorbent that is treated with the same promoters outside the flue gas.

The M.P.E.P. at the beginning of § 2143.02 states (emphasis added) "[a] rationale to support a conclusion that a claim would have been obvious is that all the claimed elements were known in the prior art and one skilled in the art could have combined the elements as claimed by known methods with no change in their respective functions, *and the combination would have yielded nothing more than predictable results to one of ordinary skill in the art.*"

As admitted by the Office Action, Felsvang fails to describe or suggest bromide promoters. Felsvang also fails to describe or suggest that treatment of an activated carbon with a chloride additive outside of flue gas has any advantages over in-flight promotion of an activated carbon with a chloride promoter. Further, as shown herein at **II(D)**, treatment of activated carbon outside the flue gas with chloride provides better mercury removal than in-flight promotion of activated carbon with chloride. Therefore, a person of ordinary skill in the art hypothetically having Felsvang in-hand would have no clue that in-flight promotion of activated carbon with a halide could give the same or better percent mercury removal over halide treatment outside of the flue gas, and would be led away from Felsvang's in-flight process if they investigated the relative mercury removal of treatment of the activated carbon with chloride outside the flue gas versus in-flight treatment with chloride in the flue gas.

Nelson mentions treating activated carbon outside of flue gas, and then adding the activated carbon to flue gas. Nelson fails to describe or suggest in-flight promotion of an activated carbon with a halide in the flue gas. Therefore, a person of ordinary skill in the art hypothetically having Nelson in-hand would *also* have no idea that in-flight promotion of activated carbon with a halide could have any advantages over halide treatment outside of the flue gas.

There is no way to predict from the presently cited references the superior mercury capture discovered by the present inventors that occurs when activated carbon is promoted with bromide promoters in-flight in the mercury-containing gas, as occurs when following the present claims. The Office Action states at the end of the last full paragraph on page 4 that Nelson's additives would be combined with Felsvang's in-flight promotion "…so as to provide an effective carbon sorbent for mercury." However, a person of ordinary skill in the art would have no idea that in-flight promotion with bromide promoters could work better than Nelson's bromide-treatment outside the flue gas. Felsvang fails to describe or suggest that in-flight promotion provides a sorbent with even the same (let alone superior) properties as a sorbent treated outside the flue gas, and, as explained herein at **II(D)**, treatment of activated carbon outside the flue gas with chloride actually provides better mercury removal than in-flight promotion of activated carbon with chloride; similarly, Nelson fails to describe in-flight promotion, let alone that in-flight promotion provides the same or superior mercury removal ability as compared to treatment outside the flue gas.

The only way that a person of ordinary skill in the art could discover that in-flight promotion of activated carbon with bromide promoters is more effective for mercury removal than bromide treatment outside the flue gas would not be from the cited references alone; instead, the person of ordinary skill would need to actually modify Felsvang with Nelson as alleged, and then to compare the mercury removal of Felsvang's modified process to Nelson's sorbent treated outside the flue gas.[1] However, the person of ordinary skill carrying out such a combination would be surprised to find that in-flight promotion with bromide is more effective for mercury removal than bromide treatment of the sorbent outside the flue gas. The process giving rise to these surprising results was discovered by the inventors of the present application. Surprising results are a hallmark of patentability; only by having the present application in-hand could such results be predicted, and a need to resort to hindsight analysis to predict the advantages of the combination asserted by the Office Action is indicative that the presently claimed invention is not obvious over the cited references. Accordingly, independent claim 2 is patentable over Felsvang in view of Nelson for at least this additional reason.

II(C)(1). In-flight promotion with bromide promoters is more effective for mercury removal than in-flight promotion with chloride-promoters.

The inventors of the present application have discovered that that in-flight bromide promotion of an activated carbon in a mercury-containing flue gas is significantly more effective for mercury removal than in-flight chloride promotion of an activated carbon.

As explained in the 132 Declaration filed herewith, pilot-scale testing was performed with NaBr or NaCl added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas. The same activated carbon was used for each sample. See, the 132 Declaration at items 8-10. The first plot given in the 132 Declaration at item 13 is reproduced below, but not showing the data from Nelson's HBr-treated AC.

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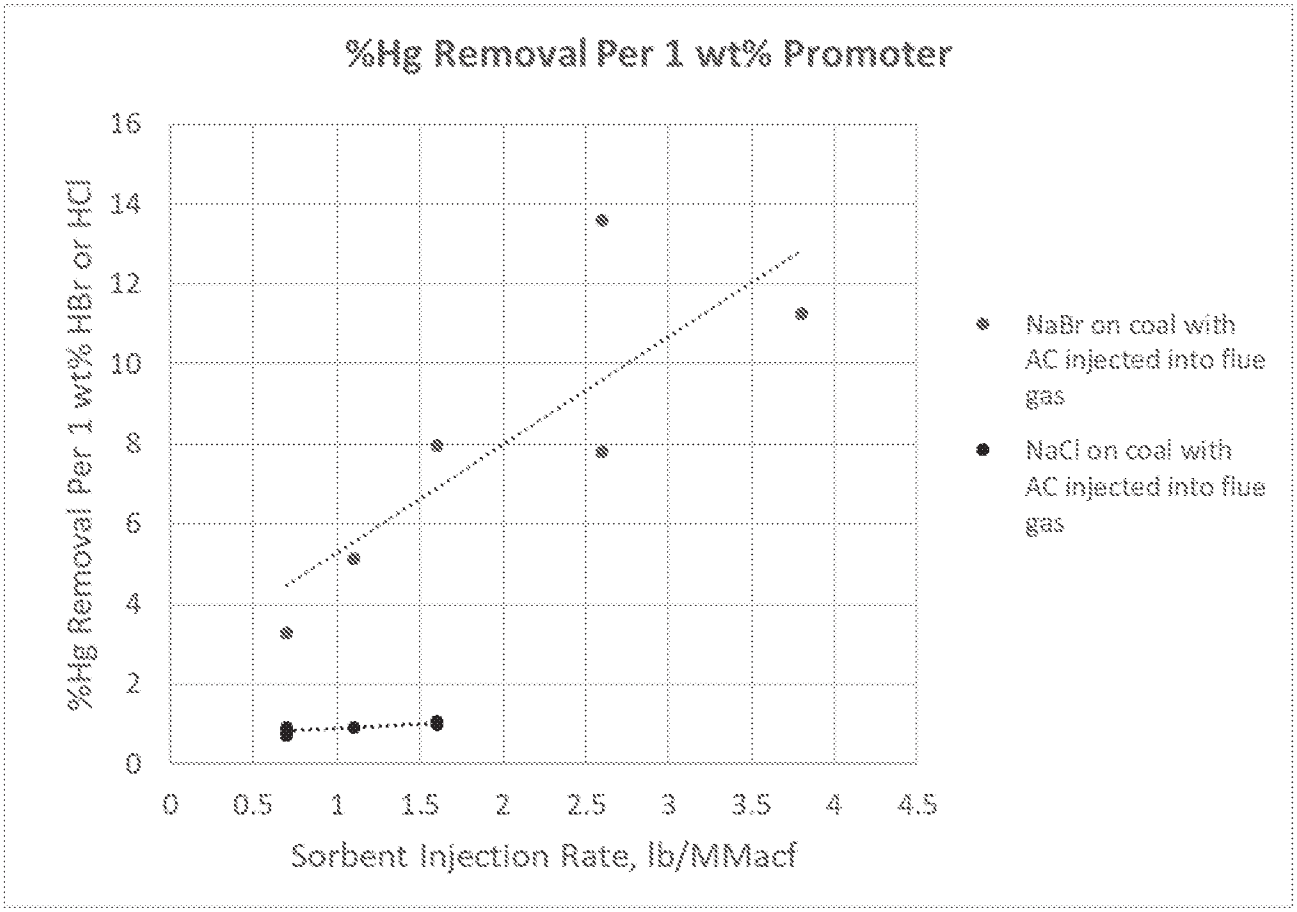
[1] In the event the Examiner intends to argue that such advantages are inherent in the cited art, Applicant notes that the claimed invention is not specifically disclosed in the prior art. The Examiner cannot reason inherency in a §103 context based on a mere proposed or hypothetical combination of features from cited references. Such reasoning would merely reflect the Examiner's reliance on impermissible hindsight. See, M.P.E.P. § 2112(IV).



The data in the plot above, derived from the first plot at item 13 of the 132 Declaration, show that the NaBr added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas provided a significantly higher (about 6-8x) percent mercruy removal per 1 wt% HBr or HCl at all tested sorbent injection rates compared to the NaCl added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas. See, 132 Declaration at item 14.

<u>II(C)(2).</u> <u>There would be no way for a person of ordinary skill in the art to predict this advantage from the from the cited references.</u>

As explained herein at **II(A)**, Nelson fails to describe or suggest that treatment of activated carbon with bromides such as HBr could provide any mercury-removal improvement, or even the same mercury-removal activity, compared to Felsvang's activated carbons promoted with chlorides.

The only way that a person of ordinary skill in the art could discover that in-flight promotion with bromide promoters is more effective for mercury removal than in-flight promotion with chloride promoters would not be from the cited references alone; instead, the person of ordinary skill would need to actually modify Felsvang with Nelson as alleged, and then to compare the mercury removal of Felsvang's modified process to Felsvang's original process.[2] However, the person of ordinary skill carrying out such a combination would be surprised to find that promotion of activated carbon with bromides such as HBr could provide any mercury-removal improvement, or even the same mercury-removal activity, compared to Felsvang's activated carbons promoted with chlorides. The process giving rise to these surprising results was discovered by the inventors of the present application. Surprising results are a hallmark of patentability; only by having the present application in-hand could such results be predicted, and a need to resort to hindsight analysis to predict the advantages of the combination asserted by the Office Action is indicative that the presently claimed invention is not obvious over the cited references. Accordingly, independent claim 2 is patentable over Felsvang in view of Nelson for at least this additional reason.

II(D). Even if a person of ordinary skill in the art compared the mercury removal of Felsvang's activated carbons promoted with chloride in the flue gas to activated carbons treated with HCl outside of the flue gas, they would not determine that in-flight promotion provides the same or better mercury removal properties.

As explained herein at **II(A)**, Felsvang fails to describe or suggest that in-flight promotion of activated carbon with chloride provides better mercury removal than treatment of activated carbon outside of the flue gas. For the sake of argument, even if a person of ordinary skill in the art were to compare mercury removal of Felsvang's activated carbons promoted with chloride in the flue gas to activated carbons treated with HCl outside of the flue gas, they would not find that in-flight promotion provides the same or better mercury-removal properties.

As explained in the 132 Declaration filed herewith, pilot-scale testing was performed with activated carbon treated with HCl outside the flue gas as per the Nelson procedure (see, 132

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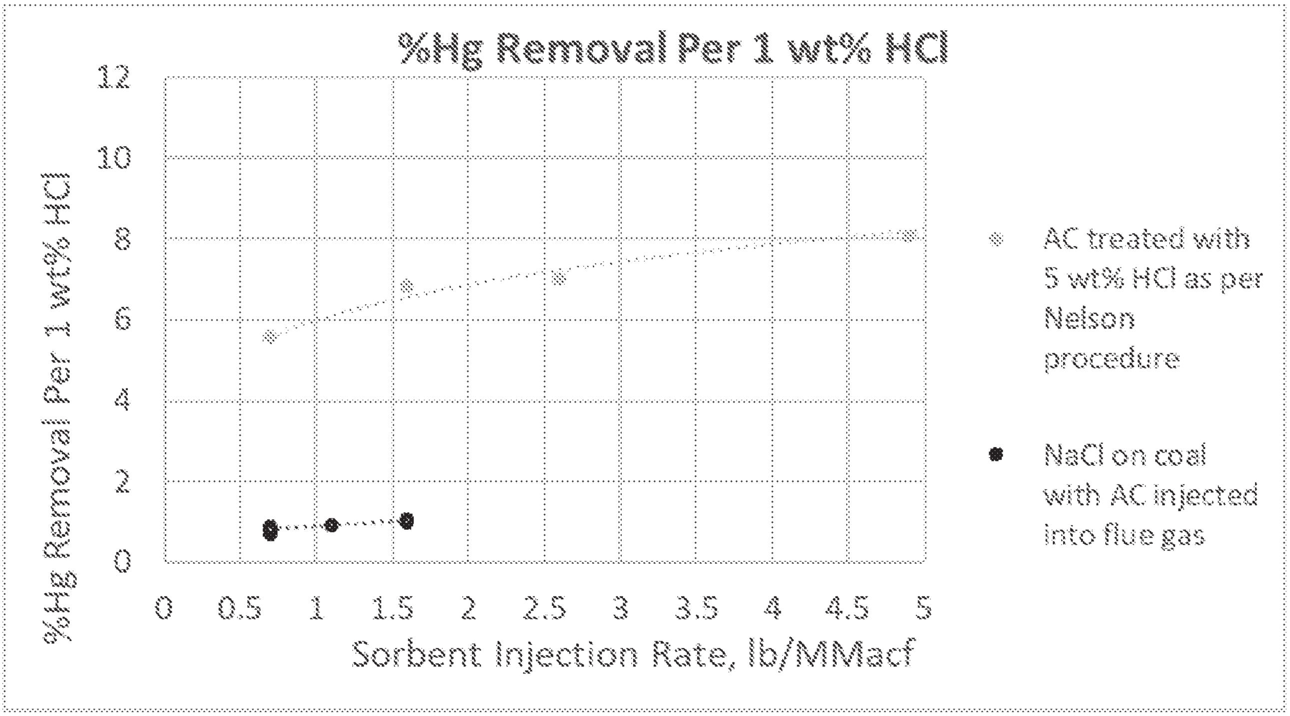
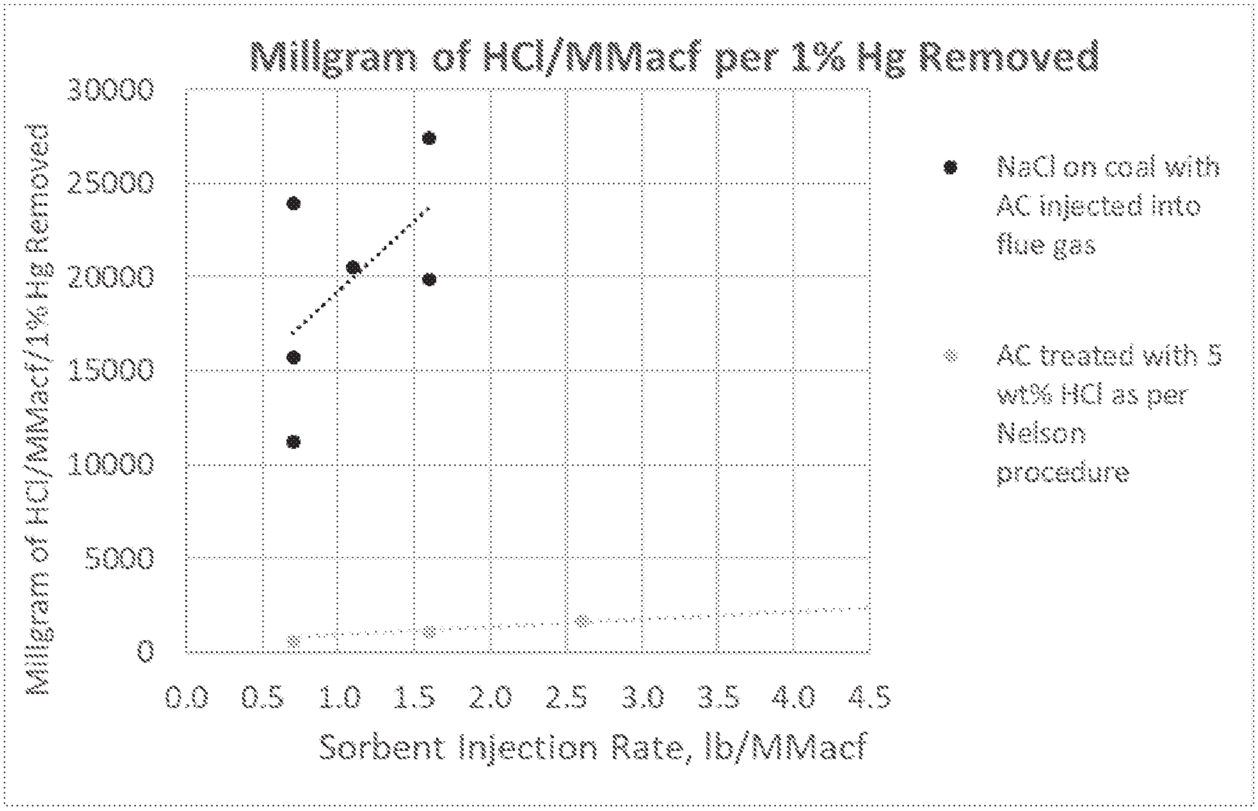
[2] In the event the Examiner intends to argue that such advantages are inherent in the cited art, Applicant notes that the claimed invention is not specifically disclosed in the prior art. The Examiner cannot reason inherency in a §103 context based on a mere proposed or hypothetical combination of features from cited references. Such reasoning would merely reflect the Examiner's reliance on impermissible hindsight. See, M.P.E.P. § 2112(IV).

Declaration at item 7), and with NaCl added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas. The same activated carbon was used for each sample. See, the 132 Declaration at items 8-10. The first plot given in the 132 Declaration at item 15 is reproduced below.



The data in the plot above from the item 15 of the 132 Declaration show that activated carbon treated with HCl outside the flue gas as per the Nelson procedure provided a much higher percent of mercury removal per 1 wt% HCl at all tested sorbent injection rates as compared to NaCl added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas. See, 132 Declaration at item 16.

The pilot-scale data was also plotted to show the milligrams of HCl/MMacf per 1% mercury removal versus the sorbent injection rate with NaCl added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas, and for the activated carbon treated with HCl outside the flue gas described herein at item 7 as per the Nelson procedure. The second plot given in the 132 Declaration at item 15 is reproduced below.



The data in the second plot above from item 15 of the Declaration show that the milligrams of HCl/MMacf per 1% mercury removal versus the sorbent injection rate with NaCl added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas was significantly higher as compared to the activated carbon treated with HCl outside the flue gas described herein at item 7 as per the Nelson procedure, indicating more efficient use of HCl for mercury removal by treatment of activated carbon outside the flue gas than by promotion in-flight.

Dependent claims 3-19 are directly or indirectly dependent on independent claim 2. As such, these claims incorporate all the features of claim 2. Accordingly, claims 3-19 are patentable for at least the reasons given herein for patentability of independent claim 2.

Applicant therefore respectfully requests reconsideration and withdrawal of the rejection of claims 2-19 under 35 U.S.C. § 103(a) over Felsvang in view of Nelson.

Double Patenting Rejections

III(A). The Office Action rejected claims 2-19 for nonstatutory double patenting over claims 1-30 of U.S. patent no. 7,435,286 in view of U.S. patent no. 5,435,980 ("Felsvang").

This rejection is respectfully traversed. Applicant does not admit that claims 2-19 are obvious over claims 1-30 of U.S. patent no. 7,435,286 in view of Felsvang.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

III(B). The Office Action rejected claims 2-19 were rejected for nonstatutory double patenting over claims 1-25 of U.S. patent no. 8,168,147 in view of U.S. patent no. 5,435,980 ("Felsvang").

This rejection is respectfully traversed. Applicant does not admit that claims 2-19 are obvious over claims 1-25 of U.S. patent no. 8,168,147 in view of Felsvang.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

III(C). The Office Action rejected claims 2-19 were rejected for nonstatutory double patenting over claims 1-60 of U.S. patent no. 8,512,655 in view of U.S. patent no. 5,435,980 ("Felsvang").

This rejection is respectfully traversed. Applicant does not admit that claims 2-19 are obvious over claims 1-60 of U.S. patent no. 8,512,655 in view of Felsvang.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

III(D). The Office Action rejected claims 2-19 were rejected for nonstatutory double patenting over claims 1-60 of U.S. patent no. 8,821,819 in view of U.S. patent no. 5,435,980 ("Felsvang").

This rejection is respectfully traversed. Applicant does not admit that claims 2-19 are obvious over claims 1-60 of U.S. patent no. 8,821,819 in view of Felsvang.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

III(E). The Office Action rejected claims 2-19 were rejected for nonstatutory double patenting over claims 1-33 of U.S. patent no. 9,757,689 in view of U.S. patent no. 5,435,980 ("Felsvang").

This rejection is respectfully traversed. Applicant does not admit that claims 2-19 are obvious over claims 1-33 of U.S. patent no. 9,757,689 in view of Felsvang.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

III(F). The Office Action rejected claims 2-19 were rejected for nonstatutory double patenting over claims 1-20 of U.S. patent no. 9,468,886 in view of U.S. patent no. 5,435,980 ("Felsvang").

This rejection is respectfully traversed. Applicant does not admit that claims 2-19 are obvious over claims 1-20 of U.S. patent no. 9,468,886 in view of Felsvang.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

III(G). The Office Action rejected claims 2-19 were rejected for nonstatutory double patenting over claims 1-30 of U.S. Patent No. 8,652,235 in view of U.S. patent no. 5,435,980 ("Felsvang").

This rejection is respectfully traversed. Applicant does not admit that claims 2-19 are obvious over claims 1-30 of U.S. Patent No. 8,652,235 in view of Felsvang.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

III(H). The Office Action rejected claims 2-19 were provisionally rejected for nonstatutory double patenting over claims 1-16 of copending application no. 15/295594.

This rejection is respectfully traversed. Applicant does not admit that claims 2-19 are obvious over claims 1-16 of copending application no. 15/295594.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

III(I). The Office Action rejected claims 2-19 were provisionally rejected for nonstatutory double patenting over claims 8-20 of copending application no. 15/589359 in view of U.S. patent no. 5,435,980 ("Felsvang").

This rejection is respectfully traversed. Applicant does not admit that claims 2-19 are obvious over claims 8-20 of copending application no. 15/589359 in view of Felsvang.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

III(J). The Office Action rejected claims 2-19 were provisionally rejected for nonstatutory double patenting over claims 1-20 of copending application no. 15/853029.

This rejection is respectfully traversed. Applicant does not admit that claims 2-19 are obvious over claims 1-20 of copending application no. 15/853029.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

III(K). The Office Action rejected claims 2-19 were provisionally rejected for nonstatutory double patenting over claims 1-20 of copending application no. 14/712558.

This rejection is respectfully traversed. Applicant does not admit that claims 2-19 are obvious over claims 1-20 of copending application no. 14/712558.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

III(L). The Office Action rejected claims 2-19 were provisionally rejected for nonstatutory double patenting over claims 1-20 of copending application no. 15/951970.

This rejection is respectfully traversed. Applicant does not admit that claims 2-19 are obvious over claims 1-20 of copending application no. 15/951970.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

III(M). The Office Action rejected claims 2-19 were provisionally rejected for nonstatutory double patenting over claims 1-20 of copending application no. 15/382114 in view of U.S. patent no. 5,435,980 ("Felsvang").

This rejection is respectfully traversed. Applicant does not admit that claims 2-19 are obvious over claims 1-20 of copending application no. 15/382114 in view of Felsvang.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

III(N). The Office Action rejected claims 2-19 were provisionally rejected for nonstatutory double patenting over claims 1-20 of copending application no. 15/853029.

This rejection is respectfully traversed. Applicant does not admit that claims 2-19 are obvious over claims 1-20 of copending application no. 15/853029. Applicant notes that this rejection is identical to the one reported herein at **III(J)**.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

CONCLUSION

It is respectfully submitted that the claims are in condition for allowance, and notification to that effect is earnestly requested. The Examiner is invited to telephone the undersigned at (612) 349-9580 to facilitate prosecution of this application.

If necessary, please charge any additional fees or deficiencies, or credit any overpayments to Deposit Account No. 19-0743.

Respectfully submitted,

SCHWEGMAN LUNDBERG & WOESSNER, P.A.
P.O. Box 2938
Minneapolis, MN 55402-0938
(612) 373-6900

Date December 3, 2018

By

Nicholas P. Lanzatella
Reg. No. 63,803

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s):	Edwin S. Olson et al.	Examiner:	Amber Orlando
Serial No.:	15/978,760	Group Art Unit:	1776
Filed:	May 14, 2018	Docket:	4820.007US4
Customer No.:	21186	Confirmation No.:	6432
Title:	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY		

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

MS Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

In compliance with the duty imposed by 37 C.F.R. § 1.56, and in accordance with 37 C.F.R. §§ 1.97 *et. seq.*, the enclosed materials are brought to the attention of the Examiner for consideration in connection with the above-identified patent application. Applicant respectfully requests that this Information Disclosure Statement be entered and the documents listed on the attached PTO 1449 Form be considered by the Examiner and made of record. Pursuant to the provisions of MPEP 609, Applicant requests that a copy of the PTO 1449 Form, initialed as being considered by the Examiner, be returned to the Applicant with the next official communication.

Pursuant to 37 C.F.R. § 1.97(c)(2), Applicant hereby authorizes the Commissioner to charge the fee of $240.00 as set forth in 37 C.F.R. § 1.17(p), to Deposit Account No. 19-0743. Please charge any additional fees or deficiencies, or credit any overpayment to Deposit Account No. 19-0743.

Pursuant to 37 C.F.R. § 1.98(a)(2), copies of cited U.S. Patents and Published Applications, and Non-Published Applications identifiable by USPTO Serial Number, are no longer required to be provided to the Office. Applicant acknowledges the requirement to submit copies of foreign patent documents and non-patent literature in accordance with 37 C.F.R § 1.98(a)(2).

The Examiner is invited to contact the undersigned at the telephone number indicated if there are any questions regarding this communication.

Respectfully submitted,

SCHWEGMAN LUNDBERG & WOESSNER, P.A.
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Minneapolis, MN 55402
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Date December 3, 2018 By

Nicholas P. Lanzatella
Reg. No. 63,803

NPL:mlr1

Substitute for form 1449A/PTO **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** (Use as many sheets as necessary)	*Complete if Known*	
	Application Number	15/978,760
	Filing Date	May 14, 2018
	First Named Inventor	Edwin S. Olson
	Group Art Unit	1776
	Examiner Name	Amber Orlando
Sheet 1 of 1	Attorney Docket No: 4820.007US4	

US PATENT DOCUMENTS

Examiner Initial *	USP Document Number	Publication Date	Name of Patentee or Applicant of cited Document
	US-4,013,516	3/22/1977	Greenfield, Charles, et al.
	US-4,699,896	10/13/1987	Sing, Kenneth S, et al.
	US-10,130,930	11/20/2018	Olson, Edwin S
	US-20180280870A1	10/4/2018	Olson, Edwin S, et al.

FOREIGN PATENT DOCUMENTS

Examiner Initial *	Foreign Document Number	Publication Date	Name of Patentee or Applicant of cited Document	T 1

OTHER DOCUMENTS – NON PATENT LITERATURE DOCUMENTS

Examiner Initial *	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T 1
	"Application Serial No. 14/712,558, Non Final Office Action mailed 10-19-18", 26 pgs	
	"Application Serial No. 14/712,558, Non-Final Office Action mailed 10-19-18", 35 pgs	
	"Application Serial No. 15/295,594, Non Final Office Action mailed 10-23-18", 20 pgs	
	"Application Serial No. 15/589,359, Non Final Office Action mailed 10-22-18", 12 pgs	
	"Application Serial No. 15/974,343, Non Final Office Action mailed 10-29-18", 22 pgs	
	"Application Serial No. 15/997,091, Non Final Office Action mailed 11-02-18", 27 pgs	
	"European Application Serial No. 14711106.6, Response filed 10-15-18 to Office Action mailed 06-05-18", w/ English Claims, 15 pgs	
	PIETRZAK, et al., "Preparation of nitrogen-enriched activated carbons from brown coal", Energy and Fuels 20.3, (2006), 1275-1280	

EXAMINER **DATE CONSIDERED**

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant is to place a check mark here if English language Translation is attached

A/N 15/978,760 **PATENT**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s): Edwin S. Olson et al. Examiner: AMBER ROSE ORLANDO
Application No.: 15/978,760 Group Art Unit: 1776
Filed: May 14, 2018 Docket No.: 4820.007US4
Confirmation No.: 6432
Title: SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY

DECLARATION UNDER 37 C.F.R. § 1.132

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

I, John Pavlish, declare and say as follows:

1. I have been the Chief Technology Officer and Senior Vice President of Midwest Energy Emissions Corporation since November 16, 2014. Prior to this, I served as an Executive Consultant Advisor to Midwest Energy Emissions Corporation. Prior to joining Midwest Energy Emissions Corporation, I was a Senior Research Advisor and the Director of the Center for Air Toxic Metals Program at the Energy & Environmental Research Center in Grand Forks, North Dakota. I have over 25 years of mercury-related experience and am regarded as an international expert on the topic of mercury. My primary areas of interest and expertise include research, technical consultation and development of mercury control technologies, in particular, for coal combustion and gasification systems. I am an inventor of a number of patented mercury control technologies and have years of experience in development and testing of these technologies for commercial applications. Over the last 15 years, I have spent much time evaluating the efficacy of a number of different mercury control technologies/approaches and their cost competiveness in the commercial market. I also have years of power plant experience and have worked for an engineering/consulting company, Black & Veatch, where I served as Unit Leader/System Engineer. I am a professional engineer, a member of the American Society of Mechanical Engineers, and a member of the Air & Waste Management Association (A&WMA). I serve on numerous professional and technical committees and am a U.S. Representative on the Mercury Emissions from Coal International Experts Working Group on Reducing Emissions from Coal and a member

of the United Nations Environment Programme Global Mercury Partnership, Reduction of Mercury Releases from Coal Combustion. I have published over 200 papers, articles, and reports on various mercury-related topics and issues.

2. U.S. patent publication no. 2004/0003716 ("Nelson") describes treatment of activated carbon outside the flue gas with hydrogen bromide (HBr), and describes testing to measure the percent mercury removal when the treated activated carbon was injected into either simulated or actual flue gas at various injection rates. Specifically, Nelson performed experiments in Example 5 (paragraphs [0082]-[0085]) and 7 (paragraphs [0089]-[0092]), and provides the data in FIG. 14 and FIG. 15.

3. In Example 5, Nelson treated Norit DARCO® FGD with gaseous HBr, and tested its use by injecting the HBr-treated sorbent into a simulated coal-fired flue-gas stream in a pilot-scale test system. Nelson's FIG. 14 shows data for one activated carbon sample treated with HBr. The activated carbon had 10 wt% HBr, and at a sorbent injection rate of about 3.7 lb/MMacf gave a mercury removal of about 82%.

4. In Example 7, Nelson treated Norit DARCO® FGD with gaseous HBr, and tested its use in a coal-fired power plant by injecting the treated sorbent into the flue gas prior to the electrostatic precipitator (ESP). Nelson's FIG. 15 shows data for two activated carbon samples treated with HBr. The two activated carbon samples contained 9 wt% HBr. The data in FIG. 15 for the two HBr-treated sorbents show that at a sorbent injection rate of about 2.2 lb/MMacf, 45% of the mercury was removed, and at a sobent injection rate of about 4.2 lb/MMacf, 62% of the mercury was removed.

5. The percent mercury removal, and the percent mercury removal per 1 wt% HBr additive on the sorbent, versus the sorbent injection rate for Nelson's HBr-treated activated carbon formed in Nelson's Examples 5 and 7 is given in the table below. The percent mercury removal per 1 wt% HBr was calculated as the percent mercury removal

divided by the HBr wt% on the sorbent. The units "lb/MMacf" are pounds of sorbent per 1 million actual cubic feet of flue gas.

Sample	Additive	Sorbent Description	Sorbent Injection Rate (lb/MMacf)	HBr wt% on Sorbent	%Hg Removal	%Hg Removal per 1 wt% HBr on Sorbent
N1	HBr outside flue gas	Norit DARCO® FGD	3.7	10	82	8.2
N2	HBr outside flue gas	Norit DARCO® FGD	2.2	9	45	5.0
N3	HBr outside flue gas	Norit DARCO® FGD	4.2	9	62	6.8

6. A bromine-treated activated carbon was prepared by exposing activated carbon (Norit DARCO® Hg, an activated carbon that a Norit Americas technical representative told me was rebranded for mercury control applications and was previously referred to as Norit DARCO® FGD) to gaseous bromine. A cement mixer was used to expose the activated carbon to the bromine gas. Tumbling vanes produced a dispersion of the activated carbon within the barrel. A cover was fit over the opening to keep the activated carbon dispersion inside the barrel. In the center of the lid, a small hole was drilled, and a tube extended to the center of the barrel. The tube was attached to a source of bromine vapor (Br_2) in dry nitrogen via a swivel so that the tube in the barrel would rotate and the tube to the source would be stationary. A charge of 1 to 5 kg of the activated carbon was weighed and transferred to the barrel. The weight of bromine transferred to the barrel was equal to 5 weight % of the amount of activated carbon.

7. An HCl-treated activated carbon was prepared by exposing activated carbon (Norit DARCO® Hg) to gaseous HCl. The carbon was weighed and added to a flask which was attached to a rotary apparatus. A hard-plastic tube was inserted into the condenser end of the apparatus for introduction of the HCl/nitrogen gas mix. This

extended to the center of the flask. HCl from a cylinder was run through a flow meter and mixed with a low flow of nitrogen in a T-tube attached to the inlet tube. The flow rate was set to provide 5 wt % HCl over 15 minutes exposure. The flask was slowly rotated in the apparatus at room temperature so that the carbon turned over but did not exit the flask. After the exposure period, the HCl flow was stopped and the HCl-treated activated carbon was removed.

8. A pilot-scale 550,000-Btu/hr pulverized coal (pc)-fired test unit was used to combust subbituminous coal and test mercury control using various sorbents. The coal combustion flue gas exiting the pilot unit was cooled down to a nominal temperature of 49°C (300°F) and then was introduced into a single wire tubular ESP unit. Activated carbon sorbents were fed with a K-Tron dual-screw feeder upstream of the ESP. The feeder was calibrated prior to the start of each carbon injection test. Before Hg control testing began, a baseline condition was established with the pilot-scale unit, and flue gas mercury content was measured. Percent mercury removal was then measured for the activated carbon alone (untreated), the activated carbon treated with Br_2 outside the flue gas described herein at item 6 as per the Nelson procedure, and with sodium bromide (NaBr) or sodium chloride (NaCl) added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas.

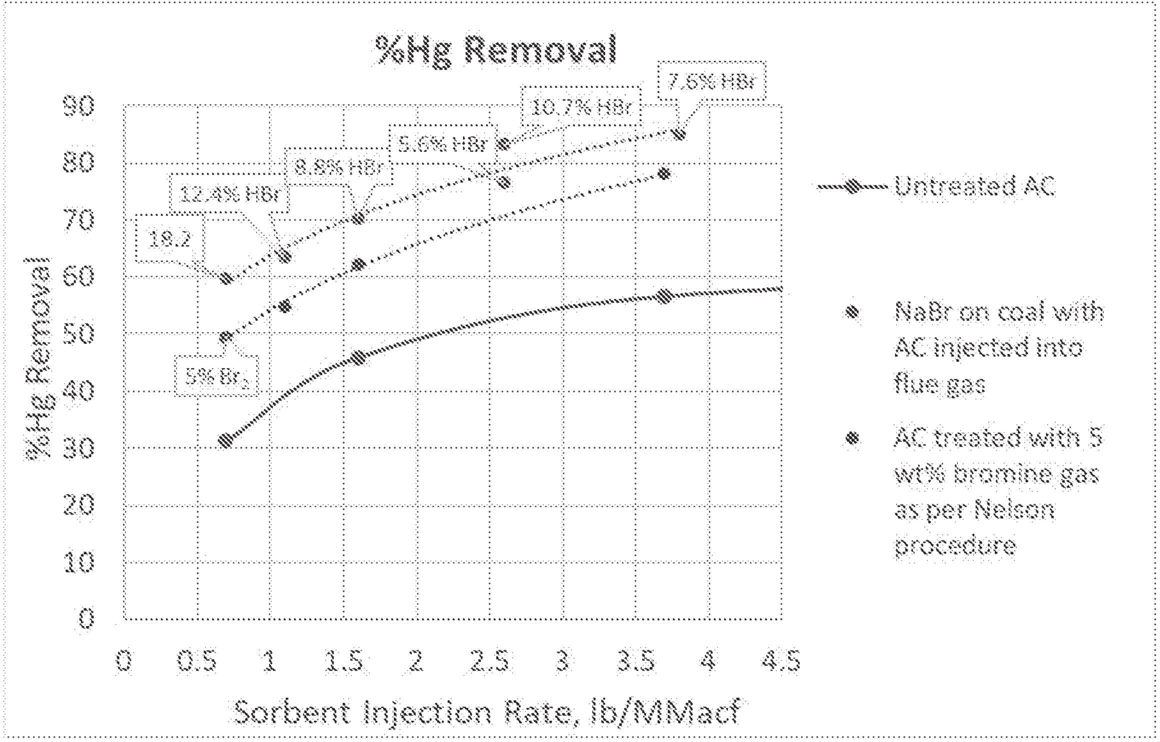
9. The results of the pilot-scale test with untreated activated carbon and with the activated carbon treated with Br_2 outside the flue gas described herein at item 6 are given in the table below.

Sample	Additive	Sorbent Description	Sorbent Injection Rate (lb/MMacf)	Br_2 or HCl wt% on Sorbent	%Hg Removal
1	None	Norit DARCO® Hg	0.7	0	31.4
2	None	Norit DARCO® Hg	1.6	0	45.9
3	None	Norit DARCO® Hg	3.7	0	56.6
4	None	Norit DARCO® Hg	9.2	0	61.2
5	None	Norit DARCO® Hg	25.7	0	62.5
6	Br_2 outside flue gas	Norit DARCO® Hg	0.7	5	49.5
7	Br_2 outside flue gas	Norit DARCO® Hg	1.1	5	54.9
8	Br_2 outside flue gas	Norit DARCO® Hg	1.6	5	62.2
9	Br_2 outside flue gas	Norit DARCO® Hg	3.7	5	78.1

10. The results from the pilot-scale test with sorbent enhancement additives (SEAs) NaBr or NaCl added to coal along with injection of untreated activated carbon into the flue gas, and with the activated carbon treated with HCl outside the flue gas described at item 7, are given in the table below. The bromide (Br^-) or chloride (Cl^-) injection rate was calculated as the SEA injection rate times the fraction of the additive (based on molecular weight) that is Br^- or Cl^-; for Br^-, $Br^-/NaBr = 79.904/(79.904+22.9898) = 0.7766$; for Cl^-, $Cl^-/NaCl = 35.453/(35.453+22.9898) = 0.6066$. The HBr or hydrogen chloride (HCl) equivalent injection rate was calculated as the Br^- or Cl^- injection rate times the molecular weight ratio of HBr/Br^- or of HCl/Cl-; for HBr/Br-, this is $(1.00794+79.904)/79.904 = 1.013$; for HCl/Cl^-, this is $(1.00794+35.453)/35.453 = 1.028$. The equivalent HBr or HCl wt% on sorbent was calculated as the HBr or HCl injection rate divided by the sum of the sorbent injection rate and the HBr or HCl injection rate (e.g., 100% of the HBr or HCl was assumed to react with the sorbent). The percent mercury removal per 1 wt% HBr or HCl was calculated as the percent mercury removal divided by the HBr wt% or HCl wt% on sorbent.

Sample	Additive	Additive injection rate (lb/MMacf)	Sorbent description	Sorbent injection rate (lb/MMacf)	Br^- or Cl^- injection rate (lb/MMacf)	HBr or HCl equivalent injection rate (lb/MMacf)	Equivalent HBr or HCl wt% on sorbent	%Hg removal	%Hg removal per 1 wt% HCl or HBr on sorbent	Milligrams HBr or HCl/MMacf per 1% Hg Removal
13	NaBr on coal	0.2	Norit DARCO® Hg	0.7	0.16	0.16	18.2	59.8	3.3	1211
14	NaBr on coal	0.2	Norit DARCO® Hg	1.1	0.16	0.16	12.4	63.6	5.1	1139
15	NaBr on coal	0.2	Norit DARCO® Hg	1.6	0.16	0.16	8.8	70.4	18.0	1029
16	NaBr on coal	0.2	Norit DARCO® Hg	2.6	0.16	0.16	5.6	76.7	13.6	944
17	NaBr on coal	0.4	Norit DARCO® Hg	2.6	0.31	0.31	10.7	83.3	7.8	1739
18	NaBr on coal	0.4	Norit DARCO® Hg	3.8	0.31	0.31	7.6	85.1	11.3	1702
19	NaCl on coal	2.4	Norit DARCO® Hg	0.7	1.46	1.50	67.5	60.6	0.9	11202
20	NaCl on coal	3.4	Norit DARCO® Hg	0.7	2.06	2.12	74.7	61.2	0.8	15714
21	NaCl on coal	4.9	Norit DARCO® Hg	0.7	2.97	3.06	80.9	57.8	0.7	23979
22	NaCl on coal	4.9	Norit DARCO® Hg	1.1	2.97	3.06	73.0	67.4	0.9	20564
23	NaCl on coal	4.9	Norit DARCO® Hg	1.6	2.97	3.06	65.0	69.6	1.1	19914
24	NaCl on coal	6.9	Norit DARCO® Hg	1.6	4.19	4.30	72.3	71.2	1.0	27412
25	HCl outside flue gas	0	Norit DARCO® Hg	0.7	0.04	0.04	5.0	27.9	5.6	569
26	HCl outside flue gas	0	Norit DARCO® Hg	1.6	0.08	0.08	5.0	34.2	6.8	1061
27	HCl outside flue gas	0	Norit DARCO® Hg	2.6	0.13	0.13	5.0	35.1	7.0	1680
28	HCl outside flue gas	0	Norit DARCO® Hg	4.9	0.24	0.25	5.0	40.3	8.1	2757
29	HCl outside flue gas	0	Norit DARCO® Hg	7.7	0.37	0.39	5.0	43.9	8.8	3978
30	HCl outside flue gas	0	Norit DARCO® Hg	15.5	0.75	0.78	5.0	52.9	10.6	6645

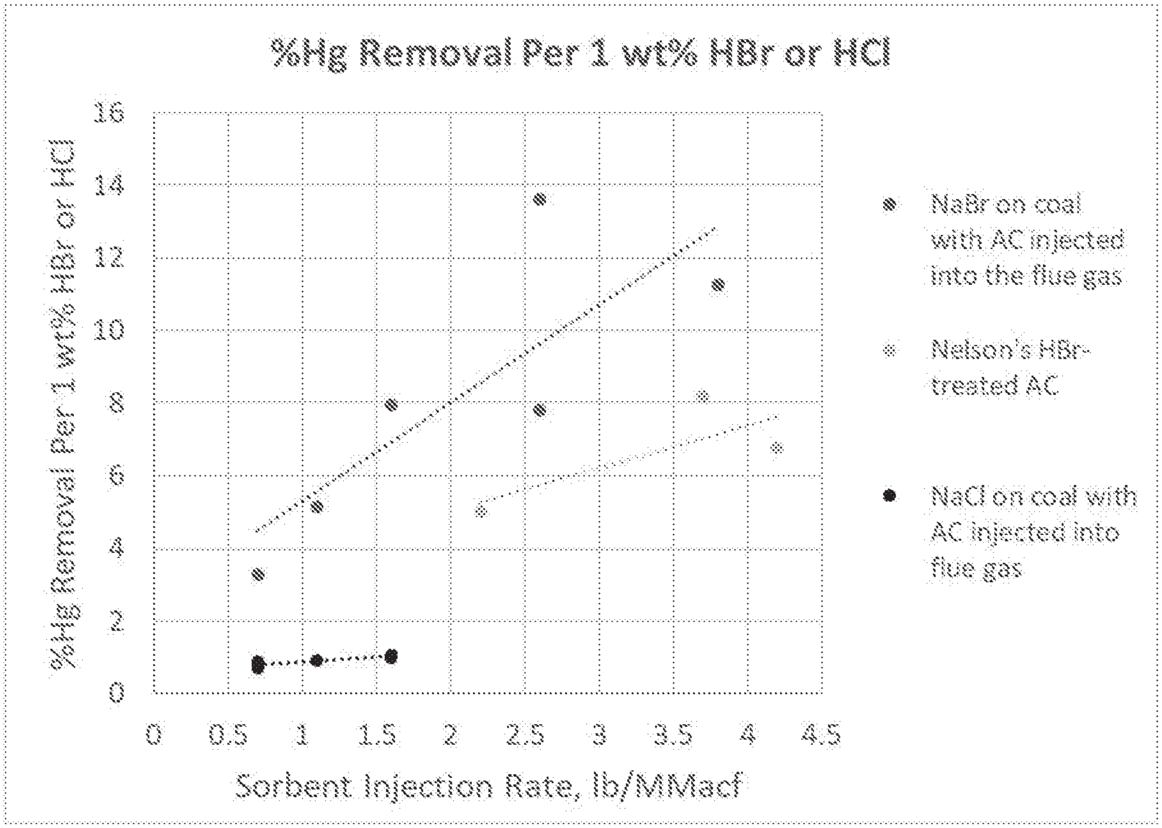
11. The following plot shows the percent mercury removal versus the sorbent injection rate for the activated carbon alone (untreated), the activated carbon treated with Br_2 outside the flue gas described herein at item 6 as per the Nelson procedure, and for NaBr added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas.

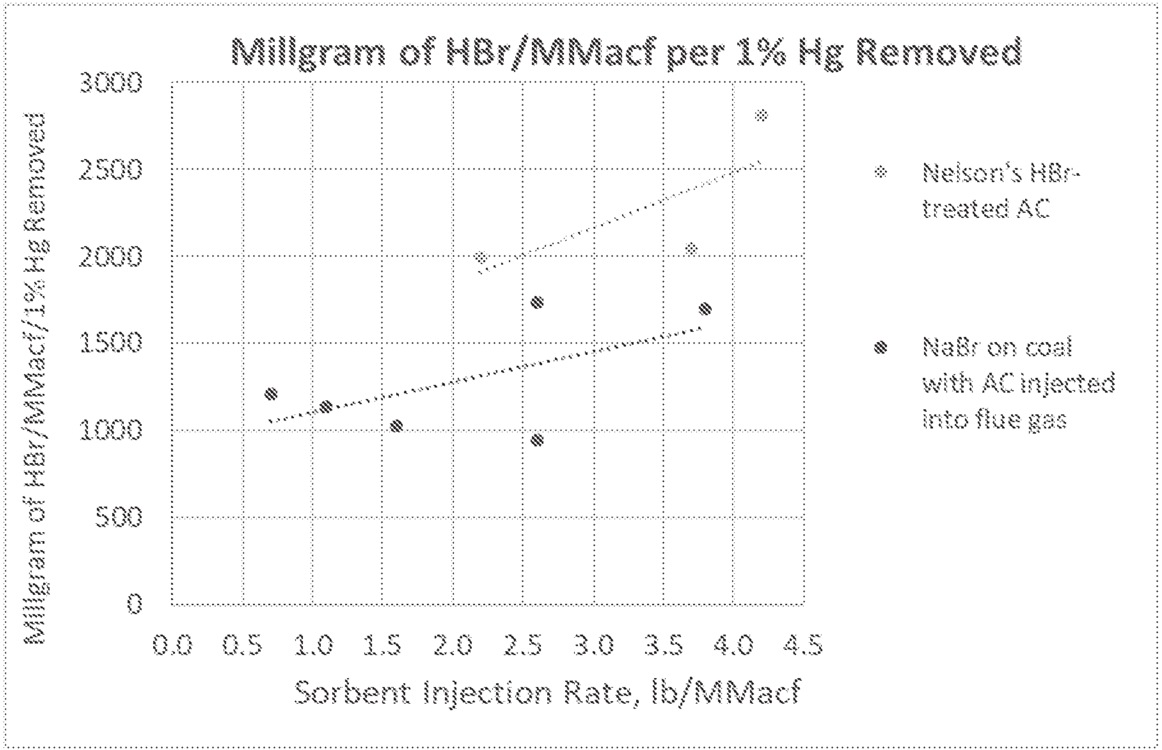


12. The data in the plot above show that the NaBr added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas (in-flight promotion with Br^-) provided a higher percent of mercury removal at all tested sorbent injection rates as compared to the activated carbon alone (untreated) and compared to the activated carbon treated with Br_2 outside the flue gas described herein at item 6 as per the Nelson procedure. With NaBr added to the coal and activated carbon injected into the flue gas, there was a significant reduction in the amount of sorbent required to acheive similar mercury removal compared to the activated carbon treated with Br_2 outside the flue gas. For example, to acheive 70% mercury removal, 2.5 lb/MMacf of Br_2-treated carbon was required, as compared to 1.6 lb/MMacf with NaBr added to the coal and

activated carbon injected into the flue gas; an additional (2.5-1.6/1.6)*100% or 56% treated sorbent was required to achieve the same leval of mercury removal.

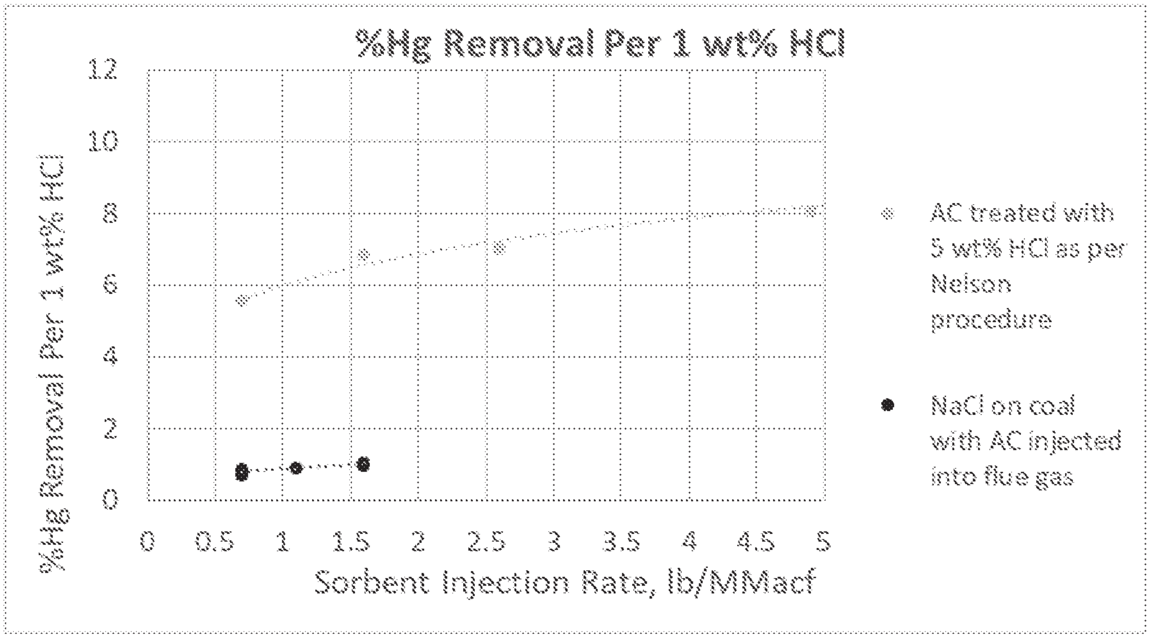
13. The following first plot shows the percent mercury removal per 1 wt% HBr or HCl versus the sorbent injection rate with NaBr or NaCl added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas, and for Nelson's activated carbon treated with HBr outside the flue gas. The following second plot shows the milligrams of HBr/MMacf per 1% mercury removal versus the sorbent injection rate with NaBr added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas, and for Nelson's activated carbon treated with HBr outside the flue gas; NaCl added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas was omitted from this plot because the values for the milligrams of HCl/MMacf per 1% mercury removal were so high (about 10,000 to 30,000).

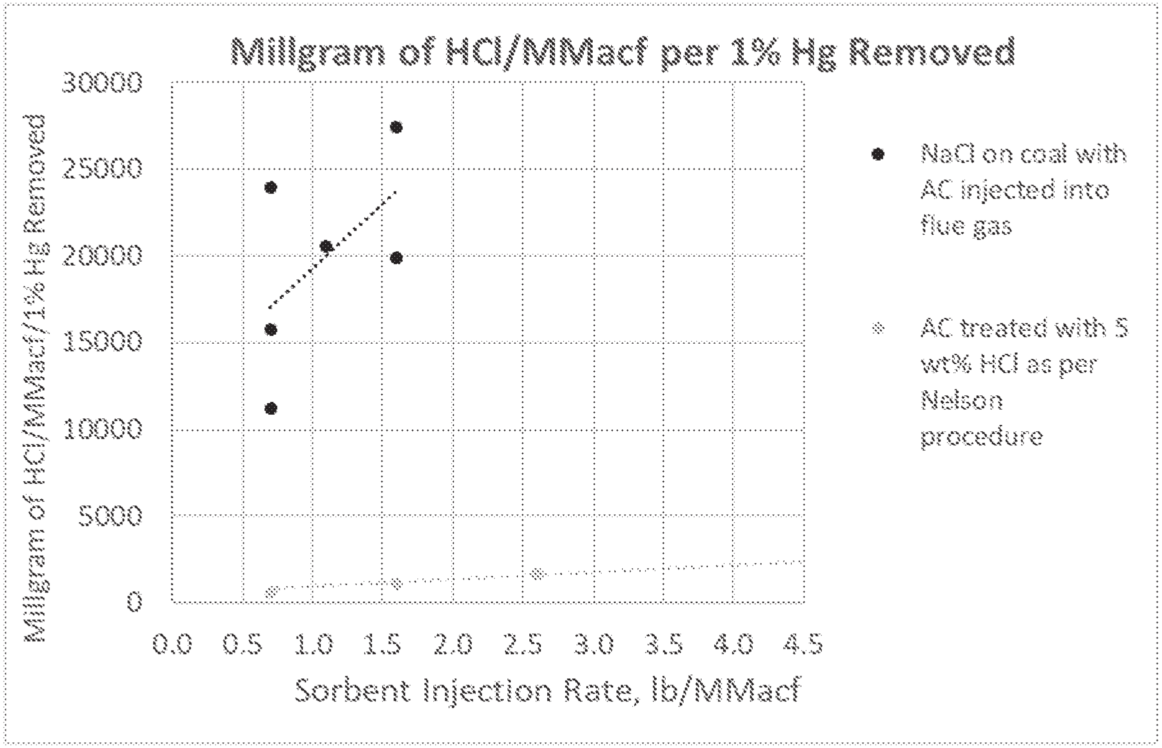




14. The data in the first plot above show that the NaBr added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas provided a significantly higher (about 2x) percent mercury removal per 1 wt% HBr at all tested sorbent injection rates as compared to Nelson's activated carbon treated with HBr outside the flue gas. Further, the data show that NaBr added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas provided a significantly higher (about 6-8x) percent mercruy removal per 1 wt% HBr or HCl at all tested sorbent injection rates compared to the NaCl added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas. The data in the second plot above shows that NaBr added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas provided a significantly lower milligrams of HBr/MMacf per 1% mercury removal at all tested sorbent injection rates as compared to Nelson's activated carbon treated with HBr outside the flue gas, indicating more efficient (approximately 2x) use of HBr for mercury removal during in-flight promotion of activated carbon than treatment of activated carbon outside the flue gas.

15. The following first plot shows the percent mercury removal per 1 wt% HCl versus the sorbent injection rate for NaCl added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas, and for the activated carbon treated with HCl outside the flue gas described herein at item 7 as per the Nelson procedure. The following second plot shows the milligrams of HCl/MMacf per 1% mercury removal versus the sorbent injection rate with NaCl added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas, and for the activated carbon treated with HCl outside the flue gas described herein at item 7 as per the Nelson procedure.





16. The data in the first plot above show that activated carbon treated with HCl outside the flue gas as per the Nelson procedure provided a much higher percent of mercury removal per 1 wt% HCl at all tested sorbent injection rates as compared to NaCl added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas. The data in the second plot above show that the milligrams of HCl/MMacf per 1% mercury removal versus the sorbent injection rate with NaCl added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas was significantly higher as compared to the activated carbon treated with HCl outside the flue gas described herein at item 7 as per the Nelson procedure, indicating more efficient use of HCl for mercury removal by treatment of activated carbon outside the flue gas than by promotion in-flight.

17. I further declare that all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by a fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application and/or any patent issued thereon.

Dated: December 3, 2018 By: John Pavlish

John Pavlish

Electronic Patent Application Fee Transmittal

Application Number:	15978760
Filing Date:	14-May-2018
Title of Invention:	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
First Named Inventor/Applicant Name:	Edwin S. Olson
Filer:	Steven M. Reid/Megan Reed
Attorney Docket Number:	4820.007US4

Filed as Large Entity

Filing Fees for **Utility under 35 USC 111(a)**

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
SUBMISSION- INFORMATION DISCLOSURE STMT	1806	1	240	240
	Total in USD ($)			**240**

Electronic Acknowledgement Receipt

EFS ID:	34470564
Application Number:	15978760
International Application Number:	
Confirmation Number:	6432
Title of Invention:	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
First Named Inventor/Applicant Name:	Edwin S. Olson
Customer Number:	21186
Filer:	Steven M. Reid/Megan Reed
Filer Authorized By:	Steven M. Reid
Attorney Docket Number:	4820.007US4
Receipt Date:	03-DEC-2018
Filing Date:	14-MAY-2018
Time Stamp:	17:59:31
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	$240
RAM confirmation Number	120418INTEFSW00005157190743
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Multipart Description/PDF files in .zip description

Document Description	Start	End
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Amendment/Req. Reconsideration-After Non-Final Reject	2	2
Claims	3	5
Applicant Arguments/Remarks Made in an Amendment	6	26
Transmittal Letter	27	28
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Affidavit-traversing rejectns or objectns rule 132	30	41

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2	Non Patent Literature	4820_001US7_OARN_10192018.pdf	4575545 3f6078548961a8f8aeaa2866bca8cbdb600fc0d6	no	35

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5	Non Patent Literature	4820001US9_OARNPE_10292018.pdf	2276933 b63c75fe3f8ee94045387324486e0c1d59ab76c7	no	22
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		Total Files Size (in bytes):	38307306		

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s): Edwin S. Olson et al.
Title: SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY

Docket No.:	4820.007US4	Serial No.:	15/978,760
Filed:	May 14, 2018	Due Date:	January 10, 2019
Examiner:	Amber Orlando	Group Art Unit:	1776
Customer No.:	21186	Confirmation No.:	6432

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

We are transmitting herewith the following attached items (as indicated with an "X"):

X Amendment and Response under 37 C.F.R. § 1.111 (25 pgs.)
X Supplemental Information Disclosure Statement (2 pgs.), Form 1449 (1 pg.) Copies of Cited References (8).
X Authorization to charge Deposit Account 19-0743 in the amount of $240.00 to cover the fee for consideration of Information Disclosure Statement under 37 C.F.R. § 1.97(c).
X Declaration Under 37 C.F.R. § 1.132 (12 pgs)

If not provided for in a separate paper filed herewith, please consider this a PETITION FOR EXTENSION OF TIME for sufficient number of months to enter these papers and please charge any additional fees or credit overpayment to Deposit Account No. 19-0743. If applicable, any papers or fees supplied herewith are considered to be timely filed pursuant to 37 C.F.R. § 1.7(a), the response period falling on a Federal Holiday, Saturday or Sunday being extended to the next succeeding business day.

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Customer No.: 21186

By /Nicholas P. Lanzatella/
Nicholas P. Lanzatella
Reg. No. 63,803

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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 15/978,760	Filing Date 05/14/2018	☐ To be Mailed

ENTITY: ☑ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $100 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $460 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	12/03/2018	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 19	Minus	** 20	= 0		x $100 =	0
	Independent (37 CFR 1.16(h))	* 1	Minus	*** 3	= 0		x $460 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	SLIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/ALA H HUNTER/
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".	
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/978,760	05/14/2018	Edwin S. Olson	4820.007US4	6432

21186 7590 12/26/2018
SCHWEGMAN LUNDBERG & WOESSNER, P.A.
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EXAMINER	
ORLANDO, AMBER ROSE	

ART UNIT	PAPER NUMBER
1776	

NOTIFICATION DATE	DELIVERY MODE
12/26/2018	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

SLW@blackhillsip.com
uspto@slwip.com

PTOL-90A (Rev. 04/07)

Office Action Summary	**Application No.** 15/978,760	**Applicant(s)** Olson et al.	
	Examiner AMBER R ORLANDO	**Art Unit** 1776	**AIA Status** No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☑ Responsive to communication(s) filed on 12/03/2018.
☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.
2a)☑ This action is **FINAL.** 2b) ☐ This action is non-final.
3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5) ☑ Claim(s) 2-19 and 22 is/are pending in the application.
5a) Of the above claim(s) _____ is/are withdrawn from consideration.
6) ☐ Claim(s) _____ is/are allowed.
7) ☑ Claim(s) 2-19 and 22 is/are rejected.
8) ☐ Claim(s) _____ is/are objected to.
9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

Application Papers

10)☐ The specification is objected to by the Examiner.
11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
Certified copies:
a)☐ All b)☐ Some** c)☐ None of the:
1.☐ Certified copies of the priority documents have been received.
2.☐ Certified copies of the priority documents have been received in Application No. _____.
3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☑ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b)
Paper No(s)/Mail Date _____.
3) ☐ Interview Summary (PTO-413)
Paper No(s)/Mail Date _____.
4) ☐ Other: _____.

DETAILED ACTION

Notice of Pre-AIA or AIA Status

The present application is being examined under the pre-AIA first to invent provisions.

Claim Rejections - 35 USC § 103

In the event the determination of the status of the application as subject to AIA 35 U.S.C. 102 and 103 (or as subject to pre-AIA 35 U.S.C. 102 and 103) is incorrect, any correction of the statutory basis for the rejection will not be considered a new ground of rejection if the prior art relied upon, and the rationale supporting the rejection, would be the same under either status.

The following is a quotation of pre-AIA 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

The factual inquiries set forth in *Graham v. John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under pre-AIA 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.

2. Ascertaining the differences between the prior art and the claims at issue.

3. Resolving the level of ordinary skill in the pertinent art.

4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

This application currently names joint inventors. In considering patentability of the claims under pre-AIA 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of pre-AIA 35 U.S.C. 103(c) and potential pre-AIA 35 U.S.C. 102(e), (f) or (g) prior art under pre-AIA 35 U.S.C. 103(a).

Claims 2-19 is/are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Felsvang et al. US 5,435,980 in view of Nelson Jr. US 2004/0003716.

For claim 2, the Felsvang et al. reference discloses a method of separating mercury from a mercury-containing gas, the method comprising: combusting coal in a combustion chamber (column 5, lines 23-25), to provide the mercury-containing gas, wherein the mercury-containing gas comprises a halogen or halide promoter (column 5, lines 60-65 and column 4, lines 42-45) injecting a sorbent material comprising activated carbon into the mercury-containing gas downstream of the combustion chamber (column 6, lines 11-14 and column 6, lines 24-26) such that the activated carbon reacts with the halogen or halide promoter in the mercury-containing gas to form a promoted sorbent (column 3, line 66-column 4, line 3, the interaction between the activated carbon and chloride component would inherently react to form the promoted sorbent); reacting mercury in the mercury-containing gas with the promoted sorbent, to form a mercury/sorbent composition (column 6, lines 20-23); separating the mercury/sorbent composition from the mercury-containing gas, to form a cleaned gas (column 5, lines 45-50); monitoring the mercury content of the cleaned gas; and controlling, in response to the monitored mercury content of the cleaned gas, an injection rate of injecting the sorbent into the mercury-containing gas, the sorbent composition, or a combination thereof, so that the mercury content of the cleaned gas is maintained at or below a desired level (column 6, lines 42-47). The reference does not disclose the halogen or halide promoter comprising HBr, Br^-, or a combination thereof.

The Nelson reference discloses the halogen or halide promoter comprising HBr, Br^-, or a combination thereof can be used to promote activated carbon (Nelson paragraphs [0017] and [0041]).

It would have been obvious to one having ordinary skill before the invention was made to have modified the Felsvang et al. reference to either replace the Cl with or include in addition to the halogen or halide promoter comprising HBr, Br^-, or a combination thereof to promote activated carbon (Nelson paragraphs [0017] and [0041]) so as to provide an effective carbon sorbent for mercury.

For claims 3 and 4, the Felsvang et al. reference discloses the method comprises removing greater than 70 wt% of the mercury in the mercury-containing gas (examples 1, 3 and 4), while the reference does not explicitly state the method comprises removing greater than 70 wt% of the mercury in the mercury-containing gas on the sorbent the reference only removes particulate (column 5, lies 50-55) so it would be apparent to one having ordinary skill in the art that the particulate would include the activated carbon reacted with the chloride having absorbed mercury (column 6, lines 26-28). Further claims 93 and 94 detail the result of the method steps. As the method steps are shown above, the result of performing said method steps of the reference would be similar or the same as that of the claimed results.

For claim 5, the Felsvang et al. reference does not explicitly state the promoted sorbent comprises about 1 g to about 30 g of the halogen or halide promoter per 100 g of the sorbent material. The reference does disclose optimizing the amount of Cl introduced (column 6, lines 42-46).

The Nelson reference discloses optimizing the amount so as to obtain a desired mercury reactivity (paragraph 0054]).

It would have been obvious to one having ordinary skill in the art before the invention was made to have modified the Felvang et al. reference to include the promoted sorbent comprises about 1 g to about 30 g of the halogen or halide promoter per 100 g of the sorbent material so as to adjust the about of halogen introduced based on the Hg content and to ensure optimum reaction between the halogen and the activated carbon (Nelson paragraph [0054]). Further the courts have held that where the general conditions of a claim are disclosed in the prior art, discovering the optimum or workable ranges involves only routine skill in the art. *In re Aller,* 105 USPQ 233.

For claim 6, the Felsvang et al. reference discloses the combustion chamber comprises the halogen or halide promoter (column 4, lines 42-44 and column 6, lines 29-34).

For claims 7 and 22, the Felsvang et al. reference discloses the coal comprises added HBr, Br^-, or a combination thereof, and the coal comprises added halide sorben enhancement additive (column 4, lines 39-58 and column 3, lines 53-56).

For claim 8, the Felsvang et al. reference discloses the promoter is reacted with the sorbent in vapor form, gaseous form, liquid form, or in an organic solvent (column 3, lines 53-56 and column 4, lines 39-59).

For claim 9, the Felsvang et al. reference discloses further comprising injecting a secondary material into the mercury-containing gas downstream of the combustion chamber (column 4, lines 42-47 and column 6, lines 24-39).

For claim 10, the Felsvang et al. reference discloses the secondary material comprises a halogen, a compound derived from a halogen, a hydrohalide, a compound comprising a Group V or Group VI element and a molecular halogen, or a combination thereof (column 4, lines 42-47 and column 6, lines 24-39).

For claims 11 and 12, the Felsvang et al. reference discloses the sorbent material injected into the mercury-containing gas further comprises a non-carbon sorbent material (column 5, lines 45-49) and the non-carbon sorbent material comprises at least one of a porous felsic material, a vesicular felsic material, a porous basaltic material, a vesicular basaltic material, a clay-based compound, an alkaline compound, a calcium hydroxide compound, a sodium acetate compound, and a bicarbonate compound (column 5, lines 45-49, column 4, lines 25-28 and column 5, lines 26-32).

For claim 13, the Felsvang et al reference discloses the activated carbon comprises powdered activated carbon, granular activated carbon, or a combination thereof (column 4, lines 5-18).

For claim 14, the Felsvang et al. reference discloses the sorbent material injected into the mercury-containing gas is substantially free of halogen and halide promotion (column 6, lines 29-35).

For claim 15, the Felsvang et al. reference discloses the sorbent material is a product-promoted sorbent obtained by reaction of a base sorbent with another halogen or halide promoter (column 4, lines ,39-50 and column 6, lines 19-42).

For claim 16, the Felsvang et al. reference discloses the combustion chamber comprises a boiler (column 5, lines 33-36).

For 17, the Felsvang et al. reference discloses the mercury-containing gas is a flue gas (column 5, lines 33-36).

For claim 18, the Felsvang et al. reference does not disclose the injection of the sorbent material into the mercury-containing gas occurs upstream of an air pre-heater.

The Nelson reference discloses the injection of the sorbent material into the mercury-containing gas occurs upstream of a particulate separator or a scrubber (figure 4, objects 71, 64 and 22 and paragraph [0062]).

It would have been obvious to one having ordinary skill in the art before the invention was made to have modified the Felsvang et al. reference to include the injection of the sorbent material into the mercury-containing gas occurs upstream of a particulate separator or a scrubber (Nelson figure 4, objects 71, 64 and 22 and paragraph [0062]) so the process can be used in a plant which has "hot-side" ESP and still have effective mercury capture.

For claim 19, the Nelson Felsvang et al. reference discloses the injection of the sorbent material into the mercury-containing gas occurs upstream of a particulate separator or a scrubber (figure, objects 4, 12, 14, 1 and 2).

Double Patenting

The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on nonstatutory double patenting provided the reference application or patent either is shown to be commonly owned with the examined application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement. See MPEP § 717.02 for applications subject to examination under the first inventor to file provisions of the AIA as explained in MPEP § 2159. See MPEP §§ 706.02(l)(1) - 706.02(l)(3) for applications not subject to examination under the first inventor to file provisions of the AIA. A terminal disclaimer must be signed in compliance with 37 CFR 1.321(b).

The USPTO Internet website contains terminal disclaimer forms which may be used. Please visit www.uspto.gov/patent/patents-forms. The filing date of the application in which the form is filed determines what form (e.g., PTO/SB/25, PTO/SB/26, PTO/AIA/25, or PTO/AIA/26) should be used. A web-based eTerminal Disclaimer may be filled out completely online using web-screens. An eTerminal Disclaimer that meets all requirements is auto-processed and approved immediately upon submission.

For more information about eTerminal Disclaimers, refer to

www.uspto.gov/patents/process/file/efs/guidance/eTD-info-I.jsp.

Claims 2-19 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-30 of U.S. Patent No. US 7,435,286 ('286) in view of Felsvang et al. US 5,435,980.

The current claim set corresponds to '286 expect for the mercury containing gas comprises a halogen or halide promoter.

Felsvang et al. discloses this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the '286 reference to include the mercury containing gas comprises a halogen or halide promoter (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the chlorine content of the system so as to increase the mercury sorption capability.

Claims 2-19 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-25 of U.S. Patent No. US 8,168,147 ('147) in view of Felsvang et al. US 5,435,980.

The current claim set corresponds to '147 expect for the mercury containing gas comprises a halogen or halide promoter.

Felsvang et al. discloses this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the '147 reference to include the mercury containing gas comprises a halogen or halide promoter (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the chlorine content of the system so as to increase the mercury sorption capability.

Claims 2-19 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-60 of U.S. Patent No. US 8,512,655 ('655) in view of Felsvang et al. US 5,435,980.

The current claim set corresponds to '655 expect for the mercury containing gas comprises a halogen or halide promoter.

Felsvang et al. discloses this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the '655 reference to include the mercury containing gas comprises a halogen or halide promoter (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the chlorine content of the system so as to increase the mercury sorption capability.

Claims 2-19 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-60 of U.S. Patent No. US 8,821,819 ('819) in view of Felsvang et al. US 5,435,980.

The current claim set corresponds to '819 expect for the mercury containing gas comprises a halogen or halide promoter.

Felsvang et al. discloses this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the '819 reference to include the mercury containing gas comprises a halogen or halide promoter (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the chlorine content of the system so as to increase the mercury sorption capability.

Claims 2-19 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-33 of U.S. Patent No. US 9,757,689 ('689) in view of Felsvang et al. US 5,435,980.

The current claim set corresponds to '689 expect combusting a fossil fuel in a combustion chamber to provide a mercury-containing gas, wherein the mercury containing gas comprises a halogen or halide promoter.

Felsvang et al. discloses this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the '689 reference to include a fossil fuel in a combustion chamber to provide a mercury-containing gas, wherein the mercury containing gas comprises a halogen or halide promoter. (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the chlorine content of the system so as to increase the mercury sorption capability within a fossil fuel operation.

Claims 2-19 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-20 of U.S. Patent No. US 9,468,886 ('886) in view of Felsvang et al. US 5,435,980.

The current claim set corresponds to '886 expect for the mercury containing gas comprises a halogen or halide promoter.

Felsvang et al. discloses this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the '886 reference to include the mercury containing gas comprises a halogen or halide promoter (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the chlorine content of the system so as to increase the mercury sorption capability.

Claims 2-19 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-30 of U.S. Patent No. 8,652,235 ('235) in view of Felsvang et al. US 5,435,980.

The current claim set corresponds to '235 expect for the mercury containing gas comprises a halogen or halide promoter.

Felsvang et al. discloses this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the '235 reference to include the mercury containing gas comprises a halogen or halide promoter (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the chlorine content of the system so as to increase the mercury sorption capability.

Claims 2-19 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-16 of copending Application No. 15/295594 ('594). Although the claims at issue are not identical, they are not patentably distinct from each other because while the current claim set includes different wording it the limitations correspond to '594.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Claims 2-19 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over claims 8-20 of copending Application No. 15/589359 (‘359) in view of Felsvang et al. US 5,435,980.

The current claim set corresponds to ‘359 expect for the mercury containing gas comprises a halogen or halide promoter.

Felsvang et al. discloses this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the ‘359 reference to include the mercury containing gas comprises a halogen or halide promoter (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the chlorine content of the system so as to increase the mercury sorption capability.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Claims 2-19 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-20 of copending Application No. 15/853029 (‘029). Although the claims at issue are not identical, they are not patentably distinct from each other because while the current claim set includes different wording it the limitations correspond to ‘029.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Claims 2-19 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-20 of copending Application No. 14/712558 (‘558) Although the claims at issue are not identical, they are not patentably distinct from each other because while the current claim set includes different wording it the limitations correspond to ‘760.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Claims 2-19 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-20 of copending Application No. 15/951970 ('970). Although the claims at issue are not identical, they are not patentably distinct from each other because while the current claim set includes different wording, the limitations correspond to '970.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Claims 2-19 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over 1-20 of copending Application No. 15/382114 ('114) in view of Felsvang et al. US 5,435,980.

The current claim set corresponds to '114 expect for the mercury containing gas comprises a halogen or halide promoter.

Felsvang et al. discloses this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the '114 reference to include the mercury containing gas comprises a halogen or halide promoter (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the chlorine content of the system so as to increase the mercury sorption capability.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Claims 2-19 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over 1-20 of copending Application No. 15/853029 ('029). Although the claims at issue are not identical, they are not patentably distinct from each other because while the current claim set includes different wording it the limitations correspond to '029.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Response to Arguments

Applicant's arguments filed 12/03/2018 have been fully considered but they are not persuasive.

I. The 112 rejection of claim 7 has been overcome by the claim amendment.

II A. The applicant traverses the combination of Felsvang and Nelson combination stating that there is no motivation for a person of ordinary skill in the art to use Nelson’s bromide additives in Felsvang’s process. The applicant contends that one having ordinary skill in the art would not be motivated to replace Felsvang’s chloride-treatment with treatment by another material as the prior art does not disclose the bromide additives performing the same or better mercury-removal efficiency.

The examiner disagrees. See Fig. 14 of Nelson which shows that about 3 times the amount of chlorine treated PAC was required to achieve the same degree of mercury removal as with bromine. (paragraph [0085]). Also see the absorption rate in the table on page 8. Further as the rejection above states. Both chlorine and bromine are known within the art to treat activated carbon and therefore it would be well within the capability of one having ordinary skill in the art to *either replace the Cl with or include in addition to* the halogen or halide promoter comprising HBr, Br$^-$, or a combination thereof to promote activated carbon (Nelson paragraphs [0017] and [0041]) so as to provide an effective carbon sorbent for mercury.

The applicant contends that the Nelson reference does not disclose HBR and Br$^-$ being more effect with activated carbons than chlorides.

The examiner disagrees. The Nelson reference discloses that HBr is used to provide bromide to the system. Example 5, paragraph [0083] states that the brominated PACs were treated with HBr or Br$_2$. Figures 14 and 15 disclose that HBr treated PAC performs better than chlorine treated PAC. Further one having ordinary skill in the art would expect PAC treated with HBr or Br$_2$ would result in a very similar modified PAC as they both include bromide (see paragraph [0092] which discloses that each of the brominated PACs performed similarly). The examiner also points to paragraph [0087] of Nelson which discloses that PAC adsorption of gaseous hydrogen bromide being ten times faster than it was for chlorine.

II(B)(1). The applicant contends that the bromide pormoters are more effective for mercury removal than treating the sorbent with bromide or bromine additives outside the mercury-containing gas. The applicant further provides a graph to demonstrate these unexpected results.

These unexpected results are not commensurate with the scope of the claims. The applicant is claiming HBr and Br^- while the graph only demonstrates HBr. Further the comparisons between the prior art and that of the current invention do no demonstrate unexpected results. The applicants data is unclear as it is either HBr (as specified in the actual graph) or NaBr (as specified in the legend). Further the 18.2 data point has no labeling on what the promoter is. None of the data point include what amount is being specified, wt%, vol% etc. The results would be expected by one having ordinary skill in the art as the wt% (if we are to assume the amount specified is wt) of the amount supported on the upper most line is greater than that of the wt% on the middle trending line. Further claim 1 does not include NaBr on coal. Lastly is unclear if the results are because of the different components being reacted or because of the different method being used. In order to establish that the method being used has unexpected results the components used must be the same for both methods.

The second graph on page 12 comparing NaBr on coal to HBr treated AC and it is unclear if the results are because of the different components being reacted or because of the different method being used. In order to establish that the method being used has unexpected results the components used must be the same for both methods. To do that the graph would have to be comparing HBr in the present method to HBr is the prior art method. Further the applicant has not shown the amount of promoter supported by each (wt%) data point. Lastly claim 1 does not include NaBr on coal.

The third graph on page 13 compares HBr treated AC and NaBr on coal with AC injected into flue gas. The graph states Millgram of HBr/MMacF/1%Hg Removed. As HBr is not a part of the current application data points it is unclear how to interpret this graph. Claim 1 does not include NaBr on coal. Further is unclear if the results are because of the different components being reacted or because of the different method being used. In order to establish that the method being used has unexpected results the components used must be the same for both methods.

II(B)(2). The applicant contends that there is no way a person of ordinary skill in the art could predict from the cited references that in-flight promotion of a sorbent with bromide promoters is more effective for mercury removal.

The examiner contends that the applicant has not established that it is more effective.

II(C)(1). The applicant contends that one having ordinary skill in the art would not have predicted in-flight chloride promotion of activated carbon to be more effective for mercury removal that in-fligh chloride promotion.

The examiner disagrees. Nelson discloses that bromide is a better promoter of AC for the purpose of mercury removal as shown above. Therefore one having ordinary skill in the art would expect an inflight bromide promoted sorbent to superior to and inflight chloride promoted sorbent.

II(C)(2). The applicant argues that one having ordinary skill in the art would not predict this advantage from the cited references.

The examiner disagrees for the reasons stated above.

II(D)(2). The applicant contends that "Even if a person of ordinary skill in th art compared the mercury removal of Felsvang's activated carbons promoted with Chloride in the flue gas to activated carbond treated with HCL outside of the flue gas, they would not determine that in-flight promotion provides the same or better mercury removal properties".

This appears to be merely conjecture by the applicant as no factual evidence has been presented.

The graphs on pages 18 and 19, has NaCl compared to HCl. It is unclear if the results are because of the different components being reacted or because of the different method being used. In order to establish that the method being used has unexpected results the components used must be the same for both methods. Further the examiner points to the y-axis which has HCl which is not included in one set (NaCl) of the data points so it is unclear how the data points are being obtained.

Response to Amendment

The Declaration under 37 CFR 1.132 filed 12/03/2018 is insufficient to overcome the rejection of claims based upon pre-AIA 35 U.S.C 103(a), Felsvang et al. US 5,435,80 in view of Nelson Jr. US 2004/0003716 as set forth in the last Office action because: the facts presented are not germane to the rejection at issues and the showings are not commensurate in scope with the claims.

Sections 2-5 details the Nelson reference.

Section 6 details a bromine treated activated carbon.

Section 7 details an HCl-treated activated carbon.

Section 8-10 detail an experiment and results of combusting coal and then exposing the exhaust of the combustion to bromine activated carbon, only activated carbon and HCl treated activated carbon.

Section 11 discloses a graph comparing NaBr on coal, AC treated with 5wt% bromine gas and untreated AC.

Section 12, the declarant contends that the data provided show that NaBr added to coal prior to introduction to the furnace in the current invention provided a higher percent of mercury removal than compared to the activated carbon treated the Br_2 outside of the flue gas as in the Nelson reference.

In response this contention does not overcome the rejection of record as these unexpected results are not commensurate with the scope of the claims. The applicant is claiming HBr and Br^- while the graph only demonstrates HBr and not NaBr as asserted. The applicants data is unclear as it is either HBr (as specified in the actual graph) or NaBr (as specified in the legend). Further the 18.2 data point has no labeling on what the promoter is. None of the data point include what amount is being specified, wt%, vol% etc. Further the comparisons between the prior art and that of the current invention do no demonstrate unexpected results. The results would be expected by one having ordinary skill in the art as the wt% (if we are to assume the amount specified is wt) of the amount supported on the upper most line is greater than that of the wt% on the middle trending line. The results are not commensurate with the scope of the claim as the claims do not include NaBr on coal. Lastly is unclear if the results are because of the different components being reacted or because of the different method being used. In order to establish that the method being used has unexpected results the components used must be the same for both methods.

Section 13 details the percent mercury removal per 1 wt% HBR or HCl and Milligram of HBr/MMacf per 1@ Hg removed.

Section 14, the declarant contends that the NaBr added to coal prior to introduction to the furnace results in a significantly higher percent mercury removal than that of Nelson's activated carbon treated with HBr outside of the flue gas. The declarant further contends that NaBr added to coal prior to introduction to the furnace provided a significantly lower milligrams of HBr/MMacf per 1% mercury removal when compared to Nelsons activated carbon treated with HBr outside of the flue gas.

The examiner asserts that these results do not overcome the rejection as claimed as they are not commensurate with the scope of the claim and do not present factual evidence germane to the patentability. The first graph has HBr treated AC compared to NaCl on coal with AC injected into flue gas. It is unclear if the results are because of the different components being reacted or because of the different method being used. In order to establish that the method being used has unexpected results the components used must be the same for both methods. Further the examiner points to the y-axis which has HCl or HBr which is not included in one set (NaCl) of the data points so it is unclear how the data points are being obtained. The second graph includes Nelson's HBr treated AC compared to NaBr on coal with AC injected into flue gas. Clearly the amount of HBr (y-axis) would be lower for the NaBr as NaBr on coal with AC injected into flue gas noes not include HBr. It is unclear how the NaBr on coal with AC inject into flue gas has any amount of HBr. Lastly it is unclear if the results are because of the different components being reacted or because of the different method being used. In order to establish that the method being used has unexpected results the components used must be the same for both methods.

Section 15 details the % Hg Removal Per 1wt% HCl and Milligram of HCl/MMacf per 1% Hg Removed.

Section 16, the declarant contends that activated carbon treated with HCl outside the flue gas provided a much higher percent of mercury removal than compared to NaCl added to coal prior to introduction to the furnace. The declarant further contends that the milligrams of HCl/MMacf per 1% mercury removal versus the sorbent injection rate with NaCl added to coal prior to introduction to the furnace with injection of untreated activated carbon in the flue gas was higher than that of activated carbon treated with HCl outside the flue gas.

The examiner asserts that these results do not overcome the rejection as claimed as they are not commensurate with the scope of the claim and do not present factual evidence germane to the patentability. The graphs have NaCl compared to HCl. It is unclear if the results are because of the different components being reacted or because of the different method being used. In order to establish that the method being used has unexpected results the components used must be the same for both methods. Further the examiner points to the y-axis which has HCl which is not included in one set (NaCl) of the data points so it is unclear how the data points are being obtained.

Conclusion

Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to AMBER ROSE ORLANDO whose telephone number is (571)270-3149. The examiner can normally be reached on Monday-Thursday 7:00-5:30.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Duane Smith can be reached on (571)272-1166. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic

Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

AMBER ROSE. ORLANDO
Primary Examiner
Art Unit 1776

/AMBER R ORLANDO/
Primary Examiner, Art Unit 1776

Search Notes	**Application/Control No.** 15/978,760	**Applicant(s)/Patent Under Reexamination** Olson et al.
	Examiner AMBER R ORLANDO	**Art Unit** 1776

CPC - Searched*		
Symbol	**Date**	**Examiner**

CPC Combination Sets - Searched*		
Symbol	**Date**	**Examiner**

US Classification - Searched*			
Class	**Subclass**	**Date**	**Examiner**

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	**Date**	**Examiner**
IDS Search (EAST and DAV)	06/24/2018	AO
Inventor Search (DAV)	06/24/2018	AO
EAST searched for inflight promotion of sorbents.	06/24/2018	AO
EAST searched for inflight promotion of sorbents.	10/04/2018	AO
EAST searched for inflight promotion of sorbents.	12/19/2018	AO

Interference Search			
US Class/CPC Symbol	**US Subclass/CPC Group**	**Date**	**Examiner**

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	45	(95/134.ccls. or 95/142.ccls. or 110/345.ccls. or 423/210.ccls.) and activated carbon and promoter	US-PGPUB; USPAT	ADJ	ON	2013/09/09 09:19
S2	0	(95/134.ccls. or 95/142.ccls. or 110/345.ccls. or 423/210.ccls.) and sorben and promoter and activated carbond and mercury	US-PGPUB; USPAT	ADJ	ON	2013/09/09 09:19
S3	0	(95/134.ccls. or 95/142.ccls. or 110/345.ccls. or 423/210.ccls.) and sorbent and promoter and activated carbond and mercury	US-PGPUB; USPAT	ADJ	ON	2013/09/09 09:20
S7	73	("20020150516" | "4786483" | "5409522" | "5505766" | "6383981" | "6878358" | "20020033097" | "4530765" | "5346674" | "6080281" | "4708853" | "6027551" | "6136072" | "6258334" | "6818043" | "20060057044" | "20080207443" | "20010002387" | "3826618" | "4814152" | "4820318" | "4889698" | "5891324" | "6528030" | "20050227146" | "5419834" | "7942566" | "20080134888" | "3662523" | "3849267" | "4196173" | "4500327" | "6942840" | "20020134242" | "20030136509" | "20050147549" | "20060112823" | "20080134888" | "6471936" | "20010003116" | "20050019240" | "20060048646" | "4956162" | "5575982" | "6372187" | "6375909" | "7435286" | "7514052" | "20050074380" | "20090081092" | "5288306" | "1984164" | "4101631" | "5695726" | "6080281" | "6848374" | "20050000197" | "5300137" | "5607496" | "5672323" | "6214304" | "6953494" | "5245120" | "20070168213" | "7938571" | "20040003716" | "20040013589" | "3194629" | "3786619" | "5827352" | "20040109800" | "20070295347" | "5435980" | "6136749" | "20030206846").PN.	US-PGPUB; USPAT	ADJ	ON	2015/03/17 12:25
S8	13	"11209163"	US-PGPUB; USPAT	ADJ	ON	2015/03/17 12:28
S9	3	"11209163" and non carbon	US-PGPUB; USPAT	ADJ	ON	2015/03/17 12:28
S10	161	(B01D53/64, B01D2257/602, B01D2253/104, B01D2253/10, B01D53/10).cpc. and (halogen or halide of HBr) with sorbent	US-PGPUB; USPAT	ADJ	ON	2015/03/17 13:49
S11	0	(95/134.ccls. or 95/142.ccls. or 110/345.ccls. or 423/210.ccls.) and	US-PGPUB; USPAT	ADJ	ON	2015/03/17 13:50

		sorbent and promoter and activated carbond and mercury				
S12	116	(95/134.ccls. or 95/142.ccls. or 110/345.ccls. or 423/210.ccls.) and (halogen or halide of HBr) with sorbent	US-PGPUB; USPAT	ADJ	ON	2015/03/17 13:50
S13	172	(B01D53/64, B01D2257/602, B01D2253/104, B01D2253/10, B01D53/10).cpc. and (halogen or halide of HBr) with sorbent	US-PGPUB; USPAT	ADJ	ON	2015/08/20 22:04
S14	67	(95/134.ccls. or 95/142.ccls. or 110/345.ccls. or 423/210.ccls.) and activated carbon and promoter	US-PGPUB; USPAT	ADJ	ON	2015/08/20 22:04
S15	67	"6136749"	US-PGPUB; USPAT	ADJ	ON	2016/05/27 09:11
S16	20	"684374"	US-PGPUB; USPAT	ADJ	ON	2016/05/27 09:12
S17	1	"20040003716"	US-PGPUB; USPAT	ADJ	ON	2016/05/27 09:12
S18	68	"6848374"	US-PGPUB; USPAT	ADJ	ON	2016/05/27 09:12
S19	41	"7435286"	US-PGPUB; USPAT	ADJ	ON	2016/05/27 09:13
S20	13	"8168147"	US-PGPUB; USPAT	ADJ	ON	2016/05/27 09:13
S21	69	(95/134.ccls. or 95/142.ccls. or 110/345.ccls. or 423/210.ccls.) and activated carbon and promoter	US-PGPUB; USPAT	ADJ	ON	2016/06/07 09:06
S22	181	(B01D53/64, B01D2257/602, B01D2253/104, B01D2253/10, B01D53/10).cpc. and (halogen or halide of HBr) with sorbent	US-PGPUB; USPAT	ADJ	ON	2016/06/07 09:06
S25	28	"5266280"	US-PGPUB; USPAT	ADJ	ON	2016/06/07 13:41
S26	281	sorbent with mercury and (diameter or size) with ("30" or "40" or "50" or "60" or "70") with (sorbent or carbon)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/09/29 15:01
S27	148	sorbent with mercury and (diameter or size) with ("30" or "40" or "50" or "60" or "70") with (sorbent or carbon) and halogen	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/09/29 15:02
S28	159	sorbent with mercury and (diameter or size) with ("30" or "40" or "50" or "60" or "70") with (sorbent or carbon) and halogen$4	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/09/29 16:18
S29	206	(sorbent or activated carbon) with mercury and (diameter or size) with ("30" or "40" or "50" or "60" or "70") with (sorbent or carbon) and halogen$4 and	US-PGPUB; USPAT; USOCR; FPRS;	ADJ	ON	2016/09/29 16:22

		activated carbon	EPO; JPO; DERWENT; IBM_TDB			
S30	195	(B01D53/64, B01D2257/602, B01D2253/104, B01D2253/10, B01D53/10).cpc. and (halogen or halide of HBr) with sorbent	US-PGPUB; USPAT	ADJ	ON	2016/09/30 13:48
S33	6	"20040003719"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 10:56
S34	49	"2004003716"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 10:57
S35	81	"6848374"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 10:58
S36	56	"7435286"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:02
S37	7	olson.in. and ("40" microns).clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:04
S38	0	("40" microns and halocarbon sorbent).clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:05
S39	0	(halocarbon sorbent).clm. and "40" microns and olson.in.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:05
S40	65	"40" microns and olson.in.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO;	ADJ	ON	2016/11/16 11:06

			DERWENT; IBM_TDB			
S41	3907	("40" microns).clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:06
S42	29	("40" microns and sorbent).clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:06
S43	1	(halocarbon sorbent).clm. and olson.in.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:08
S44	36	(sorbent).clm. and olson.in.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:08
S45	0	(sorbent).clm. and olson.in. and "40" micron	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:08
S46	17	"11209163"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:09
S47	2	"20110233133"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:27
S48	7	"20110023427"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:28
S49	15	"2004025274"	US-PGPUB; USPAT; USOCR;	ADJ	ON	2016/11/16 11:32

			FPRS; EPO; JPO; DERWENT; IBM_TDB			
S50	11	"20040025274"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:32
S51	15	"2004025274"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:33
S52	40	"6312489"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 11:33
S53	30	("20030024872" | "20050045553" | "20050144916" | "4008060" | "4640779" | "4655921" | "4673503" | "4738778" | "4746432" | "4799944" | "5043000" | "5051118" | "5120296" | "5174896" | "5320657" | "5512075" | "5674302" | "6152979" | "6312489" | "6315130" | "6336946" | "6398836" | "6585793" | "6598749" | "7648546").PN. OR ("7931723").URPN.	US-PGPUB; USPAT; USOCR	ADJ	ON	2016/11/16 11:36
S54	33	("4200444" | "4640779" | "5968215" | "6059851").PN. OR ("6312489").URPN.	US-PGPUB; USPAT; USOCR	ADJ	ON	2016/11/16 11:40
S55	5	"8518142"	US-PGPUB; USPAT; USOCR	ADJ	ON	2016/11/16 11:54
S56	4	"8747505"	US-PGPUB; USPAT; USOCR	ADJ	ON	2016/11/16 11:57
S57	2	"14318270"	US-PGPUB; USPAT; USOCR	ADJ	ON	2016/11/16 12:06
S58	13	pac with size with sorbent	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2016/11/16 12:13
S59	197	(B01D53/64, B01D2257/602, B01D2253/104, B01D2253/10, B01D53/10).cpc. and (halogen or halide of HBr) with sorbent	US-PGPUB; USPAT	ADJ	ON	2016/11/16 15:23
S60	0	(B01D53/64, B01D2257/602, B01D2253/104, B01D2253/10,	US-PGPUB; USPAT	ADJ	ON	2016/11/17 12:39

		B01D53/10).cpc. and (halogen or halide of HBr) with sorbent "4198388"				
S61	10	"4198388"	US-PGPUB; USPAT	ADJ	ON	2016/11/17 12:39
S62	0	"2010083696"	US-PGPUB; USPAT	ADJ	ON	2016/11/17 13:32
S63	2	"20100083696"	US-PGPUB; USPAT	ADJ	ON	2016/11/17 13:32
S64	2	absorp$5 with mea with methanol with acid	US-PGPUB; USPAT	ADJ	ON	2016/11/17 13:36
S65	2	"20070283813"	US-PGPUB; USPAT	ADJ	ON	2016/11/17 13:39
S66	21	"4469596"	US-PGPUB; USPAT	ADJ	ON	2016/11/21 08:29
S67	4	"2003229245"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2017/05/10 10:36
S68	2	"20030229245"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2017/05/10 10:36
S69	45	"5,338,458"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2017/05/10 10:38
S70	45	"5338458"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2017/05/10 10:38
S71	213	(B01D53/64, B01D2257/602, B01D2253/104, B01D2253/10, B01D53/10).cpc. and (halogen or halide of HBr) with sorbent	US-PGPUB; USPAT	ADJ	ON	2017/05/10 11:02
S72	64	("1786483" | "1984164" | "2317857" | "20010002387" | "20010003116" | "20020134242" | "20020150516" | "20030136509" | "20040003716" | "20040013589" | "20050019240" | "20060048646" | "20060191835" | "20090062119" | "20100047146" | "20120183458" | "20140056787" | "3194629" | "3662523" | "3786619" | "3826618" | "3849267" | "4196173" | "4500327" | "4814152" | "4820318" | "4889698" | "4959162" | "5300137" | "5409522" | "5462908" | "5505766" | "5575982" | "5607496" | "5672323" |	US-PGPUB; USPAT	ADJ	ON	2017/05/10 11:20

		"5695726" | "5827352" | "5891324" | "6027551" | "6080281" | "6136072" | "6136749" | "6214304" | "6258334" | "6372187" | "6375909" | "6383981" | "6471936" | "6528030" | "6818043" | "6848374" | "6878358" | "6942840" | "6953494" | "7101631" | "7435286" | "7479263" | "7514052" | "7563311" | "7611564" | "8007749" | "8168147" | "8168149" | "8512655").PN.				
S73	3	("20090235848" | "20110076210" | "20150246315").PN.	US-PGPUB; USPAT	ADJ	ON	2017/05/10 11:31
S79	3	("20090235848" | "20110076210" | "20140224121").PN.	US-PGPUB; USPAT	ADJ	ON	2017/06/27 09:36
S80	96	("1984164" | "2317857" | "20010002387" | "20010003116" | "20020043496" | "20020134242" | "20020150516" | "20030104937" | "20030136509" | "20040003716" | "20040013589" | "20040076570" | "20050019240" | "20060048646" | "20060191835" | "20080182747" | "20080292512" | "20090062119" | "20090136401" | "20090320678" | "20100047146" | "20110168018" | "20120183458" | "20130280156" | "20140056787" | "20140255279" | "20140308188" | "20150098878" | "3194629" | "3662523" | "3786619" | "3826618" | "3849267" | "3876393" | "4094777" | "4101631" | "4196173" | "4338896" | "4500327" | "4708853" | "4786483" | "4814152" | "4820318" | "4889698" | "4956162" | "5300137" | "5336835" | "5409522" | "5462908" | "5505766" | "5575982" | "5607496" | "5672323" | "5695726" | "5827352" | "5891324" | "6027551" | "6080281" | "6136072" | "6136749" | "6214304" | "6258334" | "6372187" | "6375909" | "6383981" | "6471936" | "6528030" | "6638485" | "6808692" | "6818043" | "6848374" | "6878358" | "6942840" | "6953494" | "6960329" | "7081434" | "7211707" | "7435286" | "7479263" | "7514052" | "7521032" | "7544338" | "7563311" | "7611564" | "7622092" | "7722843" | "7767174" | "7780765" | "8007749" | "8168147" | "8168149" | "8216535" | "8512655" | "8652235" | "8821819" | "9011805").PN.	US-PGPUB; USPAT	ADJ	ON	2017/06/27 09:41
S81	593	honeycomb with plug$4 and plug$4 with length	US-PGPUB; USPAT	ADJ	ON	2017/06/27 14:45
S82	0	honeycomb with plug$4 and plug$4 with length with less than with "5"	US-PGPUB; USPAT	ADJ	ON	2017/06/27 14:45
S83	0	honeycomb with plug$4 and plug$4 with length with less than	US-PGPUB; USPAT	ADJ	ON	2017/06/27 14:45
S84	127	honeycomb with plug$4 and plug$4 with length with "5"	US-PGPUB; USPAT	ADJ	ON	2017/06/27 14:46
S85	241	honeycomb with plug$4 and plug$4 with length with mm	US-PGPUB; USPAT	ADJ	ON	2017/06/27 14:47
S86	41	honeycomb with plug$4 and plug$4 with	US-PGPUB;	ADJ	ON	2017/06/27

		length with "3 mm "	USPAT			14:49
S87	28	honeycomb with plug$4 and plug$4 with length with "3 mm " and plug$4 with porosity	US-PGPUB; USPAT	ADJ	ON	2017/06/27 14:52
S88	28	honeycomb and plug$4 with length with "3 mm " and plug$4 with porosity	US-PGPUB; USPAT	ADJ	ON	2017/06/27 14:53
S89	43	honeycomb and plug$4 with porosity with "100"	US-PGPUB; USPAT	ADJ	ON	2017/06/27 15:06
S90	20	honeycomb and plug$4 with pore (size or diameter) with "100"	US-PGPUB; USPAT	ADJ	ON	2017/06/27 15:07
S91	8	saw with honeycomb with filter	US-PGPUB; USPAT	ADJ	ON	2017/06/29 13:31
S92	230	(B01D53/64, B01D2257/602, B01D2253/104, B01D2253/10, B01D53/10).cpc. and (halogen or halide of HBr) with sorbent	US-PGPUB; USPAT	ADJ	ON	2017/12/01 14:36
S93	2	"20060260468"	US-PGPUB; USPAT	ADJ	ON	2018/07/03 10:34
S94	19	engine with air with inlet with filter$4 with cone	US-PGPUB; USPAT	ADJ	ON	2018/07/03 15:26
S95	36	engine with air with inlet with filter$4 with (cone or conical or (diameter with (increas$4 or decreas$4)))	US-PGPUB; USPAT	ADJ	ON	2018/07/03 15:27
S96	24	("3771638" | "3870495" | "3872012" | "4157902" | "4702754" | "5125940" | "5522909" | "5549724" | "5632793").PN. OR ("5888260").URPN.	US-PGPUB; USPAT; USOCR	ADJ	ON	2018/07/03 15:31
S97	41	("0153535" | "0439091" | "1398685" | "1530163" | "1887052" | "2087688" | "4003836" | "4018580" | "4032455" | "4039308" | "4065276" | "4261710" | "4410341" | "4414110" | "4699715" | "5106397" | "5178656" | "5522909" | "5549722" | "5549724" | "5888260" | "6397842" | "6508052" | "D401597" | "D401942" | "D403414" | "D403416").PN. OR ("6808552").URPN.	US-PGPUB; USPAT; USOCR	ADJ	ON	2018/07/03 15:31
S98	15	("D403416").URPN.	USPAT	ADJ	ON	2018/07/03 15:33
S99	0	"20030089233"	USPAT	ADJ	ON	2018/07/04 12:29
S100	3	"20030089233"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/07/04 12:29
S101	26	"6833023"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/07/04 12:29
S102	2	"20070168213"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/07/09 13:08
S103	14	carbocations with sorbent with bromine	US-PGPUB; USPAT;	ADJ	ON	2018/07/09 13:14

			USOCR; FPRS; EPO; JPO			
S104	0	a side forming a cross sectional shape of each of the first	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/07/09 13:47
S105	0	non of side forming	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/07/09 13:56
S106	0	none of side forming	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/07/09 13:56
S107	0	none of sides forming	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/07/09 13:56
S109	13	olson.in. and (alkali and promoter and earth).clm.	US-PGPUB; USPAT	ADJ	ON	2018/07/17 16:22
S110	0	olson.in. and (alkali and promoter and earth with vapor).clm.	US-PGPUB; USPAT	ADJ	ON	2018/07/17 16:22
S111	10	olson.in. and (alkali and promoter with vapor).clm.	US-PGPUB; USPAT	ADJ	ON	2018/07/17 16:22
S112	0	"2015008283"	US-PGPUB; USPAT	ADJ	ON	2018/07/23 06:26
S113	2	"20150082833"	US-PGPUB; USPAT	ADJ	ON	2018/07/23 06:26
S114	24	olson.in. and liquid.clm. and promoted	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/07/23 07:50
S115	75	remov$4 with mercury and (br or bromine) with liquid with carbon	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/07/23 07:54
S116	0	separating greater than "70" wt% of the mercury	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/07/23 09:17
S117	0	((separating greater) with (of the mercury)).clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/07/23 09:17
S118	20	"11209163"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/07/23 09:43

S119	40	(during with after with mercury with sorbent)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/01 17:38
S120	304	sorbent with mercury and sorbent with boiler	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/01 17:39
S121	2	"20070168213"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/01 17:41
S122	18	before with burn$4 with coal with sorbent	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/01 17:42
S123	204	("0174348" | "0202092" | "0208011" | "0224649" | "0229159" | "0298727" | "0346765" | "0347078" | "0367014" | "0537926" | "0537998" | "0541025" | "0625754" | "0647622" | "0685719" | "0688782" | "0700888" | "0744908" | "0846338" | "0894110" | "0896876" | "0911960" | "0945331" | "0945846" | "1112547" | "1167471" | "1167472" | "1183445" | "1788466" | "1984164" | "20020065581" | "20020114749" | "20020184817" | "20030088370" | "20030103882" | "20040003716" | "20040013589" | "20040086439" | "20040219083" | "20050039598" | "20060047526" | "20060210463" | "2016821" | "2059388" | "2089599" | "2511288" | "3194629" | "3288576" | "3437476" | "3599610" | "3662523" | "3725530" | "3764496" | "3823676" | "3838190" | "3849267" | "3849537" | "3956458" | "3961020" | "3974254" | "4040802" | "4075282" | "4094777" | "4101631" | "4115518" | "4148613" | "4174373" | "4196173" | "4226601" | "4233274" | "4272250" | "4280817" | "4305726" | "4322218" | "4377599" | "4387653" | "4394354" | "4440100" | "4472278" | "4474896" | "4519807" | "4519995" | "4555392" | "4582936" | "4602918" | "4629721" | "4693731" | "4716137" | "4741278" | "4758418" | "4764219" | "4786483" | "4804521" | "4807542" | "4824441" | "4830829" | "4873930" | "4886519" | "4892567" | "4915818" | "4933158" | "4936047" | "4964889" | "5013358" | "5024171" | "5049163" | "5116793" | "5126300" | "5137854" | "5162598" | "5190566" | "5238488" | "5350728" | "5368617" | "5409522" | "5435980" | "5447703" | "5460643" | "5505746" | "5505766" | "5571490").PN. OR ("5587003" |	US-PGPUB; USPAT; USOCR	ADJ	ON	2018/10/01 17:42

		"5618508" | "5635150" | "5659100" | "5670122" | "5733516" | "5738834" | "5787823" | "5810910" | "5897688" | "5910292" | "5989506" | "6024931" | "6083289" | "6240859" | "6258334" | "6372187" | "6375909" | "6475451" | "6521021" | "6528030" | "6533842" | "6558454" | "6610263" | "6613110" | "6719828" | "6732055" | "6737031" | "6746531" | "6790420" | "6808692" | "6848374" | "6878358" | "6942840" | "6953494" | "6962617" | "6974564" | "6975975" | "7468170" | "7507083" | "7674442" | "7758827" | "7776301").PN.				
S124	1	"15573128"	US-PGPUB; USPAT; USOCR	ADJ	ON	2018/10/02 12:07
S125	2	"20110207597"	US-PGPUB; USPAT; USOCR	ADJ	ON	2018/10/02 12:08
S126	2	"20070168213"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/02 17:30
S127	71	sorbent with before with coal and remov$4 with mercury	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/02 17:30
S128	234	"6953494"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/02 17:38
S129	121	"5435980"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/02 17:40
S130	35	promoter with sorbent and "30" g	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/02 22:19
S131	28	promoter with sorbent with mercury and "30" g	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/02 22:19
S132	4	promoter with sorbent with mercury and ("30" g).clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/02 22:20
S133	4	promot$4 with sorbent with mercury and ("30" g).clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/02 22:23

S134	4	promot$4 with sorbent with mercury and pre.clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/02 22:41
S135	2	promot$4 with sorbent with mercury and pre-heater	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/02 22:42
S136	2	promot$4 with sorbent with mercury and pre heater	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 08:36
S137	57	promot$4 with sorbent with mercury and pre	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 08:36
S138	24	sorbent with preheat$4 with coal	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 08:39
S139	121	"5435980"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 08:47
S140	23	"11209163"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 11:28
S141	5	"14102896"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 11:48
S142	7	"12429058"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 12:09
S143	4	"12202595"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 12:23
S144	20	"12201595"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 12:24
S145	3	"14564860"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 12:27

S146	1	"15978760"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 12:28
S147	1	"15589359"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 12:32
S148	1	"15853029"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 12:37
S149	8	"15997091"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 12:42
S150	6	"14712558"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 12:42
S151	2	"15951970"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 15:18
S152	4	"15382114"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 15:47
S153	1	"15853029"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 15:51
S154	2	"20070168213"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 18:18
S155	69	"4279873"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/03 18:42
S156	75	"7435286"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/04 07:59
S157	4	"15295594"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/04 08:08

S158	1	("20180257030").PN.	US-PGPUB; USPAT	ADJ	ON	2018/10/04 09:31
S159	86	"5569436"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/04 09:32
S160	6	"5785935"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/04 09:33
S161	8	"6475471"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/04 09:33
S162	53	"6103205"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/04 11:46
S163	0	pyrolysis with char with mercury with activated	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/04 11:49
S164	17	pyrolysis with char with mercury	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/04 11:49
S165	121	pyrolysis with char with activated carbon	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/04 11:50
S166	0	pyrolysis with char with activated carbon with mercury with sorbent	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/04 11:50
S167	43	pyrolysis with char with activated carbon and mercury with sorbent	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/04 11:50
S168	118	pyrolysis with char with tire	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/04 12:04
S169	58	pyrolysis with char with activated carbon and mercury	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/04 12:04
S170	8	"20040081724"	US-PGPUB; USPAT; USOCR;	ADJ	ON	2018/10/04 15:07

			FPRS; EPO; JPO			
S171	4	"14128179"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/04 15:10
S172	84	activat$4 carbon with boiler with coal and remov$4 with mercury	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/15 13:27
S173	88	activat$4 carbon with boiler with coal and (remov$4 or filter$4 or absorb$4 or adsorb$4) with mercury	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/15 13:27
S174	0	mercury with stabiliz$4 with sulfer dioxide	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/15 14:23
S175	75	"7435286"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/15 15:07
S176	6	"9468886"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/16 06:48
S177	17	"8821819"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/16 06:51
S178	15	"8652235"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/16 06:55
S179	93	"6136749"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/24 09:08
S180	4	"9757689"	US-PGPUB; USPAT	ADJ	ON	2018/10/24 12:37
S181	9	"8939388"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/29 09:59
S182	669	urea with inject$4 with filter$4 with exhaust	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/29 10:15

S183	2	urea with inject$4 with filter$4 with exhaust and urea with quench$4	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/29 10:16
S184	13	"3615165"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/29 10:35
S185	136	urea with quench$4 with remov$4	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/29 10:39
S186	48	urea dust with scrub$4	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/29 11:25
S187	38	"6221155"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/29 12:04
S188	6	"9468886"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/10/29 14:12
S189	773	ammonium with remov$4 with mercury	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/12/03 14:14
S190	108	ammonium with salt with remov$4 with mercury	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/12/03 14:15
S191	45	ammonium with salt with remov$4 with mercury and activated carbon	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/12/03 14:15
S192	42	"5556447"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/12/03 14:21
S193	174	"4500327"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/12/03 14:21
S194	72	"4500327" and ammonium	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/12/03 14:23

S195	3	anionic couterion	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/12/03 14:32
S196	3480	anionic counterion	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/12/03 14:32
S197	2422	anionic counterion and ammonium with salt	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/12/03 14:32
S198	9	anionic counterion and ammonium with salt and remov$4 with mercury	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/12/03 14:32
S199	52	"6960329"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/12/03 14:50
S200	4	"20040003716"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/12/06 11:23
S201	1	"45219176".FMID.	US-PGPUB; USPAT; FPRS	ADJ	ON	2018/12/06 13:32
S202	2	"20060185335"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/12/18 16:12
S203	30	plug$4 with porosity with heat capacity	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/12/18 17:04
S204	6	plug$4 with pore (size or diameter) with heat capacity	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/12/18 17:05
S205	67	plug$4 with pore (size or diameter) with thermal	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO	ADJ	ON	2018/12/18 17:06

12/19/2018 11:05:47 AM
C:\Users\amillerharris\Documents\EAST\Workspaces\12429058.wsp

Substitute for form 1449A/PTO **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** (Use as many sheets as necessary)	*Complete if Known*	
	Application Number	15/978,760
	Filing Date	May 14, 2018
	First Named Inventor	Edwin S. Olson
	Group Art Unit	1776
	Examiner Name	Amber Orlando
Sheet 1 of 1	Attorney Docket No: 4820.007US4	

US PATENT DOCUMENTS

Examiner Initial *	USP Document Number	Publication Date	Name of Patentee or Applicant of cited Document
	US-4,013,516	3/22/1977	Greenfield, Charles, et al.
	US-4,699,896	10/13/1987	Sing, Kenneth S, et al.
	US-10,130,930	11/20/2018	Olson, Edwin S
	US-20180280870A1	10/4/2018	Olson, Edwin S, et al.

FOREIGN PATENT DOCUMENTS

Examiner Initial *	Foreign Document Number	Publication Date	Name of Patentee or Applicant of cited Document	T 1

OTHER DOCUMENTS – NON PATENT LITERATURE DOCUMENTS

Examiner Initial *	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T 1
	"Application Serial No. 14/712,558, Non Final Office Action mailed 10-19-18", 26 pgs	
	"Application Serial No. 14/712,558, Non-Final Office Action mailed 10-19-18", 35 pgs	
	"Application Serial No. 15/295,594, Non Final Office Action mailed 10-23-18", 20 pgs	
	"Application Serial No. 15/589,359, Non Final Office Action mailed 10-22-18", 12 pgs	
	"Application Serial No. 15/974,343, Non Final Office Action mailed 10-29-18", 22 pgs	
	"Application Serial No. 15/997,091, Non Final Office Action mailed 11-02-18", 27 pgs	
	"European Application Serial No. 14711106.6, Response filed 10-15-18 to Office Action mailed 06-05-18", w/ English Claims, 15 pgs	
	PIETRZAK, et al., "Preparation of nitrogen-enriched activated carbons from brown coal", Energy and Fuels 20.3, (2006), 1275-1280	

EXAMINER /AMBER R ORLANDO/ DATE CONSIDERED 12/19/2018

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant is to place a check mark here if English language Translation is attached

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.R.O/

Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Complete if Known

Application Number	15/978,760
Filing Date	May 14, 2018
First Named Inventor	Edwin S. Olson
Group Art Unit	1776
Examiner Name	Amber Orlando

Sheet 1 of 1

Attorney Docket No: 4820.007US4

US PATENT DOCUMENTS

Examiner Initial *	USP Document Number	Publication Date	Name of Patentee or Applicant of cited Document

FOREIGN PATENT DOCUMENTS

Examiner Initial *	Foreign Document Number	Publication Date	Name of Patentee or Applicant of cited Document	T 1

OTHER DOCUMENTS – NON PATENT LITERATURE DOCUMENTS

Examiner Initial *	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T 1
	"Canadian Application Serial No. 2,904,039, Office Action mailed 02-18-19", 6 pgs	

EXAMINER **DATE CONSIDERED**

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant is to place a check mark here if English language Translation is attached

S/N 15/978,760 **PATENT**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s):	Edwin S. Olson et al.	Examiner: Amber Orlando
Serial No.:	15/978,760	Group Art Unit: 1776
Filed:	May 14, 2018	Docket: 4820.007US4
Customer No.:	21186	Confirmation No.: 6432
Title:	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY	

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT UNDER 37 C.F.R §1.97(e)(2)

MS Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

In compliance with the duty imposed by 37 C.F.R. § 1.56, and in accordance with 37 C.F.R. §§ 1.97 *et. seq*., the enclosed materials are brought to the attention of the Examiner for consideration in connection with the above-identified patent application. Applicant respectfully requests that this Information Disclosure Statement be entered and the documents listed on the attached PTO 1449 Form be considered by the Examiner and made of record. Pursuant to the provisions of MPEP 609, Applicant requests that a copy of the PTO 1449 Form, initialed as being considered by the Examiner, be returned to the Applicant with the next official communication.

Pursuant to 37 C.F.R. § 1.97(d)(1) and 37 C.F.R. § 1.97(e)(2), Applicant states that no item of information contained in the Supplemental Information Disclosure Statement was cited in any communication from a foreign patent office in a counterpart foreign application and that no item of information contained in the Supplemental Information Disclosure Statement was known to any individual designated in § 1.56(c) more than three months prior to the filing of the information disclosure statement.

Pursuant to 37 C.F.R. § 1.98(a)(2), copies of cited U.S. Patents and Published Applications, and Non-Published Applications identifiable by USPTO Serial Number, are no longer required to be provided to the Office. Applicant acknowledges the requirement to submit copies of foreign patent documents and non-patent literature in accordance with 37 C.F.R § 1.98(a)(2).

The Examiner is invited to contact the undersigned at the telephone number indicated if there are any questions regarding this communication.

Respectfully submitted,

SCHWEGMAN LUNDBERG & WOESSNER, P.A.
P.O. Box 2938
Minneapolis, MN 55402
(612) 349-9580

Date 02/26/2019 By
Nicholas P. Lanzatella
Reg. No. 63,803

NPL:jj

Substitute for form 1449A/PTO **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** (Use as many sheets as necessary)	*Complete if Known*	
	Application Number	15/978,760
	Filing Date	May 14, 2018
	First Named Inventor	Edwin S. Olson
	Group Art Unit	1776
	Examiner Name	Amber Orlando
Sheet 1 of 1	Attorney Docket No: 4820.007US4	

US PATENT DOCUMENTS

Examiner Initial *	USP Document Number	Publication Date	Name of Patentee or Applicant of cited Document
	US-20190009247A1	1/10/2019	Olson, Edwin S, et al.

FOREIGN PATENT DOCUMENTS

Examiner Initial *	Foreign Document Number	Publication Date	Name of Patentee or Applicant of cited Document	T 1

OTHER DOCUMENTS – NON PATENT LITERATURE DOCUMENTS

Examiner Initial *	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T 1
	"Application Serial No. 14/712,558, Amendment and Response filed 12-03-18 to Non Final Office Action mailed 10-19-18", 28 pgs	
	"Application Serial No. 14/712,558, Final Office Action mailed 01-11-19", 27 pgs	
	"Application Serial No. 15/382,114, Non Final Office Action mailed 12-12-18", 46 pgs	
	"Application Serial No. 15/589,359, Amendment and Response filed 01-17-19 to Non Final Office Action mailed 10-22-18", 14 pgs	
	"Application Serial No. 15/974,343, Amendment and Response filed 12-03-18 to Non Final Office Action mailed 10-29-18", 37 pgs	
	"Application Serial No. 15/974,343, Final Office Action mailed 01-14-19", 25 pgs	
	"Application Serial No. 15/997,091, Final Office Action mailed 01-11-19", 20 pgs	
	"Application Serial No. 15/997,091, Response filed 12-03-18 Non Final Office Action mailed 11-02-18", 40 pgs	

EXAMINER **DATE CONSIDERED**

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant is to place a check mark here if English language Translation is attached

Electronic Patent Application Fee Transmittal

Application Number:	15978760
Filing Date:	14-May-2018
Title of Invention:	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
First Named Inventor/Applicant Name:	Edwin S. Olson
Filer:	David L. Buck/Jamie Johnson
Attorney Docket Number:	4820.007US4

Filed as Large Entity

Filing Fees for **Utility under 35 USC 111(a)**

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
SUBMISSION- INFORMATION DISCLOSURE STMT	1806	1	240	240
	Total in USD ($)			**240**

Electronic Acknowledgement Receipt

EFS ID:	35258431
Application Number:	15978760
International Application Number:	
Confirmation Number:	6432
Title of Invention:	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
First Named Inventor/Applicant Name:	Edwin S. Olson
Customer Number:	21186
Filer:	David L. Buck/Jamie Johnson
Filer Authorized By:	David L. Buck
Attorney Docket Number:	4820.007US4
Receipt Date:	26-FEB-2019
Filing Date:	14-MAY-2018
Time Stamp:	16:54:08
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	$240
RAM confirmation Number	022719INTEFSW00004077190743
Deposit Account	
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		15978760_SIDS_02-26-2019.pdf	292660 9855231eefe4d9afb3f574e4e30615d038480d10	yes	8

Multipart Description/PDF files in .zip description

Document Description	Start	End
Miscellaneous Incoming Letter	1	1
Miscellaneous Incoming Letter	2	2
Transmittal Letter	3	4
Information Disclosure Statement (IDS) Form (SB08)	5	5
Transmittal Letter	6	7
Information Disclosure Statement (IDS) Form (SB08)	8	8

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
2	Non Patent Literature	0001_2_npl_4820001u10_foar_01112019_f.pdf	891808 6ba80c712a7452b16b3f246717479bd8f0a1d443	no	20

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
3	Non Patent Literature	0002_2_npl_4820001u10_response_f.pdf	915746 b3ee64642d401e51a12318a0f2bc112ce13b1294	no	40

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
4	Non Patent Literature	0003_2_npl_4820001us7_aarn_120318_f.pdf	645370 4b6d7a942ae0897c15729f380b130074cd567f03	no	28

Warnings:					
Information:					
5	Non Patent Literature	0004_2_npl_4820001us7_foar_01112019_f.pdf	1277410 7245c7f23fe880d8b4bd15b074dade2ff580150a	no	27
Warnings:					
Information:					
6	Non Patent Literature	0005_2_npl_4820001us9_foar_01142019_f.pdf	1164983 55992c8bd625dbd9c2066b62330af4b8c211bdef	no	25
Warnings:					
Information:					
7	Non Patent Literature	0006_2_npl_4820003ca1_oarmisc_02182019_f.pdf	557901 f71ed0936bba9662fc42eb40f897a980f3852d51	no	6
Warnings:					
Information:					
8	Non Patent Literature	0007_2_npl_4820003us2_aarn_011719_f.pdf	177621 7dce4a72bf514b7875612ee25989d8410c78a6cb	no	14
Warnings:					
Information:					
9	Non Patent Literature	0008_2_npl_4820004us1_oarn_12122018_f.pdf	1799080 16da58cb37ab75b961952e1f4865dfc0e4035c36	no	46
Warnings:					
Information:					
10	Non Patent Literature	0009_2_npl_4820_001us9_aarn_120318_f.pdf	950258 375f14e1c530af4613f51fb0f58350ddf8c2a6ef	no	37
Warnings:					
Information:					
11	Fee Worksheet (SB06)	fee-info.pdf	30655 079d33967cd69092a2fc78bf93aa32b6d938d9b2	no	2
Warnings:					
Information:					

Total Files Size (in bytes):	8703492

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s): Edwin S. Olson et al.
Title: SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY

Docket No.:	4820.007US4	Serial No.:	15/978,760
Filed:	May 14, 2018	Due Date:	N/A
Examiner:	Amber Orlando	Group Art Unit:	1776
Customer No.:	21186	Confirmation No.:	6432

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

We are transmitting herewith the following attached items (as indicated with an "X"):

X Communication Concerning Prior and Copending Applications (1 pg.)
X Supplemental Information Disclosure Statement **Pursuant to 37 C.F.R. § 1.97(d)(1) and 37 C.F.R. § 1.97(e)(1)** (2 pgs.), Form 1449 (1 pg.) Copies of Cited References (1).
X Authorization to charge Deposit Account 19-0743 in the amount of $240.00 to cover the fee for consideration of Information Disclosure Statement under 37 C.F.R. § 1.97(c).
X Supplemental Information Disclosure Statement **Pursuant to 37 C.F.R. § 1.97(d)(1) and 37 C.F.R. § 1.97(e)(2)** (2 pgs.), Form 1449 (1 pg.) Copies of Cited References (8).

If not provided for in a separate paper filed herewith, please consider this a PETITION FOR EXTENSION OF TIME for sufficient number of months to enter these papers and please charge any additional fees or credit overpayment to Deposit Account No. 19-0743. If applicable, any papers or fees supplied herewith are considered to be timely filed pursuant to 37 C.F.R. § 1.7(a), the response period falling on a Federal Holiday, Saturday or Sunday being extended to the next succeeding business day.

SCHWEGMAN LUNDBERG & WOESSNER, P.A.
Customer No.: 21186

By /Nicholas P. Lanzatella/
Nicholas P. Lanzatella
Reg. No. 63,803

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s): Edwin S. Olson et al. Examiner: Amber Orlando
Serial No.: 15/978,760 Group Art Unit: 1776
Filed: May 14, 2018 Docket: 4820.007US4
Customer No.: 21186 Confirmation No.: 6432
Title: SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY

COMMUNICATION CONCERNING PRIOR OR COPENDING APPLICATION(S)

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Pursuant to the guidance of MPEP §§ 2001.06(b) and 2004(9), Applicant would like to bring the following additional application(s) to the Examiner's attention. The identification of these applications is not intended to suggest that the subject matter claimed in any listed application is, or has been, substantially similar to any claim or claims in the present application.

Serial No./ Patent No.	Filing Date	Attorney Docket	Title
16/130,670	September 13, 2018	4820.005US2	SORBENT COMPRISING CARBON AND NITROGEN AND METHODS OF USING THE SAME

Respectfully submitted,

SCHWEGMAN LUNDBERG & WOESSNER, P.A.
P.O. Box 2938
Minneapolis, MN 55402
(612) 349-9580

Date 02/26/2019 By /Nicholas P. Lanzatella/
Nicholas P. Lanzatella
Reg. No. 63,803

S/N 15/978,760 **PATENT**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s): Edwin S. Olson et al. Examiner: Amber Orlando
Serial No.: 15/978,760 Group Art Unit: 1776
Filed: May 14, 2018 Docket: 4820.007US4
Customer No.: 21186 Confirmation No.: 6432
Title: SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT UNDER 37 C.F.R §1.97(e)(1)

MS Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

In compliance with the duty imposed by 37 C.F.R. § 1.56, and in accordance with 37 C.F.R. §§ 1.97 *et. seq.*, the enclosed materials are brought to the attention of the Examiner for consideration in connection with the above-identified patent application. Applicant respectfully requests that this Information Disclosure Statement be entered and the documents listed on the attached PTO 1449 Form be considered by the Examiner and made of record. Pursuant to the provisions of MPEP 609, Applicant requests that a copy of the PTO 1449 Form, initialed as being considered by the Examiner, be returned to the Applicant with the next official communication.

Pursuant to 37 C.F.R. § 1.97(d)(1) and 37 C.F.R. § 1.97(e)(1), Applicant states that each item of information contained in the Information Disclosure Statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the Information Disclosure Statement.

Pursuant to 37 C.F.R. § 1.97(d)(2), Applicant hereby authorizes the Commissioner to charge the fee of $240.00 as set forth in 37 C.F.R. § 1.17(p), to Deposit Account No. 19-0743. Please charge any additional fees or deficiencies, or credit any overpayment to Deposit Account No. 19-0743.

Pursuant to 37 C.F.R. § 1.98(a)(2), copies of cited U.S. Patents and Published Applications, and Non-Published Applications identifiable by USPTO Serial Number, are no longer required to be provided to the Office. Applicant acknowledges the requirement to submit copies of foreign patent documents and non-patent literature in accordance with 37 C.F.R §