

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

UNION ELECTRIC COMPANY,
Petitioner,

v.

BIRCHTECH CORPORATION,
Patent Owner.

Case: IPR2025-01324
Patent 10,933,370

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. 10,933,370. 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. 10,933,370 (“ 370 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	File History for United States Patent No. 10,933,370 (U.S. Application No. 15/951,970) (“the ‘970 Application”)
1026	Reserved

Exhibit No.	Exhibit Description
1027	Reserved
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	Reserved
1036	Reserved
1037	US Patent Publication No. US 2018/0280870A1 (“Olson-870”)
1038	Institution Decision, IPR2020–00832, Patent 10,343,114 (“832 DI”)
1039	Institution Decision, IPR2020–00834, Patent 10,343,114 (“834 DI”)
1040	Oxtoby et al., PRINCIPLES OF MODERN CHEMISTRY, 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”)
1042	Babcock & Wilcox, STEAM: ITS GENERATION AND USE, 40th ed. (The Babcock & Wilcox Company: 1992) (“B&W: Steam”)
1043	U.S. EPA, AP–42: External Combustion Sources, Chapter 1: Fifth Edition, Volume I (Sep. 1998), available at https://www3.epa.gov/ttn/chief/ap42/ch01/index.html (last visited Apr 10, 2020) (“Chapter 1 of AP–42”)

Exhibit No.	Exhibit Description
1044	Thomas J. Feeley, et al., “A Review of DOE/NETL’s Mercury Control Technology R&D Program for Coal-Fired Power Plants,” <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 ”)
1053	Charlene R. Crocker et al., “Mercury Control with the Advanced Hybrid Particulate Collector Technical Progress Report,” U.S. DOE–NETL (Nov. 2003) (“ Crocker ”)
1054	C. Eckberg et al., “Mercury Control Evaluation of Halogen Injection into a Texas Lignite-Fired Boiler,” Track A, Session A3 (Mercury – Control), Presentation A3c, EUEC: 8TH ELECTRIC UTILITIES

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

Exhibit No.	Exhibit Description
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.
1074	Change, R and Offen, G, “Mercury Emission Control Technologies: An EPRI Synopsis,” Power Engineering, Vol. 99, No. 11, pp. 51-57, 1995.

Exhibit No.	Exhibit Description
1075	Liu, W., Vidic, R.D., Brown, T.D. “Optimization of high temperature sulfur impregnation in activated carbon for permanent sequestration of mercury,” <i>Environmental Science Technology</i> , 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,” <i>Environmental Science Technology</i> , 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,” <i>Industrial Engineering Chemistry Research</i> , 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,” <i>Atmospheric Environment</i> , 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,” <i>Fuel</i> 79 (2000) 903–921.
1086	U.S. Patent Application Publication No. US 2011/025011 A1 (Oct. 13, 2011) (“ Pollack ”)

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 ‘370 Patent are entitled to a priority date of August 2004 or April 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 ‘370 Patent (Claims 1-6, 8, 11, 14 and 15) would have been anticipated or obvious to a POSITA at the time of the invention. My conclusions are summarized in the following chart:

Ground	Claim(s)	Basis for Unpatentability
1	1-6, 8, 11, 14-15	Obvious over Downs and Nelson, or Downs, Altman and Nelson**
2	1-6, 8, 11, 14-15	Obvious over Vosteen and Nelson, or Vosteen, Altman and Nelson**
3	1-6, 8, 11, 14-15	Anticipated by Pollack
4	1-6, 8, 11, 14-15	Obvious over Pollack, Pollack and Olson-235, or Pollack and Nelson

**as evidenced by Julien for claim 6

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 April 12, 2018 filing date of the '370 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.

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

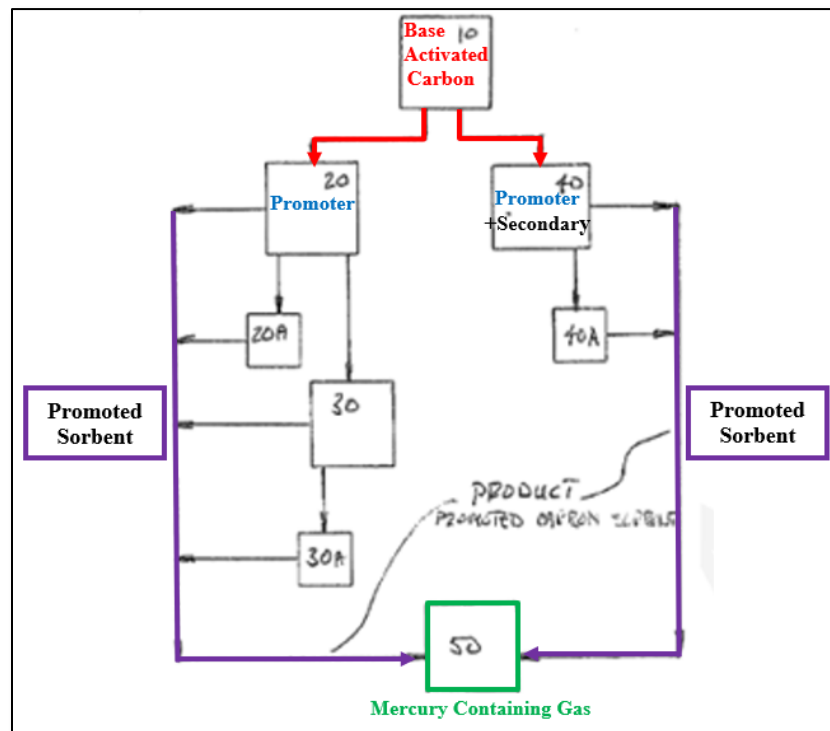
33. As of the ‘370 Patent’s earliest claimed priority date (August 2004), a POSITA would have had at least a bachelor’s degree in chemical engineering, mechanical engineering, environmental engineering, or a related field of study. A POSITA would also have at least two years’ experience investigating, 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.

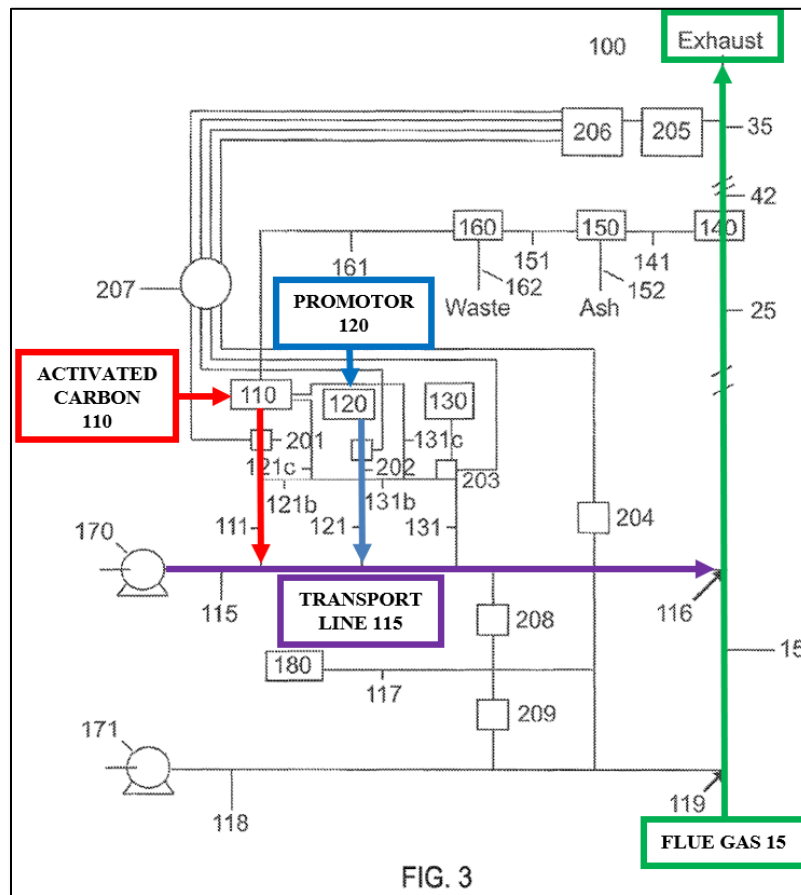
VI. THE ‘370 PATENT AND THE CHALLENGED CLAIMS

A. The ‘370 Patent

34. The ‘370 Patent is titled “Sorbents for the Oxidation and Removal of Mercury” and relates to removal of mercury from a flue gas. EX1001, 1: 40–44. The ‘370 Patent acknowledges that known “mercury control methods” included “injection of fine sorbent particles into a flue gas duct” such as “activated carbon.” EX1001, 2:5–11.

35. The '370 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. Independent Claim 1 of the '370 Patent requires both (1) adding an additive chosen from halide, halogen, salt thereof or combination thereof (*e.g.*, Br₂, HBr, sodium bromide, calcium bromide, or a combination thereof) to coal and/or the combustion chamber and (2) adding activated carbon sorbent into the mercury-containing gas. EX1001, Claim 1. Claim 1 also requires a weight ratio of the additive added to the coal or the combustion chamber to the sorbent added to the mercury-containing gas to be from about 1:100 to about 30:100. There is no support for adding a promoter to coal, much less adding these two limitations of Claim 1 of

the '370 Patent or the claimed weight ratio in the application as filed or in any of its priority applications.

37. Figure 1 of the '370 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:

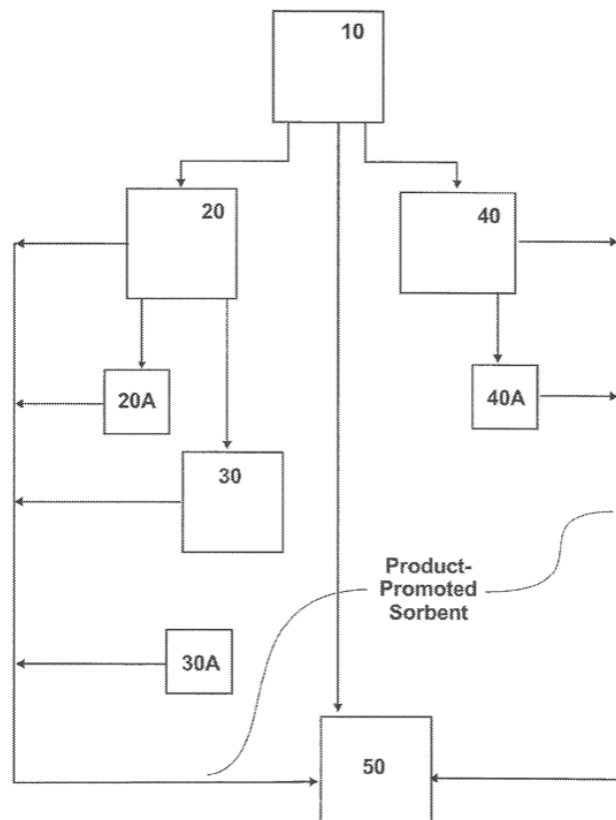
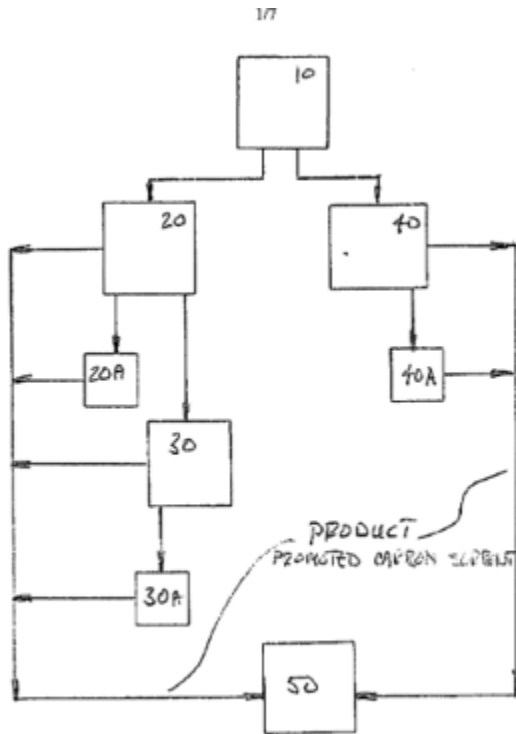


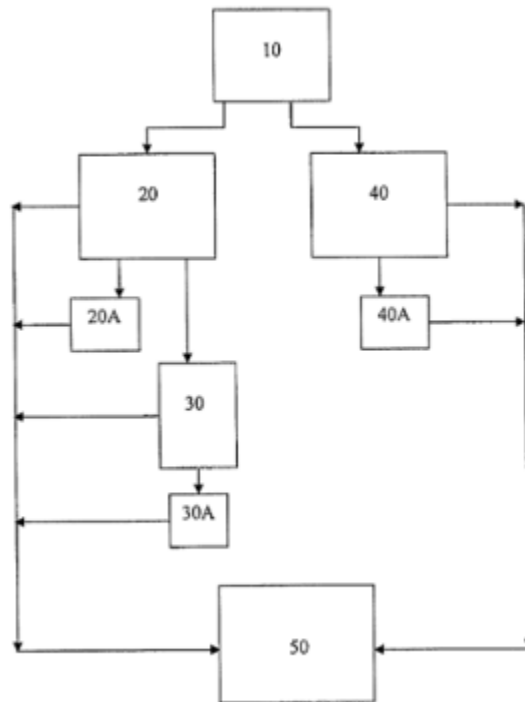
FIG. 1

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



'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 '370 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)	1. A method for separating mercury from a mercury-containing gas, the method comprising:
1(a)	combusting a mixture of coal and an additive in a combustion chamber, to form the mercury-containing gas, wherein the additive is chosen from halides, halogens, salts thereof, and combinations thereof;
1(b)	adding a particulate sorbent material comprising activated carbon into the mercury-containing gas,
1(c)	wherein a weight ratio of the additive added to the coal, added to the combustion chamber, or a combination thereof, to an amount of the sorbent material added to the mercury-containing gas is from about 1:100 to about 30:100;
1(d)	contacting mercury in the mercury-containing gas with the sorbent material, to form a mercury-sorbent; and
1(e)	separating the mercury-sorbent from the mercury-containing gas.
2	2. The method of claim 1, further comprising adding the additive to the coal before combusting the coal.
3	3. The method of claim 2, wherein the additive mixed with the coal is in a liquid.
4	4. The method of claim 3, wherein the liquid is a hydrocarbon, supercritical carbon dioxide, water, salt solution, or a combination thereof.
5	5. The method of claim 1, wherein carbocations in the activated carbon of the mercury-sorbent accept electrons from mercury atoms of the mercury-sorbent.
6	6. The method of claim 1, wherein the additive is substantially in vapor form in the mercury-containing gas.
8	8. The method of claim 1, wherein the additive is chosen from Br ₂ , HBr, sodium bromide, calcium bromide, and a combination thereof.
11	11. The method of claim 1, wherein the activated carbon is chosen from powdered activated carbon, granular activated

Claim Element	Claim Language
	carbon, carbon black, carbon fiber, aerogel carbon, pyrolysis char, and combinations thereof.
14	14. The method of claim 1, further comprising contacting the sorbent material with a secondary component chosen from halogens, hydrogen halides, Group V halides, Group VI halides, and combinations thereof.
15	15. The method of claim 14, wherein the secondary component is chosen from halogens, halide salts, HI, HBr, HCl, and combinations thereof.

VII. TECHNOLOGY BACKGROUND

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

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

B. EPA Regulations and Rulemaking

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

C. Mercury Control Technologies

43. Mercury emissions from CFPP occur in either elemental/metallic (Hg^0) or oxidized (either Hg^+ (mercurous) or Hg^{2+} (mercuric)) form. Most of the oxidized mercury forms can be removed by the existing air pollution control devices. Wet scrubbers are effective in this process because of the high solubility of oxidized mercury (EX1069) while fabric filters provide the additional contact time for oxidation and capture of mercury onto the fly ash. Mercury chlorination is the dominant mechanism responsible for the conversion of elemental mercury to its oxidized form in CFPP (EX1070). Review of ICR data on mercury capture in boiler and existing control devices indicate that the level of mercury oxidation at the exit of the boiler increased for higher coal chlorine content and lower exit temperatures. Therefore, the initial efforts in controlling mercury emissions from CFPP were

focused on affecting enhanced oxidation of mercury through the addition of chlorine compounds to the combustion process. However, the kinetics of mercury oxidation by chlorine-containing species in the CFPP are kinetically limited (EX1072, EX1073) and adding these species will not be of much benefit in the field.

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

D. Enhancement of Activated Carbon for Mercury Uptake

45. Even before the EPA regulations, activated-carbon sorbents were used to remove mercury by adsorption, and researchers were investigating improving their effectiveness and cost. EX1001, 1:55-60; EX1046, 2-54 to 2-57; EX1040, 1.

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

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

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

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

49. Halogens were known as Group VII elements, which include fluorine (F), chlorine (Cl), bromine (Br), and iodine (I), and that are highly reactive oxidizing agents that cause other species to give up electrons (become more positively charged). EX1040, 788, 791, A.44. It was known that halogens exist in nature as diatomic molecules (e.g., Br₂), halides/halide compounds (e.g., NaBr, CaBr₂), and hydrohalides (e.g., HBr).

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

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

52. It was known that halogens, particularly bromine-containing species, were effective at improving effectiveness of activated carbon in removing mercury. See, e.g., EX1004; EX1012; EX1008; EX1066. By 2003, bromine was known to be

more than 25 times more effective for metallic mercury oxidation than chlorine in coal combustion. EX1056, 3. In addition to using halides, it was also known that adjusting the sorbent injection rate would control mercury emissions. EX1058, 14; EX1059; EX1060, 4676.

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

54. The ‘370 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.

‘370 Patent, 7:49-57.

55. The ‘370 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.

‘370 Patent, 9:24-28.

56. The '370 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." '370 Patent, 30:27-36.

VIII. THE PRIORITY DATE OF THE '370 PATENT

57. I have been asked to review the '370 Patent, the '370 Patent file history of prosecution of the application for the '370 Patent before the U.S. Patent and Trademark Office, and the earlier filed applications to which the '370 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.

58. 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.

59. 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 '370 Patent or the earlier-filed applications. More specifically, limitations of independent Claim 1 requiring that the coal and/or the combustion chamber comprises an additive chosen from halides, halogens, salts thereof, and combinations thereof and the weight ratio of additive added to the coal

or combustion chamber to sorbent added to the mercury-containing gas are not disclosed in those applications.

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

A. File History of the ‘370 Patent and its Predecessors

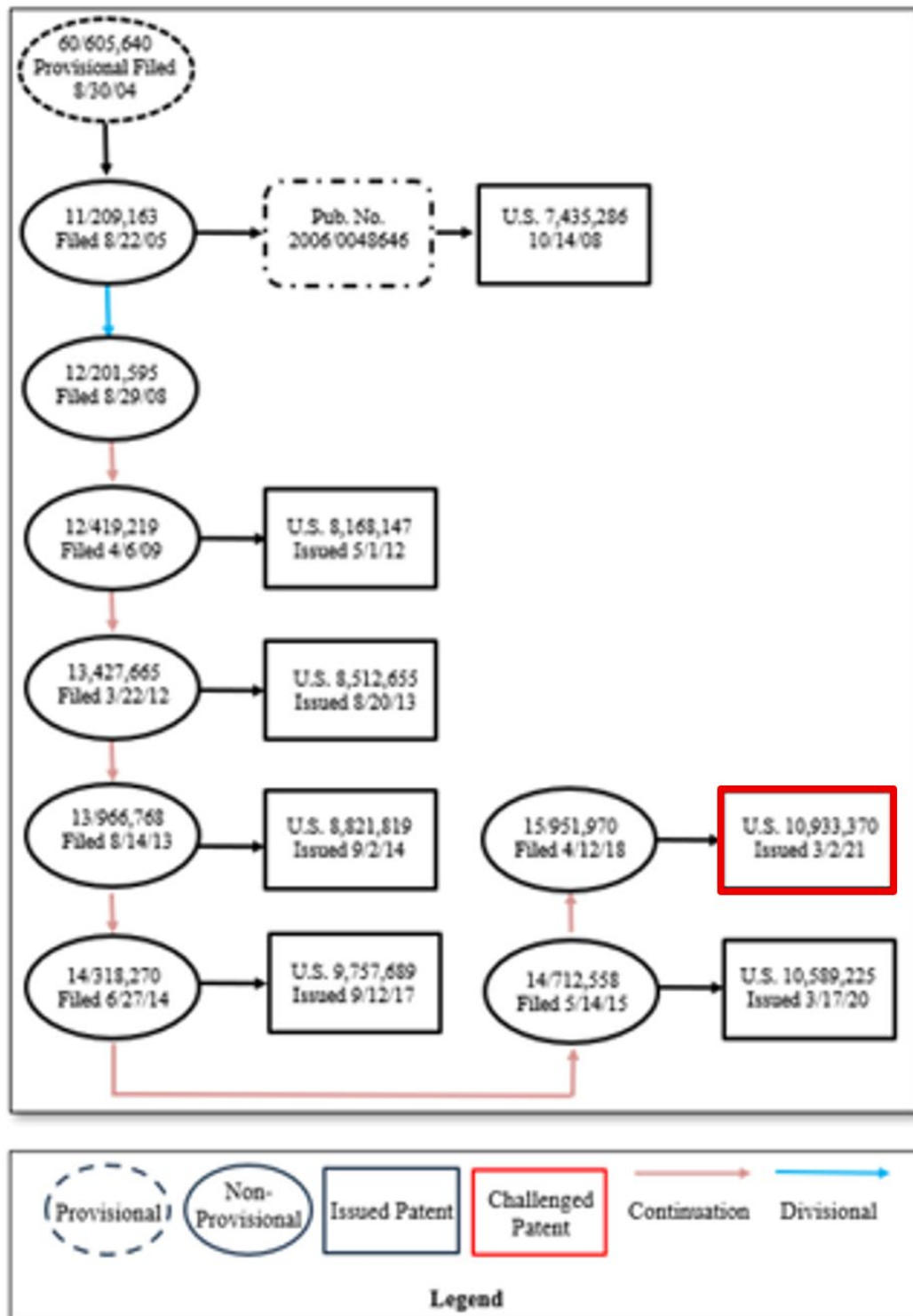
61. I understand that the application that issued as the ‘370 Patent was filed on April 12, 2018 and that the ‘370 patent purports to claim priority as follows:

- 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:
- 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, 1:7–23.

62. The alleged priority chain for the ‘370 Patent is depicted in the following image:



B. The '970 Application Does Not Disclose Br₂, HBr, Bromide Compound, or a Combination Thereof as a Coal Additive or the Claimed Weight Ratio

63. I have reviewed the '970 Application, which I understand is the application that issued as the '370 Patent. In the '970 Application, "coal" is generally described as a fossil fuel (EX1025, 2:1-2)¹ in examples where subbituminous, lignite or pulverized coal is introduced to a combustor (EX1025, 27:1-5, 26-29; 28:2-5; 32:6-8, 13-14). Other references to "coal" in the '970 Application refer to coal combustion facilities or coal combustion flue gas (EX1025, 2:9-16; 9:17-18; 17:24-26; 35:1-3). None of these disclosures of "coal" in the '970 Application describe halide or halogen promoter compounds such as Br₂, HBr, sodium bromide, calcium bromide, or a combination thereof being added to coal.

64. An "additive" in the '970 Application is generally described as "sorbent enhancement additives" (EX1025, 3:13-16), "optional additives discussed herein" (EX1025, 10:8-11), "additive to a treatment facility" (EX1025, 20:30-31) and "additive-sorbent ratios" (EX1025, 21:6-9). Again, none of these disclosures describe a promoter or additive being added to coal, nor the specific addition of Br₂, HBr, sodium bromide, calcium bromide, or a combination to coal.

¹ References to the '970 Application (EX1025) in this section of my Declaration refer to the page:line numbers of the "Specification" as filed on April 12, 2018 and included in EX1025 at AMEREN UE Exhibit pages 10-70. Page numbers greater than 70 refer to those assigned in the exhibit as filed (Ameren UE Exhibit page numbers).

65. Page 23 of the '970 Application states that several examples are presented to "more clearly illustrate the present invention." EX1025, 23:6-10. Examples 1-9 generally discuss ways in which a promoted sorbent is created. In Examples 1 and 6, certain promoted sorbents were created and tested by injecting them into a mercury-containing gas. EX1025, 23:12-25:17; 26:29-30:11. 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 halide or halogen promoter compounds such as Br₂, HBr, sodium bromide, calcium bromide, or a combination thereof to coal.

66. The '970 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)." EX1025, 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.

67. 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 a halide or halogen such as Br₂, HBr, sodium bromide, calcium bromide, or a combination thereof.

68. 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 ‘970 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.”

69. 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*

EX1025, 14:3-5. 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.

70. Examples 11A and 11B involve adding an "Optional Alkaline Component." EX1025, 32:26-34:11. 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.

71. The final example, Example 12, involved "Brominated Carbon Sorbent for Gasification Fuel Gas." EX1025, 34:13-36:9. No coal was used in this example.

72. The '970 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 '970 Application as disclosing only the combustion of untreated coal.

73. The '970 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 '970 Application indicates that:

- Molecular bromine (Br_2) 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.” EX1025, 46:1-4, 17:19-21.
- 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. EX1025, 46:4-7, 17:21-24.
- A halide (e.g., a hydrohalide such as HBr) is “very much less reactive” than molecular halogen (e.g., Br_2) and “cannot therefore oxidize anything by itself.” EX1025, 46:8-12, 17:28-30.
- In the Provisional disclosure recited in the ‘970 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.” EX1025, 46:12-14. This Provisional disclosure was changed over time in the ‘970 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.” EX1025, 18:1-2.

74. 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 ‘370 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 ‘370 Patent, not coal to which a halide or halogen such as HBr, Br₂, sodium bromide, calcium bromide, or a combination thereof is added.

75. 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, sodium bromide, calcium bromide, 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 ‘370 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.

76. As the '370 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." EX1025, 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.

77. Regarding the claimed weight ratio, Claim 1 of the '370 patent requires "a weight ratio of the additive added to the coal, added to the combustion chamber, or a combination thereof, to an amount of the sorbent material added to the mercury-containing gas is from about 1:100 to about 30:100." My review of the '970 Application does not reveal a disclosure of this ratio anywhere in the '970 Application for the '370 Patent. It is the promoted sorbent (not the amount of additive added to the coal or combustion chamber relative to the amount of the sorbent added to the flue gas) that is described as comprising about 1-30g promoter per 100g base sorbent. EX1025, 4:19-23; 5:14-15; 6:22-26; 7:14-24; 16:28-30; 31:30-32:2; EX1001, 3:21-23, 54-56; 4:42-47; 5:6-20; 11:1-3; 20:34-37.

78. Based on my review of the '370 Patent and the '970 Application, as well as my education, skill, training, and experience in the relevant fields of emission reduction technology, it is my opinion that the '970 Application does not disclose a

promoter added to coal or the claimed weight ratio as required by Claim 1 of the '370 Patent for the reasons explained in Paragraphs 63-77 above.

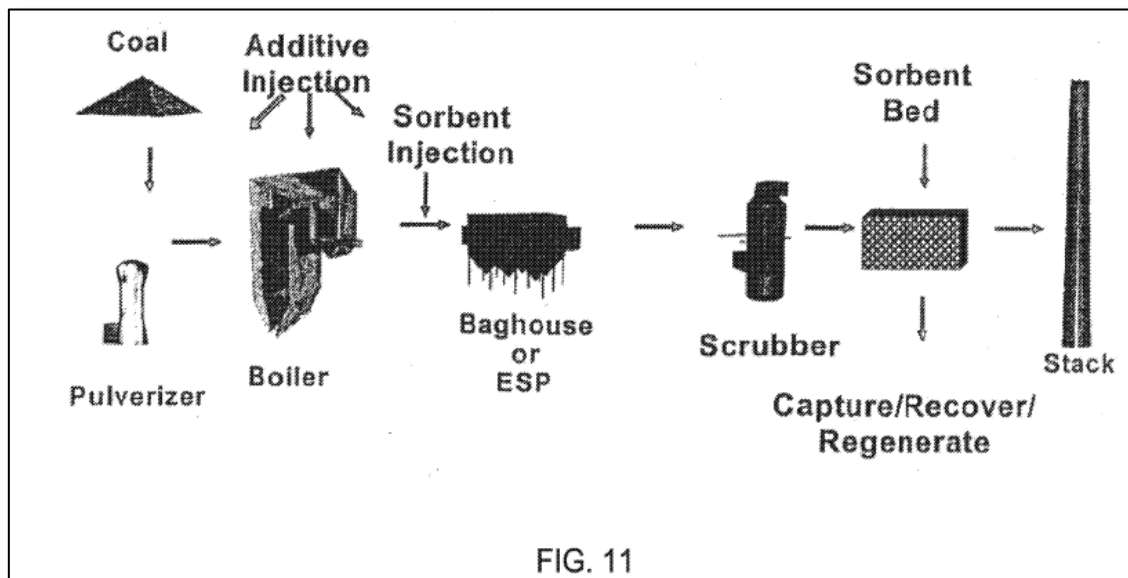
C. The Provisional, Which Was Copied into the '970 Application, Does Not Disclose Br₂, HBr, Bromide Compound, or a Combination Thereof as a Coal Additive or the Claimed Weight Ratio

79. The '970 Application copies the entire disclosure of its earliest priority the Provisional into the specification. EX1001, 24:8–35:46. The Provisional section mentions mercury removal from “coal-fired utility or synthesis gas” (EX1025, 44:1-3; EX1017, 6), mercury within coal (EX1025, 44:17-20, 26-27; EX1017, 6), coal combustion flue gas (EX1025, 46:1-4; EX1017, 7), and a facility fired with lignite coal (EX1025, 54:9-10; EX1017, 14). None of these disclosures describe promoter compounds added to coal.

80. The Provisional disclosure includes Figure 2, which is reproduced below as Figure 11 in the '970 Application, showing a “coal fueled facility” burning “pulverized coal” where “additive can be injected where desired (e.g., before, after or within the boiler).” EX1025, 52:6-14, Figure 11; EX1017, 12, Figure 2.

81. 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.



82. 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.

83. 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.” EX1025, 38:15; EX1017, 2. There are 15 such examples in the Provisional. None of these examples discloses

applying Br_2 , HBr, a bromide compound, or a combination thereof as an “additive” to coal.

84. Provisional Examples 1–4 disclose a modified carbon sorbent prepared by reacting carbon with a Br_2 solution, a Br_2 gas, an HBr solution or an HBr gas. EX1025, 38:18-25; 40:14-18; 40:28-41:3; 41:9-13; EX1017, 2–3. Provisional Examples 5 and 6 further include a sulfur or selenium reagent when preparing the promoted sorbent. EX1025, 41:17-25; EX1017, 4. Example 7 treats “carbon with a Group V or VI element combined with Group VII element, such as PBr_3 .” EX1025, 41:27-31; EX1017, 4.

85. In sum, Provisional Examples 1-7 disclose methods of preparing a promoted sorbent by reacting a carbon sorbent with Br_2 , HBr or PBr_3 . None of these examples disclose applying Br_2 , HBr or PBr_3 as an “additive” to coal. These Examples do not disclose applying the promoted sorbent to coal or applying a halide or halogen promoter such as Br_2 , HBr, sodium bromide, calcium bromide, or a combination thereof to coal.

86. The Provisional also explains that Examples 1-3 may include an “additional promoting substance” in the Br_2 solution, Br_2 gas, or HBr solution used in preparing the promoted sorbent. EX1025, 38:22-23; 40:5-12, 25-26; 41:6-7; EX1017, 2-3. The Provisional explains that this additional promoter can be HBr. EX1025, 40:8; EX1017, 3.

87. 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.

88. I note that my analysis and conclusion mirrors the position taken by the applicants during prosecution of the ‘370 Patent. 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.” EX1025, 472, ¶ 17.

89. Provisional Example 8 describes injecting the promoted sorbents of Provisional Examples 1-6 into a contaminated gas stream. EX1025, 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.” EX1025, 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.”

90. “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.” EX1025, 52:12-13, Figure 11; EX1017, 12, Figure 2.

91. The only other mentions of “additive” in the Provisional do not identify what the “additive” is, either. EX1025, 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”).

92. Regarding the claimed weight ratio, Claim 1 of the ‘370 patent requires “a weight ratio of the additive added to the coal, added to the combustion chamber, or a combination thereof, to an amount of the sorbent material added to the mercury-containing gas is from about 1:100 to about 30:100.” My review of the Provisional does not reveal a disclosure of this ratio anywhere in the Provisional. It is the promoted sorbent (not the amount of additive added to the coal or combustion chamber relative to the amount of the sorbent added to the flue gas) that is described as comprising about 1-30g promoter per 100g base sorbent. EX1025, 38:23-25; 40:16-18; 41:1-3, 11-13, 28-29; 54:6-8; EX1017, 2-4, 14; EX1001, 24:55-57; 25:45-48, 64-67; 26:8-11, 26-28; 33:56-59.

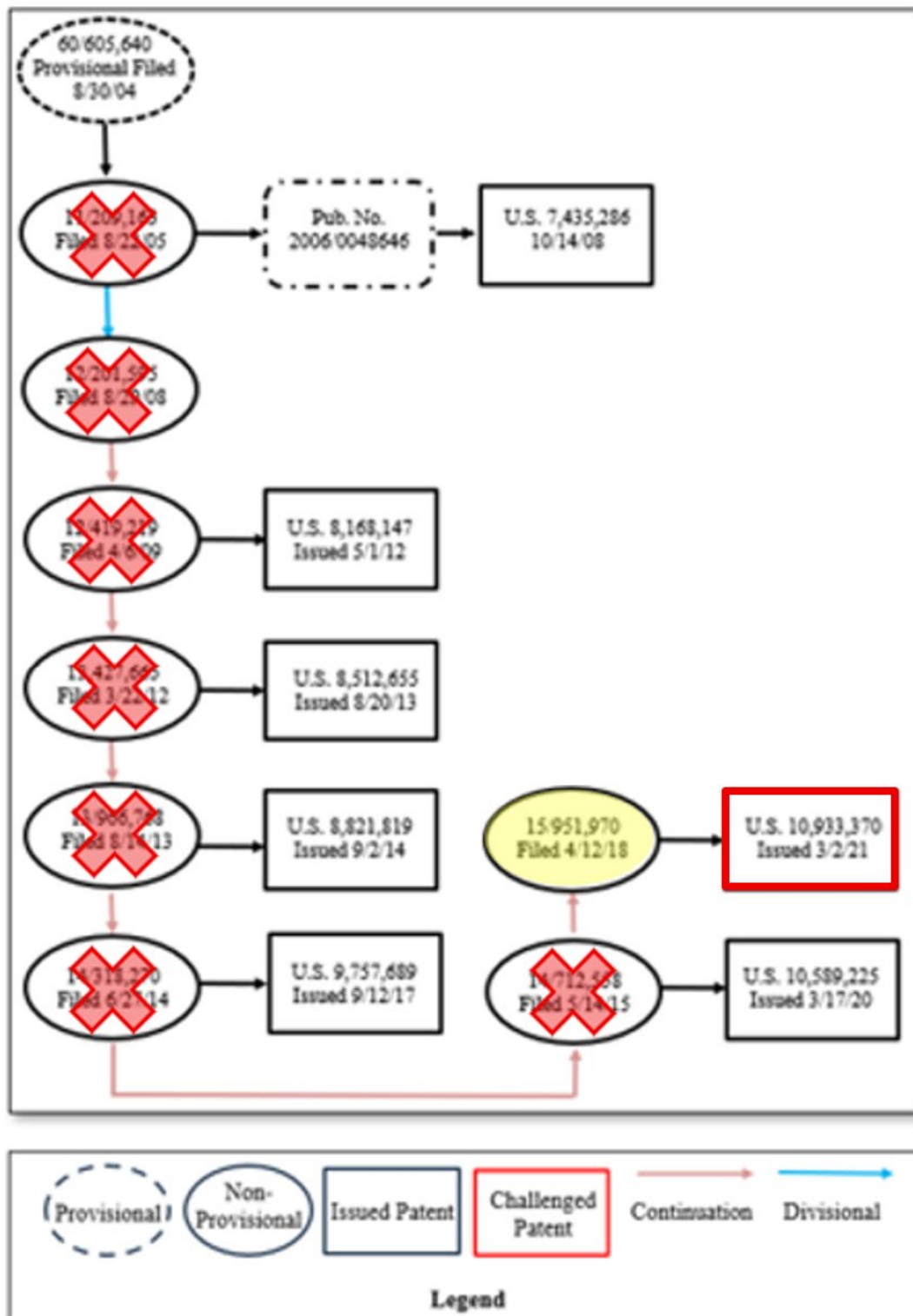
93. Based on my review of the Provisional, as well as my education, skill, training, and experience in the relevant fields of emission reduction technology, it is my opinion that the Provisional does not disclose halide or halogen promoter compounds such as Br₂, HBr, sodium bromide, calcium bromide, or a combination

thereof being added to coal or a combustor (and thus combusting a mixture of coal and a promoter) for the reasons explained in Paragraphs 79-92. 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.

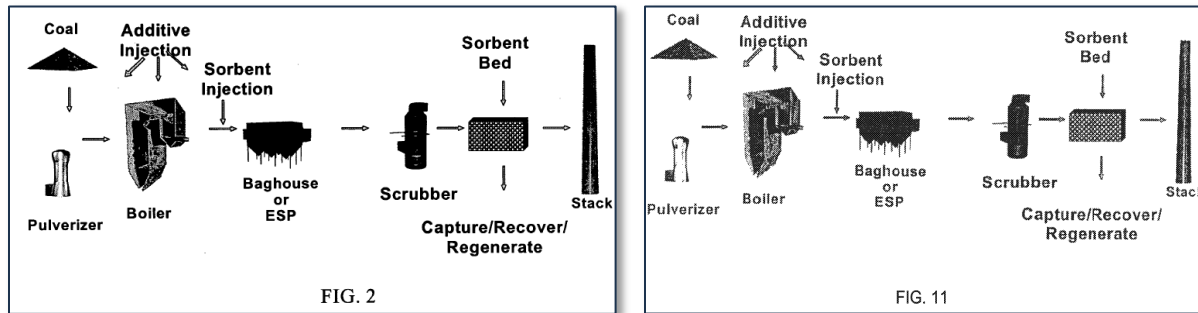
D. The Applications to Which the '370 Patent Claims Priority Do Not Disclose the Challenged Claims

94. 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–EX1034 (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 specification of the '970 Application, as discussed above.

95. The inclusion or exclusion of the Provisional Figure 2 is shown in the following image depicting the family of the '370 Patent wherein the applications marked with a Red X did not include Figure 2 from the Provisional. The application that does include Provisional Figure 2 is shaded yellow:



96. Figure 11 of the '370 Patent is identical to Provisional Figure 2 as seen in the following side-by-side comparison:



97. The disclosures of the '163, '595, '219, '665, '768, '270, '558, or '970 Applications thus have the same “coal” and “additive” disclosures and weight ratio disclosures discussed above regarding the '970 Application in Section VIII(B). Because the discussions of “coal” and “additives” in the '970 Application do not disclose a halide or halogen promoter or additive such as Br_2 , HBr , sodium bromide, calcium bromide, or a combination thereof being added to coal, the '163, '595, '219, '665, '768, '270, or '558 Applications also lack any such disclosure. Because the discussions of weight ratios of promoter to sorbent in the '970 Application do not disclose a ratio of the amount of halide or halogen promoter or additive such as Br_2 , HBr , sodium bromide, calcium bromide, or a combination thereof being added to coal relative to the amount of sorbent added to the mercury-containing gas, the '163, '595, '219, '665, '768, '270, or '558 Applications also lack any such disclosure.

98. I note again that the Board found in its Institution Decision in IPR2020–00832 for related U.S. Patent No. 10,343,114 that the first two non-provisional applications filed after the Provisional (the ‘163 and ‘595 Applications) do not disclose “(1) the addition of the promoter with the coal or the combustion chamber and (2) the injection of a sorbent material into the mercury-containing gas downstream of the combustion chamber,” both of which are required by the ‘370 Patent’s independent Claim 1. EX1038, 28–29.

99. The Board explained in the Institution Decision that the disclosure as referenced in Example 10 of the ‘370 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.

100. Based on my review of the applications identified above, as well as my education, skill, training, and experience in the relevant fields of emission reduction technology, it is my opinion that none of the '163, '595, '219, '665, '768, '270, or '558 Applications disclose promoter compounds such as Br₂, HBr, sodium bromide, calcium bromide, or a combination thereof being added to coal or the claimed weight ratio for the reasons explained above in Paragraphs 94-99. It is also therefore my opinion that a POSITA would not have reasonably concluded that the inventors had possession of the Challenged Claims at the time those applications were filed.

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

101. No indication of support was made for the claims as filed with the '970 Application for the '370 Patent. Therefore, no information was provided regarding support in the specification for adding a halide or halogen to coal.

102. Claim 1 was amended on November 25, 2020 as shown below to include a weight ratio. EX1025, 358.

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

- combusting a mixture of coal and an additive in a combustion chamber, to form the mercury-containing gas, wherein the additive is chosen from halides, halogens, salts thereof, and combinations thereof;
- adding a particulate sorbent material comprising activated carbon into the mercury-containing gas, wherein a weight ratio of I₂, Br₂, Cl₂, or a combination thereof in the additive fed to the combustion chamber to an amount of the sorbent material added to the mercury-containing gas is from 1:100 to 30:100;
- ~~promoting at least a portion of the sorbent material by chemically reacting the sorbent material with the additive in the mercury-containing gas, to form a promoted sorbent material;~~
- ~~chemically reacting~~contacting mercury in the mercury-containing gas with the promoted sorbent material, to form a mercury-sorbent; and
- separating the mercury-sorbent from the mercury-containing gas.

Support for the weight ratio from the published application US2018/0229182A1 was alleged to be found at paragraphs [0021], [0025] and [0072] as shown below.

Independent claim 1 is presently amended to recite “...wherein a weight ratio of I₂, Br₂, Br₂, Cl₂, or a combination thereof in the additive fed to the combustion chamber to an amount of the sorbent material added to the mercury-containing gas is from 1:100 to 30:100...”

Independent claim 20 is correspondingly amended. Support can be found in the present published U.S. application at paragraphs [0021], [0025], and [0072].

EX1025, 344.

103. Paragraph [0021] states in part that “[in] another embodiment, the promoter is added at from about 1 to about 30 grams per 100 grams of activated carbon.” This is not a disclosure of addition of the promoter to coal.

104. Paragraph [0025] states in part that “[in] another embodiment, the injected sorbent is prepared 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, ... wherein the promoter is added at from about 1 to about 30 grams per 100 grams of activated carbon, wherein the rate at which the promoter is added and the rate of sorbent injection are determined by a digital computer based at least in part on the monitored mercury content of the cleaned flue gas.” (emphasis added). This disclosure is directed to preparing a promoted sorbent in-flight, and then injecting the promoted sorbent into a flue gas post combustion. The promoter is not added to coal pre-combustion.

105. Paragraph [0072] describes the carbon structure of the promoted sorbent after the sorbent reacts with bromine and does not disclose a weight ratio or adding a promoter to coal.

106. Claim 2 of the published application US2018/0229182A1 recites “mixing the additive and the coal before combusting the coal.” This claim was added to the ‘970 Application when it was filed on April 12, 2018, without any indication of support for the claim in the specification of the ‘970 Application. EX1025, 58.

107. In sum, the ‘970 Application and each of its priority applications fail to provide support for adding any of the claimed halide or halogen promoters (*e.g.*, Br₂, HBr, sodium bromide, calcium bromide, or a combination thereof) to coal or for the weight ratio as recited in the Challenged Claims of the ‘370 Patent for the reasons explained above in Paragraphs 101-106. It follows that none of the Challenged

Claims of the '370 Patent are entitled to a priority date before the April 12, 2018 filing date of the '970 Application.

IX. CLAIM CONSTRUCTION

108. 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 '370 Patent.

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

110. I note that Magistrate Judge Burke in the District of Delaware provided constructions for two terms in patents from the same family as the '370 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.

111. 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.

112. 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.”

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

114. 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 '370 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)

115. 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).

116. 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 (April 12, 2018) of the '370 Patent, which applies if the '370 Patent is not entitled to an earlier priority date.

117. 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 '370 Patent.

118. 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.

119. 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 120-142.

1. Disclosures of Downs and Downs-Provisional

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

121. Downs is analogous art to the '370 Patent as Downs describes processes for improving mercury removal from the flue gas of coal combustion facilities.

122. 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].

123. 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:

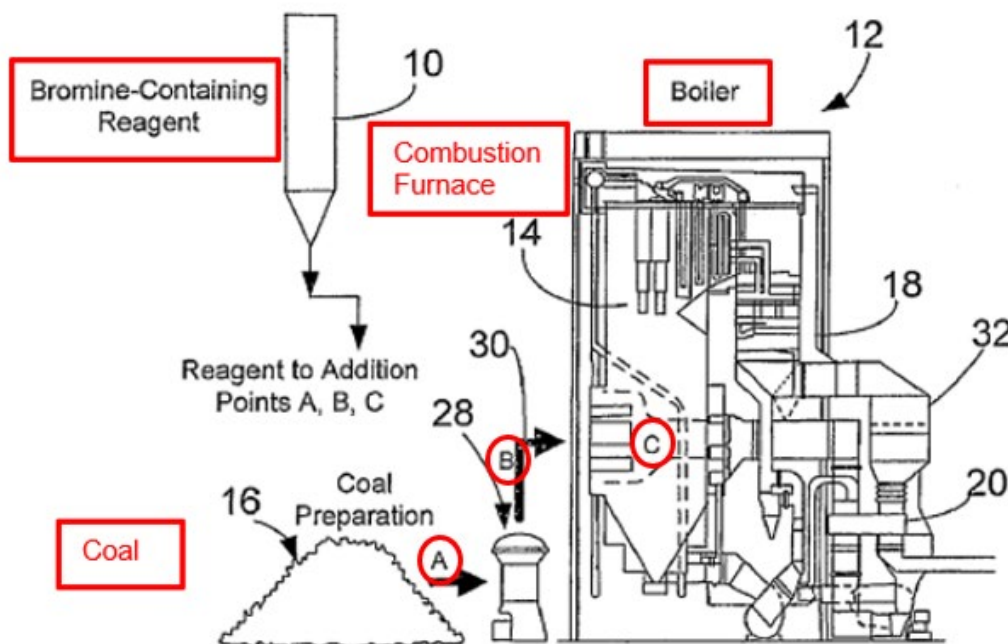


FIG. 2

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.

124. 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:

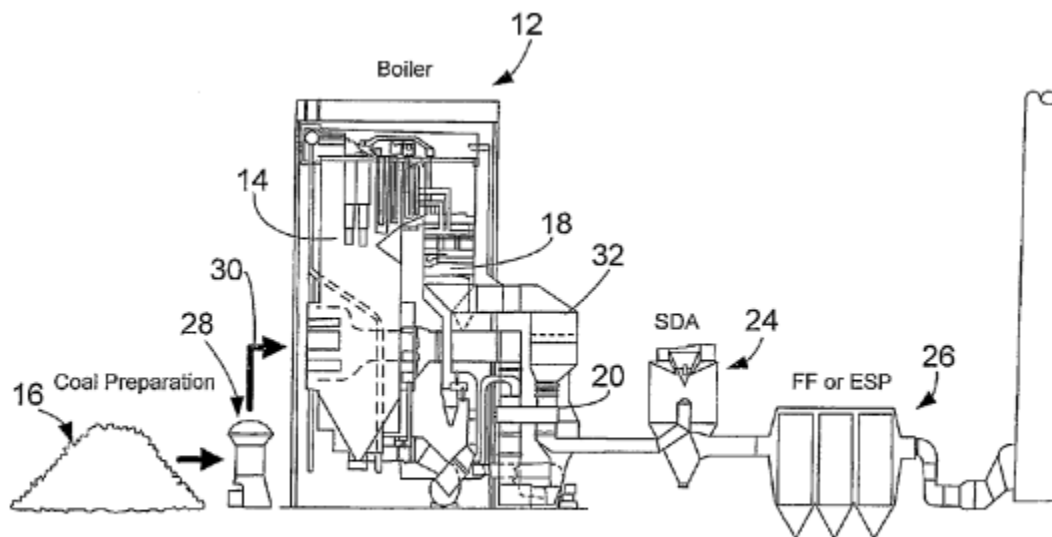


FIG. 4

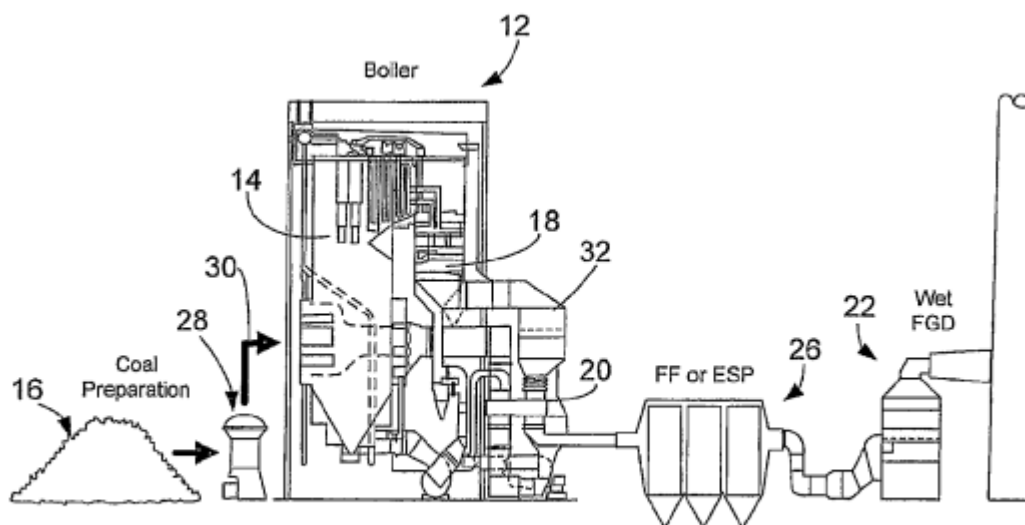


FIG. 6

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

125. 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**

126. 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.

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

128. 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.”

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

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

130. 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.”

131. 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].

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

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

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

134. 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].

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

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

136. 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].

137. Downs-Provisional further explains that “[b]romine species released during the combustion process enhance the oxidation of mercury as the combustion gases pass through the furnace and, in particular, through the cooler sections of the boiler convection pass and combustion air preheater. The increased fraction of mercury appearing in the oxidized form enhances mercury removal in downstream pollution control systems such as wet and SDA FGD systems, and PAC [powdered activated carbon] injection systems.” *Id.*, [0018].

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

138. 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.”

139. 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].

140. 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].

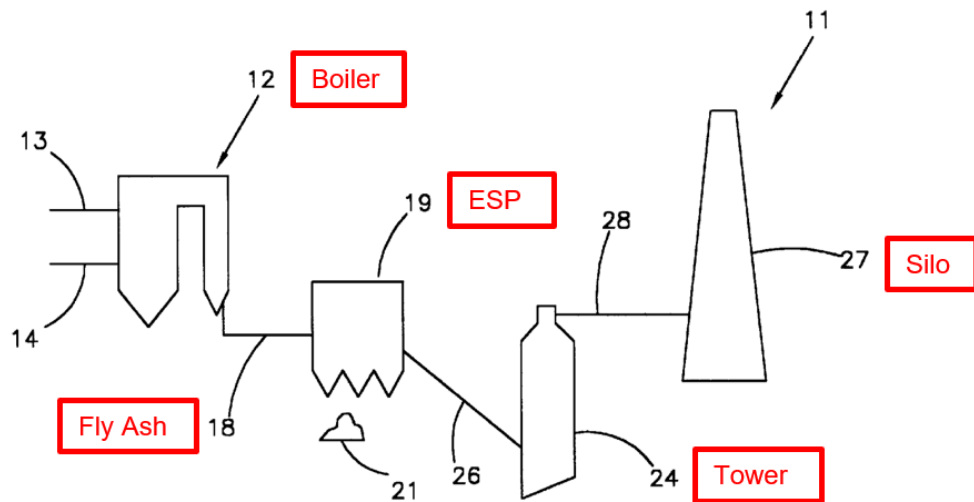
141. Downs-Provisional also states that the inventors “have determined through experimental testing that the use of bromine-containing compounds, added to the coal, or to the boiler combustion furnace, are significantly more effective than chlorine-containing compounds in enhancing the oxidation of mercury,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

142. 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 115-141. 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)

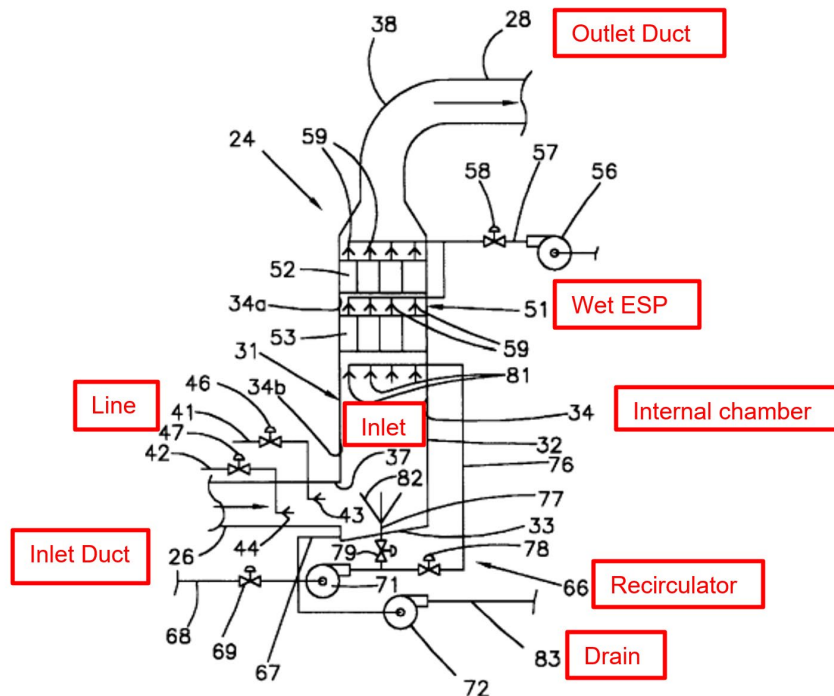
143. Altman issued on October 27, 1998. Accordingly, I understand that Altman qualifies as a prior art patent regardless of whether the effective filing date of the '370 patent is April 12, 2018 or August 30, 2004.

144. 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).

145. 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).

146. 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.

147. 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.

148. 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.

149. 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.

150. 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.

151. 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)

152. 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.

153. 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 '370 Patent (August 30, 2004).

154. 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.

155. 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.

156. 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 157-172.

1. Disclosures of Nelson and Nelson-Provisional

157. 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).

158. Nelson is analogous art to the ‘370 Patent as Nelson describes processes for improving mercury removal from the flue gas of coal combustion facilities. EX1008, Abstract, [0004]; EX1009, 1, 4.

159. 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).

160. 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.

161. 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.

162. 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

163. 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).

164. 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) Claim Element (18a)-“A process for manufacturing a mercury sorbent, comprising:”

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

(b) Element (18b)-“providing a carbonaceous substrate;”

166. 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.

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

(c) Element (18c)-“providing a bromine-containing gas, and”

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

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

(d) Element (18d)-“contacting the carbonaceous substrate with the bromine containing gas for a sufficient time to

increase the mercury adsorbing ability of the carbonaceous substrate.”

170. 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).

171. 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.

172. 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 152-171. 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)

173. 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,

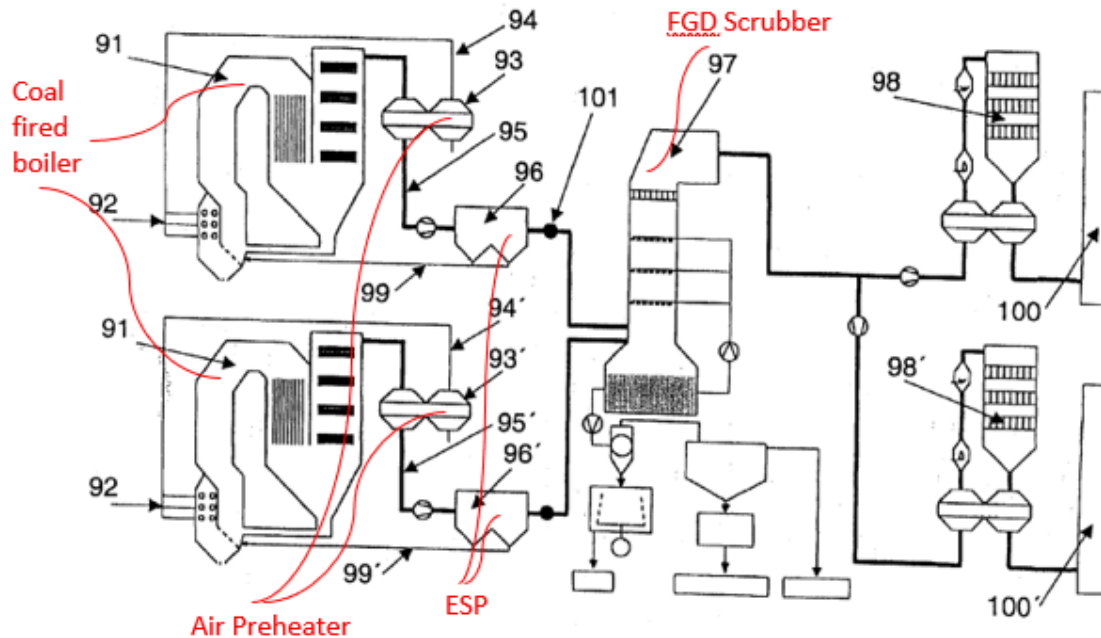
I understand that Vosteen qualifies as a prior art published patent application as of its January 22, 2004 publication date and as of its July 24, 2002 filing date, both of which are earlier than the earliest priority date of the '370 Patent (August 30, 2004).

174. 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]

175. 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].

176. 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].

177. 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].

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

179. 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

HgBr₂ adsorbs more strongly to dry sorbents than mercury chloride HgCl₂.” *Id.*, [0016], [0019]-[0020].

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

181. 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].

182. 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. Pollack (US Patent Application Publication No. 2011/0250111 A1) (EX1086)

183. Pollack, titled “METHODS FOR REMOVAL OF MERCURY FROM FLUE GAS,” was published October 13, 2011. It is my understanding that Pollack qualifies as prior art if the ‘370 Patent is entitled to a priority date of April 12, 2018.

184. Pollack acknowledges that mercury is a “known environmental hazard,” a “significant fraction” of the 50 tons of mercury per year released in the U.S. “comes from emissions from coal burning facilities such as electric utilities,”

and the industry continues to develop systems to reduce mercury emissions by capturing mercury post-combustion so that it is not released into the atmosphere. EX1086, [0014].

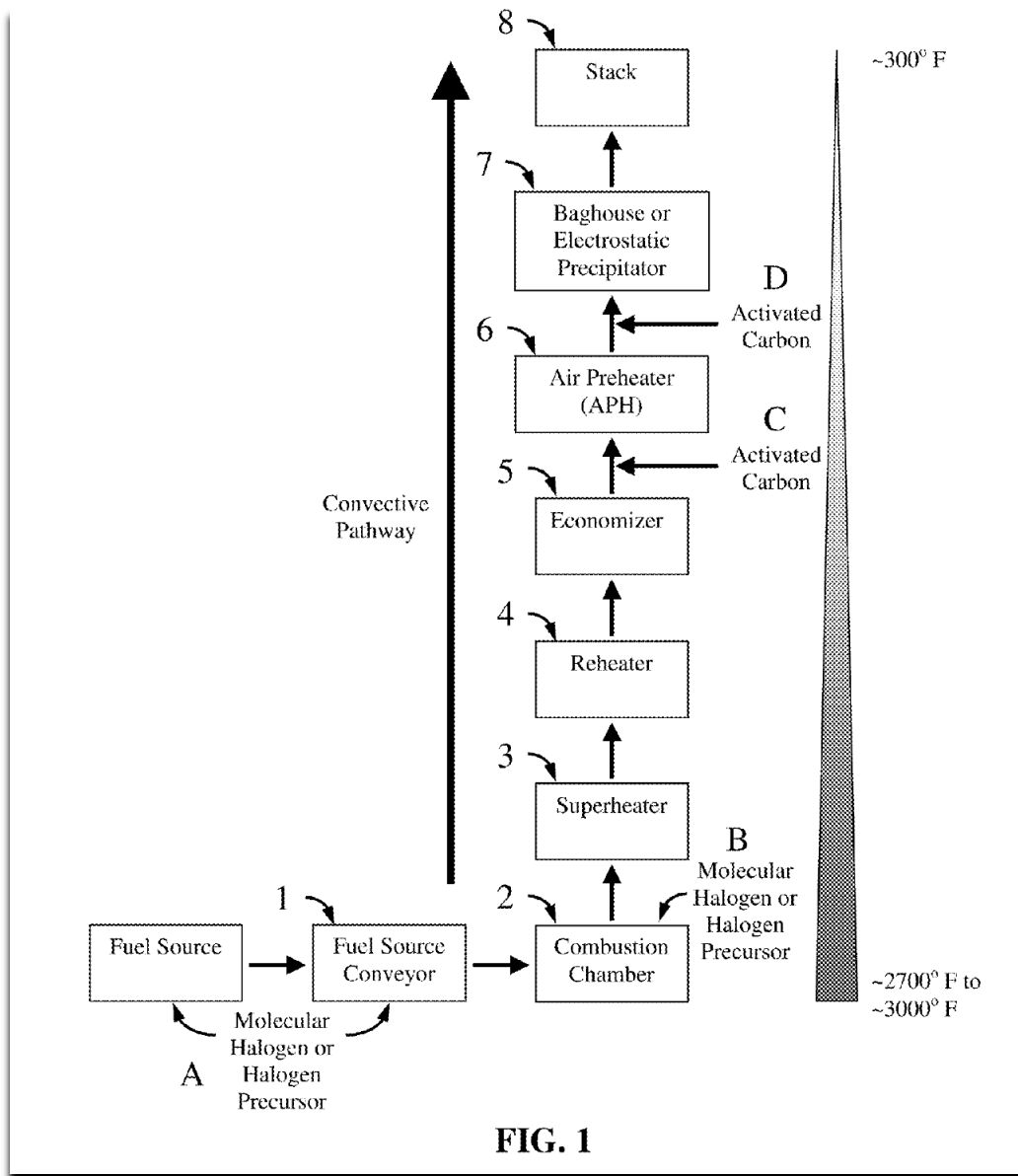
185. Activated carbon injection is described by Pollack as “[o]ne of the most promising solutions.” EX1086, [0015]. However, “short contact time between the activated carbon and the flue gas stream results in an inefficient use of the full adsorption capacity of the activated carbon.” *Id.*

186. Pollack discloses a method for removing mercury from a flue gas by “applying a molecular halogen or halogen precursor to the fuel source or introducing a molecular halogen or halogen precursor into a combustion chamber during combustion of the fuel source or introducing a molecular halogen or halogen precursor into an exhaust stream resulting from the combustion of the fuel source ... and injecting sorbent material into the exhaust stream, i.e. flue gas, resulting from consumption of the fuel source.” *Id.*, [0016]. The fuel source can be coal. *Id.*, [0018].

187. The molecular halogen includes bromine gas and the halogen precursors can be hydrogen bromide, sodium bromide and calcium bromide. *Id.*, [0021], [0035]. “[O]ne or more halogen precursors may be applied to the fuel source, introduced into the combustion chamber, injected into the exhaust stream near the combustion chamber, or a combination thereof.” *Id.*, [0020]. The “halogen

precursor may be ... a liquid ... in some embodiments, the halogen precursor may be an aqueous solution that can be sprayed onto the fuel source such as coal before combustion.” *Id.*, [0023]. The halogen precursor can be applied at a rate to provide from about 50 to about 500 ppm (dry basis) of bromine to the fuel source. *Id.*, [0025]. The “rate at which a solution of a halogen precursor may be significantly reduced by combining the application of a halogen containing composition with injection of sorbent material into the fluid stream of the combustion gases.” *Id.* [0028].

188. Pollack’s Figure 1 depicts a coal fired power plant having a conveyor 1 for delivering coal into a furnace or combustion chamber 2. Ash and combustion gas leave the combustion chamber and are fed into a “baghouse or electrostatic precipitator 7 where particulate matter is collected.” *Id.*



189. The “molecular halogen or halogen precursor may be introduced into one or more combustion chambers and into an exhaust stream after combustion. *Id.*, [0026]. Sorbent is introduced upstream of the baghouse or ESP 7. *Id.*, [0019]. The sorbent can be activated carbon of any size, such as those having a “mean particle diameter (MPD) of about 0.1 μm to about 100 μm .” *Id.*, [0031]. The sorbent can be

untreated or treated with a halogen before it is injected into the combustion gas. *Id.*, [0032]. The injection rate of the sorbent will ‘vary depending upon the flow rate of the exhaust gas in the ductwork.... The rate of addition of the sorbent ... may be from about 0.25 lb/MMacf to about 5 lbs/MMacf.’ *Id.*, [0034]. Mercury emissions “may be reduced by greater than about 80% and in some embodiments, greater than 90%.” *Id.*, [0035], [0038].

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

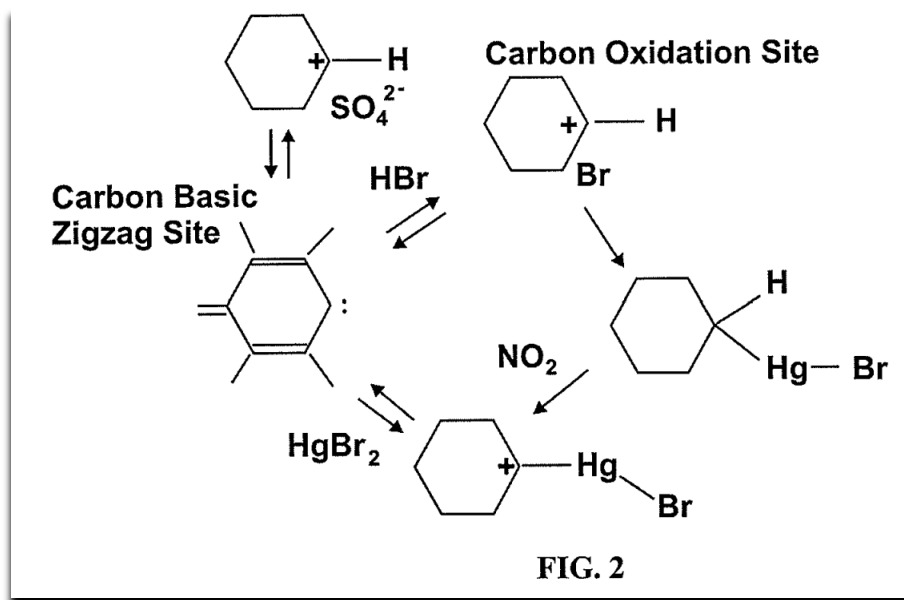
190. Olson-235 issued as U.S. Patent 8,652,235 on February 18, 2014 from an application filed on April 23, 2009. EX1013. It is my understanding that Olson-235 qualifies as prior art if the ‘370 Patent is entitled to a priority date of April 12, 2018.

191. Olson-235 describes a method “for reducing mercury in flue gas comprising providing a base sorbent, either by injection or in situ creation, into a mercury-containing flue gas stream.” EX1013, 5:30–36. Olson-235 discloses 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.

192. Olson-235 discloses an embodiment wherein “the injected sorbent is prepared in-flight by reacting a base sorbent (carbon, non-carbon or their combination) and a promoter within a pneumatic transport line from which the reaction product is injected to the mercury-containing flue gas stream.” EX1013,

5:43–48. Olson-235 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.

193. Olson depicts the “mechanistic model of the chemical reactions resulting in the oxidation and capture of mercury” in Figure 2 as shown below.



Olson-235 explains that

x-ray photoelectron spectroscopy has established that the addition of bromine, chlorine, HBr, or HCl formed a chemical compound in the carbon structure. Thus the promoted sorbent produced from halogen and base sorbent does not represent a molecular halogen form, but rather a new chemically modified structure.... **In the case of bromine, modified cationic carbon has a high chemical potential for oxidation of mercury.** Thus an entirely new model is presented for the reactivity of the bromine-treated carbon with mercury shown in FIG. 2.... **Halogen treatment resulted in higher-activity carbons because halide anions (especially bromide and iodide) were effective in promoting oxidation by stabilizing the developing positive charge on the mercury in the transition state for oxidation.**

EX1013, 16:49-17:4 (emphasis added).

XI. GROUND 1 – CLAIMS 1-6, 8, 11 AND 14-15 WOULD HAVE BEEN OBVIOUS IN LIGHT OF DOWNS COMBINED WITH ALTMAN OR DOWNS/ALTMAN AND NELSON

194. 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 1-6, 8, 11 and 14-15 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 1-6, 8, 11 and 14-15 would have been obvious to a POSITA at the time of the invention.

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

196. 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 '370 Patent regardless of

whether the '370 Patent is entitled to an April 12, 2018 priority date or the August 30, 2004 filing date of the Provisional.

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

197. 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 '370 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.

198. 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.

199. 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.

200. 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.

201. 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].

202. 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. Nelson’s sorbent injection rates are about 2, 4, 6 or 7 lbs PAC/MMacf. EX1008, Figure 14. A POSITA thus would have been motivated to use PAC sorbents at the 7 lbs PAC/MMacf sorbent injection rate of Nelson with the systems and processes of Downs or Downs and Altman as this injection rate increased the mercury removal capabilities of the system.

B. Independent Claim 1

1. Element 1(Preamble)–“A method for separating mercury from 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 separate mercury from 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. Element 1(a)—“combusting a mixture of coal and an additive in a combustion chamber, to form the mercury-containing gas, wherein the additive is chosen from halides, halogens, salts thereof, and combinations thereof;”

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 bromide 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 a mixture of coal and an additive in a combustion chamber, to form the mercury-containing gas, wherein the additive is chosen from halides, halogens, salts thereof, and combinations thereof, 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. Element 1(b) –“adding a particulate sorbent material comprising activated carbon into the mercury-containing gas,”

Element 1(d)-“contacting mercury in the mercury-containing gas with the sorbent material, to form a mercury-sorbent; and”

Element 1(e)-“separating the mercury-sorbent from the mercury-containing gas.”

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

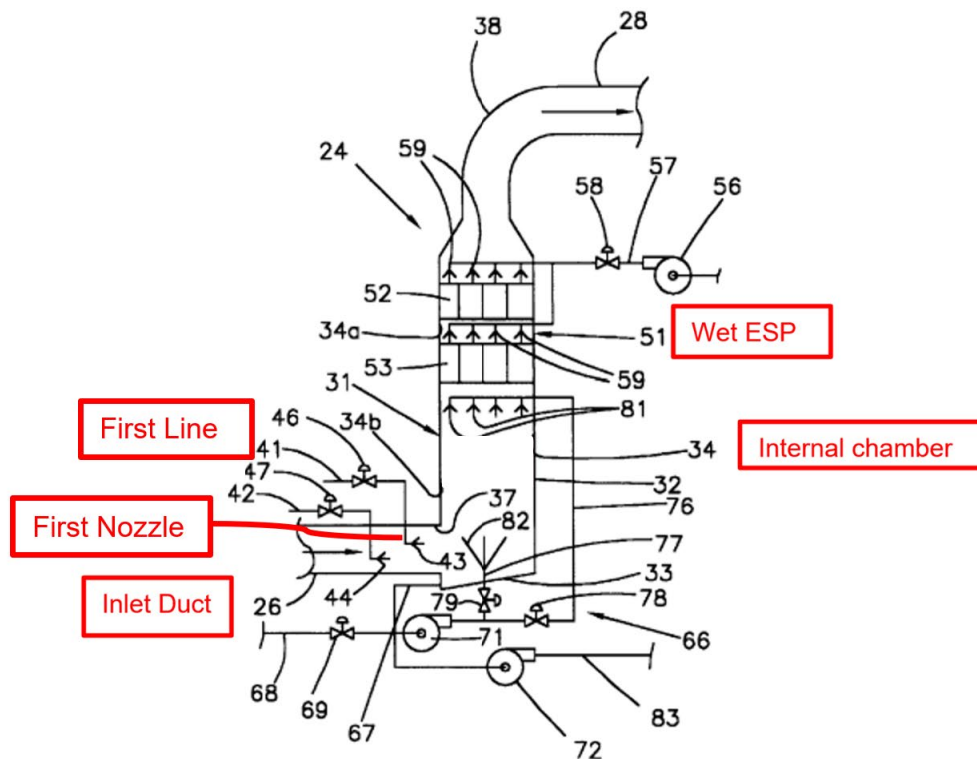
control systems such as wet 22 and SDA 24 FGD systems, and PAC injection systems. As is described herein, experimental results indicate that bromine addition also results in an increased fraction of particulate bound mercury. This enhances removal of mercury across particulate collectors 26 such as fabric 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. Altman describes 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. Altman’s Figure 2 depicts sorbent injection into duct 26 upstream of chamber 34 by means of first line 41 and first nozzle 43. 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

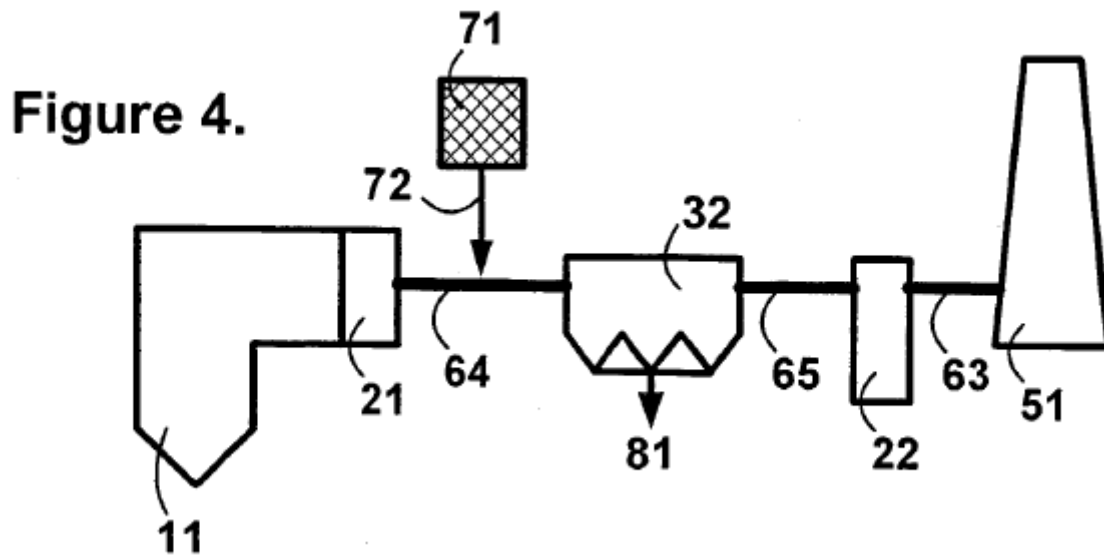
activated carbon sorbent. EX1007, 4:62–5:5. Flue gas residence time within chamber 34 ranges from 1–20 seconds, preferably 5–10 seconds, to “allow a large portion of the mercury in the flue gas to be removed by the injected sorbent.” EX1007, 5:6–12. The flue gas rises through chamber 34 into wet ESP 51, which is a particulate control device 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.



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

220. Nelson describes injecting PAC sorbent from bin 71 into flue gas to remove elemental and oxidized mercury using an ESP 32 as depicted below.

EX1008, [0040], [0062], Figure 4; EX1009, 4.



221. Regarding Element 1(e), 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:

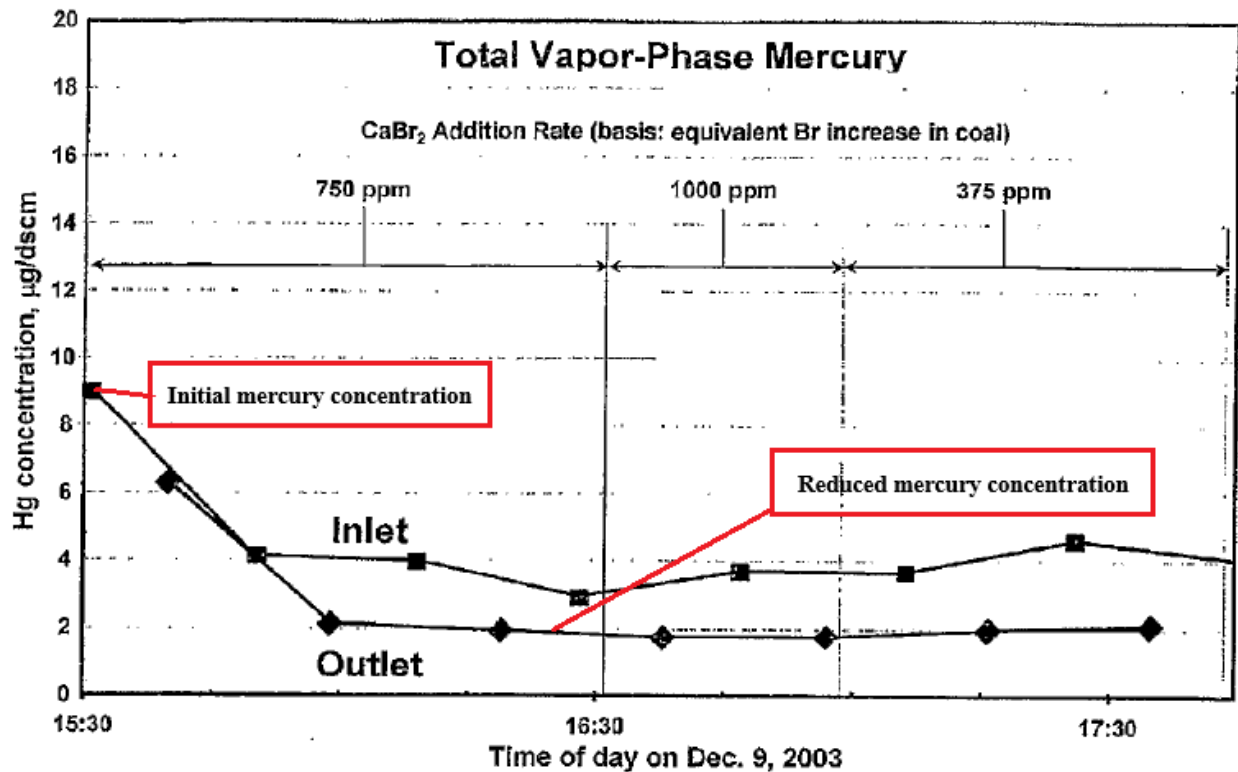


FIG. 3

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

222. 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].

223. 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].

224. 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.

225. Downs or Downs and Altman therefore, in my opinion, disclose adding a particulate sorbent material comprising activated carbon into the mercury-containing gas, contacting mercury in the mercury-containing gas with the sorbent material, to form a mercury-sorbent, and separating the mercury-sorbent from the mercury-containing gas for the reasons explained above in Paragraphs 215-224. EX1004, [0004], [0015], [0016], [0023], [0025], Claims 15-16; EX1005, [0005], [0018], [0019], [0026], [0028].

4. **Element 1(c)-“ wherein a weight ratio of the additive added to the coal, added to the combustion chamber, or a combination thereof, to an amount of the sorbent material added to the mercury-containing gas is from about 1:100 to about 30:100;”**

226. Claim 1 requires a weight ratio of the additive as added to the coal, combustion chamber or both to the sorbent as added to the mercury-containing gas.

As discussed above, my review of the ‘970 Application does not reveal a disclosure of this ratio anywhere in the ‘970 Application for the ‘370 Patent. It is the promoted sorbent (not the amount of additive added to the coal or combustion chamber relative to the amount of the sorbent added to the flue gas) that is described as comprising about 1-30g promoter per 100g base sorbent. EX1025, 4:19-23; 5:14-15; 6:22-26; 7:14-24; 16:28-30; 31:30-32:2; 38:23-25; 40:16-18; 41:1-3, 11-13, 28-29; 54:6-8; EX1001, 3:21-23, 54-56; 4:42-47; 5:6-20; 11:1-3; 20:34-37; 24:55-57; 25:45-48, 64-67; 26:8-11, 26-28; 33:56-59.

227. My review of the ‘370 Patent and its prosecution history 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 added to the combustion chamber or to the coal and/or activated carbon sorbent added to the flue gas 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.

228. In my opinion, the sorbent of Claim 1 can be a promoted sorbent or an unpromoted sorbent when it is added into the mercury-containing gas.

229. In considering the relative amounts of bromine to sorbent for Claim 1, Downs discloses addition of 375, 750 or 1,000 ppm calcium bromide aqueous solution added to the combustion chamber, and discloses that the calcium bromide solution can be sprayed onto the coal. EX1004, [0018]-[0019], Figure 3; EX1005, [0021]-[0022], Figure 3. Nelson discloses PAC sorbent injection rates of about 2, 4 or 6 or 7 lbs/MMacf. EX1008, Figure 14.

230. The ratio of Down's Br- concentration and Nelson's sorbent concentration is within the claimed range. Downs discloses adding 375 ppm calcium bromide to coal. EX1004, Figure 3, EX1005, Figure 3. Nelson discloses a sorbent concentration of about 7 lbs PAC/MMacf. EX1008, Figure 14. Dividing these concentrations and unit conversions yields a mercury-containing gas with 27 grams of the element bromine per 100 grams activated carbon sorbent.

231. More particularly in order to determine a ratio of bromine concentration in the flue gas to activated carbon in the flue gas, the concentrations must have the same units—such as grams per actual cubic feet (acf) or pounds per million actual cubic feet (MMacf). Downs provides the concentration of bromine to coal, which can be converted to a concentration of bromine in the flue gas. Activated-carbon injection concentrations were typically provided in pounds (lbs.) per million actual

cubic feet (MMacf) of flue gas, as in Nelson. Converting between the two would have been a routine calculation for a POSITA and would have involved such basic concepts as the ideal gas law (to convert concentrations between temperatures and pressures), which is taught in first semester undergraduate chemistry. Such unit conversion would have also involved basic engineering knowledge of a power-plant operation as well-known to a POSITA, such as typical flue gas temperature, pressure, and moisture content.

232. Downs uses “western U.S. subbituminous coal,” which is another name for Powder River Basin (PRB). EX1004, [0017]; EX1005, [0020]. The concentration of Br in the mercury-containing gas is estimated for typical parameters for firing Powder River Basin (PRB) subbituminous coal in full-scale utility boilers beginning with the Br loading on coal. For a value of 375 ppm Br on coal from Downs,² the equivalent concentration of Br in flue gas can be calculated as follows:

$$\frac{375 \text{ g Br}}{10^6 \text{ g coal}} = \frac{3.75 \times 10^{-4} \text{ g Br}}{\text{g coal}}$$
$$\frac{3.75 \times 10^{-4} \text{ g Br}}{\text{g coal}} \times \frac{1 \text{ g coal}}{10 \text{ g flue gas}} = \frac{3.75 \times 10^{-5} \text{ g Br}}{\text{g flue gas}}$$

² EX1004, [0018], Figure 3; EX1005, [0021], Figure 3. Downs discloses the units of “ppm.” A POSITA would have understood this to refer to ppm by weight, rather than on a molar basis, because the comparison is with respect to coal.

233. The above ratio of 10 grams flue gas per gram coal is a nominal value for subbituminous coals fired at 15 – 20 % excess air, and representative of the typical firing practices at coal-fired utility boilers. (In other words, combustion of 1 gram of subbituminous coal can be expected to provide approximately 10 grams flue gas). The molecular weight of flue gas is typically between 28-32 grams per mole (depending on the type of coal and amount of excess air), because flue gas is primarily: molecular nitrogen (molecular weight of 28, from excess air), carbon dioxide (molecular weight of 44), water (molecular weight of 18), and excess oxygen (molecular weight of 32). Accordingly, a typical value for the molecular weight of flue gas is 30 g/mol.

$$3.75 \times 10^{-5} \frac{\text{g Br}}{\text{g flue gas}} \times \frac{30 \text{ g flue gas}}{\text{mol flue gas}} = 1.12 \times 10^{-3} \frac{\text{g Br}}{\text{mol flue gas}}$$

234. Regarding the second conversion, a POSITA would have understood from the ideal gas law ($PV = nRT$) that the density of a gas is proportional to pressure and inversely proportional to temperature. A POSITA would have known that a typical flue gas temperature where sorbent would be injected is 150 °C (413 K) and also 1 atm of pressure. In fact, Nelson discloses a temperature of 175 °C (448 K). A POSITA would have understood that this temperature is a typical value for sorbent injection downstream of an air preheater and upstream of an ESP or fabric filter. A POSITA would have known that air preheaters typically do not operate with outlet

gas temperatures below the acid dew points of sulfuric acid, which are given as 120–150 °C. This dewpoint range restricts the outlet temperatures to somewhat hotter values like 150 °C. Thus, a temperature of 448 Kelvin (175 °C) is used for the calculations, as this temperature is disclosed by Nelson.

$$\frac{1.12 \times 10^{-3} \text{ g Br}}{\text{mol flue gas}} \times \frac{1 \text{ atm}}{(448\text{K})(0.082058 \text{ L atm}/(\text{mol K}))(1 \text{ acf}/28.3 \text{ L})} \times \frac{10^6 \text{ acf}}{\text{MMacf}} \\ = 862 \frac{\text{g Br}}{\text{MMacf flue gas}}$$

235. A POSITA would convert pounds activated carbon to grams activated carbon (and vice versa) through the well-known unit conversion of 453.6 grams per pound. For an injection concentration of 7 lb PAC/MMacf (as disclosed in Nelson), the concentration of PAC in the flue gas can be calculated in grams as shown below. EX1007, 20.

$$\frac{7 \text{ pounds PAC}}{\text{MMacf}} \times \frac{453.6 \text{ g}}{\text{pound}} = 3,175 \frac{\text{g PAC}}{\text{MMacf}}$$

236. The estimated concentration of Br in flue gas is 862 g Br/MMacf flue gas. For an injection concentration of 7 lb PAC/MMacf, the concentration of PAC in the flue gas is 3,175 g PAC/MMacf flue gas. Dividing these two rates derived from the bromine addition rate of Downs and the activated carbon injection rate of Nelson provides a mercury-containing gas that comprises about 27 grams of the

element bromine per 100 grams of activated-carbon sorbent, which is within the range of 1 gram to 30 grams per 100 grams of activated-carbon sorbent.

237. 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.

238. 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.

239. Because Downs or Downs and Altman disclose elements 1(preamble)-1(b) and 1(d)-1(e) of Claim 1, and Downs and Nelson disclose relative amounts of

calcium bromide added to coal and sorbent added into the mercury-containing gas within the claimed range as specified by element 1(c), it is 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 Downs and Nelson or Downs, Altman and Nelson for the reasons explained above in Paragraphs 203-238.

C. Claims Depending From Claim 1

1. Claim 2—“adding the additive to the coal before combusting the coal”

240. 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].

241. 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].

242. 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].

243. Because Downs and Nelson or Downs, Altman and Nelson disclose every element of Claim 1 and Downs specifically teaches that the bromide additive 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 Claim would have been obvious to a POSITA at the time of the invention in light of Downs and Nelson or Downs, Altman and Nelson for the reasons explained above in Paragraphs 240-242. EX1004, [0007], [00015], [0019], [0021]; EX1005, [0009], [0018], [0022], [0024].

2. Claim 3—“the additive mixed with the coal is in a liquid.”

Claim 4—“the liquid is a hydrocarbon, supercritical carbon dioxide, water, salt solution, or a combination thereof.”

244. 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].

245. 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].

246. Because Downs and Nelson or Downs, Altman and Nelson disclose every element of Claim 1 and Downs discloses mixing coal with an aqueous solution of calcium bromide additive, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claims 3 and 4 would have been obvious to a POSITA at the time of the invention in light of Downs and Nelson or Downs, Altman and Nelson for the reasons explained above

in Paragraphs 244-245. EX1004, [0019], [0021]–[0022]; EX1005, [0022], [0024]–[0025].

3. Claim 5– “carbocations in the activated carbon of the mercury-sorbent accept electrons from mercury atoms of the mercury-sorbent”

247. Downs discloses that “calcium bromide also enhances the formation of particulate-bound mercury” across a PAC injection process. EX1004, [0016], [0018]; EX1005, [0019], [0021].

248. 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.

249. It would have been obvious to a POSITA that the activated carbon reacts with promoter in the mercury-containing gas to form a promoted sorbent when the HBr in the gas contacts the sorbent. It was well-known in the art that halogens (including bromine) “promoted” activated-carbon sorbents because they improved mercury removal by increasing the ability of the activated carbon to bind with the mercury. See §§ VII.D and VII.E. Lead inventor Dr. Olson admitted that, when

bromides are added to coal “and activated carbon is injected downstream of the furnace,” then there would be “in-flight promotion.” EX1047, 231:3-9, 98:23-100:3. “[P]romotion” of activated carbon by halogens is a reaction. EX1083, 156 (labeled as limitation 24e, O’Keefe explaining how bromine containing ingredients added to coal would contact and react with sorbent), 160 (labeled as limitation 1c, O’Keefe explaining how activated carbon reacts with bromine). It follows the sorbent of Downs or Downs/Altman comprises bromine, sorbent and mercury when in-flight promotion occurs.

250. The reaction of hydrogen bromide with carbon in an activated carbon particle forms a carbocation oxidation site that accepts an electron from mercury adsorbed by the activated carbon particle, forming particulate-bound mercury. These reactions necessarily occur when the hydrogen bromide contacts activated carbon as evidenced by “irreversible fixation of bromine giving a stable carbon-bromine complex” with “complete substitution of hydrogen by bromine” when HBr reacts with carbon or charcoal. EX1050, 260.

251. Nelson explains “in exposing PAC to concentrated bromine gas, ... the bromine reacts with the carbon, forming surface compounds on ... the carbon. When the PAC is then injected into the flue gas, the elemental mercury and oxidized mercury species there appear to react with at least one form of the bromine-carbon

surface compounds When the carbon particles are removed from the flue gas ... the mercury is removed with them.” EX1008, [0043]; EX1009, 4.

252. Because Downs and Nelson or Downs, Altman and Nelson disclose every element of Claim 1 and Downs (as evidenced by Julien) and Nelson disclose contact of hydrogen bromide, mercury and activated carbon in flue gas, which would necessarily result in carbocations in the activated carbon of the mercury-sorbent accepting electrons from mercury atoms on the mercury-sorbent, 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 and Nelson or Downs, Altman and Nelson as evidenced by Julien for the reasons explained above in Paragraphs 247-251. EX1004, [0016], [0018]; EX1005, [0019], [0021]; EX1008, [0043]; EX1009, 4; EX1014, 1658; EX1047, 231:3-9, 98:23-100:3; EX1083, 156, 160.

4. Claim 6—“the additive is substantially in vapor form in the mercury-containing gas”

253. 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].

254. 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.

255. Because Downs and Nelson or Downs, Altman and Nelson disclose every element of Claim 1 and Downs (as evidenced by Julien) discloses that calcium bromide converts to HBr in vapor form in the mercury-containing flue gas formed from combustion, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 6 would have been obvious to a POSITA at the time of the invention in light of Downs and Nelson or Downs, Altman and Nelson (as evidenced by Julien) for the reasons explained above in Paragraphs 253-254. EX1004, [0019]; EX1005, [0022]; EX1014, 1658.

5. Claim 8—“the additive is chosen from Br₂, HBr, sodium bromide, calcium bromide, and a combination thereof.”

256. Downs 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].

257. 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].

258. Because Downs and Nelson or Downs, Altman and Nelson disclose every element of Claim 1 and Downs discloses that its additive is calcium bromide, HBr or Br₂, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 8 would have been obvious to a POSITA at the time of the invention in light of Downs and Nelson or Downs, Altman and Nelson for the reasons explained above in Paragraphs 256-257. EX1004, [0019], [0021]; EX1005, [0022], [0024].

6. Claim 11—“the activated carbon is chosen from powdered activated carbon, granular activated carbon, carbon black,

carbon fiber, aerogel carbon, pyrolysis char, and combinations thereof.”

259. As discussed above regarding element 1(b), 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].

260. Because Downs and Nelson or Downs, Altman and Nelson disclose every element of Claim 1 and Downs describes at least one of the types of activated carbon required by Claim 11, 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 Downs and Nelson or Downs, Altman and Nelson for the reasons provided in Paragraph 259. EX1004, [0004], [0015]–[0016], [0025], claims 15–16; EX1005, [0005], [0018], [0028].

7. **Claim 14 – “contacting the sorbent material with a secondary component chosen from halogens, hydrogen halides, Group V halides, Group VI halides, and combinations thereof.”**

Claim 15 – “the secondary component is chosen from halogens, halide salts, HI, HBr, HCl, and combinations thereof.”

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

262. Because Downs and Nelson or Downs, Altman and Nelson disclose every element of Claim 1 and HCl would have necessarily been present in the flue gas, as evidenced by Julien, and would have contacted the sorbent, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claims 14-15 would have been obvious to a POSITA at the time of the invention in light of Downs and Nelson or Downs, Altman and Nelson for the reasons provided in Paragraph 261. EX1014, 165; EX1072, 199 (Table 1).

XII. GROUND 2: CLAIMS 1-6, 8, 11 AND 14-15 ARE OBVIOUS OVER VOSTEEN, ALTMAN AND NELSON

263. 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 1-6, 8, 11 and 14-15 would have been obvious in light of 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 1-6, 8, 11 and 14-15 would have been obvious in light of Vosteen and Nelson or Vosteen, Altman, and Nelson.

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

264. 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.

265. Vosteen, Altman, and Nelson are analogous art to the '370 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.

266. 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.*

267. 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.

268. 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.

269. 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 ‘370 Patent itself also acknowledges that activated-carbon injection was well-known in the art. EX1001, 2:5-11, 7:49-55; 28:9-22.

270. 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.

271. Nelson’s sorbent injection rates are about 2, 4, 6 or 7 lbs PAC/MMacf. EX1008, Figure 14. A POSITA thus would have been motivated to use PAC sorbents at the 7 lbs PAC/MMacf sorbent injection rate of Nelson with the systems and processes of Vosteen and Altman as this injection rate increased the mercury removal capabilities of the system.

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

273. 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.

274. 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.

275. 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.

276. 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.

277. Vosteen and Altman, in my opinion, each disclose the preamble of claim 1 as both references describe multiple methods for removing mercury in a mercury-containing gas, more specifically a flue gas at a coal burning power plant for the reasons explained above in Paragraphs 273-276. EX1011, Abstract, Title; [0001]; [0007]–[0008], Claim 1; EX1007, Abstract, Claim 1.

2. Element 1(a)—“combusting a mixture of coal and an additive in a combustion chamber, to form the mercury-containing

gas, wherein the additive is chosen from halides, halogens, salts thereof, and combinations thereof;”

278. 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).

279. 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).

280. 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.

281. Vosteen and Altman, in my opinion, disclose combusting a mixture of coal and an additive in a combustion chamber, to form the mercury-containing gas, wherein the additive is chosen from halides, halogens, salts thereof, and combinations thereof for the reasons explained above in Paragraphs 278-280. EX1011, [0005], [0006], [0007], [0009], [0013], [0025], [0047], Example 5; EX1007, 3:41-44.

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

Element 1(d)–“contacting mercury in the mercury-containing gas with the sorbent material, to form a mercury-sorbent; and”

Element 1(e)–“separating the mercury-sorbent from the mercury-containing gas.”

282. 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].

283. 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.

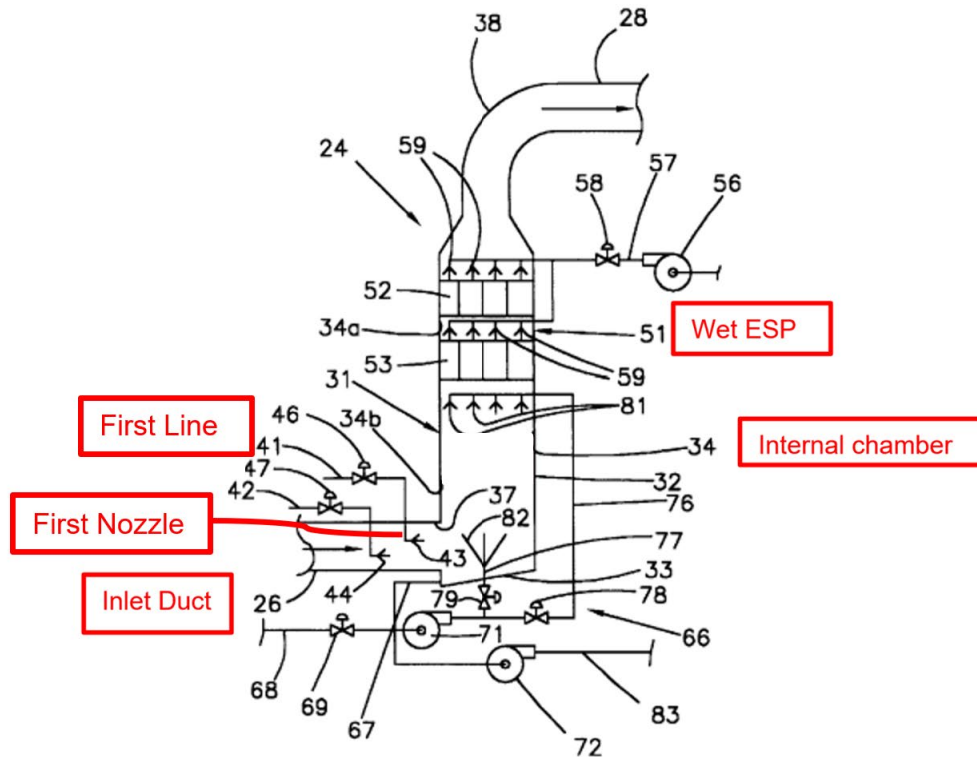
284. Instead of using a packed bed with stationary sorbent, Altman injects activated carbon and lime into flue gas in the emission control system such that they flow with the flue gas. EX1007, 4:53–61, 5:50–61. Flue gas residence time within chamber 34 ranges from 1–20 seconds, preferably 5–10 seconds,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

285. 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.

286. The ‘370 Patent itself also acknowledges that activated-carbon injection as a sorbent was well-known in the art. EX1001, 2:5–11, 7:49–55; 28:9–22.

287. Altman describes 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. Altman’s Figure 2 depicts sorbent injection into duct 26 upstream of chamber 34 by means of first line 41 and first nozzle 43. 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. Flue gas residence time within

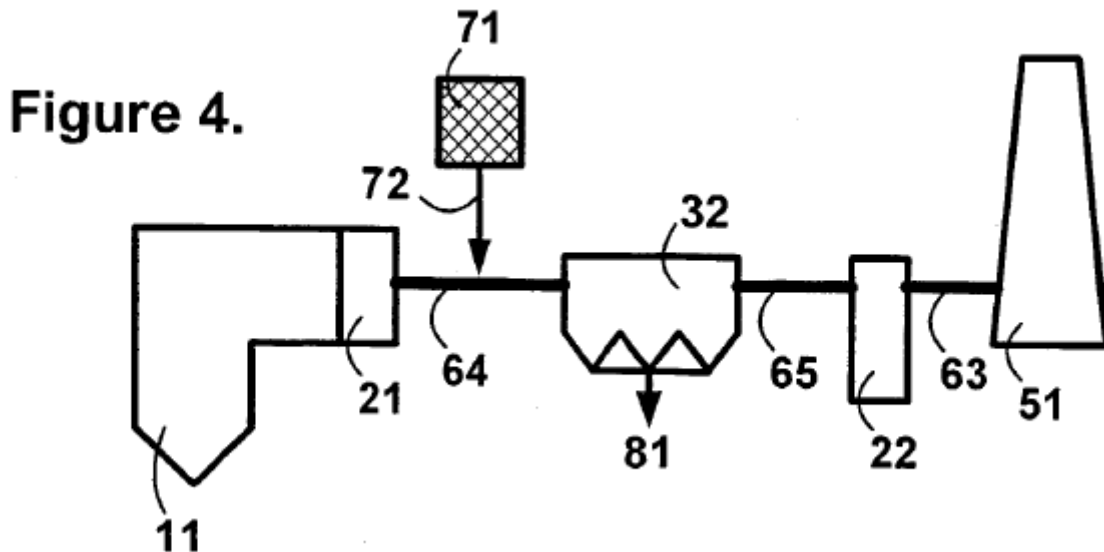
chamber 34 ranges from 1–20 seconds, preferably 5–10 seconds, to “allow a large portion of the mercury in the flue gas to be removed by the injected sorbent.” EX1007, 5:6–12. The flue gas rises through chamber 34 into wet ESP 51, which is a particulate control device where sorbent, remaining fly ash 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.



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

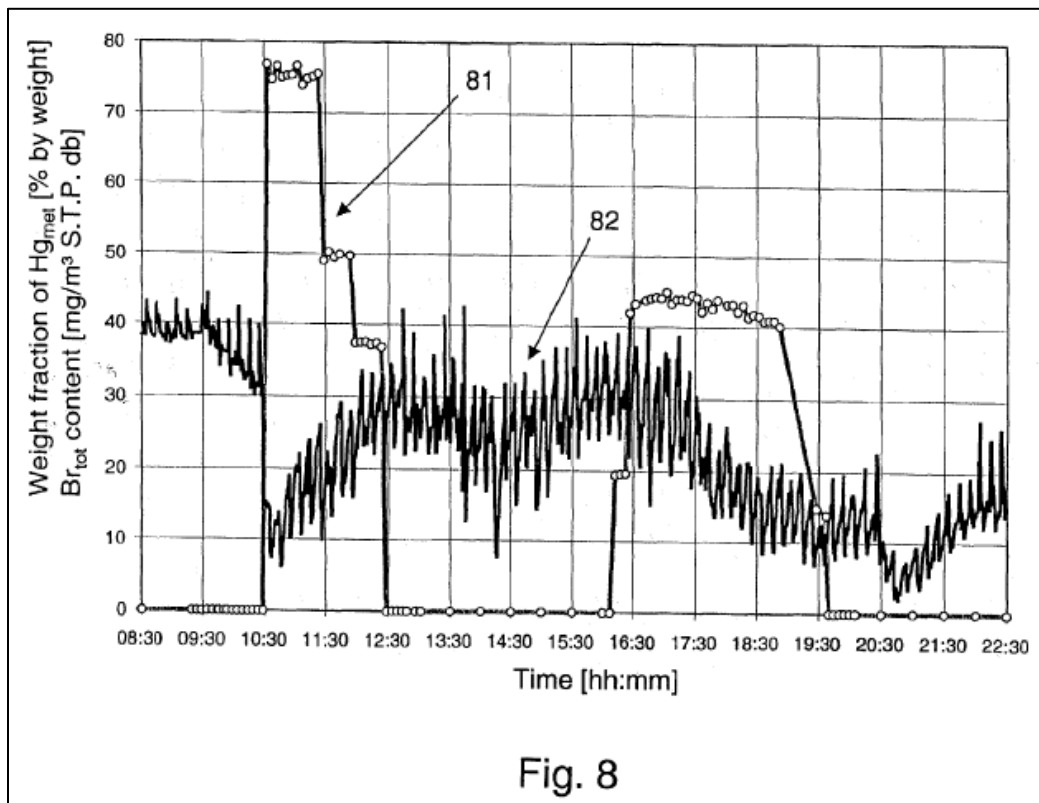
288. Nelson describes injecting PAC sorbent from bin 71 into flue gas to remove elemental and oxidized mercury using an ESP 32 as depicted below.

EX1008, [0040], [0062], Figure 4; EX1009, 4.



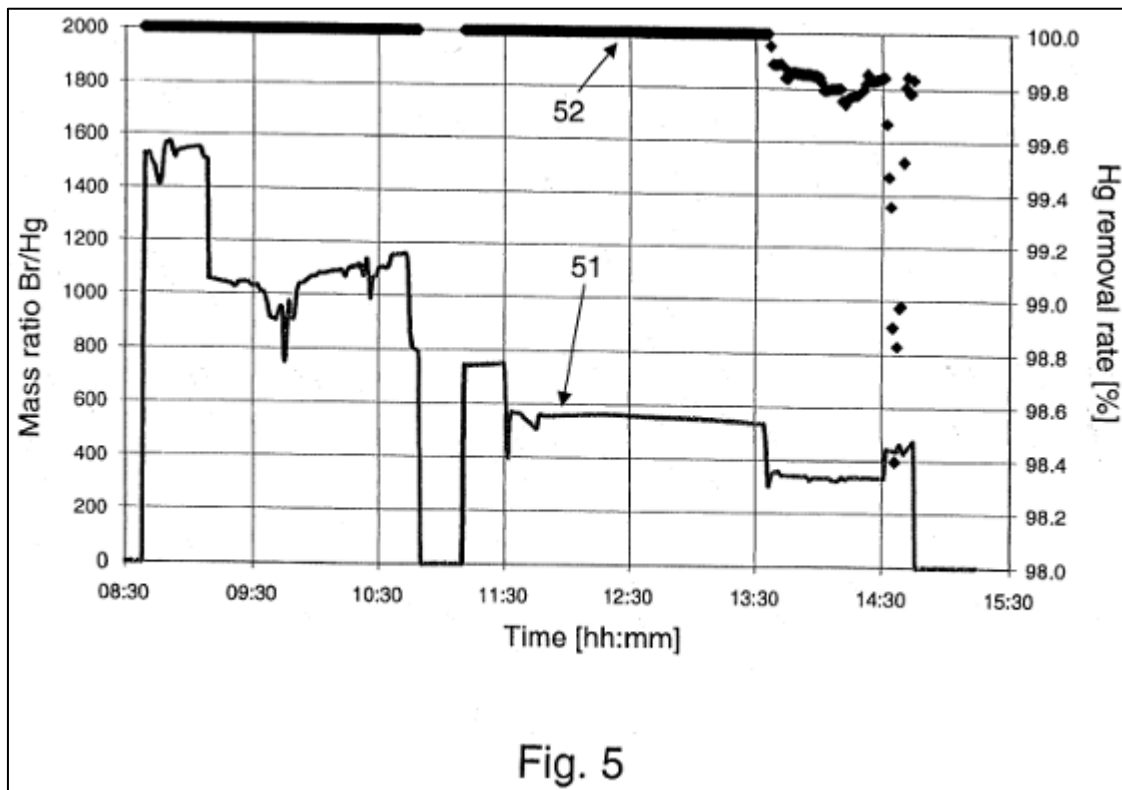
289. Regarding element 1(e), Vosteen discloses that “an object of the invention to provide a process for removing mercury, in particular for the substantially complete removal of mercury (Hg), from flue gases of high temperature processes.” EX1011, [0005].

290. 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.

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



292. 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].

293. 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].

294. 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.

295. 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.

296. 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 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 ‘370 Patent itself also acknowledges that activated-carbon injection was well-known in the art. EX1001, 2:5-11, 7:49-55; 28:9-22.

297. Vosteen and Altman, in my opinion, disclose adding a particulate sorbent material comprising activated carbon into the mercury-containing gas, contacting mercury in the mercury-containing gas with the sorbent material, to form

a mercury-sorbent, and separating the mercury-sorbent from the mercury-containing gas for the reasons stated above in Paragraphs 282-296. EX1011, [0005], [0007], [0015], [0019], [0037], [0042], [0047]-[0049], Figures 5 & 8; EX1007, 1:30-40, 2:14-31; 4:53-61, 5:6-12, 18-22, 41-61.

4. Element 1(c)-“wherein a weight ratio of the additive added to the coal, added to the combustion chamber, or a combination thereof, to an amount of the sorbent material added to the mercury-containing gas is from about 1:100 to about 30:100;”

298. Claim 1 requires a weight ratio of the additive as added to the coal, combustion chamber or both to the sorbent as added to the mercury-containing gas. As discussed above, my review of the ‘970 Application does not reveal a disclosure of this ratio anywhere in the ‘970 Application for the ‘370 Patent. It is the promoted sorbent (not the amount of additive added to the coal or combustion chamber relative to the amount of the sorbent added to the flue gas) that is described as comprising about 1-30g promoter per 100g base sorbent (i.e., additive to sorbent ratio of 1:100 to 30:100). EX1025, 4:19-23; 5:14-15; 6:22-26; 7:14-24; 16:28-30; 31:30-32:2; 38:23-25; 40:16-18; 41:1-3, 11-13, 28-29; 54:6-8; EX1001, 3:21-23, 54-56; 4:42-47; 5:6-20; 11:1-3; 20:34-37; 24:55-57; 25:45-48, 64-67; 26:8-11, 26-28; 33:56-59.

299. My review of the ‘370 Patent and its prosecution history 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 added to the combustion chamber or to the coal and/or activated carbon sorbent added to the flue gas 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.

300. In my opinion, the sorbent of Claim 1 can be a promoted sorbent or an unpromoted sorbent when it is added into the mercury-containing gas.

301. In considering the relative amounts of bromine to sorbent for Claim 1, Vosteen does not report the relative proportions of bromine to sorbent. It is my opinion that a POSITA would have looked to other references like Nelson to identify rates of activated carbon injection post-combustion upstream of an ESP particulate control device.

302. The ratio of Vosteen’s Br- concentration and Nelson’s sorbent concentration is within the range claimed in Claim 1. Vosteen discloses “total bromine content (Br_{tot}) in the boiler flue gas” of 43 or 75 mg/m^3 S.T.P. db (*i.e.*, milligrams Br per cubic-meter of mercury-containing flue gas, on a dry basis at standard temperature and pressure). EX1011, [0031], [0046], [0048], Figure 8.

Nelson discloses PAC sorbent injection rates of about 2, 4 6 or 7 lb/MMacf. EX1008, Figure 14.

303. These values and unit conversions can be used to calculate the mass of the element bromine per 100 grams activated carbon sorbent in a mercury-containing gas.

304. More particularly in order to determine a ratio of bromine concentration in the flue gas to activated carbon in the flue gas, the concentrations must have the same units—such as grams per actual cubic feet (acf) or pounds per million actual cubic feet (MMacf). Vosteen provides the gas-phase concentration of bromine in units of mg/m^3 Standard Temperature and Pressure (STP) dry basis (db). Activated-carbon injection concentrations were typically provided in pounds (lbs.) per million actual cubic feet (MMacf) of flue gas, as in Nelson. Converting between the two would have been a routine calculation to a POSITA and would have involved such basic concepts as the ideal gas law (to convert concentrations between temperatures and pressures), which would have been taught in first semester undergraduate chemistry. Such unit conversion would have also involved basic engineering knowledge of a power-plant operation well-known to a POSITA, such as a typical flue gas temperature, pressure, and moisture content.

305. A POSITA would have known that a typical flue gas has approximately 10% water content by volume. As such, volume on an actual basis equals (volume

on a dry basis) / 0.9. A person of ordinary skill in the art would have understood that ten percent is a nominal value for moisture in flue gas because moisture levels diminish for coals of progressively higher rank. It was known, for example, that lignite and subbituminous coals can produce flue gas with 15% moisture or greater, and anthracites can produce as little as 5% moisture or less. EX1042, 8-5 to 8-6.

306. Regarding the second conversion, a POSITA would have understood from the ideal gas law ($PV = nRT$) that the density of a gas is proportional to pressure and inversely proportional to temperature. A POSITA would have learned from undergraduate chemistry that standard temperature and pressure (STP) refers to 0 °C (273 K) and 1 bar, respectively, and would have known that a typical flue gas temperature where sorbent would be injected is 150 °C (413 K) and 1 atm of pressure. In fact, Nelson discloses a temperature of 175 °C (448 K). EX1008, [0082]. A person of ordinary skill in the art would have understood that this temperature is a typical value for sorbent injection downstream of an air preheater and upstream of an ESP or fabric filter. A POSITA would have known that air preheaters typically do not operate with outlet gas temperatures below the acid dew points of sulfuric acid, which are given as 120–150 °C. EX1042, 19-11. Thus, a temperature of 448 Kelvin (175 °C) is used for the calculations, as this temperature is disclosed by Nelson. Last, a POSITA would have found in readily available tables of unit conversions that $1 \text{ m}^3 = 35.3 \text{ ft}^3$. Accordingly, 43 mg/m³ S.T.P. db (as

disclosed by Vosteen, and which equals 0.043 g/m³ S.T.P. db) and at a temperature of 448 K (the temperature of flue gas where the activated carbon is injected, as in Nelson) converts to the following in terms of grams bromine/million actual cubic feet.

$$\frac{0.043 \text{ g Br}}{1 \text{ m}^3_{\text{STP db}}} \times \frac{0.9 \text{ m}^3_{\text{STP db}}}{1.0 \text{ m}^3_{\text{STP}}} \times \frac{273\text{K std}}{448\text{K act}} \times \frac{1 \text{ m}^3}{35.3 \text{ ft}^3} \times \frac{10^6 \text{ acf}}{1 \text{ MMacf}}$$
$$= 668 \frac{\text{g Br element}}{\text{MMacf flue gas}}$$

307. A person of ordinary skill in the art would convert pounds activated carbon to grams activated carbon (and vice versa) through the well-known unit conversion of 453.6 grams per pound. It follows that at a typical activated-carbon injection rate of 7 pounds per MMacf, as in Nelson, the injection rate of activated carbon would be equal to:

$$\frac{7 \text{ pounds PAC}}{\text{MMacf}} \times \frac{453.6 \text{ g}}{\text{pound}} = 3,175 \frac{\text{g PAC}}{\text{MMacf}}$$

308. Dividing the two rates of the bromine concentration of Vosteen (43 mg/m³ S.T.P. db) with the activated carbon concentration of Nelson (7 lb/MMacf)—provides a mercury-containing gas that comprises about 21 grams of the element bromine per 100 grams of activated-carbon sorbent, which is within the range of 1 gram to 30 grams. EX1011, [0048].

309. 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.

310. Because Vosteen and Altman disclose elements 1(preamble)-1(b) and 1(d)-1(e) of Claim 1, and Vosteen and Nelson disclose relative amounts of sodium bromide added to coal and sorbent added into the mercury-containing gas within the claimed range as specified by element 1(c), it is 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, Altman and Nelson for the reasons explained above in Paragraphs 273-309.

C. Claims Depending From Claim 1

1. Claim 2—“adding the additive to the coal before combusting the coal.”

311. 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].

312. 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 2 would have been obvious to a POSITA at the time of the invention in light of Vosteen combined with Altman for the reasons explained above in Paragraph 311. EX1011, [0013].

2. Claim 3—“the additive mixed with the coal is in a liquid.”

Claim 4—“the liquid is a hydrocarbon, supercritical carbon dioxide, water, salt solution, or a combination thereof.”

313. 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.” EX1011, [0013] (emphasis added).

314. Because the combination of Vosteen, Altman and Nelson discloses every element of Claim 1, and Vosteen specifically discloses that an aqueous

solution of sodium bromide can be added to the coal as required by Claims 3 and 4, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claims 3 and 4 would have been obvious to a POSITA at the time of the invention in light of Vosteen, Altman and Nelson for the reasons explained above in Paragraph 313. EX1011, [0013].

3. Claim 5—“carbocations in the activated carbon of the mercury-sorbent accept electrons from mercury atoms of the mercury-sorbent.”

315. 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. . . . The addition can also be made to a plant section upstream of the furnace, for example, ... to a coal mill.” EX1011, [0013].

316. 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.

317. It would have been obvious to a POSITA that the activated carbon reacts with promoter in the mercury-containing gas to form a promoted sorbent when the HBr in the gas contacts the sorbent. It was well-known in the art that halogens (including bromine) “promoted” activated-carbon sorbents because they improved mercury removal by increasing the ability of the activated carbon to bind with the mercury. See §§ VII.D and VII.E. Lead inventor Dr. Olson admitted that, when bromides are added to coal “and activated carbon is injected downstream of the furnace,” then there would be “in-flight promotion.” EX1047, 231:3-9, 98:23-100:3. “[P]romotion” of activated carbon by halogens is a reaction. EX1083, 156 (labeled as limitation 24e, O’Keefe explaining how bromine containing ingredients added to coal would contact and react with sorbent), 160 (labeled as limitation 1c, O’Keefe explaining how activated carbon reacts with bromine). It follows the sorbent of Vosteen or Vosteen /Altman comprises bromine, sorbent and mercury when in-flight promotion occurs.

318. The reaction of hydrogen bromide with carbon in an activated carbon particle forms a carbocation oxidation site that accepts an electron from mercury adsorbed by the activated carbon particle, forming particulate-bound mercury. These reactions necessarily occur when the hydrogen bromide and mercury in flue gas contact activated carbon, as evidenced by “irreversible fixation of bromine giving a

stable carbon-bromine complex” with “complete substitution of hydrogen by bromine” when HBr reacts with carbon or charcoal. EX1050, 260.

319. Nelson explains “in exposing PAC to concentrated bromine gas, ... the bromine reacts with the carbon, forming surface compounds on ... the carbon. When the PAC is then injected into the flue gas, the elemental mercury and oxidized mercury species there appear to react with at least one form of the bromine-carbon surface compounds When the carbon particles are removed from the flue gas ... the mercury is removed with them.” EX1008, [0043]; EX1009, 4.

320. Because Vosteen, Altman and Nelson disclose every element of Claim 1 and Vosteen (as evidenced by Julien) and Nelson disclose contact of hydrogen bromide, mercury and activated carbon in flue gas, which would necessarily result in carbocations in the activated carbon of the mercury-sorbent accepting electrons from mercury atoms of the mercury-sorbent, 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 as evidenced by Julien for the reasons explained above in Paragraphs 315-319. EX1008, [0043]; EX1009, 4; EX1011, [0013]; EX1014, 1658; EX1047, 231:3-9, 98:23-100:3; EX1083, 156, 160.

4. Claim 6—“the additive is substantially in vapor form in the mercury-containing gas.”

321. 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. EX1014, 1658. It is therefore my opinion that HBr is contacted with sorbent in vapor form in the combination of Vosteen and Altman.

322. 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 vapor form 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 Claim 6 would have been obvious to a POSITA at the time of the invention in light of Vosteen combined with Altman for the reasons provided in Paragraph 321. EX1011, [0010]; EX1014, 1658.

5. Claim 8—“the additive is chosen from Br₂, HBr, sodium bromide, calcium bromide, and a combination thereof.”

323. 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.

324. 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].

325. 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.” *Id.*

326. 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].

327. 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.

328. Because the combination of Vosteen, Altman and Nelson discloses every element of Claim 1 and HBr, Br, and sodium bromide as additive to coal or the combustion chamber, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 8 would have been obvious to a POSITA at the time of the invention in light of Vosteen, Altman and Nelson for the reasons explained above in Paragraphs 323-327. EX1011, [0006]-[0007], [0013], [0047], Example 5, Claim 1.

6. Claim 11–“the activated carbon is chosen from powdered activated carbon, granular activated carbon, carbon black, carbon fiber, aerogel carbon, pyrolysis char, and combinations thereof.”

329. 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.

330. 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.

331. Because the combination of Vosteen, Altman and Nelson discloses every element of Claim 1 and a powdered form of activated carbon, 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, Altman and Nelson for the reasons explained above in Paragraphs 329-330. EX1007, 5:59-61; EX1011, [0019]; EX1008, [0040]; EX1009, 4.

7. **Claim 14—“contacting the sorbent material with a secondary component chosen from halogens, hydrogen halides, Group V halides, Group VI halides, and combinations thereof.”**

Claim 15—“the secondary component is chosen from halogens, halide salts, HI, HBr, HCl, and combinations thereof.”

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

333. Vosteen discloses that, in addition to the halogens added to the coal and/or the combustion chamber, “bromine and/or a bromine compound ... is fed to the if appropriate multistage furnace **and/or to the flue gas in a plant section downstream of the furnace.**” EX1011, cl. 1, [0006], [0013]; *see* [0014] (adding Br to “recirculated flue gas”); [0016] (also adding iodine). The bromine compound can be “an aqueous solution of hydrogen bromide or sodium bromide.” *Id.*, [0014].

334. Vosteen also discloses that “[i]odine compounds oxidize mercury more effectively compared with bromine compounds.... The iodine compound can be fed

... as a supplement to, or partial replacement of, the added bromine compound.” *Id.*, [0016]. The iodine compound can be iodine (I₂). *Id.*, claim 6.

335. Additional halogens injected into the flue gas are examples of a secondary material. The HBr or I₂ added by Vosteen to the flue gas or the HCl present in the flue gas would contact the sorbent in the flue gas before the sorbent is removed in a particulate removal device such as an ESP.

336. Because Vosteen, Altman and Nelson disclose every element of Claim 1 and Vosteen further teaches contacting the sorbent material with a secondary component chosen from halogens as required by Claims 14 and 15, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claims 14 and 15 would have been obvious to a POSITA at the time of the invention in light of Vosteen, Altman and Nelson for the reasons explained above in Paragraphs 332-335. EX1011, cl. 1, [0006], [0014], [0016].

XIII. GROUND 3 - CLAIMS 1-6, 8, 11 AND 14-15 ARE ANTICIPATED BY POLLACK

337. Based on my review of Pollack, and my education, skill, training, and experience in the relevant fields of emission reduction technology, it is my opinion that Claims 1-6, 8, 11 and 14-15 are anticipated by Pollack. In the subsections that

follow, I explain the bases for my opinion that Claims 1-6, 8, 11 and 14-15 are anticipated by Pollack.

A. Independent Claim 1

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

338. Pollack is titled “METHODS FOR REMOVAL OF MERCURY FROM FLUE GAS.” Pollack acknowledges that a significant fraction of mercury emissions in the U.S. come from coal burning electric utilities, and that the industry continues to develop systems to reduce mercury emissions by capturing mercury post-combustion so that it is not released into the atmosphere. EX1086, [0014].

339. Activated carbon injection is described by Pollack as “[o]ne of the most promising solutions.” *Id.*, [0015]. However, “short contact time between the activated carbon and the flue gas stream results in an inefficient use of the full adsorption capacity of the activated carbon.” *Id.* Pollack’s process utilizes both activated carbon and halogens or halides to optimize the feed rates of these components to remove mercury from flue gas. *Id.*, [0028]. After the activated carbon contacts the mercury and halogen or halide in the flue gas, it is collected in a baghouse or ESP. *Id.*, [0019], [0028].

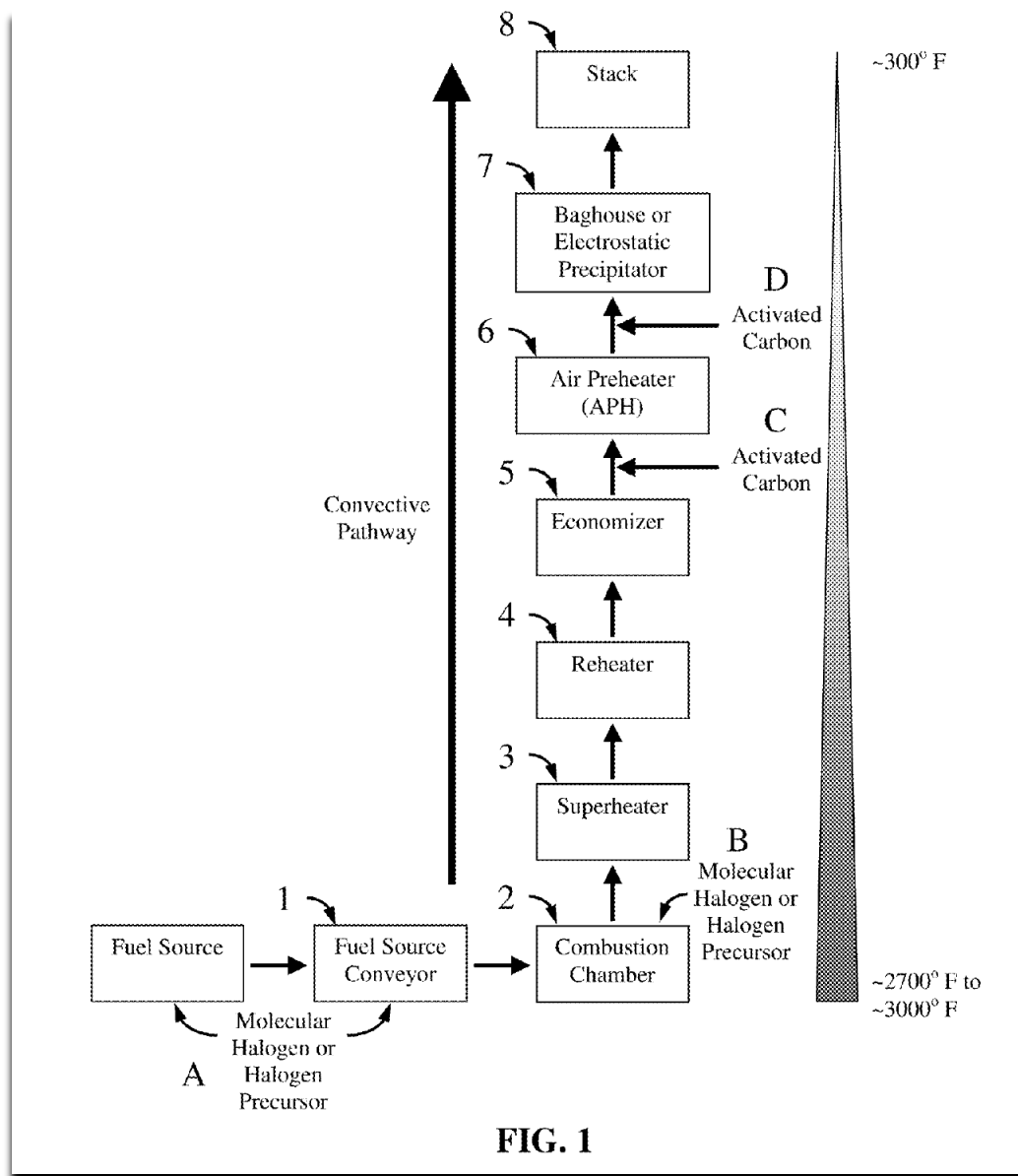
340. Pollack, in my opinion, discloses the preamble of claim 1 as Pollack describes methods for separating mercury from a mercury-containing gas, more

specifically a flue gas at a coal burning power plant for the reasons explained above in Paragraphs 338-339. EX1086, Title, [0014]-[0015], [0019], [0028].

2. Element 1(a)—“combusting a mixture of coal and an additive in a combustion chamber, to form the mercury-containing gas, wherein the additive is chosen from halides, halogens, salts thereof, and combinations thereof;”

341. Pollack discloses this claim limitation as well. More specifically, Pollack discloses a method for removing mercury from a flue gas by “**applying a molecular halogen or halogen precursor to the fuel source or introducing a molecular halogen or halogen precursor into a combustion chamber during combustion of the fuel source** or introducing a molecular halogen or halogen precursor into an exhaust stream resulting from the combustion of the fuel source ... and injecting sorbent material into the exhaust stream, i.e. flue gas, resulting from consumption of the fuel source.” *Id.*, [0016] (emphasis added). The fuel source can be coal. *Id.*, [0018].

342. Pollack’s Figure 1 depicts a coal fired power plant having a conveyor 1 for delivering coal into a furnace or combustion chamber 2. *Id.* See locations A and B of Figure 1 as shown below.



343. The molecular halogen includes bromine gas and the halogen precursors can be hydrogen bromide, sodium bromide and calcium bromide. *Id.*, [0021], [0035]. “[O]ne or more halogen precursors may be applied to the fuel source, introduced into the combustion chamber, injected into the exhaust stream near the combustion chamber, or a combination thereof.” *Id.*, [0020].

344. Pollack, in my opinion, discloses combusting a mixture of coal and an additive in a combustion chamber, to form the mercury-containing gas, wherein the additive is chosen from halides, halogens, salts thereof, and combinations thereof for the reasons explained above in Paragraphs 341-343. EX1086, [0016], [0018], [0020]-[0021], [0035], Figure 1.

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

Element 1(d)–“contacting mercury in the mercury-containing gas with the sorbent material, to form a mercury-sorbent; and”

2. **Element 1(e)–“separating the mercury-sorbent from the mercury-containing gas.”**

345. 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 ‘370 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.

‘370 Patent, 7:49-57.

346. With respect to activated carbon injection, Pollack discloses a method for removing mercury from a flue gas which includes “injecting sorbent material into the exhaust stream, i.e. flue gas, resulting from consumption of the fuel source.”

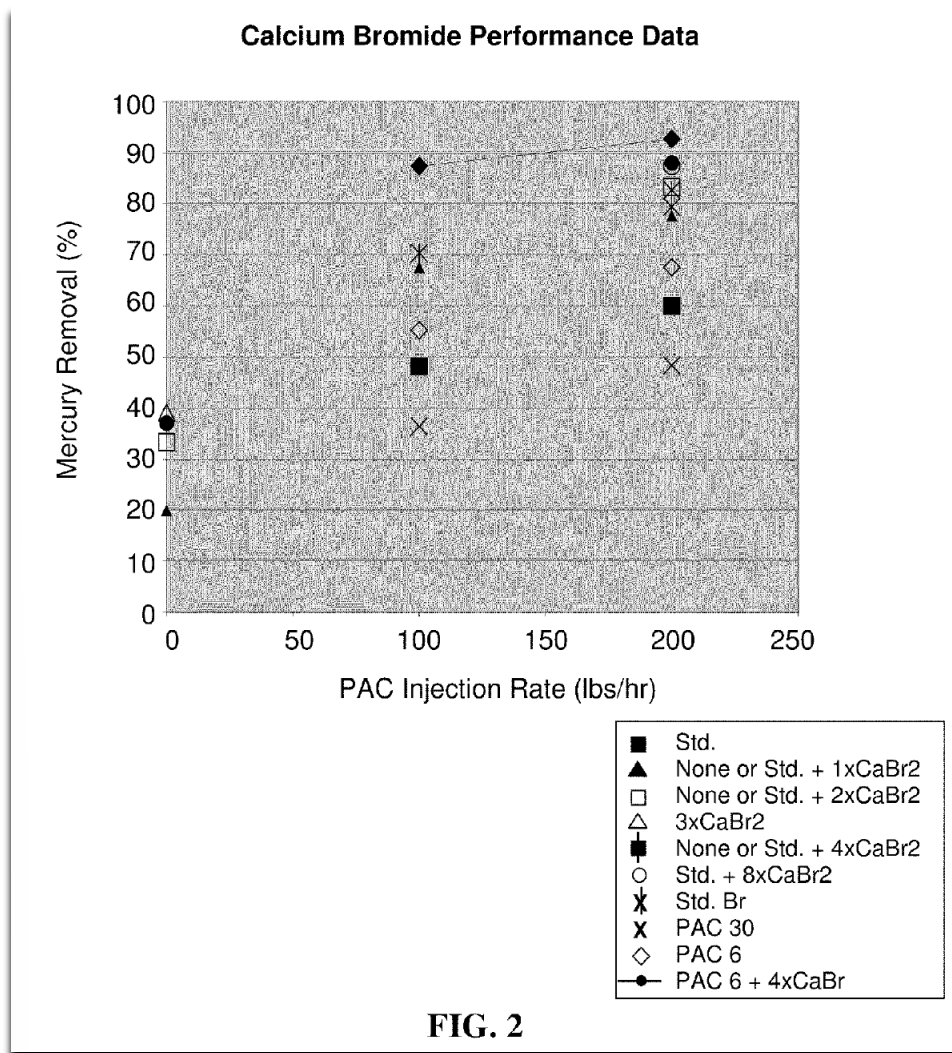
Id., [0016]. The fuel source can be coal. *Id.*, [0018]. “[O]xidized heavy metals, such as mercuric halide species ... may be adsorbed by activated carbon.” *Id.*, [0028].

347. In Pollack’s Figure 1 as shown above, ash and combustion gas leave the combustion chamber and are fed into a “baghouse or electrostatic precipitator 7 where particulate matter is collected.” *Id.*

348. Sorbent is introduced at locations C and/or D upstream of the baghouse or ESP 7 as shown in Figure 1. *Id.*, [0019]. The sorbent can be activated carbon of any size, such as those having a “mean particle diameter (MPD) of about 0.1 μm to about 100 μm .” *Id.*, [0031]. The sorbent can be untreated or treated with a halogen before it is injected into the combustion gas. *Id.*, [0032]. The combustion gas and sorbent are fed into the “baghouse or electrostatic precipitator 7 where particulate matter is collected.” *Id.*, [0028].

349. “[M]ercury emissions from the plant employing such methods and systems may be reduced by greater than about 80% and in some embodiments, greater than 90%.” *Id.*, [0035], [0038]. “[M]ercury emissions can be monitored once an hour to ensure compliance with government regulations and to adjust the rate of halogen precursor introduction into the combustion chamber, the rate of sorbent material injection, or both.” *Id.*, [0039].

350. Pollack's examples vary the feed rate of calcium bromide, the injection rate of activated carbon, and the mean particle diameter of activated carbon to determine how these combinations improve reduction in mercury emissions. *Id.*, [0042]-[0043]. Figure 2 depicts how mercury removal percentage increases as a function of increasing PAC injection rate as shown below.



351. Pollack, in my opinion, discloses adding a particulate sorbent material comprising activated carbon into the mercury-containing gas, contacting mercury in

the mercury-containing gas with the sorbent material, to form a mercury-sorbent, and separating the mercury-sorbent from the mercury-containing gas for the reasons explained above in Paragraphs 345-350. EX1086, [0016], [0018]-[0019], [0028], [0031]-[0032], [0035], [0038]-[0039], [0042]-[0043], Figures 1-2.

3. Element 1(c)-“ wherein a weight ratio of the additive added to the coal, added to the combustion chamber, or a combination thereof, to an amount of the sorbent material added to the mercury-containing gas is from about 1:100 to about 30:100;”

352. Claim 1 requires a weight ratio of the additive (as added to the coal, combustion chamber or both) to the sorbent (as added to the mercury-containing gas). As discussed above, my review of the ‘970 Application does not reveal a disclosure of this ratio anywhere in the ‘970 Application for the ‘370 Patent. It is the promoted sorbent (not the amount of additive added to the coal or combustion chamber relative to the amount of the sorbent added to the flue gas) that is described as comprising about 1-30g promoter per 100g base sorbent. EX1025, 4:19-23; 5:14-15; 6:22-26; 7:14-24; 16:28-30; 31:30-32:2; 38:23-25; 40:16-18; 41:1-3, 11-13, 28-29; 54:6-8; EX1001, 3:21-23, 54-56; 4:42-47; 5:6-20; 11:1-3; 20:34-37; 24:55-57; 25:45-48, 64-67; 26:8-11, 26-28; 33:56-59.

353. In my opinion, the sorbent of Claim 1 can be a promoted sorbent or an unpromoted sorbent when it is added into the mercury-containing gas.

354. In considering the relative amounts of bromine to sorbent for Claim 1, Pollack discloses that halogen precursor can be applied at a rate to provide about 125 ppm (dry basis) of bromine to the coal (*i.e.*, about 10 gal/hr of a 50% by weight aqueous solution of calcium bromide). EX1086, [0025]. Pollack also discloses that the injection rate of the sorbent will ‘vary depending upon the flow rate of the exhaust gas in the ductwork’ and describes a rate of 2.5 lbs PAC/MMacf in Example 2. *Id.*, [0034], Table 3.

355. The ratio of these Br- and sorbent concentrations of Pollack is within the claimed range. Pollack discloses adding 125 ppm (dry basis) of bromine to the coal and injecting about 2.5 lb/MMacf of activated carbon sorbent into the flue gas. Dividing these concentrations and unit conversions yields a weight ratio of the additive added to the coal to an amount of sorbent added to the mercury-containing flue gas of about 25:100, which is within the claimed range of about 1:100 to about 30:100.

356. More particularly in order to determine a ratio of bromine concentration in the flue gas to activated carbon in the flue gas, the concentrations must have the same units—such as grams per actual cubic feet (acf) or pounds per million actual cubic feet (MMacf). Pollack provides the concentration of bromine to coal, which can be converted to a concentration of bromine in the flue gas. Activated-carbon injection concentrations were typically provided in pounds (lbs.) per million actual

cubic feet (MMacf) of flue gas, as in Pollack. Converting between the two would have been a routine calculation for a POSITA and would have involved such basic concepts as the ideal gas law (to convert concentrations between temperatures and pressures), which is taught in first semester undergraduate chemistry. Such unit conversion would have also involved basic engineering knowledge of a power-plant operation as well-known to a POSITA, such as typical flue gas temperature, pressure, and moisture content.

357. The concentration of Br in the mercury-containing gas is estimated for typical parameters for firing Powder River Basin (PRB) subbituminous coal in full-scale utility boilers beginning with the Br loading on coal. For a value of 125 ppm Br on coal from Pollack,³ the equivalent concentration of Br in flue gas can be calculated as follows:

$$\frac{125 \text{ g Br}}{10^6 \text{ g coal}} = 1.25 \times 10^{-4} \frac{\text{g Br}}{\text{g coal}}$$
$$1.25 \times 10^{-4} \frac{\text{g Br}}{\text{g coal}} \times \frac{1 \text{ g coal}}{10 \text{ g flue gas}} = 1.25 \times 10^{-5} \frac{\text{g Br}}{\text{g flue gas}}$$

³ Pollack discloses the units of “ppm.” A POSITA would have understood this to refer to ppm by weight, rather than on a molar basis, because the comparison is with respect to coal.

358. The above ratio of 10 grams flue gas per gram coal is a nominal value for subbituminous coals fired at 15 – 20 % excess air, and representative of the typical firing practices at coal-fired utility boilers. (In other words, combustion of 1 gram of subbituminous coal can be expected to provide approximately 10 grams flue gas). The molecular weight of flue gas is typically between 28-32 grams per mole (depending on the type of coal and amount of excess air), because flue gas is primarily: molecular nitrogen (molecular weight of 28, from excess air), carbon dioxide (molecular weight of 44), water (molecular weight of 18), and excess oxygen (molecular weight of 32). Accordingly, a typical value for the molecular weight of flue gas is 30 g/mol.

$$1.25 \times 10^{-5} \frac{\text{g Br}}{\text{g flue gas}} \times \frac{30 \text{ g flue gas}}{\text{mol flue gas}} = 3.75 \times 10^{-4} \frac{\text{g Br}}{\text{mol flue gas}}$$

359. Regarding the second conversion, a POSITA would have understood from the ideal gas law ($PV = nRT$) that the density of a gas is proportional to pressure and inversely proportional to temperature. A POSITA would have known that a typical flue gas temperature where sorbent would be injected is 150 °C (413 K) and 1 atm of pressure. In fact, Pollack discloses a temperature of less than about 350°F (176 °C or 449 K). EX1086, [0033]. A POSITA would have understood that this temperature is a typical value for sorbent injection downstream of an air preheater and upstream of an ESP or fabric filter. A POSITA would have known that air

preheaters typically do not operate with outlet gas temperatures below the acid dew points of sulfuric acid, which are given as 120–150 °C. This dewpoint range restricts the outlet temperatures to somewhat hotter values like 150 °C. Thus, a temperature of 448 Kelvin (175 °C) is used for the calculations, as this temperature is “less than about 350°F” as disclosed by Pollack.

$$\frac{3.75 \times 10^{-4} \text{ g Br}}{\text{mol flue gas}} \times \frac{1 \text{ atm}}{(448\text{K})(0.082058 \text{ L atm}/(\text{mol K}))(1 \text{ acf}/28.3 \text{ L})} \times \frac{10^6 \text{ acf}}{\text{MMacf}} \\ = 288.5 \frac{\text{g Br}}{\text{MMacf flue gas}}$$

360. A POSITA would convert pounds activated carbon to grams activated carbon (and vice versa) through the well-known unit conversion of 453.6 grams per pound. For an injection concentration of 2.5 lb PAC/MMacf (as disclosed in Pollack), the concentration of PAC in the flue gas can be calculated in grams as shown below. EX1086, Table 3.

$$\frac{2.5 \text{ pounds PAC}}{\text{MMacf}} \times \frac{453.6 \text{ g}}{\text{pound}} = 1,134 \frac{\text{g PAC}}{\text{MMacf}}$$

361. The estimated concentration of Br in flue gas is 288.5 g Br/MMacf flue gas. For an injection concentration of 2.5 lb PAC/MMacf, the concentration of PAC in the flue gas is 1,134 g PAC/MMacf flue gas. Dividing these two rates derived from the bromine addition rate of Pollack and the activated carbon injection rate of Pollack provides a mercury-containing gas that comprises about 25 grams of the

element bromine per 100 grams of activated-carbon sorbent. Thus, these two disclosed halogen and sorbent concentrations from Pollack result in a weight ratio of the additive added to the coal to an amount of sorbent added to the mercury-containing flue gas of about 25:100, which is within the claimed range of about 1:100 to about 30:100.

362. Pollack discloses that, the feed rate for “a solution of a halogen precursor may be significantly reduced by combining the application of a halogen containing composition with injection of sorbent material into the fluid stream of the combustion gases.” *Id.* [0028].

363. 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.

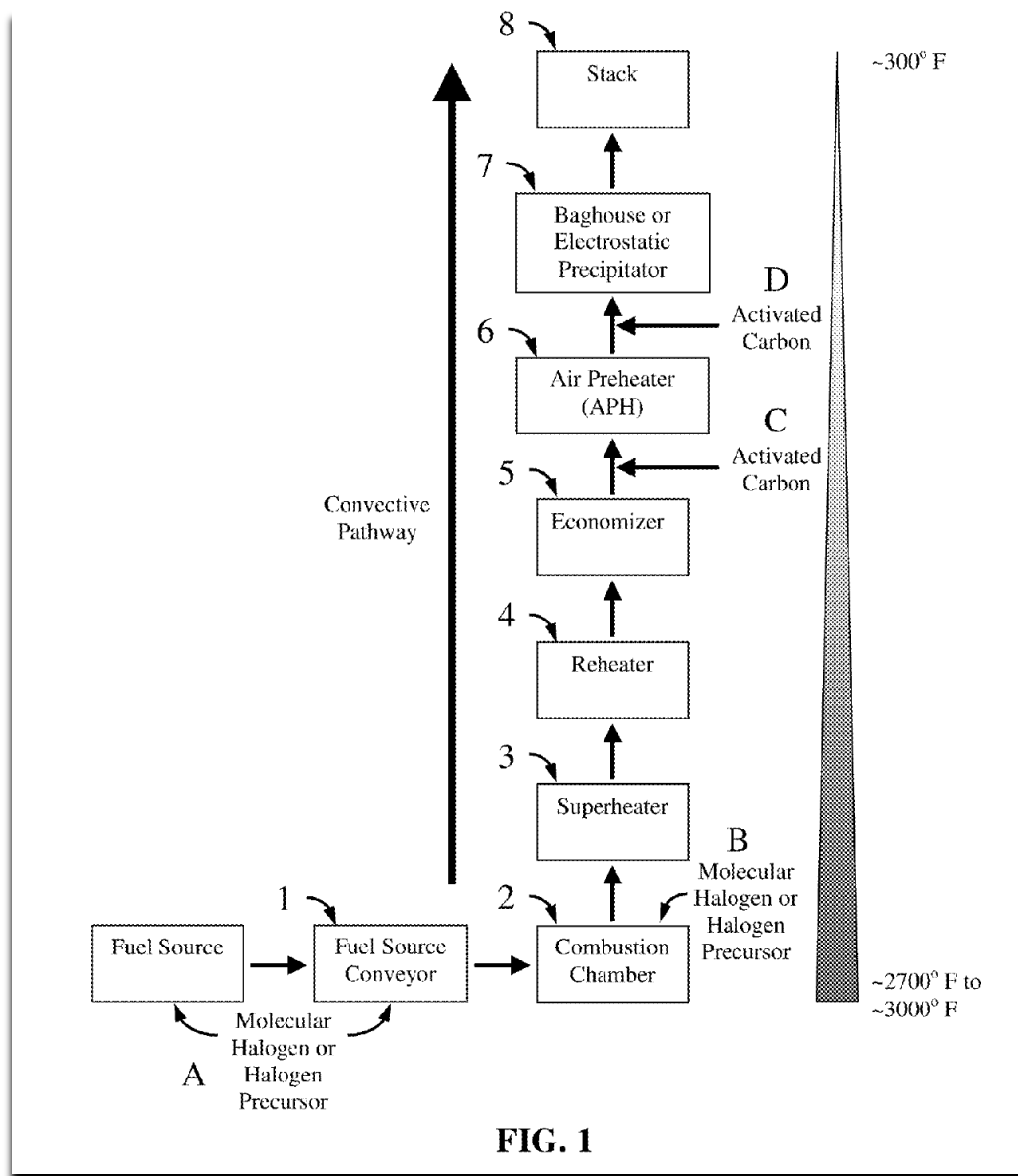
364. Because Pollack discloses elements 1(preamble)-1(b) and 1(d)-1(e) of Claim 1, and Pollack discloses relative amounts of calcium bromide added to coal and sorbent added into the mercury-containing gas within the claimed weight ratio range as specified by element 1(c), it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 1 is anticipated by Pollack for the reasons explained above in Paragraphs 338-363. EX1086, [0025], [0034], Table 3; EX1083, 153.

B. Claims Depending From Claim 1

1. Claim 2—“ adding the additive to the coal before combusting the coal.”

365. I discussed this claim element above regarding claim element 1(a). Pollack discloses this claim element.

366. As discussed above regarding claim element 1(a), Pollack discloses a method for removing mercury from a flue gas by “applying a molecular halogen or halogen precursor to the fuel source or introducing a molecular halogen or halogen precursor into a combustion chamber during combustion of the fuel source or introducing a molecular halogen or halogen precursor into an exhaust stream resulting from the combustion of the fuel source ... and injecting sorbent material into the exhaust stream, i.e. flue gas, resulting from consumption of the fuel source.” EX1086, [0016]. The fuel source can be coal. *Id.*, [0018]. Pollack’s Figure 1 depicts a coal fired power plant having a conveyor 1 for delivering coal into a furnace or combustion chamber 2. *Id.* See locations A and B of Figure 1 as shown below.



367. Because Pollack discloses every element of Claim 1 and specifically teaches that the halogen 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 Pollack anticipates Claim

2 for the reasons explained above in Paragraphs 365-366. EX1086, [0016], [0018], Figure 1.

2. Claim 3—“the additive mixed with the coal is in a liquid.”

Claim 4—“the liquid is a hydrocarbon, supercritical carbon dioxide, water, salt solution, or a combination thereof.”

368. Pollack discloses that the “halogen precursor may be ... a liquid ... in some embodiments, the halogen precursor may be an aqueous solution that can be sprayed onto the fuel source such as coal before combustion” before it is conveyed to the combustion chamber. EX1086, [0018], [0023]. Pollack describes, for example, a 50% by weight aqueous solution of calcium bromide (CaBr_2) as a halogen precursor. *Id.*, [0024]-[0025]. Examples 1-2 disclose application of a calcium bromide solution to coal.

369. Because Pollack discloses every element of Claim 1 and specifically teaches spraying an aqueous solution of a calcium bromide additive onto the coal before it is conveyed 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 Pollack anticipates Claims 3 and 4 for the reasons explained above in Paragraph 368. EX1086, [0018], [0023]-[0025].

3. Claim 5—“carbocations in the activated carbon of the mercury-sorbent accept electrons from mercury atoms of the mercury-sorbent.”

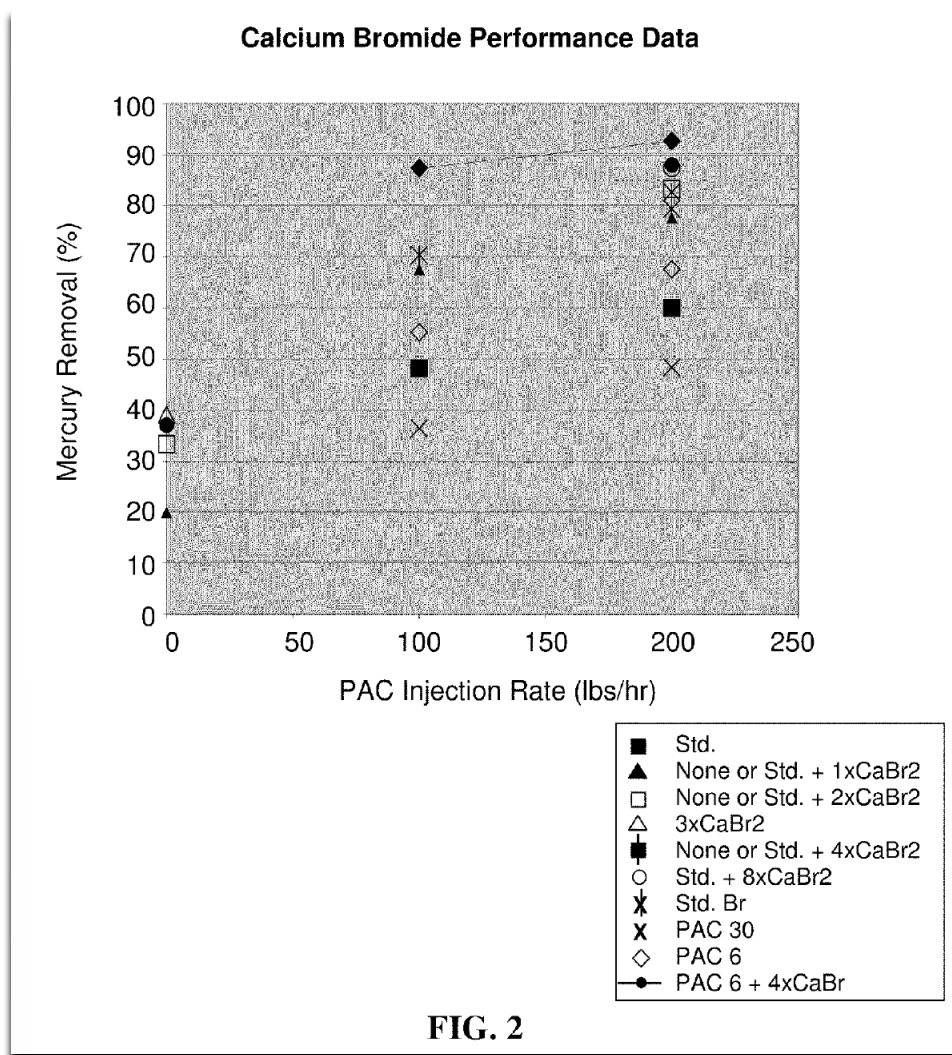
370. With respect to activated carbon injection, Pollack discloses a method for removing mercury from a flue gas which includes “injecting sorbent material into the exhaust stream, i.e. flue gas, resulting from consumption of the fuel source.” EX1086, [0016]. The fuel source can be coal. *Id.*, [0018]. “[O]xidized heavy metals, such as mercuric halide species ... may be adsorbed by activated carbon.” *Id.*, [0028].

371. In Pollack’s Figure 1 as shown above, ash and combustion gas leave the combustion chamber and are fed into a “baghouse or electrostatic precipitator 7 where particulate matter is collected.” *Id.*

372. Sorbent is introduced at locations C and/or D upstream of the baghouse or ESP 7 as shown in Figure 1. *Id.*, [0019]. The sorbent can be activated carbon of any size, such as those having a “mean particle diameter (MPD) of about 0.1 μm to about 100 μm .” *Id.*, [0031]. The sorbent can be untreated or treated with a halogen before it is injected into the combustion gas. *Id.*, [0032].

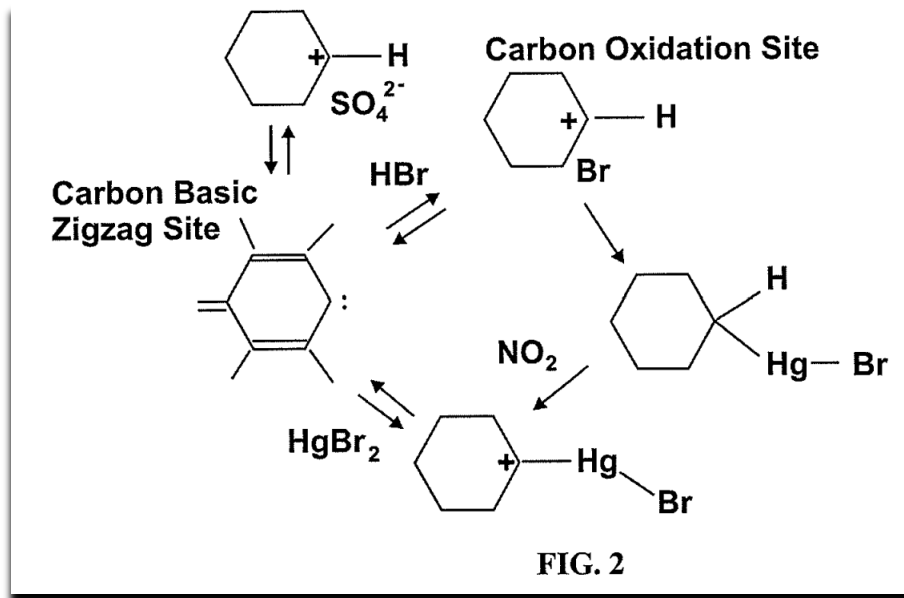
373. “[M]ercury emissions from the plant employing such methods and systems may be reduced by greater than about 80% and in some embodiments, greater than 90%.” *Id.*, [0035], [0038]. “[M]ercury emissions can be monitored once an hour to ensure compliance with government regulations and to adjust the

rate of halogen precursor introduction into the combustion chamber, the rate of sorbent material injection, or both.” *Id.*, [0039]. Pollack’s examples vary the feed rate of calcium bromide, the injection rate of activated carbon, and the mean particle diameter of activated carbon to determine the combinations that improve reduction in mercury emissions. *Id.*, [0042]-[0043]. Figure 2 depicts how mercury removal percentage increases as a function of increasing PAC injection rate as shown below.



374. It was well-known in the art that halogens (including bromine) “promoted” activated-carbon sorbents because they improved mercury removal by increasing the ability of the activated carbon to bind with the mercury. See §§ VII.D and VII.E. Lead inventor Dr. Olson admitted that, when bromides are added to coal “and activated carbon is injected downstream of the furnace,” then there would be “in-flight promotion.” EX1047, 231:3-9, 98:23-100:3. “[P]romotion” of activated carbon by halogens is a reaction. EX1083, 156 (labeled as limitation 24e, O’Keefe explaining how bromine containing ingredients added to coal would contact and react with sorbent), 160 (labeled as limitation 1c, O’Keefe explaining how activated carbon reacts with bromine). It follows the sorbent of Pollack comprises bromine, sorbent and mercury when in-flight promotion occurs.

375. The reaction of hydrogen bromide with carbon in an activated carbon particle forms a carbocation oxidation site that accepts an electron from mercury adsorbed by the activated carbon particle, forming particulate-bound mercury. These reactions necessarily occur when the hydrogen bromide and mercury in flue gas contact activated carbon, as evidenced by the carbon-bromine complex labelled as “Carbon Oxidation Site” in Olson-235’s depiction of the “mechanistic model of the chemical reactions resulting in the oxidation and capture of mercury” in Figure 2 as shown below.



EX1013, Figure 2. It follows that Claim 5 is inherent and necessarily results from the contact of the hydrogen bromide, mercury and activated carbon in the flue gas.

376. Because Pollack discloses every element of Claim 1 and Pollack discloses contact of hydrogen bromide, mercury and activated carbon in flue gas, which would necessarily result in carbocations in the activated carbon of the mercury-sorbent accepting electrons from mercury atoms of the mercury-sorbent, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Pollack anticipates Claim 5 for the reasons explained above in Paragraphs 370-375. EX1086, [0016], [0018]-[0019], [0028], [0031]-[0032], [0035], [0038]-[0039], [0042]-[0043], Figure 2; EX1047, 231:3-9, 98:23-100:3; EX1083, 156, 160.

4. Claim 6—“the additive is substantially in vapor form in the mercury-containing gas.”

377. Pollack discloses that the “molecular halogen ... such as bromine gas ... can be injected into the exhaust stream near the combustion chamber.” EX1086, [0020]. Pollack also describes that the “halogen precursor may be a gaseous precursor such as, for example, ... hydrogen bromide.” Id., [0021], [0024]. Thus, Pollack discloses gaseous forms of the additive in the flue gas.

378. Because Pollack discloses every element of Claim 1 and specifically teaches that the halide or halogen additive is substantially in vapor form in 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 Pollack anticipates Claim 6 for the reasons provided in Paragraph 377. EX1086, [0020]-[0021], [0024].

5. Claim 8—“the additive is chosen from Br₂, HBr, sodium bromide, calcium bromide, and a combination thereof.”

379. Pollack describes that the “halogen precursor may be a gaseous precursor such as, for example, hydrogen chloride, **hydrogen bromide, or molecular** chloride or **bromide**.... Non-limiting examples of inorganic halogen salts including alkali metal and alkali earth metal counterions include ... **calcium bromide, ...sodium bromide**....” EX1086, [0021] (emphasis added), [0035]. “[O]ne or more halogen precursors may be applied to the fuel source, introduced

into the combustion chamber, injected into the exhaust stream near the combustion chamber, or a combination thereof.” *Id.*, [0020].

380. Pollack describes, for example, a 50% by weight aqueous solution of calcium bromide (CaBr) as a halogen precursor. *Id.*, [0024]-[0025]. Examples 1-2 disclose application of a calcium bromide solution to coal.

381. Because Pollack discloses every element of Claim 1 and specifically teaches that the additive is chosen from one or more of Br₂, HBr, sodium bromide, or calcium bromide, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Pollack anticipates Claim 8 for the reasons explained above in Paragraphs 379-380. EX1086, [0020]-[0021], [0024]-[0025], [0035], Examples 1-2.

6. Claim 11—“the activated carbon is chosen from powdered activated carbon, granular activated carbon, carbon black, carbon fiber, aerogel carbon, pyrolysis char, and combinations thereof.”

382. Pollack discloses that “Activated carbon may be used in any embodiment. In such embodiments, the activated carbon may be obtained from any source and can be made from a variety of starting materials.” *Id.*, [0029]. “The carbonaceous material may be processed into carbon adsorbents by any conventional thermal or chemical method known in the art.” *Id.*, [0029]. Pollack’s sorbent can be activated carbon of any size, such as those having a “mean particle diameter (MPD)

of about 0.1 μm to about 100 μm .” EX1086, [0031]. Examples 1-2 tested “various powdered activated carbons (PACs)” at a “coal-fired power plant fitted with a system to add calcium bromide onto the coal prior to the combustion chamber and lances for injecting activated carbon into the ductwork of the power plant.” *Id.*, [0041]-[0043]. In Example 2, PAC was used to “remove 90% of the flue gas mercury.” *Id.*, [0043].

383. Because Pollack discloses every element of Claim 1 and specifically teaches that the activated carbon is powdered activated carbon, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Pollack anticipates Claim 11 for the reasons explained above in Paragraph 382. EX1086, [0029], [0031], [0041]-[0043].

7. Claim 14—“contacting the sorbent material with a secondary component chosen from halogens, hydrogen halides, Group V halides, Group VI halides, and combinations thereof.”

Claim 15—“the secondary component is chosen from halogens, halide salts, HI, HBr, HCl, and combinations thereof.”

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

385. Pollack discloses a method for removing mercury from a flue gas by “applying a molecular halogen or halogen precursor to the fuel source or introducing a molecular halogen or halogen precursor into a combustion chamber during combustion of the fuel source **or introducing a molecular halogen or halogen precursor into an exhaust stream resulting from the combustion of the fuel source ... and injecting sorbent material into the exhaust stream, i.e. flue gas, resulting from consumption of the fuel source.**” EX1086, [0016] (emphasis added). The fuel source can be coal. *Id.*, [0018]. Thus, the molecular halogen or halogen precursor would contact the sorbent material since both are introduced into the flue gas.

386. “[O]ne or more halogen precursors may be applied to the fuel source, introduced into the combustion chamber, **injected into the exhaust stream near the combustion chamber, or a combination thereof.**” *Id.*, [0020] (emphasis added). Thus, Pollack describes adding a halogen to coal or the combustion chamber **while also** injecting the halogen into the flue gas.

387. Pollack describes that the “halogen precursor may be a gaseous precursor such as, for example, **hydrogen chloride, hydrogen bromide, or molecular chloride or bromide...** the halogen precursor may be one or more inorganic halogen salts, which for bromine may include bromides, ... for iodine may

include iodides, ... and for chlorine may be chlorides.” *Id.*, [0021] (emphasis added).

388. Because Pollack discloses every element of Claim 1 and that HBr, HCl, Br₂ or Cl₂ can be added both to the coal or combustion chamber and to the mercury-containing flue gas where the HBr, HCl, Br₂ or Cl₂ contacts the sorbent, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Pollack anticipates Claims 14 and 15 for the reasons explained above in Paragraphs 384-387. EX1086, [0016], [0018], [0020]-[0021].

XIV. GROUND 4: CLAIMS 1–6, 8, 11 AND 14-15 ARE OBVIOUS OVER POLLACK, POLLACK AND OLSON-235 OR POLLACK AND NELSON

389. For the reasons explained with respect to Ground 3 above, it is my opinion that Pollack anticipates Claims 1-6, 8, 11 and 14-15 of the ‘370 Patent. 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 Pollack. In the subsections that follow, I explain additional bases for my opinion that Claims 1, 5 and 6 would have been obvious to a POSITA at the time of the invention in light of Pollack, Pollack and Olson-235 or Pollack and Nelson.

A. A POSITA Would Have Been Motivated to Combine Pollack with Olson-235 or Nelson

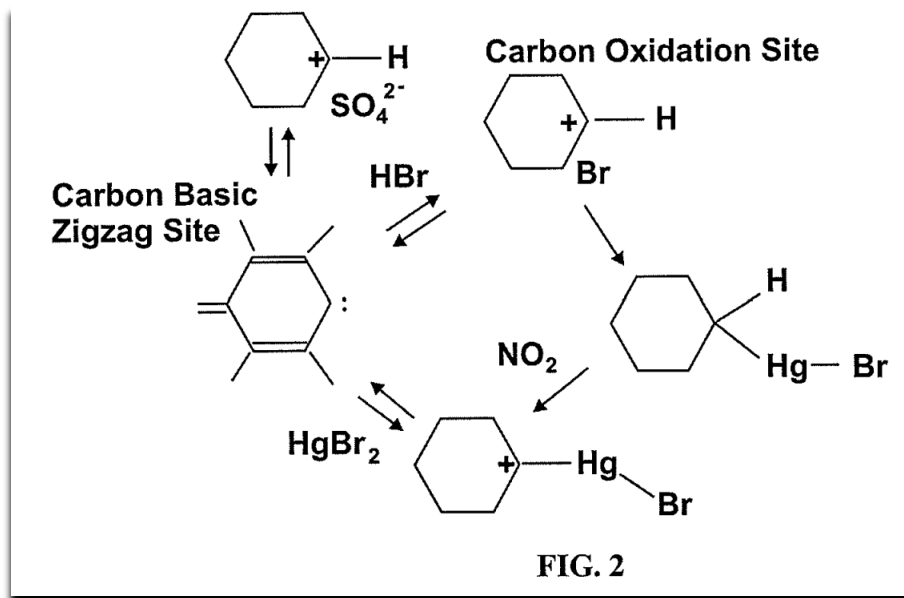
390. In my opinion, a POSITA would have been motivated to combine Pollack with Olson-235 or Nelson because each reference relates to mercury removal from coal-fired boilers using particulate control devices such as ESPs to collect powdered activated carbon (PAC) or promoted PAC after it has adsorbed mercury. Pollack, Olson-235, and Nelson are thus analogous art to the '370 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 Pollack with Olson-235 or Nelson incorporates prior art elements according to known activated carbon injection (ACI) methods to yield predictable results in removing mercury from flue gas.

391. With respect to activated carbon injection, Pollack discloses a method for removing mercury from a flue gas which includes “injecting sorbent material into the exhaust stream, i.e. flue gas, resulting from consumption of the fuel source.” *Id.*, [0016]. The fuel source can be coal. *Id.*, [0018]. “[O]xidized heavy metals, such as mercuric halide species ... may be adsorbed by activated carbon.” *Id.*, [0028].

392. Olson-235 discloses an embodiment wherein “the injected sorbent is prepared in-flight by reacting a base sorbent (carbon, non-carbon or their

combination) and a promoter within a pneumatic transport line from which the reaction product is injected to the mercury-containing flue gas stream.” EX1013, 5:43–48.

393. Olson depicts the “mechanistic model of the chemical reactions resulting in the oxidation and capture of mercury” in Figure 2 as shown below.



Olson-235 explains that

x-ray photoelectron spectroscopy has established that the addition of bromine, chlorine, HBr, or HCl formed a chemical compound in the carbon structure. Thus the promoted sorbent produced from halogen and base sorbent does not represent a molecular halogen form, but rather a new chemically modified structure.... **In the case of bromine, modified cationic carbon has a high chemical potential for oxidation of mercury.** Thus an entirely new model is presented for the reactivity of the bromine-treated carbon with mercury shown in FIG. 2.... **Halogen treatment resulted in higher-activity carbons because halide anions (especially bromide and iodide) were effective in promoting oxidation by stabilizing the developing positive charge on the mercury in the transition state for oxidation.**

EX1013, 16:49-17:4 (emphasis added).

394. 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. Nelson explains “in exposing PAC to concentrated bromine gas, ... the bromine reacts with the carbon, forming surface compounds on ... the carbon. When the PAC is then injected into the flue gas, the elemental mercury and oxidized mercury species there appear to react with at least one form of the bromine-carbon surface compounds When the carbon particles are removed from the flue gas ... the mercury is removed with them.” EX1008, [0043]; EX1009, 4.

395. In my opinion, a POSITA with knowledge of these disclosures of Nelson and Olson-235, would have known that the reaction of hydrogen bromide with carbon in Pollack’s activated carbon particle forms a carbocation oxidation site that accepts an electron from mercury adsorbed by the activated carbon particle, forming particulate-bound mercury. These reactions necessarily occur when the hydrogen bromide and mercury in flue gas contact activated carbon.

396. Nelson's sorbent injection rates are about 2, 4, 6 or 7 lbs PAC/MMacf. EX1008, Figure 14. A POSITA thus would have been motivated to use PAC sorbents at the 7 lbs PAC/MMacf sorbent injection rate of Nelson with the systems and processes of Pollack as this injection rate increased the mercury removal capabilities of the system.

B. Independent Claim 1

1. Claim Element 1(Preamble)—“ A method for separating mercury from a mercury-containing gas, the method comprising:”

397. Pollack is titled “METHODS FOR REMOVAL OF MERCURY FROM FLUE GAS.” Pollack acknowledges that a significant fraction of mercury emissions in the U.S. come from coal burning electric utilities, and that the industry continues to develop systems to reduce mercury emissions by capturing mercury post-combustion so that it is not released into the atmosphere. EX1086, [0014].

398. Activated carbon injection is described by Pollack as “[o]ne of the most promising solutions.” *Id.*, [0015]. However, “short contact time between the activated carbon and the flue gas stream results in an inefficient use of the full adsorption capacity of the activated carbon.” *Id.* Pollack's process utilizes both activated carbon and halogens or halides to optimize the feed rates of these components to remove mercury from flue gas. *Id.*, [0028]. After the activated

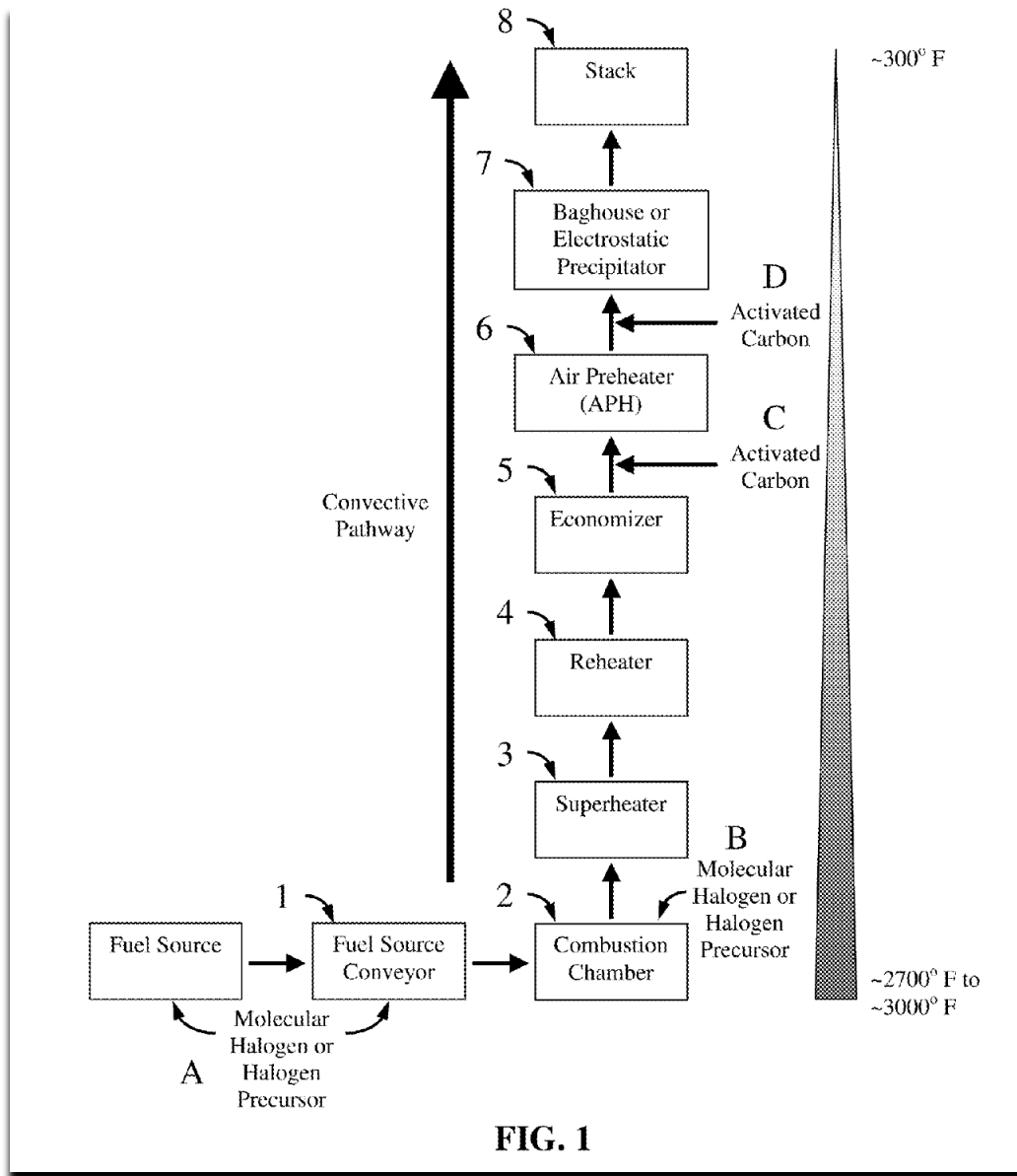
carbon contacts the mercury and halogen or halide in the flue gas, it is collected in a baghouse or ESP. *Id.*, [0019], [0028].

399. Pollack, in my opinion, discloses the preamble of claim 1 as Pollack describes methods for separating mercury from a mercury-containing gas, more specifically a flue gas at a coal burning power plant for the reasons explained above in Paragraphs 397-398. EX1086, Title, [0014]-[0015], [0019], [0028].

2. Element 1(a)—“combusting a mixture of coal and an additive in a combustion chamber, to form the mercury-containing gas, wherein the additive is chosen from halides, halogens, salts thereof, and combinations thereof;”

400. Pollack discloses this claim limitation as well. More specifically, Pollack discloses a method for removing mercury from a flue gas by **“applying a molecular halogen or halogen precursor to the fuel source or introducing a molecular halogen or halogen precursor into a combustion chamber during combustion of the fuel source** or introducing a molecular halogen or halogen precursor into an exhaust stream resulting from the combustion of the fuel source ... and injecting sorbent material into the exhaust stream, i.e. flue gas, resulting from consumption of the fuel source.” *Id.*, [0016] (emphasis added). The fuel source can be coal. *Id.*, [0018].

401. Pollack's Figure 1 depicts a coal fired power plant having a conveyor 1 for delivering coal into a furnace or combustion chamber 2. *Id.* See locations A and B of Figure 1 as shown below.



402. The molecular halogen includes bromine gas and the halogen precursors can be hydrogen bromide, sodium bromide and calcium bromide. *Id.*,

[0021], [0035]. “[O]ne or more halogen precursors may be applied to the fuel source, introduced into the combustion chamber, injected into the exhaust stream near the combustion chamber, or a combination thereof.” *Id.*, [0020].

403. Pollack, in my opinion, discloses combusting a mixture of coal and an additive in a combustion chamber, to form the mercury-containing gas, wherein the additive is chosen from halides, halogens, salts thereof, and combinations thereof for the reasons explained above in Paragraphs 400-402. EX1086, [0016], [0018], [0020]-[0021], [0035], Figure 1.

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

Element 1(d)–“contacting mercury in the mercury-containing gas with the sorbent material, to form a mercury-sorbent; and”

4. **Element 1(e)–“separating the mercury-sorbent from the mercury-containing gas.”**

404. 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 ‘370 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.

‘370 Patent, 7:49-57.

405. With respect to activated carbon injection, Pollack discloses a method for removing mercury from a flue gas which includes “injecting sorbent material into the exhaust stream, i.e. flue gas, resulting from consumption of the fuel source.” *Id.*, [0016]. The fuel source can be coal. *Id.*, [0018]. “[O]xidized heavy metals, such as mercuric halide species ... may be adsorbed by activated carbon.” *Id.*, [0028].

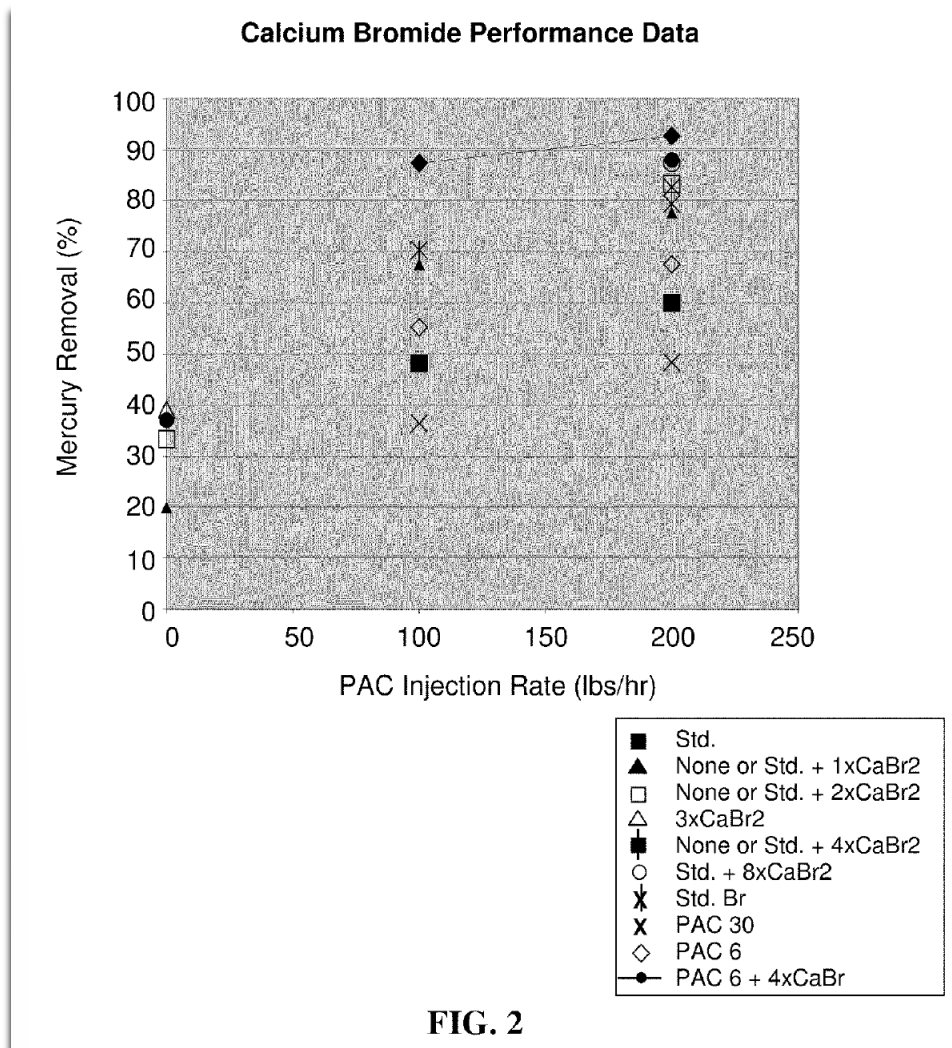
406. In Pollack’s Figure 1 as shown above, ash and combustion gas leave the combustion chamber and are fed into a “baghouse or electrostatic precipitator 7 where particulate matter is collected.” *Id.*

407. Sorbent is introduced at locations C and/or D upstream of the baghouse or ESP 7 as shown in Figure 1. *Id.*, [0019]. The sorbent can be activated carbon of any size, such as those having a “mean particle diameter (MPD) of about 0.1 μm to about 100 μm .” *Id.*, [0031]. The sorbent can be untreated or treated with a halogen before it is injected into the combustion gas. *Id.*, [0032]. The combustion gas and sorbent are fed into the “baghouse or electrostatic precipitator 7 where particulate matter is collected.” *Id.*, [0028].

408. “[M]ercury emissions from the plant employing such methods and systems may be reduced by greater than about 80% and in some embodiments, greater than 90%.” *Id.*, [0035], [0038]. “[M]ercury emissions can be monitored once an hour to ensure compliance with government regulations and to adjust the

rate of halogen precursor introduction into the combustion chamber, the rate of sorbent material injection, or both.” *Id.*, [0039].

409. Pollack’s examples vary the feed rate of calcium bromide, the injection rate of activated carbon, and the mean particle diameter of activated carbon to determine how these combinations improve reduction in mercury emissions. *Id.*, [0042]-[0043]. Figure 2 depicts how mercury removal percentage increases as a function of increasing PAC injection rate as shown below.



410. Pollack, in my opinion, discloses adding a particulate sorbent material comprising activated carbon into the mercury-containing gas, contacting mercury in the mercury-containing gas with the sorbent material, to form a mercury-sorbent, and separating the mercury-sorbent from the mercury-containing gas for the reasons explained above in Paragraphs 404-409. EX1086, [0016], [0018]-[0019], [0028], [0031]-[0032], [0035], [0038]-[0039], [0042]-[0043], Figures 1-2.

5. Element 1(c)-“ wherein a weight ratio of the additive added to the coal, added to the combustion chamber, or a combination thereof, to an amount of the sorbent material added to the mercury-containing gas is from about 1:100 to about 30:100;”

411. Claim 1 requires a weight ratio of the additive (as added to the coal, combustion chamber or both) to the sorbent (as added to the mercury-containing gas). As discussed above, my review of the ‘970 Application does not reveal a disclosure of this ratio anywhere in the ‘970 Application for the ‘370 Patent. It is the promoted sorbent (not the amount of additive added to the coal or combustion chamber relative to the amount of the sorbent added to the flue gas) that is described as comprising about 1-30g promoter per 100g base sorbent. EX1025, 4:19-23; 5:14-15; 6:22-26; 7:14-24; 16:28-30; 31:30-32:2; 38:23-25; 40:16-18; 41:1-3, 11-13, 28-29; 54:6-8; EX1001, 3:21-23, 54-56; 4:42-47; 5:6-20; 11:1-3; 20:34-37; 24:55-57; 25:45-48, 64-67; 26:8-11, 26-28; 33:56-59.

412. My review of the '370 Patent and its prosecution history 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 Pollack reference identified the amount of promoter added to the combustion chamber or to the coal and/or activated carbon sorbent added to the flue gas 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.

413. In my opinion, the sorbent of Claim 1 can be a promoted sorbent or an unpromoted sorbent when it is added into the mercury-containing gas.

414. In considering the relative amounts of bromine to sorbent for Claim 1, Pollack discloses halogen precursor can be applied at a rate to provide about 125 ppm (dry basis) of bromine to the coal (*i.e.*, about 10 gal/hr of a 50% by weight aqueous solution of calcium bromide). EX1086, [0025]. Pollack also discloses that the injection rate of the sorbent will 'vary depending upon the flow rate of the exhaust gas in the ductwork" and describes a rate of 2.5 lbs PAC/MMacf in Example 2. *Id.*, [0034], Table 3.

415. The ratio of these Br- and sorbent concentrations of Pollack is within the claimed range. Pollack discloses adding 125 ppm (dry basis) of bromine to the coal and injecting about 2.5 lb/MMacf of activated carbon sorbent into the flue gas. Dividing these concentrations and unit conversions yields a weight ratio of the additive added to the coal to an amount of sorbent added to the mercury-containing flue gas of about 25:100, which is within the claimed range of about 1:100 to about 30:100.

416. More particularly in order to determine a ratio of bromine concentration in the flue gas to activated carbon in the flue gas, the concentrations must have the same units—such as grams per actual cubic feet (acf) or pounds per million actual cubic feet (MMacf). Pollack provides the concentration of bromine to coal, which can be converted to a concentration of bromine in the flue gas. Activated-carbon injection concentrations were typically provided in pounds (lbs.) per million actual cubic feet (MMacf) of flue gas, as in Pollack. Converting between the two would have been a routine calculation for a POSITA and would have involved such basic concepts as the ideal gas law (to convert concentrations between temperatures and pressures), which is taught in first semester undergraduate chemistry. Such unit conversion would have also involved basic engineering knowledge of a power-plant operation as well-known to a POSITA, such as typical flue gas temperature, pressure, and moisture content.

417. The concentration of Br in the mercury-containing gas is estimated for typical parameters for firing Powder River Basin (PRB) subbituminous coal in full-scale utility boilers beginning with the Br loading on coal. For a value of 125 ppm Br on coal from Pollack,⁴ the equivalent concentration of Br in flue gas can be calculated as follows:

$$\frac{125 \text{ g Br}}{10^6 \text{ g coal}} = 1.25 \times 10^{-4} \frac{\text{g Br}}{\text{g coal}}$$
$$1.25 \times 10^{-4} \frac{\text{g Br}}{\text{g coal}} \times \frac{1 \text{ g coal}}{10 \text{ g flue gas}} = 1.25 \times 10^{-5} \frac{\text{g Br}}{\text{g flue gas}}$$

418. The above ratio of 10 grams flue gas per gram coal is a nominal value for subbituminous coals fired at 15 – 20 % excess air, and representative of the typical firing practices at coal-fired utility boilers. (In other words, combustion of 1 gram of subbituminous coal can be expected to provide approximately 10 grams flue gas). The molecular weight of flue gas is typically between 28-32 grams per mole (depending on the type of coal and amount of excess air), because flue gas is primarily: molecular nitrogen (molecular weight of 28, from excess air), carbon dioxide (molecular weight of 44), water (molecular weight of 18), and excess oxygen

⁴ Pollack discloses the units of “ppm.” A POSITA would have understood this to refer to ppm by weight, rather than on a molar basis, because the comparison is with respect to coal.

(molecular weight of 32). Accordingly, a typical value for the molecular weight of flue gas is 30 g/mol.

$$1.25 \times 10^{-5} \frac{\text{g Br}}{\text{g flue gas}} \times \frac{30 \text{ g flue gas}}{\text{mol flue gas}} = 3.75 \times 10^{-4} \frac{\text{g Br}}{\text{mol flue gas}}$$

419. Regarding the second conversion, a POSITA would have understood from the ideal gas law ($PV = nRT$) that the density of a gas is proportional to pressure and inversely proportional to temperature. A POSITA would have known that a typical flue gas temperature where sorbent would be injected is 150 °C (413 K) and also 1 atm of pressure. In fact, Pollack discloses a temperature of less than about 350°F (176 °C or 449 K). EX1086, [0033]. A POSITA would have understood that this temperature is a typical value for sorbent injection downstream of an air preheater and upstream of an ESP or fabric filter. A POSITA would have known that air preheaters typically do not operate with outlet gas temperatures below the acid dew points of sulfuric acid, which are given as 120–150 °C. This dewpoint range restricts the outlet temperatures to somewhat hotter values like 150 °C. Thus, a temperature of 448 Kelvin (175 °C) is used for the calculations, as this temperature is “less than about 350°F” as disclosed by Pollack.

$$\begin{aligned} & \frac{3.75 \times 10^{-4} \text{ g Br}}{\text{mol flue gas}} \times \frac{1 \text{ atm}}{(448\text{K})(0.082058 \text{ L atm}/(\text{mol K}))(1 \text{ acf}/28.3 \text{ L})} \times \frac{10^6 \text{ acf}}{\text{MMacf}} \\ &= 288.5 \frac{\text{g Br}}{\text{MMacf flue gas}} \end{aligned}$$

420. A POSITA would convert pounds activated carbon to grams activated carbon (and vice versa) through the well-known unit conversion of 453.6 grams per pound. For an injection concentration of 2.5 lbs PAC/MMacf (as disclosed in Pollack), the concentration of PAC in the flue gas can be calculated in grams as shown below. EX1086, Table 3.

$$\frac{2.5 \text{ pounds PAC}}{\text{MMacf}} \times \frac{453.6 \text{ g}}{\text{pound}} = 1,134 \text{ g PAC/MMacf}$$

421. The estimated concentration of Br in flue gas is 288.5 g Br/MMacf flue gas. For an injection concentration of 2.5 lb PAC/MMacf, the concentration of PAC in the flue gas is 1,134 g PAC/MMacf flue gas. Dividing these two rates derived from the bromine addition rate of Pollack and the activated carbon injection rate of Pollack provides a mercury-containing gas that comprises about 25 grams of the element bromine per 100 grams of activated-carbon sorbent. Thus, these two disclosed halogen and sorbent concentrations from Pollack result in a weight ratio of the additive added to the coal to an amount of sorbent added to the mercury-containing flue gas of about 25:100, which is within the claimed range of about 1:100 to about 30:100.

422. Pollack discloses that, the feed rate for “a solution of a halogen precursor may be significantly reduced by combining the application of a halogen containing composition with injection of sorbent material into the fluid stream of the

combustion gases.” *Id.* [0028]. A POSITA had reason to load the activated carbon with bromine sufficiently to increase its ability to adsorb mercury given Pollack’s emphasis on achieving optimal mercury removal by adjusting the rates of halogen addition and/or sorbent injection. EX1086, [0039]; EX1045, 2–3.

423. Pollack explains that “[i]n embodiments in which the halogen is applied to the sorbent material before being injected into the flue gas stream, the ratio of halogen to sorbent material may be the same as the ratio of halogen to sorbent material when sorbent material is introduced separately.” EX1086, [0037]. 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.

424. A POSITA also would have recognized that a weight ratio of the additive added to the coal to an amount of sorbent added to the mercury-containing flue gas of from about 1:100 to about 30:100 would have provided sufficient bromine in the flue gas to provide a ratio of 1–30 g of bromine per 100 g of activated carbon sorbent. 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.

425. Because Pollack discloses elements 1(preamble)-1(b) and 1(d)-1(e) of Claim 1, and Pollack discloses relative amounts of calcium bromide added to coal and sorbent added into the mercury-containing gas within the claimed weight ratio range as specified by element 1(c), it is 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 at the time of the invention in light of Pollack for the reasons explained above in Paragraphs 397-424. EX1086, [0025], [0028], [0034], [0037], [0039], Table 3; EX1083, 153; EX1045, 2–3; EX1050, 260.

C. Claims Depending From Claim 1

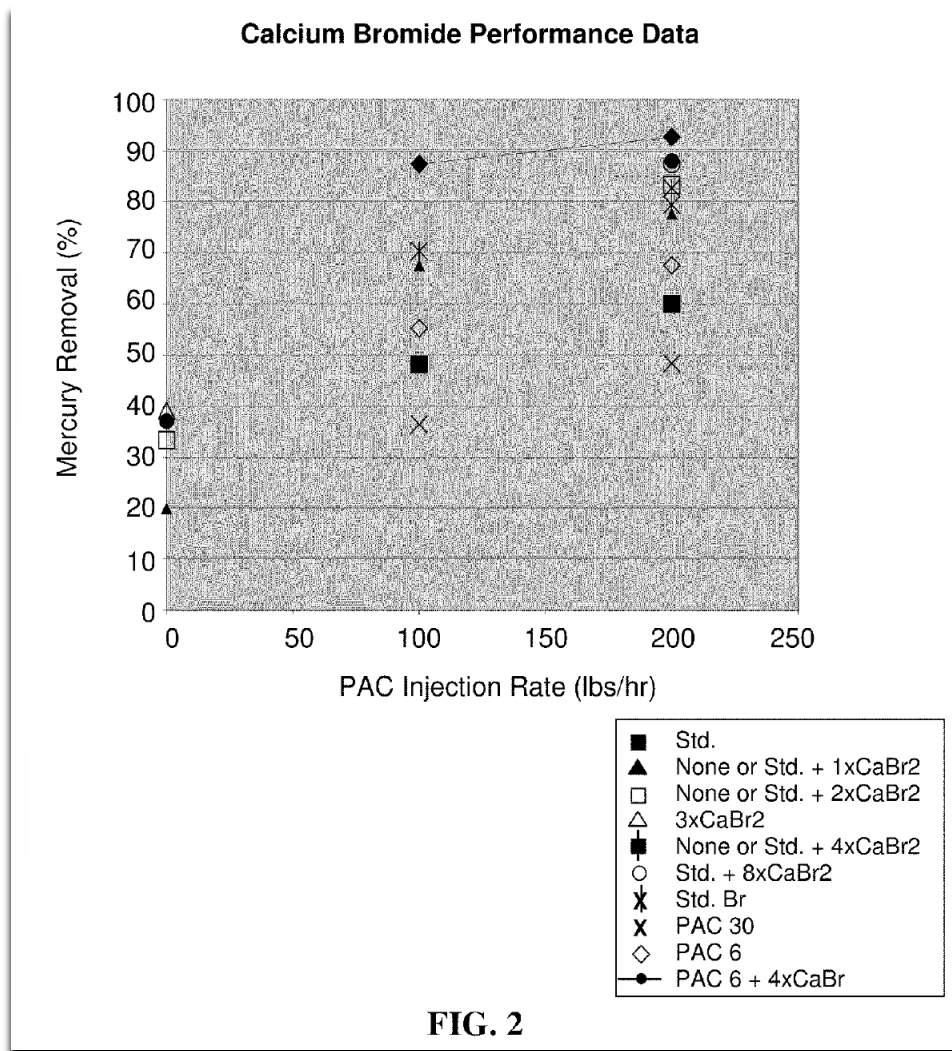
1. Claim 5—“carbocations in the activated carbon of the mercury-sorbent accept electrons from mercury atoms of the mercury-sorbent.”

426. With respect to activated carbon injection, Pollack discloses a method for removing mercury from a flue gas which includes “injecting sorbent material into the exhaust stream, i.e. flue gas, resulting from consumption of the fuel source.” EX1086, [0016]. The fuel source can be coal. *Id.*, [0018]. “[O]xidized heavy metals, such as mercuric halide species ... may be adsorbed by activated carbon.” *Id.*, [0028].

427. In Pollack’s Figure 1 as shown above, ash and combustion gas leave the combustion chamber and are fed into a “baghouse or electrostatic precipitator 7 where particulate matter is collected.” *Id.*

428. Sorbent is introduced at locations C and/or D upstream of the baghouse or ESP 7 as shown in Figure 1. *Id.*, [0019]. The sorbent can be activated carbon of any size, such as those having a “mean particle diameter (MPD) of about 0.1 μm to about 100 μm .” *Id.*, [0031]. The sorbent can be untreated or treated with a halogen before it is injected into the combustion gas. *Id.*, [0032]. The combustion gas and sorbent are fed into the “baghouse or electrostatic precipitator 7 where particulate matter is collected.” *Id.*, [0028].

429. “[M]ercury emissions from the plant employing such methods and systems may be reduced by greater than about 80% and in some embodiments, greater than 90%.” *Id.*, [0035], [0038]. “[M]ercury emissions can be monitored once an hour to ensure compliance with government regulations and to adjust the rate of halogen precursor introduction into the combustion chamber, the rate of sorbent material injection, or both.” *Id.*, [0039]. Pollack’s examples vary the feed rate of calcium bromide, the injection rate of activated carbon, and the mean particle diameter of activated carbon to determine the combinations that improve reduction in mercury emissions. *Id.*, [0042]-[0043]. Figure 2 depicts how mercury removal percentage increases as a function of increasing PAC injection rate as shown below.



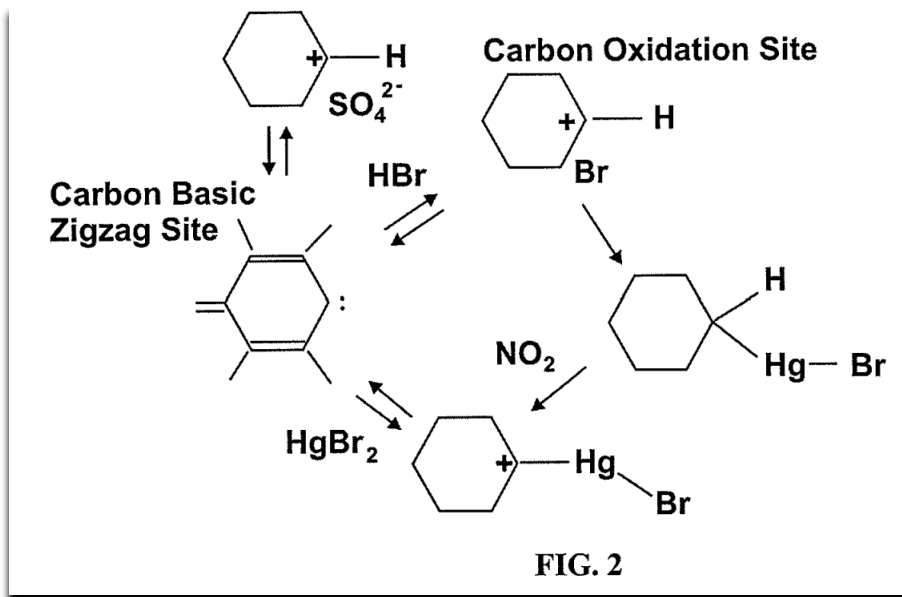
430. Julien discloses that when calcium bromide is added to a coal combustor, that “[f]ree energy calculations suggest that complete decomposition of CaBr_2 to HBr and CaO in the presence of water vapour is favoured over the full range of temperatures in the [circulating fluidized bed combustor] CFBC.” 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.

431. It would have been obvious to a POSITA that the activated carbon reacts with promoter in the mercury-containing gas to form a promoted sorbent when the HBr in the gas contacts the sorbent. It was well-known in the art that halogens (including bromine) “promoted” activated-carbon sorbents because they improved mercury removal by increasing the ability of the activated carbon to bind with the mercury. See §§ VII.D and VII.E. Lead inventor Dr. Olson admitted that, when bromides are added to coal “and activated carbon is injected downstream of the furnace,” then there would be “in-flight promotion.” EX1047, 231:3-9, 98:23-100:3. “[P]romotion” of activated carbon by halogens is a reaction. EX1083, 156 (labeled as limitation 24e, O’Keefe explaining how bromine containing ingredients added to coal would contact and react with sorbent), 160 (labeled as limitation 1c, O’Keefe explaining how activated carbon reacts with bromine). It follows the sorbent of Pollack comprises bromine, sorbent and mercury when in-flight promotion occurs.

432. Nelson explains “in exposing PAC to concentrated bromine gas, ... the bromine reacts with the carbon, forming surface compounds on ... the carbon. When the PAC is then injected into the flue gas, the elemental mercury and oxidized mercury species there appear to react with at least one form of the bromine-carbon surface compounds When the carbon particles are removed from the flue gas ... the mercury is removed with them.” EX1008, [0043]; EX1009, 4.

433. Olson-235 discloses an embodiment wherein “the injected sorbent is prepared in-flight by reacting a base sorbent (carbon, non-carbon or their combination) and a promoter within a pneumatic transport line from which the reaction product is injected to the mercury-containing flue gas stream.” EX1013, 5:43–48.

434. Olson depicts the “mechanistic model of the chemical reactions resulting in the oxidation and capture of mercury” in Figure 2 as shown below.



Olson-235 explains that

x-ray photoelectron spectroscopy has established that the addition of bromine, chlorine, HBr, or HCl formed a chemical compound in the carbon structure. Thus the promoted sorbent produced from halogen and base sorbent does not represent a molecular halogen form, but rather a new chemically modified structure.... **In the case of bromine, modified cationic carbon has a high chemical potential for oxidation of mercury.** Thus an entirely new model is presented for the reactivity of the bromine-treated carbon with mercury shown in FIG.

2.... Halogen treatment resulted in higher-activity carbons because halide anions (especially bromide and iodide) were effective in promoting oxidation by stabilizing the developing positive charge on the mercury in the transition state for oxidation.

EX1013, 16:49-17:4 (emphasis added).

435. From these disclosures of Nelson or Olson-235, it is evident that the reaction of hydrogen bromide with carbon in an activated carbon particle forms a carbocation oxidation site that accepts an electron from mercury adsorbed by the activated carbon particle, forming particulate-bound mercury. These reactions necessarily occur when the hydrogen bromide and mercury in flue gas contact activated carbon. It follows that Claim 5 is inherent and necessarily results from the contact of the hydrogen bromide, mercury and activated carbon in the flue gas.

436. Because Pollack discloses every element of Claim 1 and Pollack (as evidenced by Julien), Pollack and Olson-235 or Pollack and Nelson disclose contact of hydrogen bromide, mercury and activated carbon in flue gas, which would necessarily result in carbocations in the activated carbon of the mercury-sorbent accepting electrons from mercury atoms of the mercury-sorbent, 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 Pollack, Pollack and Olson-235, or Pollack and Nelson as evidenced by Julien for the reasons explained above in Paragraphs

426-435. EX1086, [0016], [0018]-[0019], [0028], [0031]-[0032], [0035], [0038]-[0039], [0042]-[0043], Figure 2; EX1014, 1658; EX1047, 231:3-9, 98:23-100:3; EX1083, 156, 160, 179; EX1008, [0043]; EX1009, 4.

2. Claim 6—“the additive is substantially in vapor form in the mercury-containing gas.”

437. Pollack discloses that the “molecular halogen ... such as bromine gas ... can be injected into the exhaust stream near the combustion chamber.” EX1086, [0020]. Pollack also describes that the “halogen precursor may be a gaseous precursor such as, for example, ... hydrogen bromide.” *Id.*, [0021], [0024]. Thus, Pollack discloses gaseous forms of the additive in the flue gas.

438. 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. 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.” *Id.* 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.

439. Because Pollack discloses every element of Claim 1 and specifically teaches that the halide or halogen additive is substantially in vapor form in the mercury-containing gas, it is my opinion, based on my education, skill, training, and experience in the relevant fields of emission reduction technology, that Claim 6 would have been obvious to a POSITA at the time of the invention in light of Pollack as evidenced by Julien for the reasons explained above in Paragraphs 437-438. EX1086, [0020]-[0021], [0024]; EX1014, 1658.

440. It is therefore also my opinion that, based on the disclosure of Pollack, Pollack and Olson-235, or Pollack and Nelson, as well as my skill, training, and experience in the relevant fields of emission reduction technology, that claims 1-6, 8, 11 and 14-15 would have been obvious to a POSITA prior to April 12, 2018 for the reasons explained above in Paragraphs 337-439.

XV. SECONDARY CONSIDERATIONS – SIMULTANEOUS INVENTION

441. I understand that the Patent Owner has asserted that the ‘370 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.

442. As I explained above, it is my opinion that claims 1-6, 8, 11, 14 and 15 of the ‘370 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.

443. As I also explained in the Technology Background section of this Declaration, “[a]ctivated carbons ha[d] been the most thoroughly studied sorbent for the capture of mercury” by 1998. EX1041, 22. In 1999, researchers demonstrated that mercury from flue gas formed chemical bonds with halogen species on activated carbons. EX1052, 119. By 2004, halide addition was observed to “improve Hg capture both by conversion of the Hg^0 to the more easily removed Hg^{2+} forms and by enhancing the reactivity of Hg^0 with activated carbons”). EX1053, 2–3.

444. 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.

445. 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.

446. Numerous researchers, many acting under Department of Energy funded contracts, had developed, tested, and implemented the same two-step process generally claimed in the '370 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.

447. 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.

448. 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 441-447.

XVI. CONCLUSION

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

450. 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.

451. In signing this declaration, I recognize that the declaration will be filed as evidence in an IPR before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subjected to cross-examination in the case and that cross-examination will take place in the United States.

452. 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.

Case No. IPR2025-01324
Patent 10,933,370

Executed on this 12th day of July, 2025.

Radisav Vidic

Radisav Vidic, Ph.D.