

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

UNION ELECTRIC COMPANY,
Petitioner,

v.

BIRCHTECH CORPORATION,
Patent Owner.

Case: IPR2025-01117
Patent 10,596,517

DECLARATION OF RADISAV VIDIC, PH.D.

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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. 10,596,517. 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. 10,596,517 (“ 517 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, 13 th Ed.), Definition of “Compound,” 291 (1997)
1016	Hawley’s Condensed Chemical Dictionary, (Van Nostrand Reinhold, 13 th 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	U.S. Application No. 14/712,558 as filed with USPTO (“the ‘558 Application”)
1025	U.S. Application No. 15/951,970 as filed with USPTO (“the ‘970 Application”)

Exhibit No.	Exhibit Description
1026	U.S. Application No. 15/974,343 as filed with USPTO (“ the ‘343 Application ”)
1027	File History for United States Patent No. 10,596,517 (U.S. Application No. 15/997,091)(“ the ‘091 Application ”)
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	Redline comparison between U.S. Application No. 14/712,558 and 15/951,970
1035	Redline comparison between U.S. Application No. 15/951,970 and 15/974,343
1036	Redline comparison between U.S. Application No. 15/974,343 and 15/997,091
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, 4 th 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 ”)

Exhibit No.	Exhibit Description
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 ”)
1044	Thomas J. Feeley, et al., “A Review of DOE/NETL’s Mercury Control Technology R&D Program for Coal-Fired Power Plants,” <i>DOE/NETL Hg R&D Program Review</i> (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 <i>Midwest Energy Emissions Corp., et al. v. Arthur J. Gallagher & Co., et al.</i> , No. 1:19-cv-01334-CJB.
1048	Deposition Transcript of Michael Holmes (Aug. 24, 2022) (excerpted), taken in <i>Midwest Energy Emissions Corp., et al. v. Arthur J. Gallagher & Co., et al.</i> , 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, <i>Surface Complexes on Carbons</i> , 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,” <i>Energy & Fuels</i> 1999(13), p. 114–121 (1999) (“ XAFS ”)

Exhibit No.	Exhibit Description
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 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

Exhibit No.	Exhibit Description
	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)
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.

Exhibit No.	Exhibit Description
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.
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 <i>In re Midwest Energy Emissions Corp. Patent Litigation</i> , 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 <i>Midwest Energy Emissions Corp., et al. v. Arthur J. Gallagher & Co., et al.</i> , 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.

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 ‘517 Patent are entitled to a priority date of August 2004 or June 2018. 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 ‘517 Patent (Claims 1-15 and 17-30) would have been anticipated or obvious to a POSITA at the time of the invention. My conclusions are summarized in the following chart:

Ground	Challenge	Claims	References
1	Anticipated	1, 4, 6-7, 11-15, 17, 22, 24-29	Anticipated by Downs
2	Obvious	1-15, 17-30	Obvious over Downs and Altman or Downs/Altman and Nelson (in view of the knowledge of a person of ordinary skill in the art, as evidenced by Felsvang for claim 18 and Julien for claim 30)

Ground	Challenge	Claims	References
3	Obvious	1-15, 17-30	Obvious over Vosteen and Altman or Vosteen/Altman and Nelson (in view of the knowledge of a person of ordinary skill in the art, as evidenced by Felsvang for claim 18 and Julien for claim 30)
4	Anticipated	1, 4, 6-7, 11-15, 17, 22-29	Anticipated by Blankinship
5	Obvious	1-15, 17-30	Obvious over Blankinship and Vosteen or Blankinship and Olson-235 (in view of the knowledge of a person of ordinary skill in the art, as evidenced by Felsvang for claim 18 and Julien for claim 30)

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 June 4, 2018 filing date of the '517 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

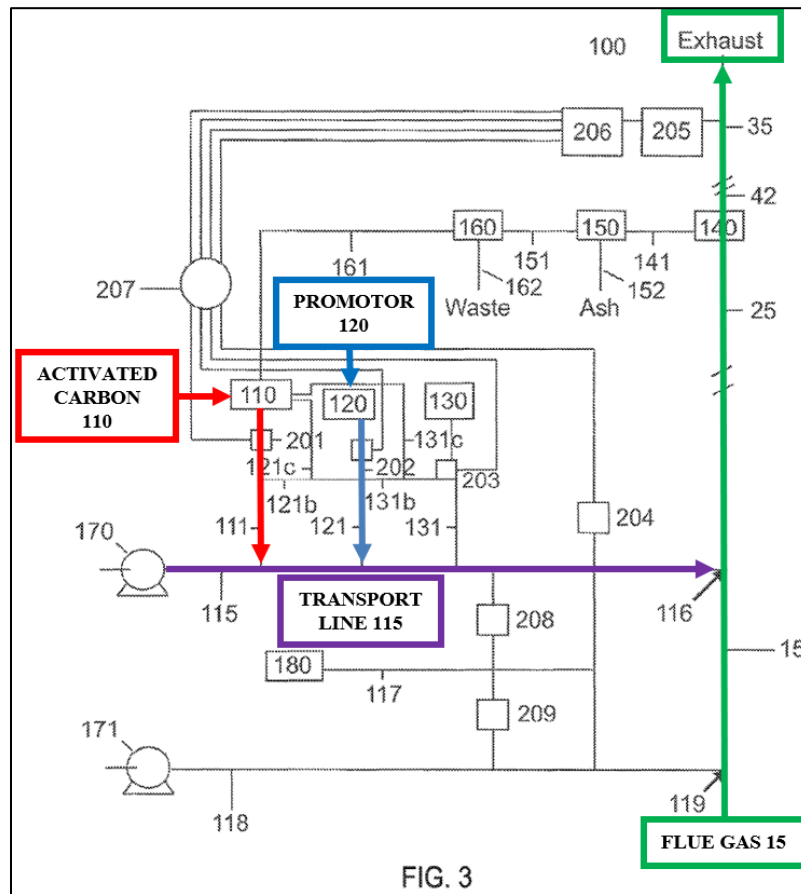
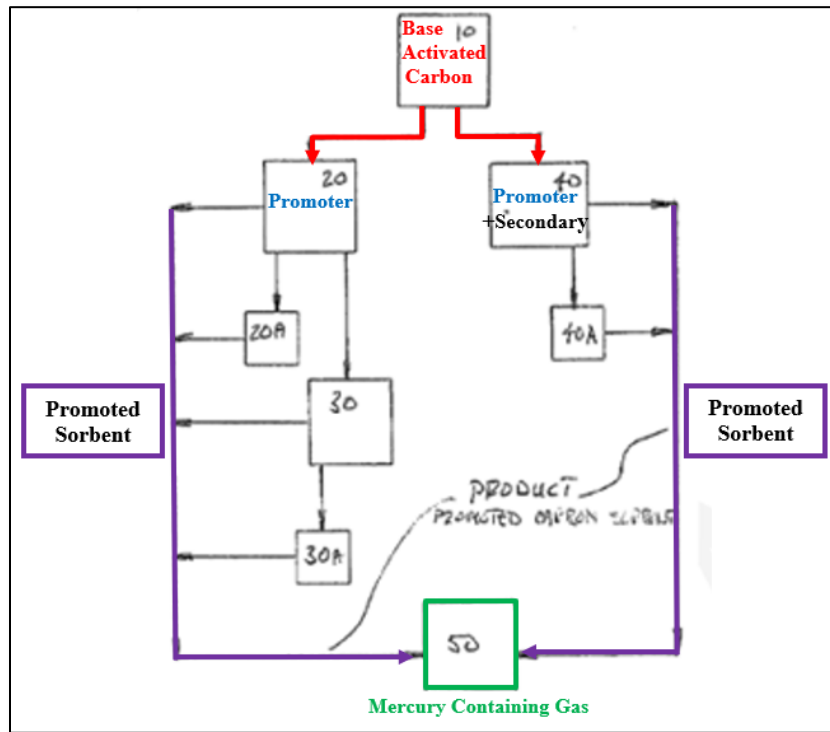
33. As of the '517 Patent's earliest claimed priority date (August 2004), a POSITA would have had at least a bachelor's degree in chemical engineering, mechanical engineering, environmental engineering, or a related field of study. A POSITA would also have at least two years' experience investigating, 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 '517 PATENT AND THE CHALLENGED CLAIMS

A. The '517 Patent

34. The '517 Patent is titled “Sorbents for the Oxidation and Removal of Mercury” and relates to removal of mercury from a flue gas. EX1001, 1:44–48. The '517 Patent acknowledges that known “mercury control methods” included “injection of fine sorbent particles into a flue gas duct” such as “activated carbon.” EX1001, 2:8–12.

35. The '517 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.



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

36. Each independent claim of the '517 Patent requires both (1) adding particular bromine-containing species (*i.e.*, Br₂, HBr, a bromide compound, or a combination thereof) to coal and/or the combustion chamber and (2) adding activated carbon sorbent to the mercury-containing gas. EX1001, Claims 1, 29, 30. There is no support for adding a promoter to coal, much less adding these two limitations of the independent claims of the '517 Patent in the application as filed or in any of its priority applications.

37. Figure 1 of the '517 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:

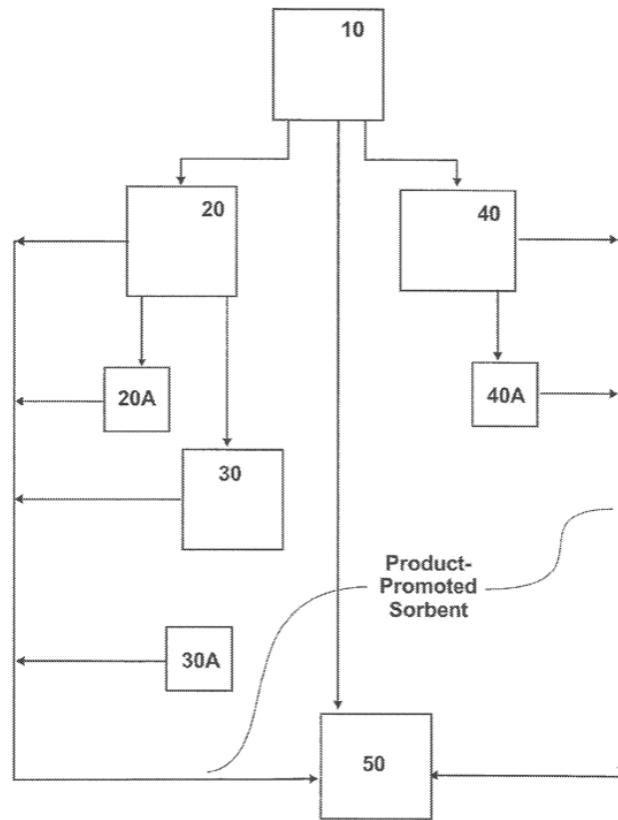


FIG. 1

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 '517 Patent claims priority. Rather, the following versions appeared in earlier applications:

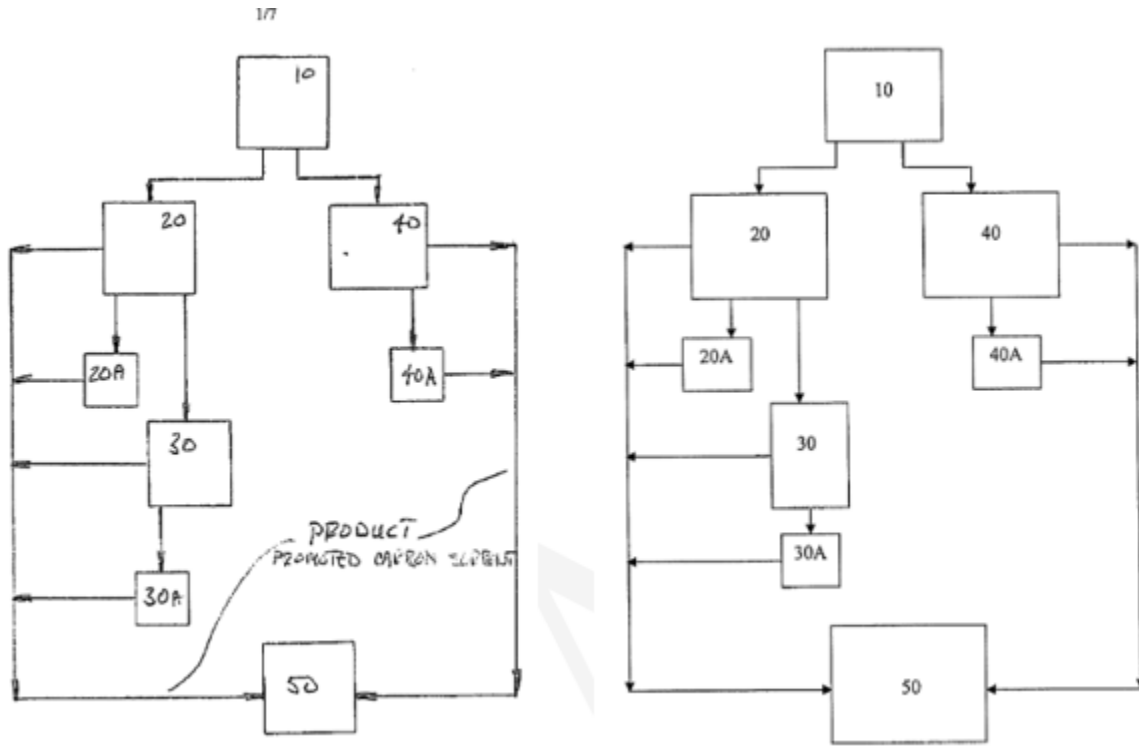


FIG. 1

‘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 ‘517 Patent are recited in the chart below. Each limitation of the Challenged Claims has been identified with a number and letter designation.

Claim Element	Claim Language
1(Preamble)	A method for reducing mercury in a mercury-containing gas, the method comprising:

Claim Element	Claim Language
1(a)	combusting coal in a combustion chamber, the coal comprising an additive comprising Br ₂ , HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas; and
1(b)	collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon.
2	The method of claim 1, further comprising injecting an alkaline sorbent into the mercury-containing gas stream.
3	The method of claim 2, wherein the alkaline sorbent is selected from the group consisting of alkali elements, alkaline earth elements, alkali salts, alkaline earth salts, and combinations thereof.
4	The method of claim 1, wherein the activated carbon is chosen from powdered activated carbon, granular activated carbon, carbon black, carbon fiber, aerogel carbon, pyrolysis char, and combinations thereof.
5	The method of claim 1, wherein the sorbent has a composition comprising from about 1 to about 30 grams of the element bromine per 100 grams of activated carbon.
6	The method of claim 1, comprising collecting greater than 70 wt % of the mercury in the mercury-containing gas.
7	The method of claim 1, comprising collecting greater than 70 wt % of the mercury in the mercury-containing gas with the sorbent.
8	The method of claim 1, further comprising: measuring mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content, an injection rate of injecting the sorbent comprising activated carbon into the mercury-containing gas, an amount of the additive comprising the Br ₂ , HBr, bromide compound, or a combination thereof, added to the coal, or a combination thereof.

Claim Element	Claim Language
9	The method of claim 8, wherein the measuring of the mercury content of the mercury-containing gas is performed substantially continuously.
10	The method of claim 1, further comprising: modifying, in response to a measured mercury content, an injection rate of injecting the sorbent comprising activated carbon into the mercury-containing gas, an amount of the Br ₂ , HBr, bromide compound, or a combination thereof, added to the coal, or a combination thereof.
11	The method of claim 1, wherein the coal comprises a subbituminous coal.
12	The method of claim 1, wherein the coal comprises a lignite coal.
13	The method of claim 1, wherein the coal comprises the added Br ₂ , HBr, the bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber.
14	The method of claim 1, wherein the combustion chamber comprises the added Br ₂ , HBr, the bromide compound, or a combination thereof.
15	The method of claim 1, wherein the coal is combusted in the combustion chamber at a coal-combustion facility, wherein the Br ₂ , HBr, bromide compound, or combination thereof, is added to the coal before the coal enters the combustion chamber, wherein the addition of the Br ₂ , HBr, bromide compound, or combination thereof, to the coal is performed at the coal-combustion facility.
17	The method of claim 1, wherein the combustion chamber is an electric utility coal combustion chamber.
18	The method of claim 1, further comprising: measuring mercury content of the mercury-containing gas; and

Claim Element	Claim Language
	modifying, in response to the measured mercury content, an injection rate of injecting the sorbent comprising activated carbon into the mercury-containing gas.
19	The method of claim 1, wherein the mercury-containing gas comprises about 1 g to about 30 g of the element bromine per 100 g of the sorbent.
20	The method of claim 1, further comprising: measuring mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content, an amount of the additive comprising the Br ₂ , HBr, bromide compound, or a combination thereof, added to the coal.
21	The method of claim 1, wherein the sorbent in the mercury-containing gas comprises about 1 g to about 30 g of the added Br ₂ , HBr, the bromide compound, or a combination thereof, per 100 g of the sorbent.
22	The method of claim 1, wherein the Br ₂ , HBr, or the bromide compound is contacted with the sorbent in vapor form, gaseous form, liquid form, or in an organic solvent.
23	The method of claim 1, wherein the sorbent injected into the mercury-containing gas is a sorbent obtained by contacting a base sorbent with a halogen or halide promoter prior to injection of the sorbent to the mercury-containing gas.
24	The method of claim 1, wherein the sorbent injected into the mercury-containing gas is free of contact with a halogen or halide promoter prior to injection of the sorbent into the mercury-containing gas.
25	The method of claim 1, wherein the injection of the sorbent into the mercury-containing gas occurs upstream of a particulate separator or a scrubber.
26	The method of claim 25, wherein the particulate separator comprises an electrostatic precipitator, a baghouse, a fabric filter, or a combination thereof.

Claim Element	Claim Language
27	The method of claim 1, wherein the coal comprises added halide sorbent enhancement additive that comprises the added Br ₂ , HBr, the bromide compound, or combination thereof.
28	The method of claim 1, wherein the sorbent enhancement additive comprises the bromide compound.
29(Preamble)	A method of separating mercury from a mercury-containing gas, the method comprising:
29(a)	combusting coal in a combustion chamber, wherein the coal comprises added Br ₂ , HBr, bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber, or the combustion chamber comprises added Br ₂ , HBr, bromide compound, or a combination thereof, or a combination thereof; and
29(b)	collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon.
30(Preamble)	A method of separating mercury from a mercury-containing gas, the method comprising:
30(a)	combusting coal in a combustion chamber, to provide the mercury-containing gas, wherein the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br ⁻ , or a combination thereof, wherein
30(b)	the coal comprises added Br ₂ , HBr, bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber, or the combustion chamber comprises added Br ₂ , HBr, bromide compound, or a combination thereof, or a combination thereof;

Claim Element	Claim Language
30(c)	collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon;
30(d)	separating the sorbent contacted with the mercury from the mercury-containing gas;
30(e)	measuring the mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content of the mercury-containing gas, an injection rate of injecting the sorbent into the mercury-containing gas, an amount of the Br ₂ , HBr, bromide compound, or a combination thereof, added to the coal or the combustion chamber, or a combination thereof.

VII. TECHNOLOGY BACKGROUND

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

46. 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

47. 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

48. 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 (EX0172, EX1073) and adding these species will not be of much benefit in the field.

49. Air pollution control processes capable of controlling elemental mercury emissions include various adsorption process with activated carbon being the prime sorbent of choice (EX0174). 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

50. 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, 1:55-60; EX1046, 2-54 to 2-57; EX1040, 1.

51. 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.

52. 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.

53. 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

54. 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., Br₂), halides/halide compounds (e.g., NaBr, CaBr₂), and hydrohalides (e.g., HBr).

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

56. 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. vidic, researchers demonstrated that mercury from flue gas formed chemical bonds with halogen species on activated carbons. EX1052, 119.

57. 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.

58. 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).

59. The '517 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.

'517 Patent, 7:56-64.

60. The '517 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.

'517 Patent, 9:31-35.

61. The '517 Patent also acknowledges that it was "known in the art" to remove "mercury from a combustion gas" by exposing "finely powdered activated carbon to a molecular bromine gas at an elevated temperature or to HBr to produce a sorbent with good mercury removal ability when injected into the flue gas duct."

'517 Patent, 30:37-46.

VIII. THE PRIORITY DATE OF THE '517 PATENT

62. I have been asked to review the '517 Patent, the '517 Patent file history of prosecution of the application for the '517 Patent before the U.S. Patent and Trademark Office, and the earlier filed applications to which the '517 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.

63. 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.

64. As explained in the 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 '517 Patent or the earlier-filed applications. More specifically, limitations of the independent claims (Claims 1, 29, and 30) requiring that the coal and/or the combustion chamber comprises an additive comprising Br₂, HBr, a bromide compound, or a combination thereof are not disclosed in those applications.

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

A. File History of the '517 Patent and its Predecessors

66. I understand that the application that issued as the '517 Patent was filed on June 4, 2018 and that the '517 patent purports to claim priority as follows:

- Continuation of U.S. Patent Application Serial No. ("USSN") 15/974,343 ("the '343 Application") filed on May 8, 2018 and issued on June 2, 2020 as U.S. Patent No. 10,668,430, which is a:
- Continuation of USSN 15/951,970 ("the '970 Application") filed on April 12, 2018 and issued on March 2, 2021 as U.S. Patent No. 10,933,370, which is a:
- Continuation of USSN 14/712,558 ("the '558 Application") filed on May 14, 2015 and issued on March 17, 2020 as U.S. Patent No. 10,589,225, which is a:
- 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:

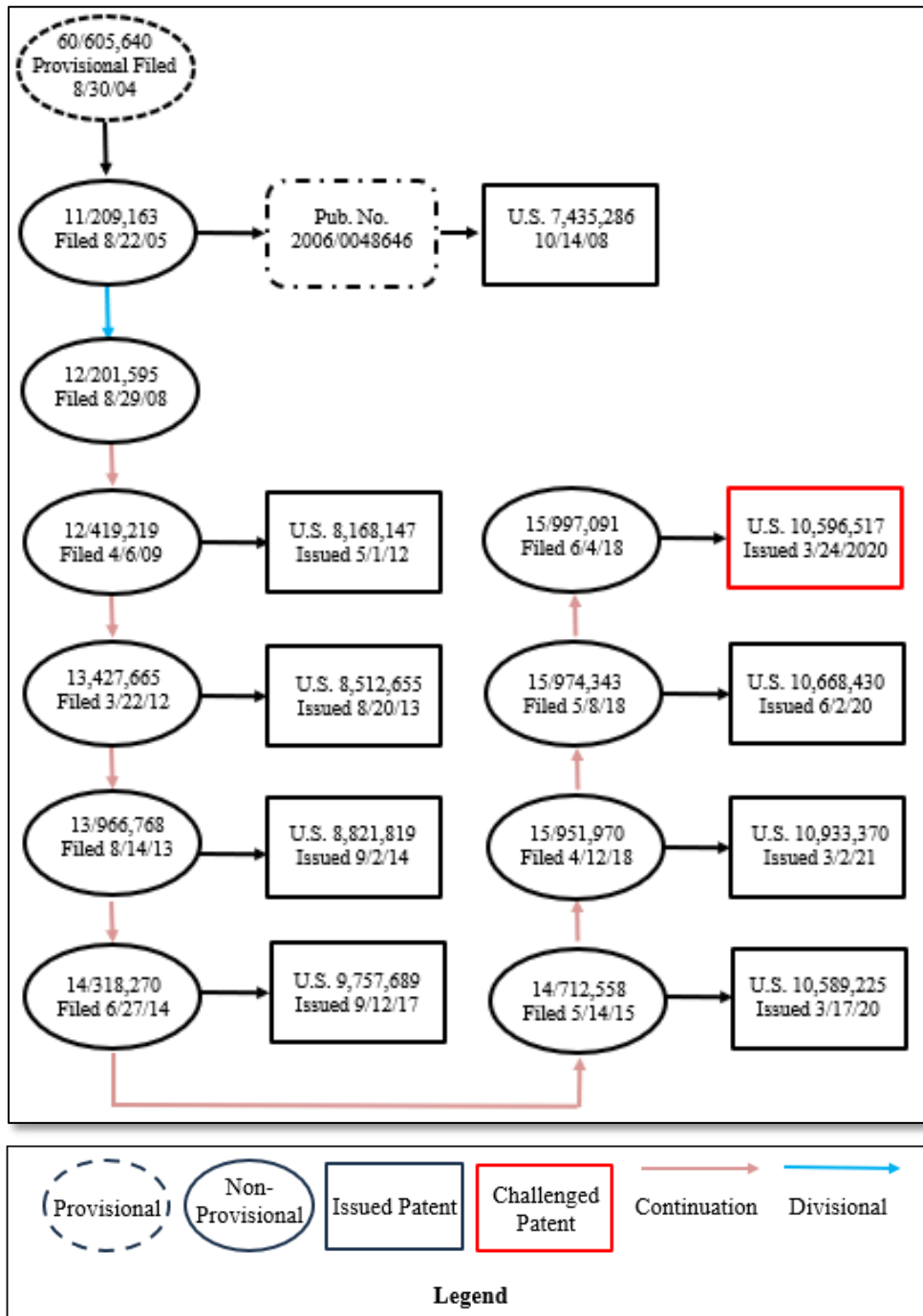
Case No. IPR2025-01117

Patent 10,596,517

- 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, 1:4–27.

67. The alleged priority chain for the ‘517 Patent is depicted in the following image:



B. The ‘091 Application Does Not Disclose Br₂, HBr, Bromide Compound, or a Combination Thereof as a Coal Additive

68. I have reviewed the ‘091 Application, which I understand is the application that issued as the ‘517 Patent. In the ‘091 Application, “coal” is

generally described as a fossil fuel (EX1027, 1:8-9)¹ in examples where subbituminous, lignite or pulverized coal is introduced to a combustor (EX1027, 27:1-5, 25-27; 28:2-5; 32:6-8, 13-14). Other references to “coal” in the ‘091 Application refer to coal combustion facilities or coal combustion flue gas (EX1027, 1:16-23; 9:21-22; 17:26-28; 35:1-3). None of these disclosures of “coal” in the ‘091 Application describe promoter compounds such as Br₂, HBr, a bromide compound, or a combination thereof being added to coal.

69. An “additive” in the ‘091 Application is generally described as “sorbent enhancement additives” (EX1027, 3:19-22), “optional additives discussed herein” (EX1027, 10:12-15), “additive to a treatment facility” (EX1027, 21:1-2) and “additive-sorbent ratios” (EX1027, 21:8-11). Again, none of these disclosures describe a promoter or additive being added to coal, nor the specific addition of Br₂, HBr, a bromide compound, or a combination to coal.

70. Page 23 of the ‘091 Application states that several examples are presented to “more clearly illustrate the present invention.” EX1027, 23:8-12. 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

¹ References to the ‘091 Application (EX1027) in this section of my Declaration refer to the page:line numbers of the “Specification” as filed on June 4, 2018 and included in EX1027 at AMEREN UE Exhibit pages 14-74. Page numbers greater than 74 refer to those assigned in the exhibit as filed (Ameren UE Exhibit page numbers).

them into a mercury-containing gas. EX1027, 23:14-25:18; 28:17-30:11. 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 Br₂, HBr, a bromide compound, or a combination thereof to coal.

71. The '091 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).” EX1027, 32:9-12. This disclosure, which is similar to the description for Figure 11 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.

72. Promoted sorbent injection before the boiler is not a disclosure of a promoter added to coal. 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 Br₂, HBr, a bromide compound, or a combination thereof.

73. 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 ‘091 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.

74. 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* EX1027, 14:6-8. 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 the coal.

75. Examples 11A and 11B involve adding an “Optional Alkaline Component.” EX1027, 32:26-33:31. In Example 11A, the optional alkaline was

applied to a filter along with “brominated activated carbon.” *Id.*, 33:3-10. In 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 Br₂, HBr, a bromide compound, or a combination thereof to coal.

76. The final example, Example 12, involved “Brominated Carbon Sorbent for Gasification Fuel Gas.” EX1027, 34:13-35:31. No coal was used in this example.

77. The ‘091 Application (including the incorporated Provisional) itself indicates that the inventors did not have possession of the Challenged Claims. This is because a POSITA would understand the ‘091 Application as disclosing only the combustion of untreated coal.

78. The ‘091 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 ‘091 Application indicates that:

- Molecular bromine (Br₂) does not react fast enough with elemental mercury to form oxidized mercury in flue gas using conventional ash control or that its “reaction with a hot flue gas components leave little to react with elemental mercury.” EX1027, 46:1-4, 17:21-23.

- 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. EX1027, 46:4-7, 17:23-28.
- A halide (e.g., a hydrohalide such as HBr) is “very much less reactive” than molecular halogen (e.g., Br₂) and “cannot therefore oxidize anything by itself.” EX1027, 46:8-12, 17:29-18:1.
- In the Provisional disclosure recited in the ‘091 Application, 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.” EX1027, 46:12-14. This Provisional disclosure was changed over time in the ‘091 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.” EX1027, 18:2-3.

79. 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

'517 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 '517 Patent, not coal to which HBr, Br₂, a bromide compound or a combination thereof is added.

80. 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 HBr, Br₂, 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. A POSITA would not have understood the disclosures of the '517 Patent as describing the addition of a promoter to coal or to the combustion chamber. Instead, the named inventors described a promoted activated carbon sorbent which was introduced into the flue gas post-combustion.

81. As the '517 Patent explains "adding HBr or Br₂ to the carbon forms a similar carbon bromide, in which the positive carbon oxidizes the mercury with the assistance of the bromide ion." EX1027, 47:6-8. 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.

82. Based on my review of the '517 Patent and the '091 Application, as well as my education, skill, training, and experience in the relevant fields of emission

reduction technology, it is my opinion that the '091 Application does not disclose a promoter added to coal as required by each of Claims 1, 29, and 30 of the '517 Patent for the reasons explained in Paragraphs 68-81 above.

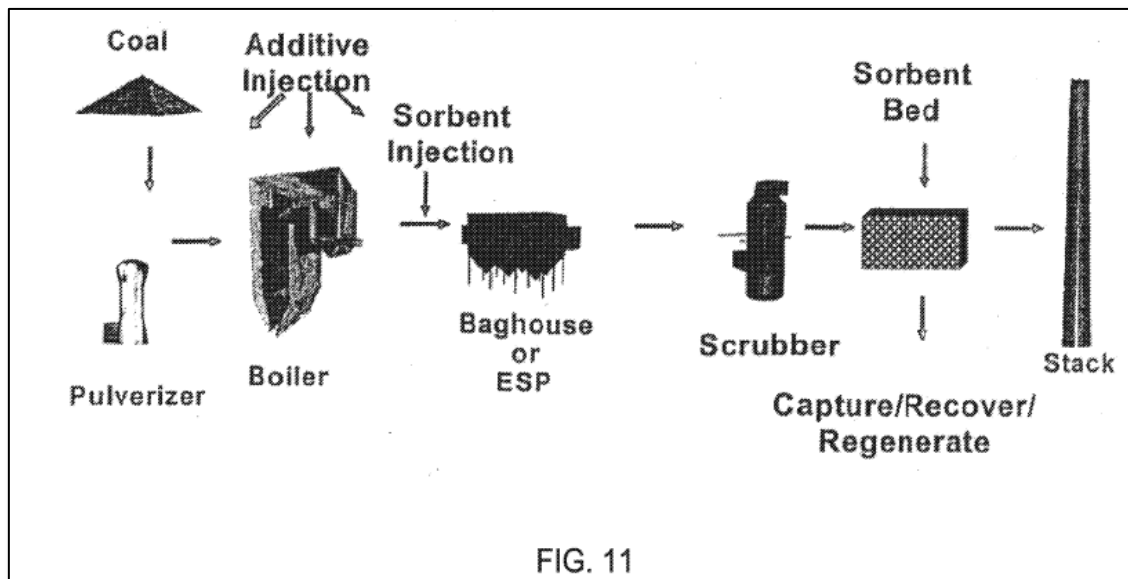
C. The Provisional, Which Was Copied into the '091 Application, Does Not Disclose Br₂, HBr, Bromide Compound, or a Combination Thereof as a Coal Additive

83. The '091 Application copies the entire disclosure of its earliest priority the Provisional into the specification. EX1001, 24:18–35:56. The Provisional section mentions mercury removal from “coal-fired utility or synthesis gas” (EX1027, 44:1-3; EX1017, 6), mercury within coal (EX1027, 44:17-20, 25-26; EX1017, 6), coal combustion flue gas (EX1027, 46:1-4; EX1017, 7), and a facility fired with lignite coal (EX1027, 54:9-10; EX1017, 14). None of these disclosures describe promoter compounds added to coal.

84. The Provisional disclosure includes Figure 2, which is reproduced below as Figure 11 in the '091 Application, showing a “coal fueled facility” burning “pulverized coal” where “additive can be injected where desired (e.g., before, after or within the boiler).” EX1027, 52:6-14, Figure 11; EX1017, 12, Figure 2.

85. 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.



86. 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 Claim 30, which requires modifying the “injection rate of injecting the sorbent into mercury containing gas” or “an amount of the Br₂, HBr, bromide compound, or a combination thereof, added to the coal or the combustion chamber....” (emphasis added). Claim 30 thus clearly distinguishes between “injecting” into the flue gas and “adding” to the coal.

87. 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.” EX1027, 38:15; EX1017, 2. There are 15 such examples in the Provisional. None of these examples discloses applying Br₂, HBr, a bromide compound, or a combination thereof as an “additive” to coal.

88. Provisional Examples 1–4 disclose a modified carbon sorbent prepared by reacting carbon with a Br₂ solution, a Br₂ gas, an HBr solution or an HBr gas. EX1027, 38:18-25; 40:14-18; 40:27-41:3; 41:9-13); EX1017, 2–3. Provisional Examples 5 and 6 further include a sulfur or selenium reagent when preparing the promoted sorbent. EX1027, 41:17-25; EX1017, 4. Example 7 treats “carbon with a Group V or VI element combined with Group VII element, such as PBr₃.” EX1027, 41:27-31; EX1017, 4.

89. In sum, Provisional Examples 1-7 disclose methods of preparing a promoted sorbent by reacting a carbon sorbent with Br₂, HBr or PBr₃. None of these examples disclose applying Br₂, HBr or PBr₃ as an “additive” to coal. These Examples do not disclose applying the promoted sorbent to coal or applying Br₂, HBr, a bromide compound, or a combination thereof to coal.

90. The Provisional also explains that Examples 1-3 may include an “additional promoting substance” in the Br₂ solution, Br₂ gas, or HBr solution used

in preparing the promoted sorbent. EX1027, 38:22-23; 40:5-12, 25-26; 41:6-7; EX1017, 2-3. The Provisional explains that this additional promoter can be HBr. EX1027, 40:8; EX1017, 3.

91. 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. Further, only HBr and not Br₂ is disclosed as an additional substance. A POSITA would know that these forms of bromine are not the same.

92. I note that my analysis and conclusion mirrors the position taken by the applicants during prosecution of the ‘517 Patent. EX1027, 419-423. More specifically, the applicants distinguished HBr from other forms of bromine-containing compounds, such as Br₂ and “bromide compounds” during prosecution. *Id.* In fact, inventor Pavlish explained that “Br₂ is not HBr and does not include HBr.” EX1027, p. 422, ¶ 17 (Pavlish/Lentz 7-10-2019 Rule 132 Affidavit (dated March 2019)).

93. Provisional Example 8 describes injecting the promoted sorbents of Provisional Examples 1-6 into a contaminated gas stream. EX1027, 42:1-6; 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.” EX1027, 42:8-19; 38:8-11; EX1017, 4, 1. Thus, Provisional Example 9 uses the term “additive” to describe sorbents. Provisional Examples 10-15 do not use the term “additive.”

94. “The additive” is not the modified carbon sorbents of the Provisional Examples 1–7 since Figure 11, 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.” EX1027, 52:12-13, Figure 11; EX1017, 12, Figure 2.

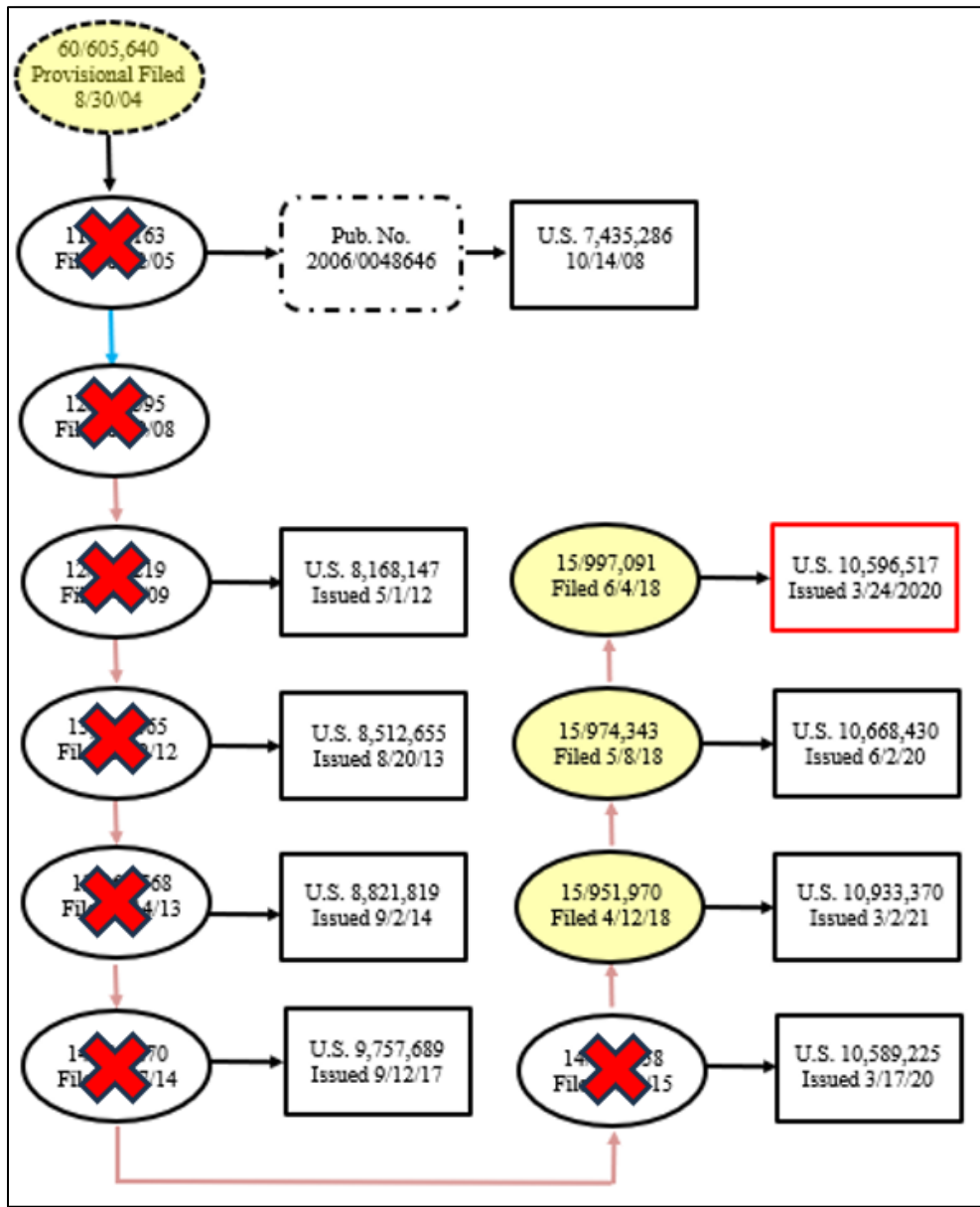
95. The only other mentions of “additive” in the Provisional do not identify what the “additive” is, either. EX1027, 44:4-8; EX1017, 6 (“a combination of additives to remove pollutants”); 50:29-30; EX1017, 11 (“additive to a treatment facility”); 51:5-7; EX1017, 11 (“additive-sorbent ratios”).

96. 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 Br₂, HBr, a bromide compound, or a combination thereof being added to coal for the reasons explained in Paragraphs 83-95. 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.

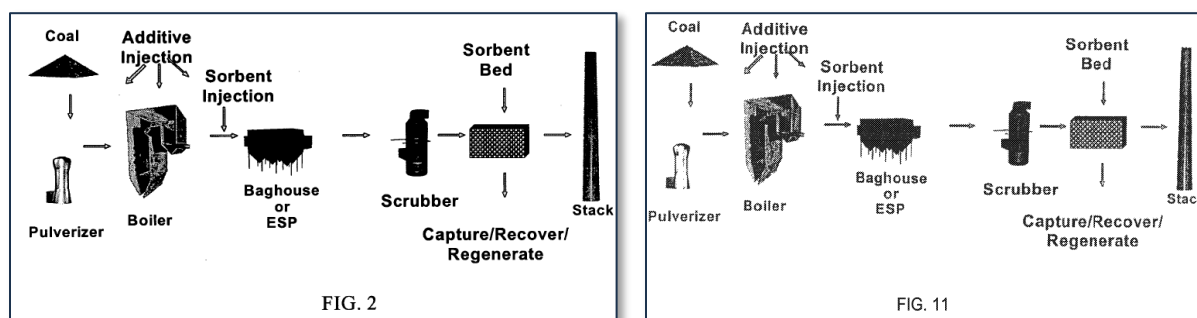
D. The Applications to Which the ‘517 Patent Claims Priority Do Not Disclose the Challenged Claims

97. 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–EX1036 (redline comparisons of each successive non-provisional application as compared to its predecessor). The text of the Provisional, as well as Provisional Figure 2, was added to the specifications of the 15/951,970, 15/974,343, and, as discussed above, the ‘091 Application.

98. The inclusion or exclusion of the Provisional Figure 2 is shown in the following image depicting the family of the ‘517 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:



99. Figure 11 of the '517 Patent is identical to Provisional Figure 2 as seen in the following side-by-side comparison:



100. The disclosures of the ‘163, ‘595, ‘219, ‘665, ‘768, ‘270, ‘558, ‘970 or ‘343 Applications thus have the same “coal” and “additive” disclosures discussed above regarding the ‘091 Application in Section VIII(B). Because the discussions of “coal” and “additives” in the ‘091 Application do not disclose a promoter or additive such as Br_2 , HBr , a bromide compound, or a combination thereof being added to coal, the ‘163, ‘595, ‘219, ‘665, ‘768, ‘270, ‘558, ‘970 or ‘343 Applications also lack any such disclosure.

101. 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 ‘517 Patent’s independent claims (claims 1, 29 and 30). EX1038, 28–29.

102. The Board explained in the Institution Decision that the disclosure as referenced in Example 10 of the ‘517 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, and injecting the sorbent into flue gas downstream of the combustion chamber.

103. 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, ‘558, ‘970 or ‘343 Applications disclose promoter compounds such as Br₂, HBr, a bromide compound, or a combination thereof being added to coal for the reasons explained above in Paragraphs 97-102. 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.

E. The Passages Cited by the Applicant During Prosecution Were Either Added in 2018 or Do Not Disclose the Addition of Br₂, HBr, or a Bromide Compound to the Coal or Combustion Chamber

104. The claims that were filed with the '091 Application (for the '517 Patent) were directed to a method of reducing mercury in a mercury-containing gas by injecting a sorbent (activated carbon) **into the mercury containing gas (i.e., after combustion)**, wherein the sorbent has at least one bromine promoter (Br₂, HBr, or Br⁻). Claim 1 of the '091 Application as filed, which I note was the only independent claim in the '091 Application as filed, is reproduced below:

1. A method for reducing mercury in a mercury-containing gas, the method comprising:
injecting a sorbent into the mercury-containing gas;
collecting mercury in the mercury-containing gas on the sorbent to produce a cleaned gas, wherein the sorbent is a promoted activated carbon that is promoted in-flight with at least one promoter that is Br₂, HBr, Br⁻, or a combination thereof, wherein the mercury-containing gas is a coal-combustion gas.

EX1027, 71, Claim 1.

105. On December 3, 2018, Applicant responded to a rejection by amending the claim to require, *inter alia*, that a bromine additive is added to the coal before combustion:

IN THE CLAIMS

Please amend the claims as follows:

1. (Currently Amended) A method for reducing mercury in a mercury-containing gas, the method comprising:

~~injecting a sorbent into the mercury-containing gas;~~

combusting coal that comprises an additive comprising Br₂, HBr, Br⁻, or a combination thereof, to form the mercury-containing gas, wherein the combusting of the coal is performed at a coal combustion facility site;

~~collecting mercury in the mercury-containing gas on [[the]]a sorbent to produce a cleaned gas, wherein the sorbent [[is]]comprises a promoted activated carbon that is promoted in-flight in a gas stream at the coal combustion facility site comprising contacting activated carbon dispersed in the gas stream with at least one promoter that is comprising [[Br₂,]]HBr, Br⁻, or a combination thereof, wherein the mercury-containing gas is a coal combustion gas.~~

EX1027, 186 (red added for emphasis). The '517 Patent's claims as issued also require the Pre-Combustion Limitation. *See, e.g.,* EX1001, Claim 1. *See also* EX1027, 533 (Pros. Hx. at July 10, 2019 Amendment to Claims).

106. I understand from my review of the '517 Patent file history that the Applicants cited paragraphs [0042], [0054], [0072], [0077–0086], and Figure 11 of the published application (US2018/0280870A1) as providing support for the Pre-Combustion Limitations:

Independent claim 1 is amended to recite “... combusting coal that comprises an additive comprising Br₂, HBr, Br⁻, or a combination thereof, to form the mercury-containing gas, wherein the combusting of the coal is performed at a coal combustion facility site...” Support can be found in the present published application at paragraphs [0042] (promoter can be bromide, Br⁻), [0054] and [0072] (bromine, bromide, or HBr can be promoter), paragraphs [0077]-[0086] (“additive” can mean promoter), and FIG. 11 (the additive can be added to the coal).

EX1027, 189 (highlighting and red added for emphasis).

107. As can be seen in the above quoted and emphasized portion of the file history, Applicants cited only Figure 11 as providing support for the concept that “the additive can be added to the coal.” As I explained in the preceding portion of this Declaration, Figure 11 of the ‘517 Patent is 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 Br₂, HBr, bromine compound and combinations thereof to coal.

108. None of the other paragraphs of the published application cited by the Applicants in the image above discloses the Pre-Combustion Limitations. Paragraph [0042], for example, discusses using “halogen/halide **promoted carbon sorbents** using a bromine (or other halogen/halide) treatment of the carbon.” EX1037 (emphasis added). Paragraphs [0054] and [0072] similarly discuss “formation of the

new bromide compound **with carbon**” and adding a “bromide compound” or “HBr or Br₂ **to the carbon.**” *Id.* (emphasis added). In my opinion, these paragraphs do not provide written description support for adding a promoter to coal, much less adding Br₂, HBr, bromine compound and combinations thereof to coal.

109. Paragraphs [0077]–[0086] discuss 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.” *Id.* (emphasis added). Again, in my opinion, these paragraphs do not provide written description support for adding a promoter to coal, much less adding Br₂, HBr, bromine compound and combinations thereof to coal.

110. Following a final rejection, I understand that the Applicants amended claim 1 and added new claims 21–42 depending from claim 1. EX1027, (July 10, 2019 Remarks). Applicant also added two new independent claims (filed claims 41 and 42) which “include[d] features that are similar to the features of independent claim 1.” *Id.* Those features included the limitations requiring that HBr, Br₂ or a “bromide compound” be added to the coal before combustion. Purported support for new claims 41 and 42 was identified by the application as “claims 1 and 20” as well as Paragraphs [0025], [0072], and [0090] of the published application. *Id.*

111. Paragraph [0072], as explained above, does not involve adding a bromine compound to the coal prior to combustion. Nor does Paragraph [0025], which instead discusses monitoring mercury content of “cleaned flue gas” as well as preparation of “the injected sorbent . . . in-flight by reacting an activated carbon and a promoter within a pneumatic transport line from which the reaction product is injected to the mercury-containing flue gas stream.” *Id.* (emphasis added).

112. Paragraph [0090], under the heading “Sorbent Injection Control Schemes,” discloses techniques for monitoring mercury levels in cleaned flue-gas to “assist in control of the sorbent injection rate.” *Id.* Again, none of these relied-upon paragraphs discuss adding one or more forms of bromine to coal before combustion.

113. In my opinion, none of Applicant’s citations to US2018/0280870A1 provides support for the limitations requiring adding HBr, Br₂ or a “bromide compound” to coal.

114. In sum, the ‘091 Application and each of its priority applications fail to provide support for adding any of the claimed promoters (Br₂, HBr, a bromide compound, or a combination thereof) to coal as recited in the claims of the ‘517 Patent for the reasons explained above in Paragraphs 104-113. It follows that none of the claims of the ‘517 Patent are entitled to a priority date before the filing date of the ‘091 Application.

IX. CLAIM CONSTRUCTION

115. 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 '517 Patent.

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

117. I note that Magistrate Judge Burke in the District of Delaware provided constructions for two terms in patents from the same family as the '517 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.

118. 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.

119. 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.”

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

121. 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 ‘517 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)

122. 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).

123. 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 (June 4, 2018) of the ‘517 Patent, which applies if the ‘517 Patent is not entitled to an earlier priority date.

124. 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 ‘517 Patent.

125. 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.

126. 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 127-148..

1. Disclosures of Downs and Downs-Provisional

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

128. Downs is analogous art to the ‘517 Patent as Downs describes processes for improving mercury removal from the flue gas of coal combustion facilities.

129. 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].

130. 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:

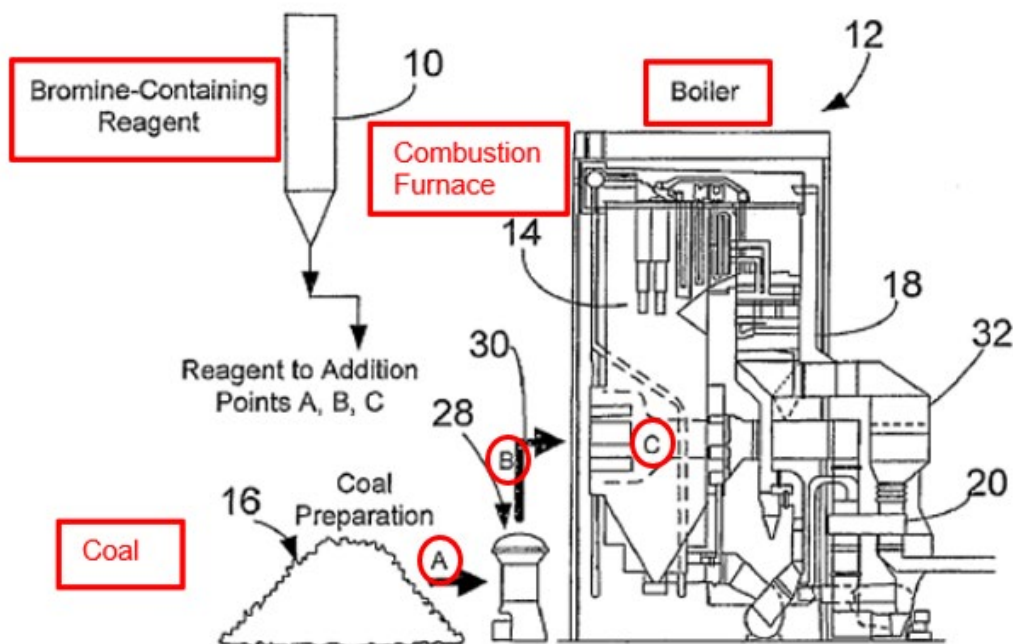


FIG. 2

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.

131. 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 (Br₂)” 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:

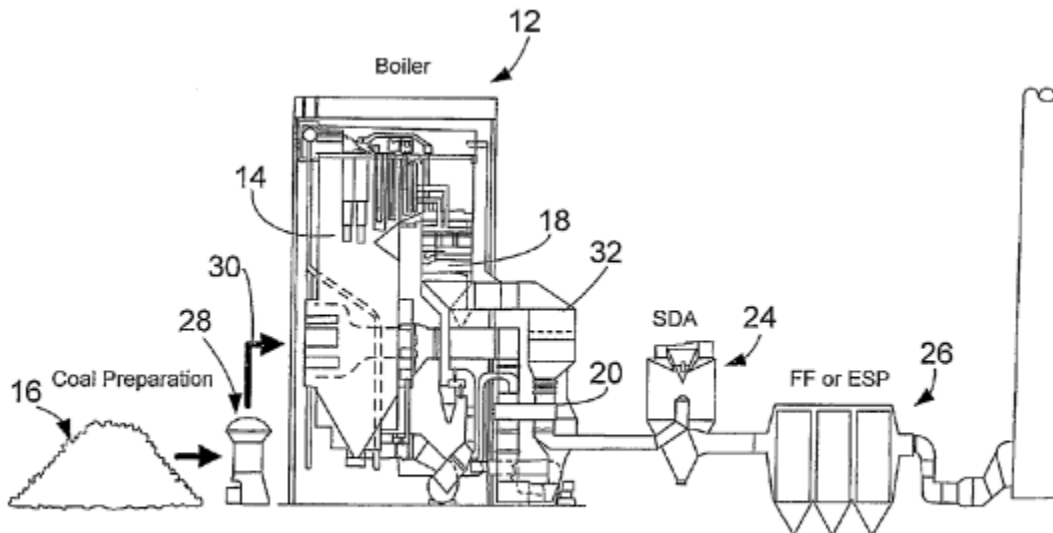


FIG. 4

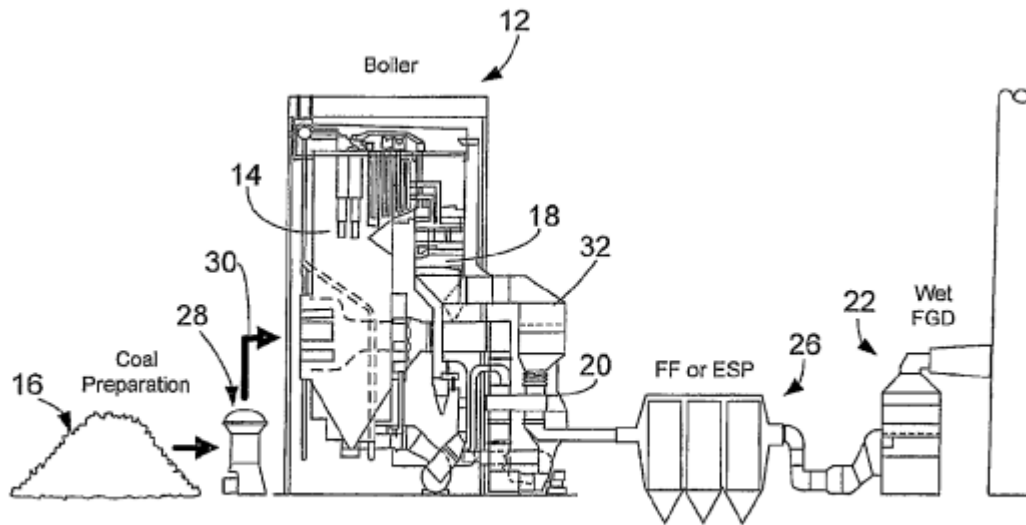


FIG. 6

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

132. 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

133. 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.

134. 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) (1a) (Preamble)—“A method of removing a portion of the elemental mercury in a flue gas created during the combustion of a fossil fuel”

135. 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.”

136. 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) (1b)—“providing a bromine containing reagent to said flue gas”

137. 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.”

138. 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].

139. 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) (1c)— “promoting the oxidation of elemental mercury with the bromine containing reagent;”

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

141. 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].

142. 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) (1d)—“creating an oxidized form of mercury from the elemental mercury; and”

143. 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].

144. 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) (1e) — “removing the oxidized mercury from the flue gas.”

145. 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.”

146. 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].

147. 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].

148. 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

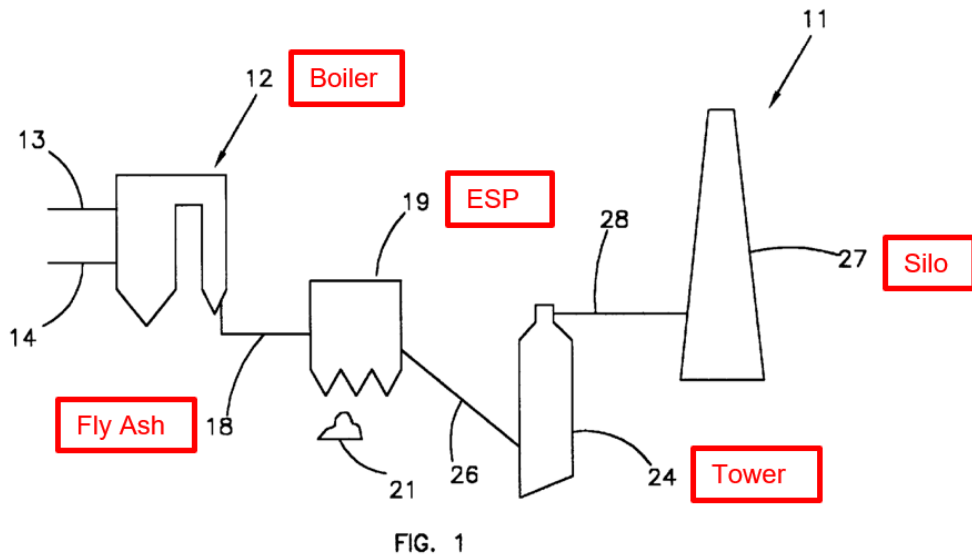
enhancing the overall removal of mercury in downstream pollution control devices.”
Id., [0009]. Having reduced the invention to practice, the Downs’ inventors demonstrated possession of the invention.

149. 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 133-148. 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)

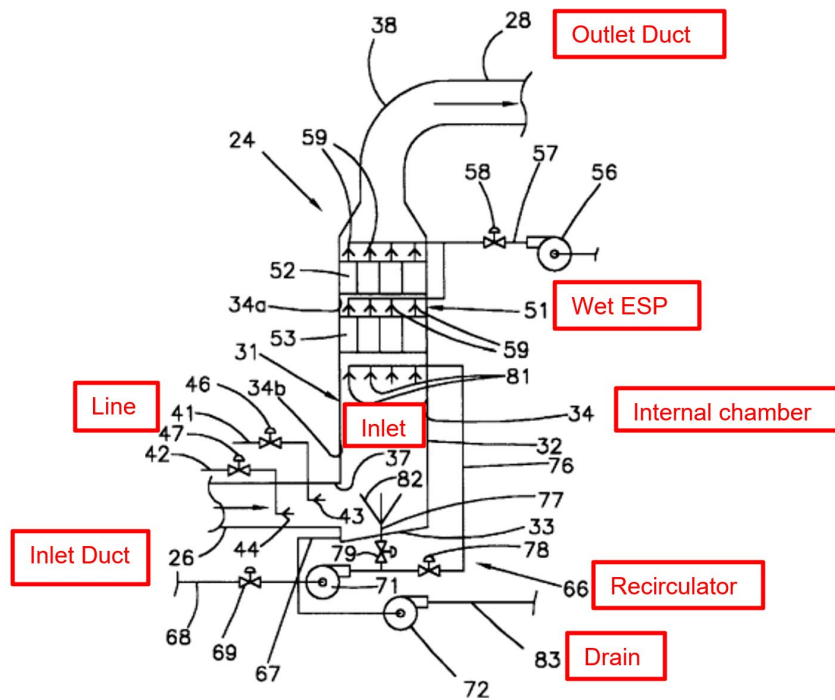
150. Altman issued on October 27, 1998. Accordingly, I understand that Altman qualifies as a prior art patent regardless of whether the effective filing date of the ‘517 patent is June 4, 2018 or August 30, 2004.

151. 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:



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

152. 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).

153. 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.

154. 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.

155. 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.

156. 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.

157. 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.

158. 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)

159. 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.

160. I understand that Nelson qualifies as prior art as of its publication date of January 8, 2004, which is earlier than the earliest priority date of the ‘517 Patent (August 30, 2004).

161. 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.

162. 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.

163. 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 164-178.

1. Disclosures of Nelson and Nelson-Provisional

164. 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).

165. Nelson is analogous art to the ‘517 Patent as Nelson describes processes for improving mercury removal from the flue gas of coal combustion facilities. EX1008, Abstract, [0004]; EX1009, 1, 4.

166. 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).

167. 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.

168. 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.

169. Nelson indicates that exposure of sorbent to Br₂ 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

170. 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).

171. 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) (18a) A process for manufacturing a mercury sorbent, comprising:

172. 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) (18b) providing a carbonaceous substrate;

173. 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.

174. 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) (18c) providing a bromine-containing gas, and

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

176. 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) (18d) contacting the carbonaceous substrate with the bromine containing gas for a sufficient time to increase the mercury adsorbing ability of the carbonaceous substrate,

177. 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).

178. 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.

179. *Id.* 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 170-178. 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.

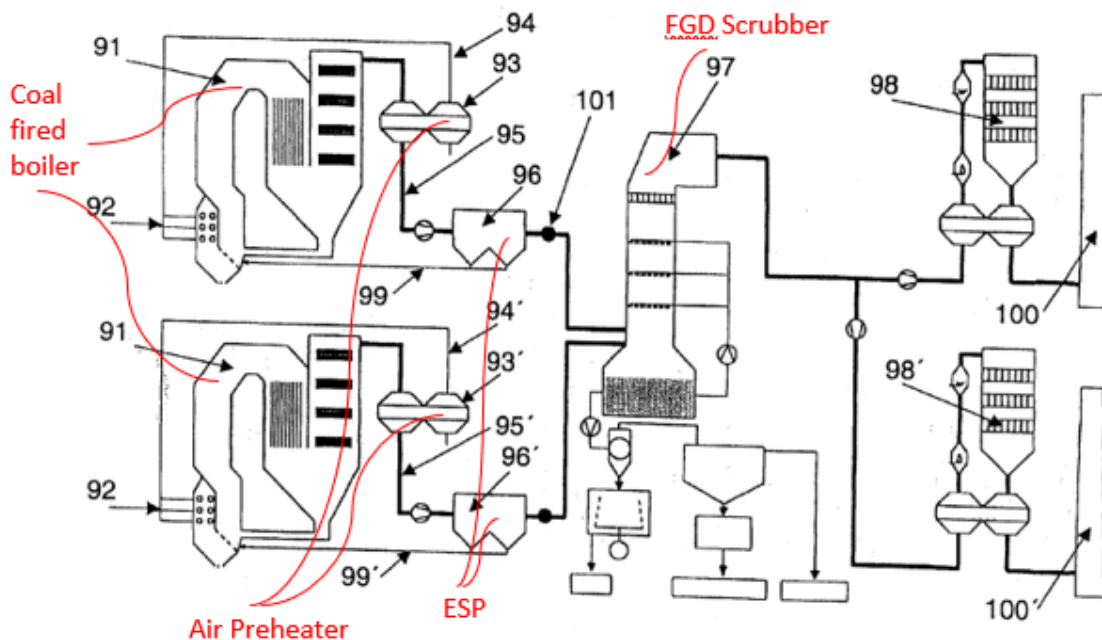
D. Vosteen (U.S. Pat. Pub. No. 2004/0013589) (EX1011)

180. 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 priority date of the ‘517 Patent (August 30, 2004).

181. 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]

182. 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].

183. 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].

184. 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].

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

186. 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].

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

188. 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].

189. 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)

190. 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 ‘517 Patent is entitled to a priority date of June 4, 2018.

191. 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.

192. 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.*

193. 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.*

194. 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.*

195. 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 “sorber usage about 50 percent compared to traditional activated carbon systems.” *Id.*, 58.

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

196. 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 ‘517 Patent is entitled to a priority date of June 4, 2018.

197. Olson-235 describes a method “for reducing mercury in flue gas comprising providing a base sorber, either by injection or in situ creation, into a mercury-containing flue gas stream,” EX1013, 5:30–36. Olson-235 discloses that the promoted sorber “comprises from about 1 to about 30 grams of promoter per 100 grams of base sorber.” EX1013, 4:53–60, Claims 3, 17.

198. Olson-235 also discloses an embodiment wherein “the injected sorber is prepared in-flight by reacting a base sorber (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. In that embodiment, “the promoter is added at from about 1 to about 30 grams per 100 grams of the base sorber.” EX1013, 6:17–31.

199. 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.

XI. GROUND 1 – CLAIMS 1, 4, 6-7, 11-15, 17, 22, AND 24-29 ARE ANTICIPATED BY DOWNS

200. 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, 4, 6-7, 11-15, 17, 22, and 24-29 are anticipated by Downs. In the subsections that follow, I explain the bases for my opinion that Claims 1, 4, 6-7, 11-15, 17, 22, and 24-29 are anticipated by Downs.

201. 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 a cite for a claim in Downs.

202. 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 ‘517 Patent regardless of

whether the '517 Patent is entitled to a June 4, 2018 priority date or the August 30, 2004 filing date of the Provisional.

A. Independent Claim 1

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

203. 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.

204. 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].

205. 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].

206. 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.

207. Downs, in my opinion, discloses the preamble of claim 1 as Downs discloses methods for reducing mercury in a mercury-containing gas for the reasons explained above in Paragraphs 203-206.

2. 1(a)–“combusting coal in a combustion chamber, the coal comprising an additive comprising Br₂, HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas”

208. 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].

209. 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].

210. 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].

211. 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.

212. 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 (Br₂).” EX1004, [0021]; EX1005, [0024].

213. 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].

214. Downs, in my opinion, discloses combusting coal in a combustion chamber wherein the coal comprises an additive comprising Br₂, HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas for the reasons explained above in Paragraphs 208-213. EX1004, [0002], [007], [0011], [0015], [0018], Fig. 3, [0019], [0021]; EX1005, [0003], 0009], [0013], Fig. 3, [0022], [0024].

3. 1(b)–“collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon”

215. 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].

216. 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].

217. 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].

218. 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].

219. Downs therefore, in my opinion, discloses methods for collecting mercury from the mercury containing flue gas wherein the sorbent is an activated carbon for the reasons explained above in Paragraphs 215-218. EX1004, [0004], [0015], [0016], [0023], [0025], Claims 15-16; EX1005, [0005], [0018], [0019], [0026], [0028].

220. As established above, Downs discloses every element of Claim 1 of the ‘517 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 4—“the activated carbon is chosen from powdered activated carbon, granular activated carbon, carbon black, carbon fiber, aerogel carbon, pyrolysis char, and combinations thereof.”**

221. As discussed above regarding element 1(c), 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].

222. Because Downs discloses every element of Claim 1 and at least one of the types of activated carbon required by Claim 4, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Downs anticipates Claim 4.

2. Claim 6—“collecting greater than 70 wt % of the mercury in the mercury-containing gas”

223. Downs’ Figure 3 reports reducing vapor-phase mercury by 77% from 9 $\mu\text{g}/\text{dscm}$ mercury at FF-inlet to 2 $\mu\text{g}/\text{dscm}$ mercury at FF-outlet:

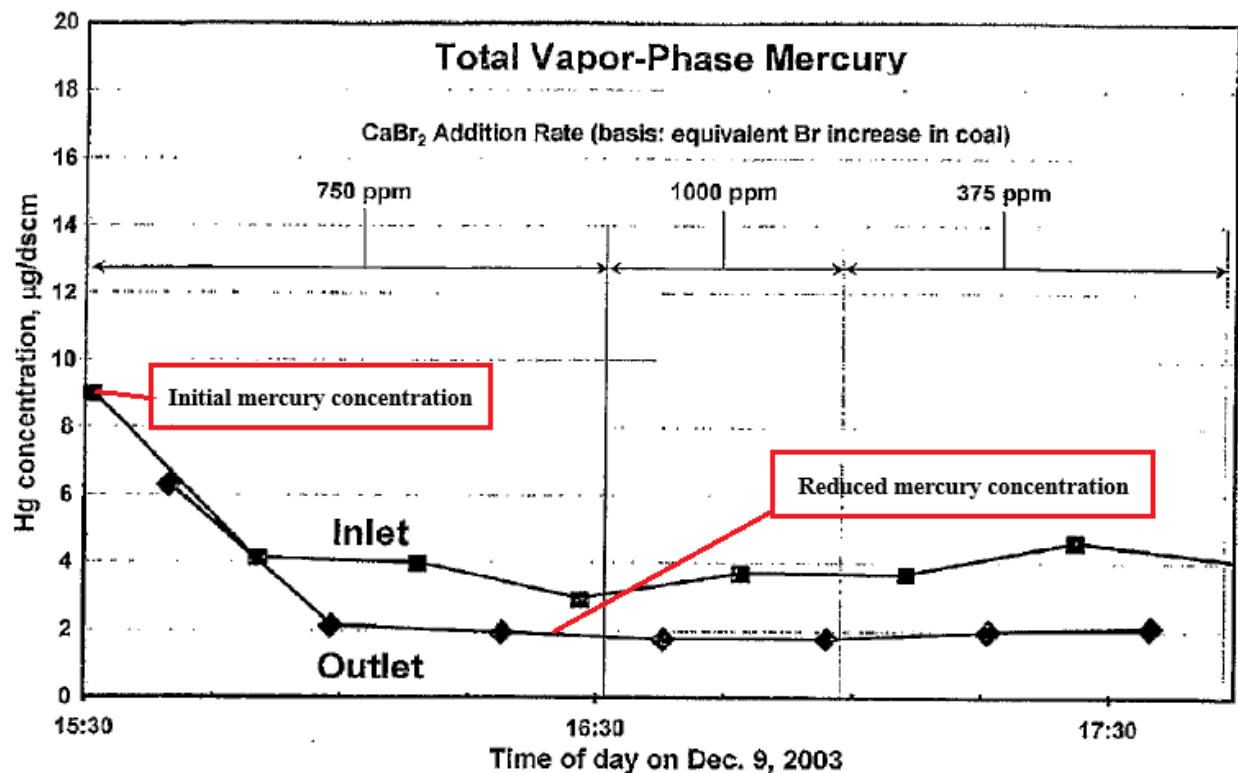


FIG. 3

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

224. 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” and describes “an increased-fraction of particulate-bound mercury” that enhances removal across particulate collectors such as fabric filters and ESPs. EX1004, [0015], [0018]; EX1005, [0018], [0021].

225. 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.

226. Because Downs discloses every element of Claim 1 and that the mercury removal is greater than 70 wt % as required by Claim 6, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Downs anticipates Claim 6 for the reasons explained above in Paragraphs 223-225. EX1004, Figure 3, [0015], [0018], [0025]; EX1005, Figure 3, [0018], [0021]; [0028].

3. Claim 7— “collecting greater than 70 wt % of the mercury in the mercury-containing gas with the sorbent”

227. As shown above for Claim 6, Downs’ Figure 3 reports reducing vapor-phase mercury by 77% from 9 $\mu\text{g}/\text{dscm}$ mercury at FF-inlet to 2 $\mu\text{g}/\text{dscm}$ mercury at FF-outlet.

228. 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].

229. 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].

230. 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].

231. 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].

232. 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.

233. Accordingly, because Downs discloses every element of Claim 1 and that the mercury removal is greater than 70 wt % using an activated carbon sorbent as required by Claim 7, it is 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 Paragraphs 227-232. EX1004, Figure 3, [0015], [0018], [0025]; EX1005, Figure 3, [0018], [0021]; [0028].

4. Claim 11— “the coal comprises a subbituminous coal”

234. 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].

235. 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 11.

5. Claim 12— “the coal comprises a lignite coal”

236. As discussed above for Claim 11, Downs discloses that “the coal-fired boiler fuel 16 may include bituminous, subbituminous, and lignite coals and blends thereof.” EX1004, [0020]; EX1005, [0023].

237. 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 12.

6. Claim 13—“the coal comprises the added Br₂, HBr, the bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber”

238. As discussed above regarding element 1(a), 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]. Downs states that other bromine compounds can be used as well, such “alkaline metal bromides, hydrogen bromide (HBr) or bromine (Br₂).” EX1004, [0021]; EX1005, [0024].

239. 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].

240. 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].

241. Because Downs discloses every element of Claim 1 and specifically teaches that the bromide is added to the coal before the coal enters the combustion chamber, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Downs anticipates Claim 13 for the reasons explained above in Paragraphs 238-240. EX1004, [0007], [00015], [0019], [0021]; EX1005, [0009], [0018], [0022], [0024].

7. Claim 14—“the combustion chamber comprises the added Br₂, HBr, the bromide compound, or a combination thereof.”

242. Again, 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]. Downs states that other bromine compounds can be used as well, such “alkaline metal bromides, hydrogen bromide (HBr) or bromine (Br₂).” EX1004, [0021]; EX1005, [0024].

243. 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].

244. Because Downs discloses every element of Claim 1 and specifically teaches that the bromide is added to the coal before the coal enters the combustion chamber or is added directly to the combustion chamber, it is 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 242-243. EX1004, [0007], [0009], [0015], [0019], [0021]; EX1005, [0009], [0018], [0022], [0024].

- 8. Claim 15—“the coal is combusted in the combustion chamber at a coal-combustion facility, wherein the Br₂, HBr, bromide compound, or combination thereof, is added to the coal before the coal enters the combustion chamber, wherein the addition of the Br₂, HBr, bromide compound, or combination thereof, to the coal is performed at the coal-combustion facility.”**

245. As discussed above regarding Claims 1 and 13, 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].

246. Downs states that other bromine containing reagents can be used as well, such “alkaline metal bromides, hydrogen bromide (HBr) or bromine (Br₂).” EX1004, [0021]; EX1005, [0024].

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

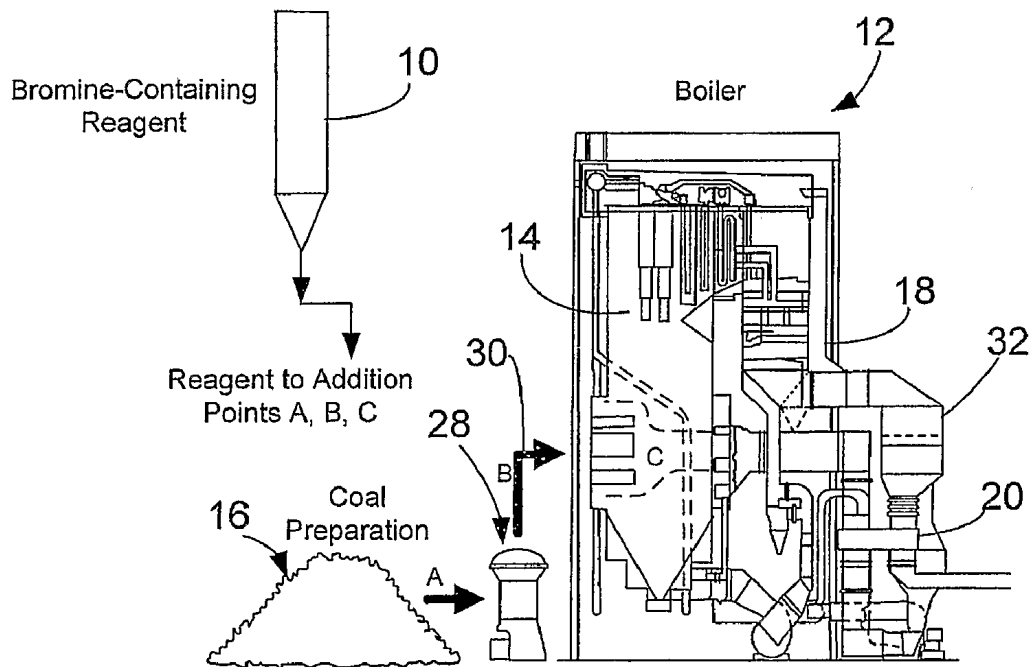


FIG. 2

248. 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].

249. 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.

250. Because Downs discloses every element of Claim 1 and specifically teaches that the coal is combusted at a coal-combustion facility, and that the Br₂, 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 15, it is 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 Paragraphs 245-249. EX1004, Fig. 2, [0015], [0016, [0019], [0021]; EX1005, [0018], [0019], [0022], [0024].

9. Claim 17—“the combustion chamber is an electric utility coal combustion chamber.”

251. 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].

252. Because Downs discloses every element of Claim 1 and specifically teaches that discloses processes are used at a coal-fired electric plant, it is 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 Paragraph 251.

10. Claim 22—“the Br₂, HBr, or the bromide compound is contacted with the sorbent in vapor form, gaseous form, liquid form, or in an organic solvent.”

253. Downs discloses that the bromine-containing reagent, which can be HBr, Br₂, a metal bromide, or calcium bromide, “may be fed to the boiler combustion zone 14 in gaseous, liquid, or solid form.” EX1004, [0021]–[0022]; EX1005, [0024]–[0025].

254. Downs also 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].

255. 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].

256. As I have explained previously in this declaration, a POSITA would know that HBr is in vapor or gaseous form in the flue gas after combustion of a bromide compound such as HBr, Br₂ or sodium bromide. A POSITA would thus know that the bromine in vapor or gaseous form in the flue gas in Downs’ systems and processes would contact the PAC injected into the flue gas.

257. Because Downs discloses every element of Claim 1 and a POSITA would know that HBr is in vapor or gaseous form in the flue gas after combustion of a bromide compound such as HBr or sodium bromide, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Downs anticipates Claim 22 for the reasons explained above in Paragraphs 253-256. EX1004, [0004], [0015]–[0016], [0021]–[0022], [0025], Claims 15-16; EX1005, [0005], [0018], [0022], [0024]–[0025], [0028].

11. Claim 24—“the sorbent injected into the mercury-containing gas is free of contact with a halogen or halide promoter prior to injection of the sorbent into 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 24 for the reasons explained above in Paragraphs 258-260.

12. Claim 25—“the injection of the sorbent into the mercury-containing gas occurs upstream of a particulate separator or a scrubber.”

262. 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.

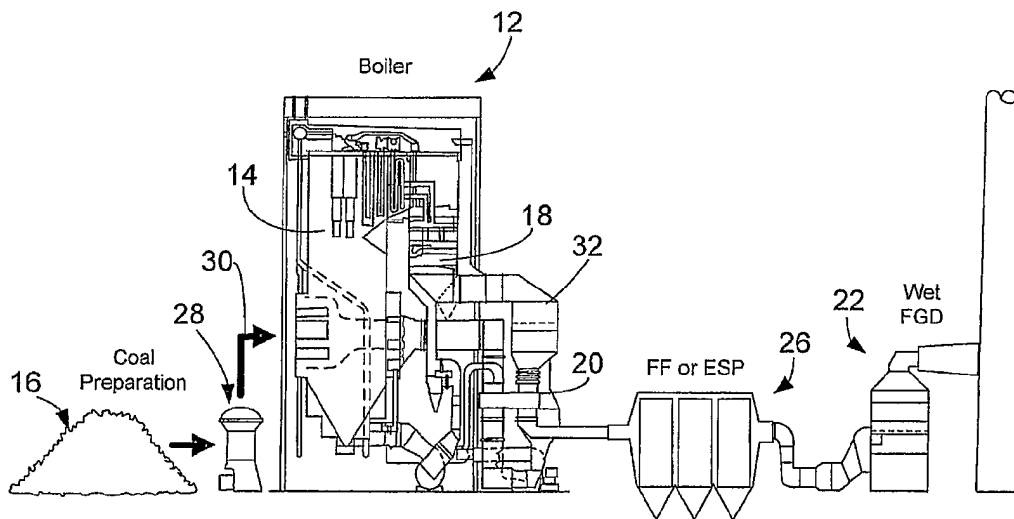


FIG. 6

263. 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].

264. 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.

265. 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 25 for the reasons explained above in Paragraphs 262-264. EX1004, [0004], [0014], [0015], [0023], Figs. 4-6; EX1005, [0005], [0016], [0018], [0026], Figs. 4-6.

13. Claim 26—“the particulate separator comprises an electrostatic precipitator, a baghouse, a fabric filter, or a combination thereof.”

266. Claim 26 depends from Claim 25 and requires that the particular separator comprise an ESP, a baghouse, a fabric filter, or a combination thereof.

267. As discussed above regarding Claim 25, 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 separators as Claim 26 itself recognizes.

268. Because Downs discloses every element of Claim 1 and Claim 25, and further teaches that the particulate separator 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 26 for the reasons explained above in Paragraphs 266-267.

14. Claim 27—“the coal comprises added halide sorbent enhancement additive that comprises the added Br₂, HBr, the bromide compound, or combination thereof.”

269. 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 (Br₂). 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].

270. 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].

271. 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.

272. 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.

273. Because Downs discloses every element of Claim 1, and further teaches that the bromine 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 27 for the reasons explained above in Paragraphs 269-272. EX1004, [0007], [0011], [0016], [0018], [0021], Fig. 3; EX1005, [0009], [0013], [0019], [0024], Fig. 3.

15. Claim 28—“the sorbent enhancement additive comprises the bromide compound.”

274. Claim 28 depends from Claim 1 and requires that “the sorbent enhancement additive comprises the bromide compound.” I note that Claim 1 does not use the term “sorbent enhancement additive.”

275. The ‘517 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, 2:41-45.

276. Assuming for purposes of my analysis that the “sorbent enhancement additive” refers to the “additive comprising Br₂, HBr, a bromide compound, or a combination thereof” in element 1(a) of Claim 1, I further assume that Claim 28 is similar to Claim 27 and requires that the “additive” is further limited to a “bromide compound.” Downs discloses this claim element.

277. As discussed repeatedly above, and in particular with regard to Claim 27, Downs discloses numerous bromine containing reagents that are added to the coal that act as sorbent enhancement additives, including sodium bromide and hydrogen bromide. EX1004, [0018]-[0019], [0021], Figure 2; EX1005, [0021]-[0022], [0024], Figure 2.

278. Because Downs discloses every element of Claim 1, and further teaches that a bromine compound is added to the coal as a sorbent enhancement additive, 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 274-277.

C. Independent Claim 29

279. Claim 29 is similar to Claim 1 discussed above, with limited differences. The preamble of Claim 29 requires “separating” mercury from a mercury-containing gas rather than “reducing mercury” in a mercury containing gas. Claim 29 further requires the addition of Br₂, HBr, bromide compound, or a combination thereof to the coal before the coal enters the combustion chamber or adding Br₂, HBr, bromide compound, or a combination thereof to the combustion chamber.

280. As explained above regarding Claims 1, 13, 14, 27, and 28, Downs discloses adding bromide reagents, such as HBr, Br₂, and/or calcium bromide, to the coal before combustion or directly to the combustion chamber.

281. 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 29.

1. Claim 29(Preamble)–“A method of separating mercury from a mercury-containing gas, the method comprising:”

282. 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.

283. 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].

284. 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].

285. 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.

286. Downs, in my opinion, discloses the preamble of claim 29 as Downs discloses methods for reducing mercury in a mercury-containing gas for the reasons

explained above in Paragraphs 282-286. 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. **29(a)–“combusting coal in a combustion chamber, wherein the coal comprises added Br₂, HBr, bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber, or the combustion chamber comprises added Br₂, HBr, bromide compound, or a combination thereof; and”**

287. 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].

288. 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].

289. 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].

290. 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 (Br₂).” EX1004, [0021]; EX1005, [0024].

291. Downs, in my opinion, discloses combusting coal in a combustion chamber, wherein the coal comprises added Br₂, HBr, bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber, or the combustion chamber comprises added Br₂, HBr, bromide compound, or a combination thereof for the reasons explained above in Paragraphs 287-290. EX1004, [0002], [007], [0011], [0015], [0018], Fig. 3, [0019], [0021]; EX1005, [0003], [0009], [0013], Fig. 3, [0022], [0024]. This limitation is essentially the same as Claim 1.

3. 29(b) –“collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon.”

292. 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].

293. 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].

294. 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].

295. Downs therefore, in my opinion, discloses methods for collecting mercury from the mercury containing flue gas wherein the sorbent is an activated carbon. EX1004, [0004], [0015], [0016], [0023], [0025], Claims 15-16; EX1005, [0005], [0018], [0019], [0026], [0028].

296. As established above, Downs discloses every element of Claim 29 of the ‘517 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 29 for the reasons explained above in Paragraphs 292-295.

XII. GROUND 2—CLAIMS 1-15 AND 17-30 WOULD HAVE BEEN OBVIOUS IN LIGHT OF DOWNS COMBINED WITH ALTMAN OR DOWNS/ALTMAN AND NELSON

297. 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 1-15 and 17-30 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 1-15 and 17-30 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

298. 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 '517 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.

299. 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.

300. 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.

301. 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.

302. 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].

303. 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 Br₂ 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, 4, 6-7, 11-15, 17, 22, And 24-29 Would Have Been Obvious In Light Of Downs Combined With Altman or Downs/Altman and Nelson

304. 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.

305. 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.

306. 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 Br₂ or HBr gas “significantly increases the carbonaceous materials ability to remove mercury species.” EX1008, [0041]; EX1009, 4.

307. In addition to the disclosure of Downs, there is specific disclosure in Altman and/or Nelson relevant to the obviousness of claims 1, 4, 6-7, 11-15, 17, 22 and 24-29, as detailed below.

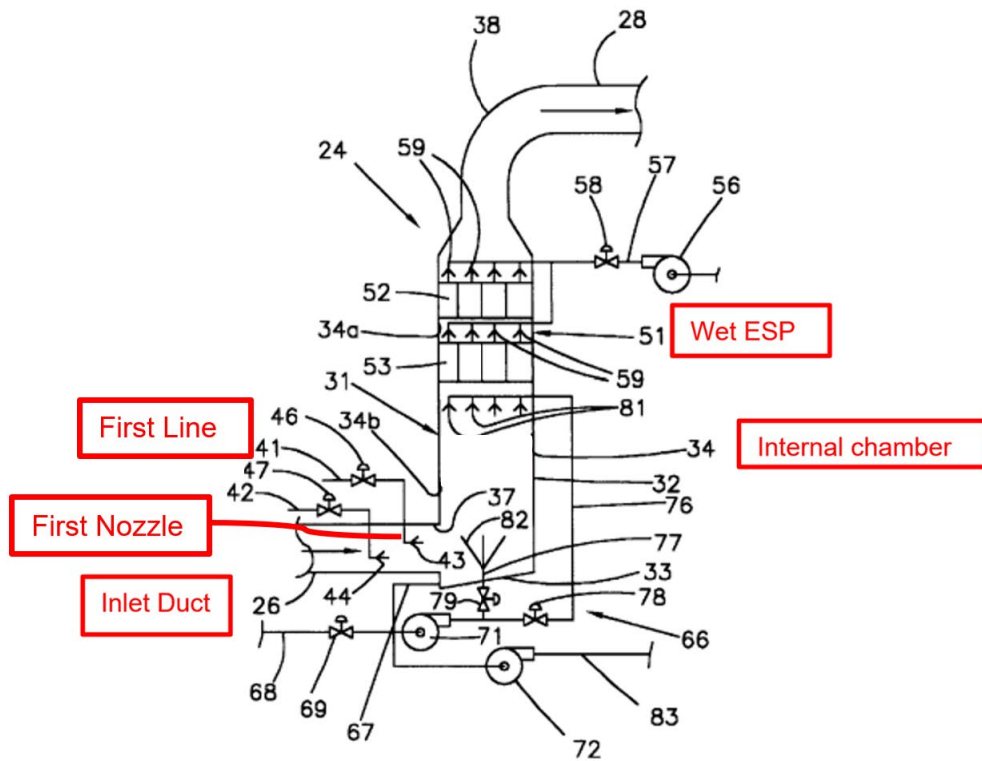
308. Regarding claim elements 1(b), 29(b), 1(c), and 29(c) and claim 4, Altman and Nelson describe injecting PAC sorbent into flue gas to remove elemental and oxidized mercury using an ESP. EX1007, 1:41–2:46; 4:53–61, 5:50–61; EX1008, [0040]; EX1009, 4.

309. Regarding claims 6-7, Downs' Figure 3 reports reducing vapor-phase mercury by 77% from 9 $\mu\text{g}/\text{dscm}$ mercury at FF-inlet to 2 $\mu\text{g}/\text{dscm}$ 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.

310. Regarding claim 17, 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.

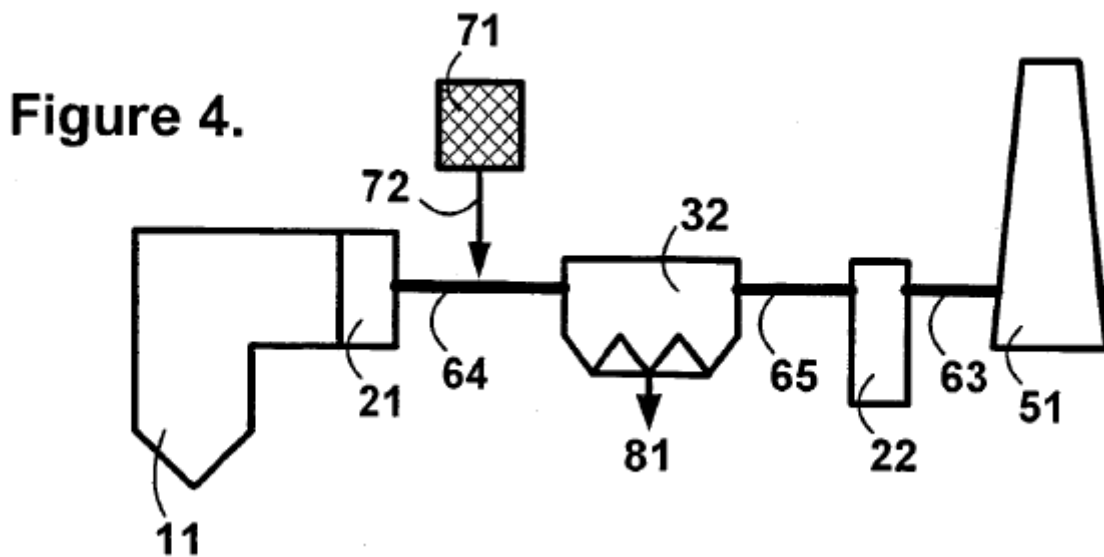
311. Regarding claim 24, Altman does not describe any contact of sorbent with a halogen or halide promoter before injection into the flue gas. EX1007. A POSITA had reason to select halogen-free activated carbon due to its lower cost as compared to halogen-promoted activated carbons especially where sufficient 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.

312. Regarding claims 25-26, Altman's Figure 2 depicts 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.

313. Regarding claims 25-26, Nelson also describes injecting sorbent from bin 71 upstream of ESP 32 as depicted below. EX1008, [0062], Figure 4.



314. 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, 4, 11-15, 17, 22, and 24-29 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 304-313.

315. In the sections that follow, I explain why Claims 2, 3, 5, 8-10, 18-21, 23, and 30 would have been obvious to a POSITA at the time of the invention in light of Downs and Altman or Downs, Altman and Nelson. Regarding claim element 30(a), I also provide evidence of the knowledge of a POSITA with respect to the mercury-containing gas comprising a halogen or halide promoter comprising HBr, Br-, or a combination thereof.

C. Claims 2, 3, 5, 8- 10, 18-21, 23 And 30 Would Have Been Obvious In Light Of Downs Combined With Altman Or Downs/Altman And Nelson

1. Claim 2—“injecting an alkaline sorbent into the mercury-containing gas stream.”

Claim 3—“the alkaline sorbent is selected from the group consisting of alkali elements, alkaline earth elements, alkali salts, alkaline earth salts, and combinations thereof.”

316. 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.

317. 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.

318. 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 Claims 2 and 3, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claims 2 and 3 would have been obvious to a POSITA at the time of the invention in light of Downs and Nelson for the reasons explained above in Paragraphs 316-317. EX1008, [0012], [0064]; EX1009, 3.

2. Claim 5—“the sorbent has a composition comprising from about 1 to about 30 grams of the element bromine per 100 grams of activated carbon.”

319. I have reviewed the ‘517 Patent and its file history. My review of the ‘517 Patent does not reveal that the applicants attributed any particular significance to the claimed range or established that it achieves “unexpected results” in mercury removal. Rather, the range merely optimizes known “result-effective” variables (amount of bromine and the amount of activated carbon) that would have been

obvious to a POSITA. It is my understanding that a “result-effect variable” in patent law is a parameter recognized in the prior art as influencing a particular property or outcome. Here, the prior art references identified the amount of promoter and/or activated carbon sorbent as impacting the level of mercury removal from a coal combustion flue gas such that adjustments in these parameters were known to achieve predictable results.

320. Claim 5 depends from Claim 1. Claim element 1(b) requires “collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon.” Claim 5 requires that “the sorbent [of claim 1] has a composition comprising from about 1 to about 30 grams of the element bromine per 100 grams of activated carbon.” The plain language of Claim 5 thus requires that the “sorbent added to the mercury containing gas” have a “composition comprising from about 1 to about 30 grams of the element bromine per 100 grams of activated carbon.” It follows that the sorbent added to the mercury-containing gas is a promoted sorbent.

321. If Claim 5 requires that “the sorbent” is a promoted sorbent, this claim element is disclosed in Nelson. More specifically, Nelson discloses brominated PAC sorbents having 1, 5, 9, 15, and over 30 wt.% loading of HBr or Br₂ (i.e., 1, 5, 9, 15 or over 30g bromine to 100g PAC). EX1008, [0054], Example 6; EX1009, 5 (15 wt.% loading for 500-1000% increase in mercury capacity).

322. If my understanding of claim 5 is not correct, and Claim 5 does not require that “the sorbent” be a promoted sorbent, then a POSITA would have looked to the relative amounts of bromine to sorbent in the flue gas. Given the residence times in flue gas, a POSITA would have understood that bromine loaded onto activated carbon would be less than the 31-38g per 100g maximum. EX1050, 260.

323. Downs discloses that, “[a]s will be appreciated by those skilled in the art, some non-zero amount of bromine must be supplied in order to apply the principles of the invention; the upper limit of the range is, as a practical matter, limited by the possible increased corrosion potential which might be created. EX1004, [0019]. *See also* EX1005, [0022] (“There are many alternative ways to implement the invention as would be [*sic*] gleamed by one of skill in the art.”). A POSITA had reason to load the activated carbon with bromine sufficiently to increase its ability to adsorb mercury given Altman’s emphasis on achieving optimal mercury sorption by ensuring sufficient activated carbon mercury adsorption capacity. EX1007, 4:66–5:5; EX1045, 2–3.

324. A POSITA also would have recognized that there would be sufficient bromine in the flue gas to provide a ratio of 1–30 g of bromine per 100 g of activated carbon. Indeed, I understand that Patent Owner’s expert in the Delaware lawsuit stated that “power plants employing bromine additives and activated carbon would

necessarily produce a sorbent that is 1g to 30g bromine per 100g of activated carbon.” EX1083, 153.

325. Because Downs alone or in combination with Altman discloses every element of Claim 1, and Nelson discloses a sorbent having a composition comprising from about 1 to about 30 grams of the element bromine per 100 grams of activated carbon as specified 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 Downs Altman, and Nelson. If Claim 5 does not require addition of a promoted sorbent, the claim would have been obvious to a POSITA at the time of the invention in light of Downs and Altman for the reasons explained above in Paragraphs 322-325.

3. **Claim 8— “measuring mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content,**

an injection rate of injecting the sorbent comprising activated carbon into the mercury-containing gas,

an amount of the additive comprising the Br₂, HBr, bromide compound, or a combination thereof, added to the coal, or

a combination thereof.”

Claim 9—“wherein the measuring of the mercury content of the mercury-containing gas is performed substantially continuously”

Claim 10—“modifying, in response to a measured mercury content,

an injection rate of injecting the sorbent comprising activated carbon into the mercury-containing gas,

an amount of the Br₂, HBr, bromide compound, or a combination thereof, added to the coal, or

a combination thereof.”

Claim 18—“measuring mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content, an injection rate of injecting the sorbent comprising activated carbon into the mercury-containing gas.”

Claim 20—“measuring mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content, an amount of the additive comprising the

**Br₂, HBr, bromide compound, or a combination thereof,
added to the coal**

326. Claims 8-10, 18, and 20 generally require measuring the mercury content of the mercury-containing gas and modifying the injection rate of the activated carbon, the amount of the bromine promoter added to the coal, or a combination thereof.

327. 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.

328. 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.

329. 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.); 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.”).

330. 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.

331. Because Downs alone discloses every element of Claim 1, 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 bromine promoter added to the coal based on the measured mercury content (when necessary) as required by Claims 8-10, 18, and 20,

it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claims 8-10, 18, and 20 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 326-330.

4. **Claim 19—“wherein the mercury-containing gas comprises about 1 g to about 30 g of the element bromine per 100 g of the sorbent.”**

Claim 21—“wherein the sorbent in the mercury-containing gas comprises about 1 g to about 30 g of the added Br₂, HBr, the bromide compound, or a combination thereof, per 100 g of the sorbent.”

332. My review of the '517 Patent does not reveal that the applicants attributed any particular significance to the claimed ranges of Claims 19 or 21 or established that it achieves “unexpected results” in mercury removal. Rather, the range merely optimizes known “result-effective” variables (amount of bromine and the amount of activated carbon) that would have been obvious to a POSITA. A workable range is claimed for combining a conventional halogen (bromine) used in a conventional way (to promote a sorbent) with a conventional sorbent (activated carbon). My opinion is consistent with that expressed by the Patent Owner’s expert in the Delaware litigation. EX1083, 153 (ratio is “necessarily” present for '114 claim 4 accordingly to PO’s expert), 168, (applying same analysis for '517 claim 5),

170 (applying same analysis for '517 claims 19 and 21). *See* my analysis for claim 5, above.

333. Regarding claim 19, my review of the '517 Patent also does not reveal a disclosure of a mercury-containing gas comprising about 1 g to about 30 g of the element bromine per 100 g of the sorbent anywhere in the '517 Patent. It is the promoted sorbent (not the mercury-containing gas) that is described as comprising about 1-30g promoter per 100g base sorbent. EX1001, 3:24-26, 57-59; 4:46-51; 5:13-25; 11:8-10; 20:43-46; 24:62-64; 25:52-55; 26:5-7, 15-18, 34-35; 33:67-34:3.

5. Claim 23—“the sorbent injected into the mercury-containing gas is a sorbent obtained by contacting a base sorbent with a halogen or halide promoter prior to injection of the sorbent to the mercury-containing gas.”

334. 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.

335. 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 Br₂ or HBr gas “significantly increases the carbonaceous materials ability to remove mercury species.” EX1009, [0041].

336. 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.

337. Because Downs discloses every element of Claim 1, and Nelson teaches that the sorbent injected into the mercury-containing gas is a sorbent obtained by contacting a base sorbent with a halogen or halide promoter prior to injection of the sorbent to the mercury-containing gas as required by Claim 23, it is my opinion that, based on my 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 the combination of Downs, Altman, and Nelson for the reasons explained above in Paragraphs 334-336.

6. Independent Claim 30

338. Claim 30 is similar to Claim 29 discussed above, with the exception that Claim 30 further requires measuring the mercury content of the mercury containing gas and modifying the injection rate of the sorbent or the amount of Br₂, HBr, bromide compound added to the coal or the combustion chamber, or a combination thereof.

339. As explained above regarding Claims 1, 13, and 14, Downs discloses adding bromine reagents, such as in the form of sodium bromide, HBr, and/or Br₂, to the coal before combustion and/or to the furnace or boiler.

340. As explained above regarding Claim 20, Downs discloses monitoring of the mercury content of the flue gas and it would have been obvious to a POSITA to control the amount of bromine/and or sorbent fed based on those measurements.

341. As a result, and as explained in the paragraphs that follow, it is my opinion that, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, Claim 30 would have been obvious to a POSITA at the time of the invention in light of Downs combined with Altman and/or Nelson.

(a) Claim 30(preamble)–“A method of separating mercury from a mercury-containing gas, the method comprising:”

342. 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.

343. 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].

344. 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].

345. 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.

346. 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.

347. 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.

348. Nelson also discloses processes for removing/separating mercury from flue gas. EX1008, Abstract; EX1009, Field.

349. Downs, Altman, and Nelson, in my opinion, disclose the preamble of Claim 30 as these references describe multiple methods for reducing mercury in a mercury-containing gas, more specifically a flue gas at a coal burning power plant for the reasons explained above in Paragraphs 342-348. EX1004, [0001], [0004], [0007], [0015]-[0016], [0018], [0025], claims 15-16; EX1005, [0005], [0009], [0018-0019], [0021], [0028]; EX1007, Abstract, Claim 1; EX1008, Abstract; EX1009, Field.

(b) 30(a)–“combusting coal in a combustion chamber, to provide the mercury-containing gas, wherein the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br⁻, or a combination thereof,”

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

351. 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].

352. 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 (Br₂).” EX1004, [0021]; EX1005, [0024].

353. 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.

354. 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]. It follows that HBr and/or Br⁻ is in vapor or gaseous form in the flue gas after combustion of a bromide reagent such as calcium bromide or sodium bromide.

355. 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].

356. Regarding the requirement that the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br⁻, or a combination thereof in element 30(a), Julien discloses that when calcium bromide is added to a coal combustor, that “[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. Julien, in my opinion, evidences the knowledge of a POSITA that 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.

357. Downs, in my opinion, discloses combusting coal in a combustion chamber wherein the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br⁻, or a combination thereof for the reasons explained above in Paragraphs 350-356. EX1004, [0002], [007], [0011], [0015], [0018], Fig. 3, [0019], [0021]; EX1005, [0003], 0009], [0013], Fig. 3, [0022], [0024].

(c) 30(b)—“wherein the coal comprises added Br₂, HBr, bromide compound, or a combination thereof, added

to the coal before the coal enters the combustion chamber,

or the combustion chamber comprises added Br₂, HBr, bromide compound, or a combination thereof, or a combination thereof;”

358. 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].

359. 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].

360. 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].

361. 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 (Br₂).” EX1004, [0021]; EX1005, [0024].

362. Downs, in my opinion, discloses combusting coal in a combustion chamber, wherein the coal comprises added Br₂, HBr, bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber, or the combustion chamber comprises added Br₂, HBr, bromide compound, or a combination thereof for the reasons explained above in Paragraphs 358-361. EX1004, [0002], [007], [0011], [0015], [0018], Fig. 3, [0019], [0021]; EX1005, [0003], [0009], [0013], Fig. 3, [0022], [0024].

(d) 30(c)—“collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon;”

363. 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].

364. 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].

365. 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].

366. Altman describes activated carbon sorbent “injected into the flue gas” – either “injected into chamber 34” or into inlet duct 26 via line 41. EX1007, 4:53–61, Figure 2. Flue gas residence time within chamber 34 ranges from 1–20 seconds to “allow a large portion of the mercury in the flue gas to be removed by the injected sorbent.” EX1007, 5:6–12. Altman also injects lime sorbent particles into the flue gas in the emission control system such that both sorbents flow with the flue gas. EX1007, 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 1996 and in waste incinerators in 1995 and 1996. EX1007, 2:23–31, 1:41–2:22, 32–46.

367. Downs and Altman, in my opinion, discloses collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon for the reasons explained above in Paragraphs

363-267. EX1004, [0004], [0015]–[0016], [0025], claims 15–16; EX1005, [0005], [0018], [0028]; EX1007, 4:53–61, 5:6–12, 5:50–61, Figure 2.

(e) 30(d)–“separating the sorbent contacted with the mercury from the mercury-containing gas;”

368. Downs’ Figure 3 reports reducing vapor-phase mercury by 77% from 9 $\mu\text{g}/\text{dscm}$ mercury at FF-inlet to 2 $\mu\text{g}/\text{dscm}$ mercury at FF-outlet:

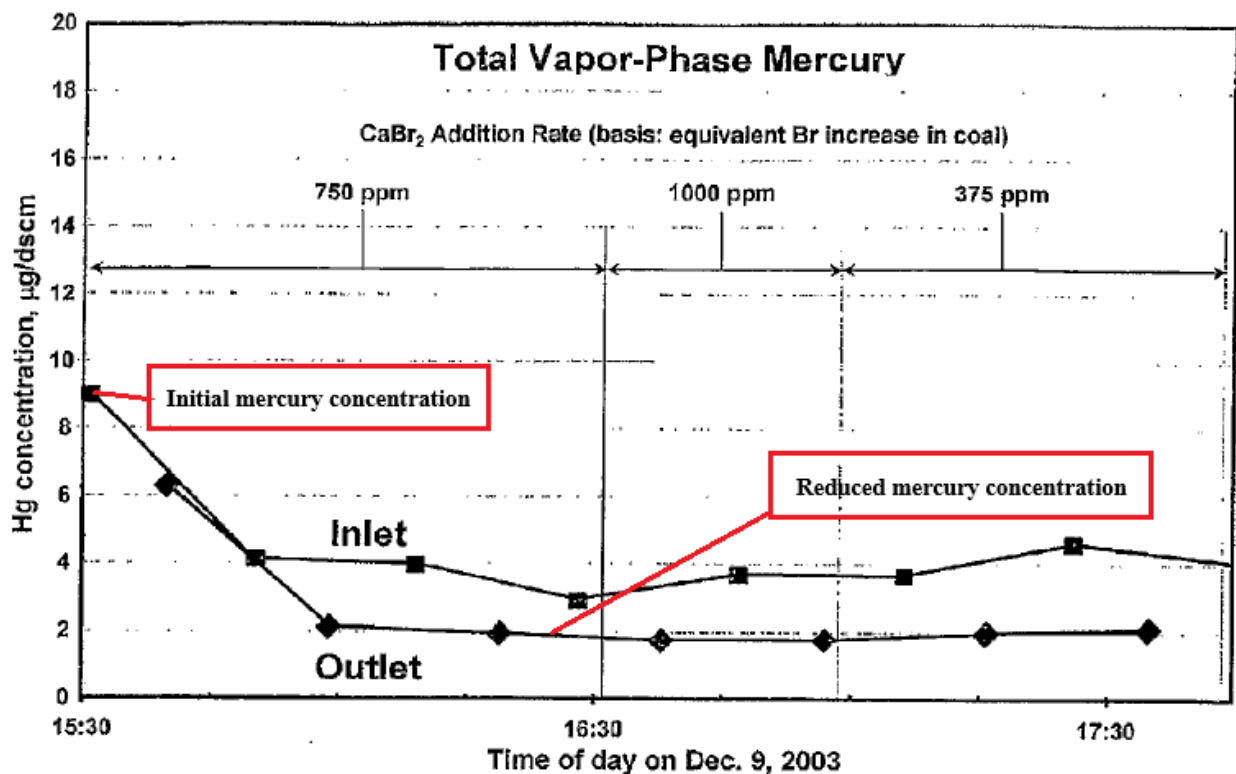


FIG. 3

EX1004, Figure 3, [0018]; EX1005, Figure 3, [0021].

369. Downs further explains that “[t]hese results identify that the current invention can offer a cost-effective method of removing elemental mercury from

coal combustion flue gases” and describes “an increased-fraction of particulate-bound mercury” that enhances removal across particulate collectors such as fabric filters and ESPs. EX1004, [0015], [0018]; EX1005, [0018], [0021].

370. Downs also 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].

371. Downs further discloses that the disclosed invention “enhances removal of mercury across particulate collectors 26 such as fabric filters (FF) and electrostatic precipitators (ESP).” EX1004, [0015]; EX1005, [0018]. A POSITA would know that the fabric filters and/or ESPs remove the sorbent that has collected the mercury from the mercury containing gas. That is, simply stated, the purpose of the activated carbon in such a system.

372. To this end, 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. 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.

373. Altman 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.

374. The ‘517 Patent itself also acknowledges that activated-carbon injection was well-known in the art. EX1001, 2:12-18, 7:48-55; 28:22-35.

375. Downs and Altman, in my opinion, discloses collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon and separating the sorbent contacted with the mercury from the mercury containing gas for the reasons explained above in Paragraphs 369-375. EX1004, Fig. 3, [0004], [0015]-[0016], [0018], [0019], [0025], Claims 15-16; EX1005, Fig. 3, [0005], [0018]-[0019], [0021], [0028]; EX1007, 2:23-31, 1:41-2:22, 32-46; 5:6-22, 41-49.

376. Nelson also describes injecting PAC into flue gas to remove elemental and oxidized mercury using an ESP. EX1008, [0040]; EX1009, 4. Thus, the combination of Downs, Altman, and Nelson also discloses this claim element.

(f) 30(e)–“measuring the mercury content of the mercury-containing gas; and”

30(f)–“modifying, in response to the measured mercury content of the mercury-containing gas, an injection rate of injecting the sorbent into the mercury-containing gas, an amount of the Br₂, HBr, bromide compound, or a combination thereof, added to the coal

or the combustion chamber, or a combination thereof.”

377. 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 and applied amounts of calcium bromide to the coal from 750 ppm to 1,000 ppm to 375 ppm in testing. EX1004, Figure 3; EX1005, Figure 3.

378. 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, 4:47-5:5. A POSITA would have considered it obvious to optimize Altman’s sorbent injection rate since the sorbent injection rate affects mercury removal from a flue gas. Adjusting sorbent injection rates based on measured mercury content of a flue gas was known to a POSITA by at least 1995, as evidenced by EX1080, Abstract (“By adjusting ... the absorbent a permanent high Hg removal is achieved.”), 6:42-46 (The amount of ... activated carbon ... 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.”)

379. A POSITA also 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 and would have been motivated to monitor the mercury content of the flue gas for this reason.

380. In my opinion, a POSITA would have considered it obvious to optimize the sorbent injection rate as shown by Altman 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.

381. Because the combination of Downs and Altman discloses every element of Claim 30, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 30 would have been obvious to a POSITA at the time of the invention in light of Downs combined with Altman or with Altman and Nelson for the reasons explained above in Paragraphs 378-381. EX1004, [0018], [0021]; EX1005, [0021], Fig. 3; EX1007, 4:47-5:5.

XIII. GROUND 3: CLAIMS 1–15 AND 17-30 ARE OBVIOUS OVER VOSTEEN AND ALTMAN OR VOSTEEN/ALTMAN AND NELSON

382. 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 1–15 and 17-30 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 1–15 and 17-30 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

383. 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.

384. Vosteen, Altman, and Nelson are analogous art to the ‘517 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 Br₂ or HBr gas “significantly increases the carbonaceous materials ability to remove mercury species.” EX1008, [0041]; EX1009, 4.

385. 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.*

386. 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.

387. 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.

388. 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 ‘517 Patent itself also acknowledges that activated-carbon injection was well-known in the art. EX1001, 2:12-18, 7:48-55; 28:22-35.

389. 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.

390. 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. 1(Preamble)–“A method for reducing mercury in a mercury-containing gas, the method comprising:”

391. 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.

392. 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.

393. 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.

394. 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.

395. Vosteen and Altman, in my opinion, each discloses the preamble of claim 1 as both references describe multiple methods for reducing mercury in a mercury-containing gas, more specifically a flue gas at a coal burning power plant for the reasons explained above in Paragraphs 392-394. EX1011, Abstract, Title; [0001]; [0007]–[0008], Claim 1; EX1007, Abstract, Claim 1.

2. 1(a)–“combusting coal in a combustion chamber, the coal comprising an additive comprising Br₂, HBr, a bromide

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

396. 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).

397. 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).

398. 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.

399. Vosteen and Altman, in my opinion, discloses combusting coal in a combustion chamber wherein the coal comprises an additive comprising Br₂, HBr, a bromide compound (e.g., NaBr), or a combination thereof, to form the mercury-containing gas for the reasons explained above in Paragraphs 397-399. EX1011, [0005], [0006], [0007], [0009], [0013], [0025], [0047], Example 5; EX1007, 3:41-44.

3. 1(b)–“collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon.”

400. 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].

401. 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.

402. 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 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.

403. 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 ‘517 Patent itself also acknowledges that activated-carbon injection as a sorbent was well-known in the art. EX1001, 2:12-18, 7:48-55; 28:22-35.

404. 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 ‘517 Patent for the reasons explained above in Paragraphs 401-404. EX1011, [0007], [0019], [0047]-[0049]; EX1007, 1:30-40, 4:53-61, 5:6-12, 50-61.

405. 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—“injecting an alkaline sorbent into the mercury-containing gas stream.”

Claim 3—“the alkaline sorbent is selected from the group consisting of 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 sorbent into the mercury containing gas stream as required by Claims 2 and 3, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claims 2 and 3 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 407-410. EX1011, [0019]; EX1007, 5:50–54; EX1008, [0064]; EX1009, 3.

2. Claim 4—“the activated carbon is chosen from powdered activated carbon, granular activated carbon, carbon black, carbon fiber, aerogel carbon, pyrolysis char, and combinations thereof.”

411. 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.

412. Altman similarly discloses that the activated carbon sorbents can be “particles.” Ex1007, 5:59-61. Nelson also describes its sorbent as PAC. EX1008, [0040]; EX1009, 4.

413. 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 4, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 4 would have been obvious to a POSITA at the time of the invention in light of Vosteen combined with Altman. Claim 4 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 412-413. Ex1007, 5:59-61; EX1011, [0019]; EX1008, [0040]; EX1009, 4.

3. Claim 5—“the sorbent has a composition comprising from about 1 to about 30 grams of the element bromine per 100 grams of activated carbon”

414. I have reviewed the ‘517 Patent and its file history. My review of the ‘517 Patent does not reveal that the applicants attributed any particular significance to the claimed range or established that it achieves “unexpected results” in mercury removal. Rather, the range merely optimizes known “result-effective” variables (amount of bromine and the amount of activated carbon) that would have been obvious to a POSITA.

415. Claim 5 depends from Claim 1. Claim element 1(b) requires “collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon.” Claim 5 requires that “the sorbent [of claim 1] has a composition comprising from about 1 to about 30 grams of the element bromine per 100 grams of activated carbon.” The plain language of Claim 5 thus requires that the “sorbent added to the mercury containing gas” have a “composition comprising from about 1 to about 30 grams of the element bromine per 100 grams of activated carbon.” It follows that the sorbent of claim 5 is a promoted sorbent.

416. Nelson discloses brominated PAC sorbents having 1, 5, 9, 15, and over 30 wt.% loading of HBr or Br₂ (i.e., 1, 5, 9, 15 or over 30g bromine to 100g PAC). EX1008, [0054], Example 6; EX1009, 5 (15 wt.% loading for 500-1000% increase in mercury capacity).

417. If my understanding of claim 5 is not correct, and Claim 5 does not require that “the sorbent” be a promoted sorbent, then a POSITA would have understood that bromine loaded onto activated carbon would be less than the 31-38g per 100g maximum. EX1050, 260. A POSITA had reason to load the activated carbon with bromine sufficiently to increase its ability to adsorb mercury given Altman’s emphasis on achieving optimal mercury sorption by ensuring sufficient activated carbon mercury adsorption capacity. EX1007, 4:66–5:5. EX1045, 2–3.

418. A POSITA also would have recognized that there would be sufficient bromine in the flue gas to provide a ratio of 1–30 g of bromine per 100 g of activated carbon. Indeed, I understand that Patent Owner’s expert in the Delaware lawsuit stated that “power plants employing bromine additives and activated carbon would necessarily produce a sorbent that is 1g to 30g bromine per 100g of activated carbon.” EX1083, 153.

419. As discussed above regarding Claim 1, the combination of Vosteen and Altman discloses a coal-fired power plant in which bromine additives are added to the combustion chamber and/or to the coal upstream of the combustion chamber and

activated carbon sorbents are injected into the flue gas to collect mercury from the flue gas.

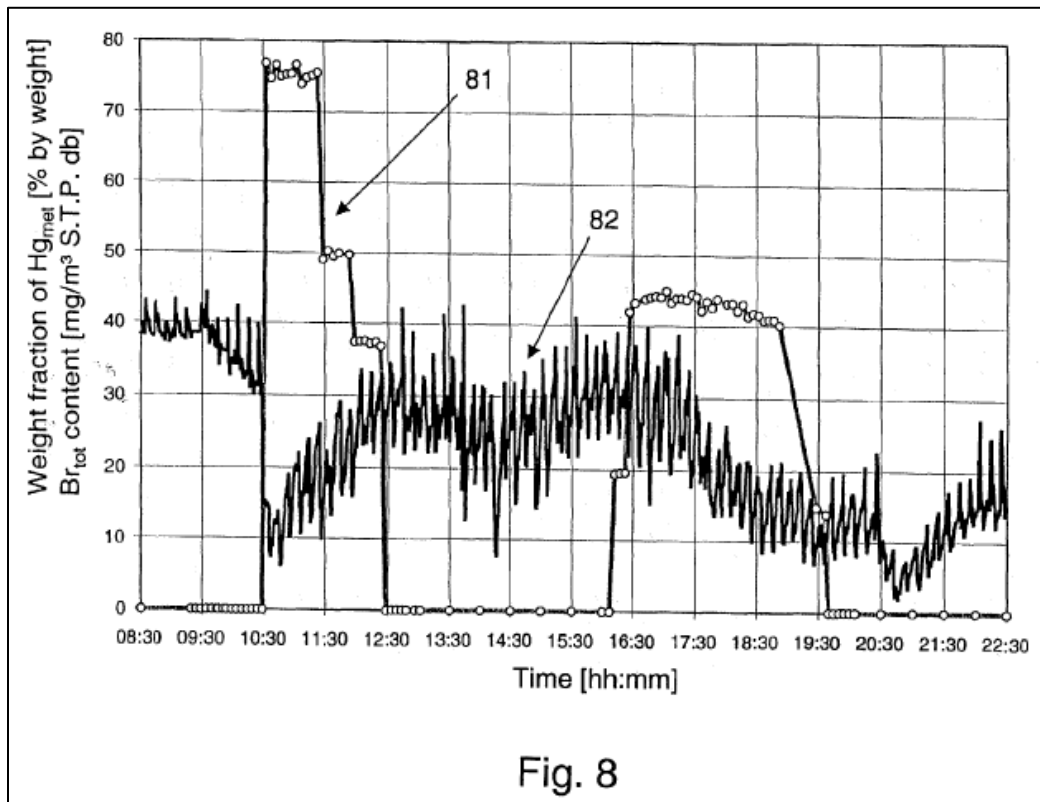
420. Because the combination of Vosteen and Altman discloses every element of Claim 1, and Nelson discloses a sorbent having a composition comprising from about 1 to about 30 grams of the element bromine per 100 grams of activated carbon as specified by Claim 5, it is my opinion, based on my education, 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, Altman, and Nelson. If Claim 5 does not require addition of a promoted sorbent, the claim would have been obvious to a POSITA at the time of the invention in light of Vosteen and Altman for the reasons explained above in Paragraphs 415-420.

4. Claim 6—“collecting greater than 70 wt % of the mercury in the mercury-containing gas”

Claim 7—“collecting greater than 70 wt % of the mercury in the mercury-containing gas with the sorbent”

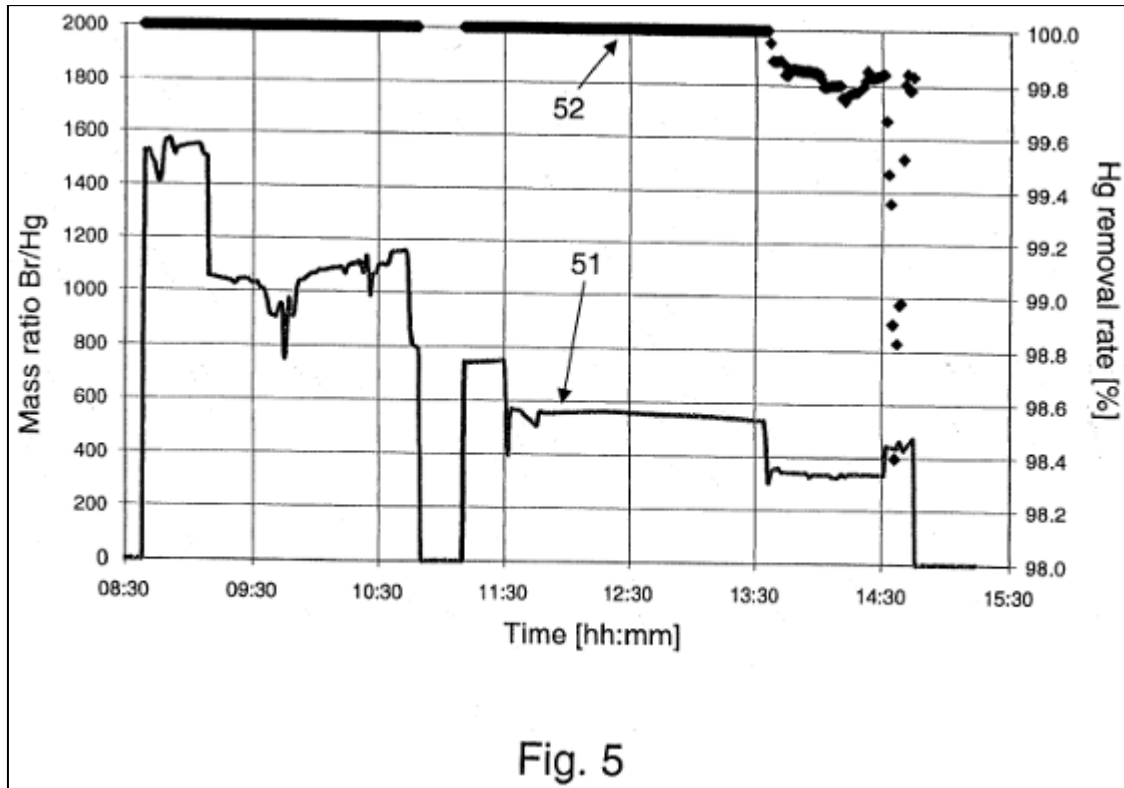
421. Vosteen discloses that “an object of the invention to provide a process for removing mercury, in particular for the substantially complete removal of mercury (Hg), from flue gases of high temperature processes.” EX1011, [0005].

422. 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].



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.

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



424. 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].

425. 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].

426. 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 ‘517 Patent itself also acknowledges that activated-carbon injection was well-known in the art. EX1001, 2:12-18, 7:48-55; 28:22-35.

427. 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.

428. 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.

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

430. 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."

431. 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 as required by Claims 6 and 7, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claims 6 and 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 Paragraphs 422-431. EX1011, [0002], [0005], [0015], [0037], [0042], [0049], Figs. 5, 8; EX1007, 2:14-22, 5:6-12.

5. **Claim 8**—“measuring mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content,

an injection rate of injecting the sorbent comprising activated carbon into the mercury-containing gas,

an amount of the additive comprising the Br₂, HBr, bromide compound, or a combination thereof, added to the coal, or

a combination thereof.”

Claim 9—“measuring of the mercury content of the mercury-containing gas is performed substantially continuously”

Claim 10—“modifying, in response to a measured mercury content, an injection rate of injecting the sorbent comprising activated carbon into the mercury-containing gas, an amount of the Br₂, HBr, bromide compound, or a combination thereof, added to the coal, or a combination thereof”

Claim 18—“measuring mercury content of the mercury-containing gas; and

modifying, in response to the measured mercury content, an injection rate of injecting the sorbent comprising activated carbon into the mercury-containing gas.”

Claim 20—“measuring mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content, an amount of the additive comprising the Br₂, HBr, bromide compound, or a combination thereof, added to the coal.”

432. Claims 8-10, 18, and 20 generally relate to measuring the mercury content of the mercury containing gas and adjusting the amount of bromine promotor

added to the coal and/or adjusting the injection rate of the sorbent in response to the measured mercury content.

433. 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.

434. 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**.

435. 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.

436. 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.

437. 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.); 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.").

438. 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.

439. Because Vosteen and Altman discloses every element of Claim 1, 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 promoter added to the coal based on the measured mercury content (when necessary) as required by Claims 8-10, 18, and 20, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claims 8-10, 18, and 20 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 433-439. EX1007, 4:47-5:5; EX1011, [0022], Claim 10; EX1080, Abstract, 6:42-46.

6. Claim 11—“the coal comprises a subbituminous coal”

440. 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/Nm³.” EX1008, [0081].

441. 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 11 would have been obvious to a POSITA at the time of the invention in light of Vosteen combined with Altman..

7. Claim 12—“the coal comprises a lignite coal”

442. 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].

443. 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 12, it is my opinion, based on my

education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 12 would have been obvious to a POSITA at the time of the invention in light of Vosteen combined with Altman.

8. Claim 13—“the coal comprises the added Br₂, HBr, the bromide compound, or a combination thereof added to the coal before the coal enters the combustion chamber.”

444. As discussed above for Claim element 1(a), Vosteen 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”. EX1011, [0013].

445. 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 upstream of the furnace, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 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 Paragraph 445. EX1011, [0013].

9. Claim 14—“the combustion chamber comprises the added Br₂, HBr, the bromide compound, or a combination thereof.”

446. Vosteen discloses that “[t]he addition of a bromine compound and if appropriate a sulphur 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].

447. 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].

448. 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 500° C., preferably at least 800° C. ...

449. 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 furnace as required by Claim 14, it is 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 for the reasons explained above in Paragraphs 447-449. EX1011, [0013], Claim 1.

10. Claim 15—“the coal is combusted in the combustion chamber at a coal-combustion facility, wherein the Br₂, HBr, bromide compound, or combination thereof, is added to the coal before the coal enters the combustion chamber, wherein the addition of the Br₂, HBr, bromide compound, or combination thereof, to the coal is performed at the coal-combustion facility”

450. 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 fired boiler [that “are charged with coal”] and a flue gas emission control system typical of a power station.” EX1011, [0045], [0047].

451. 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.

452. 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 at a coal-combustion facility as required by Claim 15, it is 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 Paragraphs 451-452. EX1011, [0013], [0045], [0047].

11. Claim 17—“the combustion chamber is an electric utility coal combustion chamber.”

453. 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.” EX1011, [0045]. A POSITA would have known that a “coal-fired power station” is an electric utility.

454. 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.

455. Because the combination of Vosteen and Altman discloses every element of Claim 1, and Vosteen and Altman specifically discloses that the coal-combustion facility is an electric utility as required by 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 454-455. EX1011, [0045]; EX1007, Cover, 3:41-44.

12. Claim 19—“wherein the mercury-containing gas comprises about 1 g to about 30 g of the element bromine per 100 g of the sorbent.”

Claim 21—“wherein the sorbent in the mercury-containing gas comprises about 1 g to about 30 g of the added Br₂, HBr, the bromide compound, or a combination thereof, per 100 g of the sorbent.”

456. My review of the ‘517 Patent does not reveal that the applicants attributed any particular significance to the claimed ranges of Claims 19 or 21 or established that it achieves “unexpected results” in mercury removal. Rather, the range merely optimizes known “result-effective” variables (amount of bromine and the amount of activated carbon) that would have been obvious to a POSITA. A workable range is claimed for combining a conventional halogen (bromine) used in a conventional way (to promote a sorbent) with a conventional sorbent (activated carbon). My opinion is consistent with that expressed by the Patent Owner’s expert

in the Delaware litigation. EX1083, 153 (ratio is “necessarily” present for ’114 claim 4 accordingly to PO’s expert), 168, (applying same analysis for ’517 claim 5), 170 (applying same analysis for ’517 claims 19 and 21). See my analysis for claim 5 above.

457. My review of the ’517 Patent also does not reveal a disclosure of a mercury-containing gas comprising about 1 g to about 30 g of the element bromine per 100 g of the sorbent anywhere in the ’517 Patent. The promoted sorbent (not the mercury-containing gas) is described as comprising about 1-30g promoter per 100g base sorbent. EX1001, 3:24-26, 57-59; 4:46-51; 5:13-25; 11:8-10; 20:43-46; 24:62-64; 25:52-55; 26:5-7, 15-18, 34-35; 33:67-34:3.

13. Claim 22—“the Br₂, HBr, or the bromide compound is contacted with the sorbent in vapor form, gaseous form, liquid form, or in an organic solvent.”

458. Vosteen describes that “addition of a bromine compound ... leads to a gas-phase reaction between mercury and bromine.” EX1011, [0010]. For the reasons I have previously explained, at least a portion of Vosteen’s NaBr added to the coal would have vaporized during combustion and reacted to form HBr in the flue gas. EX1016, 1658. It is therefore my opinion that HBr is contacted with sorbent in vapor form in the combination of Vosteen and Altman.

459. Because the combination of Vosteen and Altman discloses every element of Claim 1, and the bromine promoter used in Vosteen would have

vaporized during combustion and thus contacted the activated carbon sorbent of Altman in at least a vapor form as required by Claim 22, 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 combined with Altman.

14. Claim 23—“the sorbent injected into the mercury-containing gas is a sorbent obtained by contacting a base sorbent with a halogen or halide promoter prior to injection of the sorbent to the mercury-containing gas.”

460. 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.

461. 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 Br₂ or HBr gas “significantly increases the carbonaceous materials ability to remove mercury species.” EX1008, [0041]; EX1009, 4.

462. 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.

463. Because Vosteen combined with Altman discloses every element of Claim 1, and Nelson discloses the sorbent injected into the mercury-containing gas is a sorbent obtained by contacting a base sorbent with a halogen or halide promoter prior to injection 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 that Claims 23 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 461-463. EX1008, [0040]-[0041]; EX1009, 4.

15. Claim 24—“the sorbent injected into the mercury-containing gas is free of contact with a halogen or halide promoter prior to injection of the sorbent into the mercury-containing gas.”

464. 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.

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

466. 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-

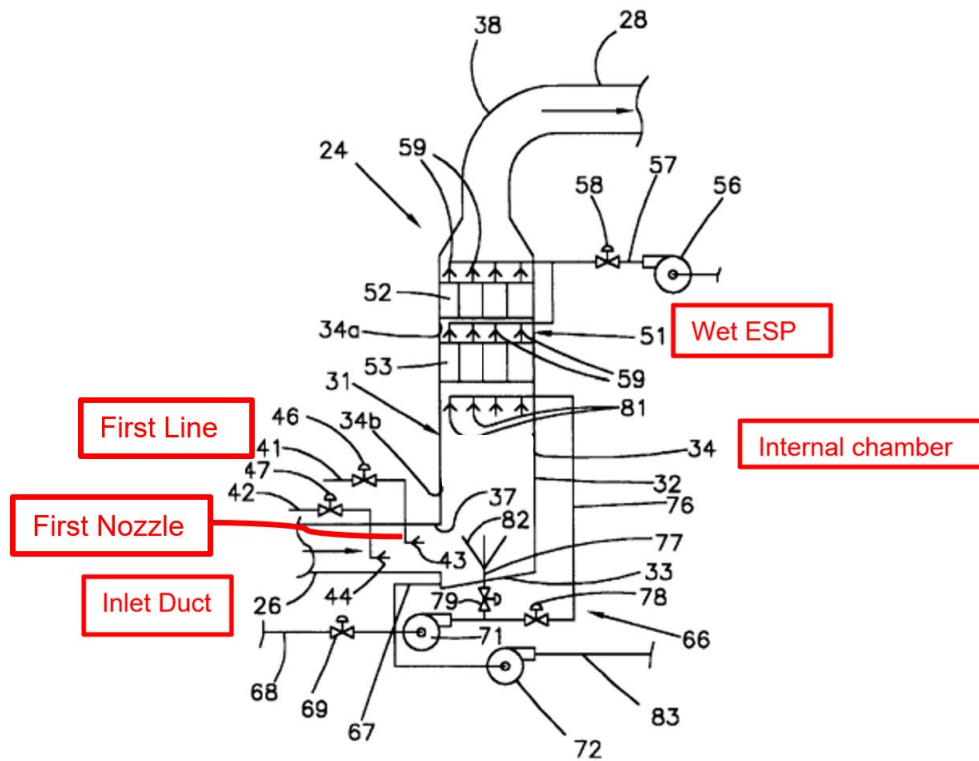
activated carbons especially where sufficient mercury removal can be achieved without resorting to halogen-activated carbons as in Vosteen and Altman.

467. 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 24, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 24 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 465-467.

16. Claim 25—“the injection of the sorbent into the mercury-containing gas occurs upstream of a particulate separator or a scrubber.”

468. 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].

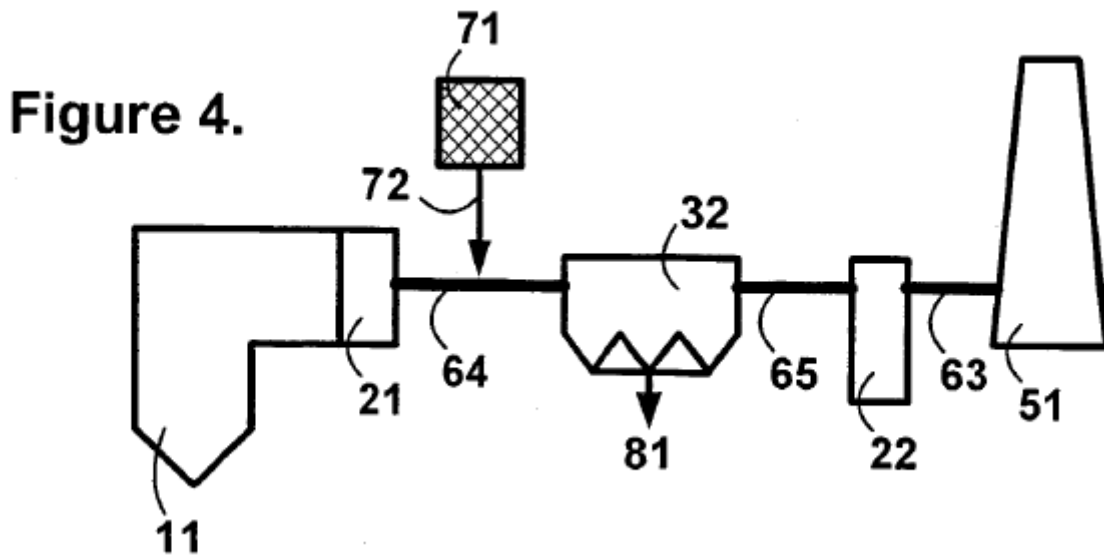
469. Altman’s Figure 2 depicts sorbent injection into duct 26 upstream of chamber 34 by means of first line 41 and first nozzle 43. Chamber 34 is upstream of wet electrostatic precipitator (ESP) 51, which is a “particulate control device” that collects sorbent.



EX1007, 4:17–21, 58–61; 5:27–29; Figure 2. An ESP is a particulate separator, as Claim 26 of the ‘517 Patent states that “the particulate separator comprises an electrostatic precipitator.”

470. Nelson describes injecting sorbent from bin 71 upstream of ESP 32.

EX1008, [0062], Figure 4.



471. Because the combination of Vosteen and Altman discloses every element of Claim 1, and both Vosteen and Altman disclose use of particular separators as required by Claim 25, 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. Claim 25 is also obvious in light of Vosteen combined with Altman and Nelson for the reasons explained above in Paragraphs 469-471. EX1011, [0017]; EX1007, 4:17-21, 58-61; 5:27-29; Figure 2; EX1008, [0062], Figure 4.

17. Claim 26—“the particulate separator comprises an electrostatic precipitator, a baghouse, a fabric filter, or a combination thereof.”

472. As discussed above regarding Claim 25, Vosteen, Altman and Nelson disclose the use of electrostatic precipitators (ESP).

473. Altman injects sorbent into tower 24 upstream of wet ESP 51. EX1007, Figure 2, 3:66–4:4, 17–20. Nelson describes injecting sorbent from bin 71 upstream of ESP 32. EX1008, [0062], Figure 4.

474. Because the combination of Vosteen and discloses every element of Claim 1, and Vosteen, Altman and Nelson disclose use of electrostatic precipitators 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 or Vosteen, Altman and Nelson for the reasons explained above in Paragraphs 473-474. EX1011, [0017] 473-474. EX1008, [0062], Fig. 4; EX1007, Fig. 2, 3:66-4:4, 17-20.

18. Claim 27—“the coal comprises added halide sorbent enhancement additive that comprises the added Br₂, HBr, the bromide compound, or combination thereof.”

475. 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].

476. 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.

477. 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 27, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 27 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 476-477. EX1011, [0007], [0013], [0047], Example 5.

19. Claim 28—“the sorbent enhancement additive comprises the bromide compound.”

478. Claim 28 depends from Claim 1 and requires that “the sorbent enhancement additive comprises the bromide compound.” I note that Claim 1 does not use the term “sorbent enhancement additive.”

479. The ‘517 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, 2:41-45.

480. Assuming for purposes of my analysis that the “sor bent enhancement additive” refers to the “additive comprising Br₂, HBr, a bromide compound, or a combination thereof” in element 1(a) of Claim 1, I further assume that Claim 28 is similar to Claim 27 and requires that the “additive” is further limited to a “bromide compound.” Vosteen discloses this limitation.

481. 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].

482. 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 28, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 28 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 479-482. EX1011, [0013].

D. Independent Claim 29

483. Claim 29 is similar to Claim 1 discussed above, with limited differences. The preamble of Claim 29 requires “separating” mercury from a

mercury-containing gas rather than “reducing mercury” in a mercury containing gas. Claim 29 further requires the addition of Br₂, HBr, bromide compound, or a combination thereof to the coal before the coal enters the combustion chamber or adding Br₂, HBr, bromide compound, or a combination thereof to the combustion chamber.

484. As explained above regarding Claims 1, 13, and 14, 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.

485. 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 29 would have been obvious to a POSITA at the time of the invention in light of Vosteen combined with Altman.

1. Claim 29(Preamble)–“A method of separating mercury from a mercury-containing gas, the method comprising:”

486. The preamble of Claim 29 is identical to the preamble of Claim 1 discussed above.

487. 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.

488. 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.

489. 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.

490. 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.

491. Vosteen and Altman, in my opinion, each discloses the preamble of Claim 29 as both references describe multiple methods for reducing mercury in a mercury-containing gas, more specifically a flue gas at a coal burning power plant for the reasons explained above in Paragraphs 487-491. EX1011, Abstract, Claim 1; EX1007, Abstract, Claim 1. This preamble is the same as Claim 1.

2. **29(a)–“combusting coal in a combustion chamber, wherein the coal comprises added Br₂, HBr, bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber, or the combustion chamber comprises added Br₂, HBr, bromide compound, or a combination thereof; and”**

492. 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.

493. 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).

494. 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].

495. 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].

496. 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 500° C., preferably at least 800° C. . . .

497. 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.

498. Vosteen, in my opinion, discloses combusting coal in a combustion chamber wherein the coal comprises an additive comprising Br₂, HBr, a bromide compound (NaBr), or a combination thereof and wherein the combustion chamber comprises added Br₂, HBr, bromide compound, or a combination thereof for the reasons explained above in Paragraphs 491-498. EX1011, [0005], [0006], [0007], [0009], [0013], [0025], [0047], Example 5; EX1007, 3:41-44.

3. 29(b) –“collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon.”

499. 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].

500. 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.

501. 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.

502. 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 ‘517 Patent itself also acknowledges that activated-carbon injection as a sorbent was well-known in the art. EX1001, 2:12-18, 7:48-55; 28:22-35.

503. 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 29 of the ‘517 Patent for the reasons explained above in Paragraphs 500-503. EX1011, [0007], [0019], [0047]-[0049]; EX1007, 1:30-40, 4:53-61, 5:6-12, 50-61.

504. It is therefore 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.

E. Independent Claim 30

505. Claim 30 is similar to Claim 29 discussed above, with the exception that Claim 30 further requires measuring the mercury content of the mercury containing gas and modifying the injection rate of the sorbent or the amount of Br₂, HBr, bromide compound added to the coal or the combustion chamber, or a combination thereof.

506. As explained above regarding Claims 1, 13, and 14, and in the paragraphs that follow, Vosteen discloses adding bromine, such as in the form of sodium bromide, to the coal before combustion and/or to the furnace or boiler.

507. As explained above regarding Claim 20, Vosteen discloses monitoring the mercury content of the flue gas and controlling the amount of bromine fed based on those measurements.

508. 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 30 would have been obvious to a POSITA at the time of the invention in light of Vosteen combined with Altman.

1. Claim 30(preamble)—“ 30. A method of separating mercury from a mercury-containing gas, the method comprising:”

509. As discussed above regarding Claims 1 and 29, Vosteen and Altman both disclose methods of separating mercury from a mercury containing gas.

510. 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.

511. 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.

512. 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.

513. 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.

514. Vosteen and Altman, in my opinion, each discloses the preamble of Claim 30 as both references describe multiple methods for reducing mercury in a mercury-containing gas, more specifically a flue gas at a coal burning power plant for the reasons explained above in Paragraphs 510-514. EX1011, Abstract, Claim 1; EX1007, Abstract, Claim 1. This preamble is the same as Claim 1 and Claim 29.

2. 30(a)–“combusting coal in a combustion chamber, to provide the mercury-containing gas, wherein the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br⁻, or a combination thereof,”

515. 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. Regarding the requirement that the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br⁻, or a combination thereof in element 30(a), Julien discloses that when calcium bromide is added to a coal combustor, that “[f]ree energy calculations

suggest that complete decomposition of CaBr_2 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. Julien, in my opinion, evidences the knowledge of a POSITA that 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.

516. 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).

517. Claim 1 of Vosteen similarly recites that the “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...” *Id.*, Claim 1.

518. 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.

519. Vosteen, in my opinion, discloses combusting coal to provide the mercury-containing gas, wherein the mercury-containing gas comprises a halogen

or halide like HBr, Br⁻, or a combination thereof for the reasons explained above in Paragraphs 516-519. EX1011, [0005], [0006], [0007], [0009], [0013], [0025], [0028], [0031], [0047], Example 5; EX1007, 3:41-44.

3. **30(b)–“wherein the coal comprises added Br₂, HBr, bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber, or the combustion chamber comprises added Br₂, HBr, bromide compound, or a combination thereof, or a combination thereof;”**

520. This claim element is similar to claim element 29(a) discussed above. Vosteen discloses this claim element.

521. 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.

522. 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).

523. 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].

524. 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].

525. 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 500° C., preferably at least 800° C. ...

526. Vosteen, in my opinion, discloses combusting coal in a combustion chamber wherein the coal comprises an additive comprising Br₂, HBr, a bromide compound (NaBr), or a combination thereof and/or wherein the combustion chamber comprises added Br₂, HBr, bromide compound, or a combination thereof for the

reasons explained above in Paragraphs 521-526. EX1011, [0007], [0013], [0047], Example 5, Claim 1.

4. 30(c)–“collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon”

527. 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.*

528. 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.

529. 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.

530. 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 ‘517 Patent itself also acknowledges that activated-carbon injection as a sorbent was well-known in the art. EX1001, 2:12-18, 7:48-55, 28:22-35.

531. 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 30(c) for the reasons stated above in Paragraphs 528-531. EX1011, [0007], [0019], [0047]-[0049]; EX1007, 1:30-40, 4:53-61, 5:6-12, 50-61.

5. 30(d)–“separating the sorbent contacted with the mercury from the mercury-containing gas;”

532. As described above for Claim 6, Vosteen discloses collecting greater than 70 wt % of the mercury in the mercury containing gas. Vosteen discloses “removal of mercury from the flue gases in a flue gas emission control system downstream of the combustion” EX1011, [0007]. A POSITA would have understood that Altman’s activated carbon sorbent in the combination with Vosteen would have collected the mercury from the flue gas.

533. 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. 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.

534. Altman 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 ‘517 Patent itself also acknowledges that activated-carbon injection was well-known in the art. EX1001, 2:12-18, 7:48-55; 28:22-35.

535. Vosteen and Altman, in my opinion, discloses collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon, and separating the sorbent contacted with the mercury from the mercury containing gas for the reasons stated above in Paragraphs 533-535. EX1011, [0007], [0019], [0047]-[0049]; EX1007, 1:30-40, 4:53-61, 5:6-12, 50-61.

6. **30(e)—“measuring the mercury content of the mercury-containing gas;” and**
- 30(f)—“modifying, in response to the measured mercury content of the mercury-containing gas,**
- an injection rate of injecting the sorbent into the mercury-containing gas,**
- an amount of the Br₂, HBr, bromide compound, or a combination thereof, added to the coal or the combustion chamber,**
- or a combination thereof.”**

536. As discussed above regarding Claims 8 and 9, Vosteen discloses these claim elements and they would have been obvious to a POSITA at the time of the invention.

537. Vosteen discloses that preferably “mercury content of the flue gas, in particular the content of metallic mercury, is measured continuously ... 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.

538. 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.

539. 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, 4:47-5:5.

540. 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.

541. 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.); 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.”).

542. 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, 4:47-5:5; EX1011, [22], Claim 10.

543. Because the combination of Vosteen and Altman discloses every element of Claim 30, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 30 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 537-543. EX1011, [0022], Claim 10; EX1007, 4:47-5:5.

XIV. GROUND 4 - CLAIMS 1, 4, 6–7, 11–15, 17 AND 22–29 ARE ANTICIPATED BY BLANKINSHIP

544. 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, 4, 6–7, 11–15, 17 and 22–29 are anticipated by Blankinship. In the subsections that follow, I explain the bases for my opinion that Claims 1, 4, 6–7, 11–15, 17 and 22–29 are anticipated by Blankinship.

A. Independent Claim 1

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

545. The title of Blankinship is “A Variety of Hg [Mercury] Capture Solutions Are Available.” EX1005. As Blankinship further explains, “coal plants in the United States emit about 50 tons of mercury per year.” *Id.*, 56.

546. 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.

547. 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.*

548. 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.

549. Blankinship, in my opinion, discloses the preamble of claim 1 as Blankinship describes multiple methods for reducing mercury in a mercury-containing gas, more specifically a flue gas at a coal burning power plant for the reasons explained above in Paragraphs 546-549. EX1005, 56, 58.

2. 1(a)–“combusting coal in a combustion chamber, the coal comprising an additive comprising Br₂, HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas”

550. 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 KNXTM 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.

551. Blankinship further discloses that Alstom’s KNXTM 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.

552. 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.

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

554. Blankinship, in my opinion, discloses combusting coal in a combustion chamber wherein the coal comprises an additive comprising Br₂, HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas for the reasons explained above in Paragraphs 551-553. EX1012, 56, 58.

3. 1(b)–“collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon.”

555. 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 '517 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.

'517 Patent, 7:56-64.

556. 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.

557. 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.*

558. 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 for collecting mercury from the flue gas.

559. Blankinship therefore, in my opinion, discloses methods for collecting mercury from the mercury containing flue gas wherein the sorbent is an activated carbon for the reasons explained above in Paragraphs 556-560.

560. As established above, Blankinship discloses every element of Claim 1 of the ‘517 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 4—“the activated carbon is chosen from powdered activated carbon, granular activated carbon, carbon black, carbon fiber, aerogel carbon, pyrolysis char, and combinations thereof.”**

561. Claim 4 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.

562. 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 KNXTM that uses calcium bromide.

563. 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.

564. Because Blankinship discloses every element of Claim 1 and at least one of the types of activated carbon required by Claim 4, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Blankinship anticipates Claim 4 for the reasons explained above in Paragraphs 562-564. EX1012, 56, 58.

2. Claims 6—“collecting greater than 70 wt % of the mercury in the mercury-containing gas”

565. Claim 6 specifies that the method of Claim 1 must collect greater than 70 wt % of the mercury in the mercury containing gas. Blankinship discloses this limitation as well.

566. 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.

567. 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.

568. Because Blankinship discloses every element of Claim 1 and that the mercury removal is greater than 70 wt % as required by Claim 6, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Blankinship anticipates Claim 6 for the reasons explained above in Paragraphs 566-568. EX1012, 56, 58.

3. Claim 7 – “ comprising collecting greater than 70 wt % of the mercury in the mercury-containing gas with the sorbent”

569. Claim 7 specifies that the collection of greater than 70 wt % of the mercury in the mercury-containing gas must be accomplished with the sorbent.

570. As discussed above, Blankinship discloses use of Alstom’s KNX™ product with the “Mer-Cure system further downstream to capture the mercury more efficiently.” As also discussed above, Mer-Cure is an “enhanced carbon injection system.”

571. As Blankinship teaches that such a system captures in excess of 70 wt % mercury in the flue gas, and that the 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.

572. Accordingly, because Blankinship discloses every element of Claim 1 and that the mercury removal is greater than 70 wt % using an activated carbon sorbent as required by Claim 7, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Blankinship anticipates Claim 7 for the reasons explained above in Paragraphs 570-572. EX1012, 56, 58.

4. Claim 11—“wherein the coal comprises a subbituminous coal”

573. Claim 11 requires that the coal combusted in the combustion chamber in Claim 1 is a subbituminous coal. This claim element is also disclosed by Blankinship.

574. 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.

575. 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 11 for the reasons explained above in Paragraphs 574-575.

5. Claim 12—“wherein the coal comprises a lignite coal”

576. While Claim 11 specifies that the coal is a subbituminous coal, Claim 12 specifies that the coal is a lignite coal. Blankinship discloses that the KNX system can be used with lignite coal.

577. More specifically, Blankinship discloses that Texas lignite has substantially higher mercury levels than other coals. *Id.*, 56.

578. Blankinship further discloses that “[l]ignite can be a good candidate for the [KNX] process as well.” *Id.*, 58.

579. 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 12 for the reasons explained above in Paragraphs 577-579.

6. Claim 13—“wherein the coal comprises the added Br₂, HBr, the bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber”

580. I discussed this claim element above regarding claim element 1(a). Blankinship discloses this claim element.

581. As discussed above regarding claim element 1(a), Blankinship discloses the application of “calcium bromide to the coal prior to combustion to promote mercury oxidation” as part of Alstom’s KNXTM process. EX1012, 56-58.

582. Because Blankinship discloses every element of Claim 1 and specifically teaches that the bromide is added to the coal before the coal enters the combustion chamber, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Blankinship anticipates Claim 13 for the reasons explained above in Paragraphs 581-582.

7. Claim 14—“the combustion chamber comprises the added Br₂, HBr, the bromide compound, or a combination thereof.”

583. Claim element 1(a) discussed above requires “combusting coal in a combustion chamber, the coal comprising an additive comprising Br₂, HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas”

584. Claim 14, however, depends from Claim 1 and requires that “the combustion chamber comprises the added Br₂, HBr, the bromide compound, or a combination thereof.”

585. As discussed above for Claim element 1(a), Blankinship discloses adding the KNX (calcium bromide) to the coal or to the boiler (i.e. combustion chamber). More specifically, Blankinship states that “[b]romide can be added to the boiler or to the coal to oxidize the mercury.” EX1012, 56.

586. Because Blankinship discloses every element of Claim 1 and specifically teaches that the bromide is added directly to the combustion chamber, it is 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 584-586. EX1012, 56, 58.

8. **Claim 15—“wherein the coal is combusted in the combustion chamber at a coal-combustion facility, wherein the Br₂, HBr, bromide compound, or combination thereof, is added to the coal before the coal enters the combustion chamber, wherein the addition of the Br₂, HBr, bromide compound, or combination thereof, to the coal is performed at the coal-combustion facility”**

587. 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.*

588. Blankinship also explains that Alstom’s KNXTM 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.

589. 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 15 for the reasons explained above in Paragraphs 588-589. EX1012, 56, 58.

9. Claim 17—“the combustion chamber is an electric utility coal combustion chamber.”

590. Claim 17 limits the combustion chamber of Claim 1 to an electric utility coal combustion chamber. Blankinship discusses the use of KNX and Mer-Cure in the context of “coal plants,” and more specifically at “power plants.” *Id.* at 56. The purpose per Blankinship is to reduce “mercury emissions from power plants and other industrial facilities.” *Id.*

591. Because Blankinship discloses every element of Claim 1 and specifically teaches that the KNX and Mer-Cure systems are used a coal power plants, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Blankinship anticipates Claim 17.

10. Claim 22—“the Br₂, HBr, or the bromide compound is contacted with the sorbent in vapor form, gaseous form, liquid form, or in an organic solvent.”

592. Blankinship explains that “Alstom’s KNX pre-combustion offering applies calcium bromide to the coal prior to combustion to promote mercury oxidation.” EX1012, 58.

593. Blankinship also explains that Alstom’s KNXTM 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

594. At least a portion of the Alstom KNX’s calcium bromide added to the coal would have vaporized during combustion and reacted to form HBr in the flue gas. EX1014, 1658. Julien discloses that when calcium bromide is added to a coal combustor, that “[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.

595. Blankinship discloses use of Alstom’s KNX product with the “Mer-Cure system further downstream to capture the mercury more efficiently.” As also discussed above, Mer-Cure is an “enhanced carbon injection system.” It is therefore

my opinion that HBr resulting from the vaporization of the calcium bromide is contacted with sorbent in vapor form in Blankinship.

596. Because Blankinship discloses every element of Claim 1 and because the vaporized HBr resulting from application of the KNX calcium bromide additive would contact the sorbent, 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 593-596. EX1012, 56, 58.

11. Claim 23—“the sorbent injected into the mercury-containing gas is a sorbent obtained by contacting a base sorbent with a halogen or halide promoter prior to injection of the sorbent to the mercury-containing gas.”

597. 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.

598. 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.

599. Because Blankinship discloses every element of Claim 1 and because the 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 23 for the reasons explained above in Paragraphs 598-599. EX1012, 56, 58.

12. Claim 24—“the sorbent injected into the mercury-containing gas is free of contact with a halogen or halide promoter prior to injection of the sorbent into the mercury-containing gas.”

600. Claim 24 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.

601. 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.

602. 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.

603. 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 24 for the reasons explained above in Paragraphs 601-603. EX1012, 56.

13. Claim 25—“the injection of the sorbent into the mercury-containing gas occurs upstream of a particulate separator or a scrubber.”

604. 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.

605. 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.*

606. 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.

607. Because Blankinship discloses every element of Claim 1 and further teaches that the Mer-Cure or other activated carbon 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 Blankinship anticipates Claim 25 for the reasons explained above in Paragraphs 605-607. EX102, 56, 58.

14. Claim 26—“the particulate separator comprises an electrostatic precipitator, a baghouse, a fabric filter, or a combination thereof.”

608. Claim 26 depends from Claim 25, which depends from Claim 1. Claim 26 requires simply that the particulate separator be an ESP, a baghouse, and/or a fabric filter. Blankinship discloses this claim element.

609. 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.” EX1012, 56. ESPs are also described as a primary target for Mer-Cure. *Id.*, 58

610. 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.*

611. Because Blankinship discloses every element of Claim 1 and Claim 25, and further teaches that the particulate separator 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 Claim 26 for the reasons explained above in Paragraphs 609-611. EX1012, 56, 58.

15. Claim 27—“the coal comprises added halide sorbent enhancement additive that comprises the added Br₂, HBr, the bromide compound, or combination thereof.”

612. 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.

613. 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.*

614. 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.*

615. 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.

616. 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 27 for the reasons explained above in Paragraphs 613-616. EX1012, 56, 58.

16. Claim 28—“the sorbent enhancement additive comprises the bromide compound.”

617. Claim 28 depends from Claim 1 and requires that “the sorbent enhancement additive comprises the bromide compound.” I note that Claim 1 does not use the term “sorbent enhancement additive.”

618. The ‘517 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, 2:41-45.

619. Assuming for purposes of my analysis that the “sorbent enhancement additive” refers to the “additive comprising Br₂, HBr, a bromide compound, or a combination thereof” in element 1(a) of Claim 1, I further assume that Claim 28 is

similar to Claim 27 and requires that the “additive” is further limited to a “bromide compound.” Blankinship discloses this claim element.

620. As discussed above regarding element 1(a) of Claim 1 as well as Claim 27, Blankinship discloses that “Alstom’s KNX process, for example, uses calcium bromide.” EX1012, 56. 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.

621. 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 bromide compound that performs as a sorbent enhancement additive.

622. Because Blankinship discloses every element of Claim 1, and further teaches that the bromine compound is added to the coal as a sorbent enhancement additive, 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 28 for the reasons explained above in Paragraphs 618-622.
EX1012, 56, 58.

C. Independent Claim 29

623. Claim 29 is similar to Claim 1 discussed above, with limited differences. The preamble of Claim 29 requires “separating” mercury from a mercury-containing gas rather than “reducing mercury” in a mercury containing gas. Claim 29 further requires the addition of Br₂, HBr, bromide compound, or a combination thereof to the coal before the coal enters the combustion chamber or adding Br₂, HBr, bromide compound, or a combination thereof to the combustion chamber.

624. As explained above regarding Claims 1, 13, and 14, 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.

625. As a result, 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 29.

1. Claim 29(Preamble)–“A method of separating mercury from a mercury-containing gas, the method comprising:”

626. The preamble of Claim 29 is identical to the preamble of Claim 1 discussed above.

627. 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.

628. 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.

629. 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.*

630. 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.

631. Blankinship, in my opinion, discloses the preamble of claim 29 as Blankinship describes multiple methods for reducing mercury in a mercury-containing gas, more specifically a flue gas at a coal burning power plant for the reasons explained above in Paragraphs 627-631. EX1012, 56, 58. This preamble is the same as Claim 1.

2. **29(a)–“combusting coal in a combustion chamber, wherein the coal comprises added Br₂, HBr, bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber,**
or the combustion chamber comprises added Br₂, HBr, bromide compound, or a combination thereof”

632. 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.

633. 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.

634. 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.”

635. 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.

636. 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 634-636. EX1012, 56-58.

3. 29(b) –“collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon.”

637. This claim element is identical to claim element 1(b) discussed above.

638. 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.

639. 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.*

640. 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.

641. Blankinship therefore, in my opinion, discloses methods for collecting mercury from the mercury containing flue gas wherein the sorbent is an activated carbon.

642. As established above, Blankinship discloses every element of Claim 29 of the '517 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 29 for the reasons explained above in Paragraphs 639-642. EX1012, 56, 58.

XV. GROUND 5: CLAIMS 1-15 AND 17-30 ARE OBVIOUS OVER BLANKINSHIP AND VOSTEEN, OR BLANKINSHIP, VOSTEEN AND OLSON-235

643. 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 1-15 and 17-30 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 1-15 and 17-30 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.

644. In my opinion, a POSITA would have been motivated 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.

645. Blankinship, Vosteen, and Olson-235 are analogous art to the '517 Patent in the same field of endeavor and reasonably pertinent to the problems the inventors faced.

646. 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.

647. 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.

648. 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.

649. 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 Br₂, 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].

650. 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.

651. Olson-235 also provides specific ranges for the ratio of halide promoters to sorbent. Olson-235 discloses promoted sorbents having from about 1 to about 30 grams of promoter per 100 grams of base sorbent. EX1013, 4:53-60. Olson-235 further discloses in-flight preparation of the sorbent by reacting a base sorbent such as activated carbon and a promoter. *Id.*, 5:43-48. For that in-flight promotion, the promoter is added at from about 1 to about 30 grams per 100 grams of the base sorbent. *Id.*, 6:17-31.

B. Claims 1, 4, 6-7, 11-17 and 22-29 Would Have Been Obvious in Light of the Combination of Blankinship and Vosteen, or Blankinship, Vosteen, and Olson-235.

652. For the reasons explained in Section XII above, it is my opinion that Blankinship anticipates Claims 1, 4, 6-7, 11-15, 17, and 22-29 of the '517 Patent.

653. 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.

654. 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, 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.

655. 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.

656. 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.*

657. 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.

Regarding claim elements 1(a) and 29(a) and claims 13-14, Vosteen adds Br₂, 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].

658. Regarding claim elements 1(b) and 29(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].

659. Regarding claim 4, Vosteen describes granulated or pulverant activated carbon in its flue gas emission control systems. EX1011, [0019].

660. Regarding claims 6 and 7, 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].

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."

661. Regarding claim 12, 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].

662. Regarding claim 15, 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] (emphasis added).

663. Regarding claim 17, Vosteen describes its "process for removing mercury from flue gases of ... power stations." EX1011, [0001], [0045].

664. Regarding claim 22, Vosteen describes that "addition of a bromine compound ... leads to a gas-phase reaction between mercury and bromine." EX1011, [0010]. At least a portion of Vosteen's NaBr added to the coal would have vaporized during combustion and reacted to form HBr in the flue gas. EX1014, 1658. Thus, HBr is contacted with Alstom's sorbent in vapor form. EX1048, 98:23–100:3, 231:3–9; EX1083 154, 170; EX1007, 6.

665. Regarding claim 23, 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.

666. Regarding claims 27 and 28, 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].

667. 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, 4, 6-7, 11-15, 17 and 22-29 would have been obvious to a POSITA prior to June 4, 2018 based on the combination of Blankinship and Vosteen or Blankinship, Vosteen, and Olson-235 for the reasons explained above in Paragraphs 653-667.

C. Claims 2-3, 5, 8-10, 18-21 and 30 Would Have Been Obvious in Light of the Combination of Blankinship and Vosteen, or Blankinship and Olson-235

668. It is also my opinion that Claims 2-3, 5, 8-10, 18-21, and 30 of the ‘517 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 2-3, 5, 8-10, 18-21 and 30 in the sections that follow.

1. **Claim 2—“injecting an alkaline sorbent into the mercury-containing gas stream.”**

Claim 3—“wherein the alkaline sorbent is selected from the group consisting of alkali elements, alkaline earth elements, alkali salts, alkaline earth salts, and combinations thereof.

669. Blankinship discloses that “mineral based non-carbon” sorbents “show some promise” and “are designed to be tolerant to higher temperatures.” EX1012, 58.

670. Vosteen discloses “finely pulverulent slaked lime/activated carbon.” or “lime” can be used in its flue gas emission control systems. EX1011, [0018]-[0019].

671. 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.

672. 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 Claims 2 and 3, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that

Claims 2 and 3 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 670-672. EX1012, 58; EX1011, [0018]-[0019].

2. Claim 5—“the sorbent has a composition comprising from about 1 to about 30 grams of the element bromine per 100 grams of activated carbon”

673. I have reviewed the ‘517 Patent and its file history. My review of the ‘517 Patent does not reveal that the applicants attributed any particular significance to the claimed range or established that it achieves “unexpected results” in mercury removal. Rather, the range merely optimizes known “result-effective” variables (amount of bromine and the amount of activated carbon) that would have been obvious to a POSITA.

674. Claim 5 depends from Claim 1. Claim element 1(b) requires “collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon.” Claim 5 requires that “the sorbent [of Claim 1] has a composition comprising from about 1 to about 30 grams of the element bromine per 100 grams of activated carbon.” The plain language of Claim 5 thus requires that the “sorbent added to the mercury containing gas” have a “composition comprising from about 1 to about 30 grams of the element bromine per 100 grams of activated carbon.” It follows that the sorbent added to the mercury-containing gas is a promoted sorbent.

675. Olson-235 discloses that the promoted sorbent “comprises from about 1 to about 30 grams of promoter per 100 grams of base sorbent.” EX1013, 4:53–60, Claims 3, 17. Olson-235 also 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. In that embodiment, “the promoter is added at from about 1 to about 30 grams per 100 grams of the base sorbent.” EX1013, 6:17–31.

676. Because Blankinship discloses every element of Claim 1, and Olson-235 discloses a sorbent having a composition comprising from about 1 to about 30 grams of the element bromine per 100 grams of activated carbon as specified 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 Blankinship and Olson-235 for the reasons explained above in Paragraphs 674-676. EX1012, 56, 58; EX1013, 4:53–60, 5:43–48, 6:17–31.

3. **Claim 8**—“measuring mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content,

an injection rate of injecting the sorbent comprising activated carbon into the mercury-containing gas,

an amount of the additive comprising the Br₂, HBr, bromide compound, or a combination thereof, added to the coal, or

a combination thereof.”

Claim 9—“measuring of the mercury content of the mercury-containing gas is performed substantially continuously”

Claim 10—“modifying, in response to a measured mercury content, an injection rate of injecting the sorbent comprising activated carbon into the mercury-containing gas, an amount of the Br₂, HBr, bromide compound, or a combination thereof, added to the coal, or a combination thereof”

Claim 18—“measuring mercury content of the mercury-containing gas; and

modifying, in response to the measured mercury content, an injection rate of injecting the sorbent comprising activated carbon into the mercury-containing gas.”

Claim 20—“measuring mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content, an amount of the additive comprising the

**Br₂, HBr, bromide compound, or a combination thereof,
added to the coal.”**

677. Claims 8-10, 18, and 20 all generally relate to the same concepts, namely monitoring the mercury content of the flue gas and modifying the injection rate of the sorbent and/or the addition rate of the bromine promoter.

678. 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.

679. 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.

680. 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.*

681. 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**.

682. 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.

683. 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 8-10, 18, and 20 would have been obvious to a POSITA at the time of the invention in light of Blankinship and Vosteen or Blankinship, Vosteen and Olson-235 for the reasons explained above in Paragraphs 678-683. EX1012, 56; EX1011, [0022], Claim 10, EX1013, 6:15-31, 20:1-11; 14:20-29.

4. **Claim 19—“wherein the mercury-containing gas comprises about 1 g to about 30 g of the element bromine per 100 g of the sorbent.”**

Claim 21—“wherein the sorbent in the mercury-containing gas comprises about 1 g to about 30 g of the added Br₂, HBr, the bromide compound, or a combination thereof, per 100 g of the sorbent.”

684. My review of the '517 Patent does not reveal that the applicants attributed any particular significance to the claimed ranges of Claims 19 or 21 or established that it achieves “unexpected results” in mercury removal. Rather, the range merely optimizes known “result-effective” variables (amount of bromine and the amount of activated carbon) that would have been obvious to a POSITA. EX1083, 153 (ratio is “necessarily” present for '114 claim 4 accordingly to PO's expert), 168, (applying same analysis for '517 claim 5), 170 (applying same analysis for '517 claims 19 and 21).

685. My review of the '517 Patent also does not reveal a disclosure of a mercury-containing gas comprising about 1 g to about 30 g of the element bromine per 100 g of the sorbent anywhere in the '517 Patent. The promoted sorbent (not the mercury-containing gas) is described as comprising about 1-30g promoter per 100g base sorbent. EX1001, 3:24-26, 57-59; 4:46-51; 5:13-25; 11:8-10; 20:43-46; 24:62-64; 25:52-55; 26:5-7, 15-18, 34-35; 33:67-34:3. *See also* my analysis of claim 5.

D. Independent Claim 30

686. Claim 30 is similar to Claim 29 discussed above, with the exception that Claim 30 further requires measuring the mercury content of the mercury containing gas and modifying the injection rate of the sorbent or the amount of Br₂, HBr, bromide compound added to the coal or the combustion chamber, or a combination thereof.

687. As explained above regarding Claims 1, 13, 14, and 29, and in the paragraphs that follow, Blankinship discloses adding calcium bromide (KNX) to the coal before combustion and/or to the furnace or boiler. Similarly, 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.

688. Blankinship and Vosteen also discloses the use of activated carbon as a sorbent.

689. As also explained above regarding Claims 8-10, 18, and 20, Blankinship and Vosteen each disclose monitoring the mercury content of the flue gas. Vosteen also discloses controlling the amount of bromine fed based on those mercury measurements.

690. 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 30 would have been obvious to a POSITA at the time of the invention in light of Blankinship and Vosteen.

1. Claim 30(preamble)–“ 30. A method of separating mercury from a mercury-containing gas, the method comprising:”

691. As discussed above regarding Claims 1 and 29, it is my opinion that Blankinship discloses the preamble. Vosteen also discloses methods of separating mercury from a mercury containing gas.

692. The title of Blankinship is “A Variety of Hg [Mercury] Capture Solutions Are Available.” EX1005.

693. 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.

694. 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.

695. Blankinship and Vosteen, in my opinion, each discloses the preamble of Claim 30 as each reference describes multiple methods for reducing mercury in a mercury-containing gas, more specifically a flue gas at a coal burning power plant for the reasons explained above in Paragraphs 692-695. EX1011, Abstract; EX1012, 56, 58. This preamble is the same as Claim 1.

2. **30(a)–“combusting coal in a combustion chamber, to provide the mercury-containing gas, wherein the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br⁻, or a combination thereof,”**

696. Blankinship further discloses that Alstom’s KNXTM 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.

697. 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.”

698. 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

699. 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. Vosteen discloses addition of a bromine, in forms such as HBr, Br₂, 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).

700. Regarding the requirement that the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br⁻, or a combination thereof in

element 30(a), Julien discloses that when calcium bromide is added to a coal combustor, that “[f]ree energy calculations suggest that complete decomposition of CaBr_2 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. Julien, in my opinion, evidences the knowledge of a POSITA that 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..

701. Blankinship and Vosteen, as evidenced by Julien. in my opinion, discloses combusting coal to provide the mercury-containing gas, wherein the mercury-containing gas comprises a halogen or halide like HBr , Br^- , or a combination thereof for the reasons explained above in Paragraphs 697-701. EX1011, [0005], [0006], [0007], [0009], [0013], [0025], [0047], Example 5; EX1007, 3:41-44; EX1012, 56, 58.

3. **30(b)–“wherein the coal comprises added Br_2 , HBr , bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber, or

the combustion chamber comprises added Br_2 , HBr , bromide compound, or a combination thereof, or

a combination thereof;”**

702. Blankinship discloses that Alstom’s KNX^{TM} 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.

Blankinship thus discloses that the bromine additive can both be added to the coal before the coal enters the combustion chamber and to the combustion chamber. 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.

703. 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

704. Vosteen also discloses addition of a bromine additive, 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.

705. 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).

706. 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].

707. 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 500° C., preferably at least 800° C. ...

708. Blankinship and Vosteen, in my opinion, each discloses combusting coal in a combustion chamber wherein the coal comprises an additive comprising Br₂, HBr, a bromide compound (CaBr₂ or NaBr), or a combination thereof and/or wherein the combustion chamber comprises added Br₂, HBr, bromide compound, or a combination thereof for the reasons explained above in Paragraphs 703-708. EX1011, [0006], [0007], [0013], [0047], Example 5; EX1012, 56, 58.

4. 30(c)–“collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon”

709. The '517 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.

'517 Patent, 7:56-64.

710. 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.

711. 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.

712. Vosteen discloses a “dry emission control system” as part of the “flue gas emission control system,” and that the dry emission control system works “based on the adsorption of ionic mercury compounds.” EX1011, [0018]-[0019]. The mercury/sorbent composition is separated from the flue gas in an ESP. EX1011, [0019], [0047]–[0049]. Vosteen discloses that an example of the sorbent is “finely pulverulent slaked lime/activated carbon.” *Id.* Vosteen does not disclose the specific details, however, of how to implement such a “dry emission control system.”

713. Blankinship and Vosteen, in my opinion, each discloses collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon for the reasons explained above in Paragraphs 710-713. EX1011, [0018], [0019], [0047]–[0049]; EX1012, 56, 58.

5. 30(d)–“separating the sorbent contacted with the mercury from the mercury-containing gas;”

714. Blankinship describes Alstom’s KNX 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.” EX1012, 58.

715. 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.*

716. 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].

717. 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].

718. The ‘517 Patent itself also acknowledges that activated-carbon injection was well-known in the art. EX1001, 2:12-18, 7:48-55; 28:22-35.

719. Blankinship and Vosteen, in my opinion, each discloses collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon, and separating the sorbent contacted with the mercury from the mercury containing gas for the reasons explained above in Paragraphs 715-719. EX1012, 56, 58; EX1011, [0005], [0049], Fig. 8.

6. **30(e)—“measuring the mercury content of the mercury-containing gas;” and**
- 30(f)—“modifying, in response to the measured mercury content of the mercury-containing gas,**
- an injection rate of injecting the sorbent into the mercury-containing gas,**
- an amount of the Br₂, HBr, bromide compound, or a combination thereof, added to the coal or the combustion chamber,**
- or a combination thereof.”**

720. These elements of Claim 30 are similar to Claims 8-10, 18, and 20 discussed above. Claim elements 30(e) and 30(f) are generally directed to monitoring the mercury content of the flue gas and modifying the amount of bromine promoter added to the coal or combustion chamber and/or the injection rate of the sorbent. Because these latter elements regarding the amount of bromine and the injection rate of the sorbent are presented as alternatives, it is my understanding that only one need be present in the combination of Blankinship and Vosteen.

721. 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.

722. Blankinship discusses “measuring vapor phase mercury” as “[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.

723. 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.*

724. Claim 10 of Vosteen also discloses these claim elements:

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**.

725. Because the combination of Blankinship and Vosteen discloses every element of Claim 30, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 30 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 721-726. EX1011, [0022], Claim 10; EX1012, 56, 58.

XVI. SECONDARY CONSIDERATIONS – SIMULTANEOUS INVENTION

726. I understand that the Patent Owner has asserted that the ‘517 Patent is generally directed to a straight-forward, two-step process: (1) apply a halogen, and more specifically bromine, to the coal; and (2) injecting activated carbon into the flue gas as a sorbent.

727. As I explained above, it is my opinion that the claims of the ‘517 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.

728. 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 Hg⁰ to the more easily removed Hg²⁺ forms and by enhancing the reactivity of Hg⁰ with activated carbons”). EX1053, 2–3.

729. 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.

730. 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.

731. Numerous researchers, many acting under Department of Energy funded contracts, had developed, tested, and implemented the same two-step process generally claimed in the '517 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.

732. 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.

733. 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 727-733.

XVII. CONCLUSION

734. The findings and opinion set forth in this declaration are based on my work and examinations to date.

735. 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.

736. 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-

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examination in the case and that cross-examination will take place in the United States.

737. 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 6th day of June, 2025.

Radisav Vidic

Radisav Vidic, Ph.D.