UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

UNION ELECTRIC COMPANY,
Petitioner,

v.

BIRCHTECH CORPORATION,
Patent Owner.

Case: IPR2025-01323
Patent 10,589,225

DECLARATION OF RADISAV VIDIC, PH.D.

TABLE OF CONTENTS

I, Radisav Vidic, Ph.D., declare as follows:

I. INTRODUCTION AND QUALIFICATIONS

1. I have been retained by Lewis Rice LLC on behalf of Ameren Corporation and Union Electric Company to provide technical analysis and opinions relating to the unpatentability of U.S. Patent. No. 10,589,225. I am being compensated for my time in preparing this declaration at my standard hourly rate, and my compensation is not dependent upon my opinions or the outcome of the proceedings.

2. My areas of expertise include environmental engineering, application of surface science for water and air purification, adsorption, membrane separations, scaling and corrosion control in engineered systems.

3. I am the Professor and Chair of the Department of Civil and Environmental Engineering at the Swanson School of Engineering, University of Pittsburgh.

4. During my career, I have graduated 35 MS students and 17 Ph.D. students and published over 300 journal papers and conference proceedings that were cited more than 13,000 times in peer-reviewed literature (h-index 58).

5. I was awarded the 2008 Professor of the Year by the Pittsburgh section of American Society of Civil Engineers and the 2013 University Research Grand Prize for Excellence in Environmental Engineering and Science by the American

Academy of Environmental Engineers and Scientists. I was ranked among the World's Top 2% Scientists by Stanford University in 2021 and was included in Who's Who in Energy in 2013 and 2014.

6. I am a registered Professional Engineer, Board Certified Environmental Engineer and Fellow of the American Society of Civil Engineers.

7. I was one of the pioneers in developing control strategies for mercury emissions from coal-fired power plants as evidenced by my contribution to the 1999 Critical Review Discussion on "Mercury Measurement and Its Control: What We Know, Have Learned, and Need to Further Investigate" J. AWMA, Vol. 49:12, 1469-1473, 1999.

8. My primary research focus was on the use on activated carbon adsorption as a control technology, with my first research project supported by the US Department of Energy in 1994. Since then, I have had 10 research projects from a variety of funding sources (e.g., Pennsylvania Energy Development Authority, US EPA, US DOE and NSF) to study mercury behavior in coal-fired power plants, compare different adsorbents for mercury control under a variety of process conditions and develop highly efficient mercury sorbents for permanent sequestration of mercury.

9. I have authored 18 journal manuscripts in top journals in the field on these topics, 1 book chapter, published 24 conference proceedings and 4 reports,

presented my work at 14 professional conferences and gave 10 invited presentations at professional meetings and other universities (complete list is included in my attached CV). I also assisted one company with the development of their mercury monitoring program and another one with their sorbent development program.

10. I currently hold the following positions:

(a) University of Pittsburgh, Chair, Department of Civil and Environmental Engineering (2007-present).

(b) University of Pittsburgh, Professor of Chemical and Petroleum Engineering (2006-present).

(c) University of Pittsburgh, Professor of Environmental Engineering (2003-present).

11. I have previously held the following positions:

(a) Associate Professor of Environmental Engineering, University of Pittsburgh, Pittsburgh, PA (1998-2003)

(b) Visiting Scientist, Institute Chemische Technologie, Fraunhofer Gesellschaft, Karlsruhe, Germany (sabbatical leave) (1999-2000).

(c) Symposium Organizer "Mercury and Other Trace Elements in Fuel: Emissions and Control" ACS Division of Fuel Chemistry, 235th American Chemical Society National Meeting, April 6-10, 2008, New Orleans, LA.

(d) Chairman of the Mercury Control Session, AIChE Spring National Meeting, March 14-18, 1999, Houston, TX.

(e) Assistant Professor of Environmental Engineering, University of Pittsburgh, Pittsburgh, PA. (1992-1998)

(f) Research and Teaching Assistant, Department of Civil and Environmental Engineering, University of Cincinnati, Cincinnati, OH. (1990-1992)

(g) Research and Teaching Assistant, Department of Civil Engineering, University of Illinois, Urbana, IL. (1988-1989)

(h) Lecturer, Department of Civil Engineering, University of Belgrade, Serbia. (1987-1988).

12. I have received the following degrees:

(a) Doctor of Philosophy, Environmental Engineering, University of Cincinnati, 1992.

(b) Masters of Science, Environmental Engineering, University of Illinois, 1989.

(c) Bachelor of Science in Civil Engineering, University of Belgrade, 1987.

13. I am a member or Fellow of the following professional societies:

(a) Association of Environmental Engineering and Science Professors, (1992 – present).

(b) American Society of Civil Engineers (1989 – present).

(c) Water Environment Federation (1989 – present).

(d) American Institute of Chemical Engineers (1998 – present).

(e) American Chemical Society (1995 – present).

(f) Sigma XI (1992 – present).

14. More complete details regarding my qualifications can be found in my curriculum vitae attached to this Declaration.

II. MATERIALS CONSIDERED

15. In addition to my education, skill, training, and experience in the relevant fields of technology, I have reviewed the materials cited throughout this Declaration in forming the opinions expressed in this Declaration, including the following materials:

Exhibit No.	Exhibit Description
1001	United States Patent No. 10,589,225 **("'225 Patent")**
1002	Declaration of Dr. Radisav Vidic
1003	Curriculum Vitae of Dr. Radisav Vidic
1004	U.S. Patent Publication No. US 2008/0107579 (May 8, 2008) **("Downs")**
1005	U.S. Provisional Patent Application No. 60/555,353 (filed Mar. 22, 2004) **("Downs-Provisional")**
1006	Redline comparison between U.S. Patent Publication No. US 2008/0107579 (Downs, EX1004) and U.S. Provisional Patent Application No. 60/555,353 (Downs-Provisional, EX1005) using Downs-Provisional as the original version **("Downs-Redline")**
1007	U.S. Patent No. 5,827,352 (**"Altman"**)
1008	U.S. Patent Pub. No. 2004/0003716 to Nelson **(**published Jan. 8, 2004) **("Nelson")**
1009	U.S. Provisional Patent Application No. 60/377,790 (filed May 6, 2002) **("Nelson-Provisional")**
1010	Redline comparison between U.S. Patent Pub. No. 2004/0003716 (Nelson, EX1008) and U.S. Provisional Patent Application No. 60/377,790 (Nelson-Provisional, EX1009) using Nelson-Provisional as the original version **("Nelson-Redline")**
1011	US Patent Publication No. 2004/0013589 (Jan. 22, 2004) **("Vosteen")**

Exhibit No.	Exhibit Description
1012	Steve Blankinship, "A Variety of Hg Capture Solutions Are Available," Power Engineering, Vol. 113, Issue 6, (Jan. 6, 2009) **("Blankinship")**
1013	U.S. Patent No. 8,652,235 (Feb. 18, 2014) **("Olson-235")**
1014	S. Julien et al., "The Effect of Halides on Emissions from Circulating Fluidized Bed Combustion of Fossil Fuels," Fuel, 75(14):1644–1663 (1996) **("Julien")**
1015	Hawley's Condensed Chemical Dictionary, (Van Nostrand Reinhold, 13th Ed.), Definition of "Compound," 291 (1997)
1016	Hawley's Condensed Chemical Dictionary, (Van Nostrand Reinhold, 13th Ed.), Definitions of "Alkaline-Earth Metals," "Calcium Hydroxide" and "Lime, Hydrated," 33, 196, 671-672 (1997)
1017	U.S. Provisional Application No. 60/605,640 as filed with U.S. Patent and Trademark Office (USPTO) **("the Provisional")**
1018	U.S. Application No. 11/209,163 as filed with USPTO **("the '163 Application")**
1019	U.S. Application No. 12/201,595 as filed with USPTO **("the '595 Application")**
1020	U.S. Application No. 12/419,219 as filed with USPTO **("the '219 Application")**
1021	U.S. Application No. 13/427,665 as filed with USPTO **("the '665 Application")**
1022	U.S. Application No. 13/966,768 as filed with USPTO **("the '768 Application")**
1023	U.S. Application No. 14/318,270 as filed with USPTO **("the '270 Application")**
1024	File History for United States Patent No. 10,589,225 (U.S. Application No. 14/712,558)**("the '558 Application"**)
1025	Reserved
1026	Reserved
1027	Reserved

Exhibit No.	Exhibit Description
1028	Redline comparison between U.S. Application No. 11/209,163 and 12/201,595
1029	Redline comparison between U.S. Application No. 12/201,595 and 12/419,219
1030	Redline comparison between U.S. Application No. 12/419,219 and 13/427,665
1031	Redline comparison between U.S. Application No. 13/427,665 and 13/966,768
1032	Redline comparison between U.S. Application No. 13/966,768 and 14/318,270
1033	Redline comparison between U.S. Application No. 14/318,270 and 14/712,558
1034	Reserved
1035	Reserved
1036	Reserved
1037	US Patent Publication No. US 2018/0280870A1 **("Olson-870")**
1038	Institution Decision, IPR2020–00832, Patent 10,343,114 **("832 DI")**
1039	Institution Decision, IPR2020–00834, Patent 10,343,114 **("834 DI")**
1040	Oxtoby et al., PRINCIPLES OF MODERN CHEMISTRY, 4th ed (Saunders College Publishing: 1999) **("Oxtoby")**
1041	Evan J. Granite et al., "Sorbents for Mercury Removal from Flue Gas," DOE/FETC/TR–98–01, U.S. Department of Energy (Jan. 1998) **("Granite")**
1042	Babcock & Wilcox, STEAM: ITS GENERATION AND USE, 40th ed. (The Babcock & Wilcox Company: 1992) **("B&W: Steam")**
1043	U.S. EPA, AP–42: External Combustion Sources, Chapter 1: Fifth Edition, Volume I (Sep. 1998), available at https://www3.epa.gov/ttn/chief/ap42/ch01/index.html (last visited Apr 10, 2020) **("Chapter 1 of AP–42")**

Exhibit No.	Exhibit Description
1044	Thomas J. Feeley, et al., "A Review of DOE/NETL's Mercury Control Technology R&D Program for Coal-Fired Power Plants," *DOE/NETL Hg R&D Program Review* (April 2003) **("Feeley")**
1045	Clean Air Mercury Rule: Basic Information, available at https://web.archive.org/web/20050920005951/http:/www.epa.gov/mercuryrule/basic.htm **("Clean Air Mercury Rule")**
1046	EPA, "Mercury Study Report to Congress Volume VIII: An Evaluation of Mercury Control Technologies and Costs," EPA Report No. EPA–452/R–97–010 (Dec. 1997), available at https://www3.epa.gov/airtoxics/112nmerc/volume8.pdf **("EPA 1997 Mercury Study Report Vol. VIII")**
1047	Deposition Transcript of Edwin Olson (Aug. 26, 2022) (excerpted), taken in Midwest Energy Emissions Corp., et al. v. Arthur J. Gallagher & Co., et al., No. 1:19-cv-01334-CJB.
1048	Deposition Transcript of Michael Holmes (Aug. 24, 2022) (excerpted), taken in Midwest Energy Emissions Corp., et al. v. Arthur J. Gallagher & Co., et al., No. 1:19-cv-01334-CJB.
1049	U.S. Patent No. 1,984,164 to Stock et al. (issued Dec. 11, 1934) **("Stock")**
1050	B.R. Puri, *Surface Complexes on Carbons*, *in* CHEMISTRY AND PHYSICS OF CARBON 191 (Philip L. Walker, ed.) (Marcel Dekker: 1970) **("Puri")**
1051	Roop Chand Bansal, et al., ACTIVE CARBON (Marcel Dekker:1988) 482 pages **("Bansal")**
1052	Frank E. Huggins et al., "XAFS Examination of Mercury Sorption on Three Activated Carbons," *Energy & Fuels* 1999(13), p. 114–121 (1999) **("XAFS")**
1053	Charlene R. Crocker et al., "Mercury Control with the Advanced Hybrid Particulate Collector Technical Progress Report," U.S. DOE–NETL (Nov. 2003) **("Crocker")**
1054	C. Eckberg et al., "Mercury Control Evaluation of Halogen Injection into a Texas Lignite-Fired Boiler," Track A, Session A3 (Mercury – Control), Presentation A3c, EUEC: 8TH ELECTRIC UTILITIES

Exhibit No.	Exhibit Description
	ENVIRONMENTAL CONFERENCE (Tucson, Arizona: January 25, 2005) **(“Eckberg”)**
1055	US Patent Publication No. 2006/0048646 (Mar. 9, 2006) **(“Olson-646”)**
1056	Vosteen, B. W. et al.: Mercury-Related Chemistry in Waste Incineration and Thermal Process Flue Gases. Poster, Air Quality IV Conference. September 22nd – 24th, 2003, Arlington VA. **(“Vosteen poster”)**
1057	“Mercury Reduction Technology Shows Promise for Texas Lignite,” Power Engineering, Vol. 109, Issue 3, (Mar. 1, 2005)
1058	J. Bustard, S. Sjostrom, et al., “Full Scale Evaluation of Sorbent Injection for Mercury Control on Coal-Fired Power Plants,” International Conference on Air Quality III, Paper No. A5–4 (Sept. 9–12, 2002: Arlington, VA) **(“Bustard”)**
1059	Sharon Sjostrom et al., “Field Studies of Mercury Control Using Injected Sorbents,” AWMA ANNUAL MEETING, Session Ae–1b (2002) **(“Sjostrom-III”)**
1060	Proposed National Emission Standards for Hazardous Air Pollutants; and, in the Alternative, Proposed Standards of Performance for New and Existing Stationary Sources: Electric Utility Steam Generating Units, 69 Fed. Reg. 4652–4752 [Volume 69, No. 20] (Jan. 30, 2004) **(“EPA-Proposal”)**
1061	Vosteen et al., “Energy Process Engineering and Environmental Protection,” Study commissioned by the State Environmental Agency of North Rhine-Westphalia (April 22, 2004)
1062	S. Sjostrom et al., “Full Scale Evaluation of Mercury Control by Injecting Activated Carbon Upstream of a Spray Dryer and Fabric Filter,” POWER GEN CONFERENCE (Orlando, Florida: Nov. 29 – Dec. 2, 2004) **(“Sjostrom-I”)**
1063	Sjostrom, S., “Evaluation of Sorbent Injection for Mercury Control,” Report No. 41986R04 (Oct. 29, 2004)
1064	Sjostrom, S., “Evaluation of Sorbent Injection for Mercury Control,” Report No. 41986R05 (Feb. 2, 2005)

Exhibit No.	Exhibit Description
1065	Mercury Information Clearinghouse, “Quarter 6 – Mercury Control Field Demonstrations” (Apr. 2005)
1066	Sharon Sjostrom, “Full Scale Evaluations of Mercury Control Technologies with PRB Coals,” Track A, Session A3 (Mercury – Control), Presentation A3b, EUEC: 8TH ELECTRIC UTILITIES ENVIRONMENTAL CONFERENCE (Tucson, Arizona: January 25, 2005) **(“Sjostrom-II”)**
1067	Sharon Sjostrom, “Evaluation of Sorbent Injection for Mercury Control,” Report No. 41986R08 (Aug. 2, 2005)
1068	Chu, P. and Porcella, D. B. “Mercury stack emissions from U.S. electric utility power plants,” Water, Air, Soil Pollution, 80, 135-144, 1995.
1069	Meij, R. “The fate of mercury in coal-fired power plants and the influence of wet flue-gas desulfurization,” Water, Air, Soil Pollution, 56, 21, 1991.
1070	Galbreath, K.C. and Zygarlicke, C.J. “Mercury transformations in coal combustion flue gas,” Fuel Processing Technology, 65–66, 289–310, 2000.
1071	Institution Decision, IPR2020–00928, Patent 8,168,147 (“928 DI”)
1072	Senior, C.L., Sarofim, A.F., Zeng, T., Helble, J.J., and Mamani-Paco, R. “Gas-phase transformations of mercury in coal-fired power plants,” Fuel Processing Technology, 63, 197–213, 2000.
1073	Sliger, R.M., Kramlich, J.C., Marinov, N.M. “Towards the development of a chemical kinetic model for the homogeneous oxidation of mercury by chlorine species,” Fuel Processing Technology, 65–66, 423–438, 2000.
1074	Change, R and Offen, G, "Mercury Emission Control Technologies: An EPRI Synopsis," Power Engineering, Vol. 99, No. 11, pp. 51-57, 1995.
1075	Liu, W., Vidic, R.D., Brown, T.D. “Optimization of high temperature sulfur impregnation in activated carbon for permanent sequestration of mercury,” Environmental Science Technology, 34, 483-488, 2000.

Exhibit No.	Exhibit Description
1076	Liu, W., Vidic, R.D., Brown, T.D. “Impact of flue gas conditions on mercury uptake by sulfur-impregnated activated carbon,” Environmental Science Technology, 34, 154-159, 2000.
1077	Brief in Support of Plaintiff’s Motion for Transfer of Actions to the Southern District of Iowa, filed in *In re Midwest Energy Emissions Corp. Patent Litigation*, No. 4:24-md-1332 (S.D. Iowa).
1078	Granite, E.J., Pennline, H.W. and Hargis, R.A. “Novel sorbents for mercury removal from flue gas,” Industrial Engineering Chemistry Research, 39, 1020-1029, 2000.
1079	Lee, S.J., Seoa, Y-C., Jurng, J., Lee, T.J. “Removal of gas-phase elemental mercury by iodine- and chlorine-impregnated activated carbons,” Atmospheric Environment, 38, 4887–4893, 2004.
1080	U.S. Patent No. 5,435,980 (“**Felsvang**”)
1081	U.S. Patent No. 6,878,358 to Vosteen
1082	Declaration of Tracey J. Olanyk (6/2/2025), authenticating various exhibits including Blankinship EX1012
1083	Expert Report of Philip J. O’Keefe, PE Regarding Infringement (Oct. 25, 2022) (excerpted), submitted by Patent Owner in Midwest Energy Emissions Corp., et al. v. Arthur J. Gallagher & Co., et al., No. 1:19-cv-01334-CJB
1084	Buschmann, J, et al., “The KNX™ Coal Additive Technology A Simple Solution for Mercury Emissions Control,” POWER GEN CONFERENCE (Las Vegas, Nevada: Dec. 6 – Dec. 8, 2005)
1085	Vassileva, S.V., et al., “Contents, modes of occurrence and origin of chlorine and bromine in coal,” Fuel 79 (2000) 903–921.
1086	Reserved
1087	NAS-NRC COMMITTEE ON CHEMISTRY OF COAL, CHEMISTRY OF COAL UTILIZATION: SECOND SUPPLEMENTARY VOLUME (Martin A. Elliott ed., 1981) (excerpted)

Exhibit No.	Exhibit Description
1088	Excerpt from File History for United States Patent No. 10,596,517 (U.S. Application No. 15/997,091)

16. I have further considered the viewpoint of a person of ordinary skill in the art ("POSITA") as of August 2004. I provide my opinion as to the proper level of skill of a POSITA in Paragraph 33, below. I understand that Ameren and Union Electric and the Patent Owner may have a dispute as to whether the claims of the '225 Patent are entitled to a priority date of August 2004 or May 2015. Unless otherwise noted, my opinions expressed in this report remain unchanged regardless of the date used.

III. SUMMARY OF MY OPINIONS

17. After a review of the materials identified above, and relying on my education, experience, and expertise in the field of mercury oxidation/adsorption for emission reduction, it is my opinion that each of the Challenged Claims of the '225 Patent (Claims 1-2, 5-15, 17-20 and 22-29) would have been anticipated or obvious to a POSITA at the time of the invention. My conclusions are summarized in the following chart:

Ground	Claim(s)	Basis for Unpatentability
1	1-2, 5, 7-8, 11-12, 14-15, 17, 19-20, 23, 25-29	Anticipated by Downs**
2	1-2, 5-9, 11-12, 14-15, 17-20, 22-29	Obvious over Downs and Altman, or Downs, Altman and Nelson**

Ground	Claim(s)	Basis for Unpatentability
3	1-2, 5-15, 17-20, 22-29	Obvious over Vosteen and Altman, or Vosteen, Altman and Nelson
4	1-2, 5, 8, 11-12, 14–15, 17, 19-20, 22–23, 25–29	Anticipated by Blankinship**
5	1-2, 5-15, 17-20, 22-29	Obvious over Blankinship and Vosteen, or Blankinship and Olson-235

**As evidenced by Julien for claims 11-12

18. It is also my opinion that not every limitation of the Challenged Claims is disclosed in the earlier-filed applications and that the Provisional does not provide support for the Challenged Claims. As such, a POSITA would not have reasonably concluded that the inventors had possession of the inventions claimed prior to the May 14, 2015 filing date of the '225 Patent, if at all.

19. My opinions, and the bases therefore, are detailed throughout this Declaration.

20. I reserve the right to supplement my opinions as expressed in this Declaration to address any new information obtained in the course of this proceeding, or based on any new positions taken by Patent Owner.

IV. LEGAL PRINCIPLES

21. I am not a legal expert. Counsel for Petitioners has informed me of the legal principles that apply in this proceeding. I have applied these legal principles in arriving at the opinions expressed in this Declaration.

22. I understand that in an inter partes review, the petitioners—here Ameren and Union Electric—have the burden of proving that the claims of a challenged patent are unpatentable by a preponderance of the evidence. I understand that a preponderance of the evidence is evidence sufficient to show that a fact is more likely true than not true. EX1011, [0005], [0006], [0007], [0009], [0013], [0025], [0047], Example 5; EX1007, 3:41-44.

23. I also understand that the meaning of the term in a patent claim is viewed from the standpoint of a person of ordinary skill in the art or a POSITA at the time of the invention. I further understand that the factors that may be considered in determining the level of skill include: (1) the types of problems encountered in the art; (2) prior art solutions to such problems; (3) the speed with which innovations are made; (4) the sophistication of the technology; and (5) the educational level of active workers in the field. I understand that not every factor may be present in every case, and one or more of them may weigh heavier in the analysis based on the circumstances.

24. I understand that a patent claim is invalid as anticipated under 35 U.S.C. § 102 where a single prior art reference discloses each and every limitation of the claimed invention. I further understand that a prior art reference may anticipate even without explicitly disclosing each of the claim limitations, if the missing limitations are necessarily present, or inherent, in the prior art reference.

25. I understand that a patent claim is invalid under 35 U.S.C. § 103 if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art ("POSITA"). A claim may be found obvious in view of a single prior art reference or from a combination of two or more prior art references.

26. I also understand that an obviousness determination includes the consideration of various factors such as (1) the scope and content of the prior art, (2) the differences between the prior art and the challenged claims, (3) the level of ordinary skill in the pertinent art, and (4) if in evidence, the existence of secondary considerations (such as commercial success, long-felt but unresolved needs, failure of others, simultaneous invention by others, etc.) to the extent they exist and have a nexus to the claimed invention.

27. I understand that the analysis under 35 U.S.C. § 103 should be guided by practical and common-sense considerations and depends on a POSITA's background, including an assessment of the background knowledge possessed by such a POSITA. Because § 103 addresses what would have been obvious at the time of the invention, this prevents a POSITA from using hindsight in evaluating the obviousness of a claim.

28. I understand that two or more prior art references that individually disclose fewer than all elements of a patent claim may nevertheless be combined to render a patent claim obvious if the combination of the prior art collectively discloses all elements of the claim and one of ordinary skill in the art at the time would have been motivated to combine the prior art in such a way with a reasonable expectation of success.

29. I understand that a reference must qualify as "analogous art" to qualify as prior art for an obviousness analysis. I further understand that a reference is considered analogous if it is from the same field of endeavor or is reasonably pertinent to the particular problem with which the inventor is involved. A reference is reasonably pertinent if it, as a result of its subject matter, logically would have commended itself to an inventor's attention in considering his problem.

30. I further understand that the motivation to combine analysis need not seek out precise teachings directed to the specific subject matter of the challenged claim, but instead can take account of the inferences and creative steps that a person of ordinary skill in the art would employ. The combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results.

31. I am also informed that a claim may also be proven obvious by showing that it was obvious to try the combination, such as when there is a design need or

market pressure to solve a problem and there are a finite number of identified, predictable solutions. In such circumstances, a POSITA has good reason to pursue or try known options within his or her technical grasp because the result is likely the product not of innovation but of ordinary skill and common sense.

32. I also understand that independent, near-simultaneous invention by others made in a comparatively short space of time can be strong evidence of obviousness when considered in light of all of the circumstances.

V. LEVEL OF ORDINARY SKILL IN THE ART

33. As of the ‘225 Patent’s earliest claimed priority date (August 2004), a POSITA would have had at least a bachelor’s degree in chemical engineering, mechanical engineering, environmental engineering, or a related field of study. A POSITA would also have at least two years’ experience investigating, researching, or implementing pollution control in power generation plants for natural gas, coal, and/or industrial waste incineration. Among other areas, the POSITA would have been familiar with the topics discussed below in the Technology Background section.

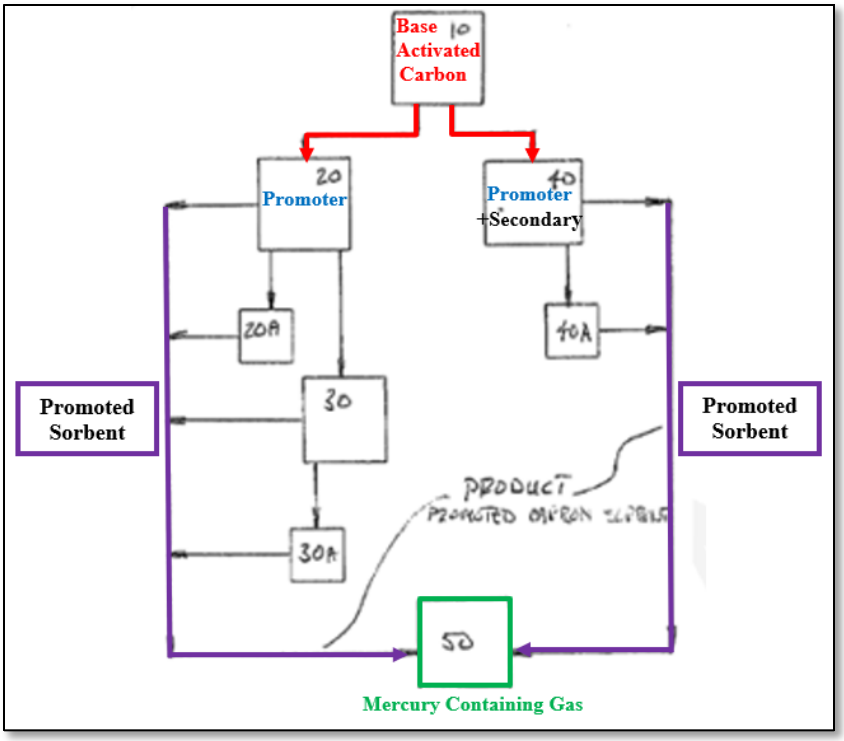
VI. THE ‘225 PATENT AND THE CHALLENGED CLAIMS

A. The ‘225 Patent

34. The ‘225 Patent is titled “Sorbents for the Oxidation and Removal of Mercury” and relates to removal of mercury from a flue gas. EX1001, 1:28–33. The

‘225 Patent acknowledges that known “mercury control methods” included “injection of fine sorbent particles into a flue gas duct” such as “activated carbon.” EX1001, 1:58–62.

35. The ‘225 Patent discloses preparing a **promoted** sorbent **outside** the mercury-containing flue gas (exhaust) as shown in the Original Version of Figure 1, below, and then injecting the promoted sorbent **into** the flue gas via a transport line **downstream** from the combustion chamber as shown in Figure 3, below. Figure 3 is thus limited to injections into flue gas, which is a gas existing post-combustion.



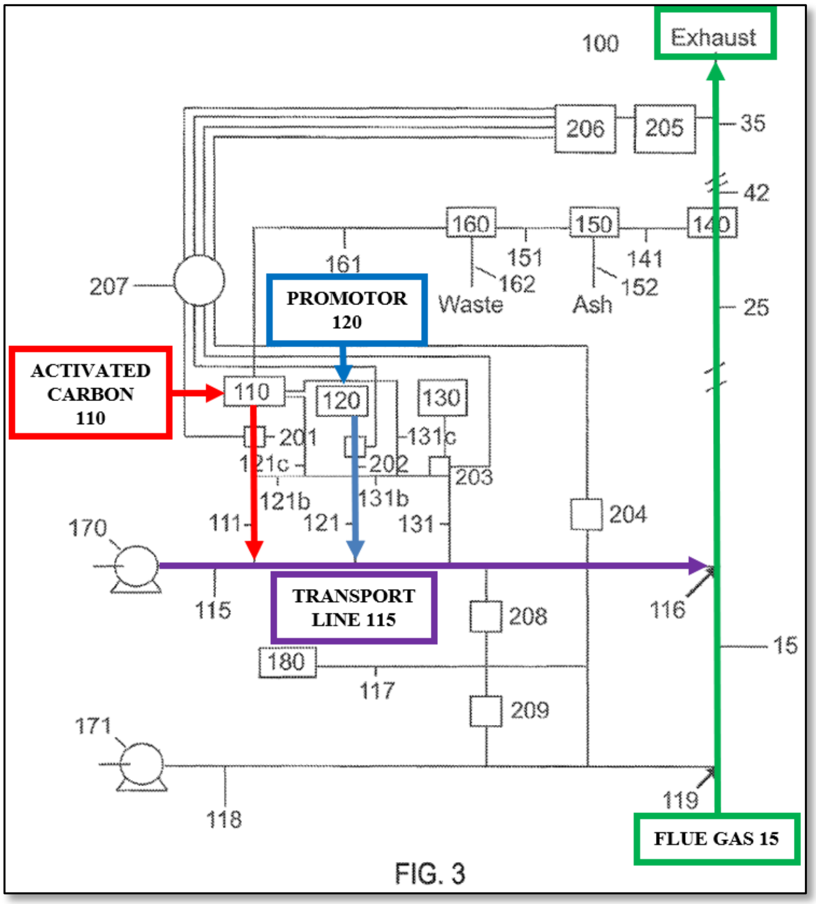


FIG. 3

EX1001, Figures 1, 3 (green, blue, purple and red annotations added).

36. Each independent Challenged claim of the ‘225 Patent requires combusting coal, pyrolysis char and an additive comprising “HBr, a bromide compound, or a combination thereof.” EX1001, Claims 1, 14, 17. There is no support for adding a promoter to the combustor or to coal added to the combustor in the application as filed or in any of its priority applications.

37. Figure 1 of the ‘225 Patent is “a block flow diagram illustrating some preferred embodiments of the process of the present invention to prepare promoted

sorbents useful for mercury capture from flue gas and/or product gas from a gasification system steams [sic, streams].” Figure 1 is reproduced below:

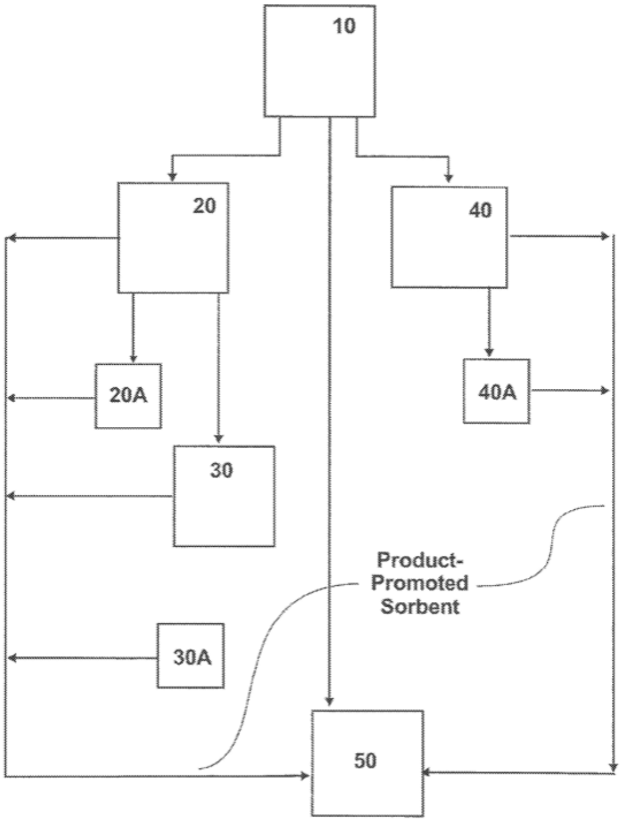


FIG. 1

38. I note that the arrow in Figure 1 directly connecting box 10 (which corresponds to base activated carbon) to box 50 (mercury-containing flue gas) was not in the version of Figure 1 in earlier filed applications to which the ‘225 Patent claims priority. Rather, the following versions appeared in earlier applications:

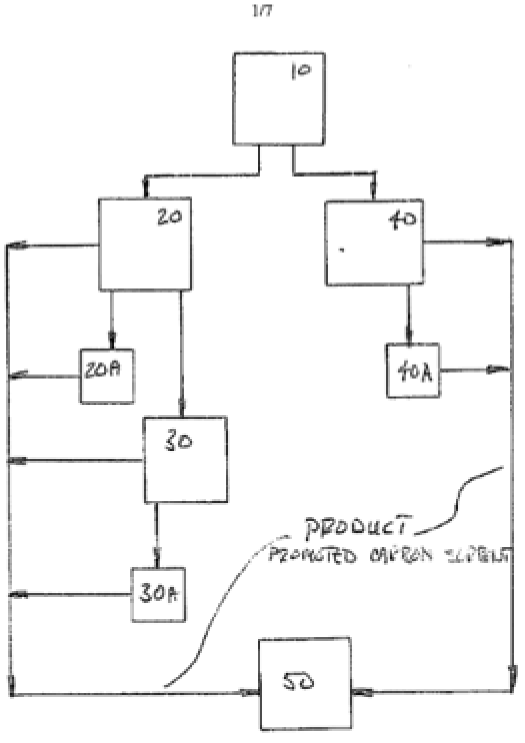
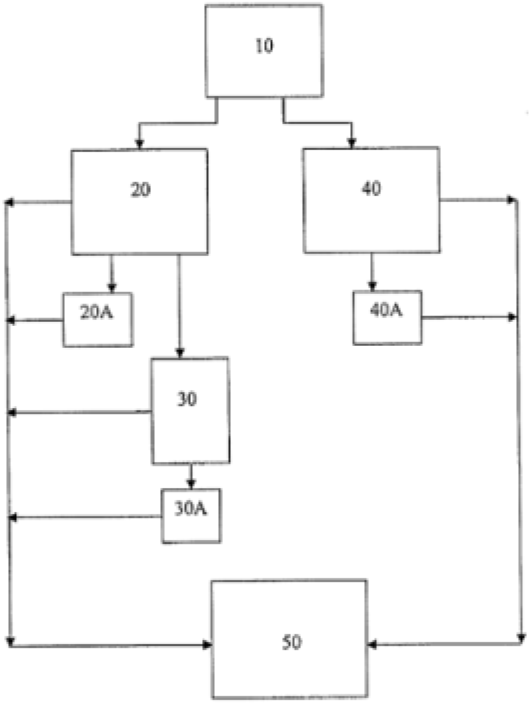


FIG. 1



'163 Application (EX1018) **'219 Application (EX1020, 8)**

39. As seen, the prior version of Figure 1 did not have an arrow pointing from the base activated carbon 10 directly to the mercury-containing flue gas 50.

B. The Challenged Claims

40. The Challenged Claims of the '225 Patent are recited in the chart below. Each limitation of the independent claims of the Challenged Claims has been identified with a number and letter designation.

Claim Element	Claim Language
1(Preamble)	1. A method for treating a mercury-containing gas, the method comprising:
1(a)	combusting a mixture comprising coal, pyrolysis char, and an additive comprising HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas; and

Claim Element	Claim Language
1(b)	adding a particulate sorbent material comprising activated carbon into the mercury-containing gas.
2	2. The method of claim 1, wherein the pyrolysis char is a promoted pyrolysis char.
5	5. The method of claim 1, further comprising using a particle separation device to remove mercury from the flue gas and comprising collecting greater than 70 wt % of the mercury in the mercury-containing gas to produce a cleaned gas.
6	6. The method of claim 5, further comprising: measuring the mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content: an injection rate of injecting the sorbent into the mercury-containing gas, an amount of the additive in the mixture, or a combination thereof.
7	7. The method of claim 1, wherein the additive further comprises Br_2.
8	8. The method of claim 1, wherein the sorbent material is chosen from powdered activated carbon, granular activated carbon, carbon black, carbon fiber, aerogel carbon, pyrolysis char, and combinations thereof.
9	9. The method of claim 1, further comprising adding an alkaline component to the mercury-containing gas, the alkaline component chosen from alkali elements, alkaline earth elements, alkali salts, alkaline earth salts, and combinations thereof.
10	10. The method of claim 1, further comprising contacting the sorbent material with a mercury-stabilizing reagent chosen from S, Se, H_2S, SO_2, H_2Se, SeO_2, CS_2, P_2S_5, and combinations thereof.
11	11. The method of claim 1, further comprising contacting the sorbent material with a secondary component chosen from

Claim Element	Claim Language
	halogens, hydrogen halides, Group V halides, Group VI halides, and combinations thereof.
12	12. The method of claim 11, wherein the secondary component is chosen from halogens, halide salts, HI, HBr, HCl, and combinations thereof.
13	13. The method of claim 11, wherein the secondary component is chosen from I_2, HI, and combinations thereof.
14(Preamble)	14. A method for treating a mercury-containing gas, the method comprising:
14(a)	combusting coal in a combustor comprising pyrolysis char and an additive comprising HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas; and
14(b)	adding a particulate sorbent material comprising activated carbon into the mercury-containing gas.
15	15. The method of claim 14, wherein the pyrolysis char is a promoted pyrolysis char.
17(Preamble)	17. A method for treating a mercury-containing gas, the method comprising:
17(a)	combusting a mixture comprising coal, pyrolysis char, and an additive comprising HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas; and
17(b)	adding a sorbent material comprising activated carbon into the mercury-containing gas.
18	18. The method of claim 1, further comprising modifying, in response to a measured mercury content, an injection rate of injecting the sorbent into the mercury-containing gas, an amount of the additive in the mixture, or a combination thereof.

Claim Element	Claim Language
19	19. The method of claim 1, wherein the coal comprises added sorbent enhancement additive that comprises the bromide compound.
20	20. The method of claim 1, wherein the coal is combusted in a combustion chamber at a coal-combustion facility, wherein the HBr, bromide compound, or combination thereof, is added to the coal before the coal enters the combustion chamber, wherein the addition of the HBr, bromide compound, or combination thereof, to the coal is performed at the coal-combustion facility.
22	22. The method of claim 1, wherein the sorbent is contacted with a halogen or halide promoter prior to the addition of the sorbent to the mercury-containing gas.
23	23. The method of claim 1, wherein the sorbent is free of contact with a halogen or halide promoter prior to the addition of the sorbent to the mercury-containing gas.
24	24. The method of claim 6, wherein the measurement of the mercury content of the mercury-containing gas comprises continuous measurement.
25	25. The method of claim 1, wherein the coal comprises subbituminous coal.
26	26. The method of claim 1, wherein the coal comprises lignite coal.
27	27. The method of claim 1, wherein the mixture is combusted in a combustion chamber of a coal-combustion facility upstream of a scrubber, a particulate control system, or a combination thereof, wherein the particulate sorbent is added to the mercury-containing gas before the mercury-containing gas encounters the scrubber, the particulate control system, or the combination thereof.
28	28. The method of claim 26, wherein the particulate control system comprises an electrostatic precipitator, a baghouse, a fabric filter, or a combination thereof.
29	29. The method of claim 19, wherein the combustion chamber is a coal combustion furnace.

VII. TECHNOLOGY BACKGROUND

A. Mercury Emissions From Coal Fired Power Plants Prior to EPA Rulemaking

41. Environmental control agencies have expressed increasing concern about the release of mercury to the environment. Two types of combustion processes that are major sources of mercury emissions are coal fired power plants (CFPPs) and municipal waste combustors. It is estimated that world-wide fossil fuel combustion produces 1,500 t of mercury annually from electricity generation and 1,210 t from other industrial uses, with CFPPs accounting for 10-15% of the total U.S. mercury emissions or about 25-50 t/yr. EX1068. The Clean Air Act Amendments of 1990 (Title III, Section 112[b][1]) required the major sources to use maximum available control technology and mandated the U.S. EPA to perform a study on the significance of mercury emissions from various sources.

B. EPA Regulations and Rulemaking

42. It was known that mercury posed health concerns. EX1046, 4–11 to 4–20. In 2000, the EPA announced plans to regulate mercury-emissions from coal-fired power plants to be proposed by December 2003 and finalized by December 2004. EX1044, 2, 7–9. The Clean Air Mercury Rule passed in 2005, requiring 70% mercury removal, after putting the industry on notice years earlier. EX1045.

The power-generation industry mobilized a massive response to develop mercury-emissions control technologies in the early 2000s. EX1044.

C. Mercury Control Technologies

43. Mercury emissions from CFPP occur in either elemental/metallic (Hg^0) or oxidized (either Hg^+ (mercurous) or Hg^{2+} (mercuric)) form. Most of the oxidized mercury forms can be removed by the existing air pollution control devices. Wet scrubbers are effective in this process because of the high solubility of oxidized mercury (EX1069) while fabric filters provide the additional contact time for oxidation and capture of mercury onto the fly ash. Mercury chlorination is the dominant mechanism responsible for the conversion of elemental mercury to its oxidized form in CFPP (EX1070). Review of ICR data on mercury capture in boiler and existing control devices indicate that the level of mercury oxidation at the exit of the boiler increased for higher coal chlorine content and lower exit temperatures. Therefore, the initial efforts in controlling mercury emissions from CFPP were focused on affecting enhanced oxidation of mercury through the addition of chlorine compounds to the combustion process. However, the kinetics of mercury oxidation by chlorine-containing species in the CFPP are kinetically limited (EX1072, EX1073) and adding these species will not be of much benefit in the field.

44. Air pollution control processes capable of controlling elemental mercury emissions include various adsorption process with activated carbon being

the prime sorbent of choice (EX1074). Activated carbon adsorption can be accomplished in two different processes: powdered activated carbon (PAC) injection and fixed-bed granular activated carbon (GAC) adsorption. PAC injection involves the injection of PAC directly into the plant's flue gas stream where it adsorbs gas-phase mercury and is collected in downstream particulate control devices, such as fabric filters or ESPs. This approach has the potential to assist about 75% of all CFPP in the U.S. that are not equipped with FGD systems. In situations in which fixed-bed GAC adsorption may be used, the adsorber should be placed downstream of the flue gas desulfurization (FGD) units and particulate collectors, serving as the final treatment process before the flue gas is discharged into the atmosphere.

D. Enhancement of Activated Carbon for Mercury Uptake

45. Even before the EPA regulations, activated-carbon sorbents were used to remove mercury by adsorption, and researchers were investigating improving their effectiveness and cost. EX1001, 1:58-62; EX1046, 2–54 to 2–57; EX1040, 1.

46. Adsorption is a process where adsorbate (e.g., mercury) in a fluid (e.g., flue gas) binds to a sorbent's surface. "Reducing" mercury in flue gas results from removing mercury by adsorbing to sorbent surface and removing the sorbent using particulate separators such as ESPs.

47. Two named inventors, Dr. Olson and Mr. Holmes, admitted that "activated carbon was the most common [or heavily] studied sorbent for mercury control." EX1047, 41:5-9; EX1048, 114:21-25.

48. Numerous studies were focused on enhancing the ability of commercial activated carbons to effectively capture mercury under the process conditions representative of CFPP by the addition of sulfur (EX1075; EX1076), iodine (EX1041, EX1078) and chlorine (EX1079) as well as other inexpensive sorbents with and without promoters (EX1041). It was also known since at least as early as 1995 that the mercury content of the flue gas from a coal-fired power plant could be monitored and that the injection rate of the sorbent could be adjusted to achieve desired levels of mercury removal. EX1080, Abstract ("By adjusting the chloride content of the flue gas **or the absorbent** a permanent high Hg removal is achieved.); 6:42-46 ("The amount of chloride introduced through 15 or 17 as well as the amount of activated carbon possibly dosed by means of 12 may be adjusted also on basis of the Hg content of the treated gas measured by means of a device 18 arranged in the duct 9.").

E. Use of Halogens and Activated Carbon as a Sorbent for Mercury Removal

49. Halogens were known as Group VII elements, which include fluorine (F), chlorine (Cl), bromine (Br), and iodine (I), and that are highly reactive oxidizing agents

that cause other species to give up electrons (become more positively charged). EX1040, 788, 791, A.44. It was known that halogens exist in nature as diatomic molecules (*e.g.*, Br_2,), halides/halide compounds (*e.g.*, NaBr, $CaBr_2$), and hydrohalides (*e.g.*, HBr).

50. By 1934, it was shown that halogens improved the ability of activated carbon to remove mercury. *See* EX1049, 1:33–41.

51. By 1970, it was known that bromine was adsorbed up to a 31–38% saturation limit (adsorption equilibrium) in carbon materials. EX1050, 260. By 1988, it was shown that bromine (Br) reacted with activated carbon to provide "carbon-bromine surface structures (surface compounds)." EX1051, 259. By 1998, "[a]ctivated carbons ha[d] been the most thoroughly studied sorbent for the capture of mercury." EX1041, 22. In 1999, researchers demonstrated that mercury from flue gas formed chemical bonds with halogen species on activated carbons. EX1052, 119.

52. It was known that halogens, particularly bromine-containing species, were effective at improving effectiveness of activated carbon in removing mercury. *See*, *e.g.*, EX1004; EX1012; EX1008; EX1066. By 2003, bromine was known to be more than 25 times more effective for metallic mercury oxidation than chlorine in coal combustion. EX1056, 3. In addition to using halides, it was also known that adjusting the sorbent injection rate would control mercury emissions. EX1058, 14; EX1059; EX1060, 4676.

53. Bromide compounds pre-combustion and activated carbon post-combustion were used at coal-fired power plants to remove mercury from flue gas at Holcomb Station in June 2004 (EX1062, 11, 15; EX1063, EX1064; EX1066), Meramec Station by September 2005 (EX1065, 17–18; EX1066, 16; EX1063; EX1064) and Laramie River by March 2005 (EX1067 , 11, 23).

54. The '225 Patent acknowledges that activated carbon, including powdered activated carbon, was known in the art:

> In some preferred embodiments, the activated carbon provided may preferably be any of several types, as understood by those skilled in the art.

EX1001, 7:32-34.

55. The '225 Patent also acknowledges that particulate separators, including electrostatic precipitators, were known in the art:

> By way of illustration and not limitation, particulate separator **140** may comprise one or more fabric filters, one or more electrostatic precipitators (hereinafter "ESP"), or other particulate removal devices as are known in the art.

EX1001, 9:7-11.

VIII. THE PRIORITY DATE OF THE '225 PATENT

56. I have been asked to review the '225 Patent, the '225 Patent file history of prosecution of the application for the '225 Patent before the U.S. Patent and Trademark Office, and the earlier filed applications to which the '225 Patent claims

priority. I have further been asked to opine on whether all of the claim limitations of the Challenged Claims are disclosed in each of those earlier filed applications.

57. I have also been asked to review the Provisional and determine whether all of the claim limitations of the Challenged Claims are disclosed in the Provisional.

58. As explained in more detail in the subsections that follow, it is my opinion that not every limitation of the Challenged Claims is disclosed in the application that issued as the ‘225 Patent or the earlier-filed applications. More specifically, limitations of the independent claims (Claims 1, 14, 17) requiring combusting coal and an additive comprising HBr, a bromide compound, or a combination thereof are not disclosed in those applications.

59. It is also my opinion that the Provisional does not disclose all of the limitations of the Challenged Claims.

A. File History of the ‘225 Patent and its Predecessors

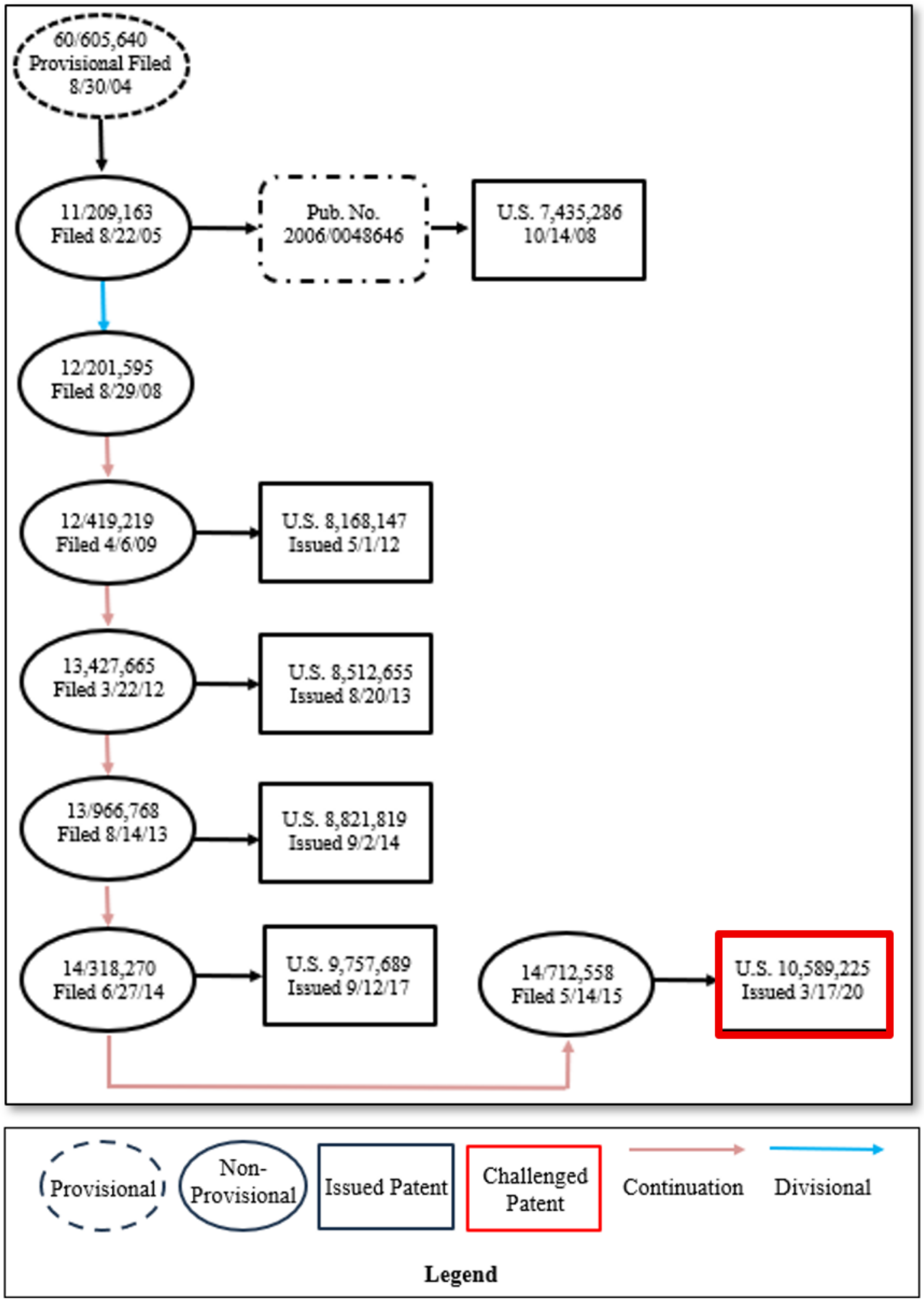
60. I understand that the application that issued as the ‘225 Patent was filed on May 14, 2015 and that the ‘225 patent purports to claim priority as follows:

- Continuation of USSN 14/318,270 (“the ‘270 Application”) filed on June 27, 2014 and issued on September 12, 2017 as U.S. Patent No. 9,757,689, which is a:
- Continuation of USSN 13/966,768 (“the ‘768 Application”) filed on August 14, 2013 and issued on September 2, 2014 as U.S. Patent No. 8,821,819, which is a:

- Continuation of USSN 13/427,665 ("the '665 Application") filed on March 22, 2012 and issued on August 20, 2013 as U.S. Patent No. 8,512,655, which is a:
- Continuation of USSN 12/419,219 ("the '219 Application") filed on April 6, 2009 and issued on May 1, 2012 as U.S. Patent No. 8,168,147, which is a:
- Continuation of USSN 12/201,595 ("the '595 Application") filed on August 29, 2008 and abandoned on September 30, 2010, which is a:
- Division of U.S. Patent Application No. 11/209,163 ("the '163 Application") filed on August 22, 2005 and issued on September 24, 2008 as U.S. Patent No. 7,435,286, which claims benefit of:
- U.S. Provisional Patent Application No. 60/605,640, filed on August 30, 2004 ("the Provisional").

EX1001, Cover Page - Related U.S. Application Data.

61. The alleged priority chain for the '225 Patent is depicted in the following image:


60/605,640
Provisional Filed
8/30/04
11/209,163
Filed 8/22/05
Pub. No.
2006/0048646
U.S. 7,435,286
10/14/08
12/201,595
Filed 8/29/08
12/419,219
Filed 4/6/09
U.S. 8,168,147
Issued 5/1/12
13,427,665
Filed 3/22/12
U.S. 8,512,655
Issued 8/20/13
13/966,768
Filed 8/14/13
U.S. 8,821,819
Issued 9/2/14
14/318,270
Filed 6/27/14
U.S. 9,757,689
Issued 9/12/17
14/712,558
Filed 5/14/15
U.S. 10,589,225
Issued 3/17/20
Provisional
Non-Provisional
Issued Patent
Challenged Patent
Continuation
Divisional
Legend

B. The ‘558 Application Does Not Disclose HBr, Bromide Compound, or a Combination Thereof as a Coal Additive

62. I have reviewed the ‘558 Application, which I understand is the application that issued as the ‘225 Patent. Each of the independent claims of the Challenged Claims of the ‘225 patent recites combusting coal, pyrolysis char and an additive. The claimed "additive" (HBr, a bromide compound, or a combination thereof) is referred to throughout the ‘225 patent as a "promoter." Thus, each of these independent claims requires the presence of the additive (HBr, a bromide compound, or a combination thereof) during coal combustion regardless of whether it is added to the coal before the coal enters the combustion chamber (as required in dependent claims 20-21) or added to the combustor (as required in dependent claim 4).

63. In the ‘558 Application, "coal" is generally described as a fossil fuel (EX1024, [0004])[1] in examples where subbituminous, lignite or pulverized coal is introduced to a combustor (EX1024, [0094], [0096], [0108]). Other references to "coal" in the ‘558 Application refer to coal combustion facilities or coal combustion flue gas (EX1024, [0004], [0068], [0107], [0116]). None of these disclosures of

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[1] References to the ‘558 Application (EX1024) in this section of my Declaration refer to the paragraph numbers of the "Specification" as filed on May 14, 2015 and included in EX1024 at AMEREN UE Exhibit pages 12-52. Page numbers greater than 52 refer to those assigned in the exhibit as filed (Ameren UE Exhibit page numbers).

"coal" in the '558 Application describe promoter compounds such as HBr, a bromide compound, or a combination thereof being added to coal or a combustor.

64. An "additive" in the '558 Application is generally described as "sorbent enhancement additives" (EX1024, [0007]), "optional additives discussed herein" (EX1024, [0042]), "additive to a treatment facility" (EX1024, [0076]) and "additive-sorbent ratios" (EX1024, [0076]). Again, none of these disclosures describe a promoter or additive being added to coal or a combustor, nor the specific addition of HBr, a bromide compound, or a combination to coal or a combustor.

65. The disclosures of "combustor," "boiler," "furnace," "chamber," "combustion facilities" or "combustion system" in the '558 Application do not describe a promoter or additive being added to coal or a combustor, nor the specific addition of HBr, a bromide compound, or a combination to coal or a combustor. EX1024, [0004], [0042], [0068], [0094], [0096], [0098]-[0099], [00111].

66. The '558 Application states that several examples are presented to "more clearly illustrate the present invention." EX1024, [0083]. Examples 1-9 generally discuss ways in which a promoted sorbent is created. In Examples 1 and 6, certain promoted sorbents were created and tested by injecting them into a mercury-containing gas. EX1024, [0084]-[0089], [0094]-[00102]. Other Example promoted sorbents were also tested using the same methodology used for Example 1. None of these Examples or test procedures involve adding the promoted sorbent

or any promoter compounds such as HBr, a bromide compound, or a combination thereof to coal or a combustor.

67. The '558 Application explains that in Example 10 (Full Scale Testing), "the halogen/halide promoted carbon sorbent was injected into the flue gas after the boiler. In general however, the inventive sorbent can be injected where desired (e.g., before, after or within the boiler.)." EX1024, [00107]. This disclosure, which is similar to the description for Figure 2 of the Provisional that I discuss below, indicates that the halogen/halide promoted sorbent was injected into the flue gas downstream from the boiler, but could be injected before or within the boiler.

68. Promoted sorbent injection before or within the boiler is not a disclosure of a promoter added to coal or a combustor. Nor is it a disclosure of adding a promoter before the boiler because, in making the promoted sorbent, the promoter reacts with the activated carbon and no longer exists in the form of HBr, a bromide compound, or a combination thereof.

69. I understand that the PO asserted in a prior IPR proceeding involving U.S. Patent No. 10,343,114 ("the '114 Patent") that paragraph [0107] in the '595 Application (the relevant portion of which reads "the inventive sorbent can be injected where desired (e.g., before, after or within the boiler)") discloses "multiple injection points" for the promoted carbon sorbents and provided support for adding a promoter to coal. EX1038, 28; EX1019, [0107]. This corresponds to the language

of Example 10 of the '558 Application as discussed above. I also understand that the Board found in its Institution Decision that "Although this describes other injection points ("e.g., before, after, or within the boiler"), this disclosure refers to promoted sorbent material. As a result, it describes the addition of both the promoter and the sorbent material at a single point, not (1) the addition of the promoter with the coal or the combustion chamber and (2) the injection of the sorbent material into mercury-containing gas downstream of the combustion chamber."[2] EX1038, 28.

70. I also understand that the Board found in its Institution Decision that the "multiple injection points" disclosure at paragraph [0056] of the '595 Application (which references Figure 3 as in the '114 Patent) referred to injection points in the flue gas stream, not multiple injection points at different points in the process, such as before combustion. EX1038, 28–29; EX1019, [0056]. *See also* EX1024, [0056], Figure 3. I agree with the Board's conclusion. A POSITA, in my opinion, would not understand the "multiple injection points" disclosure to be a disclosure of adding a promoter or additive to coal or a combustor.

71. Examples 11A and 11B involve adding an "Optional Alkaline Component." EX1024, [00109]-[00112]. In Example 11A, the optional alkaline was applied to a filter along with "brominated activated carbon." *Id.*, [00110]. In

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[2] The term "combustion chamber" is not used in the specification of the '558 Application but is synonymous with the term "combustor."

Example 11B, only an "Optional Alkaline Component" in combination with "standard activated carbon" was tested. Again, neither Example 11A nor Example 11B involved adding the promoted sorbent or any promoter compounds such as HBr, a bromide compound, or a combination thereof to coal or a combustor.

72. The final example, Example 12, involved "Brominated Carbon Sorbent for Gasification Fuel Gas." EX1024, [00113]-[00119]. No coal was used in this example.

73. In the '558 Application, the only disclosure of pyrolysis char is as a type of activated carbon sorbent. EX1024, [0047]-[0048]. As discussed above, the Board decided that the Example 10 language "describes other injection points ("e.g., before, after, or within the boiler")" for "promoted sorbent," by adding the promoted sorbent "at a single point" and not "the addition of the promoter" to "the coal or the combustion chamber." EX1038, 28. Thus, the pyrolysis char disclosures do not describe adding the promoter to coal or the combustion chamber.

74. A POSITA would have known that pyrolysis char forms during the coal combustion process and thus necessarily would be present in the combustor when coal is combusted to form the mercury-containing gas. EX1087, 673 ("pyrolysis, even under the most favorable conditions, includes the formation of … residual char"). A POSITA would have known that during coal combustion, pyrolysis char will exist for a short period of time during the initial stages of coal combustion but

should then be burned in the combustion chamber to generate heat if the combustion process is operated properly. Pyrolysis char is created during pyrolysis, which is incomplete combustion under oxygen starvation conditions. If the Patent Owner disputes that pyrolysis char is necessarily present during coal combustion, then the Challenged Claims are not entitled to an earlier priority date for the additional reason of a lack of disclosure of combusting coal, pyrolysis char and HBr, a bromide compound, or a combination thereof in the specification of the '558 Application or any of its potential priority applications.

75. The '558 Application itself indicates that the inventors did not have possession of the Challenged Claims. This is because a POSITA would understand the '558 Application as disclosing only the combustion of untreated coal.

76. The '558 Application explains that adding bromine by itself to the flue gas would not be able to sufficiently oxidize mercury to allow easy capture by activated carbon, so bromine was added to the activated carbon itself to make a promoted sorbent to add to the flue gas. The '558 Application indicates that:

- Molecular bromine (Br_2) "reaction with a hot flue gas components leave little to react with elemental mercury." EX1024, [0068].

- Elemental bromine (Br) "is about a million times more reactive to mercury" but is in such "extremely low" concentration that it will not result in mercury oxidation in flue gas. EX1024, [0068].

- A halide (e.g., a hydrohalide such as HBr) is "much less reactive" than molecular halogen (e.g., Br_2) and "do not, alone, oxidize other compounds." EX1024, [0069].

- In the Provisional, it was stated that for these reasons, "it is not obvious that a halide-halogen treated activated carbon would be effective at oxidizing elemental mercury and provide effective capture of elemental mercury." EX1017, 7. This Provisional disclosure was changed over time in the '558 Application to "[in] the conventional view therefore, a halide-salt-treated activated carbon will not effectively oxidize elemental mercury and capture elemental mercury," recharacterizing PO's rationale for nonobviousness of a promoted activated carbon sorbent as a "conventional view." EX1024, [0069].

77. A POSITA would have known that lignite or subbituminous coal contains very low amounts of bromine on the order of 1-3 ppm (median). EX1084, 1; EX1085, 905. In my opinion, a POSITA therefore would have understood the '225 Patent's disclosure of "extremely low" concentrations of elemental bromine

(Br) present in the flue gas to mean that native untreated coal is combusted in the combustion processes of the '225 Patent, not coal to which HBr, a bromide compound or a combination thereof is added.

78. A POSITA also would have known that any bromine source added to the combustion chamber would be completely converted to hydrogen bromide (HBr). EX1014, 1658. Thus, had <u>HBr, a bromide compound or a combination thereof been added to the coal before combustion, the concentration of elemental bromine (Br) would have been much higher</u>. A POSITA would not have understood the disclosures of the '225 Patent as describing the <u>addition of a promoter</u> to coal or to the combustion chamber. Instead, the named inventors described <u>addition of a promoted</u> activated carbon <u>sorbent</u>.

79. As the '225 Patent explains "adding HBr or Br_2 to the carbon forms a similar carbon bromide, in which the positive carbon oxidizes the mercury with the assistance of the bromide ion." EX1024, [0053]. This carbon bromide results from the reaction between the promoter and activated carbon when making the promoted sorbent before the promoted sorbent is injected into the flue gas. It is not a disclosure of what occurs in the combustion chamber or of adding a promoter to coal or the combustor.

80. Based on my review of the '225 Patent and the '558 Application, as well as my education, skill, training, and experience in the relevant fields of emission

reduction technology, it is my opinion that the ‘558 Application does not disclose a promoter added to coal or the combustor and thus does not disclose “combusting … coal … and an additive” as required by each of Claims 1, 14 and 17 of the ‘225 Patent for the reasons explained in Paragraphs 62-79 above.

C. The Provisional Does Not Disclose Br_2, HBr, Bromide Compound, or a Combination Thereof as a Coal Additive

81. The Provisional mentions mercury removal from “coal-fired utility or synthesis gas” (EX1017, 6), mercury within coal (EX1017, 6), coal combustion flue gas (EX1017, 7), and a facility fired with lignite coal (EX1017, 14). None of these disclosures describe promoter compounds added to coal or a combustor.

82. The Provisional disclosure includes Figure 2, which is reproduced below, showing a “coal fueled facility” burning “pulverized coal” where “additive can be injected where desired (e.g., before, after or within the boiler).” EX1017, 12, Figure 2.

83. In my opinion, the disclosure of injecting “additive” “before, after or within the boiler” is not a disclosure of additive injection to coal. For example, a POSITA in 2004 would have known that there are system components other than coal where an additive could be “injected” that would supply the additive to a boiler such as a separate feed inlet, a secondary-air system, or a low-NO_x overfire air

system. I note that nowhere in the text of the Provisional is there a disclosure of adding "additive" directly to the coal.

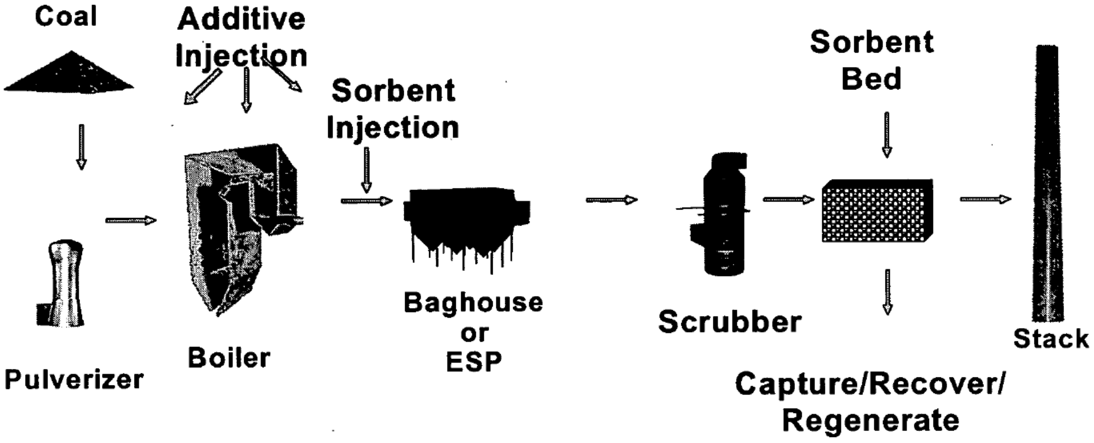


FIG. 2

84. Further, use of the word "injection" is important to how a POSITA would understand this disclosure. Applying an additive to the "coal" would not be described as "injecting" the additive. The additive is not going "into" the coal. Rather, it is "added" to the coal. This distinction is exemplified in at least Challenged Claims 6 and 18, which require modifying the "injection rate of injecting the sorbent into the mercury-containing gas" or "an amount of the additive in the mixture…." Claims 6 and 18 thus clearly distinguishes between "injecting" into the flue gas and modifying an amount of the additive.

85. Figure 2 of the Provisional and its accompanying description does not define what constitutes the "additive." Elsewhere in the Provisional is a section that

includes "an outline of examples of the invention." EX1017, 2. There are 15 such examples in the Provisional. None of these examples discloses applying HBr, a bromide compound, or a combination thereof as an "additive" to coal or the combustor.

86. Provisional Examples 1–4 disclose a modified carbon sorbent prepared by reacting carbon with a Br_2 solution, a Br_2 gas, an HBr solution or an HBr gas. EX1017, 2–3. Provisional Examples 5 and 6 further include a sulfur or selenium reagent when preparing the promoted sorbent. EX1017, 4. Example 7 treats "carbon with a Group V or VI element combined with Group VII element, such as PBr_3." EX1017, 4.

87. In sum, Provisional Examples 1-7 disclose methods of preparing a promoted sorbent by reacting a carbon sorbent with Br_2, HBr or PBr_3. None of these examples disclose applying Br_2, HBr or PBr_3 as an "additive" to coal or the combustor. These Examples do not disclose applying the promoted sorbent to coal or applying Br_2, HBr, a bromide compound, or a combination thereof to coal or the combustor.

88. The Provisional also explains that Examples 1-3 may include an "additional promoting substance" in the Br_2 solution, Br_2 gas, or HBr solution used in preparing the promoted sorbent. EX1017, 2-3. The Provisional explains that this additional promoter can be HBr. EX1017, 3.

89. This additional substance is outlined under "1E" and "same additives as 1E" without indicating what the "additive" references. The Provisional is, in my opinion, clear that this additional substance is used in preparing a promoted sorbent, not as an "additive" to coal or the combustor. Further, only HBr and not Br_2 is disclosed as an additional substance. A POSITA would know that these forms of bromine are not the same.

90. I note that my analysis and conclusion mirrors the position taken by the applicants during prosecution of the '225 Patent. EX1024, 625 ("the comparison of efficacy is only with respect to elemental bromine (Br_2) and not hydrogen bromide"). More specifically, the applicants distinguished HBr from other forms of bromine-containing compounds, such as Br_2 during prosecution of related applications, where inventor Pavlish explained that "Br_2 is not HBr and does not include HBr." EX1088, p. 7, ¶ 17 (Pavlish/Lentz 7-10-2019 Rule 132 Affidavit (dated March 2019)).

91. Provisional Example 8 describes injecting the promoted sorbents of Provisional Examples 1-6 into a contaminated gas stream. EX1017, 4. Provisional Example 9 refers to the promoted sorbents as "additives (1-8)" and describes their use with sorbents to capture acid gases, further referring to these sorbents as "additives" or "additives of base chemistry." EX1017, 4, 1. Thus, Provisional Example 9 uses the term "additive" to describe sorbents. Provisional Examples 10-15 do not use the term "additive."

92. “The additive” is not the modified carbon sorbents of the Provisional Examples 1–7 since Provisional Figure 2, above, separately depicts “sorbent injection,” and the figure description states that “[i]n the example shown, the sorbent is injected into the flue gas after the boiler.” EX1017, 12, Figure 2.

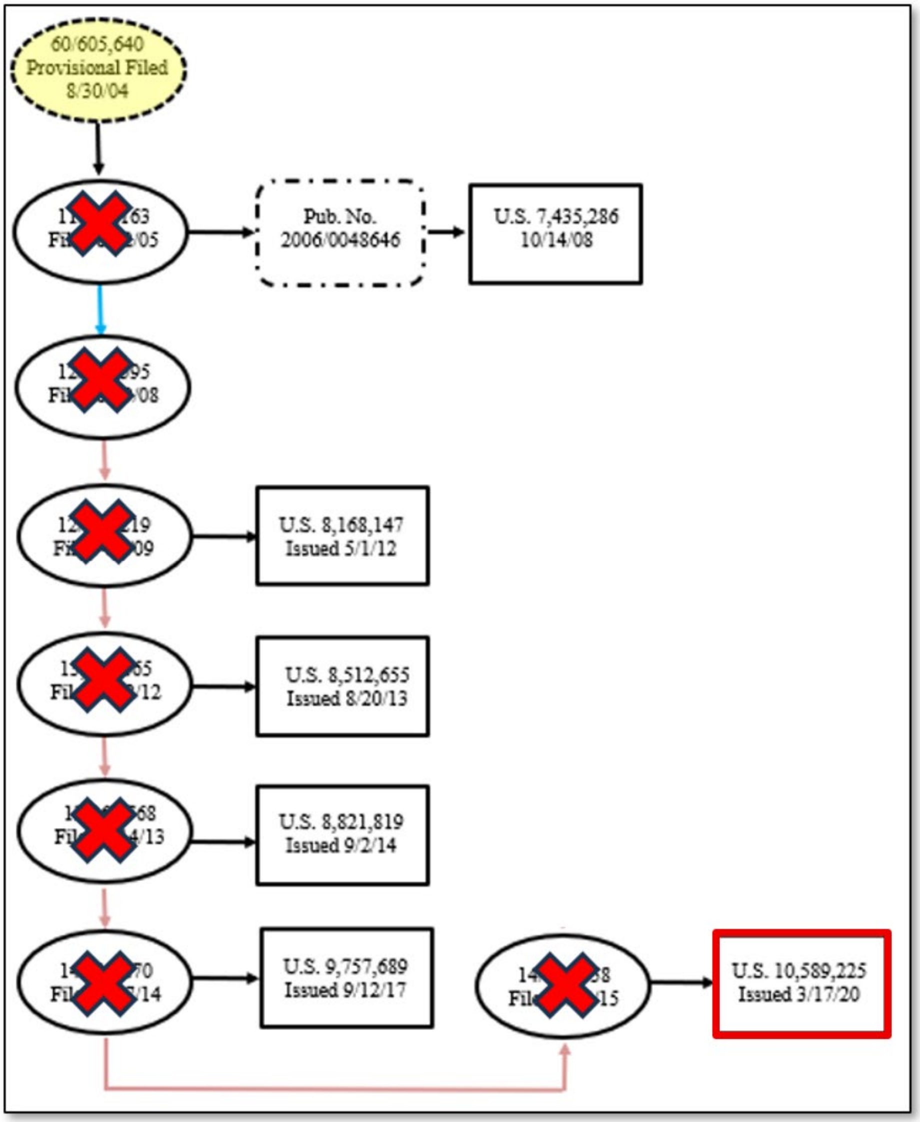
93. The only other mentions of “additive” in the Provisional do not identify what the “additive” is, either. EX1017, 6 (“a combination of additives to remove pollutants”); EX1017, 11 (“additive to a treatment facility”); EX1017, 11 (“additive-sorbent ratios”).

94. Based on my review of the Provisional, as well as my education, skill, training, and experience in the relevant fields of emission reduction technology, it is my opinion that the Provisional does not disclose promoter compounds such as Br_2, HBr, a bromide compound, or a combination thereof being added to coal or the combustor for the reasons explained in Paragraphs 81-93, and thus does not disclose “combusting … coal … and an additive” as required in the independent claims 1, 14 and 17. It is also therefore my opinion that a POSITA would not have reasonably concluded that the inventors had possession of the Challenged Claims at the time the Provisional was filed.

D. The Applications to Which the ‘225 Patent Claims Priority Do Not Disclose the Challenged Claims

95. The Provisional Disclosure (including Figure 2) was not included in the ‘163, ‘595, ‘219, ‘665, ‘768, ‘270, or ‘558 Applications, which have essentially the same specification, with minor differences. *See* EX1028–EX1033 (redline comparisons of each successive non-provisional application as compared to its predecessor).

96. The inclusion or exclusion of the Provisional Figure 2 is shown in the following image depicting the family of the ‘225 Patent wherein the applications marked with a Red X did not include Figure 2 from the Provisional. The applications that do include Provisional Figure 2 are shaded yellow:



97. The disclosures of the ‘163, ‘595, ‘219, ‘665, ‘768, ‘270 and ‘558 Applications thus have the same “coal,” “additive,” “pyrolysis char” and “combustor” disclosures discussed above regarding the ‘558 Application in Section VIII(B). Because these discussions in the ‘558 Application do not disclose a promoter or additive such as Br_2, HBr, a bromide compound, or a combination thereof being added to coal or the combustor, and thus does not disclose “combusting

… coal … and an additive,” the ‘163, ‘595, ‘219, ‘665, ‘768, ‘270 and ‘558 Applications also lack any such disclosure.

98. I note again that the Board found in its Institution Decision in IPR2020–00832 for related U.S. Patent No. 10,343,114 that the first two non-provisional applications filed after the Provisional (the ‘163 and ‘595 Applications) do not disclose “(1) the addition of the promoter with the coal or the combustion chamber and (2) the injection of a sorbent material into the mercury-containing gas downstream of the combustion chamber,” both of which are required by each of the ‘225 Patent’s independent claims of the Challenged Claims (claims 1, 14 and 17). EX1038, 28–29.

99. The Board explained in the Institution Decision that the disclosure as referenced in Example 10 of the ‘225 Patent that the “halogen/halide promoted carbon sorbent was injected into the flue gas after the boiler” describes “a **combination of promoter and sorbent material being added at one single point**”) (emphasis added). *Id.* The Board also considered the disclosure in that same example that “[i]n general however, the inventive sorbent can be injected where desired (e.g., before, after, or within the boiler)” *Id.* The Board stated as follows:

> Although this describes other injection points (“e.g., before, after, or within the boiler”), this disclosure regards the promoted sorbent material. As a result, it describes the addition of both the promoter and the sorbent material at a

> single point, not (1) the addition of the promoter with the coal or the combustion chamber and (2) the injection of the sorbent material into mercury-containing gas downstream of the combustion chamber.

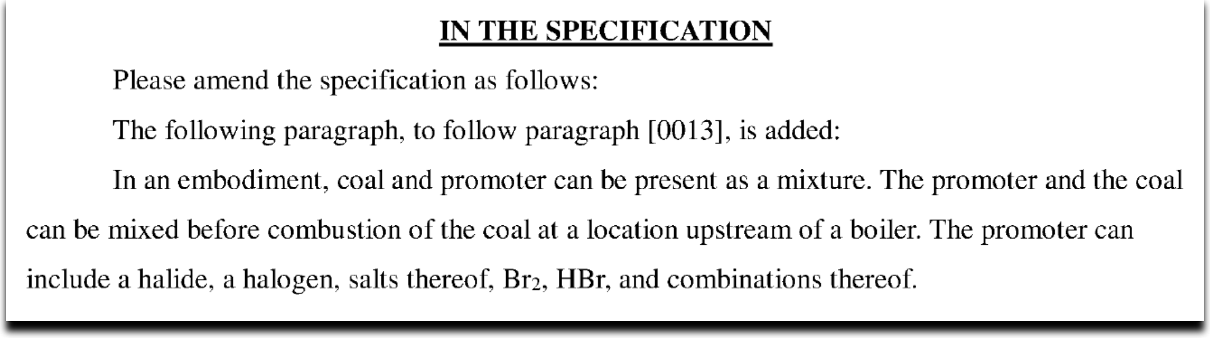
EX1038, 28. It follows that the Board did not find injection of a promoted sorbent before, after or within the boiler to be adding the promoter to coal or the combustor, and injecting the sorbent into flue gas downstream of the combustor.

100. Based on my review of the applications identified above, as well as my education, skill, training, and experience in the relevant fields of emission reduction technology, it is my opinion that none of the ‘163, ‘595, ‘219, ‘665, ‘768, ‘270 or ‘558 Applications disclose promoter compounds such as Br_2, HBr, a bromide compound, or a combination thereof being added to coal or the combustor and thus does not disclose “combusting … coal … and an additive” for the reasons explained above in Paragraphs 95-99. It is also therefore my opinion that a POSITA would not have reasonably concluded that the inventors had possession of the Challenged Claims at the time those applications were filed. Simply put, a POSITA would not understand PO to have invented a method for combusting coal, pyrolysis char, and an additive comprising HBr, a bromide compound or a combination thereof.

E. The Passages Cited by the Applicant During Prosecution Do Not Disclose the Addition of HBr, or a Bromide Compound to the Coal or Combustion Chamber

101. The claim that was filed with the ‘558 Application (for the ‘225 Patent) was directed to a promoted carbon sorbent. EX1024, 30. This claim was replaced the next day with claims directed to a method for separating reducing mercury in a mercury-containing gas by combusting coal comprising a promoter or adding a promoter to coal and adding sorbent into the mercury-containing gas, without any indication of support for the claim amendments. EX1024, 60-63.

102. The specification was later amended as follows to add disclosure regarding the coal and promoter after the claims were rejected as lacking adequate support:



IN THE SPECIFICATION

Please amend the specification as follows:

The following paragraph, to follow paragraph [0013], is added:

In an embodiment, coal and promoter can be present as a mixture. The promoter and the coal can be mixed before combustion of the coal at a location upstream of a boiler. The promoter can include a halide, a halogen, salts thereof, Br_2, HBr, and combinations thereof.

EX1024, 151. This paragraph was rejected as new matter and deleted from the specification. EX1024, 237, 247.

103. The independent claims and this new paragraph were allegedly supported by Provisional Figure 2 and pages 2, 3 and 9 of the Provisional, for the reasons provided below:

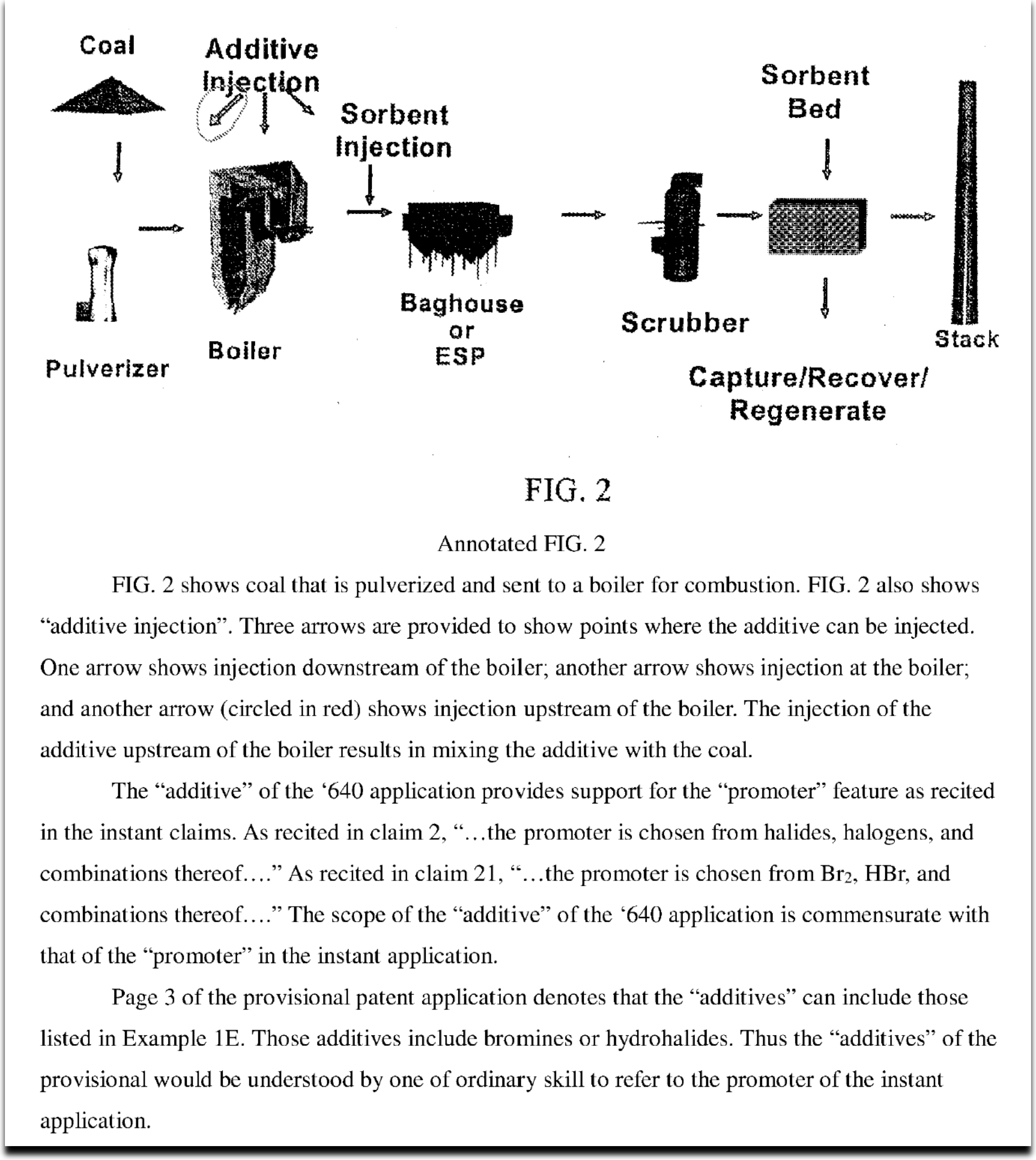


FIG. 2

Annotated FIG. 2

FIG. 2 shows coal that is pulverized and sent to a boiler for combustion. FIG. 2 also shows “additive injection”. Three arrows are provided to show points where the additive can be injected. One arrow shows injection downstream of the boiler; another arrow shows injection at the boiler; and another arrow (circled in red) shows injection upstream of the boiler. The injection of the additive upstream of the boiler results in mixing the additive with the coal.

The “additive” of the ‘640 application provides support for the “promoter” feature as recited in the instant claims. As recited in claim 2, “…the promoter is chosen from halides, halogens, and combinations thereof….” As recited in claim 21, “…the promoter is chosen from Br_2, HBr, and combinations thereof….” The scope of the “additive” of the ‘640 application is commensurate with that of the “promoter” in the instant application.

Page 3 of the provisional patent application denotes that the “additives” can include those listed in Example 1E. Those additives include bromines or hydrohalides. Thus the “additives” of the provisional would be understood by one of ordinary skill to refer to the promoter of the instant application.

EX1024, 156-159.

104. As I explained in the preceding portion of this Declaration, Provisional Figure 2 was not included in any of the Red X Applications. As I explained above in Section VIII(C) above, a POSITA would not have understood from the disclosures of the Provisional that the inventors had possession of the invention involving adding a promoter to coal, much less adding HBr, a bromine compound or a combination thereof to coal.

105. In considering these statements of alleged support, PO states that the circled arrow in Provisional Figure 2 "shows injection upstream of the boiler. The injection of the additive upstream of the boiler results in mixing the additive with the coal." As noted above, injection of an additive upstream of the boiler is not a disclosure of adding a promoter to coal. The additive could be added via a separate feed inlet, a secondary-air system, or a low-NO_x overfire air system that would not contact the coal.

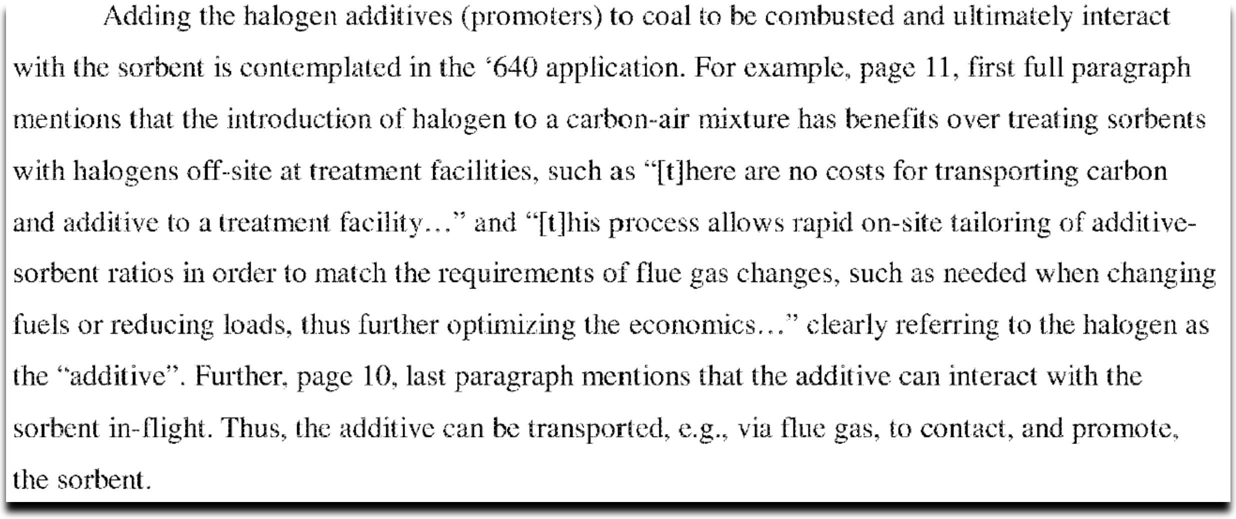
106. PO also alleges that the "additive" of the Provisional "provides support for the 'promoter'" as claimed. As addressed above, there is no disclosure that the Provisional's "additive" is a promoter, let alone HBr, a bromide compound or a combination thereof. PO further points to the Example 1E list as "additives" but as addressed above, the Provisional is, in my opinion, clear that this additional

substance is used in preparing a promoted sorbent, not as an "additive" to coal or the combustor.

107. After the claims and the new specification paragraph were rejected as lacking support, PO stated that the Provisional "goes on to state that those additional promoting substances can be added to the carbon (e.g., coal)." EX1024, 253. This is not true. As discussed above, Provisional Example 1 is directed to a "modified carbon sorbent … prepared by reacting the carbon with molecular bromine by applying a solution of molecular bromine in an organic solvent to the carbon … The solution may also contain an additional promoting substance in small amounts." Thus, the additional promoting substance is added to the molecular bromine solution used in making a promoted carbon sorbent, not added to the coal.

108. PO also states that the "(e.g., before, after or within the boiler)" language from Example 10 as discussed above means that "where the additive is injected before the boiler, the additive is in contact with the coal shown in FIG. 2. Thus, the coal comprises the additive or promoter." EX1024, 253-254. This is not true. As noted above, the injection of an additive upstream of the boiler is <u>not</u> a disclosure of adding a promoter to coal. The additive could be added via a separate feed inlet, a secondary-air system, or a low-NO_x overfire air system that would not contact the coal.

109. PO alleges that page 11 of the Provisional describes adding promoters to coal:



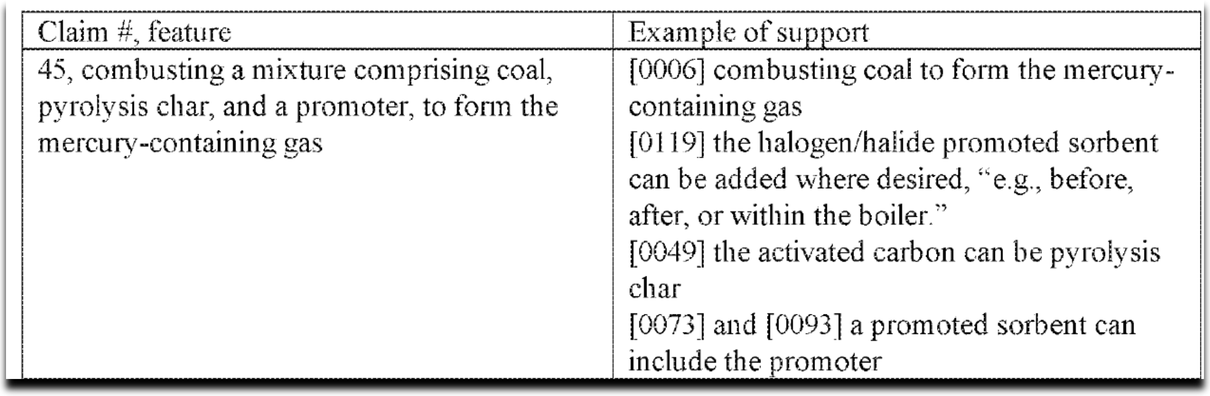
Adding the halogen additives (promoters) to coal to be combusted and ultimately interact with the sorbent is contemplated in the '640 application. For example, page 11, first full paragraph mentions that the introduction of halogen to a carbon-air mixture has benefits over treating sorbents with halogens off-site at treatment facilities, such as "[t]here are no costs for transporting carbon and additive to a treatment facility…" and "[t]his process allows rapid on-site tailoring of additive-sorbent ratios in order to match the requirements of flue gas changes, such as needed when changing fuels or reducing loads, thus further optimizing the economics…" clearly referring to the halogen as the "additive". Further, page 10, last paragraph mentions that the additive can interact with the sorbent in-flight. Thus, the additive can be transported, e.g., via flue gas, to contact, and promote, the sorbent.

EX1024, 254.

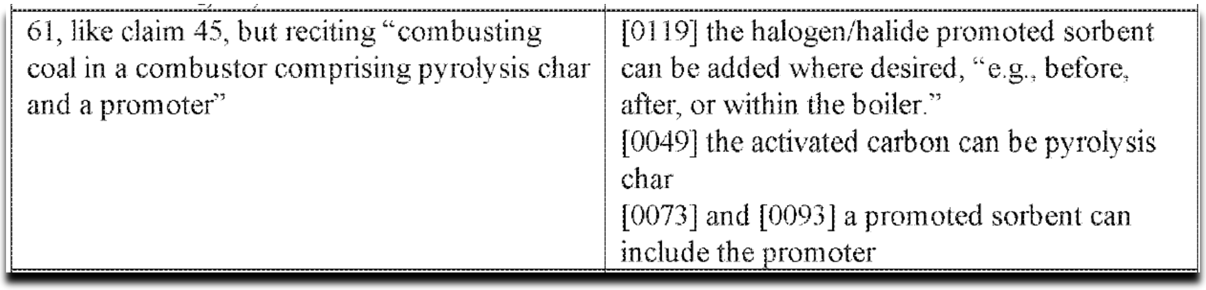
110. The list at page 11 of the Provisional discusses purported advantages of "[i]n flight preparation of the halogen/halide promoted carbon sorbent" wherein the "halogen/halide is introduced to the carbon-air (or other gas) in a transport line (or other part of the sorbent storage and injection system." *See* EX1001, 13:5-33, Figure 3. Again, in my opinion, these paragraphs do not provide written description support for adding a promoter to coal, much less adding HBr, bromine compound or a combination thereof to coal.

111. All claims were cancelled in June 2018 and the new independent claims directed to methods for separating mercury from a mercury-containing gas required combusting coal, pyrolysis char and a promoter. EX1024, 327-331, Claims 45, 61,

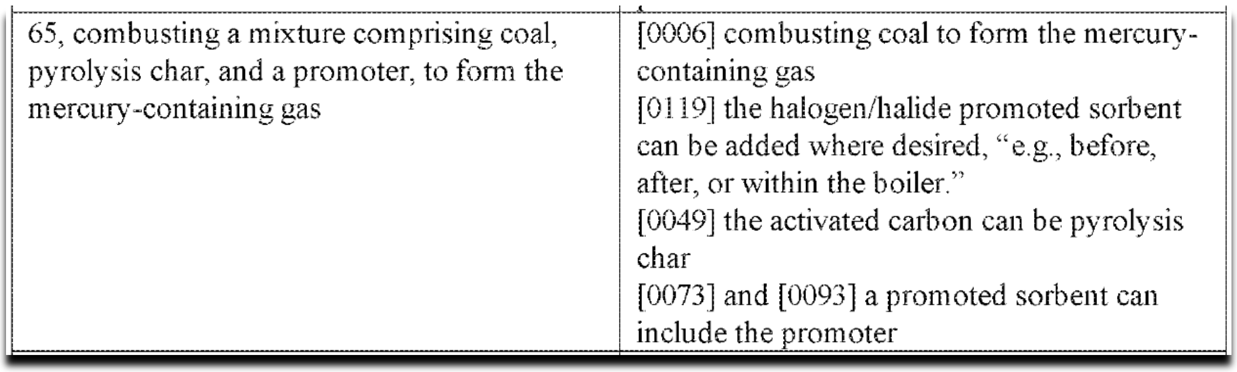
65. PO cited the following paragraphs of US Published Application No. 2015/0246315A1 as support for this feature of claims 45, 61 and 65:



Claim #, feature	Example of support
45, combusting a mixture comprising coal, pyrolysis char, and a promoter, to form the mercury-containing gas	[0006] combusting coal to form the mercury-containing gas [0119] the halogen/halide promoted sorbent can be added where desired, "e.g., before, after, or within the boiler." [0049] the activated carbon can be pyrolysis char [0073] and [0093] a promoted sorbent can include the promoter



61, like claim 45, but reciting "combusting coal in a combustor comprising pyrolysis char and a promoter"	[0119] the halogen/halide promoted sorbent can be added where desired, "e.g., before, after, or within the boiler." [0049] the activated carbon can be pyrolysis char [0073] and [0093] a promoted sorbent can include the promoter



65, combusting a mixture comprising coal, pyrolysis char, and a promoter, to form the mercury-containing gas	[0006] combusting coal to form the mercury-containing gas [0119] the halogen/halide promoted sorbent can be added where desired, "e.g., before, after, or within the boiler." [0049] the activated carbon can be pyrolysis char [0073] and [0093] a promoted sorbent can include the promoter

EX1024, 333, 337-338.

112. Paragraph [0006] specifies that "combustion … of … coal generates flue gas that contains mercury." This paragraph does not describe a promoter.

113. Paragraph [0119], which is paragraph [0107] of the specification as filed in the '558 Application, states that "the inventive sorbent can be injected where desired (e.g., before, after, or within the boiler)." PO states in the excerpts above that this paragraph means that "the **halogen/halide promoted sorbent** can be added where desired." (emphasis added). As addressed above regarding Example 10, this is not a disclosure of adding a **promoter** where desired.

114. Paragraph [0073] states that "X-ray spectroscopy has established that the addition of bromine, chlorine, HBr, or HCl formed a chemical compound in the carbon structure. Thus, the sorbent produced from halogen and activated carbon **does not represent a molecular halogen form, but rather a new chemically modified carbon (or halocarbon) structure**" (emphasis added). In the excerpt above, PO characterizes this paragraph as "a promoted sorbent can include the promoter." In my opinion, the paragraph indicates that the promoter is no longer present as such because it has reacted to form a new halocarbon structure.

115. Paragraph [0093] describes the promoted carbon sorbent as having "a carbocation that accepts electrons from the neutral mercury atom forming the oxidized mercury species." This paragraph does not describe combusting coal and a promoter.

116. The claims were then cancelled and replaced with claims including the same combusting feature and replacing "promoter" with "additive comprising HBr,

a bromide compound, or a combination thereof." EX1024, 354-357, 662-666, Claims 66, 79, 82. Paragraphs [0054] and [0071] of the published application US 2015/0246315A1 were cited as support. EX1024, 611.

117. Paragraph [0054] refers to Figure 2 and states that "hydrogen bromide reacts with the unsaturated structure of the activated carbon." Paragraph [0071] defines the term "halide." These paragraphs do not describe combusting coal and a promoter.

118. In my opinion, none of these paragraphs provide written description support for combusting coal and a promoter, much less combusting coal and HBr, a bromine compound or a combination thereof.

119. In sum, the '558 Application and each of its priority applications fail to provide support for adding any of the claimed promoters (Br_2, HBr, a bromide compound, or a combination thereof) to coal or a combustor and thus does not disclose "combusting … coal … and an additive" as recited in the claims of the '225 Patent for the reasons explained above in Paragraphs 104-121. It follows that none of the claims of the '225 Patent are entitled to a priority date before the filing date of the '558 Application.

IX. CLAIM CONSTRUCTION

120. It is my understanding that the terms of a claim in an IPR are given the meaning that the term would have to a person of ordinary skill in the art in question

at the time of the application. I have reviewed how a POSITA would have understood the terms of the Challenged Claims of the ‘225 Patent.

121. For purposes of this declaration, I have used the earliest possible priority date, August 2004, the filing date of the Provisional Application.

122. I note that Magistrate Judge Burke in the District of Delaware provided constructions for two terms in patents from the same family as the ‘225 Patent. Specifically, I understand that Magistrate Judge Burke construed the terms “combusting a mixture comprising coal, pyrolysis char, and an additive comprising HBr, a bromide compound, or a combination thereof” (claim 1), “combusting coal in a combustor comprising pyrolysis char and an additive comprising HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas” (claim 14), and “combusting a mixture comprising coal, pyrolysis char, and an additive comprising HBr, a bromide compound, or a combination thereof” (claim 17) in U.S. Patent No. 10,589,225 to have their plain and ordinary meaning.

123. In reaching this construction, I understand that Magistrate Judge Burke explained that these terms allow for the pyrolysis char to be created within the combustor — i.e., by combusting a mixture of coal and a bromine compound that produces pyrolysis char — and then be combusted along with the coal and the bromine compound in the combustor. He rejected a definition that would have

required the coal, bromine compound and pyrolysis char to each be added to the combustor, and then be combusted.

124. I further understand that Magistrate Judge Burke construed the term "injecting the particulate sorbent material at a sorbent material injection rate and injecting separately the bromine containing promoter into a gas stream whereby inflight reaction produces the promoted brominated sorbent" (claim 17) in U.S. Patent No. 8,168,147 to have its plain and ordinary meaning. In reaching this construction Magistrate Judge Burke explained that the plain language of the disputed phrase counseled against a narrower construction, which would have required that: "(a) the injecting term's reference to 'gas stream' after 'the bromine containing promoter' be moved, inter alia, to before 'the bromine containing promoter'; and (b) the bromine promoter and sorbent material must both be injected downstream of a furnace exit."

125. In performing my analysis of the unpatentability issues presented in this Declaration, I have applied the guidance given by Magistrate Judge Burke referenced above.

126. I did not apply any special meanings or constructions to any of the terms of the Challenged Claims. In my opinion, each of the claim terms in the '225 Patent has a well-understood plain and ordinary meaning to a POSITA.

X. OVERVIEW OF THE PRIOR ART

A. Downs (U.S. Patent Publication No. 2008/0107579) (EX1004)

127. I understand that Downs was published by the USPTO on May 8, 2008 as U.S. Patent Publication No. 2008/0107579 from U.S. Patent Application No. 10/591,855. EX1004 (Downs). I also understand that Downs claims priority to U.S. Provisional Patent Application No. 60/555,353 ("Downs-Provisional"), which was filed on March 22, 2004. EX1005 (Downs-Provisional).

128. I also understand that Downs qualifies as prior art as of its publication date of May 8, 2008, which is earlier than the filing date (May 14, 2015) of the '225 Patent, which applies if the '225 Patent is not entitled to an earlier priority date.

129. I also understand that Downs qualifies as prior art as of the March 22, 2004 filing date of Downs-Provisional if the Downs-Provisional has written-description support for at least one of the claims in Downs and describes the subject matter relied upon as prior art in Downs. The March 22, 2004 filing date of Downs-Provisional is earlier than August 30, 2004, which is the earliest potential priority date of the '225 Patent.

130. In the section that follows, I provide an overview of Downs with citations to both Downs and the Downs-Provisional. In my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that the Downs-Provisional discloses the subject matter of Downs.

131. I have also been provided with a red-line comparison of Downs and Downs-Provisional using Downs-Provisional as the original version. That red-line comparison is EX1006. Review of this red-line comparison further supports my opinion that Downs-Provisional discloses the subject matter relied upon as prior art in Downs. As seen in the red-line comparison, there are minor differences between Downs and the Downs-Provisional. Ultimately, all of the subject matter relied on in my unpatentability analysis regarding the disclosures of Downs is supported in the Downs-Provisional as explained below in Paragraphs 132-154.

1. Disclosures of Downs and Downs-Provisional

132. Downs is titled "Bromine Addition for the Improved Removal of Mercury from Flue Gas. EX1004; EX1005, page 3.

133. Downs is analogous art to the '225 Patent as Downs describes processes for improving mercury removal from the flue gas of coal combustion facilities.

134. Downs states that the "mercury removal" may be performed with "carbonaceous sorbents [that] include, but are not limited to, powdered activated carbon (PAC)." EX1004, [0025]; EX1005, [0028].

135. Downs explains that "[b]romine-containing compounds, added to the coal, or to the boiler combustion furnace, are used to enhance the oxidation of mercury, thereby enhancing the overall removal of mercury in downstream pollution control devices." EX1004, Abstract, [0001], [0010]; EX1005, [0009], [0018].

Downs' schematic is reproduced below with certain features of relevance highlighted in red:

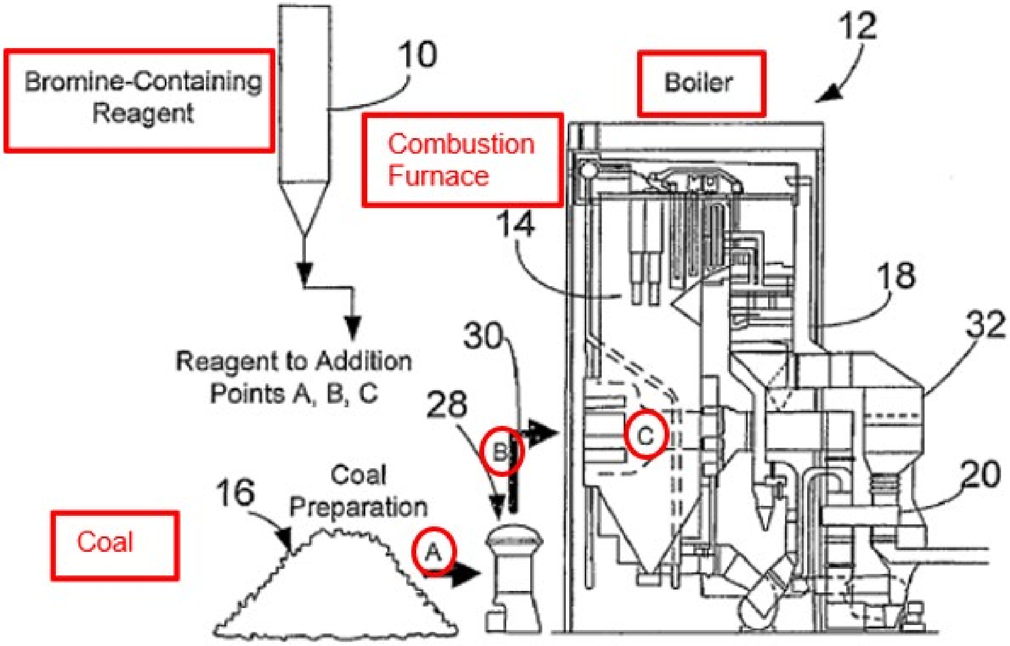


FIG. 2

EX1004, Figure 2 (annotations added in red); EX1005, Figure 2. As shown, Downs discloses that the bromine-containing compounds (reagent) can be added at, for example, any of the Points A, B, and C emphasized above in Figure 2.

136. For example, Figure 2 illustrates adding bromine-containing reagent 10 to boiler 12 of combustion furnace 14 "either directly or by premixing with the incoming coal 16." EX1004, [0015]; EX1005, [0018]. Downs describes injecting an aqueous solution of calcium bromide into furnace 14, and using "alkali metal and alkaline earth metal bromides, hydrogen bromide (HBr) or bromine (Br_2)" as the

bromine-containing reagent 10. EX1004, [0018], [0021]; EX1005, [0021], [0024]. Downs describes "downstream pollution control systems such as wet 22 and SDA 24 FGD systems, and PAC injection systems" with "powdered activated carbon (PAC)" as a sorbent. EX1004, [0015], [0025]; EX1005, [0018], [0028]. Wet 22 and SDA 24 FGD systems and ESP or FF particulate collectors 26 are shown in Figures 4 and 6, below:

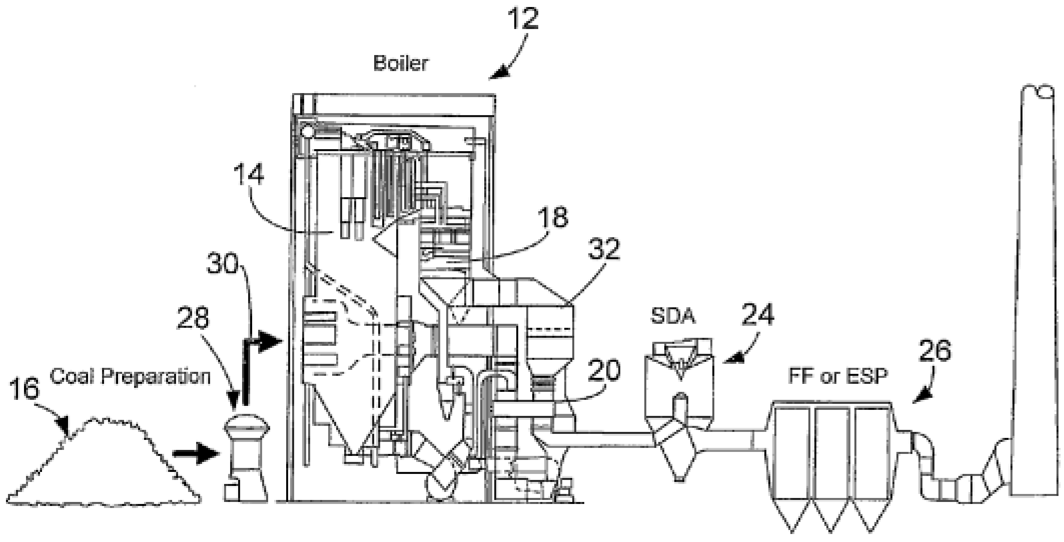


FIG. 4

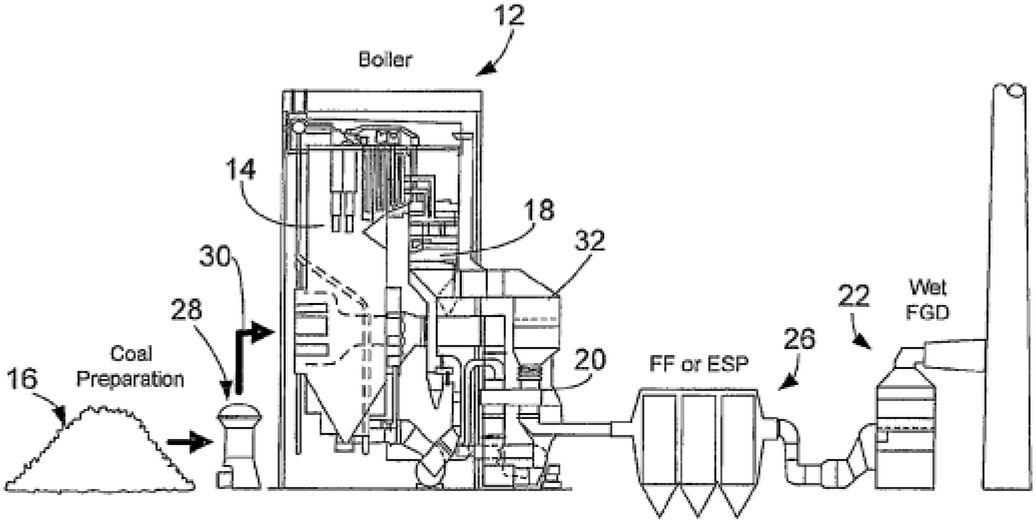


FIG. 6

EX1004, Figures 4 & 6; EX1005, Figures 4 & 6.

137. Downs states that "experimental results indicate that bromine addition also results in an increased fraction of particulate-bound mercury," enhancing mercury removal from particulate collectors 26 (FF or ESP). EX1004, [0015]; EX1005, [0018].

2. Downs-Provisional Provides Written Description Support for at Least Claim 1 of Downs

138. Claim 1 of Downs is reproduced below with annotations designating each of the claim elements that are discussed in the paragraphs below:

> (1a) A method of removing a portion of the elemental mercury in a flue gas created during the combustion of a fossil fuel, comprising:
>
> (1b) providing a bromine containing reagent to said flue gas;

> (1c) promoting the oxidation of elemental mercury with the bromine containing reagent;
>
> (1d) creating an oxidized form of mercury from the elemental mercury; and
>
> (1e) removing the oxidized mercury from the flue gas.

For the reasons explained in the following paragraphs, it is my opinion that each of these claim elements is supported by Downs-Provisional.

139. It is my understanding that to satisfy the written description requirement, a patent specification must describe the claimed invention in sufficient detail that one skilled in the art can reasonably conclude that the inventor had possession of the claimed invention. I further understand that this requirement can be satisfied if the claimed invention is described with all of its limitations using such descriptive means as words, structures, figures, diagrams, and formulas that fully set forth the claimed invention.

(a) Element (1a) (Preamble)—"A method of removing a portion of the elemental mercury in a flue gas created during the combustion of a fossil fuel"

140. Downs-Provisional discloses the preamble of Claim 1 of Downs. Downs-Provisional is titled "Bromine Addition for the Improved Removal of Mercury From Flue Gas."

141. Downs-Provisional further states that "the current invention can offer a cost-effective method of removing elemental mercury from coal combustion flue gases." EX1005, [0021].

(b) Element (1b)—"providing a bromine containing reagent to said flue gas"

142. Downs-Provisional discloses element (1b) of Claim 1 of Downs. Downs-Provisional is titled "Bromine Addition for the Improved Removal of Mercury From Flue Gas."

143. Downs-Provisional discloses that "[a] bromine-containing reagent is added to the boiler combustion furnace, either directly or by premixing with the incoming coal." EX1005, [0018].

144. Downs-Provisional further discloses that "[b]romine species released during the combustion process enhance the oxidation of mercury as the combustion gases pass through the furnace" and then "enhances mercury removal in downstream pollution control systems such as wet and SDA FGD systems, and PAC injection systems." *Id.*

(c) Element (1c)—"promoting the oxidation of elemental mercury with the bromine containing reagent;"

145. Downs-Provisional discloses element (1c) of Claim 1 of Downs.

146. Downs-Provisional explains several advantages of the disclosed processes:

> First, increasing the fraction of mercury appearing in the oxidized and particulate-bound forms enhances the removal of mercury in conventional pollution control systems such as particulate collectors and wet and SDA FGD systems. This reduces, or may eliminate entirely, the need for PAC injection to remove elemental mercury. Second, the increased fraction of oxidized mercury also enhances the removal of mercury across a PAC injection process, due to the higher reactivity of oxidized mercury with PAC.

EX1005, [0019].

147. Downs-Provisional further explains that "SCR catalysts have been shown to promote the oxidation of elemental mercury if the correct species (in this case bromine species) are present in the flue gas." *Id.*, [0027].

(d) Element (1d)—"creating an oxidized form of mercury from the elemental mercury; and"

148. Downs-Provisional discloses element (1d) of Claim 1 of Downs. As discussed above regarding element (1c), Downs-Provisional discloses that "SCR catalysts have been shown to promote the oxidation of elemental mercury if the correct species (in this case bromine species) are present in the flue gas." *Id.*, [0027].

149. Downs-Provisional further explains that "[b]romine species released during the combustion process enhance the oxidation of mercury as the combustion

gases pass through the furnace and, in particular, through the cooler sections of the boiler convection pass and combustion air preheater. The increased fraction of mercury appearing in the oxidized form enhances mercury removal in downstream pollution control systems such as wet and SDA FGD systems, and PAC [powdered activated carbon] injection systems." *Id.*, [0018].

(e) Element (1e)—"removing the oxidized mercury from the flue gas."

150. Downs-Provisional discloses element (1e) of Claim 1 of Downs. Again, the title of Downs-Provisional is "Bromine Addition for the Improved Removal of Mercury from Flue Gas."

151. Downs-Provisional explains that the "the increased fraction of oxidized mercury also enhances the removal of mercury across a PAC injection process, due to the higher reactivity of oxidized mercury with PAC." *Id.*, [0019].

152. Downs-Provisional further explains that "[b]oth wet and spray dryer absorber (SDA) flue gas desulfurization (FGD) systems remove significant amounts of oxidized mercury." *Id.*, [0004].

153. Downs-Provisional also states that the inventors "have determined through experimental testing that the use of bromine-containing compounds, added to the coal, or to the boiler combustion furnace, are significantly more effective than chlorine-containing compounds in enhancing the oxidation of mercury, thereby

enhancing the overall removal of mercury in downstream pollution control devices." *Id.*, [0009]. Having reduced the invention to practice, the Downs' inventors demonstrated possession of the invention.

154. In my opinion, Downs-Provisional discloses all of the elements of Claim 1 of Downs and supports the subject matter of Downs relied upon in my unpatentability analysis for the reasons explained above in Paragraphs 127-153. Accordingly, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Downs-Provisional provides written description support for Downs and that Downs is entitled to the March 22, 2004 priority date of Downs-Provisional.

B. Altman (US Patent 5,827,352) (EX1007)

155. Altman issued on October 27, 1998. Accordingly, I understand that Altman qualifies as a prior art patent regardless of whether the effective filing date of the '225 patent is May 14, 2015 or August 30, 2004.

156. Altman relates to removing mercury from flue gas of a coal-fired boiler 12 by injecting activated carbon sorbent into the flue gas. EX1007, 1:5–9, 3:41–45, 4:57–58. Flue gas exiting boiler 12 is processed through ESP 19 to remove fly ash 21 and then through tower 24 and silo 27:

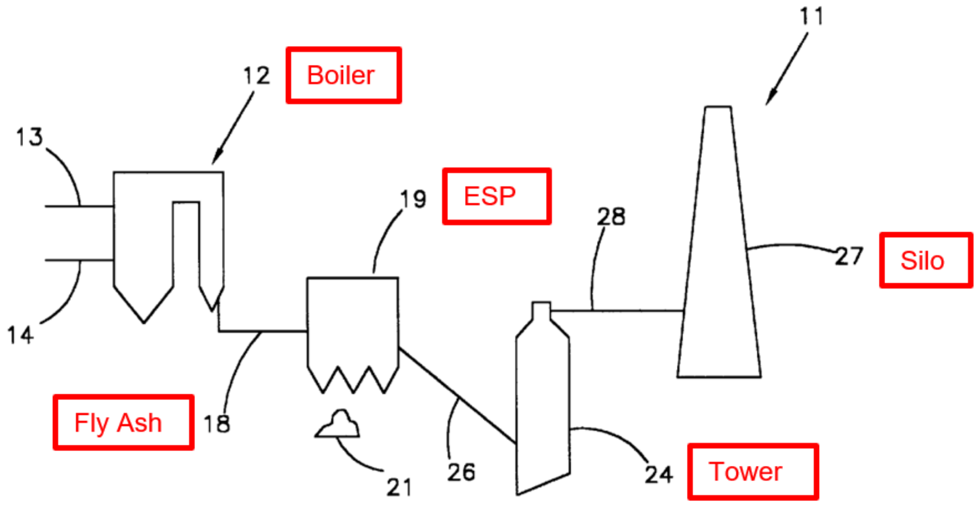
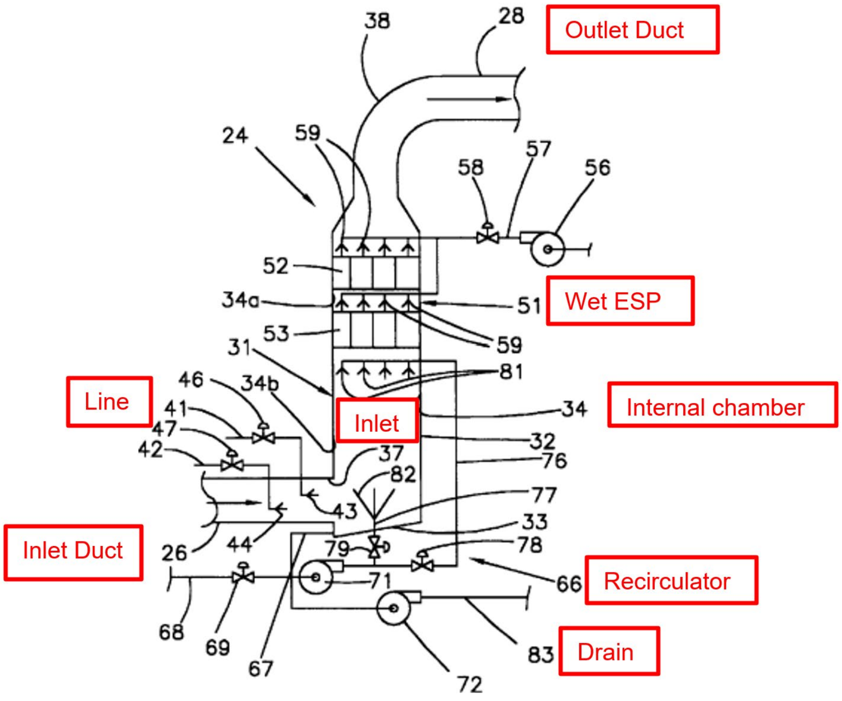


FIG. 1

EX1007, Figure 1, 3:53–65 (annotations added in red).

157. Tower 24 includes a particulate control device (wet ESP 51) located above internal chamber 34:



EX1007, Figure 2, 3:66–4:4, 17–20 (annotations added in red).

158. The flue "gas stream from ESP 19 thus enters internal chamber 34 through inlet 37 and travels upwardly through the chamber before exiting through outlet duct 28." EX1007, 4:6–9. The activated carbon sorbent is "injected into the flue gas" – either "injected into chamber 34" or into inlet duct 26 via line 41. EX1007, 4:53–61.

159. Water or a water/sorbent mixture is injected into chamber 34 to lower the temperature of the flue gas such that temperature and sorbent injection rate provide "optimal mercury sorption" by activated carbon sorbent. EX1007, 4:62–5:5.

160. Flue gas residence time within chamber 34 ranges from 1–20 seconds, preferably 5–10 seconds, to "allow a large portion of the mercury in the flue gas to be removed by the injected sorbent." EX1007, 5:6–12.

161. The flue gas rises through chamber 34 into wet ESP 51 where sorbent, remaining fly ash and condensed water are collected and either removed from tower 24 through drain 83 or partially recycled by recirculator 66. EX1007, 5:18–22, 41–49.

162. Altman discloses that while flue gas can be passed through a packed bed of activated carbon sorbent to remove mercury, packed beds "are complex to design and operate" and "produce high pressure drops and require periodic regeneration." EX1007, 1:30–40.

163. Instead of using a packed bed with stationary sorbent, Altman injects activated carbon and lime sorbent particles into flue gas in his emission control system such that the sorbents flow with the flue gas. EX1007, 4:53–61, 5:50–61. Altman also discloses that injection of activated carbon into flue gas was known in the art for removing mercury in coal-fired boilers before April 1997. EX1007, 2:23–31, 1:41–2:22, 32–46.

C. Nelson (US Patent App. Pub. US2004/0003716) (EX1008)

164. Nelson, titled "SORBENTS AND METHODS FOR THE REMOVAL OF MERCURY FROM COMBUSTION GASES," published by the U.S. Patent Office as U.S. Patent Publication No. 2004/0003716 on January 8, 2004. EX1008. Nelson also claims priority to a provisional application filed on May 6, 2002.

165. I understand that Nelson qualifies as prior art as of its publication date of January 8, 2004, which is earlier than the earliest potential priority date of the '225 Patent (August 30, 2004).

166. I also understand that Nelson qualifies as prior art as of the May 6, 2002 filing date of Nelson-Provisional if the Nelson-Provisional has written-description support for at least one of the claims in Nelson and describes the subject matter relied upon as prior art in Nelson.

167. In the section that follows, I provide an overview of Nelson with citations to both Nelson and the Nelson-Provisional. In my opinion, based on my

education, skill, training, and experience in the relevant fields of emission reduction technology, the Nelson-Provisional discloses the subject matter of Nelson and has written description support for at least claim 18 of Nelson.

168. I have also been provided with a red-line comparison of Nelson and Nelson-Provisional using Nelson-Provisional as the original version. That red-line comparison is EX1010. Review of this red-line comparison further supports my opinion that Nelson-Provisional discloses the subject matter of Nelson. Ultimately, all of the subject matter relied on in my unpatentability analysis regarding the disclosures of Nelson is supported in the Nelson-Provisional for the reasons explained below in Paragraphs 169-184.

1. Disclosures of Nelson and Nelson-Provisional

169. Nelson is titled "SORBENTS AND METHODS FOR THE REMOVAL OF MERCURY FROM COMBUSTION GASES." EX1008. Nelson-Provisional is titled "Methods to Remove Mercury from Combustion Gases." EX1009, 1 (Cover Sheet).

170. Nelson is analogous art to the '225 Patent as Nelson describes processes for improving mercury removal from the flue gas of coal combustion facilities. EX1008, Abstract, [0004]; EX1009, 1, 4.

171. Nelson further describes "steps of providing a mercury sorbent; injecting the mercury sorbent into a stream of the mercury-containing combustion

gas for a sufficient time to allow at least an effective amount of the mercury and mercury-containing compounds in the combustion gas to adsorb onto the mercury sorbent, and collecting and removing the mercury sorbent from the combustion gas stream." EX1008, Abstract, [0023]; EX1009, 6 (Claim A.1).

172. Nelson further discloses that "[t]he mercury sorbent is prepared by treating a carbonaceous substrate with an effective amount of a bromine-containing gas for a sufficient time to increase the ability of the carbonaceous substrate to adsorb mercury and mercury-containing compounds." EX1008, Abstract, [0023]; EX1009, 4-5, Claim A.2.

173. Nelson explains that the "the bromine containing gas comprises at least one of elemental bromine and hydrogen bromide. In some aspects of the invention, the carbonaceous substrate comprises activated carbon " EX1008, [0024]. EX1009, 4-5, Claim A.3.

174. Nelson indicates that exposure of sorbent to Br_2 or HBr gas "significantly increases the carbonaceous materials ability to remove mercury species." EX1008 [0041]; EX1009, 5 ("The bromine pretreatments increased the elemental mercury capacity of these PACs by 500% to 1000%").

2. Nelson-Provisional Provides Written Description Support for at Least Claim 18 of Nelson

175. Claim 18 of Nelson is reproduced below with annotations designating each of the claim elements that are discussed in the paragraphs below:

> (18a) A process for manufacturing a mercury sorbent, comprising:
>
> (18b) providing a carbonaceous substrate;
>
> (18c) providing a bromine-containing gas, and
>
> (18d) contacting the carbonaceous substrate with the bromine- containing gas for a sufficient time to increase the mercury adsorbing ability of the carbonaceous substrate.

For the reasons explained in the following paragraphs, it is my opinion that each of these claim elements is supported by Nelson-Provisional (EX1009).

176. It is my understanding that to satisfy the written description requirement, a patent specification must describe the claimed invention in sufficient detail that one skilled in the art can reasonably conclude that the inventor had possession of the claimed invention. I further understand that this requirement can be satisfied if the claimed invention is described with all of its limitations using such descriptive means as words, structures, figures, diagrams, and formulas that fully set forth the claimed invention.

(a) Element (18a)–"A process for manufacturing a mercury sorbent, comprising:"

177. Nelson-Provisional discloses the preamble of Nelson. Nelson-Provisional explains processes for brominating powdered active carbon (PAC) to significantly increase the PAC's ability to remove elemental mercury when injected into coal-fired flue-gas compositions at high temperatures. EX1009, 4. Nelson-Provisional further explains that production of such a mercury sorbent "is simple. The carbon material and the bromine gas need simply be exposed to each other for the advantageous mercury-reactive surface compounds to form." *Id.*

(b) Element (18b)–"providing a carbonaceous substrate;"

178. Nelson-Provisional discloses element (18b) of claim 18 of Nelson. As discussed above, Nelson-Provisional describes processes for brominating activated carbon to be used as a mercury sorbent in coal-fired flue gas. *Id.*, 4.

179. Nelson-Provisional further explains that "[t]his gas-phase bromine treatment was tested on many different commercially-available powdered activated carbons (PACs). Each was found to be easily 'brominated' to at least 15 wt% Br, including PACs from Barnaby Sutcliffe, Calgon (both Centaur® and Fluepac A), General Carbon, Nichem, Action Carbon, Advance Recovery Technologies, and Norit's Darco FGD®, the standard PAC typically used by other researchers." *Id.*, 8.

(c) Element (18c)–"providing a bromine-containing gas, and"

180. Nelson-Provisional discloses element (18c) of Claim 18 of Nelson. As explained above, Nelson-Provisional describes processes for brominating activated carbon.

181. Nelson-Provisional further states that "[h]ydrogen bromide is a gas at even room temperature. Using a gas the carbon reactant considerably simplifies production of the sorbent. … It is also preferable that the mixing of bromine gas and carbon be done at an elevated temperature." *Id.*, 7. *See also Id.* at 8 ("This gas-phase bromine treatment was tested on many different commercially-available powdered activated carbons (PACs).").

(d) Element (18d)–"contacting the carbonaceous substrate with the bromine containing gas for a sufficient time to increase the mercury adsorbing ability of the carbonaceous substrate."

182. Nelson-Provisional discloses element (18d) of Claim 18 of Nelson. As explained above, Nelson-Provisional discloses methods of creating a brominated activated carbon using bromine gas and powdered activated carbon (PACs).

183. Nelson-Provisional explains that "[t]he bromine-gas treatment markedly increased the elemental-mercury removal-capacity of every PAC tested. … The bromine pretreatments increased the element mercury capacity of these PACs by 500% to 1000%." *Id.*, 5.

184. In my opinion, Nelson-Provisional discloses all of the elements of Claim 18 of Nelson and supports the subject matter of Nelson relied upon in my unpatentability analysis for the reasons explained above in Paragraphs 164-183. Accordingly, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Nelson-Provisional provides written description support for Nelson and that Nelson is entitled to the May 6, 2002 priority date of Nelson-Provisional.

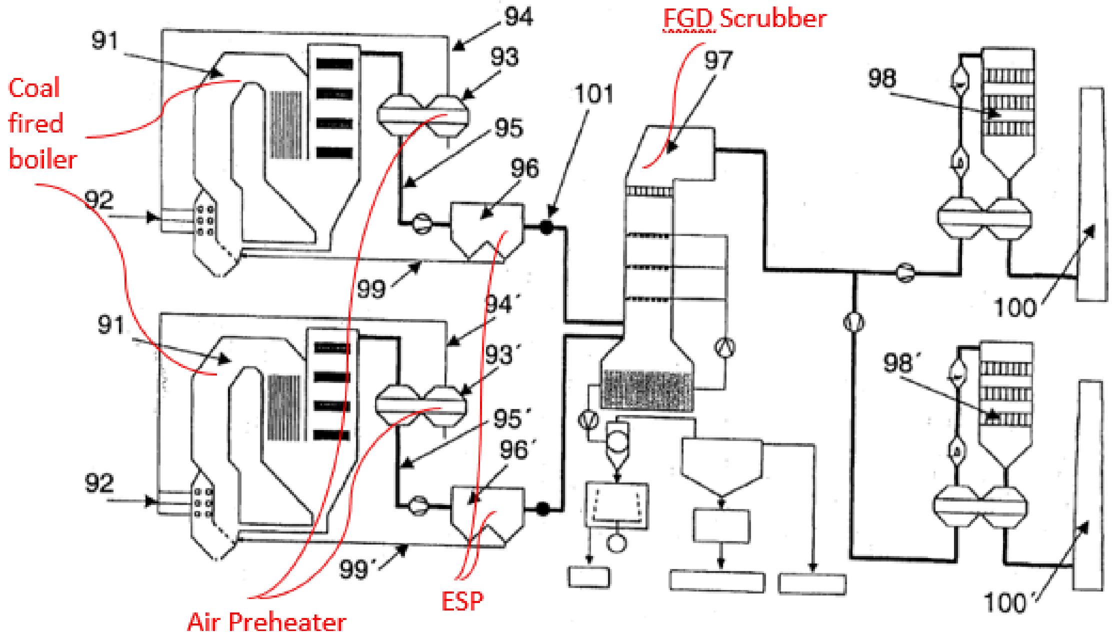
D. Vosteen (U.S. Pat. Pub. No. 2004/0013589) (EX1011)

185. Vosteen, titled a "PROCESS FOR REMOVING MERCURY FROM FLUE GASES," was published by the USPTO on January 22, 2004 from an application filed on July 24, 2002 (U.S. Patent App. No. 10/202,571). Accordingly, I understand that Vosteen qualifies as a prior art published patent application as of its January 22, 2004 publication date and as of its July 24, 2002 filing date, both of which are earlier than the earliest potential priority date of the '225 Patent (August 30, 2004).

186. Vosteen describes "a process for removing mercury from flue gases of high temperature plants, in particular power stations," in a flue gas emission control system downstream of the combustion. EX1011, [0001], [0007]-[0008]. Vosteen notes that at that time, "[p]revious techniques for reduction [of mercury] are not sufficient effective" and were "relatively expensive." *Id.* at [0004]

187. Vosteen discloses that "addition of bromine or bromine compounds to the furnace causes ... a substantial, essentially complete, oxidation of the mercury" allowing "substantially complete removal of mercury (Hg), from flue gases." EX1011, [0005], [0007]. Vosteen describes removing mercury by applying "bromine and/or a bromine compound and/or a mixture of various bromine compounds" directly to the coal, into the "multistage furnace and/or to the flue gas." *Id.*, [0006], [0013].

188. Vosteen reports adding sodium bromide (NaBr), a bromide compound, into coal-fired boilers 91 of a power plant to "demonstrate the effect of bromine on Hg oxidation." EX1011, Example 5, [0047]. Vosteen describes a flue gas emissions control system as known in the art "based either on wet scrubbing or dry cleanup or a combination of the two." EX1011, [0017]. Vosteen exemplifies a boiler flue gas fed through air preheaters 93,93' ESPs 96,96' and FGD scrubber 97 as depicted in the figure reproduced below.



EX1011, Figure 9 (annotations added in red), Example 5, [0047].

189. Vosteen's system includes bromide addition to the coal-fired boilers to oxidize metallic mercury and maximize the proportion of ionic mercury present during combustion. EX1011, [0007], [0049].

190. Vosteen discloses the use of activated carbon and alkaline materials such as lime in the flue gas emissions control system. EX1011, [0019].

191. Vosteen further discusses use of activated carbon as part of a "dry emission control system" for the mercury removal process (a "dry or semi-dry absorption based emission control stage"), and explains that "[m]ercury bromide $HgBr_2$ adsorbs more strongly to dry sorbents than mercury chloride $HgCl_2$." *Id.*, [0016], [0019]-[0020].

192. Vosteen reports that the disclosed processes remove more than 90% of the mercury. EX1011, Figure 5, [0028], [0042].

193. Vosteen also explains that iodine compounds can be used and "oxidize mercury more effectively compared with bromine compounds. However, from economic aspects, bromine compounds are preferably used in the inventive process." EX1011, [0016].

194. Vosteen further states that "ionic mercury is readily water soluble, that is to say it can be scrubbed out, and is readily adsorbable to a range of adsorbents." *Id.* Vosteen describes adding the bromide to "coal or the like to be burnt, upstream of the furnace." EX1011, [0013].

E. Blankinship (Power Engineering Magazine, Vol. 113, Issue 6, June 2009) (EX1012)

195. Blankinship, titled "A Variety of Hg Capture Solutions Are Available," was published in the June 2009 issue of Power Engineering Magazine. Blankinship thus qualifies as prior art if the '225 Patent is entitled to a priority date of May 14, 2015.

196. Blankinship explains that "[o]ne way of enhancing Hg capture from FGD and SCR at power plants that cannot meet their mercury emission limits through co-benefits alone is to treat the coal (which typically for these situations

lacks enough chlorine to force the mercury into a soluble compound) by adding something to it." EX1012, 58.

197. Blankinship explains that "Alstom is attacking Hg from two different approaches that, in some cases, might be used simultaneously. Alstom's KNX pre-combustion offering applies calcium bromide to the coal prior to combustion to promote mercury oxidation." *Id.* This is done because "[i]f you can oxidize the mercury, you can collect it in downstream equipment." *Id.*

198. Blankinship explains that Alstom's KNX™ calcium bromide solution is "added to the boiler or to the coal" pre-combustion in concentrations where it "enhances mercury oxidation without causing other concerns such as corrosion in the boiler." *Id.*, 56, 58. Blankinship also explains that "injecting activated carbon upstream of the FGD to improve its mercury capture performance even more." *Id.*

199. Blankinship further describes Alstom's approach as removing 80–90% mercury from flue gases in coal-fired power plants burning subbituminous or lignite coal by using a bromide compound pre-combustion and activated carbon injection post-combustion "upstream of a particulate control device." *Id.*

200. A MER-CURE™ activated carbon sorbent injection system is used post-combustion to capture mercury on activated carbon particles injected into the flue gas upstream of the air heater to provide "more residence time for the sorbent

to absorb the mercury," reducing "sorbent usage about 50 percent compared to traditional activated carbon systems." *Id.*, 58.

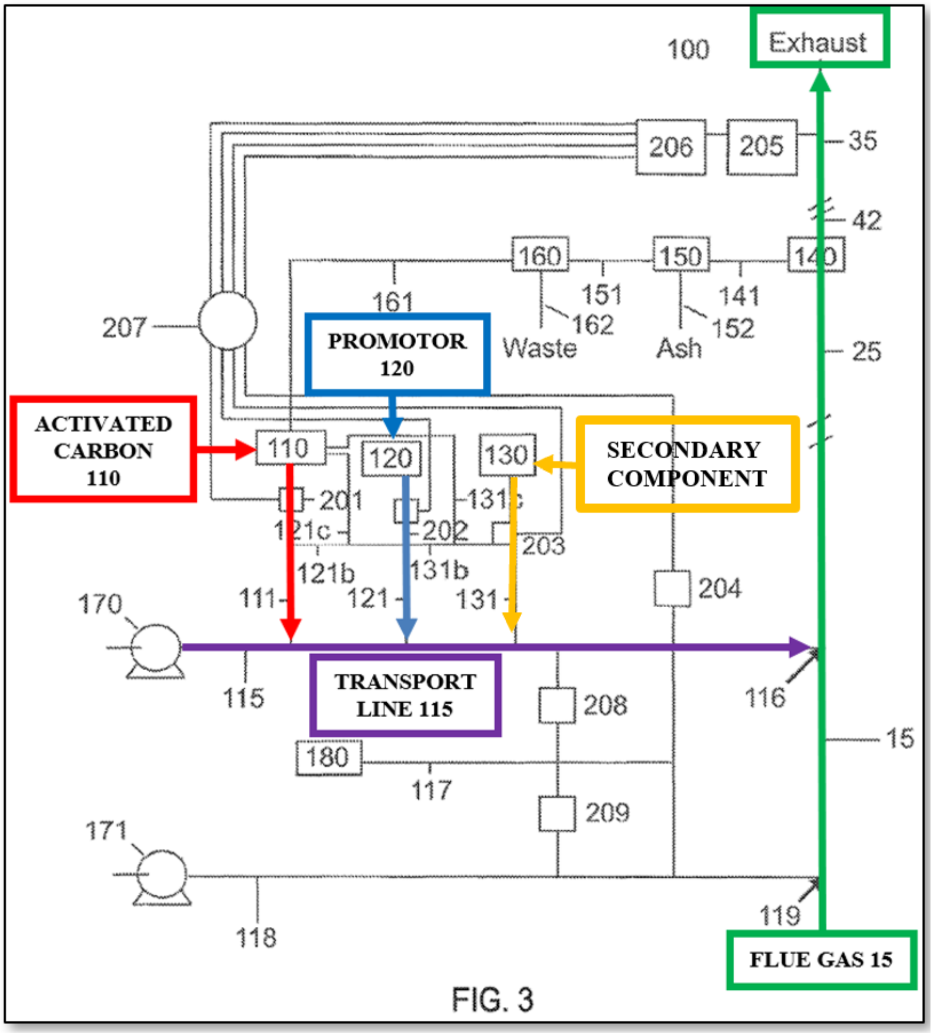
F. Olson-235 (U.S. Patent No. 8,652,235) (EX1013)

201. Olson-235 issued as U.S. Patent 8,652,235 on February 18, 2014 from an application filed on April 23, 2009. EX1013. It is my understanding that Olson-235 qualifies as prior art if the '225 Patent is entitled to a priority date of May 14, 2015.

202. Olson-235 describes a method "for reducing mercury in flue gas comprising providing a base sorbent, either by injection or in situ creation, into a mercury-containing flue gas stream," EX1013, 5:30–36. Olson-235 discloses an embodiment wherein "the injected sorbent is prepared in-flight by reacting a base sorbent (carbon, non-carbon or their combination) and a promoter within a pneumatic transport line from which the reaction product is injected to the mercury-containing flue gas stream." EX1013, 5:43–48. Olson-235 also discloses addition of an alkali, secondary component or mercury-stabilizing reagent to the flue gas to "increase reactivity and mercury capacity." *Id.*, 3:25-35; 4:39-52; 17:5-45.

203. Olson-235 discloses that "the halogen/halide promoter and optional secondary component(s) may preferably be sprayed in solution form into or on the base sorbent." EX1013, 15:26-28. Figure 3 depicts "base sorbent reservoir 110, a halogen/halide promoter reservoir 120, a secondary component reservoir 130, and

an alkali component reservoir 180, each of which with corresponding flow control device(s) 201, 202, 203, and 208/209, respectively … reservoirs 110, 120, 130 and 180 … can be used in any combination." *Id.*, 13:10-26. "One mode of operation, by example, comprises providing base sorbent 110 in a common line which is promoted inline "in-flight" using promoter 120 and/or 130 and injected at point 116" into flue gas 15. *Id.*, 13:56-59. The "secondary component(s) may preferably comprise iodine or other halogens, hydrohalides, including without limitation HI, HBr, HCl, a Group V or Group VI element with a molecular halogen, such as SCl_2." *Id.*, 15:39-43.



EX1013, Figure 3 (annotations added in red, blue, green, purple and yellow).

204. Olson-235 describes a method "whereby a mercury stabilizing reagent is added to a promoted sorbent … stabilizing reagent(s) may be sequentially added, either before or after the addition and reaction of the halogen/halide…. The halogen/halide preferably comprises Br or HBr, and the mercury-stabilizing reagent may comprise S, Se, H_2S, SO_2, H_2Se, SeO_2, CS_2, P_2S_5, and combinations thereof." EX1013, 15:56-63.

205. Olson-235 describes that "promoted sorbent … is injected into contaminated flue gas stream 15." EX1013, 14:30-32, Figure 3. The sorbent of the promoted sorbent can be a "pyrolysis char." *Id.*, 10:51-59.

206. Olson-235 describes "collecting greater than 70 wt % of the mercury in the flue gas on the promoted sorbent to produce a cleaned flue gas." EX1013, 3:25–32, 5:30–36, 7:52–58, 10:51–59.

207. Olson-235 describes "continuous measurement of mercury emissions as feedback to assist in control of the sorbent injection rate. Tighter control on the sorbent … will ensure mercury removal requirements are met with minimal material requirements, thus minimizing the associated costs." EX1013, 20:1-11, 14:20–29. Olson-235 discloses that "the rate at which the promoter is added and the rate of promoted sorbent injection are determined by a digital computer based, at least in part, on the monitored mercury content of the cleaned flue gas." EX1013, 6:15-31.

XI. GROUND 1—CLAIMS 1-2, 5, 7-8, 11-12, 14-15, 17, 19-20, 23 AND 25-29 ARE ANTICIPATED BY DOWNS

208. Based on my review of Downs, and my education, skill, training, and experience in the relevant fields of emission reduction technology, it is my opinion that Claims 1-2, 5, 7-8, 11-12, 14-15, 17, 19-20, 23 and 25-29 are anticipated by

Downs. In the subsections that follow, I explain the bases for my opinion that Claims 1-2, 5, 7-8, 11-12, 14-15, 17, 19-20, 23 and 25-29 are anticipated by Downs.

209. As discussed above in Section X(E)(2), it is my opinion that the Downs-Provisional supports all of the subject matter in Downs that I discuss and rely upon below in forming my opinions regarding Ground 1. Accordingly, I have included citations to both Downs and Downs-Provisional where appropriate in the subsections that follow. As an example, Downs-Provisional does not have any claims, whereas Downs does have claims. Accordingly, there is no corollary in Downs-Provisional to cite for a claim in Downs.

210. As also explained above, it is my opinion that the Downs-Provisional supports at least claim 1 of Downs. It is therefore my understanding that Downs has a priority date of March 22, 2004 and is prior art to the ‘225 Patent regardless of whether the ‘225 Patent is entitled to a May 14, 2015 priority date or the August 30, 2004 filing date of the Provisional.

A. Independent Claim 1

1. Element 1(Preamble)–“A method for treating a mercury-containing gas, the method comprising:”

211. The title of Downs is “Bromine Addition for the Improved Removal of Mercury from Flue Gas.” EX1004; EX1005. As discussed throughout this

Declaration, flue gas is an example of a mercury-containing gas. And removal of mercury from a flue gas would plainly reduce the amount of mercury in the gas.

212. Downs further discloses that "the use of bromine-containing compounds, added to the coal, or to the boiler combustion furnace, are significantly more effective than chlorine-containing compounds in enhancing the oxidation of mercury, thereby enhancing the overall removal of mercury in downstream pollution control devices." EX1004, [0007]; EX1005, [0009].

213. Downs also explains that "the current invention can offer a cost-effective method of removing elemental mercury from coal combustion flue gases." EX1004, [0018]; EX1005, [0021].

214. Claim 1 of Downs is similarly directed to "[a] method of removing a portion of the elemental mercury in a flue gas created during the combustion of a fossil fuel …" EX1004, Claim 1.

215. Downs, in my opinion, discloses the preamble of claim 1 as Downs discloses methods for treating a mercury-containing gas by reducing its mercury content for the reasons explained above in Paragraphs 211-214.

2. Element 1(a)–"combusting a mixture comprising coal, pyrolysis char, and an additive comprising HBr, a bromide

compound, or a combination thereof, to form the mercury-containing gas; and"

216. Downs discloses that "Mercury appears in coal combustion flue gases in both solid and gas phases (particulate-bound mercury and vapor-phase mercury, respectively)." EX1004, [0002]; EX1005, [0003].

217. Downs discloses a "bromine-containing reagent 10 is added to the boiler 12 combustion furnace 14, either directly or by premixing with the incoming coal 16." EX1004, [0015], [0021]; EX1005, [0018], [0024].

218. Downs further discloses that "[t]he present inventors have determined through experimental testing that the use of bromine-containing compounds, added to the coal, or to the boiler combustion furnace, are significantly more effective than chlorine-containing compounds in enhancing the oxidation of mercury, thereby enhancing the overall removal of mercury in downstream pollution control devices." EX1004, [0007]; EX1005, [0009].

219. Downs further discloses test data illustrating the effect of calcium bromine on the total vapor phase mercury produced during the combustion of coal. EX1004, [0011], [0018], Fig. 3; EX1005, [0013], Fig. 3.

220. Downs also discloses that the "bromine-containing reagent 10 could comprise, but is not limited to, alkali metal and alkaline metal bromides, hydrogen bromide (HBr) or bromine (Br_2)." EX1004, [0021]; EX1005, [0024].

221. Downs further explains that "[i]n the preferred embodiment, an aqueous solution of calcium bromide is sprayed onto the crushed coal 16 before the coal 16 is pulverized for combustion. The aqueous solution is easily handled and metered onto the coal 16, **coal pulverizers 28 intimately mix the bromide reagent 10 with the coal 16**, and the pulverized coal conveying system 30 to the several coal burners (not shown) ensures an even distribution of the reagent 10 across the boiler furnace 14." EX1004, [0019]; EX1005, [0022] (emphasis added). Julien discloses that when calcium bromide is added to a coal combustor, "[f]ree energy calculations suggest that complete decomposition of CaBr2 to HBr and CaO in the presence of water vapour is favoured over the full range of temperatures in the [circulating fluidized bed combustor] CFBC." EX1014, 1658. Thus, HBr is in vapor or gaseous form in the mercury-containing flue gas after combustion of a bromide compound such as calcium bromide or sodium bromide.

222. Pyrolysis char is necessarily present when coal is combusted. EX1087, 673 ("pyrolysis, even under the most favorable conditions, includes the formation of … residual char"). Thus, a mixture of coal, pyrolysis char and the bromine additive is necessarily present in Downs' combustion.

223. Downs, in my opinion, discloses combusting a mixture comprising coal, pyrolysis char, and an additive comprising HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas for the reasons explained

above in Paragraphs 216-222. EX1004, [0002], [007], [0011], [0015], [0018], Fig. 3, [0019], [0021]; EX1005, [0003], 0009], [0013], Fig. 3, [0022], [0024].

3. Element 1(b) –"adding a particulate sorbent material comprising activated carbon into the mercury-containing gas."

224. Downs discloses using a powdered activated carbon (PAC) sorbent injection system to remove mercury from coal combustion flue gas via particulate collectors such as ESPs or fabric filters. EX1004, [0004], [0015]–[0016], [0023], [0025], claims 15–16; EX1005, [0005], [0018], [0026] [0028].

225. For example, Downs discloses that "[t]he increased fraction of mercury appearing in the oxidized form enhances mercury removal in downstream pollution control systems such as wet 22 and SDA 24 FGD systems, and PAC injection systems. As is described herein, experimental results indicate that bromine addition also results in an increased fraction of particulate bound mercury. This enhances removal of mercury across particulate collectors 26 such as fabric filters (FF) and electrostatic precipitators (ESP)." EX1004, [0015]; EX1005, [0018].

226. Downs further explains that a benefit of its invention is that "the increased fraction of oxidized mercury also enhances the removal of mercury across a PAC injection process, due to the higher reactivity of oxidized mercury with PAC." EX1004, [0016]; EX1005, [0019].

227. Downs describes "injection of a carbonaceous sorbent (e.g., powdered activated carbon, or PAC) into the flue gas … to adsorb vapor-phase mercury" and that the "sorbent, and its burden of adsorbed mercury, are subsequently removed from the flue gases in a downstream particulate collector." EX1004, [0004]; EX1005, [0005].

228. Downs therefore, in my opinion, discloses adding a particulate sorbent material comprising activated carbon into the mercury-containing gas for the reasons explained above in Paragraphs 224-227. EX1004, [0004], [0015], [0016], [0023], [0025], Claims 15-16; EX1005, [0005], [0018], [0019], [0026], [0028].

229. As established above, Downs discloses every element of Claim 1 of the '225 Patent. It is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Downs anticipates Claim 1.

B. Claims Depending From Claim 1

1. Claim 2–"the pyrolysis char is a promoted pyrolysis char."

230. According to PO's expert in the Delaware litigation, "pyrolysis char forms in the presence of bromine that has been added to the coal. Thus, it is promoted pyrolysis char." EX1083, 163.

231. Because Downs discloses every element of Claim 1, and PO's expert admits that a promoted pyrolysis char is necessarily present during combusting of

coal and bromine, it is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Downs anticipates Claim 2 for the reasons explained above in Paragraph 230. EX1083, 163.

2. Claim 5—"using a particle separation device to remove mercury from the flue gas and comprising collecting greater than 70 wt % of the mercury in the mercury-containing gas to produce a cleaned gas."

232. Downs' Figure 3 reports reducing vapor-phase mercury by 77% from 9 µg/dscm mercury at fabric filter (FF)-inlet to 2 µg/dscm mercury at FF-outlet:

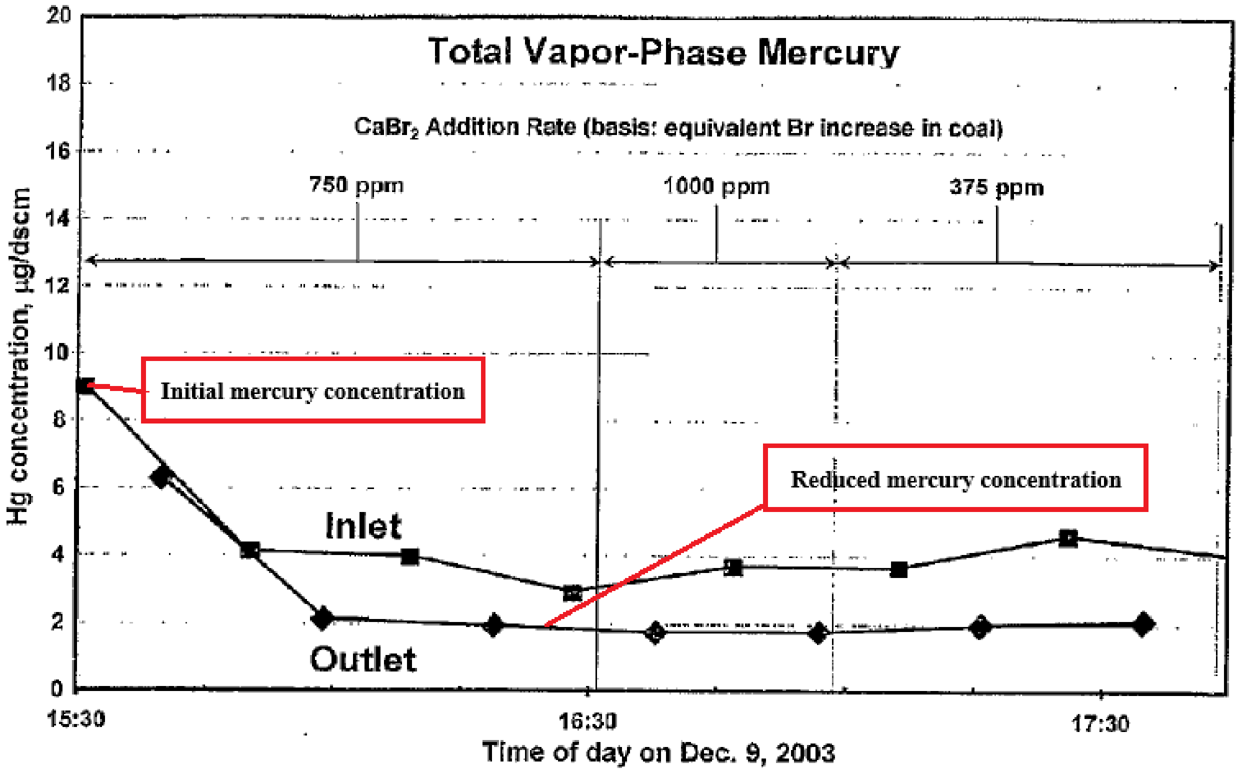


FIG. 3

EX1004, Figure 3, [0018]; EX1005, Figure 3, [0021] (red annotations added).

233. Downs further explains that "These results identify that the current invention can offer a cost-effective method of removing elemental mercury from coal combustion flue gases." EX1004, [0015], [0018]; EX1005, [0018], [0021]. Downs further explains that "[t]he increased fraction of mercury appearing in the oxidized form enhances mercury removal in downstream pollution control systems such as wet 22 and SDA 24 FGD systems, and PAC injection systems. As is described herein, experimental results indicate that bromine addition also results in an increased fraction of particulate bound mercury. This enhances removal of mercury across particulate collectors 26 such as fabric filters (FF) and electrostatic precipitators (ESP)." EX1004, [0015]; EX1005, [0018].

234. Downs also states that in "another embodiment mercury removal may be further enhanced by utilizing an sorbent injection system in conjunction with the present invention. Such carbonaceous sorbents include, but are not limited to, powdered activated carbon (PAC), carbons and chars produced from coal and other organic materials, and unburned carbon produced by the combustion process itself. EX1004, [0025]; EX1005, [0028].

235. Downs further explains that a benefit of its invention is that "the increased fraction of oxidized mercury also enhances the removal of mercury across a PAC injection process, due to the higher reactivity of oxidized mercury with PAC." EX1004, [0016]; EX1005, [0019].

236. Downs also explains that studies have focused on "injection of a carbonaceous sorbent (e.g., powdered activated carbon, or PAC) into the flue gas upstream of the dust collector to adsorb vapor-phase mercury. The sorbent, and its burden of adsorbed mercury, are subsequently removed from the flue gases in a downstream particulate collector. Adsorption is a technique that has often been successfully applied for the separation and removal of trace quantities of undesirable components." EX1004, [0004]; EX1005, [0005].

237. A POSITA would have known that the EPA had by 2004 already put the industry on notice of upcoming laws and regulations requiring 70% mercury removal, including EPA's Clean Air Mercury Rule (CAMR). EX1045. A POSITA thus would have known that any mercury control system would have to comply with these laws and regulations.

238. As Downs teaches that its system captures in excess of 70 wt % mercury in the flue gas, and that a sorbent used in the system is activated carbon, the mercury captured in the mercury-containing gas is collected with the sorbent. That is, simply stated, the purpose of the activated carbon in such a system.

239. Because Downs discloses every element of Claim 1 and that the mercury removal is greater than 70 wt % across a fabric filter particulate separation device to produce a clean flue gas as required by Claim 5, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission

reduction technology, that Downs anticipates Claim 5 for the reasons explained above in Paragraphs 232-238. EX1004, Figure 3, [0015], [0018], [0025]; EX1005, Figure 3, [0018], [0021]; [0028].

3. Claim 7–"the additive further comprises Br_2."

240. Downs describes the "use of bromine-containing compounds, added to the coal, or to the boiler combustion furnace." EX1004, [0007]; EX1005, [0009]. The bromine-containing compounds can comprise "alkali metal and alkaline earth metal bromides, hydrogen bromide (HBr) or bromine (Br_2)." EX1004, [0021]; EX1005, [0024].

241. Because Downs discloses every element of Claim 1, and further teaches that bromide compounds, including HBr and Br_2 can be added to coal or the combustor, it is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Downs anticipates Claim 7 for the reasons explained above in Paragraph 240. EX1004, [0007], [0021]; EX1005, [0009], [0024].

4. Claim 8–"the sorbent material is chosen from powdered activated carbon, granular activated carbon, carbon black, carbon fiber, aerogel carbon, pyrolysis char, and combinations thereof."

242. Downs discloses using a powdered activated carbon (PAC) sorbent injection system to remove mercury from coal combustion flue gas via particulate

collectors such as ESPs or fabric filters. EX1004, [0004], [0015]–[0016], [0025], claims 15–16; EX1005, [0005], [0018], [0028].

243. Because Downs discloses every element of Claim 1 and at least one of the types of activated carbon required by Claim 8, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Downs anticipates Claim 8.

5. Claim 11–"further comprising contacting the sorbent material with a secondary component chosen from halogens, hydrogen halides, Group V halides, Group VI halides, and combinations thereof."

Claim 12–"the secondary component is chosen from halogens, halide salts, HI, HBr, HCl, and combinations thereof."

244. Julien discloses that "94-99% of the chlorine in coal is volatilized and emitted as gaseous HCl during pulverized firing." EX1014, 165; EX1072, 199 (Table 1). Thus, coal-fired power plant flue gas necessarily contains HCl that would contact the sorbent.

245. Because Downs discloses every element of Claim 1, and coal-fired power plant flue gas necessarily contains HCl that would contact the sorbent as evidenced by Julien, it is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that

Downs anticipates Claims 11-12 for the reasons explained above in Paragraph 244. EX1014, 165; EX1072, 199 (Table 1).

6. Claim 19–"the coal comprises added sorbent enhancement additive that comprises the bromide compound."

246. The '225 Patent does not define the term "sorbent enhancement additive." The term is used only once outside of the claims, and that single use states: "This invention provides for cost-effective removal of pollutants including mercury, using sorbent enhancement additives and/or highly reactive sorbents." EX1001, 2:24-28.

247. I assume for purposes of my analysis that the "sorbent enhancement additive" refers to the "additive comprising HBr, a bromide compound, or a combination thereof" in element 1(a) of Claim 1. As discussed above regarding claim element 1(a), Downs discloses several forms of bromine applied to the coal, including sodium bromide, alkaline metal bromides, hydrogen bromide (HBr) or bromine (Br_2). EX1004, [0011], [0018], [0021] Fig. 3; EX1005, [0013], [0024], Fig. 3. Downs further discloses that in a preferred embodiment, "an aqueous solution of calcium bromide is sprayed onto the crushed coal before the coal is pulverized for combustion." EX1004, [0016]; EX1005, [0019].

248. Downs further discloses that "[t]he present inventors have determined through experimental testing that the use of bromine-containing compounds, added

to the coal, or to the boiler combustion furnace, are significantly more effective than chlorine-containing compounds in enhancing the oxidation of mercury, thereby enhancing the overall removal of mercury in downstream pollution control devices." EX1004, [0007]; EX1005, [0009].

249. Downs further discloses test data illustrating the effect of calcium bromide on the total vapor phase mercury produced during the combustion of coal. EX1004, [0011], [0018], Fig. 3; EX1005, [0013], Fig. 3.

250. Downs further discloses the use of a "sorbent injection system in conjunction with the present invention" in which PAC, for example, is used as it "enhances the removal of mercury across a PAC injection process, due to the higher reactivity of oxidized mercury with PAC." EX1004, [0016]; EX1005, [0019]. Downs thus makes clear that the bromine containing reagents enhance the ability of the PAC as a sorbent.

251. Because Downs discloses every element of Claim 1, and further teaches that the bromide compound is a sorbent enhancement additive that is applied to the coal, it is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Downs anticipates Claim 19 for the reasons explained above in Paragraphs 246-250. EX1004, [0007], [0011], [0016], [0018], [0021], Fig. 3; EX1005, [0009], [0013], [0019], [0024], Fig. 3.

7. Claim 20—"the coal is combusted in a combustion chamber at a coal-combustion facility, wherein the HBr, bromide compound, or combination thereof, is added to the coal before the coal enters the combustion chamber, wherein the addition of the HBr, bromide compound, or combination thereof, to the coal is performed at the coal-combustion facility."

252. As discussed above regarding Claim 1, Downs explains that "[i]n the preferred embodiment, an aqueous solution of calcium bromide is sprayed onto the crushed coal 16 before the coal 16 is pulverized for combustion. The aqueous solution is easily handled and metered onto the coal 16, coal pulverizers 28 intimately mix the bromide reagent 10 with the coal 16, and the pulverized coal conveying system 30 to the several coal burners (not shown) ensures an even distribution of the reagent 10 across the boiler furnace 14." EX1004, [0019]; EX1005, [0022].

253. Downs states that other bromine containing reagents can be used as well, such "alkaline metal bromides, hydrogen bromide (HBr) or bromine (Br_2)." EX1004, [0021]; EX1005, [0024].

254. This process is shown in Figure 2, as the bromine-containing reagent is depicted being added to the coal at Addition Point A:

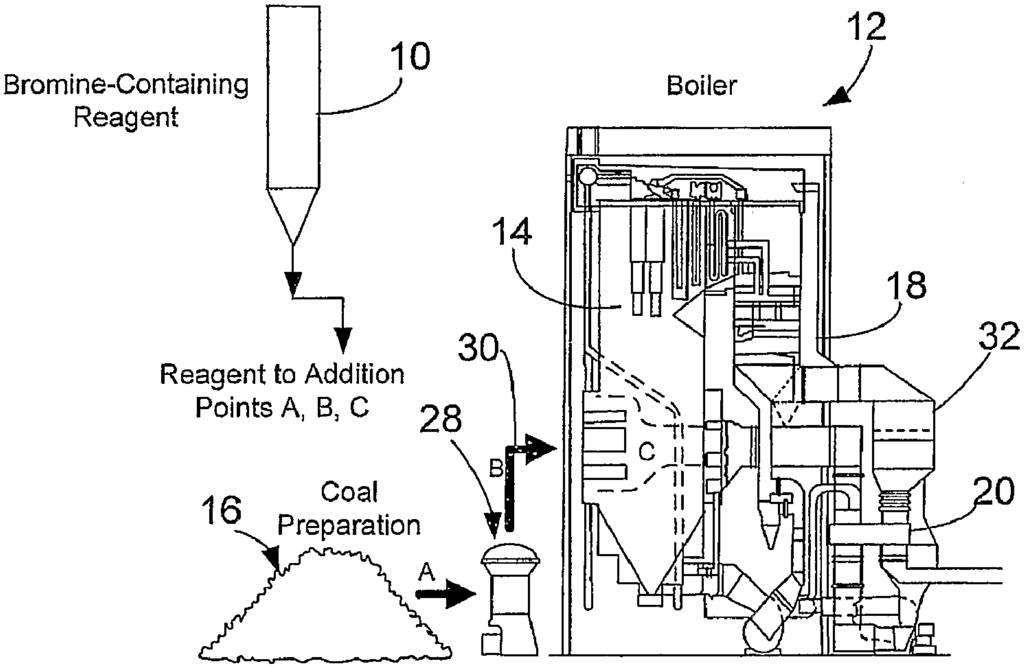


FIG. 2

255. In describing Figure 2, Downs states that "[a] bromine-containing reagent 10 is added to the boiler 12 combustion furnace 14, either directly or by premixing with the incoming coal 16. Bromine species released during the combustion process enhance the oxidation of mercury as the combustion gases pass through the furnace 14 and, in particular, through the cooler sections of the boiler convection pass 18 and combustion air preheater 20." EX1004, [0015]; EX1005, [0018].

256. Downs further explains that "[t]he present invention promises to significantly reduce the cost of mercury removal at coal-fired electric plants."

EX1004, [0016]; EX1005, [0019]. A coal-fired electric plant is a coal-combustion facility.

257. Because Downs discloses every element of Claim 1 and specifically teaches that the coal is combusted at a coal-combustion facility, and that the Br_2, HBr, bromide compound, or combination thereof, is added to the coal at the coal combustion facility before the coal enters the combustion chamber as required by Claim 20, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Downs anticipates Claim 20 for the reasons explained above in Paragraphs 252-256. EX1004, Fig. 2, [0015], [0016, [0019], [0021]; EX1005, [0018], [0019], [0022], [0024].

8. Claim 23–"the sorbent is free of contact with a halogen or halide promoter prior to the addition of the sorbent to the mercury-containing gas."

258. Nowhere does Downs describe contacting a sorbent, such as PAC, with a halogen or halide promoter prior to injection into the flue gas. EX1004; EX1005.

259. Downs instead states that, with regard to at least one embodiment, the sorbent is injected via a separate system:

> mercury removal may be further enhanced by utilizing a sorbent injection system in conjunction with the present invention. Such carbonaceous sorbents include, but are not limited to, powdered activated carbon (PAC), carbons and chars produced from coal and other organic materials, and unburned carbon produced by the combustion process itself.

EX1004, [0025]; EX1005, [0028].

260. In my opinion, a POSITA at the time of the invention had reason to select halogen-free activated carbon due to its lower cost as compared to halogen-promoted activated carbons especially where sufficient mercury removal can be achieved without resorting to halogen-promoted activated carbons as in Downs.

261. Because Downs discloses every element of Claim 1 and because a POSITA would understand that PAC or other sorbents are injected prior to being contacted by a halogen or halide promoter, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Downs anticipates Claim 23 for the reasons explained above in Paragraphs 258-260. EX1004; EX1005.

9. Claim 25— "the coal comprises subbituminous coal."

262. Downs explains that tests performed by the inventors used "a western U.S. subbituminous coal." EX1004, [0017]; EX1005, [0020]. Downs further states that "the coal-fired boiler fuel 16 may include bituminous, subbituminous, and lignite coals and blends thereof." EX1004, [0020]; EX1005, [0023].

263. Because Downs discloses every element of Claim 1 and specifically teaches that the disclosed methods can be "most attractive" for subbituminous coal, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Downs anticipates Claim 25

for the reasons explained in Paragraph 262. EX1004, [0017], [0020]; EX1005, [0020], [0023].

10. Claim 26— "the coal comprises lignite coal."

264. As discussed above for Claim 25, Downs discloses that "the coal-fired boiler fuel 16 may include bituminous, subbituminous, and lignite coals and blends thereof." EX1004, [0020]; EX1005, [0023].

265. Because Downs discloses every element of Claim 1 and specifically teaches that the disclosed methods can be used for lignite coal as well, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Downs anticipates Claim 26 for the reasons explained in Paragraph 264. EX1004, [0020]; EX1005, [0023].

11. Claim 27–"the mixture is combusted in a combustion chamber of a coal-combustion facility upstream of a scrubber, a particulate control system, or a combination thereof, wherein the particulate sorbent is added to the mercury-containing gas before the mercury-containing gas encounters the scrubber, the particulate control system, or the combination thereof."

266. Figure 6 of Downs, reproduced below, depicts "a schematic illustration of a coal-fired electric utility plant configuration comprising a boiler equipped with a downstream particulate collection means such as a fabric filter (FF) or an electrostatic precipitator (ESP) and a wet flue gas desulfurization (FGD) system." EX1004, [0014]; EX1005, [0016]. Downs describes "sorbent … removed from the

flue gases in a downstream particulate collector" 26 such as an ESP or FF, or a wet FGD system 22. EX1004, [0004], [0015], [0023], Figures 4–6; EX1005, [0005], [0018], [0026], Figures 4–6.

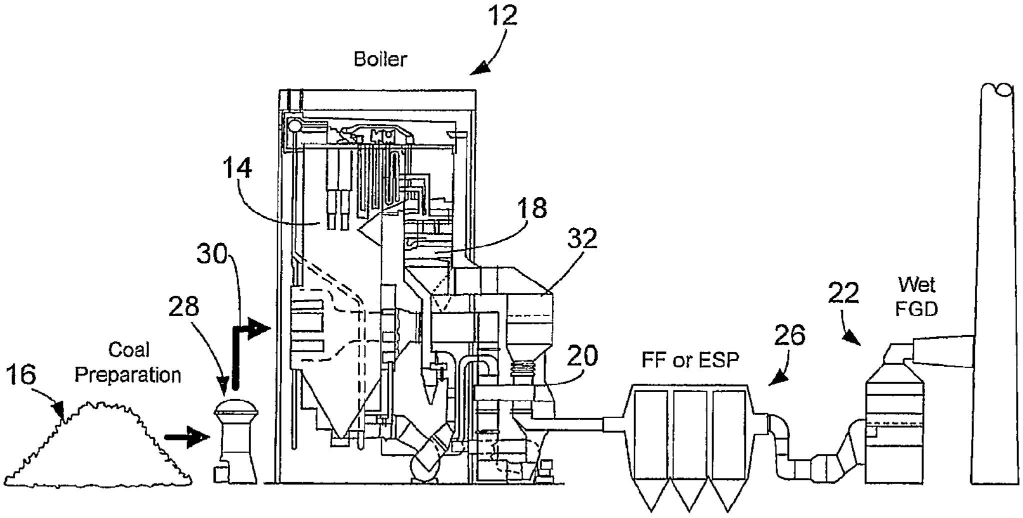


FIG. 6

267. Downs further discloses that "injection of a carbonaceous sorbent (e.g., powdered activated carbon, or PAC) into the flue gas upstream of the dust collector to adsorb vapor-phase mercury. The sorbent, and its burden of adsorbed mercury, are subsequently removed from the flue gases in a downstream particulate collector." EX1004, [0004]; EX1005, [0005].

268. As the sorbent is "subsequently" removed in a "downstream" particulate collector such as an ESP and/or wet FGD, the sorbent was necessarily injected upstream of the particulate collector.

269. Because Downs discloses every element of Claim 1 and further teaches that the PAC sorbent can be injected upstream of a particular separator or scrubber, it is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Downs anticipates Claim 27 for the reasons explained above in Paragraphs 266-268. EX1004, [0004], [0014], [0015], [0023], Figs. 4-6; EX1005, [0005], [0016], [0018], [0026], Figs. 4-6.

12. Claim 28–"the particulate control system comprises an electrostatic precipitator, a baghouse, a fabric filter, or a combination thereof."

270. Claim 28 depends from Claim 26 and requires that the particulate control system comprises an ESP, a baghouse, a fabric filter, or a combination thereof.

271. As discussed above regarding Claim 27, Downs discloses an ESP, a baghouse, and a fabric filter. EX1004, [0003], [0015], [0023], Figs. 4-6; EX1005, [0004], Figs. 4-6. These are examples of particulate control systems as Claim 28 itself recognizes.

272. Because Downs discloses every element of Claim 1 and Claim 26, and further teaches that the particulate control system can be an ESP, baghouse, or fabric filter, it is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Downs

anticipates Claim 28 for the reasons explained above in Paragraphs 270-271. EX1004, [0003], [0015], [0023], Figs. 4-6; EX1005, [0004], Figs. 4-6.

13. Claim 29–“the combustion chamber is a coal combustion furnace.”

273. Again, Downs explains that “[t]he present invention promises to significantly reduce the cost of mercury removal at coal-fired electric plants.” EX1004, [0016]; EX1005, [0019]. Downs also describes and depicts coal-fired electric utility plants having a combustion furnace. EX1004, [0012]–[0015]; EX1005, [0014]–[0018].

274. Because Downs discloses every element of Claim 1 and specifically teaches that discloses processes are used at a coal-fired electric plant with a combustion furnace, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Downs anticipates Claim 29 for the reasons explained above in Paragraph 273. EX1004, [0012]–[0016]; EX1005, [0014]–[0019].

C. Independent Claim 14

275. Claim 14 is similar to Claim 1 discussed above, with one difference. Claim 14 replaces “combusting a mixture comprising coal,” with “combusting coal in a combustor comprising”.

276. As explained above regarding Claims 1 and 19, Downs discloses adding bromide reagents, such as HBr, Br_2, and/or calcium bromide, to the coal before combustion or directly to the combustion chamber.

277. As a result, and explained in more detail below, it is my opinion that, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Downs anticipates Claim 14.

1. Element 14(Preamble)–"A method for treating a mercury-containing gas, the method comprising:"

278. The title of Downs is "Bromine Addition for the Improved Removal of Mercury from Flue Gas." EX1004; EX1005. As discussed throughout this Declaration, flue gas is an example of a mercury-containing gas. And removal of mercury from a flue gas would plainly reduce the amount of mercury in the gas.

279. For example, Downs further discloses that "the use of bromine-containing compounds, added to the coal, or to the boiler combustion furnace, are significantly more effective than chlorine-containing compounds in enhancing the oxidation of mercury, thereby enhancing the overall removal of mercury in downstream pollution control devices." EX1004, [0007]; EX1005, [0009].

280. Downs also explains that "the current invention can offer a cost-effective method of removing elemental mercury from coal combustion flue gases." EX1004, [0018]; EX1005, [0021].

281. Claim 1 of Downs is similarly directed to "[a] method of removing a portion of the elemental mercury in a flue gas created during the combustion of a fossil fuel …" EX1004, Claim 1. "[R]emoving a portion of the elemental mercury" from the flue gas is a method of separating mercury from the gas.

282. Downs, in my opinion, discloses the preamble of claim 14 as Downs discloses methods for treating a mercury-containing gas by reducing its mercury content for the reasons explained above in Paragraphs 278-281. EX1004, [0001], [0004], [0007], [0015]-[0016], [0018], [0025], claims 15-16; EX1005, [0005], [0009], [0018-0019], [0021], [0028]. This preamble is the same as claim 1.

2. Element 14(a)–"combusting coal in a combustor comprising pyrolysis char and an additive comprising HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas; and"

283. Downs discloses that "[t]he present inventors have determined through experimental testing that the use of bromine-containing compounds, added to the coal, or to the boiler combustion furnace, are significantly more effective than chlorine-containing compounds in enhancing the oxidation of mercury, thereby enhancing the overall removal of mercury in downstream pollution control devices." EX1004, [0007]; EX1005, [0009].

284. Downs further explains that "[i]n the preferred embodiment, an aqueous solution of calcium bromide is sprayed onto the crushed coal 16 before the

coal 16 is pulverized for combustion. The aqueous solution is easily handled and metered onto the coal 16, coal pulverizers 28 intimately mix the bromide reagent 10 with the coal 16, and the pulverized coal conveying system 30 to the several coal burners (not shown) ensures an even distribution of the reagent 10 across the boiler furnace 14." EX1004, [0019]; EX1005, [0022].

285. Pyrolysis char is necessarily present when coal is combusted. EX1087, 673 ("pyrolysis, even under the most favorable conditions, includes the formation of … residual char"). Thus, a mixture of coal, pyrolysis char and the bromine additive is necessarily present in Downs' combustion.

286. Downs further discloses that a "bromine-containing reagent 10 is added to the boiler 12 combustion furnace 14, either directly or by premixing with the incoming coal 16." EX1004, [0015], [0021]; EX1005, [0018], [0024].

287. Downs also discloses that the "bromine-containing reagent 10 could comprise, but is not limited to, alkali metal and alkaline metal bromides, hydrogen bromide (HBr) or bromine (Br_2)." EX1004, [0021]; EX1005, [0024].

288. Downs, in my opinion, discloses combusting coal in a combustor comprising pyrolysis char and an additive comprising HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas for the reasons explained above in Paragraphs 283-287. EX1004, [0002], [007], [0011], [0015], [0018], Fig. 3, [0019], [0021]; EX1005, [0003], 0009], [0013], Fig. 3, [0022], [0024].

3. Element 14(b) –"adding a particulate sorbent material comprising activated carbon into the mercury-containing gas."

289. This limitation is the same as claim element 1(b).

290. Downs discloses using a powdered activated carbon (PAC) sorbent injection system to remove mercury from coal combustion flue gas via particulate collectors such as ESPs or fabric filters. EX1004, [0004], [0015]–[0016], [0025], claims 15–16; EX1005, [0005], [0018], [0028].

291. For example, Downs discloses that "[t]he increased fraction of mercury appearing in the oxidized form enhances mercury removal in downstream pollution control systems such as wet 22 and SDA 24 FGD systems, and PAC injection systems. As is described herein, experimental results indicate that bromine addition also results in an increased fraction of particulate bound mercury. This enhances removal of mercury across particulate collectors 26 such as fabric filters (FF) and electrostatic precipitators (ESP)." EX1004, [0015]; EX1005, [0018].

292. Downs further explains that a benefit of its invention is that "the increased fraction of oxidized mercury also enhances the removal of mercury across a PAC injection process, due to the higher reactivity of oxidized mercury with PAC." EX1004, [0016]; EX1005, [0019].

293. Downs therefore, in my opinion, discloses methods for treating a mercury-containing flue gas by adding a sorbent that is an activated carbon into the

flue gas. EX1004, [0004], [0015]-[0016], [0023], [0025], Claims 15-16; EX1005, [0005], [0018]-[0019], [0026], [0028].

294. As established above, Downs discloses every element of Claim 14 of the ‘225 Patent. It is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Downs anticipates Claim 14 for the reasons explained above in Paragraphs 289-293. EX1004, [0004], [0015], [0016], [0023], [0025], Claims 15-16; EX1005, [0005], [0018], [0019], [0026], [0028].

D. Claim 15–“the pyrolysis char is a promoted pyrolysis char.”

295. According to PO’s expert in the Delaware litigation, “pyrolysis char forms in the presence of bromine that has been added to the coal. Thus, it is promoted pyrolysis char.” EX1083, 163.

296. Because Downs discloses every element of Claim 14, and PO’s expert admits that a promoted pyrolysis char is necessarily present during combusting of coal and bromine, it is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Downs anticipates Claim 15 for the reasons explained above in Paragraph 295. EX1083, 163.

E. Independent Claim 17

297. Claim 17 is nearly identical to Claim 1 discussed above, with one difference. Claim 17 does not require the "sorbent material" to be "a particulate sorbent material."

298. As explained above regarding Claims 1 and 19, Downs discloses adding powdered activated carbon sorbent to flue gas.

299. As a result, and explained in more detail below, it is my opinion that, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Downs anticipates Claim 17.

1. Element 17(Preamble)–"A method for treating a mercury-containing gas, the method comprising:"

300. The title of Downs is "Bromine Addition for the Improved Removal of Mercury from Flue Gas." EX1004; EX1005. As discussed throughout this Declaration, flue gas is an example of a mercury-containing gas. And removal of mercury from a flue gas would plainly reduce the amount of mercury in the gas.

301. For example, Downs further discloses that "the use of bromine-containing compounds, added to the coal, or to the boiler combustion furnace, are significantly more effective than chlorine-containing compounds in enhancing the oxidation of mercury, thereby enhancing the overall removal of mercury in downstream pollution control devices." EX1004, [0007]; EX1005, [0009].

302. Downs also explains that "the current invention can offer a cost-effective method of removing elemental mercury from coal combustion flue gases." EX1004, [0018]; EX1005, [0021].

303. Claim 1 of Downs is similarly directed to "[a] method of removing a portion of the elemental mercury in a flue gas created during the combustion of a fossil fuel …" EX1004, Claim 1. "[R]emoving a portion of the elemental mercury" from the flue gas is a method of separating mercury from the gas.

304. Downs, in my opinion, discloses the preamble of claim 17 as Downs discloses methods for treating a mercury-containing gas by reducing its mercury content for the reasons explained above in Paragraphs 300-303. EX1004, [0001], [0004], [0007], [0015]-[0016], [0018], [0025], claims 15-16; EX1005, [0005], [0009], [0018-0019], [0021], [0028]. This preamble is the same as claim 1.

2. Element 17(a)–"combusting a mixture comprising coal, pyrolysis char, and an additive comprising HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas; and"

305. Downs discloses that "[t]he present inventors have determined through experimental testing that the use of bromine-containing compounds, added to the coal, or to the boiler combustion furnace, are significantly more effective than chlorine-containing compounds in enhancing the oxidation of mercury, thereby

enhancing the overall removal of mercury in downstream pollution control devices." EX1004, [0007]; EX1005, [0009].

306. Downs further explains that "[i]n the preferred embodiment, an aqueous solution of calcium bromide is sprayed onto the crushed coal 16 before the coal 16 is pulverized for combustion. The aqueous solution is easily handled and metered onto the coal 16, coal pulverizers 28 intimately mix the bromide reagent 10 with the coal 16, and the pulverized coal conveying system 30 to the several coal burners (not shown) ensures an even distribution of the reagent 10 across the boiler furnace 14." EX1004, [0019]; EX1005, [0022].

307. Pyrolysis char is necessarily present when coal is combusted. EX1087, 673 ("pyrolysis, even under the most favorable conditions, includes the formation of … residual char"). Thus, a mixture of coal, pyrolysis char and the bromine additive is necessarily present in Downs' combustion.

308. Downs further discloses that a "bromine-containing reagent 10 is added to the boiler 12 combustion furnace 14, either directly or by premixing with the incoming coal 16." EX1004, [0015], [0021]; EX1005, [0018], [0024].

309. Downs also discloses that the "bromine-containing reagent 10 could comprise, but is not limited to, alkali metal and alkaline metal bromides, hydrogen bromide (HBr) or bromine (Br_2)." EX1004, [0021]; EX1005, [0024].

310. Downs, in my opinion, discloses combusting a mixture comprising coal, pyrolysis char, and an additive comprising HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas for the reasons explained above in Paragraphs 305-309. EX1004, [0002], [007], [0011], [0015], [0018], Fig. 3, [0019], [0021]; EX1005, [0003], 0009], [0013], Fig. 3, [0022], [0024]. This limitation is the same as claim element 1(a).

3. Element 17(b) –"adding a sorbent material comprising activated carbon into the mercury-containing gas."

311. Downs discloses using a powdered activated carbon (PAC) sorbent injection system to remove mercury from coal combustion flue gas via particulate collectors such as ESPs or fabric filters. EX1004, [0004], [0015]–[0016], [0025], claims 15–16; EX1005, [0005], [0018], [0028].

312. For example, Downs discloses that "[t]he increased fraction of mercury appearing in the oxidized form enhances mercury removal in downstream pollution control systems such as wet 22 and SDA 24 FGD systems, and PAC injection systems. As is described herein, experimental results indicate that bromine addition also results in an increased fraction of particulate bound mercury. This enhances removal of mercury across particulate collectors 26 such as fabric filters (FF) and electrostatic precipitators (ESP)." EX1004, [0015]; EX1005, [0018].

313. Downs further explains that a benefit of its invention is that "the increased fraction of oxidized mercury also enhances the removal of mercury across a PAC injection process, due to the higher reactivity of oxidized mercury with PAC." EX1004, [0016]; EX1005, [0019].

314. Downs therefore, in my opinion, discloses methods for treating a mercury-containing flue gas by adding a sorbent that is an activated carbon into the flue gas for the reasons explained above in Paragraphs 311-313. EX1004, [0004], [0015], [0016], [0023], [0025], Claims 15-16; EX1005, [0005], [0018], [0019], [0026], [0028].

315. As established above, Downs discloses every element of Claim 17 of the '225 Patent. It is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Downs anticipates Claim 17 for the reasons explained above in Paragraphs 300-314. EX1004, [0004], [0015]-[0016], [0023], [0025], Claims 15-16; EX1005, [0005], [0018]-[0019], [0026], [0028].

XII. GROUND 2—CLAIMS 1-2, 5-9, 11-12, 14-15, 17-20 AND 22-29 WOULD HAVE BEEN OBVIOUS IN LIGHT OF DOWNS COMBINED WITH ALTMAN OR DOWNS/ALTMAN AND NELSON

316. Based on my review of Downs, Altman and Nelson and my education, skill, training, and experience in the relevant fields of emission reduction technology, it is my opinion that Claims 1-2, 5-9, 11-12, 14-15, 17-20 and 22-29

would have been obvious to a POSITA at the time of the invention. In the subsections that follow, I explain the bases for my opinion that Claims 1-2, 5-9, 11-12, 14-15, 17-20 and 22-29 would have been obvious to a POSITA at the time of the invention.

A. A POSITA Would Have Been Motivated to Combine Downs, Altman, and Nelson

317. In my opinion, a POSITA would have been motivated to combine Downs, Altman, and Nelson because each reference relates to mercury removal from coal-fired boilers using particulate control devices such as ESPs to collect powdered activated carbon (PAC) or promoted PAC after it has adsorbed mercury. Downs, Altman, and Nelson are thus analogous art to the '225 Patent in the same field of endeavor and reasonably pertinent to the problems the inventors faced. It is also my opinion that the combination of Downs, Altman, and Nelson incorporates prior art elements according to known activated carbon injection (ACI) methods to yield predictable results in removing mercury from flue gas.

318. Downs discloses that a power plant equipped with a Flue Gas Desulfurization System (FGD) can have a wet scrubber to remove oxidized mercury. EX1004, [0003]. Downs discloses using a PAC "sorbent injection system" and states that many "studies have focused on the injection of a carbonaceous sorbent (e.g., powdered activated carbon, or PAC) into the flue gas .... The sorbent, and its

burden of adsorbed mercury, are subsequently removed from the flue gases in a downstream particulate collector." EX1004, [0004], [0025], claims 15–16.

319. Altman also discloses that injection of activated carbon into flue gas was known in the art for removing mercury in coal-fired boilers before April 1997. EX1007, 2:23–31.

320. Altman discloses that while flue gas can be passed through a packed bed of activated carbon sorbent to remove mercury, packed beds "are complex to design and operate" and "produce high pressure drops and require periodic regeneration." EX1007, 1:30–40. Instead of using a packed bed with stationary sorbent, Altman injects activated carbon and lime sorbent particles into flue gas in his emission control system such that the sorbents flow with the flue gas. EX1007, 4:53–61, 5:50–61. Altman also discloses that injection of activated carbon into flue gas was known in the art for removing mercury in coal-fired boilers before April 1997. EX1007, 2:23–31, 1:41–2:22, 32–46.

321. In my opinion, a POSITA had reason to select Altman's wet flue gas emissions system (including tower 24 having chamber 34 and wet ESP 51) as Downs' PAC sorbent injection system because: (i) Altman's tower 24 ensures "there is sufficient activated carbon mercury adsorption capacity at reasonable adsorption injection rates" to achieve "optimal mercury sorption" in a flue gas residence time of only 1 to 20 seconds; (ii) Downs describes its process as enhancing mercury

removal in conventional particulate collectors 26 such as ESPs and in a PAC injection process due to "higher reactivity of oxidized mercury with PAC;" (iii) Downs and Altman disclose that activated carbon injection into flue gas was known in the art for mercury removal from "numerous studies" since 1997; and (iv) Altman's wet ESP captures sorbent particles for recycling or disposal. EX1007, 1:23–40, 2:23–31, 4:62–5:17, 59–61; EX1015, [0004], [0016].

322. Nelson describes exposing activated carbon sorbent to a bromine-containing gas before the sorbent is mixed with mercury-containing flue gas. EX1008, [0040]; EX1009, 4. Nelson indicates that exposure of sorbent to Br_2 or HBr gas "significantly increases the carbonaceous materials ability to remove mercury species." EX1008, [0041]; EX1009, 4. A POSITA thus would have been motivated to use the promoted sorbents of Nelson with the systems and processes of Downs and Altman as the promoted sorbents would further increase the mercury removal capabilities of the system.

B. Claims 1, 5, 7-8, 11-12, 14, 17, 19-20, 23 and 25-29 Would Have Been Obvious In Light Of Downs Combined With Altman or Downs/Altman and Nelson

323. I explained above in Section XI that these claims are anticipated by Downs. It is my understanding that anticipation is the epitome of obviousness under the patent law. Accordingly, it is also my opinion that these claims would have been

obvious to a POSITA at the time of the invention in light of Downs alone or in combination with Altman and/or Nelson.

324. Like Downs, Altman and Nelson each disclose processes for removing mercury from flue gas using activated carbon injection. Altman, for example, discloses that injection of activated carbon into flue gas was known in the art for removing mercury in coal-fired boilers before April 1997. EX1007, 2:23–31.

325. Nelson describes exposing activated carbon sorbent to a bromine-containing gas before the sorbent is mixed with mercury-containing flue gas. EX1008, [0040]; EX1009, 4. Nelson indicates that exposure of sorbent to Br_2 or HBr gas "significantly increases the carbonaceous materials ability to remove mercury species." EX1008, [0041]; EX1009, 4.

326. In addition to the disclosure of Downs, there is specific disclosure in Altman and/or Nelson relevant to the obviousness of claims 1, 5, 7-8, 11-12, 14, 17, 19-20, 23 and 25-29, as detailed below.

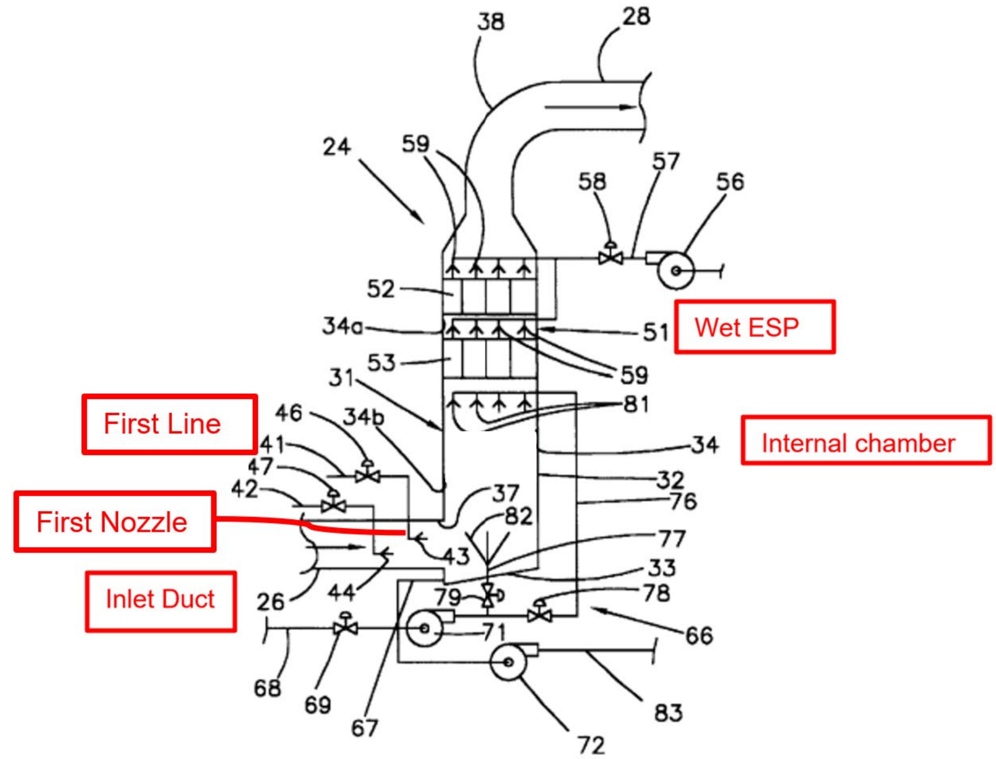
327. Regarding claim elements 1(b), 14(b), and 17(b) and claims 27 and 28, Altman and Nelson describe injecting PAC sorbent into flue gas to remove elemental and oxidized mercury using an ESP. EX1007, 1:41–2:46; 4:53–61, 5:50–61; EX1008, [0040]; EX1009, 4.

328. Regarding claim 5, Downs' Figure 3 reports reducing vapor-phase mercury by 77% from 9 µg/dscm mercury at FF-inlet to 2 µg/dscm mercury at FF-

outlet. EX1004, Figure 3, [0018]; EX1005, Figure 3, [0021]. A POSITA would have reasonably expected that the Downs/Altman combination of bromide and sorbent treatments would achieve greater than 70% mercury removal by the sorbent due to bromide's ability to increase oxidized mercury and "higher reactivity of oxidized mercury with PAC." EX1004, [0016]; EX1005, [0019]; EX1007, 2:14-22.

329. Regarding claim 23, Altman does not describe any contact of sorbent with a halogen or halide promoter before injection into the flue gas. EX1007. A POSITA had reason to select halogen-free activated carbon due to its lower cost as compared to halogen-promoted activated carbons especially where sufficient mercury removal can be achieved without resorting to halogen-promoted activated carbons. Nelson also discloses tests using Norit DARCO FGD, which is not halogen- or halide-promoted. EX1008, Ex. 1; EX1009, 5.

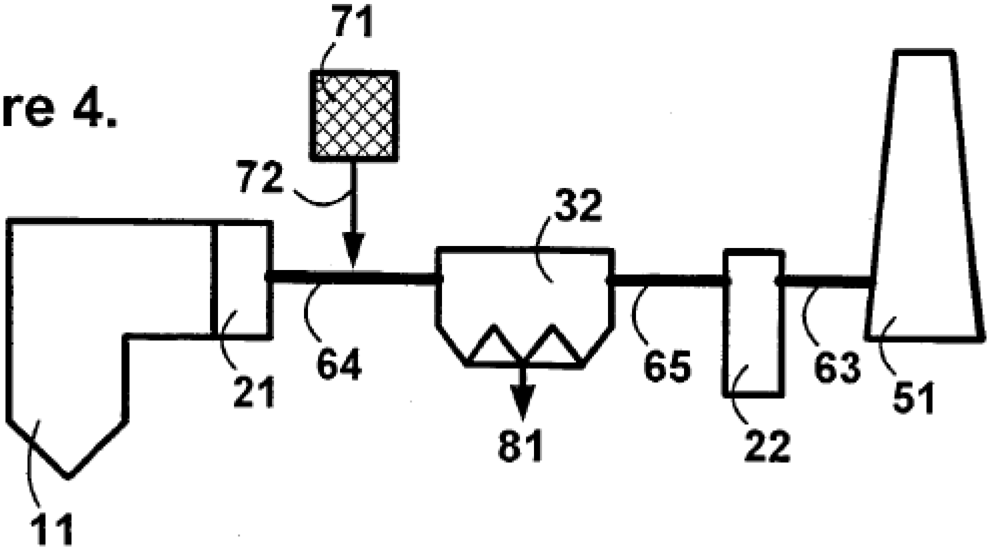
330. Regarding claims 27-28, Altman's Figure 2 depicts coal combustion in boiler 12 and sorbent injection into duct 26 upstream of chamber 34 by means of first line 41 and first nozzle 43. Chamber 34 is upstream of wet electrostatic precipitator (ESP) 51, which is a "particulate control device" that collects sorbent.



EX1007, 3:41-45; 4:17–21, 58–61; 5:27–29; Figure 2.

331. Regarding claims 27-28, Nelson also describes combusting coal in boiler 11 and injecting sorbent from bin 71 upstream of ESP 32 as depicted below. EX1008, [0059], [0062], Figure 4.

Figure 4.



332. Regarding claim 29, the assignee of Altman is Electric Power Research Institute, Inc. EX1007, Cover. As a POSITA would have known, EPRI is a non-profit organization that conducts research and development related to the generation, delivery, and use of electricity. Altman further discloses that its "invention is for use with a combustion source such as a fossil-fuel-fired boiler 12 which receives air through air inlet duct 13 to combust fuel such as coal received through fuel inlet duct." EX1007, 3:41-44. Nelson discloses "halogenated carbon materials to reduce the emissions of mercury from coal-fired power plants." EX1008, [0004]; EX1009, 1.

333. It is therefore also my opinion that, based on the disclosures of Downs, Altman, and Nelson, as well as my skill, training, and experience in the relevant fields of emission reduction technology, that claims 1-2, 5, 7-8, 11-12, 14-15, 17, 19-20, 23 and 25-29 would have been obvious to a POSITA at the time of the

invention in light of Downs and Altman or Downs, Altman and Nelson for the reasons explained above in Paragraphs 316-332.

334. In the sections that follow, I explain why Claims 6, 9, 11-12, 18, 22 and 24 would have been obvious to a POSITA at the time of the invention in light of Downs and Altman or Downs, Altman and Nelson.

C. Claims 6, 9, 11-12, 18, 22 and 24 Would Have Been Obvious In Light Of Downs Combined With Altman Or Downs/Altman And Nelson

1. Claim 6—"measuring the mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content: an injection rate of injecting the sorbent into the mercury-containing gas, an amount of the additive in the mixture, or a combination thereof."

Claim 24—"the measurement of the mercury content of the mercury-containing gas comprises continuous measurement."

Claim 18—"modifying, in response to a measured mercury content, an injection rate of injecting the sorbent into the mercury-containing gas, an amount of the additive in the mixture, or a combination thereof."

335. Claims 6, 18 and 24 generally require measuring the mercury content of the mercury-containing gas and modifying the injection rate of the activated carbon, the amount of the additive in the mixture, or a combination thereof. Claim 6 depends from claim 5. Claim 24 depends from claim 6. Claim 18 depends from claim 1.

336. Downs describes use of an "on-line mercury analyzer" to detect "vapor-phase mercury species." EX1004, [0018]; EX1005, [0021]. Downs measured vapor-phase mercury in flue gas in tests performed with varying amounts of calcium bromide applied to the coal, ranging from 750 ppm to 1,000 ppm to 375 ppm. EX1004, Figure 3; EX1005, Figure 3. Altman discloses that injection of activated carbon into flue gas was known in the art for removing mercury in coal-fired boilers before April 1997. EX1007, 2:23–31. Altman further discloses that its system seeks to ensure "that there is sufficient activated carbon mercury adsorption capacity at reasonable adsorption injection rates." EX1007, 4:62-5:5.

337. A POSITA would have known that the EPA had by 2004 already put the industry on notice of upcoming laws and regulations requiring 70% mercury removal, including EPA's Clean Air Mercury Rule (CAMR). EX1045. It thus would have been obvious to a POSITA that any mercury control system would have to comply with these laws and regulations.

338. A POSITA also would have known since at least as early as 1995 that the mercury content of the flue gas from a coal-fired power plant could be monitored and that the injection rate of the sorbent could be adjusted to achieve desired levels of mercury removal. EX1080, Abstract ("By adjusting the chloride content of the flue gas **or the absorbent** a permanent high Hg removal is achieved.") (emphasis added); 6:42-46 ("The amount of chloride introduced through 15 or 17 as well as the

amount of activated carbon possibly dosed by means of 12 may be adjusted also on basis of the Hg content of the treated gas measured by means of a device 18 arranged in the duct 9.”).

339. In my opinion, a POSITA would have considered it obvious to optimize the sorbent injection rate in the Altman system and/or the amount of bromine additive as shown by Downs since both variables affect mercury removal from a flue gas. EX1007, 4:62-5:5; EX1004, [0018], Figure 3; EX1005, [0021], Figure 3; EX1080, Abstract, 6:42-46.

340. Because Downs alone discloses every element of Claims 1 and 5, and because the combination of Downs and Altman, as well a POSITA’s knowledge of the applicable EPA rules and regulations, would lead a POSITA to substantially continuously measure the mercury content of the flue gas and modify the injection rate of the sorbent or the amount of additive in the mixture based on the measured mercury content as required by Claims 6, 18 and 24, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claims 6, 18 and 24 would have been obvious to a POSITA at the time of the invention in light of the combination of Downs and Altman for the reasons explained above in Paragraphs 335-339. EX1007, 2:23–31, 4:62-5:5; EX1004, [0018], Figure 3; EX1005, [0021], Figure 3; EX1080, Abstract, 6:42-46.

2. Claim 9—"adding an alkaline component to the mercury-containing gas, the alkaline component chosen from alkali elements, alkaline earth elements, alkali salts, alkaline earth salts, and combinations thereof."

341. Claim 9 depends from claim 1.

342. Altman discloses that "additional sorbent such as hydrated lime is injected into the flue gas upstream of chamber 34." EX1007, 5:50–54. Nelson describes injecting "calcium or magnesium hydroxide" sorbent into flue gas with the mercury sorbents. EX1008, [0012], [0064]; EX1009, 3.

343. Lime is calcium oxide (CaO), and slaked or hydrated lime is calcium hydroxide ($Ca(OH)_2$), each of which is highly alkaline. Calcium hydroxide is alkaline and is a salt of an alkaline-earth metal (calcium). EX1016, 33, 196, 671-672.

344. Because Downs discloses every element of Claim 1, and Altman and Nelson disclose injecting an alkaline sorbent into the mercury-containing gas as required by Claim 9, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 9 would have been obvious to a POSITA at the time of the invention in light of Downs and Altman or Downs, Altman and Nelson for the reasons explained above in Paragraphs 341-343. EX1008, [0012], [0064]; EX1009, 3; EX1016, 33, 196, 671-672.

3. Claim 11–"contacting the sorbent material with a secondary component chosen from halogens, hydrogen halides, Group V halides, Group VI halides, and combinations thereof."

Claim 12–"the secondary component is chosen from halogens, halide salts, HI, HBr, HCl, and combinations thereof."

345. Julien discloses that "94-99% of the chlorine in coal is volatilized and emitted as gaseous HCl during pulverized firing." EX1014, 165; EX1072, 199 (Table 1). Thus, a POSITA would have known that coal-fired power plant flue gas necessarily contains HCl that would contact the sorbent.

346. Because Downs discloses every element of Claim 1, and a POSITA would have known that a coal-fired power plant flue gas necessarily contains HCl that would contact the sorbent, it is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claims 11-12 would have been obvious to a POSITA at the time of the invention in light of Downs and Altman as evidenced by Julien for the reasons explained above in Paragraph 345. EX1014, 165; EX1072, 199 (Table 1).

4. Claim 22–"the sorbent is contacted with a halogen or halide promoter prior to the addition of the sorbent to the mercury-containing gas."

347. Claim 22 depends from claim 1.

348. Nelson describes exposing activated carbon sorbent to a bromine-containing gas before the sorbent is mixed with mercury-containing flue gas. EX1008, [0040]; EX1009, 4.

349. In my opinion, a POSITA would have had reason to substitute Nelson's brominated-activated carbon sorbent for the activated carbon sorbent in Downs because Nelson indicates that exposure of sorbent to Br_2 or HBr gas "significantly increases the carbonaceous materials ability to remove mercury species." EX1009, [0041].

350. In my opinion, a POSITA would have known that this approach would have increased overall mercury capture. For example, it was known since the 1930s to remove mercury vapors by contacting halogen-impregnated activated-carbon sorbents with a mercury-containing gas. EX1049, 1:33–41.

351. Because Downs discloses every element of Claim 1, and Nelson teaches that the sorbent is contacted with a halogen or halide promoter prior to the addition of the sorbent to the mercury-containing gas as required by Claim 22, it is my opinion that, based on my skill, training, and experience in the relevant fields of emission reduction technology, that Claim 22 would have been obvious to a POSITA at the time of the invention in light of the combination of Downs, Altman, and Nelson for the reasons explained above in Paragraphs 347-350. EX1008, [0040]-[0041]; EX1009, 4; EX1049, 1:33–41.

XIII. GROUND 3—CLAIMS 1-2, 5-15, 17-20 AND 22-29 ARE OBVIOUS OVER VOSTEEN AND ALTMAN OR VOSTEEN/ALTMAN AND NELSON

352. Based on my review of Vosteen, Altman, and Nelson, and my education, skill, training, and experience in the relevant fields of emission reduction technology, it is my opinion that Claims 1-2, 5-15, 17-20 and 22-29 would have been obvious in light of Vosteen and Altman or Vosteen, Altman, and Nelson. In the subsections that follow, I explain the reasons that a POSITA would have combined Vosteen, Altman, and Nelson as well as the bases for my opinion that Claims 1-2, 5-15, 17-20 and 22-29 would have been obvious in light of Vosteen and Altman or Vosteen, Altman, and Nelson.

A. A POSITA Would Have Been Motivated to Combine Vosteen, Altman, and Nelson

353. In my opinion, a POSITA would have been motivated to combine Vosteen, Altman, and Nelson, and had a reasonable expectation of success in doing so, because each reference relates to mercury removal from coal-fired boilers (or waste incinerators) using particulate control devices such as ESPs.

354. Vosteen, Altman, and Nelson are analogous art to the '225 Patent in the same field of endeavor and reasonably pertinent to the problems the inventors faced. Vosteen is titled "PROCESS FOR REMOVING MERCURY FROM FLUE GASES" and is generally directed to "a process for removing mercury from flue

gases of high-temperature plants, in particular power stations and waste incineration plants in which a bromine compound is fed to the if appropriate multistage furnace and/or the flue gas in a plant section downstream of the furnace." EX1011, Abstract. Altman is titled "METHOD FOR REMOVING MERCURY FROM A GAS STREAM AND APPARATUS FOR SAME" and is generally directed to "[a] method for removing mercury from a gas stream" in which "sorbent is injected into the gas stream." EX1007, Abstract. Nelson describes exposing activated carbon sorbent to a bromine-containing gas before the sorbent is mixed with mercury-containing flue gas. EX1008, [0040]; EX1009, 4. Nelson indicates that exposure of sorbent to Br_2 or HBr gas "significantly increases the carbonaceous materials ability to remove mercury species." EX1008, [0041]; EX1009, 4.

355. Vosteen suggests using wet scrubbers or dry systems or a combination as known in the art. EX1011, [0017]. Vosteen describes wet scrubbing "performed, for example, in a quench sprayed with circulated scrubbing water, a pressurized nozzle scrubber or rotary atomizer scrubber or a packed-bed scrubber" without indicating what packing was used in the packed-bed. *Id.*

356. Altman discloses that while flue gas can be passed through a packed bed of activated carbon sorbent to remove mercury, packed beds "are complex to design and operate" and "produce high pressure drops and require periodic regeneration." EX1007, 1:30–40.

357. Instead of using a packed bed with stationary sorbent, Altman injects activated carbon and lime sorbent particles into flue gas in his emission control system such that the sorbents flow with the flue gas. EX1007, 4:53–61, 5:50–61.

358. Altman also discloses that injection of activated carbon into flue gas was known in the art for removing mercury in coal-fired boilers before April 1997 and in waste incinerators in 1995 and 1996. EX1007, 2:23–31, 1:41–2:22, 32–46. The ‘225 Patent itself also acknowledges that activated-carbon injection was well-known in the art. EX1001, 1:58-63, 7:32-40.

359. In my opinion, a POSITA had reason to substitute Altman’s wet flue gas emissions control system (including tower 24 having chamber 34 and wet ESP 51) for Vosteen’s packed bed wet scrubber because: (i) Altman discloses that activated carbon sorbent injection into flue gas entering a wet scrubber avoids the disadvantages of high pressure drop and sorbent regeneration associated with packed-bed wet scrubbers; (ii) Altman’s tower ensures “there is sufficient activated carbon mercury adsorption capacity at reasonable adsorption injection rates” to achieve “optimal mercury sorption” in a flue gas residence time of only 1 to 20 seconds; (iii) Altman discloses that activated carbon injection into coal-fired boiler flue gas was known in the art for mercury removal by 1997; and (iv) Altman’s wet ESP captures sorbent particles for recycling or disposal. EX1007, 1:23–40, 2:23–31, 4:62–5:17, 59–61.

360. The combination of Vosteen, Altman, and Nelson incorporates prior art elements according to known ACI methods to yield predictable results in removing mercury.

B. Independent Claim 1

1. Element 1(Preamble)–"A method for treating a mercury-containing gas, the method comprising:"

361. Vosteen is titled "PROCESS FOR REMOVING MERCURY FROM FLUE GASES" and is generally directed to "a process for removing mercury from flue gases of high-temperature plants, in particular power stations and waste incineration plants in which a bromine compound is fed to the if appropriate multistage furnace and/or the flue gas in a plant section downstream of the furnace." EX1011, Abstract. Such flue gases are examples of a mercury-containing gas.

362. This preamble is also disclosed in claim 1 of Vosteen, which is reproduced and emphasized below:

> 1. **Process for removing mercury from flue gases of high-temperature plants, in particular from power stations** and waste incineration plants, characterized in that
>
> > bromine and/or a bromine compound and/or a mixture of various bromine compounds is fed to the if appropriate multistage 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 at least 500° C., preferably at least 800° C.,
> >
> > …

> **and then the flue gas being subjected to an if appropriate multistage cleanup for removing mercury from the flue gas, which cleanup comprises a wet scrubber and/or a dry cleanup**.

363. Altman is titled "METHOD FOR REMOVING MERCURY FROM A GAS STREAM AND APPARATUS FOR SAME" and is generally directed to "[a] method for removing mercury from a gas stream" in which "sorbent is injected into the gas stream." EX1007, Abstract.

364. Claim 1 of Altman, reproduced and emphasized below, also discloses the preamble:

> 1. **A method for removing mercury from a gas stream comprising the steps of injecting sorbent into the gas stream**, dispersing water into the gas stream to create a cooled gas stream, allowing the cooled gas stream to dwell with the sorbent in a chamber **for removing mercury from the cooled gas stream** and passing the cooled gas stream through an electrostatic precipitator located above the chamber to collect water and recycle the collected water back into the chamber for cooling the gas stream in the chamber.

365. Vosteen and Altman, in my opinion, each discloses the preamble of claim 1 as both references describe multiple methods of treating a mercury-containing gas by reducing mercury in the flue gas, more specifically a flue gas at a coal burning power plant for the reasons explained above in Paragraphs 361-364. EX1011, Abstract, Title; [0001]; [0007]–[0008], Claim 1; EX1007, Abstract, Claim 1.

2. Element 1(a)–"combusting a mixture comprising coal, pyrolysis char, and an additive comprising HBr, a bromide

compound, or a combination thereof, to form the mercury-containing gas; and"

366. Vosteen discloses this claim element. Vosteen discloses addition of a bromine, in forms such as HBr, Br, and sodium bromide (NaBr), **to the furnace or directly to the coal in coal-fired boilers** of a power plant, and that "addition of bromine or bromine compounds to the furnace causes ... a substantial, essentially complete, oxidation of the mercury and therefore allows substantial removal of the mercury from flue gases." EX1011, [0007], [0013], [0047], Example 5 (emphasis added).

367. Vosteen further discloses that "[t]he bromine compound, for example, sodium bromide, can be added in solid form, for example as salt, or liquid form, for example as aqueous solution, **to the** waste mixture, **coal or the like to be burnt**, **upstream of the furnace**. . . . . The addition can also be made to a plant section upstream of the furnace, for example, … to a coal mill." *Id.*, [0013] (emphasis added).

368. Altman also discloses that "the present invention is for use with a combustion source such as a fossil-fuel-fired boiler 12 which receives air through air inlet duct 13 to combust fuel such as coal received through fuel inlet duct" EX1007, 3:41-44.

369. Pyrolysis char is necessarily present when coal is combusted. EX1087, 673 ("pyrolysis, even under the most favorable conditions, includes the formation of … residual char"). Thus, a mixture of coal, pyrolysis char and the bromine additive is necessarily present in Vosteen's combustion.

370. Vosteen and Altman, in my opinion, discloses combusting a mixture comprising coal, pyrolysis char, and an additive comprising HBr, a bromide compound (e.g., NaBr), or a combination thereof, to form the mercury-containing gas for the reasons explained above in Paragraphs 366-369. EX1011, [0005], [0006], [0007], [0009], [0013], [0025], [0047], Example 5; EX1007, 3:41-44.

3. Element 1(b) –"adding a particulate sorbent material comprising activated carbon into the mercury-containing gas."

371. Vosteen suggests using wet scrubbers or dry systems or a combination as known in the art. EX1011, [0017]. Vosteen describes wet scrubbing "performed, for example, in a … a packed-bed scrubber" without indicating what packing was used in the packed-bed. *Id.* Vosteen discloses "removal of mercury from the flue gases in a flue gas emission control system downstream of the combustion" using "finely pulverant slaked lime/activated carbon." EX1011, [0007], [0019], [0047]-[0049].

372. Altman discloses that while flue gas can be passed through a packed bed of activated carbon sorbent to remove mercury, packed beds "are complex to

design and operate" and "produce high pressure drops and require periodic regeneration." EX1007, 1:30–40.

373. Instead of using a packed bed with stationary sorbent, Altman injects activated carbon and lime into flue gas in the emission control system such that the they flow with the flue gas. EX1007, 4:53–61, 5:50–61. Flue gas residence time within chamber 34 ranges from 1–20 seconds, preferably 5–10 seconds, to "allow a large portion of the mercury in the flue gas to be removed by the injected sorbent." EX1007, 5:6–12.

374. Altman also discloses that injection of activated carbon into flue gas was known in the art for removing mercury in coal-fired boilers before April 1996 and in waste incinerators in 1995 and 1996. EX1007, 2:23–31, 1:41–2:22, 32–46. The '225 Patent itself also acknowledges that activated-carbon injection as a sorbent was well-known in the art. EX1001, 1:58-63, 7:32-40.

375. As previously explained above in the Motivation to Combine section, it is my opinion that a POSITA would have been motivated to combine the activated carbon injection system of Altman with the bromine introduction system of Vosteen. The combination, in my opinion, discloses every element of Claim 1 of the '225 Patent for the reasons explained above in Paragraphs 371-374. EX1011, [0007], [0019], [0047]-[0049]; EX1007, 1:30-40, 4:53-61, 5:6-12, 50-61.

376. It is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 1 would have been obvious to a POSITA at the time of the invention in light of Vosteen combined with Altman.

C. Claims Depending From Claim 1

1. Claim 2–"the pyrolysis char is a promoted pyrolysis char."

377. According to PO's expert in the Delaware litigation, "pyrolysis char forms in the presence of bromine that has been added to the coal. Thus, it is promoted pyrolysis char." EX1083, 163.

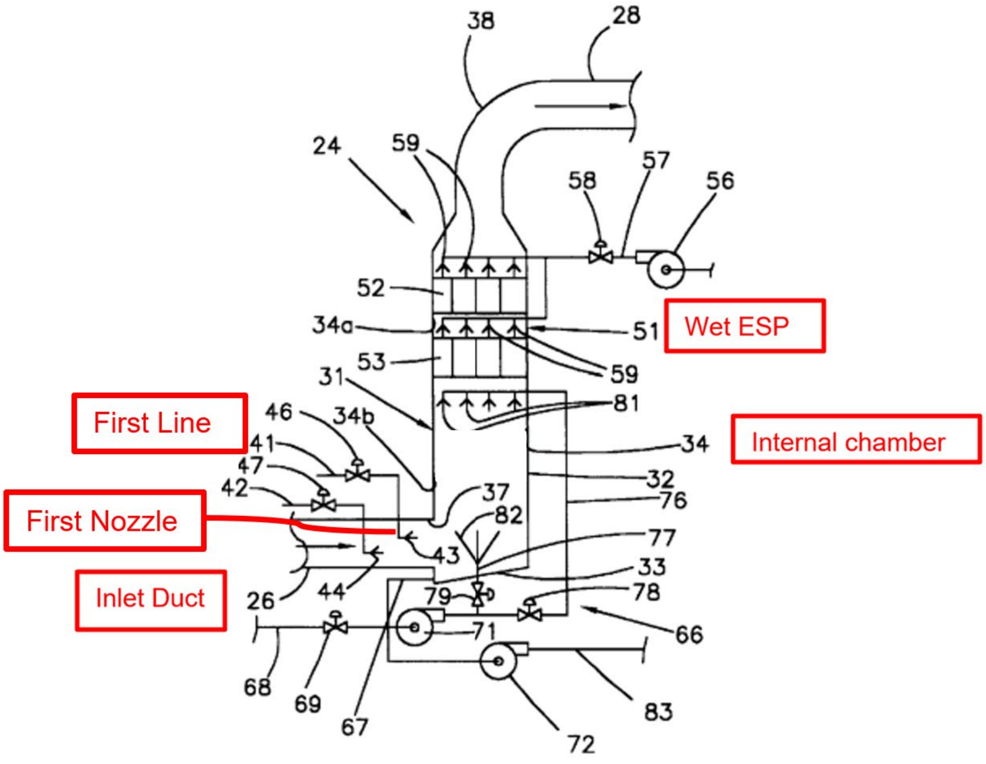
378. Because Vosteen and Altman disclose every element of Claim 1, and PO's expert admits that a promoted pyrolysis char is necessarily present during combusting of coal and bromine, it is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 2 would have been obvious to a POSITA at the time of the invention in light of Vosteen combined with Altman for the reasons explained above in Paragraph 377. EX1083, 163.

2. Claim 5–"using a particle separation device to remove mercury from the flue gas and comprising collecting greater

than 70 wt % of the mercury in the mercury-containing gas to produce a cleaned gas.”

379. Vosteen describes a flue gas emissions control system as known in the art “based either on wet scrubbing or dry cleanup or a combination of the two.” EX1011, [0017].

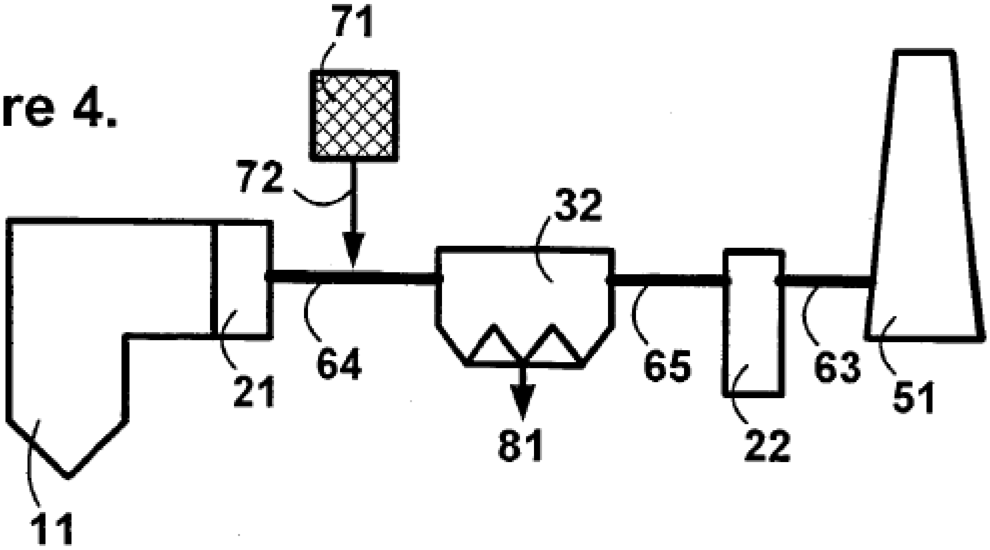
380. Altman’s Figure 2 depicts coal combustion in boiler 12 and sorbent injection into duct 26 upstream of chamber 34 by means of first line 41 and first nozzle 43. Chamber 34 is upstream of wet electrostatic precipitator (ESP) 51, which is a “particulate control device” that collects sorbent.



EX1007, 3:41-45; 4:17–21, 58–61; 5:27–29; Figure 2. An ESP is a particulate separator, as Claim 26 of the '225 Patent states that "the particulate separator comprises an electrostatic precipitator."

381. Nelson also describes combusting coal in boiler 11 and injecting sorbent from bin 71 upstream of ESP 32. EX1008, [0059], [0062], Figure 4.

Figure 4.



382. Vosteen discloses that "an object of the invention to provide a process for removing mercury, in particular for the substantially complete removal of mercury (Hg), from flue gases of high temperature processes." EX1011, [0005].

383. Vosteen reports mercury removal greater than 70 wt.% in that flue gas Hg_{met} content was about 40 wt.% and was reduced to 10 wt.% at time 10:30. *Id.*, Figure 8, [0049].

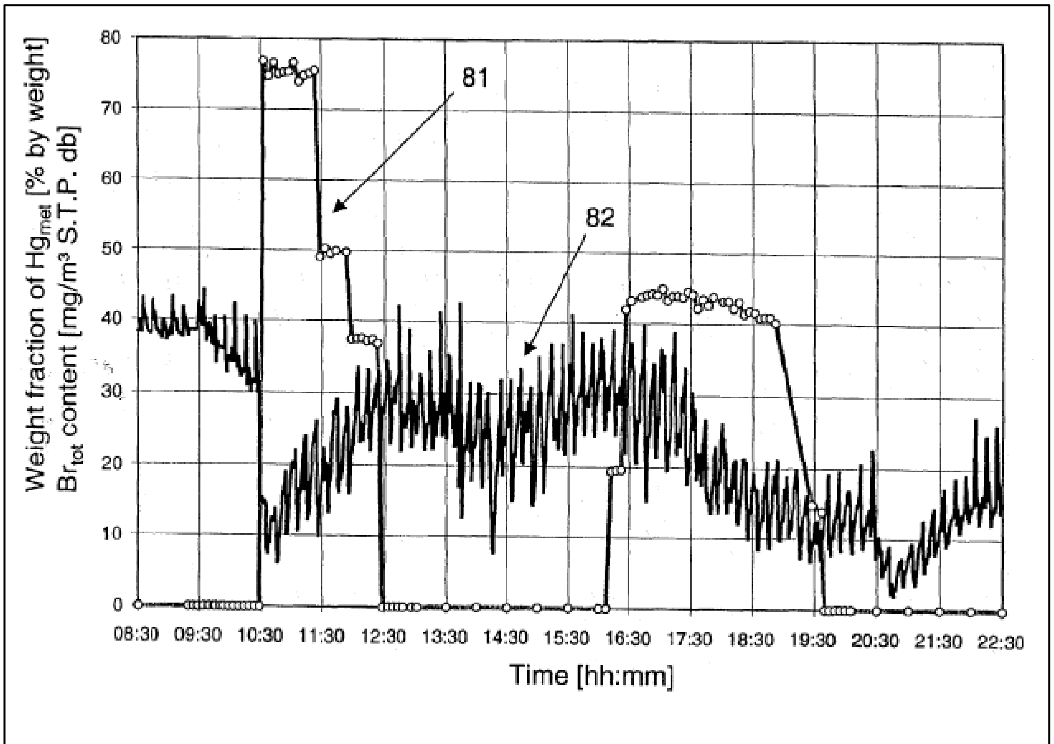


Fig. 8

A POSITA would know that the conversion of elemental mercury to oxidized mercury at nearly 90% would result in greater than 70 wt % of the mercury in the mercury-containing gas being collected by the sorbent because oxidized mercury is easily adsorbed on solid surfaces or dissolved in scrubbing solution and thereby easily removed from the flue gas.

384. Vosteen also discloses, in Figure 5 reproduced below, collecting more than 98% of the mercury from the mercury-containing gas. *Id.*, Fig. 5, [0042].

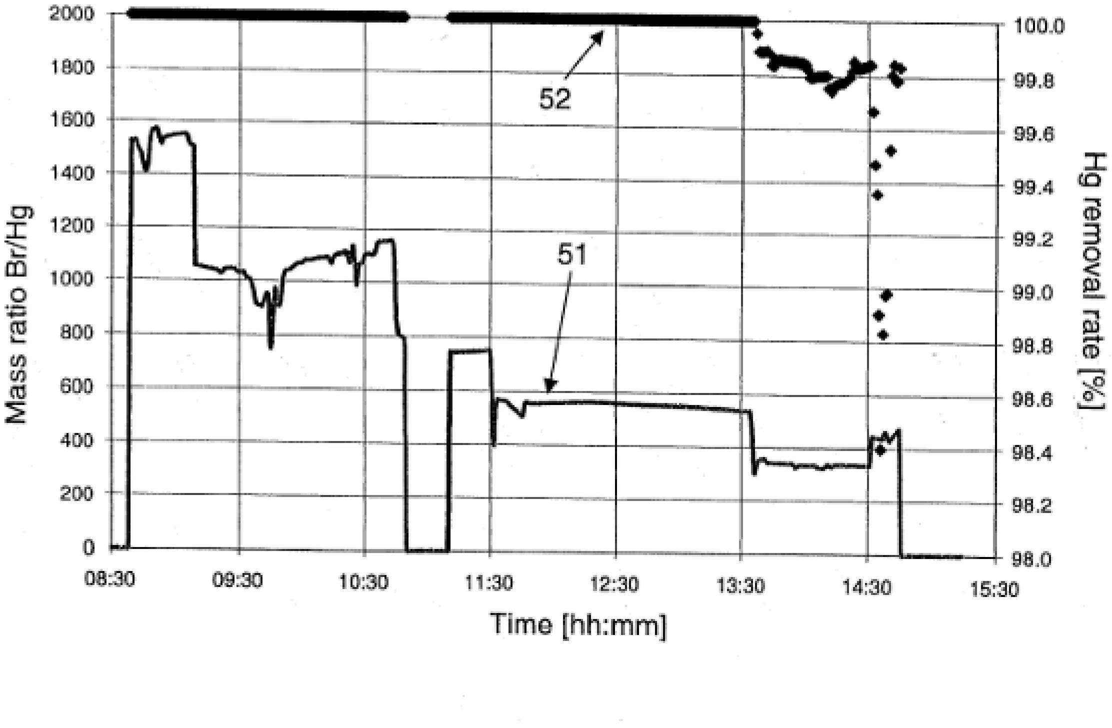


Fig. 5

385. Vosteen further explains that in one example where effluent scrubbing water was analyzed that the system was able to collect and remove more than 99.9% of total mercury. *Id.,* [0037].

386. Vosteen further discloses that "[i]n order to achieve mercury oxidation as complete as possible, in particular 100%, by adding a bromine compound, the bromine compound is preferably added in a mass ratio of bromine to mercury in the range from 10^2 to 10^4. If the bromine compound is added in a great excess, this does not have a disadvantageous effect on the inventive process. Too great an excess must be avoided, however, not least for reasons of cost." *Id.*, [0015].

387. Altman also notes that it was known in the art that " 90%" of mercury can be removed "when an 'appropriate absorbent' is used." EX1007, 2:14-22. Altman also discloses that injection of activated carbon into flue gas was known in the art for removing mercury in coal-fired boilers before April 1996 and in waste incinerators in 1995 and 1996. EX1007, 2:23–31, 1:41–2:22, 32–46. The '225 Patent itself also acknowledges that activated-carbon injection was well-known in the art. EX1001, 1:58-63, 7:32-40.

388. A POSITA also would have understood that the activated carbon sorbent disclosed in Altman would have collected mercury from the flue gas. Altman explains that the flue gas residence time for the sorbent is to "allow a large portion of the mercury in the flue gas to be removed by the injected sorbent." EX1007, 5:6–12.

389. A POSITA would have known that the EPA had by 2004 already put the industry on notice of upcoming laws and regulations requiring 70% mercury removal, including EPA's Clean Air Mercury Rule (CAMR). EX1045. It thus would have been obvious to a POSITA that any mercury control system would have to comply with these laws and regulations.

390. In fact, Vosteen acknowledges that there are "strict limiting values [that] exist for the legally permissible emission of mercury." EX1011, [0002].

391. In my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, a POSITA at the time of the invention would have reasonably expected that the Vosteen/Altman combination of bromide and sorbent treatments would achieve greater than 70% mercury removal by the sorbent due to bromide's ability to increase oxidized mercury and "higher reactivity of oxidized mercury with PAC."

392. Because the combination of Vosteen and Altman discloses every element of Claim 1 and Vosteen's and Altman's methods remove greater than 70 wt % of the mercury from the mercury-containing gas using a particle separation device as required by Claim 5, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 5 would have been obvious to a POSITA at the time of the invention in light of Vosteen combined with Altman for the reasons explained above in Paragraphs 379-391. EX1011, [0002], [0005], [0015], [0037], [0042], [0049], Figs. 5, 8; EX1007, 2:14-22, 5:6-12.

3. Claim 6—"measuring the mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content: an injection rate of injecting the sorbent

> **into the mercury-containing gas, an amount of the additive in the mixture, or a combination thereof."**
>
> **Claim 24—"the measurement of the mercury content of the mercury-containing gas comprises continuous measurement."**
>
> **Claim 18—"modifying, in response to a measured mercury content, an injection rate of injecting the sorbent into the mercury-containing gas, an amount of the additive in the mixture, or a combination thereof."**

393. Claims 6, 18 and 24 generally require measuring the mercury content of the mercury-containing gas and modifying the injection rate of the activated carbon, the amount of the additive in the mixture, or a combination thereof. Claim 6 depends from claim 5. Claim 24 depends from claim 6. Claim 18 depends from claim 1.

394. Vosteen discloses that preferably "in the inventive process, the mercury content of the flue gas, in particular the content of metallic mercury, is measured continuously downstream of the flue gas emission control system and on the basis of the measured mercury content the amount of bromine fed and/or bromine compounds and/or the mixture of bromine compounds ... is controlled." EX1011, [0022]. If mercury is removed incompletely, additional bromine compound is fed. *Id.*

395. Claim 10 of Vosteen also discloses this claim element:

> 10. Process according to one of claims 1 to 9, characterized in that the mercury content of the flue gas, **in particular the content of metallic**

> **mercury, is measured continuously** downstream of the flue gas emission control system and on the basis of the measured mercury content the amount of bromine fed and/or bromine compounds fed and any sulphur and/or sulphur compounds fed **is** controlled. (emphasis added).

396. Altman discloses that injection of activated carbon into flue gas was known in the art for removing mercury in coal-fired boilers before April 1997. EX1007, 2:23–31. Altman further discloses that it seeks to ensure "that there is sufficient activated carbon mercury adsorption capacity at reasonable adsorption injection rates." EX1007, 4:57-5:5.

397. A POSITA would have known that the EPA had by 2004 already put the industry on notice of upcoming laws and regulations requiring 70% mercury removal, including EPA's Clean Air Mercury Rule (CAMR). EX1045. It thus would have been obvious to a POSITA that any mercury control system would have to comply with these laws and regulations.

398. A POSITA also would have known since at least as early as 1995 that the mercury content of the flue gas from a coal-fired power plant could be monitored and that the injection rate of the sorbent could be adjusted to achieve desired levels of mercury removal. EX1080, Abstract ("By adjusting the chloride content of the flue gas **or the absorbent** a permanent high Hg removal is achieved.)(emphasis added); 6:42-46 ("The amount of chloride introduced through 15 or 17 as well as the amount of activated carbon possibly dosed by means of 12 may be adjusted also on

basis of the Hg content of the treated gas measured by means of a device 18 arranged in the duct 9.”).

399. In my opinion, a POSITA would have considered it obvious to optimize the sorbent injection rate in the Altman system and/or the amount of bromine additive as shown by Vosteen since both variables affect mercury removal from a flue gas.

400. Because Vosteen and Altman discloses every element of Claims 1 and 5, and because the combination of Vosteen and Altman, as well a POSITA’s knowledge of the applicable EPA rules and regulations, would lead a POSITA to substantially continuously measure the mercury content of the flue gas and modify the injection rate of the sorbent or the amount of bromine additive in the mixture based on the measured mercury content as required by Claims 6, 18 and 24, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claims 6, 18 and 24 would have been obvious to a POSITA at the time of the invention in light of the combination of Vosteen and Altman for the reasons explained above in Paragraphs 393-399. EX1007, 4:47-5:5; EX1011, [0022], Claim 10; EX1080, Abstract, 6:42-46.

4. Claim 7–“the additive further comprises Br_2.”

401. Vosteen states, “It is not critical for the inventive process in what form the bromine supplied is present. It is possible to use free or organically bound or

inorganically bound bromine. The bromine or the bromine compounds can be fed individually or in a mixture." EX1011, [0009]. A POSITA would understand that "free … bromine" is molecular bromine (Br_2), and that Vosteen's disclosure of "bromine" refers to Br_2. *Id.*, [0006], claims 1 & 4.

402. Because Vosteen and Altman disclose every element of Claim 1, and Vosteen further teaches that bromide compounds, including HBr and Br_2 can be added to coal or the combustor, it is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 7 would have been obvious to a POSITA at the time of the invention in light of Vosteen combined with Altman for the reasons explained above in Paragraph 401. EX1011, [0006], [0009].

5. Claim 8–"the sorbent material is chosen from powdered activated carbon, granular activated carbon, carbon black, carbon fiber, aerogel carbon, pyrolysis char, and combinations thereof."

403. Vosteen discloses that the sorbent material can be a "granulated activated carbon" or "pulverulent slaked lime/activated carbon." EX1011, [0019]. A POSITA would, in my opinion, recognize that a "granulated" or pulverulent activated carbon is granular or powdered activated carbon.

404. Altman similarly discloses that the activated carbon sorbents can be "particles." EX1007, 5:59-61. Nelson also describes its sorbent as PAC or "char." EX1008, [0040], [0046]; EX1009, 4.

405. Because the combination of Vosteen and Altman discloses every element of Claim 1 and that a powdered, pulverulent, or particle form of activated carbon is of the types specified by Claim 8, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 8 would have been obvious to a POSITA at the time of the invention in light of Vosteen combined with Altman. Claim 8 is also obvious over the combination of Vosteen, Altman and Nelson for the reasons explained above in Paragraphs for the reasons explained above in Paragraphs 403-404. EX1007, 5:59-61; EX1008, [0040], [0046]; EX1009, 4; EX1011, [0019].

6. Claim 9–"adding an alkaline component to the mercury-containing gas, the alkaline component chosen from alkali elements, alkaline earth elements, alkali salts, alkaline earth salts, and combinations thereof."

406. Vosteen discloses "finely pulverulent slaked lime/activated carbon." or "lime" can be used in its flue gas emission control systems. EX1011, [0019].

407. Altman discloses that "additional sorbent such as hydrated lime is injected into the flue gas upstream of chamber 34." EX1007, 5:50–54.

408. Nelson describes injecting calcium hydroxide sorbent into flue gas with the PAC sorbent. EX1008, [0064]; EX1009, 3.

409. Lime is calcium oxide (CaO), and slaked or hydrated lime is calcium hydroxide ($Ca(OH)_2$), each of which is highly alkaline. Calcium hydroxide is a salt of an alkaline-earth metal (calcium). EX1016, 33, 196, 671-672.

410. Because the combination of Vosteen and Altman discloses every element of Claim 1, and Vosteen, Altman, and Nelson disclose the injection of an alkaline earth metal salt sorbent into the mercury-containing gas stream as required by Claim 9, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 9 would have been obvious to a POSITA at the time of the invention in light of Vosteen and Altman, or Vosteen, Altman, and Nelson for the reasons explained above in Paragraphs 406-409. EX1011, [0019]; EX1007, 5:50–54; EX1008, [0064]; EX1009, 3; EX1016, 33, 196, 671-672.

7. Claim 10–"contacting the sorbent material with a mercury-stabilizing reagent chosen from S, Se, H_2S, SO_2, H_2Se, SeO_2, CS_2, P_2S_5, and combinations thereof."

411. Vosteen describes the "addition of a bromine compound and if appropriate a sulphur compound … to the flue gas in a plant section downstream of the furnace." EX1011, [0013]. Sulphur dioxide is present in the flue gas. *Id.*, [0010]. Vosteen states that "bromine compounds oxidize mercury more effectively

under the given conditions of high-temperature processes, such as temperature and in particular also at a high sulphur dioxide concentration." *Id.*, [0016]. The sulfur dioxide in the flue gas would contact the sorbent in the flue gas before both are removed in downstream desulfurization and particulate removal devices.

412. Because Vosteen and Altman disclose every element of Claim 1, and Vosteen further teaches addition of a sulfur compound to flue gas where it would contact the sorbent, it is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 10 would have been obvious to a POSITA at the time of the invention in light of Vosteen combined with Altman for the reasons explained above in Paragraph 411. EX1011, [0010], [0013], [0016].

8. Claim 11–"contacting the sorbent material with a secondary component chosen from halogens, hydrogen halides, Group V halides, Group VI halides, and combinations thereof."

Claim 12–"the secondary component is chosen from halogens, halide salts, HI, HBr, HCl, and combinations thereof."

Claim 13–"the secondary component is chosen from I_2, HI, and combinations thereof."

413. Vosteen describes the "addition of a bromine compound … to the flue gas in a plant section downstream of the furnace." EX1011, [0013]. The HBr in the flue gas would contact the sorbent in the flue gas before the sorbent is removed in a particulate removal device such as an ESP. The bromine compound can be "an

aqueous solution of hydrogen bromide or sodium bromide." *Id.*, [0014]. Sodium bromide is a halide salt. A POSITA would have known that every coal-fired power plant flue gas contains HCl that would inevitably contact the sorbent.

414. Vosteen also discloses that "[i]odine compounds oxidize mercury more effectively compared with bromine compounds…. The iodine compound can be fed … as a supplement to, or partial replacement of, the added bromine compound." *Id.*, [0016]. The iodine compound can be iodine (I_2). *Id.*, claim 6. The I_2 added to the flue gas would contact the sorbent in the flue gas before the sorbent is removed in a particulate removal device such as an ESP.

415. Julien discloses that "94-99% of the chlorine in coal is volatilized and emitted as gaseous HCl during pulverized firing." EX1014, 165; EX1072, 199 (Table 1). Thus, a POSITA would have known that coal-fired power plant flue gas necessarily contains HCl that would contact the sorbent.

416. Because Vosteen and Altman disclose every element of Claim 1, and Vosteen further teaches addition of HBr or a halide salt to flue gas where it would contact the sorbent, it is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claims 11-13 would have been obvious to a POSITA at the time of the invention in light of Vosteen combined with Altman for the reasons explained above in Paragraphs 413-415. EX1011, [0013]-[0014], [0016], claim 6.

9. Claim 19–"the coal comprises added sorbent enhancement additive that comprises the bromide compound."

417. Vosteen discloses that "bromine compound, for example, sodium bromide, can be added in solid form, for example as salt, or liquid form, for example as aqueous solution, to the waste mixture, coal or the like to be burnt, upstream of the furnace. The addition can also be made to a plant section upstream of the furnace, for example ... to a coal mill." EX1011, [0013].

418. Vosteen further discloses "addition of bromine or bromine compounds to the furnace causes ... a substantial, essentially complete, oxidation of the mercury and therefore allows substantial removal of the mercury from flue gases." EX1011, [0007], [0013], [0047], Example 5.

419. Because the combination of Vosteen and Altman discloses every element of Claim 1, and Vosteen specifically discloses that the bromine compound can be added directly to the coal as required by Claim 19, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 19 would have been obvious to a POSITA at the time of the invention in light of Vosteen combined with Altman for the reasons explained above in Paragraphs 417-418. EX1011, [0007], [0013], [0047], Example 5.

10. Claim 20—"the coal is combusted in a combustion chamber at a coal-combustion facility, wherein the HBr, bromide compound, or combination thereof, is added to the coal before the coal enters the combustion chamber, wherein the addition of the HBr, bromide compound, or combination thereof, to the coal is performed at the coal-combustion facility."

420. Vosteen explains that "[t]he invention describes a process for removing mercury from flue gases of high-temperature plants, in particular power stations." EX1011, Abstract. An example of such a facility is the "coal-fired power station of Bayer AG in Uerdingen" having "a slag-tap filed boiler [that "are charged with coal"] and a flue gas emission control system typical of a power station." EX1011, [0045], [0047].

421. Vosteen further discloses "[t]he bromine compound, for example, sodium bromide, can be added in solid form, for example as salt, or liquid form, for example as aqueous solution, to the waste mixture, coal or the like to be burnt, upstream of the furnace." *Id.*, [0013]. A POSITA would understand this disclosure to teach that the bromine compound is added directly to the coal upstream of the furnace before the coal enters the combustion chamber.

422. Because the combination of Vosteen and Altman discloses every element of Claim 1, and Vosteen specifically discloses that the bromine compound can be added directly to coal, which is combusted in a combustion chamber at a coal-combustion facility as required by Claim 20, it is my opinion, based on my

education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 20 would have been obvious to a POSITA at the time of the invention in light of Vosteen combined with Altman for the reasons explained above in Paragraphs 420-421. EX1011, Abstract, [0013], [0045], [0047].

11. Claim 22–"the sorbent is contacted with a halogen or halide promoter prior to the addition of the sorbent to the mercury-containing gas."

423. Nelson describes exposing activated carbon sorbent to a bromine-containing gas before the sorbent is mixed with mercury-containing flue gas. EX1008, [0040]; EX1009, 4.

424. In my opinion, a POSITA had reason to substitute Nelson's brominated-activated carbon sorbent for Altman's activated carbon sorbent in the Vosteen/Altman process because Nelson indicates that exposure of sorbent to Br_2 or HBr gas "significantly increases the carbonaceous materials ability to remove mercury species." EX1008, [0041]; EX1009, 4.

425. A POSITA further would have known that Nelson's approach would have increased overall mercury capture as it was known since the 1930s to remove mercury vapors by contacting halogen-impregnated activated-carbon sorbents with mercury-containing gas. EX1049, 1:33–41.

426. Because Vosteen combined with Altman discloses every element of Claim 1, and Nelson discloses the sorbent is contacted with a halogen or halide

promoter prior to the addition of the sorbent to the mercury-containing gas, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 22 would have been obvious to a POSITA at the time of the invention in light of Vosteen and Altman combined with Nelson for the reasons explained above in Paragraphs 423-425. EX1008, [0040]-[0041]; EX1009, 4; EX1049, 1:33–41.

12. Claim 23–"the sorbent is free of contact with a halogen or halide promoter prior to the addition of the sorbent to the mercury-containing gas."

427. As discussed repeatedly throughout this section of my Declaration, Vosteen discloses a system in which activated carbon—"granulated activated carbon" or "pulverulent slaked lime/activated carbon" is used as a sorbent. Nothing in Vosteen discloses or suggests adding bromine or any other halogen promoter to the activated carbon sorbent. EX1011.

428. Similarly, Altman does not describe any contact of PAC sorbent with a halogen or halide promoter before injection into the flue gas. EX1007.

429. In my opinion, a POSITA at the time of the invention had reason to select halogen-free activated carbon due to its lower cost as compared to halogen-activated carbons especially where sufficient mercury removal can be achieved without resorting to halogen-activated carbons as in Vosteen and Altman.

430. Because the combination of Vosteen and Altman discloses every element of Claim 1, and a POSITA would have been motivated to select a halogen free activated carbon as required by Claim 23, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 23 would have been obvious to a POSITA at the time of the invention in light of Vosteen combined with Altman for the reasons explained above in Paragraphs 427-429. EX1007; EX1011.

13. Claim 25—"the coal comprises subbituminous coal."

431. Vosteen discloses that its "present invention," which includes the use of bromine compounds such as sodium bromide applied to the coal upstream of the furnace or boiler, can be used at "power stations, for example bituminous coal-fired or lignite-fired power stations." EX1011, [0008]. A POSITA would have known that there are four main types or ranks of coal used in the United States: anthracite, bituminous, subbituminous, and lignite. Bituminous and subbituminous are the most common and are used for power generation. While a POSITA would know that subbituminous coal generally has lower mercury concentrations than bituminous, a POSITA also would have known that EPA regulations did not exclude power plants using subbituminous coal. Accordingly, a POSITA would have been motivated to use mercury control processes such as those taught by Vosteen and Altman at facilities combusting subbituminous coal. For example, Nelson discloses testing

performed using brominated sorbents at "The Pleasant Prairie power plant in Wisconsin," which "burns a low-sulfur subbituminous coal and has a high mercury of about 14 ug/Nm^3." EX1008, [0081].

432. Because the combination of Vosteen and Altman discloses every element of Claim 1, and it would have been obvious to a POSITA at the time of the invention to implement mercury control systems at any coal-fired power plant, including those combusting subbituminous coal, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 25 would have been obvious to a POSITA at the time of the invention in light of Vosteen combined with Altman for the reasons explained above in Paragraph 431. EX1008, [0081]; EX1011, [0008].

14. Claim 26—"the coal comprises lignite coal."

433. Vosteen discloses that its "present invention," which includes the use of bromine compounds such as sodium bromide applied to the coal upstream of the furnace or boiler, can be used at "power stations, for example bituminous coal-fired or lignite-fired power stations." EX1011, [0008].

434. Because the combination of Vosteen and Altman discloses every element of Claim 1, and Vosteen discloses that its processes can be used at lignite-fired power stations as required by Claim 26, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction

technology, that Claim 26 would have been obvious to a POSITA at the time of the invention in light of Vosteen combined with Altman for the reasons explained above in Paragraph 433. EX1011, [0008].

15. Claim 27–"the mixture is combusted in a combustion chamber of a coal-combustion facility upstream of a scrubber, a particulate control system, or a combination thereof, wherein the particulate sorbent is added to the mercury-containing gas before the mercury-containing gas encounters the scrubber, the particulate control system, or the combination thereof."

Claim 28–"the particulate control system comprises an electrostatic precipitator, a baghouse, a fabric filter, or a combination thereof."

435. Claim 28 depends from Claim 26 and requires that the particulate control system comprises an ESP, a baghouse, a fabric filter, or a combination thereof.

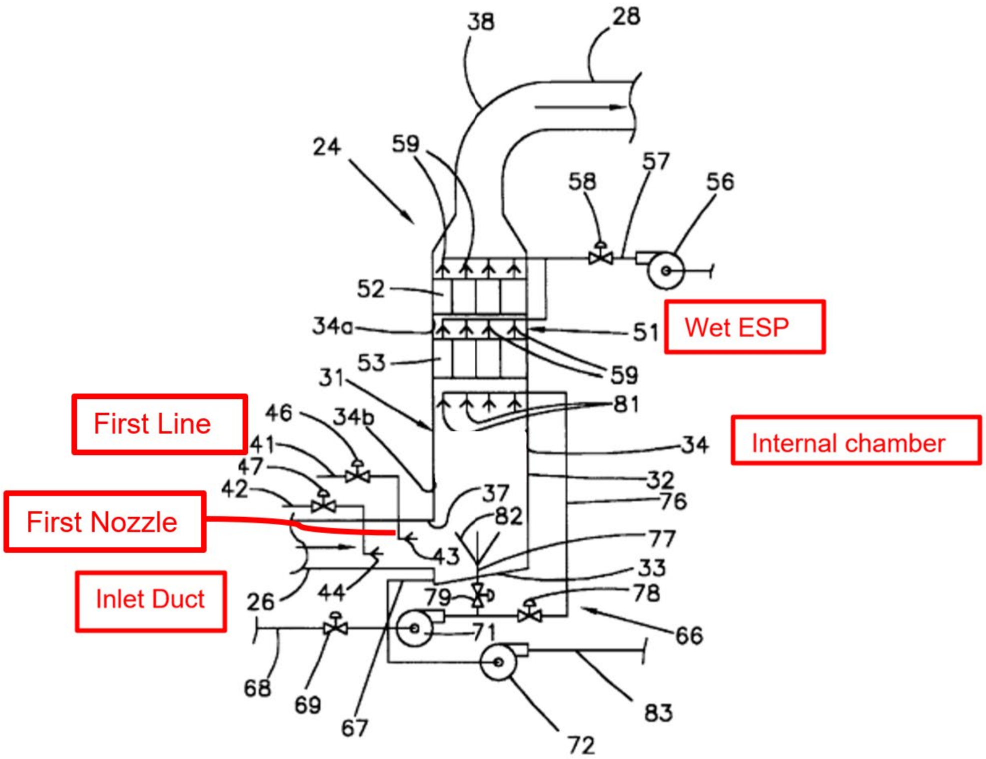
436. Vosteen explains that "[t]he invention describes a process for removing mercury from flue gases of high-temperature plants, in particular power stations." EX1011, Abstract. An example of such a facility is the "coal-fired power station of Bayer AG in Uerdingen" having "a slag-tap filed boiler [that "are charged with coal"] and a flue gas emission control system typical of a power station." EX1011, [0045], [0047].

437. Vosteen further discloses "[t]he bromine compound, for example, sodium bromide, can be added in solid form, for example as salt, or liquid form, for

example as aqueous solution, to the waste mixture, coal or the like to be burnt, upstream of the furnace." *Id.*, [0013]. A POSITA would understand this disclosure to teach that the bromine compound is added directly to the coal upstream of the furnace before the coal enters the combustion chamber.

438. Vosteen describes a flue gas emissions control system as known in the art "based either on wet scrubbing or dry cleanup or a combination of the two." *Id.*, [0017].

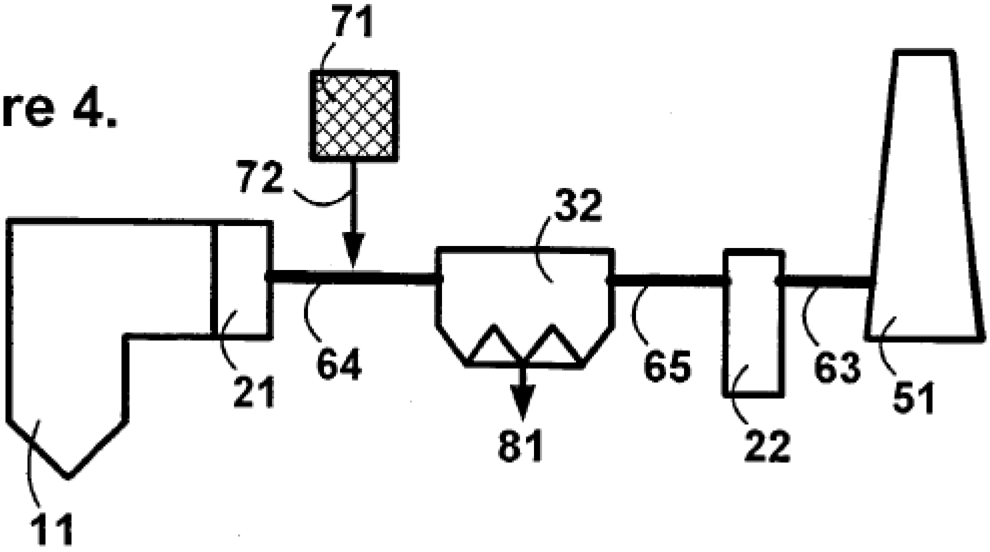
439. Altman's Figure 2 depicts coal combustion in boiler 12 and sorbent injection into duct 26 upstream of chamber 34 by means of first line 41 and first nozzle 43. Chamber 34 is upstream of wet electrostatic precipitator (ESP) 51, which is a "particulate control device" that collects sorbent.



EX1007, 4:17–21, 58–61; 5:27–29; Figure 2. An ESP is a particulate separator, as Claim 28 of the '225 Patent states that "the particulate control system comprises an electrostatic precipitator."

440. Nelson describes combusting coal in boiler 11 and injecting sorbent from bin 71 upstream of ESP 32. EX1008, [0059], [0062], Figure 4.

Figure 4.



441. Because the combination of Vosteen and Altman discloses every element of Claims 1 and 26, and Vosteen discloses that the bromine compound can be added directly to coal, which is combusted in a combustion chamber upstream of a scrubber and/or a particulate control system at a coal-combustion facility and the sorbent is added to the flue gas before the particulate control system as required by Claim 27, and each of Vosteen, Altman and Nelson discloses use of particulate control systems comprising an ESP, baghouse or fabric filter as required by Claim 28, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claims 27 and 28 would have been obvious to a POSITA at the time of the invention in light of Vosteen and Altman or Vosteen, Altman and Nelson for the reasons explained above in Paragraphs 435-440. EX1007, 4:17–21, 58–61; 5:27–29; Figure 2; EX1008, [0059], [0062], Figure 4; EX1011, Abstract, [0013], [0017], [0045], [0047].

16. Claim 29–"the combustion chamber is a coal combustion furnace."

442. Claim 29 depends from claim 19. Vosteen discloses that "[t]he invention relates to the process for the removal of mercury and other pollutant species from gas streams generated during the burning of fossil fuels, such as in a coal-fired utility or synthesis gas from gasification facilities." An example of such a facility is the "coal-fired power station of Bayer AG in Uerdingen" with boilers 91, 91' (also referenced as a furnace). EX1011, [0046]-[0047].

443. The assignee of Altman is Electric Power Research Institute, Inc. EX1007, Cover. As a POSITA would have known, EPRI is a non-profit organization that conducts research and development related to the generation, delivery, and use of electricity. Altman further discloses that its "invention is for use with a combustion source such as a fossil-fuel-fired boiler 12 which receives air through air inlet duct 13 to combust fuel such as coal received through fuel inlet duct." EX1007, 3:41-44.

444. Because the combination of Vosteen and Altman discloses every element of Claims 1 and 19, and Vosteen and Altman specifically discloses a coal-combustion facility having furnaces as required by Claim 29, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 29 would have been obvious to a POSITA at the

time of the invention in light of Vosteen combined with Altman for the reasons explained above in Paragraphs 442-443. EX1011, [0045]; EX1007, Cover, 3:41-44.

D. Independent Claim 14

445. Claim 14 is similar to Claim 1 discussed above, with one difference. Claim 14 replaces "combusting a mixture comprising coal," with "combusting coal in a combustor comprising".

446. As explained above regarding Claims 1 and 19, and in the paragraphs that follow, Vosteen discloses adding bromine, such as in the form of HBr or sodium bromide, to the coal before combustion and/or to the furnace or boiler.

447. As a result, it is my opinion that, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, Claim 14 would have been obvious to a POSITA at the time of the invention in light of Vosteen combined with Altman.

1. Element 14(Preamble)–"A method for treating a mercury-containing gas, the method comprising:"

448. The preamble of Claim 14 is identical to the preamble of Claim 1 discussed above.

449. Vosteen is titled "PROCESS FOR REMOVING MERCURY FROM FLUE GASES" and is generally directed to "a process for removing mercury from flue gases of high-temperature plants, in particular power stations and waste

incineration plants in which a bromine compound is fed to the if appropriate multistage furnace and/or the flue gas in a plant section downstream of the furnace.” EX1011, Abstract. Such flue gases are examples of a mercury-containing gas.

450. This preamble is also disclosed in claim 1 of Vosteen, which is reproduced and emphasized below:

> 1. **Process for removing mercury from flue gases of high-temperature plants, in particular from power stations** and waste incineration plants, characterized in that
>
>> bromine and/or a bromine compound and/or a mixture of various bromine compounds is fed to the if appropriate multistage 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 at least 500° C., preferably at least 800° C.,
>>
>> …
>>
>> **and then the flue gas being subjected to an if appropriate multistage cleanup for removing mercury from the flue gas, which cleanup comprises a wet scrubber and/or a dry cleanup**.

451. Altman is titled “METHOD FOR REMOVING MERCURY FROM A GAS STREAM AND APPARATUS FOR SAME” and is generally directed to “[a] method for removing mercury from a gas stream” in which “sorbent is injected into the gas stream.” EX1007, Abstract.

452. Claim 1 of Altman, reproduced and emphasized below, also discloses the preamble:

> 1. **A method for removing mercury from a gas stream comprising the steps of injecting sorbent into the gas stream**, dispersing water into the gas

> stream to create a cooled gas stream, allowing the cooled gas stream to dwell with the sorbent in a chamber **for removing mercury from the cooled gas stream** and passing the cooled gas stream through an electrostatic precipitator located above the chamber to collect water and recycle the collected water back into the chamber for cooling the gas stream in the chamber.

453. Vosteen and Altman, in my opinion, each discloses the preamble of Claim 14 as both references describe multiple methods for treating a mercury-containing gas by reducing mercury in the gas, more specifically a flue gas at a coal burning power plant for the reasons explained above in Paragraphs 448-452. EX1011, Abstract, Claim 1; EX1007, Abstract, Claim 1.

2. Element 14(a)–"combusting coal in a combustor comprising pyrolysis char and an additive comprising HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas; and"

454. Vosteen discloses this claim element. Vosteen discloses addition of a bromide compound, in forms such as HBr and sodium bromide (NaBr), to the furnace or directly to the coal in coal-fired boilers of a power plant, and that "addition of bromine or bromine compounds to the furnace causes ... a substantial, essentially complete, oxidation of the mercury and therefore allows substantial removal of the mercury from flue gases." EX1011, [0007], [0013], [0047], Example 5.

455. Vosteen further discloses that "[t]he bromine compound, for example, sodium bromide, can be added in solid form, for example as salt, or liquid form, for

example as aqueous solution, to the waste mixture, coal or the like to be burnt, upstream of the furnace. . . . . The addition can also be made to a plant section upstream of the furnace, for example, … to a coal mill." *Id.*, [0013] (emphasis added).

456. Vosteen further discloses that "[t]he addition of a bromine compound … is made according to the invention to the furnace and/or to the flue gas in a plant section downstream of the furnace." EX1011, [0013].

457. Vosteen further discloses that "[its] invention relates to a process for removing mercury from flue gases of high-temperature plants, in particular from power stations and waste incineration plants, in which bromine and/or a bromine compound and/or a mixture of various bromine compounds is fed to the if appropriate multistage furnace." *Id.*, [0006].

458. Claim 1 of Vosteen also discloses this limitation:

> 1. Process for removing mercury from flue gases of high-temperature plants, in particular from power stations and waste incineration plants, characterized in that bromine and/or a bromine compound and/or a mixture of various **bromine compounds is fed to the if appropriate multistage 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 at least 500º C., preferably at least 800º C. …(Emphasis added).

459. Pyrolysis char is necessarily present when coal is combusted. EX1087, 673 ("pyrolysis, even under the most favorable conditions, includes the formation of

… residual char”). Thus, a mixture of coal, pyrolysis char and the bromine additive is necessarily present in Vosteen’s combustion.

460. Altman discloses that its “invention is for use with a combustion source such as a fossil-fuel-fired boiler 12 which receives air through air inlet duct 13 to combust fuel such as coal received through fuel inlet duct.” EX1007, 3:41-44.

461. Vosteen, in my opinion, discloses combusting coal in a combustor comprising pyrolysis char and an additive comprising HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas for the reasons explained above in Paragraphs 454-460. EX1011, [0005]-[0007], [0009], [0013], [0025], [0047], Example 5; EX1007, 3:41-44.

3. Element 14(b)–“adding a particulate sorbent material comprising activated carbon into the mercury-containing gas.”

462. Vosteen suggests using wet scrubbers or dry systems or a combination as known in the art. EX1011, [0017]. Vosteen describes wet scrubbing “performed, for example, in … a packed-bed scrubber” without indicating what packing was used in the packed-bed. *Id.* Vosteen discloses “removal of mercury from the flue gases in a flue gas emission control system downstream of the combustion” using “finely pulverant slaked lime/activated carbon.” EX1011, [0007], [0019], [0047]-[0049].

463. Altman discloses that while flue gas can be passed through a packed bed of activated carbon sorbent to remove mercury, packed beds “are complex to

design and operate" and "produce high pressure drops and require periodic regeneration." EX1007, 1:30–40.

464. Instead of using a packed bed with stationary sorbent, Altman injects activated carbon and lime sorbent particles into flue gas in the emission control system such that the sorbents flow with the flue gas. EX1007, 4:53–61, 5:50–61.

465. Altman also discloses that injection of activated carbon into flue gas was known in the art for removing mercury in coal-fired boilers before April 1996 and in waste incinerators in 1995 and 1996. EX1007, 2:23–31, 1:41–2:22, 32–46. The '225 Patent itself also acknowledges that activated-carbon injection as a sorbent was well-known in the art. EX1001, 1:58-63, 7:32-40.

466. As previously explained above in the Motivation to Combine section, it is my opinion that a POSITA would have been motivated to combine the activated carbon injection system of Altman with the bromine introduction system of Vosteen. The combination, in my opinion, discloses every element of Claim 14 of the '225 Patent for the reasons explained above in Paragraphs 462-465. EX1011, [0007], [0019], [0047]-[0049]; EX1007, 1:30-40, 4:53-61, 5:6-12, 50-61; EX1001, 1:58-63, 7:32-40.

467. It is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 14

would have been obvious to a POSITA at the time of the invention in light of Vosteen combined with Altman.

E. Claim 15–"the pyrolysis char is a promoted pyrolysis char."

468. Claim 15 depends from claim 14. According to PO's expert in the Delaware litigation, "pyrolysis char forms in the presence of bromine that has been added to the coal. Thus, it is promoted pyrolysis char." EX1083, 163.

469. Because Vosteen and Altman disclose every element of Claim 14, and PO's expert admits that a promoted pyrolysis char is necessarily present during combusting of coal and bromine, it is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 15 would have been obvious to a POSITA at the time of the invention in light of Vosteen combined with Altman for the reasons explained above in Paragraph 468. EX1083, 163.

F. Independent Claim 17

470. Claim 17 is nearly identical to Claim 1 discussed above, with one difference. Claim 17 does not require the "sorbent material" to be "a particulate sorbent material."

471. As explained above regarding Claims 1 and 19, and in the paragraphs that follow, Vosteen discloses the use of flue gas emission control systems which

can use activated carbon. Altman describes adding an activated carbon particulate sorbent material into the mercury-containing gas.

472. As a result, it is my opinion that, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, Claim 17 would have been obvious to a POSITA at the time of the invention in light of Vosteen combined with Altman.

1. Element 17(Preamble)–"A method for treating a mercury-containing gas, the method comprising:"

473. As discussed above regarding Claims 1 and 14, Vosteen and Altman both disclose methods of treating a mercury-containing gas by separating mercury from the gas.

474. Vosteen is titled "PROCESS FOR REMOVING MERCURY FROM FLUE GASES" and is generally directed to "a process for removing mercury from flue gases of high-temperature plants, in particular power stations and waste incineration plants in which a bromine compound is fed to the if appropriate multistage furnace and/or the flue gas in a plant section downstream of the furnace." EX1011, Abstract. Such flue gases are examples of a mercury-containing gas.

475. This preamble is also disclosed in claim 1 of Vosteen, which is reproduced and emphasized below:

> 1. **Process for removing mercury from flue gases of high-temperature plants, in particular from power stations** and waste incineration plants, characterized in that
>
> > bromine and/or a bromine compound and/or a mixture of various bromine compounds is fed to the if appropriate multistage 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 at least 500° C., preferably at least 800° C.,
> >
> > …
> >
> > **and then the flue gas being subjected to an if appropriate multistage cleanup for removing mercury from the flue gas, which cleanup comprises a wet scrubber and/or a dry cleanup**.

476. Altman is titled "METHOD FOR REMOVING MERCURY FROM A GAS STREAM AND APPARATUS FOR SAME" and is generally directed to "[a] method for removing mercury from a gas stream" in which "sorbent is injected into the gas stream." EX1007, Abstract.

477. Claim 1 of Altman, reproduced and emphasized below, also discloses the preamble:

> 1. **A method for removing mercury from a gas stream comprising the steps of injecting sorbent into the gas stream**, dispersing water into the gas stream to create a cooled gas stream, allowing the cooled gas stream to dwell with the sorbent in a chamber **for removing mercury from the cooled gas stream** and passing the cooled gas stream through an electrostatic precipitator located above the chamber to collect water and recycle the collected water back into the chamber for cooling the gas stream in the chamber.

478. Vosteen and Altman, in my opinion, each discloses the preamble of Claim 17 as both references describe multiple methods for treating a mercury-

containing gas by reducing mercury in the gas, more specifically a flue gas at a coal burning power plant for the reasons explained above in Paragraphs 473-477. EX1011, Abstract, Claim 1; EX1007, Abstract, Claim 1. This preamble is the same as Claim 1 and Claim 14.

2. Element 17(a)–"combusting a mixture comprising coal, pyrolysis char, and an additive comprising HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas; and"

479. This claim element is identical to claim element 1(a) discussed above.

480. Vosteen describes "the mass ratio of bromine to mercury in the flue gas." EX1011, [0025], [0028], [0031]. Figures 2, 5, 6, and 8 of Vosteen each display the concentration of bromine and mercury in the flue gas.

481. Vosteen discloses addition of a bromine, in forms such as HBr, Br, and sodium bromide (NaBr), to the furnace or directly to the coal in coal-fired boilers of a power plant, and that "addition of bromine or bromine compounds to the furnace causes ... a substantial, essentially complete, oxidation of the mercury and therefore allows substantial removal of the mercury from flue gases." EX1011, [0007], [0013], [0047], Example 5.

482. Vosteen further discloses that "[t]he **bromine compound**, for example, sodium bromide, can be **added** in solid form, for example as salt, or liquid form, for example as aqueous solution, **to the** waste mixture**, coal or the like to be burnt,**

upstream of the furnace. . . . . The addition can also be made to a plant section upstream of the furnace, for example, … to a coal mill." *Id.*, [0013] (emphasis added).

483. Vosteen further discloses that "[t]he addition of a bromine compound … is made according to the invention to the furnace and/or to the flue gas in a plant section downstream of the furnace." EX1011, [0013].

484. Vosteen further discloses that "[its] invention relates to a process for removing mercury from flue gases of high-temperature plants, in particular from power stations and waste incineration plants, in which bromine and/or a bromine compound and/or a mixture of various bromine compounds is fed to the if appropriate multistage furnace." *Id.*, [0006].

485. Claim 1 of Vosteen also discloses this limitation:

> 1. Process for removing mercury from flue gases of high-temperature plants, in particular from power stations and waste incineration plants, characterized in that bromine and/or a bromine compound and/or a mixture of various **bromine compounds is fed to the if appropriate multistage 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 at least 500º C., preferably at least 800º C. … (Emphasis added).

486. Altman discloses that its "invention is for use with a combustion source such as a fossil-fuel-fired boiler 12 which receives air through air inlet duct 13 to combust fuel such as coal received through fuel inlet duct." EX1007, 3:41-44.

487. Pyrolysis char is necessarily present when coal is combusted. EX1087, 673 ("pyrolysis, even under the most favorable conditions, includes the formation of … residual char"). Thus, a mixture of coal, pyrolysis char and the bromine additive is necessarily present in Vosteen's combustion.

488. Vosteen, in my opinion, discloses combusting a mixture comprising coal, pyrolysis char, and an additive comprising HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas for the reasons explained above in Paragraphs 479-487. EX1011, [0005], [0006], [0007], [0009], [0013], [0025], [0028], [0031], [0047], Example 5; EX1007, 3:41-44.

3. Element 17(b)–"adding a sorbent material comprising activated carbon into the mercury-containing gas."

489. Vosteen suggests using wet scrubbers or dry systems or a combination as known in the art. EX1011, [0017]. Vosteen describes wet scrubbing "performed, for example, in … a packed-bed scrubber" without indicating what packing was used in the packed-bed. *Id.*

490. Altman discloses that while flue gas can be passed through a packed bed of activated carbon sorbent to remove mercury, packed beds "are complex to design and operate" and "produce high pressure drops and require periodic regeneration." EX1007, 1:30–40.

491. Instead of using a packed bed with stationary sorbent, Altman injects activated carbon and lime sorbent particles into flue gas in the emission control system such that the sorbents flow with the flue gas. EX1007, 4:53–61, 5:50–61.

492. Altman also discloses that injection of activated carbon into flue gas was known in the art for removing mercury in coal-fired boilers before April 1996 and in waste incinerators in 1995 and 1996. EX1007, 2:23–31, 1:41–2:22, 32–46. The ‘225 Patent itself also acknowledges that activated-carbon injection as a sorbent was well-known in the art. EX1001, 1:58-63, 7:32-40.

493. As previously explained above in the Motivation to Combine section, it is my opinion that a POSITA would have been motivated to combine the activated carbon injection system of Altman with the bromine introduction system of Vosteen. The combination, in my opinion, discloses claim element 17(b) for the reasons stated above in Paragraphs 489-492. EX1011, [0007], [0019], [0047]-[0049]; EX1007, 1:30-40, 4:53-61, 5:6-12, 50-61.

494. Because the combination of Vosteen and Altman discloses every element of Claim 17, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 17 would have been obvious to a POSITA at the time of the invention in light of Vosteen combined with Altman for the reasons explained above in Paragraphs 473-

493. EX1007, 1:30–2:46, 4:53–61, 5:6-12, 50-61; EX1011, [0007], [0017], [0019], [0047]-[0049]; EX1001, 1:58-63, 7:32-40.

XIV. GROUND 4—CLAIMS 1-2, 5, 8, 11-12, 14–15, 17, 19-20, 22–23 AND 25–29 ARE ANTICIPATED BY BLANKINSHIP

495. Based on my review of Blankinship, and my education, skill, training, and experience in the relevant fields of emission reduction technology, it is my opinion that Claims 1-2, 5, 8, 11-12, 14–15, 17, 19-20, 22–23 and 25–29 are anticipated by Blankinship. In the subsections that follow, I explain the bases for my opinion that Claims 1-2, 5, 8, 11-12, 14–15, 17, 19-20, 22–23 and 25–29 are anticipated by Blankinship.

A. Independent Claim 1

1. Element 1(Preamble)–"A method for treating a mercury-containing gas, the method comprising:"

496. The title of Blankinship is "A Variety of Hg [Mercury] Capture Solutions Are Available." EX1012. As Blankinship further explains, "coal plants in the United States emit about 50 tons of mercury per year." *Id.*, 56.

497. Blankinship states that "[o]ne way of enhancing Hg capture from FGD and SCR at power plants that cannot meet their mercury emission limits through co-benefits alone is to treat the coal (which typically for these situations lacks enough chlorine to force the mercury into a soluble compound) by adding something to it. Alstom's KNX process, for example, uses calcium bromide. Bromide can be added

to the boiler or to the coal to oxidize the mercury and facilitate its capture in wet scrubbers. Newly under consideration is the practice of injecting activated carbon upstream of the FGD to improve its mercury capture performance even more." *Id.*, 56.

498. Blankinship also teaches that "[p]ower plants without an FGD would likely use sorbent injection, mostly an activated carbon, upstream of a particulate control device. The particulate control can be either the plant's existing device or a compact baghouse installed following the primary particulate control, with sorbent injection between the primary control and the new baghouse." *Id.*

499. Blankinship also discloses that upstream injection is beneficial as "it's a higher temperature region with more internal duct area and provides more residence time for the sorbent to absorb the mercury." *Id.* The mercury is absorbed from the flue gas.

500. Blankinship, in my opinion, discloses the preamble of claim 1 as Blankinship describes multiple methods for treating a mercury-containing gas by reducing mercury in the gas, more specifically a flue gas at a coal burning power plant for the reasons explained above in Paragraphs 496-499. EX1012, 56, 58.

2. Element 1(a)–"combusting a mixture comprising coal, pyrolysis char, and an additive comprising HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas; and"

501. Blankinship discloses this claim limitation as well. More specifically, Blankinship discloses the application of "calcium bromide to the coal prior to combustion to promote mercury oxidation" as part of Alstom's KNX^{TM} process. EX1012, 56, 58. I understand that Patent Owner asserts in the Multidistrict Litigation that applying calcium bromide to the coal satisfies this claim element. I agree that calcium bromide is a "bromide compound" as a POSITA would understand the plain and ordinary meaning of that term. Calcium bromide is a "bromide compound" because it is "a substance composed of atoms or ions of two or more elements in chemical combination" in which "constituents are united by bonds or valence forces." EX1015, 291.

502. Blankinship further discloses that Alstom's KNX™ calcium bromide solution "can be added to the boiler or to the coal to oxidize the mercury and facilitate its capture in wet scrubbers" or in electrostatic precipitators (ESPs). EX1012, 56, 58.

503. Pyrolysis char is necessarily present when coal is combusted. EX1087, 673 ("pyrolysis, even under the most favorable conditions, includes the formation of

… residual char”). Thus, a mixture of coal, pyrolysis char and the bromine additive is necessarily present in Blankinship’s combustion.

504. Blankinship also explains that KNX “can be stand-alone to enhance the capabilities of the existing air quality control system or can be applied in combination with another mercury control technology such as our Mer-Cure post-combustion technology or activated carbon injection.” EX1012, 58.

505. Blankinship also discloses that Alstom’s KNX™ “applied to the coal provides better oxidation of the mercury at a lower cost that brominated sorbents.” EX1012, 58.

506. Blankinship, in my opinion, discloses combusting a mixture comprising coal, pyrolysis char, and an additive comprising HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas for the reasons explained above in Paragraphs 501-505. EX1012, 56, 58; EX1015, 291; EX1087, 673.

3. Element 1(b) –“adding a particulate sorbent material comprising activated carbon into the mercury-containing gas.”

507. As I explained in the Technological Background Section above, the use of activated carbon as a sorbent for mercury in flue gas at coal-fired power plants was long known. The ‘225 Patent acknowledges that activated carbon, including powdered activated carbon, was known in the art:

> In some preferred embodiments, the activated carbon provided may preferably be any of several types, as understood by those skilled in the art.

‘225 Patent, 7: 32-34.

508. With respect to activated carbon injection, Blankinship states that “[t]here are also variations of sorbent injection that provide ways to introduce activated carbon into flu gas. It can be injected in front of the air heater instead of behind it to provide more flue gas reaction time. There are also ways to agglomerate the carbon or grind it finer on site to achieve better mass transfer. These processes are also being offered commercially. The post combustion Mer-Cure process Alstom offers is a combination of some of those methods.” EX1012, 58.

509. Blankinship further explains that KNX™ “can be stand-alone to enhance the capabilities of the existing air quality control system or can be applied in combination with another mercury control technology such as our Mer-Cure post-combustion technology or activated carbon injection.” *Id.*

510. Mer-Cure, Blankinship states, “is essentially an enhanced carbon injection system … It has a silo, feed system and injection lances that inject the activated carbon into the duct work.” *Id.* A POSITA would understand from this disclosure that the activated carbon in the Mer-Cure system is a sorbent added to the flue gas.

511. Blankinship therefore, in my opinion, discloses methods for adding a particulate activated carbon sorbent into mercury-containing flue for the reasons explained above in Paragraphs 507-510. EX1012, 58.

512. As established above, Blankinship discloses every element of Claim 1 of the ‘225 Patent. It is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Blankinship anticipates Claim 1.

B. Claims Depending From Claim 1

1. Claim 2–“the pyrolysis char is a promoted pyrolysis char.”

513. According to PO’s expert in the Delaware litigation, “pyrolysis char forms in the presence of bromine that has been added to the coal. Thus, it is promoted pyrolysis char.” EX1083, 163.

514. Because Blankinship discloses every element of Claim 1, and PO’s expert admits that a promoted pyrolysis char is necessarily present during combusting of coal and bromine, it is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Blankinship anticipates Claim 2 for the reasons explained above in Paragraph 513. EX1083, 163.

2. Claim 5–“using a particle separation device to remove mercury from the flue gas and comprising collecting greater

> **than 70 wt % of the mercury in the mercury-containing gas to produce a cleaned gas."**

515. Claim 5 specifies that the method of Claim 1 must use a particle separation device to remove mercury from flue gas and remove greater than 70 wt % of the mercury in the mercury-containing gas. Blankinship discloses this limitation as well.

516. Blankinship states that "[t]here are also variations of sorbent injection that provide ways to introduce activated carbon into flu gas. It can be injected in front of the air heater instead of behind it to provide more flue gas reaction time. There are also ways to agglomerate the carbon or grind it finer on site to achieve better mass transfer. These processes are also being offered commercially. The post combustion Mer-Cure process Alstom offers is a combination of some of those methods." *Id.*, 56.

517. Blankinship further discloses that "[p]ower plants without an FGD would likely use sorbent injection, mostly an activated carbon, upstream of a particulate control device. The particulate control can be either the plant's existing device or a compact baghouse installed following the primary particulate control, with sorbent injection between the primary control and the new baghouse." *Id.*

518. Blankinship also describes the Mer-Cure system as being "targeted primarily to ESP configurations, [but] Alstom has also installed it on wet scrubber

applications where the combination of Mer-Cure and KNX worked well." EX1012, 58.

519. A POSITA would have known that the EPA had by 2004 already put the industry on notice of upcoming laws and regulations requiring 70% mercury removal, including EPA's Clean Air Mercury Rule (CAMR). EX1045. It thus would have been obvious to a POSITA that any mercury control system would have to comply with these laws and regulations.

520. Blankinship explains that Alstom's KNX method achieves greater than 70 wt % mercury reduction. More specifically, Blankinship states that without KNX, mercury removal levels are "20 to 30 percent." With the KNX system, Blankinship explains, mercury removal is "80 to 90 percent." EX1012, 58.

521. Because Blankinship discloses every element of Claim 1 and that a particle separation device is used to remove mercury from flue gas and the mercury removal is greater than 70 wt % as required by Claim 5, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Blankinship anticipates Claim 5 for the reasons explained above in Paragraphs 515-520. EX1012, 56, 58; EX1045.

3. Claim 8–"the sorbent material is chosen from powdered activated carbon, granular activated carbon, carbon black,

> **carbon fiber, aerogel carbon, pyrolysis char, and combinations thereof."**

522. Claim 8 specifies that the activated carbon sorbent of Claim 1 must be one or more of the following: powdered activated carbon, granular activated carbon, carbon black, carbon fiber, aerogel carbon, pyrolysis char. Blankinship, in my opinion, discloses at least a powdered activated carbon and/or a granular activated carbon.

523. Blankinship discloses that the Mer-Cure system "has an on line processor that keeps the resulting material from sticking together and de-agglomerates it to create smaller particle sizes and greater surface area." EX1012, 58. As discussed above, Blankinship states that the Mer-Cure system can be used with Alstom's KNX^{TM} that uses calcium bromide.

524. Blankinship also discloses that "[t]here are also ways to agglomerate the [activated] carbon or grind it finer on site to achieve better mass transfer." EX1012, 56. Thus, Blankinship describes activated carbon particles which would be powdered or granular.

525. Because Blankinship discloses every element of Claim 1 and at least one of the types of activated carbon required by Claim 8, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission

reduction technology, that Blankinship anticipates Claim 8 for the reasons explained above in Paragraphs 522-524. EX1012, 56, 58.

4. Claim 11–"contacting the sorbent material with a secondary component chosen from halogens, hydrogen halides, Group V halides, Group VI halides, and combinations thereof."

Claim 12–"the secondary component is chosen from halogens, halide salts, HI, HBr, HCl, and combinations thereof."

526. Julien discloses that "94-99% of the chlorine in coal is volatilized and emitted as gaseous HCl during pulverized firing." EX1014, 165; EX1072, 199 (Table 1). Thus, coal-fired power plant flue gas necessarily contains HCl that would contact the sorbent.

527. Because Blankinship discloses every element of Claim 1, and coal-fired power plant flue gas necessarily contains HCl that would contact the sorbent, it is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Blankinship anticipates Claims 11-12 as evidenced by Julien for the reasons explained above in Paragraph 526. EX1014, 165; EX1072, 199 (Table 1).

5. Claim 19–"the coal comprises added halide sorbent enhancement additive that comprises the added Br_2, HBr, the bromide compound, or combination thereof."

528. The '225 Patent does not define the term "sorbent enhancement additive." The term is used only once outside of the claims, and that single use

states: "This invention provides for cost-effective removal of pollutants including mercury, using sorbent enhancement additives and/or highly reactive sorbents." EX1001, 2:24-28.

529. I assume for purposes of my analysis that the "sorbent enhancement additive" refers to the "additive comprising HBr, a bromide compound, or a combination thereof" in element 1(a) of Claim 1. Blankinship discloses this claim element.

530. Blankinship states that "Alstom's KNX process, for example, uses calcium bromide. Bromide can be added to the boiler or to the coal to oxidize the mercury and facilitate its capture in wet scrubbers. Newly under consideration is the practice of injecting activated carbon upstream of the FGD to improve its mercury capture performance even more." EX1012, 56.

531. Blankinship also teaches that "Power plants without an FGD would likely use sorbent injection, mostly an activated carbon, upstream of a particulate control device. The particulate control can be either the plant's existing device or a compact baghouse installed following the primary particulate control, with sorbent injection between the primary control and the new baghouse." *Id.*

532. Blankinship also discloses that upstream injection is beneficial as "it's a higher temperature region with more internal duct area and provides more residence time for the sorbent to absorb the mercury." *Id.*

533. Blankinship discloses that one "might see 20 to 30 percent mercury removal with the existing AQCS system. When they apply the KNX to the coal it goes from 20 to 30 percent removal to 80 to 90 percent. You may find other cases where they are burning a coal that is not sub-bituminous and you may already have a relatively high mercury removal of say 60 to 80 percent and we can enhance that even 90 percent removal." *Id.*, 58. The KNX product, which is calcium bromide, is thus a halide sorbent enhancement additive.

534. Because Blankinship discloses every element of Claim 1, and further teaches that the bromine compound is added to the coal, it is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Blankinship anticipates Claim 19 for the reasons explained above in Paragraphs 528-533. EX1012, 56, 58.

6. Claim 20— "the coal is combusted in a combustion chamber at a coal-combustion facility, wherein the HBr, bromide compound, or combination thereof, is added to the coal before the coal enters the combustion chamber, wherein the addition of the HBr, bromide compound, or combination thereof, to the coal is performed at the coal-combustion facility."

535. As discussed above regarding claim element 1(a), Blankinship explains that "Alstom is attacking Hg from two different approaches that, in some cases, might be used simultaneously. Alstom's KNX pre-combustion offering applies calcium bromide to the coal prior to combustion to promote mercury oxidation."

EX1012, 58. This is done because "[i]f you can oxidize the mercury, you can collect it in downstream equipment." *Id.*

536. Blankinship also explains that Alstom's KNX™ calcium bromide solution is "added to the boiler or to the coal" pre-combustion in concentrations where it "enhances mercury oxidation without causing other concerns such as corrosion in the boiler." *Id.*, 56, 58. Blankinship further explains that "Alstom's KNX business model is to offer the technology and let the customer supply the additive. 'There is some equipment used to inject the solution … but it's a fairly simple approach. It can be a capital solution or just a technology approach.'" *Id.*, 58. Blankinship thus discloses that the bromine additive can be applied at the coal-combustion facility.

537. Because Blankinship discloses every element of Claim 1 and specifically teaches that the bromide is added to the coal at the coal-combustion facility, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Blankinship anticipates Claim 20 for the reasons explained above in Paragraphs 535-536. EX1012, 56, 58.

7. Claim 22—"the sorbent is contacted with a halogen or halide promoter prior to the addition of the sorbent to the mercury-containing gas."

538. Blankinship discloses that a "Strategy" being deployed is to "treat the coal (which typically for these situations lacks enough chlorine to force the mercury

into a soluble solution) by adding something to it. Alstom's KNX process, for example, uses calcium bromide." EX1012, 56.

539. Blankinship further discloses that both "[a]ctivated carbon and brominated activated carbon injection technology are being deployed at a number of power plants." *Id.* A POSITA would know that a "brominated activated carbon" is obtained by contacting the base activated carbon with a halogen or halide promoter (a bromine promoter) prior to injecting the brominated activated carbon into the flue gas.

540. Because Blankinship discloses every element of Claim 1 and because Blankinship discloses a sorbent obtained by contacting the base sorbent with a halogen or halide promoter (*i.e.*, obtaining brominated activated carbon), it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Blankinship anticipates Claim 22 for the reasons explained above in Paragraphs 538-539. EX1012, 56, 58.

8. Claim 23–-"the sorbent is free of contact with a halogen or halide promoter prior to the addition of the sorbent to the mercury-containing gas."

541. Claim 23 requires that the activated carbon (sorbent) of Claim 1 is injected into the mercury-containing gas prior to contacting a halogen or halide promoter. A POSITA would understand that Blankinship discloses this claim element.

542. Blankinship states that "[a]ctivated carbon and brominated activated carbon injection technology are being deployed at a number of power plants." EX1012, 56. A POSITA would understand this disclosure as distinguishing between systems where the sorbent (activated carbon) is contacted with a bromide compound prior to injection of the sorbent into the mercury-containing gas and those systems where the bromide compound (KNX) is added directly to the coal and/or combustion chamber without contacting the sorbent prior to injection of the sorbent.

543. In my opinion, a POSITA at the time of the invention had reason to select halogen-free activated carbon due to its lower cost as compared to halogen-activated carbons especially where sufficient mercury removal can be achieved without resorting to halogen-activated carbons as in Blankinship.

544. Because Blankinship discloses every element of Claim 1 and because a POSITA would understand that the activated carbon in the Mer-Cure system is free of contact with a halogen or halide promoter prior to injection, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Blankinship anticipates Claim 23 for the reasons explained above in Paragraphs 541-543. EX1012, 56.

9. Claim 25—"wherein the coal comprises subbituminous coal."

545. Claim 25 requires that the coal combusted in the combustion chamber in Claim 1 is subbituminous coal. This claim element is also disclosed by Blankinship.

546. Blankinship discloses that "Alstom says KNX is most attractive for a client burning sub-bituminous coal" and that "[l]ignite can be a good candidate for the process as well." EX1012, 58.

547. Because Blankinship discloses every element of Claim 1 and specifically teaches that the disclosed methods can be "most attractive" for subbituminous coal, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Blankinship anticipates Claim 25 for the reasons explained above in Paragraphs 545-546. EX1012, 58.

10. Claim 26—"wherein the coal comprises lignite coal."

548. While Claim 26 specifies that the coal is subbituminous coal, Claim 26 specifies that the coal is lignite coal. Blankinship discloses that the KNX system can be used with lignite coal.

549. More specifically, Blankinship discloses that Texas lignite has substantially higher mercury levels that other coals. EX1012, 56.

550. Blankinship further discloses that "[l]ignite can be a good candidate for the [KNX] process as well." *Id.*, 58.

551. Because Blankinship discloses every element of Claim 1 and specifically teaches that the disclosed methods can be used for lignite coal as well, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Blankinship anticipates Claim 26 for the reasons explained above in Paragraphs 548-550. EX1012, 56, 58.

11. Claim 27–"the mixture is combusted in a combustion chamber of a coal-combustion facility upstream of a scrubber, a particulate control system, or a combination thereof, wherein the particulate sorbent is added to the mercury-containing gas before the mercury-containing gas encounters the scrubber, the particulate control system, or the combination thereof."

Claim 28–"the particulate control system comprises an electrostatic precipitator, a baghouse, a fabric filter, or a combination thereof."

552. Claim 28 depends from Claim 26, which depends from Claim 1. Claim 28 requires simply that the particulate control system be an ESP, a baghouse, and/or a fabric filter. Blankinship discloses this claim element.

553. Blankinship states that "[t]here are also variations of sorbent injection that provide ways to introduce activated carbon into flu gas. It can be injected in front of the air heater instead of behind it to provide more flue gas reaction time. There are also ways to agglomerate the carbon or grind it finer on site to achieve

better mass transfer. These processes are also being offered commercially. The post combustion Mer-Cure process Alstom offers is a combination of some of those methods." EX1012*,* 56.

554. Blankinship further discloses that "[p]ower plants without an FGD would likely use sorbent injection, mostly an activated carbon, upstream of a particulate control device. The particulate control can be either the plant's existing device or a compact baghouse installed following the primary particulate control, with sorbent injection between the primary control and the new baghouse." *Id.*

555. Blankinship also describes the Mer-Cure system as being "targeted primarily to ESP configurations, [but] Alstom has also installed it on wet scrubber applications where the combination of Mer-Cure and KNX worked well." *Id.*, 58.

556. Blankinship also discloses that upstream injection is beneficial as "it's a higher temperature region with more internal duct area and provides more residence time for the sorbent to absorb the mercury." *Id.*

557. Blankinship discloses that "Alstom's KNX pre-combustion offering applies calcium bromide to the coal prior to combustion to promote mercury oxidation" and that Alstom installs the "equipment used to inject the [KNX] solution." *Id.*, 58.

558. Because Blankinship discloses every element of Claims 1 and 26, and further teaches that the Mer-Cure or other activated carbon sorbent can be injected

upstream of a particular separator or scrubber and that the particulate control can be an ESP or baghouse, it is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Blankinship anticipates Claims 27 and 28 for the reasons explained above in Paragraphs 552-557. EX1012, 56, 58.

12. Claim 29—"the combustion chamber is a coal combustion furnace."

559. Blankinship discusses the use of KNX and Mer-Cure in the context of "coal plants," and more specifically at "power plants." EX1012, 56. The purpose per Blankinship is to reduce "mercury emissions from power plants and other industrial facilities." *Id.* The combustion boiler would necessarily include a furnace. *Id.*, 58.

560. Because Blankinship discloses every element of Claim 1 and specifically teaches that the KNX and Mer-Cure systems are used a coal power plants having a boiler and boilers are known to include a furnace, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Blankinship anticipates Claim 29 for the reasons explained in Paragraph 559. EX1012, 56, 58.

C. Independent Claim 14

561. Claim 14 is similar to Claim 1 discussed above, with one difference. Claim 14 replaces "combusting a mixture comprising coal," with "combusting coal in a combustor comprising".

562. As explained above regarding Claims 1 and 19, and in the paragraphs that follow, Blankinship discloses adding calcium bromide (KNX) to the coal before combustion and/or adding calcium bromide (KNX) to the furnace or boiler.

563. As a result, and explained in more detail below, it is my opinion that, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Blankinship anticipates Claim 14.

1. Element 14(Preamble)–"A method for treating a mercury-containing gas, the method comprising:"

564. The preamble of Claim 14 is identical to the preamble of Claim 1 discussed above.

565. The title of Blankinship is "A Variety of Hg [Mercury] Capture Solutions Are Available." EX1012. As Blankinship further explains, "coal plants in the United States emit about 50 tons of mercury per year." *Id.*, 56.

566. Blankinship states that "[o]ne way of enhancing Hg capture from FGD and SCR at power plants that cannot meet their mercury emission limits through co-benefits alone is to treat the coal (which typically for these situations lacks enough

chlorine to force the mercury into a soluble compound) by adding something to it. Alstom's KNX process, for example, uses calcium bromide. Bromide can be added to the boiler or to the coal to oxidize the mercury and facilitate its capture in wet scrubbers. Newly under consideration is the practice of injecting activated carbon upstream of the FGD to improve its mercury capture performance even more." *Id.*, 56.

567. Blankinship also teaches that "Power plants without an FGD would likely use sorbent injection, mostly an activated carbon, upstream of a particulate control device. The particulate control can be either the plant's existing device or a compact baghouse installed following the primary particulate control, with sorbent injection between the primary control and the new baghouse." *Id.*

568. Blankinship also discloses that upstream injection is beneficial as "it's a higher temperature region with more internal duct area and provides more residence time for the sorbent to absorb the mercury." *Id.* The mercury is absorbed from the flue gas.

569. Blankinship, in my opinion, discloses the preamble of claim 14 as Blankinship describes multiple methods for treating a mercury-containing gas by reducing mercury in the gas, more specifically a flue gas at a coal burning power plant for the reasons explained above in Paragraphs 564-568. EX1012, 56, 58.

2. Element 14(a)–"combusting coal in a combustor comprising pyrolysis char and an additive comprising HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas; and"

570. Blankinship discloses the application of "calcium bromide to the coal prior to combustion to promote mercury oxidation" as part of Alstom's KNX™ process. EX1012, 56, 58. I understand that Patent Owner asserts in the Multidistrict Litigation that applying calcium bromide to the coal satisfies this claim element. I agree that calcium bromide is a "bromide compound" as a POSITA would understand the plain and ordinary meaning of that term. Calcium bromide is a "bromide compound" because it is "a substance composed of atoms or ions of two or more elements in chemical combination" in which "constituents are united by bonds or valence forces." EX1015, 291.

571. Blankinship further discloses that Alstom's KNX™ calcium bromide solution "can be added to the boiler or to the coal to oxidize the mercury. EX1012, 56, 58.

572. Blankinship also explains that KNX "can be stand-alone to enhance the capabilities of the existing air quality control system or can be applied in combination with another mercury control technology such as our Mer-Cure post-combustion technology or activated carbon injection." *Id.*

573. Blankinship also discloses that Alstom's KNX™ "applied to the coal provides better oxidation of the mercury at a lower cost than brominated sorbents." *Id.*, 58.

574. Pyrolysis char is necessarily present when coal is combusted. EX1087, 673 ("pyrolysis, even under the most favorable conditions, includes the formation of … residual char"). Thus, a mixture of coal, pyrolysis char and the bromine additive is necessarily present in Blankinship's combustion.

575. Blankinship, in my opinion, discloses a method in which an additive (KNX – calcium bromide) is added to the coal before combustion to form the mercury-containing gas as well as a method in which the KNX additive is added to the combustion chamber (boiler in Blankinship) and thus, discloses combusting coal in a combustor comprising pyrolysis char and an additive comprising a bromide compound for the reasons explained above in Paragraphs 570-574. EX1012, 56, 58; EX1015, 291; EX1087, 673.

3. Element 14(b)–"adding a particulate sorbent material comprising activated carbon into the mercury-containing gas."

576. This claim element is identical to claim element 1(b) discussed above.

577. With respect to activated carbon injection, Blankinship explains that "[t]here are also variations of sorbent injection that provide ways to introduce activated carbon into flu gas. It can be injected in front of the air heater instead of

behind it to provide more flue gas reaction time. There are also ways to agglomerate the carbon or grind it finer on site to achieve better mass transfer. These processes are also being offered commercially. The post combustion Mer-Cure process Alstom offers is a combination of some of those methods." *Id.*, 58.

578. Blankinship further explains that KNX™ "can be stand-alone to enhance the capabilities of the existing air quality control system or can be applied in combination with another mercury control technology such as our Mer-Cure post-combustion technology or activated carbon injection." *Id.*

579. Mer-Cure, Blankinship states, "is essentially an enhanced carbon injection system … It has a silo, feed system and injection lances that inject the activated carbon into the duct work." *Id.* A POSITA would understand from this disclosure that the activated carbon is a sorbent for collecting mercury from the flue gas.

580. Blankinship therefore, in my opinion, discloses methods for adding a particulate activated carbon sorbent into the mercury-containing gas.

581. As established above, Blankinship discloses every element of Claim 14 of the '225 Patent. It is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Blankinship anticipates Claim 14 for the reasons explained above in Paragraphs 576-580. EX1012, 56, 58.

D. Claim 15–"the pyrolysis char is a promoted pyrolysis char."

582. Claim 15 depends from Claim 14. According to PO's expert in the Delaware litigation, "pyrolysis char forms in the presence of bromine that has been added to the coal. Thus, it is promoted pyrolysis char." EX1083, 163.

583. Because Blankinship discloses every element of Claim 14, and PO's expert admits that a promoted pyrolysis char is necessarily present during combusting of coal and bromine, it is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Blankinship anticipates Claim 15 for the reasons explained above in Paragraph 582. EX1083, 163.

E. Independent Claim 17

584. Claim 17 is nearly identical to Claim 1 discussed above, with one difference. Claim 17 does not require the "sorbent material" to be "a particulate sorbent material."

585. As explained above regarding Claims 1 and 19, Blankinship discloses adding an activated carbon sorbent to the flue gas.

586. As a result, and explained in more detail below, it is my opinion that, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Blankinship anticipates Claim 17.

1. Element 17(Preamble)–"A method for treating a mercury-containing gas, the method comprising:"

587. The preamble of Claim 17 is identical to the preamble of Claim 1 discussed above.

588. The title of Blankinship is "A Variety of Hg [Mercury] Capture Solutions Are Available." EX1012. As Blankinship further explains, "coal plants in the United States emit about 50 tons of mercury per year." *Id.*, 56.

589. Blankinship states that "[o]ne way of enhancing Hg capture from FGD and SCR at power plants that cannot meet their mercury emission limits through co-benefits alone is to treat the coal (which typically for these situations lacks enough chlorine to force the mercury into a soluble compound) by adding something to it. Alstom's KNX process, for example, uses calcium bromide. Bromide can be added to the boiler or to the coal to oxidize the mercury and facilitate its capture in wet scrubbers. Newly under consideration is the practice of injecting activated carbon upstream of the FGD to improve its mercury capture performance even more." *Id.*, 56.

590. Blankinship also teaches that "Power plants without an FGD would likely use sorbent injection, mostly an activated carbon, upstream of a particulate control device. The particulate control can be either the plant's existing device or a

compact baghouse installed following the primary particulate control, with sorbent injection between the primary control and the new baghouse." *Id.*

591. Blankinship also discloses that upstream injection is beneficial as "it's a higher temperature region with more internal duct area and provides more residence time for the sorbent to absorb the mercury." *Id.* The mercury is absorbed from the flue gas.

592. Blankinship, in my opinion, discloses the preamble of claim 17 as Blankinship describes multiple methods for treating a mercury-containing gas by reducing mercury in the gas, more specifically a flue gas at a coal burning power plant for the reasons explained above in Paragraphs 587-591. EX1012, 56, 58.

2. Element 17(a)–"combusting a mixture comprising coal, pyrolysis char, and an additive comprising HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas; and"

593. This claim element is identical to claim element 1(a) discussed above.

594. Blankinship discloses the application of "calcium bromide to the coal prior to combustion to promote mercury oxidation" as part of Alstom's KNX^{TM} process. EX1012, 56, 58. I understand that Patent Owner asserts in the Multidistrict Litigation that applying calcium bromide to the coal satisfies this claim element. I agree that calcium bromide is a "bromide compound" as a POSITA would understand the plain and ordinary meaning of that term. Calcium bromide is a

"bromide compound" because it is "a substance composed of atoms or ions of two or more elements in chemical combination" in which "constituents are united by bonds or valence forces." EX1015, 291.

595. Blankinship further discloses that Alstom's KNX™ calcium bromide solution "can be added to the boiler or to the coal to oxidize the mercury. EX1012, 56, 58.

596. Blankinship also explains that KNX "can be stand-alone to enhance the capabilities of the existing air quality control system or can be applied in combination with another mercury control technology such as our Mer-Cure post-combustion technology or activated carbon injection."

597. Blankinship also discloses that Alstom's KNX™ "applied to the coal provides better oxidation of the mercury at a lower cost than brominated sorbents." EX1012, 58.

598. Pyrolysis char is necessarily present when coal is combusted. EX1087, 673 ("pyrolysis, even under the most favorable conditions, includes the formation of … residual char"). Thus, a mixture of coal, pyrolysis char and the bromine additive is necessarily present in Blankinship's combustion.

599. Blankinship, in my opinion, discloses a method in which an additive (KNX – calcium bromide) is added to the coal before combustion to form the mercury-containing gas as well as a method in which the KNX additive is added to

the combustion chamber (boiler in Blankinship) for the reasons explained above in Paragraphs 593-598. EX1012, 56, 58; EX1015, 291; EX1087, 673.

3. Element 17(b) –"adding a sorbent material comprising activated carbon into the mercury-containing gas."

600. With respect to activated carbon injection, Blankinship explains that "[t]here are also variations of sorbent injection that provide ways to introduce activated carbon into flu gas. It can be injected in front of the air heater instead of behind it to provide more flue gas reaction time. There are also ways to agglomerate the carbon or grind it finer on site to achieve better mass transfer. These processes are also being offered commercially. The post combustion Mer-Cure process Alstom offers is a combination of some of those methods." EX1012, 58.

601. Blankinship further explains that KNX™ "can be stand-alone to enhance the capabilities of the existing air quality control system or can be applied in combination with another mercury control technology such as our Mer-Cure post-combustion technology or activated carbon injection." *Id.*

602. Mer-Cure, Blankinship states, "is essentially an enhanced carbon injection system … It has a silo, feed system and injection lances that inject the activated carbon into the duct work." *Id.* A POSITA would understand from this disclosure that the activated carbon is a sorbent for collecting mercury from the flue gas.

603. Blankinship therefore, in my opinion, discloses methods for adding a activated carbon sorbent into the mercury-containing gas.

604. As established above, Blankinship discloses every element of Claim 17 of the ‘225 Patent. It is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Blankinship anticipates Claim 17 for the reasons explained above in Paragraphs 600-603. EX1012, 56, 58.

XV. GROUND 5—CLAIMS 1-2, 5-15, 17-20 AND 22-29 ARE OBVIOUS OVER BLANKINSHIP AND VOSTEEN, OR BLANKINSHIP, VOSTEEN AND OLSON-235

605. Based on my review of Blankinship, Vosteen, and Olson-235 and my education, skill, training, and experience in the relevant fields of emission reduction technology, it is my opinion that Claims 1-2, 5-15, 17-20 and 22-29 would have been obvious to a POSITA at the time of the invention. In the subsections that follow, I explain the bases for my opinion that Claims 1-2, 5-15, 17-20 and 22-29 would have been obvious to a POSITA at the time of the invention.

A. A POSITA Would Have Been Motivated to Combine Blankinship and Vosteen or Blankinship, Vosteen, and Olson-235.

606. In my opinion, a POSITA would have been motived to combine Blankinship, Vosteen, and Olson-235, and had a reasonable expectation of success

in doing so, because each reference relates to mercury removal from coal-fired boilers using particulate control devices such as ESPs.

607. Blankinship, Vosteen, and Olson-235 are analogous art to the ‘225 Patent in the same field of endeavor and reasonably pertinent to the problems the inventors faced.

608. The title of Blankinship is “A Variety of Hg [Mercury] Capture Solutions Are Available.” EX1005. Blankinship states that “[o]ne way of enhancing Hg capture from FGD and SCR at power plants that cannot meet their mercury emission limits through co-benefits alone is to treat the coal (which typically for these situations lacks enough chlorine to force the mercury into a soluble compound) by adding something to it. Alstom’s KNX process, for example, uses calcium bromide. Bromide can be added to the boiler or to the coal to oxidize the mercury and facilitate its capture in wet scrubbers. Newly under consideration is the practice of injecting activated carbon upstream of the FGD to improve its mercury capture performance even more.” *Id.*, 56.

609. Vosteen is titled “PROCESS FOR REMOVING MERCURY FROM FLUE GASES” and is generally directed to “a process for removing mercury from flue gases of high-temperature plants, in particular power stations and waste incineration plants in which a bromine compound is fed to the if appropriate

multistage furnace and/or the flue gas in a plant section downstream of the furnace." EX1011, Abstract.

610. Blankinship and Vosteen thus each disclose systems and processes for reducing mercury emissions using a combination of bromine additives added to the coal or to the boiler and activated carbon injection upstream of a particulate control device. A POSITA would thus be motivated, in my opinion, to combine the teachings of Blankinship and Vosteen.

611. Vosteen discloses that "mercury content of the flue gas … is measured continuously … and on the basis of the measured mercury content the amount of bromine fed and/or bromine compounds … is controlled." EX1011, [0022], claim 10. If mercury is removed incompletely, additional bromine compound is fed. *Id.* Vosteen adds Br_2, HBr, and bromide compounds (*e.g.* NaBr) to the combustion chamber and or to the coal upstream of the combustion chamber. EX1011, [0007], [0013], [0047], Example 5. A POSITA would have considered it obvious to optimize the amount of bromine additive in Blankinship since Vosteen describes this variable as affecting mercury removal from a flue gas. EX1011, [0022].

612. In my opinion, a POSITA also had reason to combine Blankinship/Vosteen with Olson-235. Each discloses mercury removal systems and processes that remove greater than 70% mercury from flue gases in coal-fired power

plants by adding a bromide compound to the boiler and activated carbon injection post-combustion upstream of a particulate control device, such as an ESP.

613. Olson-235 discloses in-flight preparation of the sorbent by reacting a base sorbent such as activated carbon and a promoter. EX1013, 5:43-48. Olson-235 also discloses addition of an alkali, secondary component or mercury-stabilizing reagent to the flue gas to "increase reactivity and mercury capacity." *Id.*, 3:25-35; 4:39-52; 17:5-45. A POSITA would have considered it obvious to add an alkali, secondary component or mercury-stabilizing reagent of Olson-235 to the flue gas in the process of Blankinship and Vosteen to increase reactivity and mercury capacity of the sorbent as taught by Olson-235.

B. Claims 1-2, 5, 8, 14-15, 17, 19-20, 22-23 and 25-29 Would Have Been Obvious in Light of the Combination of Blankinship and Vosteen, or Blankinship, Vosteen, and Olson-235

614. For the reasons explained in Section XII above, it is my opinion that Blankinship anticipates Claims 1-2, 5, 8, 14-15, 17, 19-20, 22-23 and 25-29 of the '225 Patent.

615. As explained in Section XII(A) immediately above, it is also my opinion that a POSITA would have been motivated to combine the mercury reduction systems and processes disclosed in Blankinship, Vosteen, and Olson-235.

616. Like Blankinship, Vosteen discloses processes for removing mercury in flue gas. EX1011, Title; [0001]; [0007]–[0008]. While Blankinship discloses

KNX calcium bromide being added to the coal and/or the combustion chamber as a promoter, Vosteen further discloses addition of a bromine promoter in forms such as HBr, Br_2, and sodium bromide (NaBr) that are added to the furnace or directly to the coal in coal-fired boilers of a power plant. Vosteen further explains that "addition of bromine or bromine compounds to the furnace causes ... a substantial, essentially complete, oxidation of the mercury and therefore allows substantial removal of the mercury from flue gases." EX1011, [0007], [0009], [0013], [0047], Example 5.

617. Vosteen further discloses a "dry emission control system" as part of a "flue gas emission control system," and that the dry emission control system works "based on the adsorption of ion mercury compounds." *Id.*, [0018]-[0019]. Vosteen discloses that an example of the sorbent is "finely pulverulent slaked lime/activated carbon." *Id.* Blankinship also discloses the use of activated carbon as well as brominated activated carbon sorbents in combination with the KNX applied to the coal and/or furnace.

618. Vosteen further discloses that its system is particularly suited "for those high-temperature plants which do not have a wet flue gas emission control system, but solely have a dry emission control system having a mercury sorption stage." *Id.*

619. Like Blankinship and Vosteen, Olson-235 also discloses methods for reducing mercury emissions in coal-fired power plants using halide promoters, such as bromine, and activated carbon sorbent injection. EX1013.

620. Regarding claim elements 1(a), 14(a) and 17(a) and claim 19, Vosteen adds Br_2, HBr, and bromide compounds (*e.g.*, NaBr) to the combustion chamber and/or to the coal upstream of the combustion chamber:

> The invention relates to a process for removing mercury from flue gases of … power stations …, in which **bromine and/or a bromine compound and/or a mixture of various bromine compounds** is fed to the appropriate multistage furnace….
>
> [A]n aqueous solution of **hydrogen bromide** [HBr] or an alkali metal bromide, in particular sodium bromide [NaBr], or an aqueous solution of the alkali metal bromide is used.…
>
> The bromine compound, … can be added … **to the … coal or the like to be burnt, upstream of the furnace**…. **The compound can also be fed during the combustion process** … [or] after the combustion…

EX1011, [0006], [0009], [0013] (emphasis added). Vosteen describes "the mass ratio of bromine to mercury in the flue gas." EX1011, [0025], [0028], [0031].

621. Regarding claim elements 1(b), 14(b) and 17(b), Vosteen discloses "removal of mercury from the flue gases in a flue gas emission control system downstream of the combustion" EX1011, [0007]. One sorbent disclosed by Vosteen is "finely pulverulent slaked lime/activated carbon." *Id.*, [0019]. The mercury/sorbent composition is separated from the flue gas in an ESP. *Id.*, [0019], [0047]–[0049].

622. Regarding claims 2 and 15, Olson-235 describes that "promoted sorbent … is injected into contaminated flue gas stream 15." EX1013, 14:30-32, Figure 3. The sorbent of the promoted sorbent can be a "pyrolysis char." *Id.*, 10:51-59.

623. Regarding claim 5, Vosteen reports mercury removal greater than 70 wt.% in that flue gas Hg_{met} content was about 40 wt.% and was reduced to 10 wt.% at time 10:30. EX1011, Figure 8, [0049], Figure 5, [0042], [0015], [0037]. Vosteen's mercury/sorbent composition is separated from the flue gas in an ESP. *Id.*, [0019], [0047]–[0049]. A POSITA would have reasonably expected that the combination of bromide as described by Blankinship and Vosteen with the sorbent treatments of Blankinship would achieve greater than 70% mercury removal by the sorbent due to bromide's ability to increase oxidized mercury and "higher reactivity of oxidized mercury with PAC."

624. Regarding claim 8, Vosteen describes granulated or pulverant activated carbon in its flue gas emission control systems. EX1011, [0019].

625. Regarding claim 19, Vosteen discloses that "bromine compound, for example, sodium bromide, can be added in solid form, for example as salt, or liquid form, for example as aqueous solution, to the waste mixture, coal or the like to be burnt, upstream of the furnace. The addition can also be made to a plant section upstream of the furnace, for example ... to a coal mill…. The compound can also be

fed during the combustion process…. [or] after the combustion, for example in a downstream waste-heat boiler." EX1011, [0013].

626. Regarding claim 20, Vosteen describes that "bromine compound, for example, sodium bromide, can be added … as aqueous solution, to the … coal or the like to be burnt, upstream of the furnace." EX1011, [0013].

627. Regarding claim 22, Olson-235 describes contacting a base sorbent 10 with a halogen or halide promoter 20 prior to injection of the sorbent into the flue gas 50. EX1013, Figure 1, 10:17-37.

628. Regarding claim 26, Vosteen's process for "removing mercury from flue gases of high-temperature plants" includes "for example bituminous coal-fired or lignite-fired power stations." EX1011, [0008].

629. Regarding claims 27 and 28, Vosteen describes a flue gas emissions control system as known in the art "based either on wet scrubbing or dry cleanup or a combination of the two" downstream of the coal combustion boiler. EX1011, [0017], [0019]. The boilers 91/91' are upstream of ESPs 96/96' and wet scrubber 97/97'. Id., [0019], Figure 9.

630. Regarding claim 29, Vosteen describes its "process for removing mercury from flue gases of … power stations" with "bromine compound … added … to the coal or the like to be burnt, upstream of the furnace." EX1011, [0001], [0013], [0045].

631. It is therefore also my opinion that, based on the disclosures of Blankinship, Vosteen, and Olson-235, as well as my skill, training, and experience in the relevant fields of emission reduction technology, that claims 1-2, 5, 8, 14-15, 17, 19-20, 22-23 and 25-29 would have been obvious to a POSITA prior to May 14, 2015 based on the combination of Blankinship and Vosteen or Blankinship, Vosteen, and Olson-235 for the reasons explained above in Paragraphs 495-630.

C. Claims 6-7, 9-13, 18 and 24 Would Have Been Obvious in Light of the Combination of Blankinship and Vosteen, or Blankinship and Olson-235

632. It is also my opinion that Claims 6-7, 9-13, 18 and 24 of the '225 Patent would have been obvious to a POSITA at the time of the invention in light of Blankinship, Vosteen, and Olson-235. I explain the specific disclosures and combinations of Blankinship, Vosteen, and Olson-235 I rely upon for claims 6-7, 9-13, 18 and 24 in the sections that follow.

1. Claim 6—"measuring the mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content: an injection rate of injecting the sorbent into the mercury-containing gas, an amount of the additive in the mixture, or a combination thereof."

Claim 24—"the measurement of the mercury content of the mercury-containing gas comprises continuous measurement."

Claim 18—"modifying, in response to a measured mercury content, an injection rate of injecting the sorbent into the

> **mercury-containing gas, an amount of the additive in the mixture, or a combination thereof."**

633. Claims 6, 18 and 24 generally require measuring the mercury content of the mercury-containing gas and modifying the injection rate of the activated carbon, the amount of the additive in the mixture, or a combination thereof. Claim 6 depends from claim 5. Claim 24 depends from claim 6. Claim 18 depends from claim 1.

634. A POSITA would have known that the EPA had by 2004 already put the industry on notice of upcoming laws and regulations requiring 70% mercury removal, including EPA's Clean Air Mercury Rule (CAMR). EX1045. It thus would have been obvious to a POSITA that any mercury control system would have to comply with these laws and regulations.

635. Blankinship discusses "measuring vapor phase mercury" and "[m]onitoring mercury," which is "essential in order to verify compliance with reduction rules" enacted by two dozen states to restrict mercury emissions from power plants. EX1012, 56.

636. Vosteen discloses that preferably "in the inventive process, the mercury content of the flue gas, in particular the content of metallic mercury, is measured continuously downstream of the flue gas emission control system and on the basis of the measured mercury content the amount of bromine fed and/or bromine

compounds and/or the mixture of bromine compounds ... is controlled." EX1011, [0022]. If mercury is removed incompletely from the flue gas, additional bromine compound is fed. *Id.*

637. Claim 10 of Vosteen further discloses this claim element:

> 10. Process according to one of claims 1 to 9, characterized in that **the mercury content of the flue gas**, in particular the content of metallic mercury**, is measured continuously** downstream of the flue gas emission control system and **on the basis of the measured mercury content the amount of bromine fed and/or bromine compounds fed** and any sulphur and/or sulphur compounds fed **is controlled**. (Emphasis added).

638. Olson-235 describes "continuous measurement of mercury emissions as feedback to assist in control of the sorbent injection rate. Tighter control on the sorbent … will ensure mercury removal requirements are met with minimal material requirements, thus minimizing the associated costs." EX1013, 20:1-11, 14:20–29. Olson-235 discloses that "the rate at which the promoter is added and the rate of promoted sorbent injection are determined by a digital computer based, at least in part, on the monitored mercury content of the cleaned flue gas." EX1013, 6:15-31.

639. Because the combination of Blankinship and Vosteen discloses every element of Claim 1, and: (1) Blankinship, Vosteen, and Olson-235 discloses measuring the mercury content of the mercury-containing gas substantially continuously, and (2) Vosteen discloses that the amount of added bromine is controlled premised on the mercury measurements of the flue gas, and (3) Olson-

235 discloses modifying the injection rate of the sorbent and addition of the promoter based on the measured mercury rate in the flue gas, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claims 6, 18 and 24 would have been obvious to a POSITA at the time of the invention in light of Blankinship and Vosteen or Blankinship and Olson-235 for the reasons explained above in Paragraphs 633-638. EX1012, 56; EX1011, [0022], Claim 10, EX1013, 6:15-31, 20:1-11; 14:20-29.

2. Claim 7–“the additive further comprises Br_2.”

640. As discussed above regarding element 1(a) and claim 19, Blankinship describes adding KNX calcium bromide solution to coal or the combustion chamber.

641. Vosteen states, “It is not critical for the inventive process in what form the bromine supplied is present. It is possible to use free or organically bound or inorganically bound bromine. The bromine or the bromine compounds can be fed individually **or in a mixture**.” EX1011, [0009](emphasis added). A POSITA would understand that “free … bromine” is molecular bromine (Br_2), and that Vosteen’s disclosure of free bromine refers to Br_2. *Id.*, [0006], claims 1 & 4.

642. Because Blankinship discloses every element of Claim 1, and Vosteen further teaches that a mixture of bromide compounds, including Br_2 can be added to coal or the combustor, it is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that

Claim 7 would have been obvious to a POSITA at the time of the invention in light of Blankinship and Vosteen for the reasons explained above in Paragraphs 640-641. EX1011, [0006], [0009], claims 1 & 4.

3. Claim 9—"adding an alkaline component to the mercury-containing gas, the alkaline component chosen from alkali elements, alkaline earth elements, alkali salts, alkaline earth salts, and combinations thereof.

643. Blankinship discloses that "mineral based non-carbon" sorbents "show some promise" and "are designed to be tolerant to higher temperatures." EX1012, 58.

644. Vosteen discloses "finely pulverulent slaked lime/activated carbon." or "lime" can be used in its flue gas emission control systems. EX1011, [0018]-[0019].

645. Lime is calcium oxide (CaO), and slaked or hydrated lime is calcium hydroxide ($Ca(OH)_2$), each of which is highly alkaline. Calcium hydroxide is alkaline and is a salt of an alkaline-earth metal (calcium). EX1016, 33, 196, 671-672.

646. Because Blankinship discloses every element of Claim 1, and Vosteen discloses the injection of an alkaline sorbent into the mercury-containing gas stream as required by Claim 9, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 9 would have been obvious to a POSITA at the time of the invention in light of

Blankinship and Vosteen for the reasons explained above in Paragraphs 643-645. EX1011, [0018]-[0019]; EX1012, 58; EX1016, 33, 196, 671-672.

4. Claim 10–"contacting the sorbent material with a mercury-stabilizing reagent chosen from S, Se, H_2S, SO_2, H_2Se, SeO_2, CS_2, P_2S_5, and combinations thereof."

647. Vosteen describes the "addition of a bromine compound and if appropriate a sulphur compound … to the flue gas in a plant section downstream of the furnace." EX1011, [0013]. Sulphur dioxide is present in the flue gas. *Id.*, [0010]. Vosteen states that "bromine compounds oxidize mercury more effectively under the given conditions of high-temperature processes, such as temperature and in particular also at a high sulphur dioxide concentration." *Id.*, [0016]. The sulfur dioxide in the flue gas would contact the sorbent in the flue gas before both are removed in downstream desulfurization and particulate removal devices.

648. Olson-235 describes a method "whereby a mercury stabilizing reagent is added to a promoted sorbent … stabilizing reagent(s) may be sequentially added, either before or after the addition and reaction of the halogen/halide…. The halogen/halide preferably comprises Br or HBr, and the mercury-stabilizing reagent may comprise S, Se, H_2S, SO_2, H_2Se, SeO_2, CS_2, P_2S_5, and combinations thereof." EX1013, 15:56-63.

649. Because Blankinship discloses every element of Claim 1, and Vosteen and Olson-235 further describe addition of a sulfur compound to flue gas where it

would contact the sorbent, it is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 10 would have been obvious to a POSITA at the time of the invention in light of Blankinship and Vosteen, or Blankinship and Olson-235 for the reasons explained above in Paragraphs 647-648. EX1011, [0010], [0013], [0016]; EX1013, 15:56-63.

5. Claim 11–"contacting the sorbent material with a secondary component chosen from halogens, hydrogen halides, Group V halides, Group VI halides, and combinations thereof."

Claim 12–"the secondary component is chosen from halogens, halide salts, HI, HBr, HCl, and combinations thereof."

Claim 13–"the secondary component is chosen from I_2, HI, and combinations thereof."

650. Vosteen describes the "addition of a bromine compound … to the flue gas in a plant section downstream of the furnace." EX1011, [0013]. The HBr in the flue gas would contact the sorbent in the flue gas before the sorbent is removed in a particulate removal device such as an ESP. The bromine compound can be "an aqueous solution of hydrogen bromide or sodium bromide." *Id.*, [0014]. Sodium bromide is a halide salt.

651. Vosteen also discloses that "[i]odine compounds oxidize mercury more effectively compared with bromine compounds…. The iodine compound can be fed … as a supplement to, or partial replacement of, the added bromine compound." *Id.*, [0016]. The iodine compound can be iodine (I_2). *Id.*, claim 6. The I_2 added to the

flue gas would contact the sorbent in the flue gas before the sorbent is removed in a particulate removal device such as an ESP. A POSITA would have known that every coal-fired power plant flue gas contains HCl that would inevitably contact the sorbent.

652. Olson-235 discloses that "the halogen/halide promoter and optional secondary component(s) may preferably be sprayed in solution form into or on the base sorbent." EX1013, 15:26-28. Figure 3 depicts "base sorbent reservoir 110, a halogen/halide promoter reservoir 120, a secondary component reservoir 130, and an alkali component reservoir 180, each of which with corresponding flow control device(s) 201, 202, 203, and 208/209, respectively … reservoirs 110, 120, 130 and 180 … can be used in any combination." *Id.*, 13:10-26. "One mode of operation, by example, comprises providing base sorbent 110 in a common line which is promoted inline "in-flight" using promoter 120 and/or 130 and injected at point 116" into flue gas 15. *Id.*, 13:56-59. The "secondary component(s) may preferably comprise iodine or other halogens, hydrohalides, including without limitation HI, HBr, HCl, a Group V or Group VI element with a molecular halogen, such as SCl_2." *Id.*, 15:39-43.

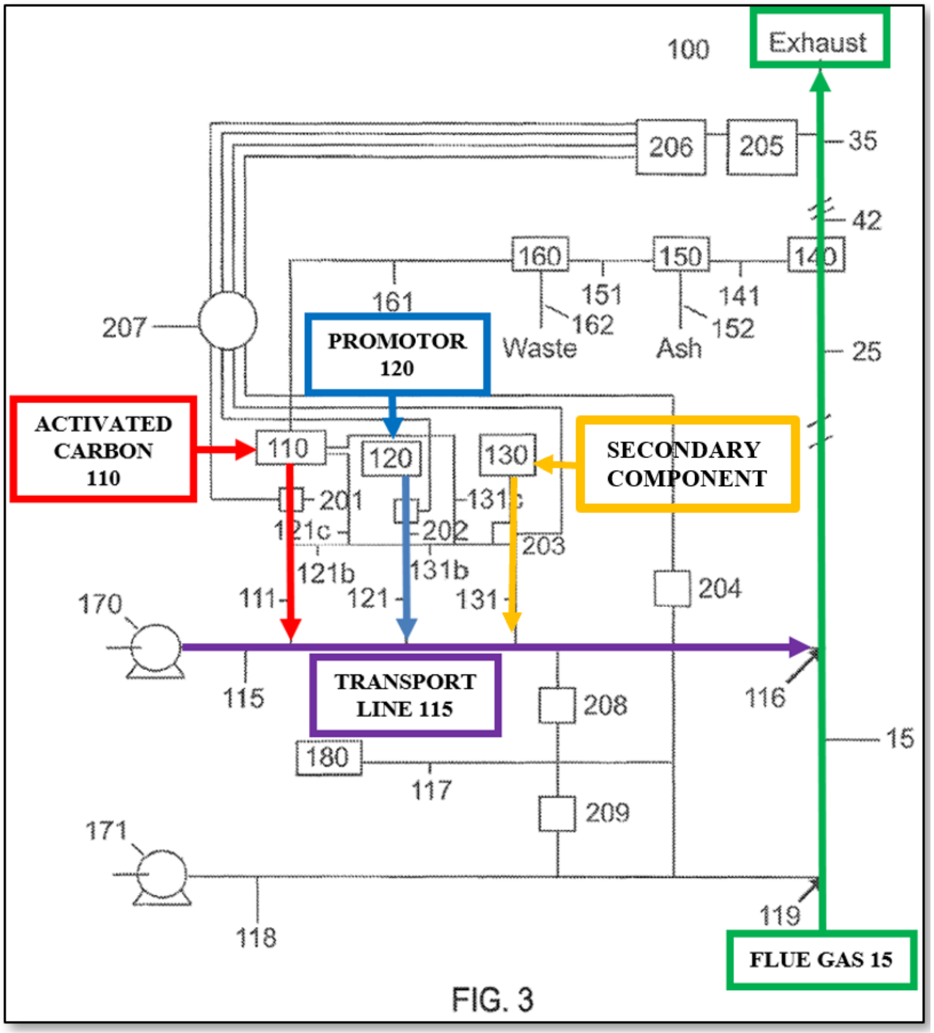


FIG. 3

EX1013, Figure 3 (annotations added in red, blue, green, purple and yellow).

653. Julien discloses that "94-99% of the chlorine in coal is volatilized and emitted as gaseous HCl during pulverized firing." EX1014, 165; EX1072, 199 (Table 1). Thus, a POSITA would have known that coal-fired power plant flue gas necessarily contains HCl that would contact the sorbent.

654. Because Blankinship discloses every element of Claim 1, and Vosteen further teaches addition of HBr or a halide salt to flue gas where it would contact the

sorbent and Olson-235 describes addition of the secondary components to base sorbent as required in Claims 11-13, it is therefore my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claims 11-13 would have been obvious to a POSITA at the time of the invention in light of Blankinship and Vosteen or Blankinship and Olson-235 for the reasons explained above in Paragraphs 650-653. EX1011, [0013], [0014], [0016], claim 6; EX1013, 13:10-26, 56-59, 15:26-28, 39-43, Figure 3.

XVI. SECONDARY CONSIDERATIONS – SIMULTANEOUS INVENTION

655. I understand that the Patent Owner has asserted that the ‘225 Patent is generally directed to a straight-forward, two-step process: (1) apply an additive, and more specifically HBr, a bromine compound or combination thereof, to the coal or combustion chamber such that a mixture of coal, pyrolysis char and additive is combusted to form a mercury-containing flue gas; and (2) injecting activated carbon into the flue gas as a sorbent.

656. As I explained above, it is my opinion that the claims of the ‘225 Patent would have been obvious to a POSITA at the time of the invention based on the prior art references discussed above as well as the POSITA’s knowledge at the time.

657. As I also explained in the Technology Background section of this Declaration, “[a]ctivated carbons ha[d] been the most thoroughly studied sorbent for the capture of mercury” by 1998. EX1041, 22. In 1999, researchers demonstrated

that mercury from flue gas formed chemical bonds with halogen species on activated carbons. EX1052, 119. By 2004, halide addition was observed to "improve Hg capture both by conversion of the Hg^0 to the more easily removed Hg^{2+} forms and by enhancing the reactivity of Hg^0 with activated carbons"). EX1053, 2–3.

658. It was also known that halogens, particularly bromine-containing species, were effective at improving effectiveness of activated carbon in removing mercury. *See, e.g.*, EX1004; EX1011; EX1008; EX1066. By 2003, bromine was known to be more than 25 times more effective for metallic mercury oxidation than chlorine in coal combustion. EX1056, 2. In addition to using halides, it was also known that adjusting the sorbent injection rate would control mercury emissions. EX1058, 14; EX1059; EX1060, 4676.

659. In short, the industry and emissions reduction researchers knew prior to the August 2004 filing date of the Provisional that bromine promoters in combination with PAC injection were effective for reducing mercury emissions.

660. Numerous researchers, many acting under Department of Energy funded contracts, had developed, tested, and implemented the same two-step process generally claimed in the '225 Patent. For example, Downs used such a two-step process before the Provisional filing date. Alstom also developed a bromine-promoter added to coal or the combustion chamber for mercury control by 2004 that sold as KNX™. ADA-ES performed testing by the third quarter of 2004 under a

Department of Energy Cooperative Agreement wherein Alstom's KNX product was applied to coal at Sunflower Electric's Holcomb Station and "enhance[d] the performance of standard activated carbon," achieving "[m]ercury removal of 86%." EX1063, 3, 25.

661. Similar tests were also performed by ADA-ES in the fourth quarter of 2004 at AmerenUE's Meramec Station using Alstom's KNX as a coal additive in combination with activated carbon. EX1064, 8, 21. Similar processes were also tested by EPRI and others at Texas Genaco's Limestone Electric Generating Station combusting lignite coal with injection of calcium bromide into the boiler and an ESP for particulate reduction and 81% mercury removal. EX1057, 12. These stations were in commercial operation supplying electric to customers during the testing.

662. In my opinion, this simultaneous development of a two-step process for reducing mercury emissions from coal-fired power plants involving use of bromine promoters added to the coal or combustion chamber in combination with PAC injection further suggests that such a two-step process was obvious to a POSITA at the time of the invention for the reasons explained above in Paragraphs 655-661.

XVII. CONCLUSION

663. The findings and opinion set forth in this declaration are based on my work and examinations to date.

664. I may continue my examination. I may also receive additional documents and other factual evidence over the course of this proceeding that will allow me to supplement and/or refine by opinions. I reserve the right to add to, alter, or delete my opinions and my declaration upon discovery of any additional information. I reserve the right to make such changes as may be deemed necessary.

665. In signing this declaration, I recognize that the declaration will be filed as evidence in an IPR before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subjected to cross-examination in the case and that cross-examination will take place in the United States.

666. I hereby 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 fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Executed on this 7th day of July, 2025.

Radisav Vidić

Radisav Vidic, Ph.D.