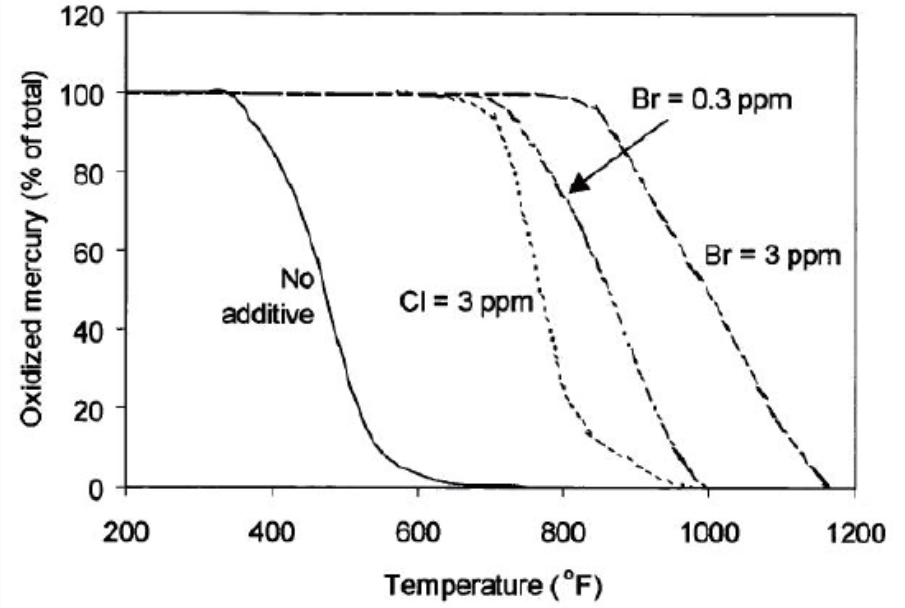


Fig. 9

Determining a ratio of oxidized mercury to total mercury, as in Figure 9 of Lissianski, is a form of monitoring the "mercury content." Based on the mercury content (e.g., % of oxidized mercury) and temperature, Lissianski-Patent determines a rate of adding the promoter of 0.3 ppm or 3 ppm.[1473]

1031. Determining a promoter-injection rate and sorbent-injection rate, at least in part on mercury speciation, would reduce costs by avoiding wastefully injecting unneeded excess materials. Due to the variability of the composition of coal as a fuel source (including for example, native mercury and halogen contents), it would have been obvious to a POSITA that some amount of adjustment to the sorbent-injection

[1473] Ex. 1036 (Lissianski-Patent) at 6:61-67, Figs. 8-9.

rate and promoter-injection rate would have been performed as part of routine process control and optimization to account for variances in the coal.

XXXII. GROUND N: OBVIOUSNESS OF THE '147 PATENT OVER DOWNS-HALOGENATION IN VIEW OF OLSON-PAPER

547. It is my opinion that Downs-Halogenation either alone or in view of Olson-Paper and/or Lissianski-Patent renders obvious each of the asserted of the '147 patent.

A. CLAIM 1

1. Claim 1: Preamble—"A method for separating mercury from a mercury containing gas comprising:"

548. The preamble is disclosed by Downs-Halogenation. Downs-Halogenation repeatedly characterizes the disclosed process as for removing *(i.e.,* separating) mercury from coal combustion: "a method of mercury removal that is applicable to virtually all coal-fired utility power plants."[1474] The title of Downs-Halogenation—"Dynamic Halogenation of Sorbents for the Removal of Mercury from Flue Gases"—confirms this purpose.[1475]Downs Halogenation explicitly refers to "separation and removal" as being the same function for the elimination of undesirable components from "exhaust gases."[1476]

[1474] Ex. 1015 (Downs-Halogenation) at ¶ [0011]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0013].

[1475] Ex. 1015 (Downs-Halogenation) at Title (emphasis added); *see also* Ex. 1016 (Downs-Halogenation-Provisional) at Title.

[1476] Ex. 1015 (Downs-Halogenation) at ¶ [0004]; Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [005].

549. Downs-Halogenation also discloses a flue gas *(i.e.,* mercury containing gas) and explains that as a general matter "[m]ercury appears in coal combustion flue gases."[1477] In fact, Downs-Halogenation goes on to recognize multiple species of mercury in the flue gas *(i.e.,* mercury containing gas) because of the "high volatility of mercury and many of its compounds, most of the mercury found in flue gases is vapor-phase mercury. Vapor-phase mercury can appear as elemental mercury (elemental, metallic mercury vapor) or as oxidized mercury (vapor-phase species of various compounds of mercury)."[1478]

550. Downs-Halogenation explains that the "sorbent, and its burden of adsorbed mercury, are subsequently removed from the flue gases in a downstream particulate collector," according to conventional systems in use at the time.[1479]

551. As additional evidence that a POSITA would have had a reasonable expectation of success in applying the teachings of Olson-Paper to Nelson, Olson-Paper also teaches separating mercury from a mercury containing gas. The title of Olson-Paper is "Chemical mechanisms in *mercury emission control* technologies.[1480] Olson-Paper further explains in the Abstract:

[1477] Ex. 1015 (Downs-Halogenation) at ¶ [0002]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [003].

[1478] Ex. 1015 (Downs-Halogenation) at ¶ [0002]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [003].

[1479] Ex. 1015 (Downs-Halogenation) at ¶ [0004]; Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [005].

[1480] Ex. 1079 (Olson-Paper) at Title (emphasis added).

> The *emission of elemental mercury* in the flue gas from coal-burning power plants is a major environmental concern. Control technologies utilizing activated carbon show promise and are currently under intense review. *Oxidation and capture of elemental mercury on activated carbon was extensively investigated in a variety of flue gas atmospheres*.[1481]

The "capture of elemental mercury on activated carbon" refers to separating the mercury from the mercury-containing flue gas by adsorbing it onto activated carbon.

2. Claim 1: Element 1(a)(1) —"promoting at least a portion of a particulate sorbent material comprising activated carbon by chemically reacting the sorbent material with a bromine containing promoter to form a promoted brominated sorbent."

552. This limitation is disclosed by Downs-Halogenation. This limitation is also obvious over Downs-Halogenation in view of Olson-Paper.

553. Downs-Halogenation discloses promoting a powdered activated carbon (PAC) sorbent by mixing a halogen-containing reagent *(e.g.,* HBr or Br_2) to form a promoted brominated sorbent."[1482] Downs-Halogenation details that the particulate material considered, and commonly used in the industry, is a "carbonaceous sorbent (e.g., powdered activated carbon, or PAC)."[1483]

1481 Ex. 1079 (Olson-Paper) at Abstract (emphasis added).

1482 Ex. 1015 (Downs-Halogenation) at ¶ [0023-24]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0026-27].

1483 Ex. 1015 (Downs-Halogenation) at ¶ [0004, 0010]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [005, 0012].

554. Downs-Halogenation describes that these the improved activated-carbon sorbents have an affinity for reacting with, and capturing, mercury from the flue gas, such that the sorbent composition can be removed by conventional particulate collectors, including fabric filters.[1484] Downs-Halogenation recognizes that the presence of halogens on the sorbent serves "to facilitate gas-solid reactions between the gaseous mercury and the solid carbon particles."[1485] The sorbent with its loading of "halogen-containing reagent 24 enter the flue gas flue(s) (sic) injection locations 28 with high reactivity for the removal of elemental mercury."[1486]

555. As further confirmation that my analysis is correct, and that the halogen-containing reagent in Downs-Halogenation is a promoter, I note that the '147 patent describes a promoter through which "activity for mercury capture is enhanced by the addition of halogen (e.g. bromine) to the carbon structure."[1487]

[1484] Ex. 1015 (Downs-Halogenation) at ¶ [0003]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [004].

[1485] Ex. 1015 (Downs-Halogenation) at ¶ [0003]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [004] (Greater "contact may ***promote*** the adsorption of vapor-phase mercury species onto the fly ash or unburned carbon particles.") (emphasis added).

[1486] Ex. 1015 (Downs-Halogenation) at ¶ [0019]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0022].

[1487] Ex. 1001 ('147 Patent) at 13:22-25; *see also* State of the Art, above, § XII.G.2.

a. Particulate sorbent material comprising activated carbon

556. Downs-Halogenation discloses this limitation. Downs-Halogenation discloses that the particulate sorbent material is a "carbonaceous sorbent (e.g., powdered activated carbon, or PAC)."[1488] As taught by Downs-Halogenation, "the carbonaceous sorbents 14 may include, but are not limited to, powdered activated carbon (PAC), carbons and chars produced from coal and other organic materials, and unburned carbon produced by the combustion process itself.'[1489]Downs-Halogenation explains that this PAC sorbent is in particulate form, referring to the sorbent as "carbonaceous sorbent 14 particle"[1490] and "sorbent 14 particles."[1491]

b. Promoting at least a portion of the sorbent material by chemically reacting the sorbent material with a bromine containing promoter to form a promoted brominated sorbent,"

557. Downs-Halogenation discloses a process for promoting at least a portion of the particulate sorbent material by treating powdered activated carbon (PAC) with a bromine-containing reagent *(i.e.,* a bromine-containing promoter), for

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[1488] Ex. 1015 (Downs-Halogenation) at ¶ [0004, 0010]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [005, 0012].

[1489] Ex. 1015 (Downs-Halogenation) at ¶ [0028]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0031].

[1490] Ex. 1015 (Downs-Halogenation) at ¶ [0024]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0027].

[1491] Ex. 1015 (Downs-Halogenation) at ¶ [0019]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0022].

instance, hydrogen bromide gas (HBr) and/or bromine (Br_2).[1492] This process of Downs-Halogenation is used to prepare a "Dynamically Halogenated PAC."[1493] Downs-Halogenation recognizes that the presence of halogens on the activated-carbon sorbent serves "to facilitate gas-solid reactions between the gaseous mercury and the solid carbon particles."[1494]As illustrated in Figure 2, reproduced below as illustrated, Downs-Halogenation discloses that the PAC sorbent (red) is treated with halogen-containing reagent (blue, *e.g.,* HBr or Br_2) to form promoted brominated sorbent:[1495]

[1492] Ex. 1015 (Downs-Halogenation) at ¶ [0026]; Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0029].

[1493] Ex. 1015 (Downs-Halogenation) at ¶ [0023]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0026].

[1494] Ex. 1015 (Downs-Halogenation) at ¶ [0003]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [004] (Greater "contact may ***promote*** the adsorption of vapor-phase mercury species onto the fly ash or unburned carbon particles.") (emphasis added).

[1495] Ex. 1015 (Downs-Halogenation) at Fig. 2 (annotated), ¶¶ [0023-24]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at Fig. 2, ¶¶ [0026-27].

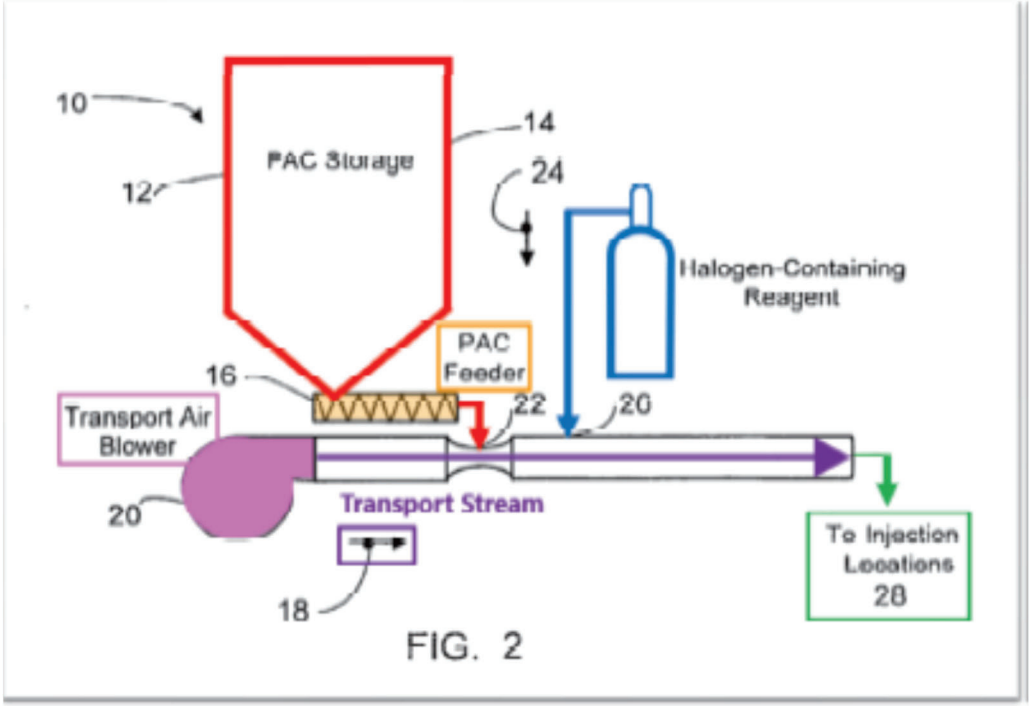


FIG. 2

As illustrated above, the halogen-containing reagent is dispensed from a gas canister.[1496] The halogen-containing reagent of Downs-Halogenation is in gaseous form when it contacts the sorbent, and includes hydrogen bromide (HBr), bromine (Br_2), hydrogen chloride (HCl), and/or chlorine gases, with HBr being "most effective."[1497]

i The bromine-containing promoter chemically reacts with the activated carbon

558. Downs-Halogenation discloses an "efficient use of the halogen-containing reagent 24 by placing it onto the carbon sorbent," where the halogen-

[1496] Ex. 1015 (Downs-Halogenation) at Fig. 2 (annotated); *see also* Ex. 1016 (Downs-Halogenation-Provisional) at Fig. 2.

[1497] Ex. 1015 (Downs-Halogenation) at ¶ [0023]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0026] ("the use of hydrogen bromide was significantly more effective than the use of hydrogen chloride.").

containing reagent is preferably a bromine-containing promoter.[1498] Placing the bromine onto the carbon sorbent as disclosed in Downs-Halogenation is accomplished through injecting the gaseous bromine "where the sorbent 14 and transport air 18 first mix."[1499] The effect of this mixing "maximizes the benefit and utilization of the halogen-containing reagent 24 by placing it exactly where it is needed to facilitate elemental mercury removal on the surface of the sorbent 14. The sorbent 14 particles with their loading of adsorbed halogen-containing reagent 24 enter the flue gas flue(s) injection locations 28 with high reactivity for the removal of elemental mercury."[1500] A POSITA would have understood that when halogens are "adsorbed onto the sorbent surface," as in Downs-Halogenation, the halogens (particularly chlorine-containing and bromine-containing species) react with activated carbon, and that the reaction was one of promotion.[1501]

559. A POSITA would have understood that at least a quantity of the bromine-containing promoter would have chemically reacted with the activated-carbon sorbent. First, Downs-Halogen states in the quote above (and in the Abstract)

[1498] Ex. 1015 (Downs-Halogenation) at ¶ [0021]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0024].

[1499] Ex. 1015 (Downs-Halogenation) at ¶ [0019]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0022].

[1500] Ex. 1015 (Downs-Halogenation) at ¶ [0019]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0022].

[1501] Ex. 1015 (Downs-Halogenation) at Abstract; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0022].

that the halogen-containing reagent "adsorbed" onto the activated carbon. Second, as I describe in the State of the Art, it was known that halogens (particularly chlorine-containing and bromine-containing species) reacted with activated carbon, and that the reaction was one of promotion of the activated carbon. A POSITA would have known that untreated activated carbon is basic in its chemical character (it can donate electrons), whereas the halides of hydrogen chloride and hydrogen bromide are acid (can accept electrons). A POSITA would have known that acids have a strong affinity for bases, and quickly surmised that Br and Cl would readily react with activated carbon.[1502]

560. A POSITA reading Downs-Halogenation would have been motivated to combine with Olson-Paper to further describe the chemical mechanism by which the halogen containing promoter reacts with the activated carbon when mixed together as taught by Downs-Halogenation. Olson-Paper confirms that these reactions are promotion, as I describe below for Claim Elements 1(a)(3) and 1(a)(4). Olson-Paper explains that the "basic carbene [on untreated activated carbon] cannot react directly with Hg^0 [elemental mercury], but reacts with HCl to form stable carbenium ion intermediates, which are then ***active for binding*** Hg^0, accepting electrons from the atom (Figure 2).[1503] A POSITA would have expected that when

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1502 *See* State of the Art, above, § § XII.C.4, XII.G.2.

1503 Ex. 1079 (Olson-Paper) at 982 (emphasis added).

using the halogen-containing gases of Downs-Halogenation that they would proceed down similar reaction and oxidation pathways as Olson-Paper. In particular, Downs-Halogenation recognizes the same interaction between hydrogen chloride and a conventional PAC sorbent as investigated by Olson-Paper.[1504] Olson-Paper explains that, when in the presence of activated carbon, a halogen, such as the hydrohalides disclosed by Downs-Halogenation, chemically react[1505].

ii The bromine-containing promoter forms a promoted brominated sorbent.

561. Downs-Halogenation discloses a promoted brominated sorbent, referred to as a "dynamically halogenated PAC."[1506] This promoted brominated sorbent prepared by Downs-Halogenation is the result of combining the "bromine-containing reagent" *(e.g.,* hydrogen bromide gas (HBr) or bromine (Br_2)) with a powdered activated carbon sorbent.[1507] Downs-Halogenation explains that "the use of bromine-containing compounds . . . enhance the capture of elemental mercury by adsorption of elemental mercury by carbonaceous sorbents"[1508] due to the increased

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[1504] Ex. 1015 (Downs-Halogenation) at ¶ [0006] ("The presence of hydrogen chloride (HCl), in particular, has been shown to significantly improve the

[1505] Ex. 1079 (Olson-Paper) at 982

[1506] Ex. 1015 (Downs-Halogenation) at ¶ [0023]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0026].

[1507] Ex. 1015 (Downs-Halogenation) at ¶ [0026]; Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0029].

[1508] Ex. 1015 (Downs-Halogenation) at ¶ [0010]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0012].

concentration of the "halogen-containing compounds [] on the surface of the carbonaceous sorbent as the sorbent is conveyed to the injection location."[1509] Downs-Halogenation further explains that the "sorbent 14 particles with their loading of adsorbed halogen-containing reagent 24 enter the flue gas [] injection locations 28 with high reactivity for the removal of elemental mercury."[1510] In contrast, Downs-Halogenation describes that the use of untreated sorbents "at a similar injection rate provided no discernable mercury removal."[1511] Downs-Halogenation therefore discloses that the bromine-containing promoter forms a promoted brominated sorbent for enhanced separation of mercury from the mercury containing gas.

3. Claim 1: Element 1(a)(2) —"wherein the bromine containing promoter is in gaseous form, vapor form, or non-aqueous liquid form,"

562. This limitation is disclosed by Downs-Halogenation. In multiple instances throughout the disclosure, Downs-Halogenation describes that the halogen-containing reagent is in gaseous form, for example:

[1509] Ex. 1015 (Downs-Halogenation) at ¶ [0009]; Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0011].

[1510] Ex. 1015 (Downs-Halogenation) at ¶ [0019]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0022].

[1511] Ex. 1015 (Downs-Halogenation) at ¶ [0023]; Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0026].

> In yet another embodiment, the bromine-containing reagent 24 could comprise *hydrogen bromide gas (HBr) or bromine (Br_2).*[1512]
>
> In yet another embodiment, the *halogen-containing gases* 24 may include any one or more of the following: hydrogen chloride, chlorine ($C1_2$), as well as compounds of fluorine and iodine, and halide derivatives thereof.[1513]

563. Downs-Halogenation further describes that it was known in the art that the injection of a halogen may be accomplished by injection of a "vapor into the flue gases."[1514]

4. Claim 1: Element 1(a)(3) —"and wherein the activated carbon contains graphene sheets having carbene species edge sites"

564. This limitation is disclosed by Olson-Paper and is obvious over Downs-Halogenation in view of Olson-Paper. As discussed above regarding the State of the Art,[1515] it was proposed since at least the 1980s that activated carbon (at least in a clean laboratory setting) has graphene sheets having carbene species edge sites. Thus, the inventors of the '147 patent were just describing a property of graphene that had been theorized decades earlier to those of skill in the art.

[1512] Ex. 1015 (Downs-Halogenation) at ¶ [0026] (emphasis added); *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0029].

[1513] Ex. 1015 (Downs-Halogenation) at ¶ [0027] (emphasis added); *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0030].

[1514] Ex. 1015 (Downs-Halogenation) at ¶ [0008]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [009].

[1515] *See* State of the Art, above, § XII.C.2.

565. Olson-Paper likewise applies these known teachings of the surface structure of graphene sheets of activated carbon. Olson-Paper supplements the teachings of Downs-Halogenation by describing surface compounds formed in the activated carbon of Downs-Halogenation, and the chemical reaction mechanisms already taking place in Downs-Halogenation. In addition to the discussion above in the Reasons to Combine section, a person of skill in the art would have had a reasonable expectation of success combining Downs-Halogenation with Olson-Paper, because no modifications would need to have been made to the process conditions, chemical reactors, activated carbon sorbent, or halogen promoter used in Downs-Halogenation. Olson-Paper is merely proposing chemical reaction mechanisms for the processes already taking place in Downs-Halogenation.

566. Downs-Halogenation describes the invention using "a conventional powdered activated carbon (PAC)."[1516] Accordingly, a POSITA would have recognized that the teachings of Downs-Halogenation applied to activated carbon in general, including the common brand Norit Darco FGD of Olson-Paper, which a POSITA would have readily understood as the benchmark activated carbon in the utility industry.[1517]

[1516] Ex. 1015 (Downs-Halogenation) at ¶ [0019]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0022].

[1517] *See, e.g.*, State of the Art, above, § XII.A.91.

567. A POSITA reading Downs-Halogenation would have combined with Olson-Paper to further describe the surface structure of activated carbon and the chemical reactions it undergoes when exposed to halogens, particularly for conventional PAC as disclosed by Downs-Halogenation. Olson-Paper describes the surface structure of activated carbon. Olson-Paper studied the surface structure of "two AC [activated carbon] sorbents, Norit FGD and the EERC lignite-derived AC, exposed to various simulated flue gas compositions."[1518]

568. Like Olson-Paper, Downs-Halogenation is concerned with the interrelated effects between untreated activated carbon, mercury, and halogens in the flue gas. In considering this, Downs-Halogenation recognizes that "[i]t has been observed that the reactivity of conventional PAC with elemental mercury vapor is dependent upon the presence of certain acid gas species (e.g., hydrogen chloride and sulfur trioxide) in the flue gas stream. The presence of hydrogen chloride (HCl), in particular, has been shown to significantly improve the adsorption of elemental mercury from coal combustion flue gases. The hydrogen chloride is apparently adsorbed onto the carbon surface, facilitating the subsequent oxidation of elemental

[1518] Ex. 1079 (Olson-Paper) at 981.

mercury"[1519]. Downs-Halogenation describes that, for mercury capture, the use of hydrogen bromide was more effective than the use of hydrogen chloride.[1520]

569. Olson-Paper describes such surface compounds and models for chemical reaction pathways between halogens and the surface of common activated carbon sorbents, such as Norit Darco FGD®. Olson-Paper proposes that activated carbon, including both that of Norit Darco FGD® and an activated carbon derived from a lignite coal, each contain graphene sheets having carbene species edge sites. Olson-Paper states in the Abstract that his model describes "a zig-zag *carbene site on the carbon edge* that performs as a Lewis base."[1521] The "carbon edge" refers to the edge sites on graphene, which contains the carbene species. Olson-Paper elaborates regarding the "carbene structures" present "at the edges of the carbon graphene layers" in activated carbon:[1522]

> A refinement of the mechanistic model for He oxidation and binding is now proposed that offers more detail on the nature of the carbon site and its interaction with flue gases and Hg. This model uses the concept of *zig-zag carbene structures recently proposed for electronic states at the edges of the carbon graphene layers* [8]. *In the edge carbene model of Hg capture, the zig-zag carbon atom positioned between aromatic rings is hypothesized to be a Lewis base site.* The basic carbene cannot react directly with Hg^0, but reacts with HCl to form stable

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1519 Ex. 1015 (Downs-Halogenation) at ¶ [0006]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [007].

1520 Ex. 1015 (Downs-Halogenation) at ¶ [0023]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0026].

1521 Ex. 1079 (Olson-Paper) at 979 (Abstract) (emphasis added).

1522 Ex. 1079 (Olson-Paper) at 982 (emphasis added).

> carbenium ion intermediates, which are then active for binding Hg^0, accepting electrons from the atom (Figure 2). Thus HCl or other acids promote the oxidization step.

Reference 8 refers to the paper by Radovic, a previous researcher who had already investigated "the surface chemistry of edge carbon atoms" in graphene layers and "argue[d] in favor of' "carbene or m-benzyne at the zigzag sites."[1523] A POSITA would have recognized that "graphene layers" described by Olson-Paper is another word for "graphene sheets." The graphene sheets are shown in Fig. 2 of Olson-Paper, reproduced below as annotated, and the carbene species edge site is labeled by Olson-Paper as "Carbon Basic Zig-Zag Site."[1524]

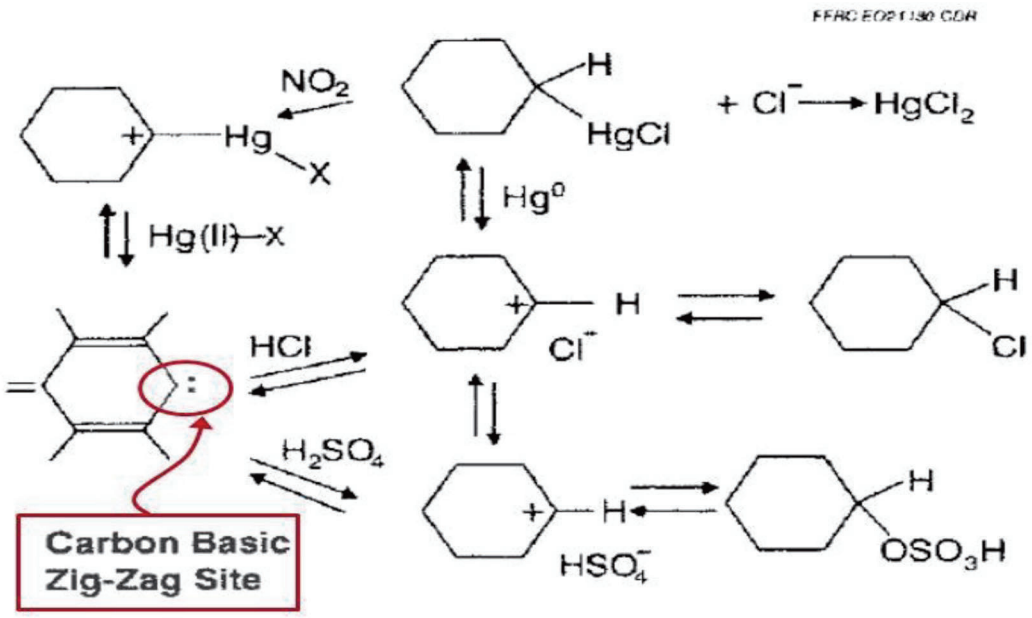


Figure 2. Reaction site model for activated carbon.

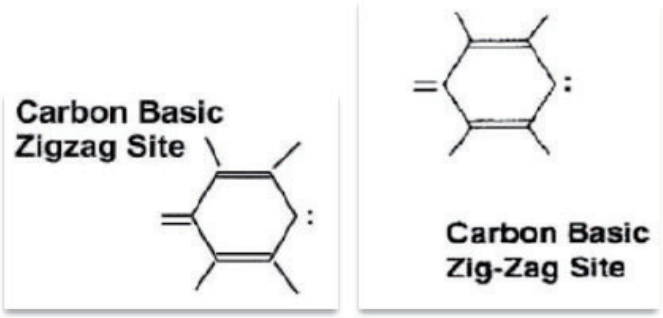
1523 Ex. 1046 (Radovic); *See* State of the Art, above, § XII.C.2.

1524 Ex. 1079 (Olson-Paper) at 982.

As I describe in the State of the Art section,[1525] a POSITA would have known that each vertex represents a carbon atom, and each hexagon represents an aromatic ring. A POSITA would have further known that graphene is a structure having sheets of such aromatic ring systems stacked in layers upon one another.[1526] Further, the "Lewis base site" described on page 982 by Olson-Paper means a site that can donate electrons.[1527] The zig-zag carbon atom, circled in red above from Fig. 2 in Olson-Paper, is a "carbene species edge site," as per claim 1 of the '147 patent, because it contains a neutral carbon atom that is bonded to two other carbon atoms and that has two unshared valence electrons *(i.e.,* a lone pair or dangling pair of electrons that it can donate when performing chemical reactions).

570. As further confirmation that my analysis of the disclosure of Olson-Paper is correct, I note that the depiction of a carbene species on a graphene sheet is nearly identical between the '147 patent (left)[1528] and Olson-Paper (right).[1529]

1525 *See* State of the Art, above, § XII.A.5.
1526 *See* State of the Art, above, § XII.C.2; Ex. 1070 (Bansal) at 238.
1527 Ex. 1079 (Olson-Paper) at 982.
1528 Ex. 1001 ('147 Patent) at Fig. 2.
1529 Ex. 1079 (Olson-Paper) at 982, Fig. 2.



And, similar to both Downs-Halogenation and Olson-Paper, the '147 patent also uses a conventional activated carbon sorbent *(e.g.,* Norit Darco FGD(D).[1530]

5. Claim 1: Element 1(a)(4) —"which react with the bromine containing promoter to form a carbocation paired with a bromide anion in the promoted brominated sorbent for oxidation of the mercury:"

571. This limitation is obvious over Downs-Halogenation in view of Olson-Paper. As I discuss above regarding Claim Element 1(a)(1), Downs-Halogenation in view of Olson-Paper describes that the activated carbon chemically reacts with the bromine-containing promoter. Olson-Paper proposes the mechanism by which the reaction takes place, namely, that an acid gas *(e.g.,* HBr or HCl) reacts with the activated carbon (conventional PAC, such as Norit Darco FGD) to form a carbocation paired with an anion *(e.g.,* the Cl^- or the Br^- from the acid gas) in the promoted brominated sorbent. The resulting promoted brominated sorbent

[1530] Ex. 1001 ('147 Patent) at 5:52-67 (describing Figs. 4-9), 14:40-46, 15:46, 20:48.

described by Downs-Halogenation is employed for the purpose of oxidation and capture of mercury.

572. Olson-Paper states that activated carbon undergoes the following reactions for purposes of oxidation of elemental mercury:

> *A refinement of the mechanistic model for Hg^0 oxidation* and binding is now proposed that offers more detail on the nature of the carbon site and its interaction with flue gases and Hg. *This model uses the concept of zig-zag carbene structures recently proposed for electronic states at the edges of the carbon graphene layers* [8]. In the edge carbene model of Hg capture, the zig-zag carbon atom positioned between aromatic rings is hypothesized to be a Lewis base site. *The basic carbene cannot react directly with Hg^0, but reacts with HCl to form stable carbenium ion intermediates, which are then active for binding Hg^0, accepting electrons from the atom (Figure 2). Thus HCl or other acids promote the oxidation step.*[1531]

In the above passage, Hg^0 refers to elemental mercury *(i.e.,* non-oxidized mercury), with an oxidation state of 0). A POSITA would have recognized that the "carbenium ion intermediates" disclosed in Olson-Paper is another term for a "carbocation." This carbenium ion intermediate, or carbocation, oxidizes mercury—"promote the oxidation step," as described by Olson-Paper. Below is an annotated Fig. 2 from Olson-Paper showing formation of a carbocation (step 1) and oxidation of elemental mercury (step 2):[1532]

1531 Ex. 1079 (Olson-Paper) at 982 (emphasis added).

1532 Ex. 1079 (Olson-Paper) at 982, Fig. 2.

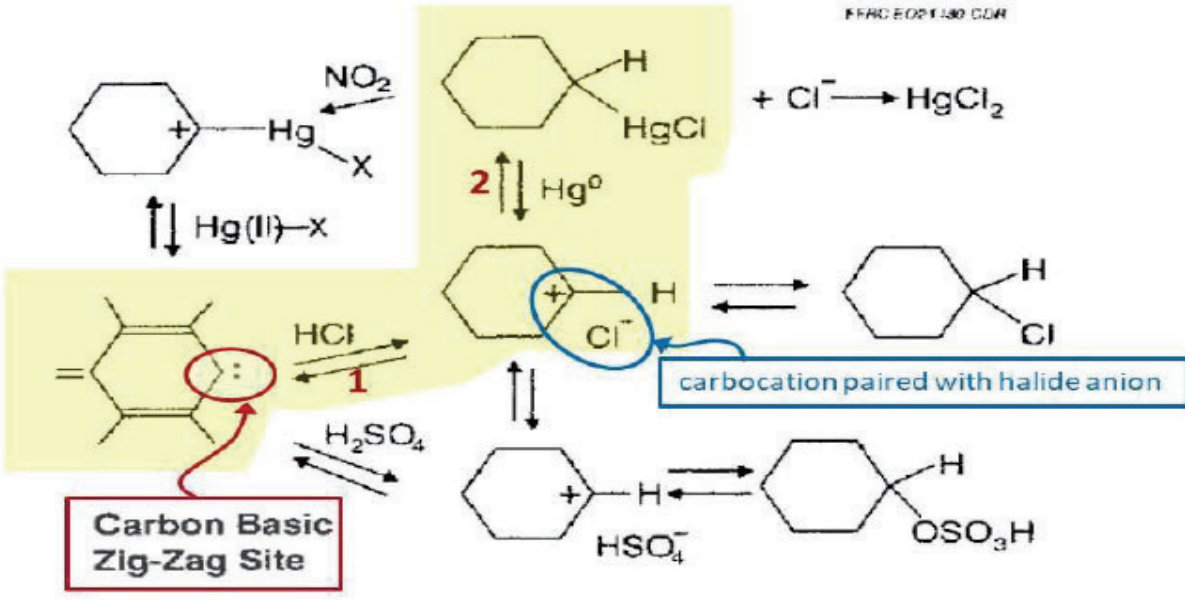


Figure 2. Reaction site model for activated carbon.

As can be seen in the above figure, annotated from Olson-Paper, a halogen-containing promoter (e.g., a hydrohalide, HCl), chemically reacts in step 1 with the carbene species (circled in red) at the edge site of a graphene layer (which contains a sheet of such hexagon rings). The result of step 1, circled in blue, is formation of a carbocation (indicated by the +) paired with a halide anion (indicated by the Cr). The carbon circled in blue (indicated by a vertex with a +) is a carbo cation because the carbon atom only has 3 bonds to neighboring elements (2 bonds to other carbon atoms, and 1 bond to hydrogen), and thus six electrons in its valence shell. As shown in step 2, the carbocation paired with the halide anion in the promoted halogenated sorbent is for oxidation of the mercury. Elemental mercury (indicated by Hg^0) is oxidized in step 2 to Hg(II) or Hg^{2+}— since the elemental mercury gives up electrons and thus gains a positive formal charge—as evidenced by the bonding of the mercury

to both the adjacent carbon and the halogen atom (Cl). This bonding configuration between Hg^{2+} and Cl is consistent with the XAFS spectra discussed above.[1533]

573. Although the example in Olson-Paper expressly identifies hydrochloric acid (HCl) and chloride anions (Cl^-), a POSITA would have recognized that Downs-Halogenation in view of Olson-Paper teaches the same mechanism for a bromine-containing promoter, such as HBr. First, Olson-Paper states that the mechanism is not limited to HCl, but is valid for "HCl or other acids."[1534] A POSITA, in view of Olson-Paper, would have recognized that such other acids would have included HBr, especially since the bond dissociation energy for HBr is lower than that for HCl.[1535] Indeed, Fig. 2 of Olson-Paper uses "—X" in the figure to indicate that the model is not limited to a chloride anion, but could include other anions. Downs-Halogenation describes HBr throughout the reference as an exemplary promoter similar to HCl.[1536]

574. A POSITA would have been further motivated to combine with Olson-Paper to propose a model for the reaction chemistry taking place in Downs-Halogenation, since both references teach using activated carbon sorbents to capture both elemental and oxidized mercury and that using a halogen with activated carbon would promote capture of elemental mercury. Downs-Halogenation expressly

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1533 *See* State of the Art, above, § XII.C.4.

1534 Ex. 1079 (Olson-Paper) at 982.

1535 *See* State of the Art, above, § XII.G.2.

1536 Ex. 1015 (Downs-Halogenation) at ¶¶ [0026-27]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶¶ [0029-30].

discloses that "PAC injection removes both oxidized and elemental mercury species."[1537] This use of PAC, in the presence of either HCl and HBr, is disclosed by Downs-Halogenation as improving the effectiveness of PAC to remove mercury.[1538] Likewise, Olson-Paper expressly discloses capture of elemental mercury and oxidized mercury.[1539] Therefore, a POSITA would have expected that when using PAC in both Downs-Halogenation and Olson-Paper, that bromine and halogen would have followed similar reaction and oxidation pathways with activated carbon. Indeed, both chlorine and bromine are in the halogen family, both are well-known oxidizing agents, and both have similar chemical properties.[1540]

575. As further confirmation that my analysis of the disclosure of Olson-Paper is correct, I note that the depiction of the reaction mechanism is nearly identical between Olson-Paper (top)[1541] and the '147 patent (bottom), reproduced below:[1542]

1537 Ex. 1015 (Downs-Halogenation) at ¶ [0004]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [005].

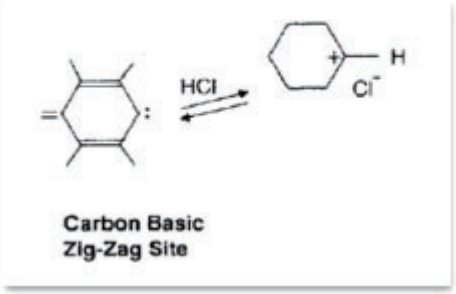
1538 Ex. 1015 (Downs-Halogenation) at ¶ [0006, 0023]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [007, 0026].

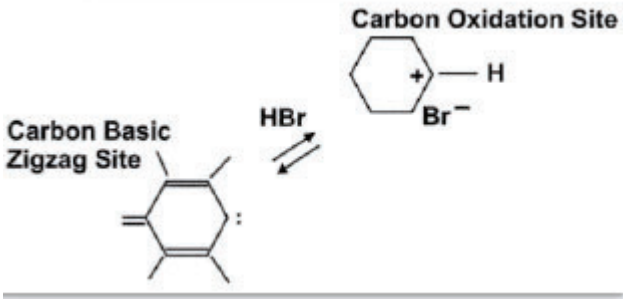
1539 Ex. 1079 (Olson-Paper) at 979, Fig. 2.

1540 *See* State of the Art, above § § XII.A.2, XII.A.7, XII.C.3, XII.G.2.

1541 Ex. 1079 (Olson-Paper) at 982, Fig.2.

1542 Ex. 1001 ('147 Patent) at Fig.2.





In both figures, the carbocation (indicated by the + symbol) is paired with the halide anion. And similar to Olson-Paper, the '147 patent also uses Norit Darco FGD® as the activated carbon sorbent of choice.[1543]

6. Claim 1: Element 1(b) —"chemically reacting elemental mercury in the mercury containing gas with the promoted brominated sorbent to form a mercury/sorbent chemical composition; and"

576. This limitation is disclosed by Downs-Halogenation. This limitation is also obvious over Downs-Halogenation in view of Olson-Paper.

577. Downs-Halogenation explains that the key benefit of the promoted brominated sorbent is its "reactivity with elemental mercury."[1544] Downs-

[1543] Ex. 1001 ('147 Patent) at 5:52-67 (describing Figs. 4-9), 14:40-46, 15:46, 20:48.

[1544] Ex. 1015 (Downs-Halogenation) at ¶ [0020]; see also Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0023].

Halogenation makes clear that this benefit of the promoted brominated sorbent is realized within a mercury containing gas, such as the flue gas of a coal-fired power plant, when the "sorbent 14 particles with their loading of adsorbed halogen-containing reagent 24 enter the flue gas flue(s) injection locations 28 *with high reactivity for the removal of elemental mercury."*[1545]

578. In addition to the express disclosures in Downs-Halogenation, Downs-Halogenation in view of Olson-Paper further reinforces to a POSITA that elemental mercury in the mercury containing gas reacts with the promoted brominated sorbent to form a mercury/sorbent chemical composition. Olson-Paper describes that activated carbon undergoes the following reactions for purposes of oxidation of elemental mercury:

> The basic carbene cannot react directly with Hg^0, but reacts with HCl to form stable carbenium ion intermediates, which are then active for binding Hg^0, accepting electrons from the atom (Figure 2). Thus HCl or other acids promote the oxidation step.[1546]

In the above passage, Hg^0 refers to elemental mercury (i.e., non-oxidized mercury). Reproduced below is an annotated version of Fig. 2 from Olson-Paper, showing in

[1545] Ex. 1015 (Downs-Halogenation) at ¶ [0019] (emphasis added); *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0022].

[1546] Ex. 1079 (Olson-Paper) at 982.

step the reaction between the promoted halogenated sorbent and elemental mercury (Hg^0) to form a mercury/sorbent chemical composition:[1547]

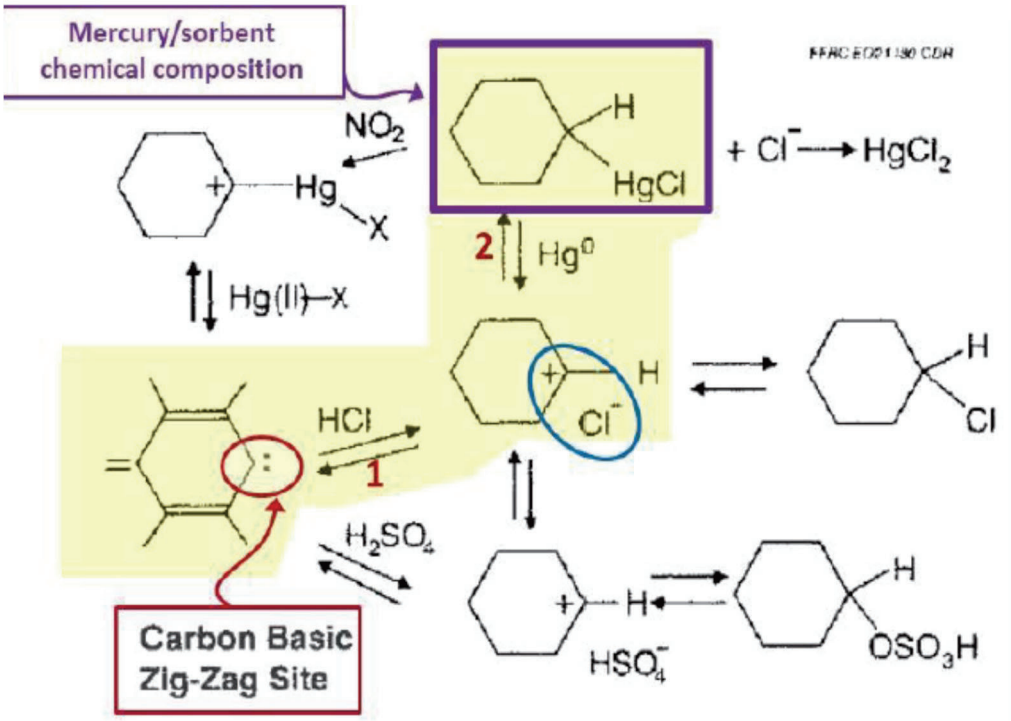


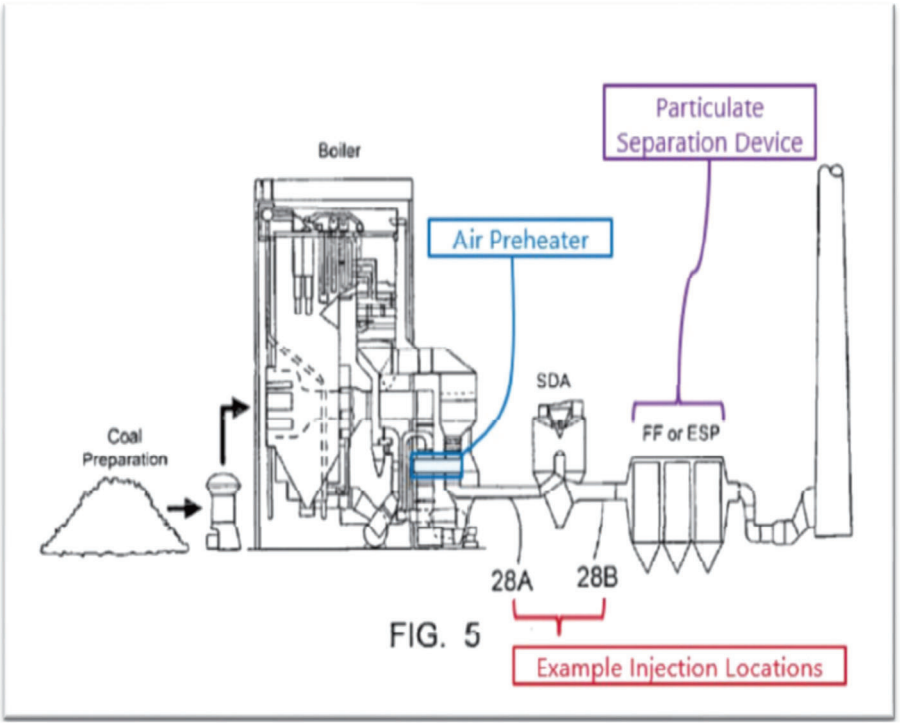
Figure 2. Reaction site model for activated carbon.

7. Claim 1: Element 1(c) —"separating particulates from the mercury containing gas, the particulates including ash and the mercury/sorbent chemical composition."

579. This limitation is disclosed by Downs-Halogenation. Downs-Halogenation describes injecting the dynamically halogenated PAC upstream of a particulate collector, such as an electrostatic precipitator (ESP) or fabric filter

[1547] Ex 1079 (Olson-Paper) at 982, Fig.2 (annotated).

(FF).[1548] This injection upstream of a particulate collector device is illustrated by Figures 4-6 of Downs-Halogenation, representative Fig. 5 as annotated is reproduced below with the direction of flow being from left to right.[1549]



580. A POSITA would have understood that the particle collectors disclosed by Downs-Halogenation, either a fabric filter (FF) or electrostatic precipitator (ESP) as illustrated above, would capture fly ash *(i.e.,* a major component of the particulate present in the flue gas) together with the mercury-bound sorbent. Downs-Halogenation explains that as the flue gases exited a boiler they "first passed through

[1548] Ex. 1015 (Downs-Halogenation) at ¶ [0003-04, 0029]; see also Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [004-05, 0032].

[1549] Ex. 1015 (Downs-Halogenation) at Fig. 5 (annotated); see also Ex. 1015 (Downs-Halogenation) at Figs. 4, 6; Ex. 1016 (Downs-Halogenation-Provisional) at Figs. 4-6.

a spray dryer absorber (SDA) for removal of sulfur dioxide, and then through a fabric filter (FF) for removal of ***fly ash*** and ***spent sorbent.”***[1550]

581. Elaborating on this understanding of a POSITA, Downs-Halogenation further teaches the flexibility of the invention, in that in a less-conventional alternate embodiment, “the spent carbonaceous sorbent can be removed separately from the coal fly ash, if desired, by adding an additional particulate collector designed specifically to capture the injected quantity of carbonaceous sorbent.”[1551] I also note that the ’147 patent admits that particulate separators, including electrostatic precipitators, were known in the art:[1552]

> 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.

B. DEPENDENT CLAIMS

1. Claim 17

a. Claim 17: Element 17(a)—”A method according to claim 1, “further comprising injecting the particulate sorbent material at a sorbent material injection rate and injecting separately the bromine containing promoter into a gas stream”

[1550] Ex. 1015 (Downs-Halogenation)at ¶ [0022](emphasis added); see also Ex.1016 (Downs-Halogenation-Provisional) at ¶ [0025]

[1551] Ex. 1015 (Downs-Halogenation) at ¶ [0030]; Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0033].

[1552] Ex. 1001 (‘147 Patent) at 8:61-66.

582. This limitation is disclosed by Downs-Halogenation. The particulate sorbent material, preferably a PAC sorbent, is discussed above in Ground C for Claim Element 1(a)(1). Downs-Halogenation makes clear throughout the disclosure that the PAC sorbent may be injected according to use with conventional PAC injection systems.[1553] As such, the preferred embodiment of Downs-Halogenation employs a "means for metering 16 the sorbent 14 into a sorbent transport air stream 18.[1554]

583. As indicated in annotated Fig. 3, reproduced below, Downs-Halogenation discloses injecting a particulate sorbent material and provides an example sorbent injection rate, labeled "PAC injection rate." [1555]

[1553] Ex. 1015 (Downs-Halogenation) at ¶ [0019]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0022].

[1554] Ex. 1015 (Downs-Halogenation) at ¶ [0019]; *see also* Ex. 1015 (Downs-Halogenation) at Fig. 2; Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0022].

[1555] Ex. 1015 (Downs-Halogenation) at Fig. 3 (annotated); *see also* Ex. 1016 (Downs-Halogenation-Provisional) at Fig. 3.

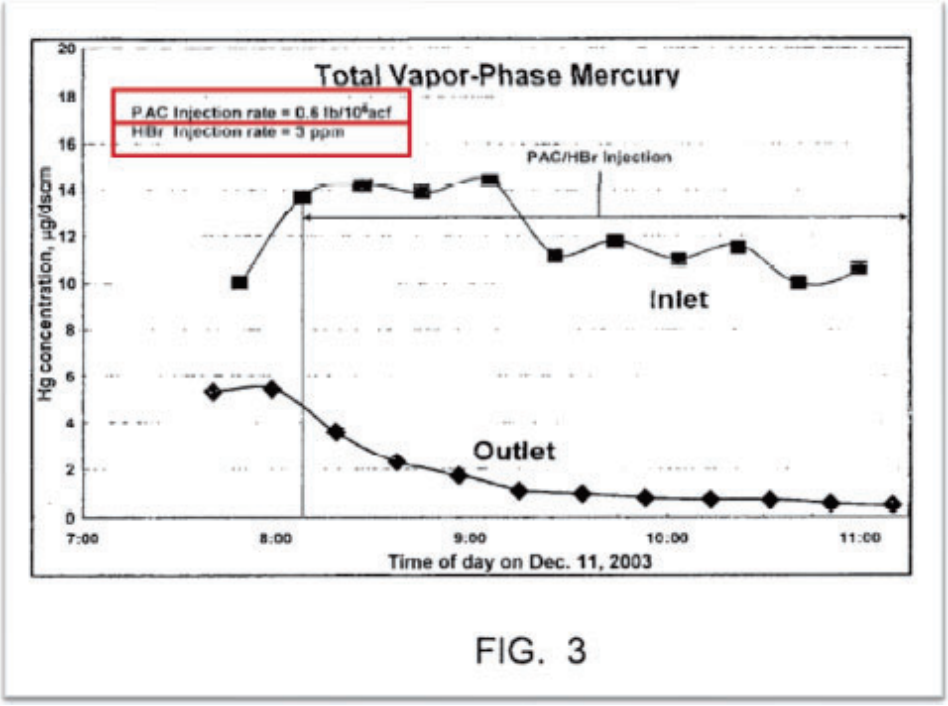
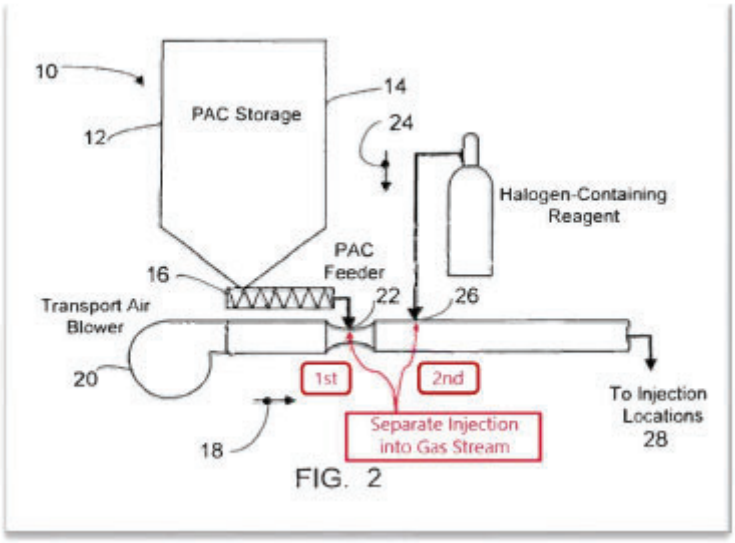


FIG. 3

584. Downs-Halogenation discloses injection of the particulate sorbent material into a gas stream as illustrated in Fig. 2, reproduced below as annotated, where the PAC 14 is injected into a gas stream by the pressure differential of the venturi effect from the constriction at pick up point 22.[1556] Downs-Halogenation further makes clear that the bromine containing promoter *(i.e.,* HBr gas) is injected separately into a gas stream from the injected particulate sorbent material. With reference to annotated Fig. 2, reproduced below, Downs-Halogenation describes injecting the particulate sorbent material into a gas stream *(e.g.,* "a conventional powdered activated carbon (PAC) injection system 10 including a sorbent storage tank 12 containing a supply of sorbent 14, a means for metering 16 the sorbent 14

[1556] Ex. 1015 (Downs-Halogenation) at Fig. 2; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at Fig. 2.

into a sorbent transport air stream") and separately the bromine containing promoter *(e.g.,* "a halogen-containing reagent or compound 24, which may be in gaseous form, is injected into the flowing transport air/sorbent stream at a point 26 *close* to the point 22 where the sorbent 14 and *transport air 18* first mix") into the gas stream *(e.g.,* "transport air stream 18").[1557]



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For the same reasons, Claim Element 17(a) would be met in the combination where the recycled flue of Lissianski-Patent is used as the transport gas 18 of Downs-Halogenation.

b. Claim 17: Element 17(b)—"whereby in-flight reaction produces the promoted brominated sorbent,"

1557 Ex. 1015 (Downs-Halogenation) at ¶ [0019] (emphasis added); *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0022].

1558 Ex. 1015 (Downs-Halogenation) at Fig. 2 (annotated); *see also* Ex. 1016 (Downs-Halogenation-Provisional) at Fig. 2.

585. This limitation is obvious over Downs-Halogenation in view of Olson-Paper. As I discuss above in Ground C for Claim Element 1(a)(2) and also for Claim Element 1(a)(4), the in-flight reaction between a bromine-containing promoter in the gas phase and the powdered activated carbon produces the promoted brominated sorbent.

586. Elaborating on the preparation of the promoted brominated sorbent as described above with respect to Claim Element 17(a), Downs-Halogenation describes that the bromine promoter mixes with the "flowing transport air/sorbent stream" such that both the sorbent and the bromine are conveyed together (reacting in-flight) within the pneumatic transport conveying system, and as a result:[1559]

> This process maximizes the benefit and utilization of the halogen-containing reagent 24 by placing it exactly where it is needed to facilitate elemental mercury removal-on the surface of the sorbent 14. The sorbent 14 particles with their loading of adsorbed halogen-containing reagent 24 enter the flue gas flue(s) injection locations 28 with high reactivity for the removal of elemental mercury.[1560]

The process of Downs-Halogenation above refers to a promotion of the activated carbon sorbent by the bromine of the halogen containing reagent which occurs within the transport gas stream. The above promotion occurs regardless of whether

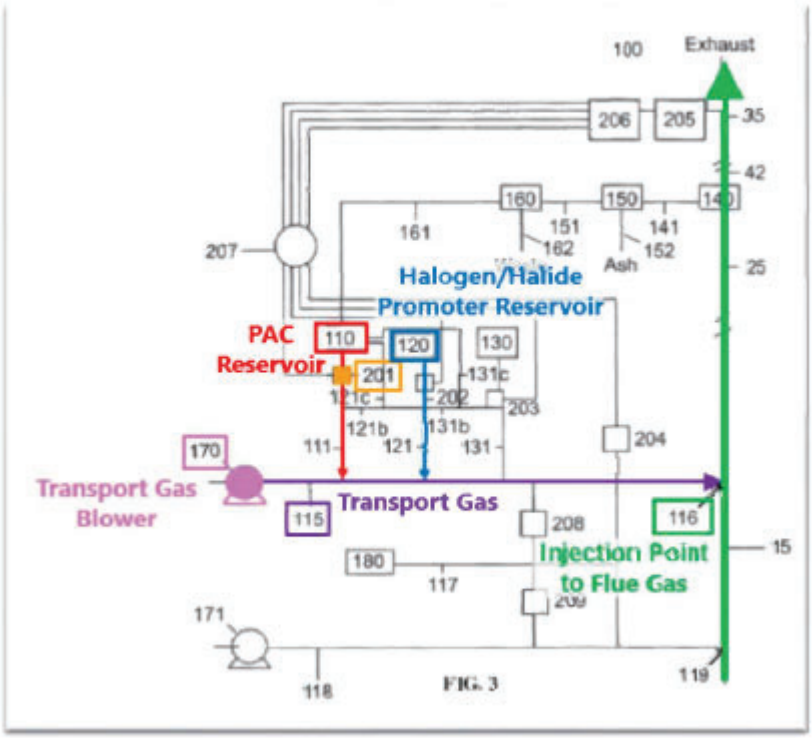
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[1559] Ex. 1015 (Downs-Halogenation) at ¶ [0019]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0022].

[1560] Ex. 1015 (Downs-Halogenation) at ¶ [0019]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at iii [0022].

the transport gas is air (as in Downs-Halogenation) [1561], or the transport gas is a recycled flue gas (as in Lissianski-Patent). [1562]

587. Further confirming this understanding, as I described above in Ground C, I again note that Downs-Halogenation and the '147 patent employ a similar setup for promoting the activated-carbon sorbent with bromine as illustrated below:[1563]



1561 Ex. 1015 (Downs-Halogenation) at ¶ [0019]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at 11] [0022].

1562 Ex. 1036 (Lissianski-Patent) at 4:20-23, claim 24.

1563 *Compare* Ex. 1001 ('147 Patent) Fig. 3 (annotated) (top), *with* Ex. 1015 (Downs-Halogenation) Fig. 2 (annotated) (bottom), *and* Ex. 1016 (Downs-Halogenation-Provisional) Fig. 2.

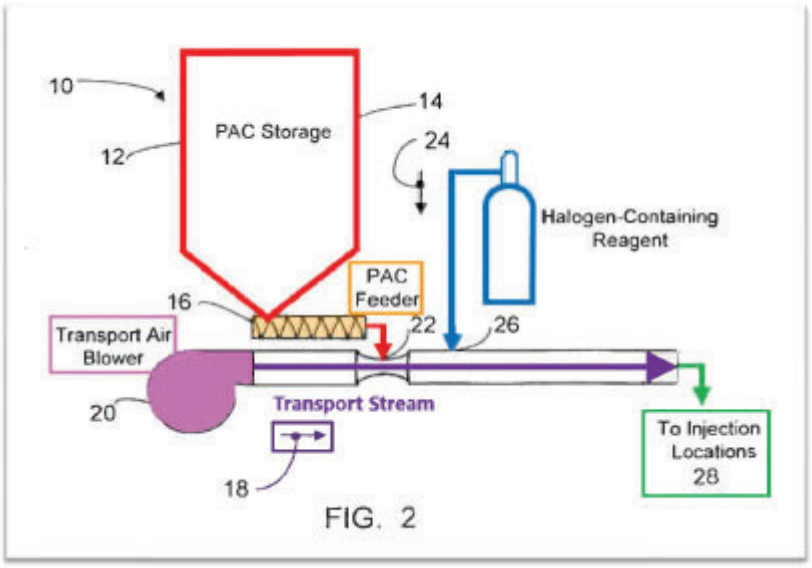


FIG. 2

As indicated above, both the '147 patent and Downs-Halogenation provide a PAC reservoir (red)[1564] that feeds PAC out of the reservoir (orange)[1565] into a stream of transport gas (purple)[1566] driven by a blower fan (pink).[1567] A halogen promoter

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1564 *Compare* Ex. 1001 ('147 Patent) 8:25-26 ("base activated carbon reservoir 110"), *with* Ex. 1015 (Downs-Halogenation) at ¶ [0019] ("sorbent storage tank 12 containing a supply of sorbent 14"), *and* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0022].

1565 *Compare* Ex. 1001 ('147 Patent) 8:29 ("flow control device(s) 201"), *with* Ex. 1015 (Downs-Halogenation) at ¶ [0019] ("means for metering 16 the sorbent 14"), *and* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0022].

1566 *Compare* Ex. 1001 ('147 Patent) 8:37-42 ("A source of air, nitrogen, or other transport gas(es) is provided by gas source 170 to transport line 115 for the purpose of entraining materials discharged from reservoirs 110, 120, 130, and 180 and injecting such materials, via injection point 116, into contaminated flue gas stream 15."), *with* Ex. 1015 (Downs-Halogenation) at ¶ [0019] ("air 18 used to convey the sorbent 14 to the injection locations in the flue gas"), *and* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0022].

1567 *Compare* Ex. 1001 ('147 Patent) 8:50-53 ("gas sources 170 and 171 are shown in FIG. 3 as compressors or blowers, any source of transport energy known in the art may be acceptable"), *with* Ex. 1015 (Downs-Halogenation) at

(blue)[1568] is injected into the transport gas downstream of the PAC injection point such that a promoted carbon sorbent is prepared "in-flight" within the transport line prior to injection into the flue gas (green).[1569]

c. Claim 17: Element 17(c)—"wherein the promoter is reacted in the gas phase or as a vapor,"

588. This limitation is obvious over Downs-Halogenation in view of Olson-Paper. As I discuss above in Ground C for Claim Element 1(a)(2) and claim 2, Downs-Halogenation discloses a bromine-containing promoter in the form

¶ [0019] ("a sorbent transport air blower 20"), *and* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0022].

[1568] *Compare* Ex. 1001 ('147 Patent) 8:26 ("halogen/halide promoter reservoir"), *with* Ex. 1015 (Downs-Halogenation) at ¶ [0019] ("halogen-containing reagent or compound 24, which may be in gaseous form, is injected into the flowing transport air/sorbent stream at a point 26 close to the point 22"), *and* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0022].

[1569] *Compare* Ex. 1001 ('147 Patent) 9:51-56 ("The halogen/halide may preferably be combined via line 121 directly into transport line 115, within which it contacts and reacts with the base activated carbon prior to injection point 116. This option is one form of what is referred to herein as "in-flight preparation of a promoted carbon sorbent in accordance with the invention."), *with* Ex. 1015 (Downs-Halogenation) at ¶ [0019] ("The key aspect of the present invention is that a halogen-containing reagent or compound 24, which may be in gaseous form, is injected into the flowing transport air/sorbent stream at a point 26 close to the point 22 where the sorbent 14 and transport air 18 first mix . . . . The sorbent 14 particles with their loading of adsorbed halogen-containing reagent 24 enter the flue gas flue(s) injection locations 28 with high reactivity for the removal of elemental mercury."), and Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0022].

"hydrogen bromide *gas* (HBr) or bromine (Br_2)." [1570] As I also discuss above in Ground C for Claim Element 1(a)(4), Olson-Paper explains that a chemical reaction takes place between the activated carbon and the halogen-containing promoter as they are mixed to form the dynamically halogenated PAC according to the process taught by Downs-Halogenation.

d. *Claim* 17: Element 17(d)—wherein the promoter is added at from about 1 to about 30 grams per 100 grams of the sorbent material."

589. Claim Element 17(d) states that the "promoter is added at . . .," but does not state where the promoter is added. In particular, Claim Element 17(d) does not specify whether: (i) the "promoter is added [to the sorbent] at from about 1 to about 30 grams per 100 grams," or (ii) the "promoter is added [to a gas stream] at from about 1 to about 30 grams per 100 grams." Claim Element 17(d) is obvious over Downs-Halogenation in view of Olson-Paper and Lissianski-Patent under either interpretation.

590. Turning to the second interpretation to begin with, Claim Element 17(d) is obvious over Downs-Halogenation in view of Lissianski-Patent. As described in the Reasons to Combine, a POSITA would have been motivated to at least try the lower bromine concentration of 0.3 ppm from Lissianski-Presentation with the PAC

[1570] Ex. 1015 (Downs-Halogenation) at ¶ [0026] (emphasis added); Ex. 1016 (Downs-Halogenation-Provisional) at 11 [0029].

injection rate of Downs-Halogenation.[1571] As discussed above, a POSITA would have had a reasonable expectation of success in substituting the concentration from Downs-Halogenation of 3 ppm with the 0.3 ppm concentration of Lissianski-Presentation because both Lissianski-Presentation and Downs-Halogenation disclose using a 3 ppm gas-phase rate of addition of "Br," but Lissianski-Presentation further discloses that a 0.3 ppm of bromine in flue gas would also be effective.[1572] This rate of addition of the promoter to the sorbent from Lissianski-Presentation would have followed the motivations in Downs-Halogenation to make cost-effective use of "lower addition rates for the halogen-containing reagent."[1573]

591. Downs-Halogenation discloses an activated carbon injection rate of 0.6 lb/MMacf (pounds per actual cubic feet).[1574] Likewise, a POSITA would have followed the direction of Downs-Halogenation to use a modest sorbent injection rate, such as the disclosed 0.6 lb/MMacf, since costs "of high injection rates can be prohibitive."[1575] As discussed above, the promoter concentrations are expressed in parts per million (ppm). In order to determine a ratio of bromine concentration to

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1571 Ex. 1036 (Lissianski-Patent) at 6:62-67, Fig. 9.

1572 Ex. 1036 (Lissianski-Patent) at Fig. 9, 6:62-67.

1573 Ex. 1015 (Downs-Halogenation) at ¶ [0021]; see also Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0024].

1574 Ex. 1015 (Downs-Halogenation) at ¶ [0023], Fig. 3; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at Fig. 3.

1575 Ex. 1015 (Downs-Halogenation) at ¶ [0004]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [005].

activated carbon in the gas phase, the concentrations must have the same units, so a unit conversion must take place between ppm (Br concentration) and pounds/acf (activated carbon concentration). In this case, converting both values to a grams/acf basis is the most convenient for comparison, and requires the fewest assumptions (the only assumptions being the flue-gas pressure and temperature).

592. Converting between ppm (Br concentration rate, per Lissianski-Patent) and pounds /MMACF (sorbent injection rate, per Downs-Halogenation) would have been routine to a POSITA. In this case, converting both values to a grams/MMACF basis is the most convenient for comparison, and requires the fewest assumptions (the only assumptions being the flue-gas pressure). Such a routine conversion of units would have involved such basic concepts as the ideal gas law (to convert concentrations between temperatures and pressures), which was taught in first semester undergraduate chemistry to a POSITA.[1576] Such a unit conversion would have also involved basic engineering knowledge of a power-plant operation, such as a typical flue gas pressure. This would have been well-known to a POSITA.

593. A POSITA would have understood from the ideal gas law that the density of a gas is proportional to pressure and inversely proportional to temperature. A POSITA would also have known that a typical flue gas temperature where sorbent would be injected is 150 °C (423 K) and also 1 atm of pressure. Last, a POSITA

[1576] *See, e.g.,* State of the Art, above, § XII.A.9.

would have found in readily available tables of unit conversions and/or basic chemistry books the following constants:

- 1 Actual Cubic Feet (ACF) = 1 ft^3 = 28.3168 L.
- 1 MMACF = 10^6 ACF
- Universal gas constant (R) = 0.082058 (L*atm) / (mol*K)
- Molecular weight of Br = 79.904g/mol

594. Based on the above constants and relationships, the concentration of active-carbon sorbent in the flue gas can be calculated as:

$$\frac{0.6\ pounds\ PAC}{MMACF} \times \frac{453.592\ grams}{pound}$$

$$= 272 \frac{0.6\ pounds\ PAgrams\ Activated\ Carbon}{MMACF}$$

Based on the above constants and relationships, the concentration of Br in the flue gas can be calculated as follows:

$$\frac{0.3\ \text{mol Br}}{10^6\ mol\ flue\ gas} \times \frac{(79.904\ \text{g Br})}{1\ \text{mol HBr}} = 2.397 \times 10^{-5} \frac{g\ Br}{mol\ flue\ gas}$$

A POSITA would have readily been able to convert the flue gas from a molar basis (mol) to a volumetric basis (ACF) as follows:

$$\frac{ACF\ flue\ gas}{\text{mol flue gas}} = \frac{(423\ \text{K}) \times \left(0.082058 \frac{L\ atm}{mol}\right) \times \frac{ACF}{28.3\ L}}{1\ atm} = \frac{1.226\ ACF\ flue\ gas}{mol\ flue\ gas}$$

Combining the above equations to calculate the grams Br per MACF flue gas:

$$2.397 \times 10^{-5} \frac{g\ Br}{mol\ flue\ gas} \times \frac{1.mol\ ACF\ flue\ gas}{1.226\ ACF} \times \frac{10^6\ ACF}{MMACF}$$

$$= 19.55 \frac{g\ Br}{\text{MMACF}}$$

Thus, when comparing the concentration of the supplied bromine promoter described by Lissianski-Patent (0.3 ppm, or 19.55 g / MACF), and the injection rate of the sorbent described by Downs-Halogenation (0.6 lb/MMacf, or 272 g /MMACF) there is 7.19 grams of bromine containing promoter added to the gas stream per 100 grams of activated carbon, which falls within the range of claim 17 under the second interpretation.

595. This proportion of 7.19 grams of bromine containing promoter per 100 grams of activated carbon added to the flue gas also leads to a disclosure that the "promoter is added [to the sorbent] at from about 1 to about 30 grams per 100 grams of the sorbent material"—the first interpretation of Claim Element 17(d) noted above. Downs-Halogenation explains that "the carbonaceous sorbent 14 and halogen-containing reagent 24 are brought together in the sorbent pneumatic transport line with sufficient residence time for the halogen-containing reagent 24 to

be adsorbed onto the carbonaceous sorbent 14 particle before the sorbent 14 is injected into the coal combustion flue gas stream." [1577] Accordingly, a POSITA would have understood that all of the 7.19 grams of the bromine containing promoter would been added to the 100 grams of activated carbon when using the lower bromine concentration of Lissianski-Patent with the sorbent material injection rate of Downs-Halogenation.

596. I also note that Claim Element 17(d) is merely an attempt to claim a workable range for combining a conventional halogen (bromine) being used in a conventional way (to promote activated carbon) with a conventional sorbent (activated carbon). Nothing in the '147 patent specification attributes significance to the claimed range or establishes that the claimed range achieves unexpected results. The range presents nothing more than optimization of result-effective variables that would have been obvious to a POSITA. Through routine process optimization and routine experimentation, a POSITA would have adjusted the rate of addition of the promoter and/or the rate of addition of the sorbent material to achieve a range from about 1 g to about 30 g of promoter per 100 grams of the sorbent material, under either interpretation of Claim Element 17(d) to achieve a more-optimum application of promoter and sorbent, from the standpoint of

[1577] Ex. 1015 (Downs-Halogenation) at ¶ [0024]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0027].

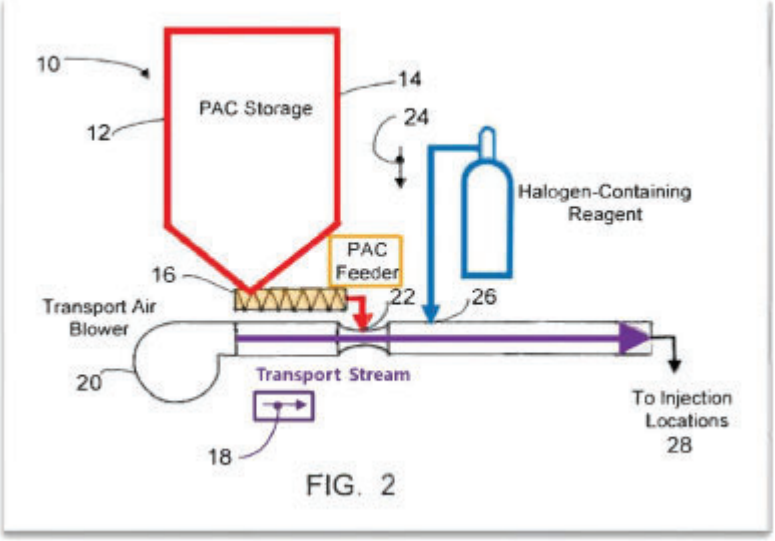
maximizing the marginal-benefit of both the promoter and the sorbent. Moreover, the range is approximate, as claim 17 recites "from *about 1 to about* 30" for the ratio and indicates in the specification that less than 1 gram of bromine may be taken up by 100 g of activated carbon.[1578] The range presents nothing more than optimization of result-effective variables that would have been obvious to a POSITA.

2. Claim 18. "A method according to claim 17, wherein the gas stream is a mercury containing gas."

597. As a preliminary matter, claim 18 depends from claim 17, which itself depends from claim 1. Claim 1 recites "***a*** mercury containing gas" and thereafter refers to it as *"**the*** mercury containing gas." Claim 18 further limits "the gas stream" of claim 17 such that "the gas stream" must be *"**a*** mercury containing gas." As I understand, the indefinite article of claim 18 ("a") means that the "gas stream is a mercury containing gas" can be validly interpreted as either: (i) the mercury containing gas of claim 1, or (ii) a second gas stream that also contains mercury. I further understand that for the purposes of invalidity it is sufficient if only one of these interpretations is rendered obvious over a combination of references. Under either interpretation of claim 18, this would have been obvious over Downs-Halogenation in view of Lissianski-Patent.

[1578] Ex. 1001 ('147 Patent) at claim 17 (emphasis added), 19:64-67 ("The amount of bromine taken up by the carbon ranges (in one example) from <1 to about 30 g per 100 g of activated carbon, depending on the proportions used.").

598. Downs-Halogenation discloses "a sorbent transport air stream 18" provided by "a sorbent transport air blower 20 for supplying the air 18 used to convey the sorbent 14 to the injection locations in the flue gas."[1579]



Downs-Halogenation also recognizes the existence of other embodiments of "pneumatic transport conveying system[s], and many other configurations could be used or developed by one of ordinary skill in the art without departing from the scope of the present invention."[1580] Lissianski-Patent expressly lists a number of example pneumatic transport conveying mediums, including: "air, ***recycled flue gas,*** nitrogen or another carrier gas.[1581] Accordingly, using a recycled flue gas as the

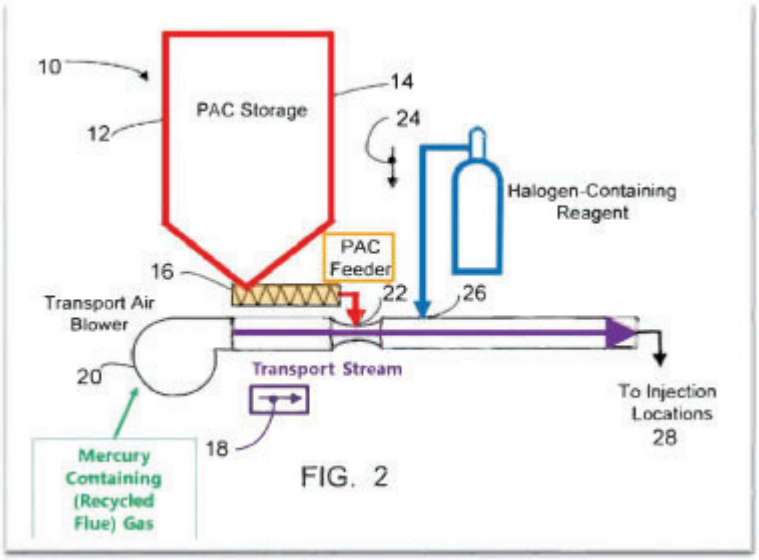
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[1579] Ex. 1015 (Downs-Halogenation) at ¶ [0019]; see also Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0022].

[1580] Ex. 1015 (Downs-Halogenation) at ¶ [0019]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0022].

[1581] Ex. 1036 (Lissianski-Patent) at 4:20-22 (emphasis added); *see also* Ex. 1036 (Lissianski-Patent) at claim 24 ("air, recycled flue gas and nitrogen gas").

pneumatic transport conveying system of Downs-Halogenation would present a system according to Fig. 2, as annotated below:



[1582]

This recycled flue gas would itself constitute a mercury containing gas, as recited by claim 18. The activated-carbon sorbent (red) and halogen-containing reagent (promoter, blue) would be injected separately into this mercury-containing gas and undergo in-flight reaction in the mercury-containing gas. Accordingly, as claim 18 modifies claim 17, the use of a recycled flue gas with the system of Downs-Halogenation would perform the method of injecting the particulate sorbent material at a sorbent injection rate (as discussed above regarding Claim Element 17(a)) and

[1582] Ex. 1015 (Downs-Halogenation) at Fig. 2 (annotated); *see also* Ex. 1016 (Downs-Halogenation-Provisional) at Fig. 2.

injecting separately the bromine containing promoter (as discussed above regarding Claim Element 17(a)) into a *mercury containing gas stream* (a recycled flue gas).

599. As described in Reasons to Combine, a POSITA would have been motivated to use a recycled flue gas stream to transport activated carbon and promoter into the main flue-gas duct (injection location 28), and would have had a reasonable expectation of success, because doing so was common and also disclosed in Lissianski-Patent. A POSITA would have understood that flue gas can easily be recycled into the transport line that stages bromination and sorbent injection. Flyash can be avoided either by recycling flue gas from downstream of the particle collection device (either an ESP or FF), or by recycling from upstream of the flyash collectors and removing flyash before the recycle stream reaches the blower in the transport line. In either situation, a POSITA would have understood that removing flyash minimizes the potential for scavenging of bromine compounds by alkaline and alkaline earth minerals before they can bind to the sorbent.

3. Claim 19. "A method according to claim 18, wherein the gas stream is a transport gas."

600. This limitation is disclosed by Downs-Halogenation. As described above for claim 18, Downs-Halogenation discloses "a sorbent ***transport*** air stream 18" for delivering sorbent and promoter to the main flue-gas duct (injection location 28), and describes "a sorbent ***transport*** air blower 20 for supplying the air 18 used

to convey the sorbent 14 to the injection locations in the flue gas."[1583] Even with the modification from Lissianski-Patent in using a recycled flue gas as the transport gas, this would still be understood by a POSITA to be a "transport gas."

4. Claim 20. "A method according to claim 17, wherein the promoter injection rate and the sorbent injection rate into the gas are determined at least in part on the monitored mercury content of the cleaned gas."

601. This claim is disclosed by Downs-Halogenation. Claim 20 recites "the cleaned gas," but does not expressly state which "cleaned gas" is being referenced. Claim 20 will be analyzed as if "the cleaned gas" were to mean a gas from which particulates including ash and the mercury/sorbent chemical composition has been separated, pursuant to Claim Element 1(c).895

602. As described above for Claim 21 in Ground C, Fig. 3 of Downs-Halogenation, annotated as reproduced below, together with the associated description, discloses monitoring the mercury content of a cleaned gas on the Y-axis (yellow):[1584]

[1583] Ex. 1015 (Downs-Halogenation) at ¶ [0019]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0022].

[1584] Ex. 1015 (Downs-Halogenation) at Fig. 3 (annotated); *see also* Ex. 1016 (Downs-Halogenation-Provisional) at Fig. 3.

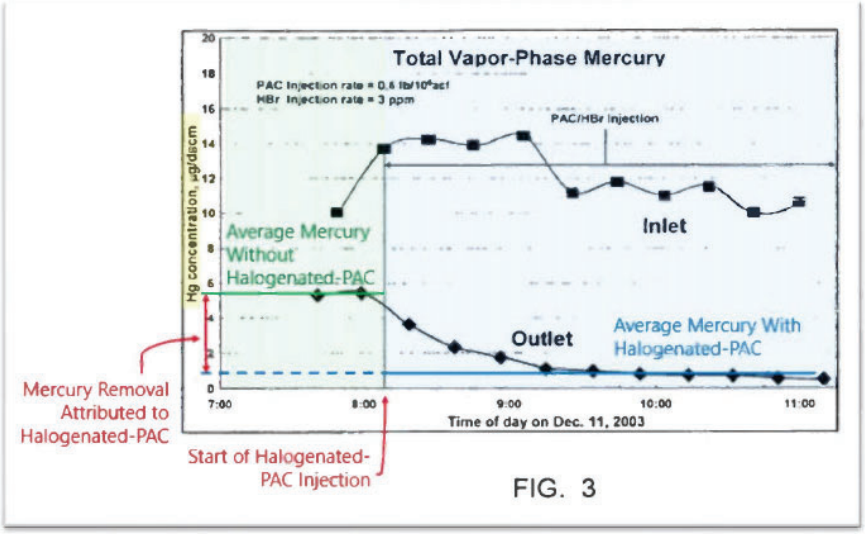


FIG. 3

As disclosed by Downs-Halogenation, the monitored mercury content of the cleaned gas (i.e., the gas stream at the "Outlet" of the fabric filter) was "well below 1 µg/dscm" (blue).[1585] As shown in the legend, Downs-Halogenation determined the sorbent "PAC Injection rate" and the promoter "HBr Injection rate" that corresponds with a monitored mercury content of 1 µg/dscm for the cleaned gas. Accordingly, a POSIT A interested in controlling the mercury content of a flue gas having a 6 µg/dscm mercury concentration (green) would have determined to use a 3 ppm promoter injection rate along with a 0.6 lb/MMacf sorbent injection rate to achieve a 1 µg/dscm mercury concentration (blue) of the cleaned gas.

603. Claim 20 does not require that sorbent and promoter injection rates "are determined" at the same time. Nor does it require continuously monitoring mercury

[1585] Ex. 1015 (Downs-Halogenation) at ¶ [0023]; *see also* Ex. 1016 (Downs- Halogenation-Provisional) at iii [0026].

content, continuously adjusting sorbent injection rate and promoter injection rate, or sending or receiving control feedback signals. As such, it would have been obvious to determine the promoter injection rate "at least in part on the monitored mercury content." For example, it was well-known that, when using halogens with activated carbon, the two primary variables to control mercury removal are: sorbent injection rate, and halogen injection rate. Downs-Halogenation describes looking to the EPA for guidance as to mercury removal,[1586] and even the EPA stated that the "extent of potential Hg removal is dependent on: (1) Efficient distribution of the sorbent (e.g., activated carbon) in the flue gas; (2) ***the amount of sorbent needed*** *to* achieve a specific level of Hg removal which will vary depending on the fuel being burned; (3) ***the amount of Cl present in the fuel***; and (4) the type of PM control device "[1587] Lissianski-Patent discloses that the reason for introducing supplemental halogens to the flue gas is to substitute for those fuels (coal) which tend to have low native halogen content.[1588] Accordingly, a POSITA would have known to control mercury emissions by adjusting the sorbent injection rate ("amount of sorbent needed") and by adjusting the halogen-promoter injection rate ("amount of [halogen] present").

1586 Ex. 1015 (Downs-Halogenation) at ¶ [0001]; *see also* Ex. 1016 (Downs- Halogenation-Provisional) at ¶ [002].

1587 Ex. 1009 (EPA-Proposal) at 4676 (emphasis added).

1588 Ex. 1036 (Lissianski-Patent) at 1:53-67.

604. A POSITA would have also taken into account the cost of the promoter and the sorbents themselves, and would have sought to minimize the injection rates (amount used) to the point that the desired level of mercury removal is maintained. These cost considerations are noted as important by Downs-Halogenation, pointing out that the "present invention promises to significantly reduce the cost of mercury removal at coal-fired electric plants,"[1589] and that "the economics of high injection rates can be prohibitive when applied to coal-fired utility plants."[1590] Therefore, Downs-Halogenation recognizes the need to minimize the injection rates, teaching that the "rates of addition of both the hydrogen bromide and PAC were many times lower than the rates for other halogen addition processes and conventional PAC injection processes, respectively."[1591] A POSITA would similarly have taken into consideration the aspect of materials cost (primarily sorbent costs) when selecting each injection rate based on the monitored mercury content of the cleaned gas. Thus, determining the promoter injection rate and/or the sorbent injection rate into the gas based at least in part on the monitored mercury content of the cleaned gas would have been obvious.

[1589] Ex. 1015 (Downs-Halogenation) at ¶ [0020]; *see also* Ex. 1015 (Downs-Halogenation) at ¶¶ [0003-04], Ex. 1016 (Downs-Halogenation-Provisional) at ¶¶ [004-05, 0023].

[1590] Ex. 1015 (Downs-Halogenation) at ¶ [0004]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [005].

[1591] Ex. 1015 (Downs-Halogenation) at ¶ [0023]; *see also* Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [0026].

605. Furthermore, claim 20 is obvious over Downs-Halogenation in view of Lissianski-Patent. As illustrated by Fig 9, reproduced below as annotated, Lissianski-Patent determined mercury oxidation corresponding to bromine concentrations of 0.3 ppm bromine and 3 ppm bromine:[1592]

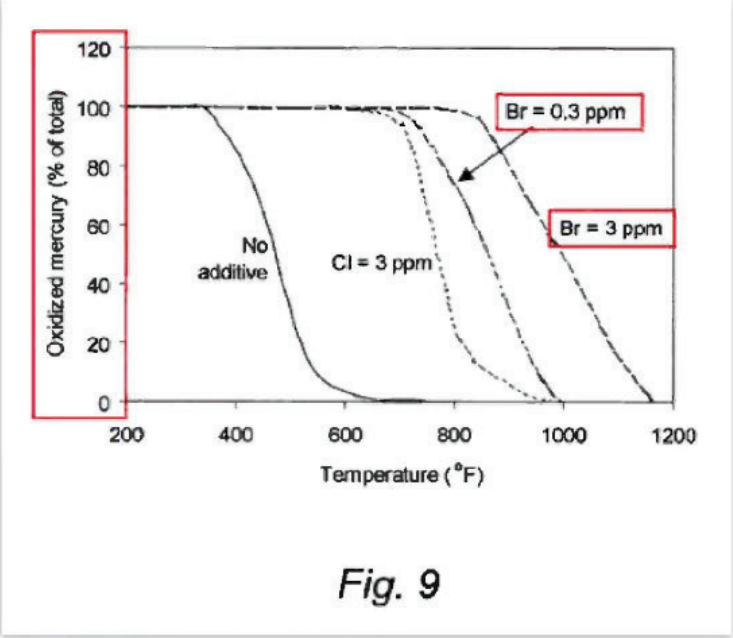


Fig. 9

Determining a ratio of oxidized mercury to total mercury, as in Figure 9 of Lissianski, is a form of monitoring the "mercury content." It would have been obvious to a POSITA to use the monitored mercury content of the cleaned gas from Downs-Halogenation to determine to inject a promoter associated witheither 0.3 or 3 ppm of bromine in the flue gas—the greater value of which corresponds with increased levels of mercury removal—along with the sorbent injection rate of

[1592] Ex. 1036 (Lissianski-Patent) at 6:62-67, Fig. 9 (annotated).

Downs-Halogenation, based at least in part on the monitored mercury content of the cleaned gas. Likewise, it would have been obvious to a POSITA to use an intermediate promoter injection rate between 0.3 and 3 ppm of bromine, along with the sorbent injection rate of Downs-Halogenation, based at least in part on the monitored mercury content of the cleaned gas.

606. Additionally, the normal desire of a POSITA to improve on a given process would have been to adjust the result-effective variables of the injection rate of the promoter and/or the sorbent so as not to wastefully inject excessive sorbent or halogen once sufficient mercury removal was demonstrated, in order to minimize costs associated with operating the sorbent injection system.[1593] Furthermore, a POSITA would have appreciated the variability in the composition of coal as a fuel source (including for example, native mercury and halogen contents), as described in the State of the Art[1594] and also Downs-Halogenation:[1595]

[1593] Ex. 1015 (Downs-Halogenation) at ¶ [0004] ("the economics of high injection rates can be prohibitive when applied to coal-fired utility plants."); Ex. 1016 (Downs-Halogenation-Provisional) at ¶ [005].

[1594] See State of the Art, above, § XII.B.1

[1595] Ex. 1015 (Downs-Halogenation) at Fig. 1; see also Ex. 1016 (Downs-Halogenation-Provisional) at Fig. 1.

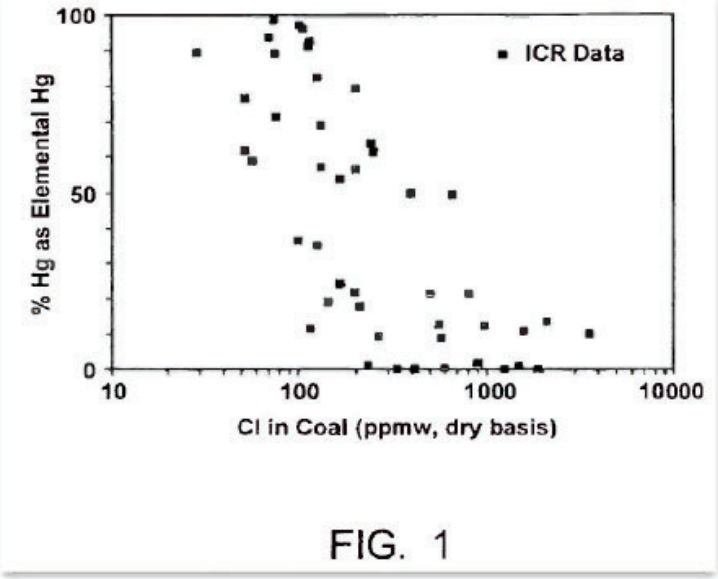


FIG. 1

It would have been obvious to a POSITA that some amount of adjustment to the sorbent-injection rate and promoter-injection rate would have been performed as part of routine process control and optimization to account for variances in the coal.

XXXIII. GROUND O: OBVIOUSNESS OF THE '147 PATENT OVER LISSIANSKI-PRESENTATION IN VIEW OF OLSON-646

275. It is my opinion that Lissianski-Presentation in view of Olson-646 renders obvious each of claims 17-19 of the '147 Patent.

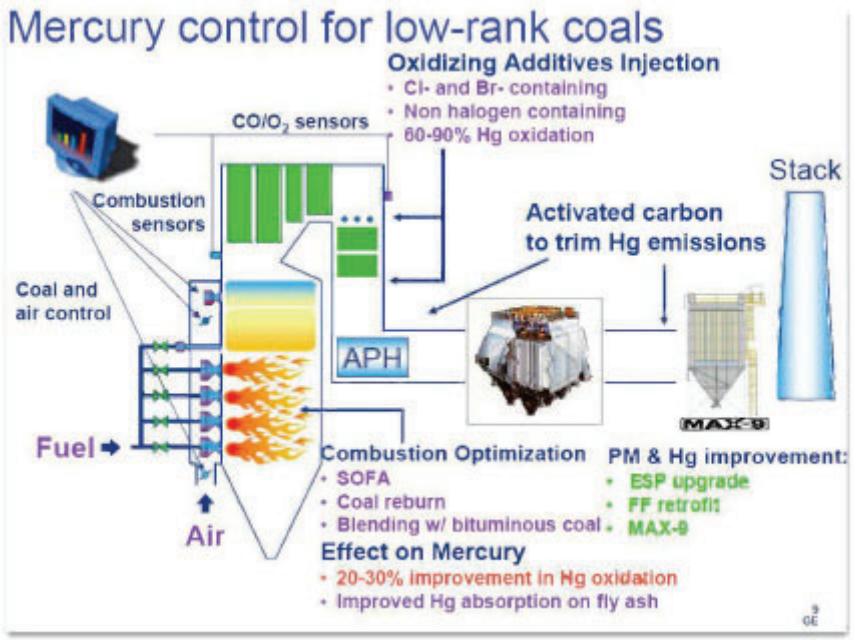
A. CLAIM 1

1. Claim 1: Preamble —"A method for separating mercury from a mercury containing gas comprising:"

276. The preamble is disclosed by Lissianski-Presentation. Lissianski-Presentation's title is "Integrated Approach to Multi-Pollutant Control."[1596]

[1596] Ex. 2014 (Lissianski-Presentation) at 1.

Specifically, Lissianski-Presentation describes an "[i]ntegrated approach to NOx and mercury control."[1597] The below figure from Lissianski-646 shows "[m]ercury control for low-rank coals."[1598] Mercury control refers to separating mercury from a mercury-containing (flue) gas, as further discussed below for Claim Element 1(c).

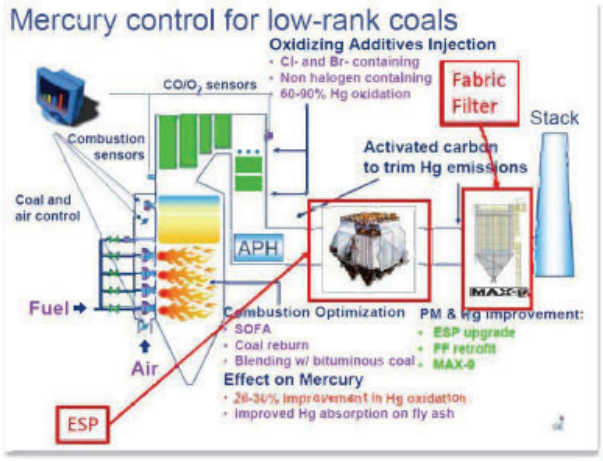


277. As described in further detail below with respect to the elements of claim 1, the system of Lissianski-Presentation would have formed a promoted brominated sorbent that would adsorb mercury to form a mercury/sorbent chemical composition. Lissianski-Presentation also discloses the use of particulate material separators to remove the mercury/sorbent chemical composition from the flue gas.

1597 Ex. 2014 (Lissianski-Presentation) at 2.

1598 Ex. 2014 (Lissianski-Presentation) at 9.

Specifically, the annotated figure of Lissianski-Presentation below discloses the use of an ESP and a fabric filter (or baghouse).[1599]



A POSITA would have understood the first unit to be an ESP because the cutaway view shows the charged flyash collection plates and the ash hoppers below. The figure shows the ESP as being downstream of both bromine injection locations and at least one proposed activated-carbon sorbent injection location. A POSITA would have understood the second unit to be a fabric filter (or baghouse) because the illustration shows the banks of suspended fabric collection bags and a single ash collection hopper below. The figure also shows the fabric filter as being downstream of both bromine injection locations and both activated-carbon sorbent injection locations. Lissianski-Presentation confirms this understanding in the below figure

[1599] Ex. 2014 (Lissianski-Presentation) at 9 (annotations in red).

that shows a pilot-scale boiler-simulation facility ("BSF"), in accordance with the system above, that includes an "ESP" and "Fabric Filter."[1600]



278. A POSITA would have understood that it was well-known that the ESP or FF would have removed solid material, including the mercury/sorbent chemical composition.[1601] Thus, Lissianski-Presentation teaches separating particulates from the mercury containing gas, the particulates including ash and the mercury/sorbent chemical composition.

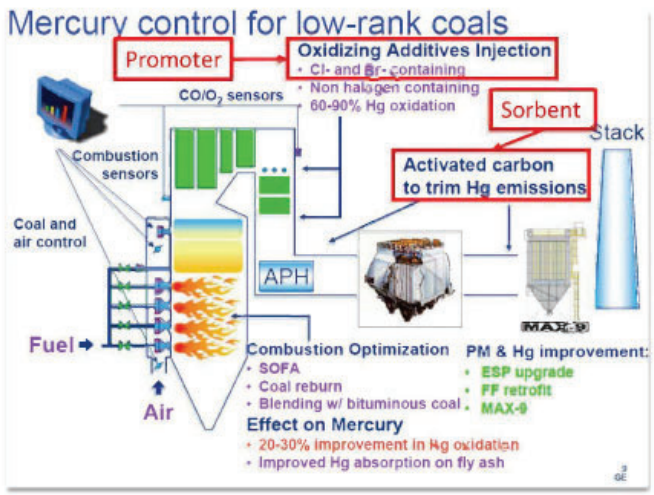
2. Claim 1: Element 1(a)(1) —"promoting at least a portion of a particulate sorbent material comprising activated carbon

[1600] Ex. 2014 (Lissianski-Presentation) at 10.

[1601] See State of the Art, above, § XII.B.5.a

by chemically reacting the sorbent material with a bromine containing promoter to form a promoted brominated sorbent"

279. This limitation is obvious in view of Lissianski-Presentation. The particulate sorbent in Lissianski-Presentation is "activated carbon" shown in the annotated figure below.[1602]



As discussed below, a POSITA would have understood that the bromine and activated carbon would have contacted and reacted in the flue gas to form at least a quantity of promoted brominated sorbent.

280. This element is also obvious over Lissianski-Presentation in view of Olson-646. Like Lissianski-Presentation, Olson-646 describes using a conventional halogen (bromine) in a conventional way (as a promoter) to increase the effectiveness of a conventional sorbent (activated carbon) to capture mercury from

1602 Ex. 2014 (Lissianski-Presentation) at 9 (annotations in red).

coal flue gas. Olson-646 provides additional discussion of underlying chemistry already theorized to take place by the processes disclosed in Lissianski-Presentation.

281. The following describes how Lissianski-Presentation alone, and Lissianski-Presentation in view of Olson-646, render element 1(a)(1) obvious.

a. Particulate sorbent material comprising activated carbon

282. Lissianski-Presentation discloses the use of activated carbon as a particulate sorbent material to capture mercury. The figure above discloses injection of [a]tivated carbon to trim Hg emissions."[1603] Lissianski-Presentation also discloses the use of "Darco FGD" as an exemplary activated carbon sorbent for injection.[1604] A POSITA would have understood that Darco FGD was a well-known type of powdered activated carbon ("PAC") used for mercury capture.[1605] A POSITA would also have understood it was well-known that PACs were commonly in a particulate form. Lissianski-Presentation also discloses the use of well-known particulate material separators (e.g., ESPs and fabric filters) to remove spent activated carbon.[1606]

[1603] Ex. 2014 (Lissianski-Presentation) at 9.

[1604] Ex. 2014 (Lissianski-Presentation) at 8, 18.

[1605] See, e.g., State of the Art, above, § § XII.C.3XII.C.1, XII.G.2.

[1606] Ex. 2014 (Lissianski-Presentation) at 9.

283. This limitation is also obvious in view of Olson-646. For example, Olson-646 discloses embodiments "wherein particulate activated carbon sorbent ... is injected into the gas stream."[1607] Claims 53 and 54 of Olson-646 confirm the use of a "particulate activated carbon sorbent."[1608] Further, Olson-646 explains that particulate control devices include a "baghouse" (e.g., fabric filter) and an "electrostatic precipitator/ESP" each to remove mercury/sorbent particles .[1609] Also, both references teach the same supplier (Norit) and specific brand name (Darco FGD®) of powdered activated carbon (PAC). Lissianski-Presentation describes mercury removal testing performed using "Darco FGD" sorbent. [1610] Likewise, Olson-646 teaches the use of "powdered activated carbon" such as "NORIT Darco FGD."[1611]

b. **Promoting at least a portion of a particulate sorbent material by chemically reacting the sorbent material with a bromine containing promoter to form a promoted brominated sorbent**

1607 Ex. 1014 (Olson-646) at ¶ [0028].

1608 Ex. 1014 (Olson-646) at claims 53, 54.

1609 Ex. 1014 (Olson-646) at ¶ [0111].

1610 Ex. 2014 (Lissianski-Presentation) at 8.

1611 Ex. 1014 (Olson-646) at ¶ [0095].

284. Lissianski-Presentation describes removing mercury from flue gas of coal-fired power plants using activated-carbon sorbent injection and halogen injection.[1612] It would have been obvious in view of the disclosure of Lissianski-Presentation that not all of the bromine would have been consumed in oxidizing mercury in the gas-phase, and that at least some of the bromine-containing promoter injected into the flue gas of Lissianski-Presentation would have contacted the sorbent in mercury-containing gas, at or downstream of the sorbent injection point.

285. First, Lissianski-Presentation discloses that only 60-90% of mercury is oxidized by the bromine in the gas phase.[1613] Second, to address the remaining 10-40% of mercury that was not oxidized, Lissianski-Presentation discloses using activated carbon (dry sorbent).[1614] It was well-known since the 1930s and in the intervening decades that halogens improve the ability of activated carbon to capture mercury. For example, it was explained in 2003 and 2004 that halogens react with

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[1612] Ex. 2014 (Lissianski-Presentation) at 9.

[1613] Ex. 2014 (Lissianski-Presentation) at 9; see also State of the Art, above § XII.G.2; Ex. 1038 (Granite) at exhibit p.16-17 (solubility of HgC12 and HgBr2 in water); Ex. 1008 (Vosteen) at 2:16-25.

[1614] Ex. 2014 (Lissianski-Presentation) at 10.

the surface of activated carbon, promoting it.[1615] Given this known effect on activated carbon, a POSITA would have been motivated to size the Br-containing injection appropriately so that some of the Br-containing additive would be available to react with activated carbon. As described in State of the Art, it was known that acid halides (e.g., HCl and HBr) are highly reactive towards activated carbon, such that any acid halides that are not consumed in oxidizing mercury would have reacted with activated carbon. Third, it was known in the art that gas-surface reactions occur between gas-phase elemental mercury and halide-adsorbed activated carbon, such that the oxidation occurs on the sorbent itself.[1616] Thus, even though Lissianski-Presentation is directed toward oxidation of the mercury, it would have been obvious to use a sufficient amount of bromine such that the sorbent also is promoted.

286. Olson-646 teaches the advantages of promoting activated-carbon sorbent with bromine-containing promoter in Lissianski-Presentation. Olson-646 "provides a cost-effective way to capture pollutants by utilizing exceptionally reactive halogen/halide promoted carbon sorbents using a bromide (or other

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[1615] See, e.g., State of the Art, above, § XII.G.2; Ex. 1062 (Crocker) at 2-3; Ex. 1079 (Olson-Paper) at 979.

[1616] See, e.g., State of the Art, above, § XII.G.2; Ex. 1062 (Crocker) at 2-3; Ex. 1079 (Olson-Paper) at 979.

halogen/halide) treatment of the carbon, that capture mercury via mercury-sorbent surface reactions, at very short contact times of seconds or less."[1617] Olson-646 teaches embodiments "wherein the halogen/halide promoter is in gaseous or vapor form" that comprises "gaseous HBr or Br_2."[1618] As described above in the Reasons to Combine section, a POSITA would have been motivated, with a reasonable expectation of success, to apply the teachings of Olson-646 (e.g., the injection of HBr or Br_2) as the bromine-containing promoter of Lissianski-Presentation.

287. Olson-646 proposes that reactions between HBr(g) and/or Br_2(g) and activated-carbon sorbent are one of promotion, as described below for Claim Elements 1(a)(3) and 1(a)(4). Olson-646 states that "[a] promoted activated carbon sorbent is described that is highly effective for the removal of mercury from flue gas streams."[1619] Specifically, Olson-646 states that "a promoted carbon sorbent is provided comprising a base activated carbon that has reacted with a promoter selected from the group consisting of halides, halogens, and combinations thereof,

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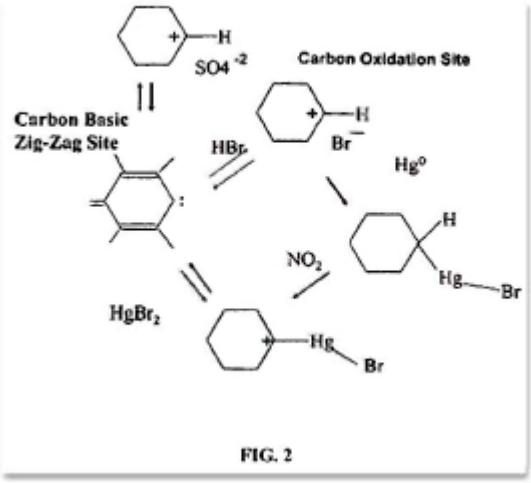
[1617] Ex. 1014 (Olson-646) at ¶ [0043].

[1618] Ex. 1014 (Olson-646) at ¶ [0066].

[1619] Ex. 1014 (Olson-646) at Abstract.

such that the reaction product is effective for the removal of mercury from a gas stream."[1620]

288. Further, Fig. 2 of Olson-646, reproduced below, illustrates that once the bromine/activated carbon complex contacts mercury, it chemically reacts with the mercury[1621]



Olson-646 explains that "hydrogen bromide *reacts* with the unsaturated structure of the activated carbon."[1622] Olson-646 teaches that the reaction may take place at "a carbene species on the edge of the graphene sheet structures of the carbon."[1623]

1620 Ex. 1014 (Olson-646) at 11 [0012].

1621 Ex. 1014 (Olson-646) at Fig. 2.

1622 Ex. 1014 (Olson-646) at ¶ [0054] (emphasis added).

1623 Ex. 1014 (Olson-646) at ¶ [0054].

Further, Olson-646 explains that "[m]olecular bromine or a bromine compound reacts to form a similar structure, with a positive carbon that is active for oxidizing the mercury with subsequent capture by the sorbent."[1624] Fig. 2 of Olson-646 shows that once the bromine/activated carbon complex contacts mercury, it chemically reacts with (e.g., adsorbs) the mercury.

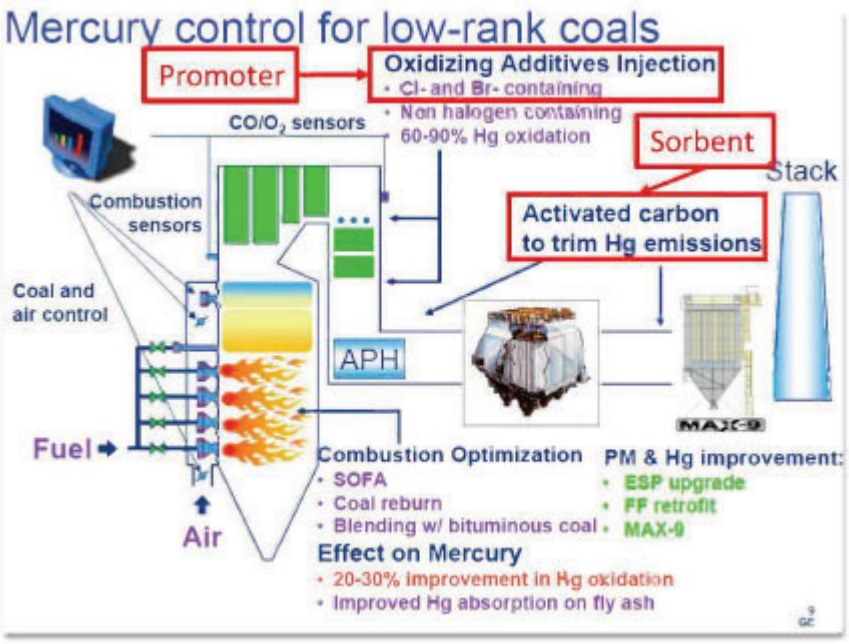
289. A POSITA would have looked to the Olson-646 reference to further understand the relationship between the bromine-containing promoter and activated carbon disclosed by Lissianski-Presentation. Specifically, a POSITA would have understood that the activated-carbon sorbent of Lissianski-Presentation would have chemically reacted with the "Br" promoter. A POSITA would have understood that by using the particular bromine-containing species disclosed in Olson-646 ("HBr or Br_2") as the source of "Br" disclosed in Lissianski-Presentation, then at least a portion of the bromine and activated sorbent would have reacted with each other.

3. Claim 1: Element 1(a)(2) —"wherein the bromine containing promoter is in gaseous form, vapor form, or non-aqueous liquid form,"

290. This limitation is obvious over Lissianski-Presentation in view of Olson-646. The annotated figure of Lissianski-Presentation below describes removing mercury from flue gas of coal-fired power plants by injecting a bromine-

[1624] Ex. 1014 (Olson-646) at ¶ [0054].

containing promoter into the flue gas, and then injecting activated carbon into the flue gas."[1625]



A POSITA would have understood that the bromine of Lissianski-Presentation would have been injected into the flue gas as a gas or vapor, as informed by the teachings of Olson-646.

291. Olson-646 also describes that the bromine-containing promoter is in gaseous or vapor form. While Olson-646 does not disclose adding HBr or Br_2 to the combustion chamber, a POSITA would have looked to Lissianski-Presentation for the injection location and to Olson-646 for the specific chemical to be injected (e.g., HBr(g) or Br_2(g)). Specifically, Olson-646 teaches embodiments "wherein the

[1625] Ex. 2014 (Lissianski-Presentation) at 9.

halogen/halide promoter is in gaseous or vapor form" that comprises "gaseous HBr or Br_2."[1626] Olson-646 explains that "[un some preferred embodiments, the halogen or halide promoter that is added to, and reacts with, the base activated carbon may preferably comprise, by way of illustration and not limitation, a molecular halogen in vapor or gaseous form."[1627] It would have been obvious to inject bromine in a gaseous phase as in Olson-646. A POSITA would have been motivated to use acid halides to aid in Sjostrom's mercury removal because it was known since the 1930s that acid halides improve the effectiveness of activated carbon in mercury removal.[1628] Among the various acid halides, such as HCl, HI, and HBr, a POSITA would be motivated to use HBr because Olson-646 discloses it as promoting activated carbon. Because the boiling point of HBr is -67 °C,[1629] a POSITA would have recognized that using HBr in any practical application in a coal plant would have involved HBr in a gaseous phase.

4. Claim 1: Element 1(a)(3) —"and wherein the activated carbon contains graphene sheets having carbene species edge sites"

1626 Ex. 1014 (Olson-646) at ¶ [0066].

1627 Ex. 1014 (Olson-646) at ¶ [0052].

1628 See State of the Art, §XII.C.3, XII.G.2.

1629 Ex. 1041 (Greenwood), exhibit p. 66

292. This limitation is obvious over Lissianski-Presentation in view of Olson-646. As discussed for Element 1(a)(1), Lissianski-Presentation describes testing mercury removal from flue gas of coal-fired power plants involving activated-carbon sorbent injection.[1630] Lissianski-Presentation also discloses the use of "Darco FGD" as an exemplary activated carbon sorbent for injection.[1631] A POSITA would have understood that Darco FGD was a well-known type of PAC used for mercury capture.[1632] For example, Olson-646 also teaches the use of the same sorbent as Lissianski-Presentation—"powdered activated carbon" such as "NORIT Darco FGD."[1633] Olson-646 proposes that "hydrogen bromide reacts with the unsaturated structure of the activated carbon."[1634] Olson-646 teaches that the reaction with bromine-containing promoter may take place at "a carbene species on the edge of the graphene sheet structures of the carbon."[1635] The carbene sites found

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1630 Ex. 2014 (Lissianski-Presentation) at 9.

1631 Ex. 2014 (Lissianski-Presentation) at 8, 18.

1632 *See, e.g.*, State of the Art, above, § § XII.C.3, XII.G.2.

1633 Ex. 1014 (Olson-646) at ¶ [0095].

1634 Ex. 1014 (Olson-646) at ¶ [0054].

1635 Ex. 1014 (Olson-646) at ¶ [0054].

in graphene sheets are shown in Figure 2 of Olson-646, labeled "Carbon Basic Zig-Zag Site."

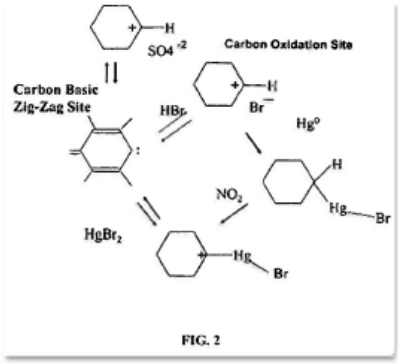
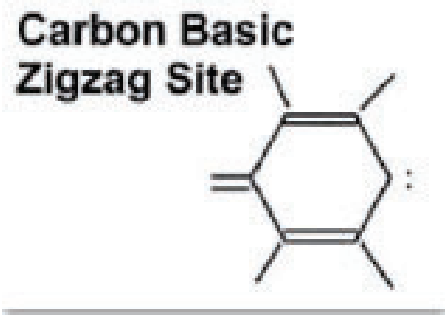


FIG. 2

In the above figure, each vertex represents a carbon atom; each hexagon represents an aromatic ring, and graphene is a structure with sheets of such aromatic rings stacked in layers upon one another. The "carbene species edge site" is excerpted below:



The carbene species is shown as a neutral carbon atom that is bonded to two other carbon atoms and that has two unshared valence electrons (indicated by the >:).

293. A person of skill in the art would have looked to the Olson-646 reference to further understand the surface chemistry of the activated-carbon sorbent disclosed by Lissianski-Presentation. Specifically, a POSITA would have

understood that the activated-carbon sorbent of Lissianski-Presentation would have included one or more carbene species located on the edge of the graphene sheet structures of the carbon, as explained by Olson-646.

5. Claim 1: Element 1(a)(4) —"which react with the bromine containing promoter to form a carbocation paired with a bromide anion in the promoted brominated sorbent for oxidation of the mercury:"

294. This limitation is obvious over Lissianski-Presentation in view of Olson-646. Olson-646 proposes that "[a]ccording to our model, adding the bromine from the bromine reagent or a proton from a hydrogen halide acid to a basic carbene site on the carbon edge structure ***forms a carbocation that accepts electrons from the neutral mercury atom forming the oxidized mercury species that is bound to the sorbent surface***."[1636] Olson-646 further explains that the reaction "may also generate reactive bromine radicals or carbon radicals at the active sites on the carbon."[1637] Specifically, Olson-646 explains that "the brominated carbon contains both covalent carbon-bound (organic) bromide as well as ***anionic bromide***."[1638] Olson-646 discloses that this reaction "provides a highly reactive bromine-containing reagent that can oxidize the mercury and promote its capture on the

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1636 Ex. 1014 (Olson-646) at ¶ [0093] (emphasis added).

1637 Ex. 1014 (Olson-646) at ¶ [0093].

1638 Ex. 1014 (Olson-646) at ¶ [0096] (emphasis added).

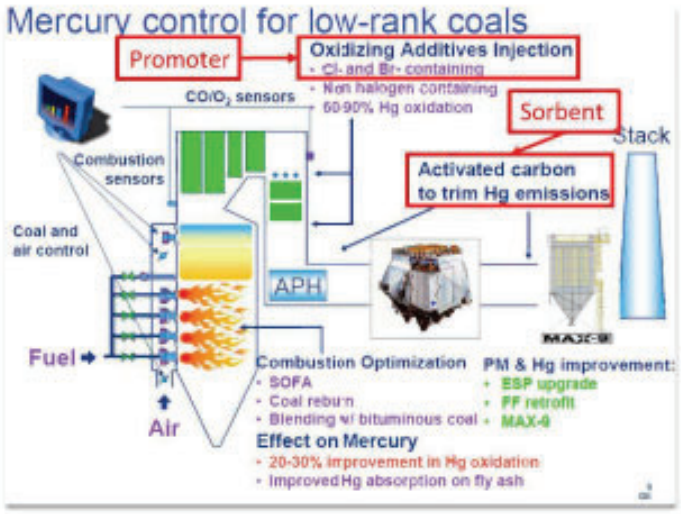
activated carbon."[1639] As described in the Reasons to Combine section, a POSITA would have looked to the Olson-646 reference to further understand the reaction mechanisms taking place when a bromine-containing promoter (as in Lissianski-Presentation) contacts activated carbon.

6. Claim 1: Element 1(b) —"chemically reacting elemental mercury in the mercury containing gas with the promoted brominated sorbent to form a mercury/sorbent chemical composition; and"

295. This limitation is obvious in view of Lissianski-Presentation. The annotated figure of Lissianski-Presentation below describes mercury removal from flue gas of coal-fired power plants involving activated-carbon sorbent injection and bromine-containing promoter injection, as detailed below.[1640]

[1639] Ex. 1014 (Olson-646) at ¶ [0093].

[1640] Ex. 2014 (Lissianski-Presentation) at 9.



A POSITA would have understood that the promoted brominated sorbent formed by the bromine-containing promoter and activated-carbon sorbent of Lissianski-Presentation would have chemically reacted with elemental mercury in the mercury containing gas (e.g., flue gas) to form a mercury/sorbent chemical composition.[1641] A POSITA would have understood that it was well-known that halogens promoted activated-carbon sorbents by increasing their capacity and effectiveness for mercury removal.[1642]

296. This limitation is also obvious over Lissianski-Presentation in view of Olson-646. Olson-646 describes that elemental mercury and activated carbon in the flue gas react to form a mercury/sorbent composition. Indeed, Olson-646 discloses a promoted activated-carbon sorbent "that capture[s] mercury via mercury-sorbent

1641 *See* State of the Art, above, § § XII.C.3, XII.G.2.

1642 *See* State of the Art, above, § § XII.C.3, XII.G.2.

surface reactions."[1643] Olson-646 further describes "AC mercury binding sites" (i.e., sites where mercury contacts the sorbent and forms a mercury/sorbent chemical composition)[1644] and shows a mercury-sorbent chemical composition in Fig. 2.[1645] Specifically, Fig. 2 of Olson-646, annotated below, shows elemental mercury (Hg^0) reacting with the promoted brominated sorbent to form a mercury/sorbent chemical composition.[1646]

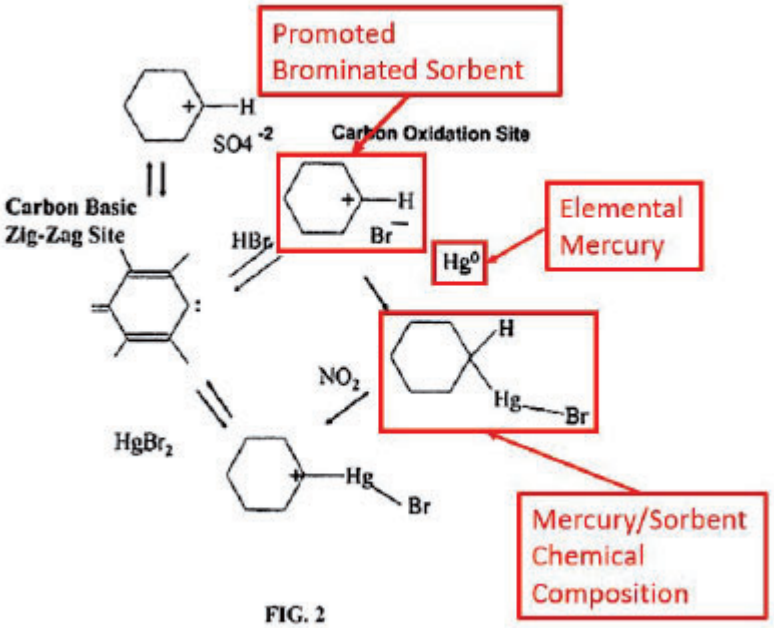


FIG. 2

1643 Ex. 1014 (Olson-646) at ¶ [0043].

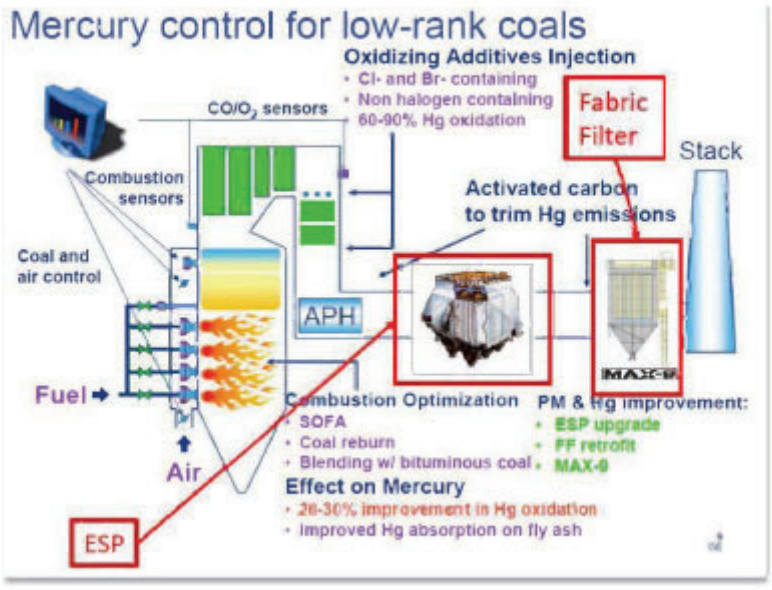
1644 Ex. 1014 (Olson-646) at ¶ [0128].

1645 Ex. 1014 (Olson-646) at Fig. 2.

1646 Ex. 1014 (Olson-646) at Fig. 2 (annotations in red).

7. Claim 1: Element 1(c) —"separating particulates from the mercury containing gas, the particulates including ash and the mercury/sorbent chemical composition."

297. This limitation is disclosed by Lissianski-Presentation. The annotated figure of Lissianski-Presentation below discloses the use of an ESP and a fabric filter (or baghouse), each of which separate mercury/sorbent particulates and fly ash."[1647]



A POSITA would have understood the first unit to be an ESP because the cutaway view shows the charged flyash collection plates and the ash hopper below. The figure shows the ESP as being downstream of both bromine injection locations and at least one activated-carbon sorbent injection location. A POSITA would have understood the second unit to be a fabric filter (or baghouse) because the illustration

[1647] Ex. 2014 (Lissianski-Presentation) at 9 (annotations in red).

shows the banks of suspended fabric collection bags and a single ash collection hopper below. The figure also shows the fabric filter as being downstream of both bromine injection locations and both activated-carbon sorbent injection locations. Lissianski-Presentation confirms this understanding in the below figure that shows a pilot-scale plant, in accordance with the system above, that includes an "ESP" and "Fabric Filter."[1648]



298. A POSITA would have understood that it was well-known that the ESP or FF would have removed solid material, including the mercury/sorbent chemical

[1648] Ex. 2014 (Lissianski-Presentation) at 10.

composition.[1649] Thus, Lissianski-Presentation teaches separating particulates from the mercury containing gas, the particulates including ash and the mercury/sorbent chemical composition.

299. I also note that the '147 Patent admits 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*.[1650]

C. DEPENDENT CLAIMS

1. Claim 17

a. Claim 17: Element 17(a)—"A method according to claim 1, further comprising injecting the particulate sorbent material at a sorbent material injection rate and injecting separately the bromine containing promoter into a gas stream"

300. This limitation is disclosed by Lissianski-Presentation. Lissianski-Presentation discloses injecting the bromine promoter into the flue gas upstream of the air preheater ("APH").[1651] Lissianski-Presentation then discloses separately

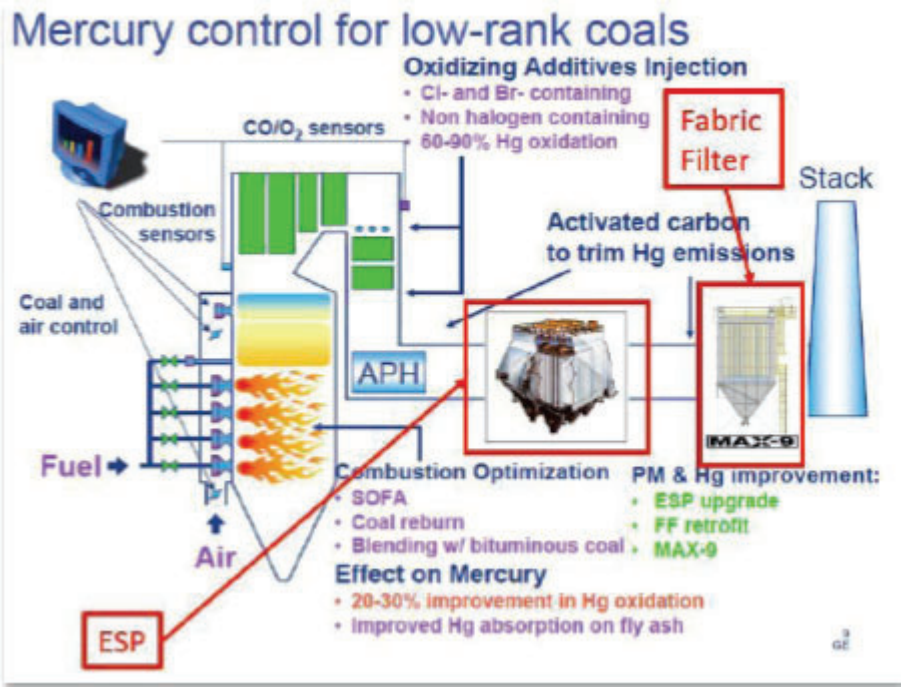
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1649 *See* State of the Art, above, § XII.B.5.a

1650 Ex. 1001 ('147 Patent) at 8:61-66.

1651 Ex. 2014 (Lissianski-Presentation) at 9.

injecting the activated-carbon sorbent into the flue gas stream either after the APH and before the ESP or between the ESP and fabric filter, as shown below.[1652]



Lissianski-Presentation discloses that the bromine-containing promoter is injected into the mercury-containing flue gas, in that it refers to "Additives Injection" and then identifies "Cl- and Br- containing." While Lissianski-Presentation does not use the words "inject" or "injection" for the activated-carbon sorbent, a POSITA would have found it obvious to introduce the sorbent by "injection," similar to the bromine promoters. For example, Olson-646 discloses a "fluidized bed" reactor as a means of mixing activated-carbon sorbent and bromine-promoter[1653] A POSITA would

1652 Ex. 2014 (Lissianski-Presentation) at 9 (annotations in red).

1653 Ex. 1014 (Olson-646) at ¶ [0066].

have understood that in a fluidized-bed reactor, as in Olson-646, activated-carbon particles and other solids are suspended in gas and then transported to a gas mixture. Olson-646 also discloses "gas source 170," such as a blower fan, to transport activated carbon into a gas mixture.[1654] Due to Lissianski-Presentation's disclosure of injecting the bromine-containing promoter, a POSITA would have understood that it would necessarily have been injected at some injection rate. Similarly, as discussed above, a POSITA would have found it obvious to introduce the sorbent by "injection" like the promoter, and thus the sorbent would have been injected at some injection rate as well. Moreover, Figure 3 of Olson-646 discloses injecting activated carbon (item 110) via an "injection point 116." Ex[1014], [0057], Fig. 3. Thus, Lissianski-Presentation discloses, or at the very least renders obvious in view of Olson-646, injecting the particulate sorbent material at a sorbent material injection rate.

b. **Claim 17: Element 17(b)—"whereby in-flight reaction produces the promoted brominated sorbent,"**

c. **Claim 17: Element 17(c)—"wherein the promoter is reacted in the gas phase or as a vapor,"**

301. These limitations are obvious over Lissianski-Presentation in view of Olson-646. As described above for Element 1(a)(1), a POSITA would have

[1654] Ex. 1014 (Olson-646) at ¶ [0057].

understood that the bromine and activated carbon would have reacted in the flue gas to form at least a quantity of promoted brominated sorbent. To the extent that Lissianski-Presentation does not explicitly identify the specific bromine-containing species used, Olson-646 teaches this limitation. Olson-646 "provides a cost-effective way to capture pollutants by utilizing exceptionally reactive halogen/halide promoted carbon sorbents using a bromide (or other halogen/halide) treatment of the carbon, that capture mercury via mercury-sorbent surface reactions, at very short contact times of seconds or less."[1655] Olson-646 teaches embodiments "wherein the halogen/halide promoter is in gaseous or vapor form" that comprises "gaseous HBr or Br_2."[1656] As described above in the Reasons to Combine section, a POSITA would have been motivated, with a reasonable expectation of success, to apply the teachings of Olson-646 (e.g., the injection of gaseous or vapor HBr or Br_2) to the system of Lissianski-Presentation.

302. A POSITA would have understood that at combustion temperatures found within the boiler the gaseous HBr or Br_2 added, especially in the amounts and locations disclosed in Olson-646 (about 1-30g of promoter per 100g of activated carbon) would have remained in the vapor phase and entered the flue gas leaving the

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1655 Ex. 1014 (Olson-646) at ¶ [0043].

1656 Ex. 1014 (Olson-646) at ¶ [0066].

boiler.[1657] At the temperature and pressure conditions present within standard flue gas systems, the HBr or Br_2 would have remained in the gaseous or vapor phase during subsequent contact with activated carbon. Accordingly, a POSITA would have understood that at least a quantity of bromine gas or bromine vapors would have made contact with the activated-carbon sorbent of Lissianski-Presentation at the sorbent injection location within the flue gas stream. Thus, Lissianski-Presentation in view of Olson-646 renders obvious an "in-flight" reaction as described in the '147 Patent.

303. Further, Olson-646 repeatedly describes an "in-flight" reaction between bromine and activated-carbon sorbents.[1658] Olson-646 explains that an "in-flight" reaction "is accomplished by ... contacting the vapors of any combination of halogens ... with very fine carbon particles."[1659] Thus, a POSITA viewing the teachings of Lissianski-Presentation and Olson-646 would have looked to Lissianski-Presentation to describe the location at which the bromine-containing promoter and activated-carbon sorbent contact one another (i.e., in a mercury-

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[1657] Ex. 1014 (Olson-646) at ¶ [0027].

[1658] Ex. 1014 (Olson-646) at Abstract, ¶¶ [0011], [0022], [0024], [0027], [0062], [0077], [0078].

[1659] Ex. 1014 (Olson-646) at ¶ [0077].

containing gas), and would have looked to Olson-646 to understand that such contact is an "in-flight" reaction. As discussed for claim 1, Lissianski-Presentation in view of Olson-646 renders obvious that this reaction forms a promoted brominated sorbent.

304. Further, Olson-646 teaches embodiments "wherein the halogen/halide promoter is in gaseous or vapor form" that comprises "gaseous HBr or Br_2."[1660] A POSITA would have understood that at flue gas temperatures and pressures, any gaseous HBr or Br_2 added at the bromine injection locations of Lissianski-Presentation would have remained in the gas phase or would have entered the vapor phase of the flue gas as an entrained liquid that vaporized on contact. Once the HBr or Br_2 reached the sorbent injection location, it would make contact with the injected sorbent. As described above with respect to claim 1, a POSITA would have been motivated, with a reasonable expectation of success, to apply the teachings of Olson-646 (i.e., the injection of HBr or Br_2) to the system of Lissianski-Presentation.

d. **Claim 17: Element 17(d)—"wherein the promoter is added at from about 1 to about 30 grams per 100 grams of the sorbent material."**

305. This limitation is obvious over Lissianski-Presentation in view of Olson-646. Olson-646 discloses this ratio of the promoter to the sorbent, using

[1660] Ex. 1014 (Olson-646) at ¶ [0066].

identical language from Element 17(d). For example, Olson-646 states that "the promoter is added at from about 1 to about 30 grams per 100 grams of activated carbon."[1661] This limitation also appears repeatedly in the claims of Olson-646. [1662] Olson-646 also discloses an embodiment wherein "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."[1663] In that embodiment, Olson-646 explains that "the promoter is added at from about 1 to about 30 grams per 100 grams of activated carbon."[1664]

306. A person of skill in the art would have looked to Olson-646 to provide the implementation details for the system of Lissianski-Presentation. Specifically, a POSITA would have been motivated to find the type of bromine-containing promoter for injection (e.g., HBr or Br_2) and the relative rates of addition for both activated carbon and bromine for optimum mercury removal.

307. Furthermore, element 17(d) is merely an attempt to claim the optimum or workable range for a process of combining a particular conventional halogen

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1661 Ex. 1014 (Olson-646) at ¶ [0023].

1662 Ex. 1014 (Olson-646) at claims 3, 17, 37, 47.

1663 Ex. 1014 (Olson-646) at ¶ [0027].

1664 Ex. 1014 (Olson-646) at ¶ [0027].

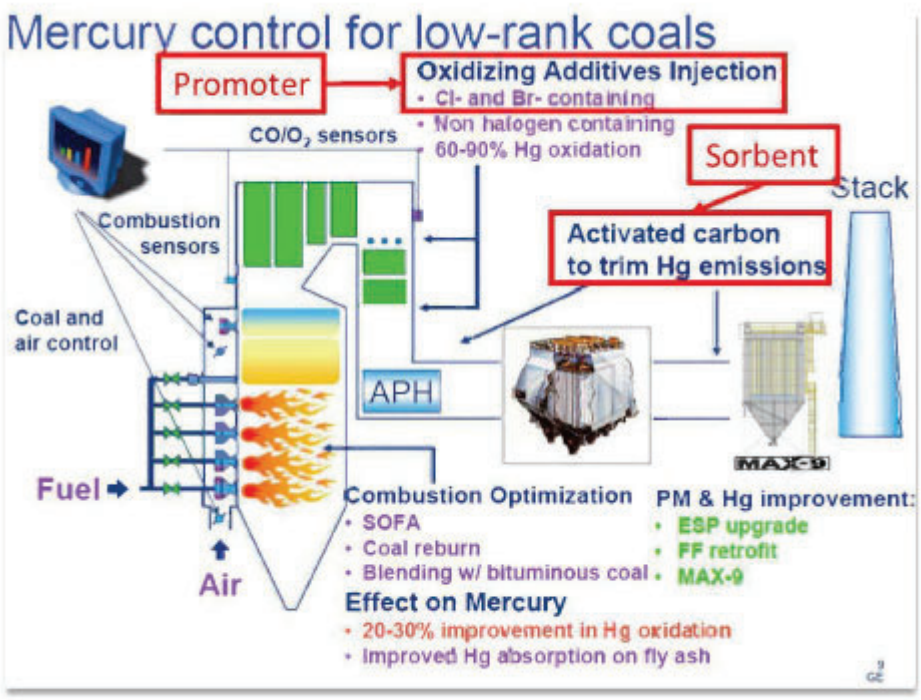
(bromine) being used in a conventional way (halogens are inherent to coal, and both oxidize mercury and promote activated carbon) with a conventional sorbent (activated carbon). Nothing about the particular range of 1 g to about 30 g of the halide promoter per 100 g of the sorbent would lead to an unexpected result from what was already known to one of skill in the art. As described in the State of the Art,[1665] it was known that the saturation limit of activated carbon for bromine (i.e., how much bromine the activated carbon can actually adsorb at equilibrium), was up to 31 to 38 grams per 100 grams of activated carbon. Through routine process optimization and routine experimentation, a POSITA would have adjusted the rate of addition of bromine-containing species and/or activated carbon injection rate to achieve about 1 g to about 30 g of halide promoter per 100g of sorbent.

2. Claim 18. "A method according to claim 17, wherein the gas stream is a mercury containing gas."

308. This limitation is disclosed by Lissianki-Presentation. The annotated figure if Lissianki-Presentation below describes testing mercury removal from flue gas of coal-fired power plants involving activated-carbon sordent injection and bromine-promoter injection, as detailed below.[1666]

1665 *See* State of the Art, above, § XII.C.3.

1666 Ex. 2014 (Lissianski-Presentation) at 9 (annotations in red).



The above figure of Lissianski-Presentation shows a mercury control process for a coal combustion system. [1667] Lissianski-Presentation discloses injecting the bromine-containing promoter into the mercury-containing flue gas upstream of the air preheater ("APH") and separately injecting the activated-carbon sorbent either after the APH and before the ESP or between the ESP and fabric filter.[1668] A POSITA would have understood that coal combustion produced a mercury-containing flue gas and that this mercury-containing flue gas would be created at or before the bromine injection points indicated in the figure above. A POSITA would have

1667 Ex. 2014 (Lissianski-Presentation) at 9 (annotations in red).

1668 Ex. 2014 (Lissianski-Presentation) at 9.

understood that coal combustion produced a mercury-containing flue gas, which would be created at or before the bromine injection points indicated in the figure above.[1669]

3. Claim 19. "A method according to claim 18, wherein the gas stream is a transport gas."

309. This limitation is obvious over Lissianski-Presentation in view of Olson-646. As I explained for claims 17-18, Lissianski-Presentation discloses an in-flight reaction in the flue gas between bromine and activated carbon to form an improved sorbent. A POSITA would have understood that flue gas obtained from coal combustion contains mercury. A POSITA would have understood that coal combustion produced a mercury-containing flue gas. A POSITA would also have understood that the mercury-containing gas transported the bromine-containing promoter of Lissianski-Presentation to the activated-carbon sorbent.

4. Claim 20. "A method according to claim 18, wherein the gas stream is a transport gas."A method according to claim 17, wherein the promoter injection rate and the sorbent injection rate into the gas are determined at least in part on the monitored mercury content of the cleaned gas."

[1669] *See* State of the Art, above, § XII.C.3

310. This limitation is obvious over Lissianski-Presentation in view of Olson-646. Lissianski-Presentation discloses determining "[c]ontinuous mercury measurements using two PSA Sir Galahad analyzers."[1670]

311. Olson-646 likewise discloses using a feedback system to adjust the rates of sorbents and additives. Olson-646 describes as beneficial "continuous measurement of mercury emissions as feedback to assist in control of the sorbent injection rate. Tighter control on the sorbent and optional component(s) levels can be achieved in this way, which will ensure mercury removal requirements are met with minimal material requirements, thus minimizing the associated costs."[1671]

312.

XXXIV. GROUND P: OBVIOUSNESS OF THE '147 PATENT OVER SJOSTROM IN VIEW OF OLSON-646

313. It is my opinion that Sjostrom in view of Olson-646 renders obvious each of the asserted claims of the '147 Patent.

A. CLAIM 1

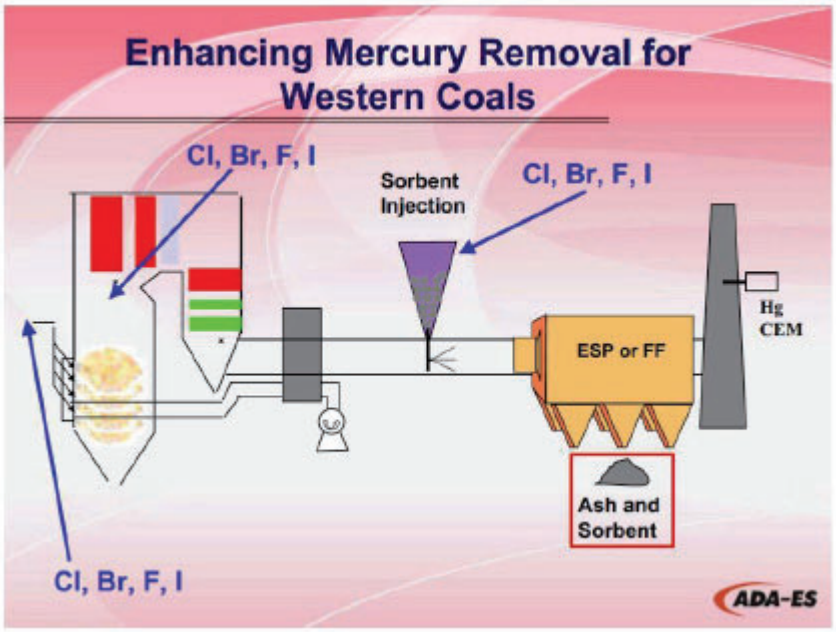
1. Claim 1: Preamble —"A method for separating mercury from a mercury containing gas comprising:"

314. The preamble is disclosed by Sjostrom. Sjostrom teaches separating mercury from a mercury-containing gas. The title of Sjostrom is "Full Scale

[1670] Ex. 2014 (Lissianski-Presentation) at 10.

[1671] Ex. 1014 (Olson-646) at ¶ [0091].

Evaluations of *Mercury Control Technologies* with PRB Coals."[1672] Specifically, Sjostrom described various mercury control tests conducted at coal-fired power plants.[1673] Sjostrom described testing mercury removal from flue gas of coal-fired power plants involving sorbent injection and halogen addition, as detailed below.[1674]



Sjostrom includes numerous charts detailing the "Hg Removal (%)" and "Hg Removal Efficiency (%)" achieved throughout the testing performed on coal flue gas.[1675] This figure in Sjostrom specifically describes separating particulate matter

1672 Ex. 1010 (Sjostrom) at 1 (emphasis added).

1673 Ex. 1010 (Sjostrom) at 12, 18.

1674 Ex. 1010 (Sjostrom) at 1 (emphasis added).

1675 Ex. 1010 (Sjostrom) at 8, 15-17, 20, and 21.

(including the mercury-sorbent composition) from a mercury-containing flue gas by an electrostatic precipitator (ESP) or fabric filter (FF). ESPs and fabric filters were well-known devices to remove particulate matter.[1676]

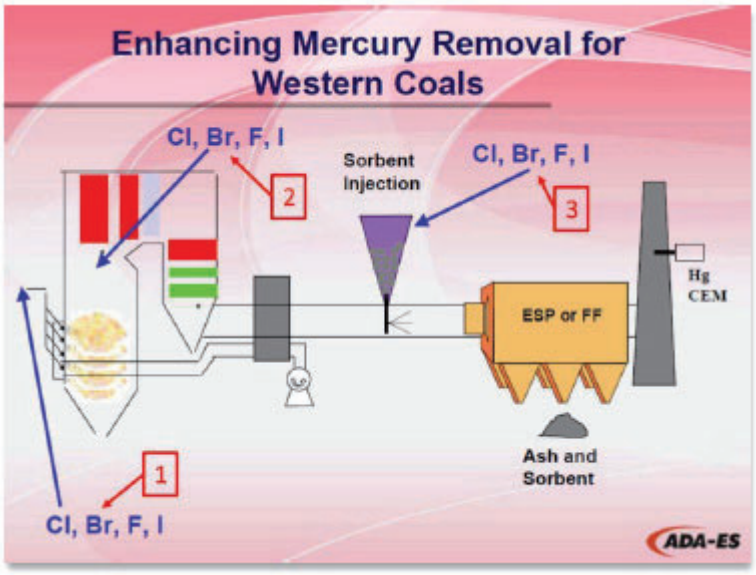
2. Claim 1: Element 1(a)(1) —"promoting at least a portion of a particulate sorbent material comprising activated carbon by chemically reacting the sorbent material with a bromine containing promoter to form a promoted brominated sorbent"

315. This limitation is obvious in view of Sjostrom. Sjostrom described testing mercury removal from flue gas of coal-fired power plants involving sorbent injection, halogen injection, and both sorbent and halogen injection.[1677] Specifically, the annotated figure below shows that Sjostrom teaches addition of bromine-containing promoter in at least three locations throughout the coal power process, including Addition Location 2 into the combustion chamber.[1678]

1676 *See* State of the Art, above, § XII.B.5.a

1677 Ex. 1010 (Sjostrom) at 4.

1678 Ex. 1010 (Sjostrom) at 4 (annotations in red).

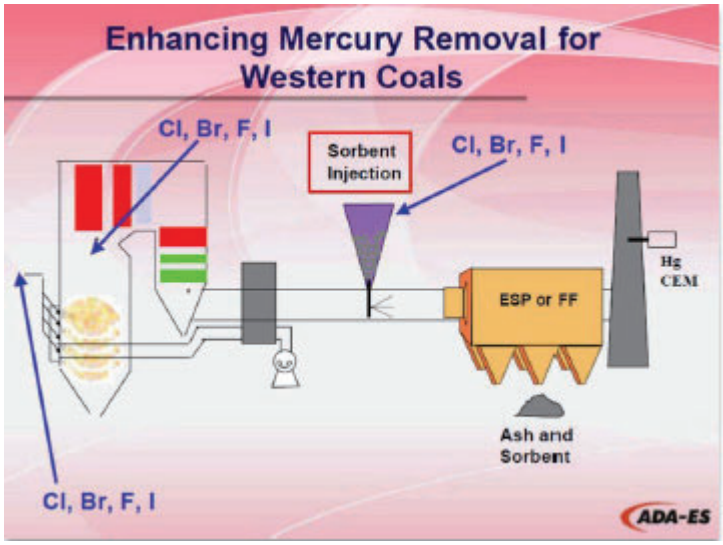


As discussed below, a POSITA would have understood that the bromine-containing promoter added at Addition Location 2 of Sjostrom would have contacted and reacted with the activated-carbon sorbent in the flue gas (i.e., downstream from the combustion chamber) to form at least a quantity of promoted brominated sorbent.

316. This element is also obvious over Sjostrom in view of Olson-646. As described in the Reasons to Combine, a POSITA would have been motivated to combine with the Olson-646 reference for guidance on selection of the particular chemical to provide the "Br" in Sjostrom, and how the "Br" reacts with the activated carbon of Sjostrom.

a. **Particulate sorbent material comprising activated carbon**

317. As shown in the annotated figure below, Sjostrom describes certain tests involving "Sorbent Injection" into a flue-gas stream.[1679]



Specifically, Sjostrom describes testing performed with activated carbon injection, including injection of "DARCO FGD."[1680] A POSITA would have understood that Darco FGD was a well-known type of powdered activated carbon ("PAC") used for mercury capture.[1681] Sjostrom describes the sorbent as "PAC," and a POSITA would have understood that a powder is a form of particulate matter.[1682] Sjostrom also discloses the use of well-known particulate material separators (e.g., ESPs and fabric

1679 Ex. 1010 (Sjostrom) at 4 (annotations in red).

1680 Ex. 1010 (Sjostrom) at 10, 11, 16.

1681 *See*, e.g., State of the Art, above, § § XII.C.3, XII.G.2.

1682 Ex. 1010 (Sjostrom) at 20.

filters) to remove the mercury/sorbent chemical composition from the flue gas.[1683] At least because the activated-carbon sorbent is removed by the particulate material separators, it falls within the claimed particulate sorbent limitation.

b. Promoting at least a portion of a particulate sorbent material by chemically reacting the sorbent material with a bromine containing promoter to form a promoted brominated sorbent

318. Sjostrom teaches injection of bromine-containing promoter directly into the combustion chamber at Addition Location 2.[1684] Sjostrom also discloses "Sorbent Injection" into the flue gas downstream of the combustion chamber.[1685] A POSITA would have understood that the bromine-containing promoter added at Addition Location 2 of Sjostrom would have contacted the sorbent in the flue gas at or downstream of the sorbent injection point. A POSITA would also have known that halides, such as the "Br" in Sjostrom, improved mercury capture both by reacting with mercury in the gas-phase to oxidize the mercury, and also by reacting with activated-carbon sorbent. In view of the teachings of Olson-646, a POSITA would have been motivated to inject sufficient bromine-containing promoter such

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1683 Ex. 1010 (Sjostrom) at 4.

1684 Ex. 1010 (Sjostrom) at 4.

1685 Ex. 1010 (Sjostrom) at 4.

that at least some quantity would be available to react with activated-carbon sorbent.[1686]

319. As discussed above, Olson-646 teaches the advantages of promoting activated-carbon sorbent with bromine-containing promoter. Olson-646 teaches to use HBr(g) and/or Br_2(g) as the source of the "Br" in Sjostrom. Olson-646 "provides a cost-effective way to capture pollutants by utilizing exceptionally reactive halogen/halide promoted carbon sorbents using a bromide (or other halogen/halide) treatment of the carbon, that capture mercury via mercury-sorbent surface reactions, at very short contact times of seconds or less.[1687] Olson-646 teaches embodiments "wherein the halogen/halide promoter is in gaseous or vapor form" that comprises "gaseous HBr or Br_2."[1688] As described above in the Reasons to Combine section, a POSITA would have been motivated, with a reasonable expectation of success, to apply the teachings of Olson-646 (e.g., the addition of HBr or Br_2) as the "Br" source of Sjostrom.

320. The Olson-646 reference further proposes the chemical reactions underlying the process in Sjostrom. Olson-646 states that "[a] promoted activated

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1686 *See* State of the Art, above, § XII.C.3, XII.G.2.

1687 Ex. 1014 (Olson-646) at ¶ [0043].

1688 Ex. 1014 (Olson-646) at ¶ [0066].

carbon sorbent is described that is highly effective for the removal of mercury from flue gas streams."[1689] Specifically, Olson-646 states that "a promoted carbon sorbent is provided comprising a base activated carbon that has reacted with a promoter selected from the group consisting of halides, halogens, and combinations thereof, such that the reaction product is effective for the removal of mercury from a gas stream."[1690]

321. Further, Olson-646 explains that "Figure 2 of Olson-646, reproduced below, shows "a theory developed from scientific evidence to explain the nature of the promoting compounds."[1691]

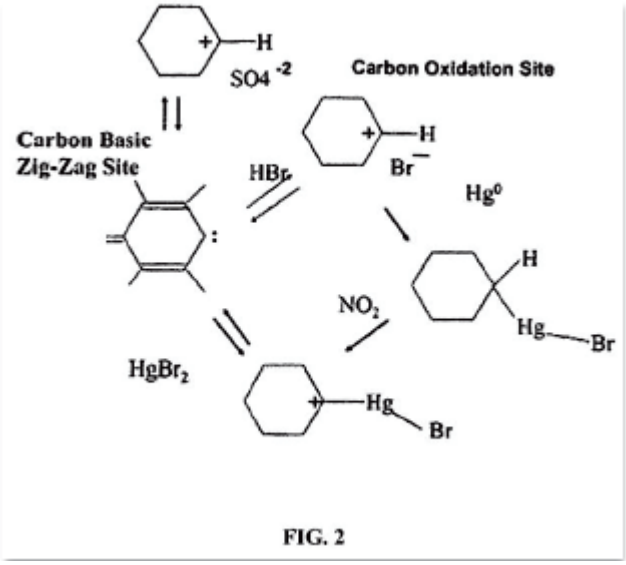


FIG. 2

1689 Ex. 1014 (Olson-646) at Abstract.

1690 Ex. 1014 (Olson-646) at ¶ [0012].

1691 Ex. 1014 (Olson-646) at ¶ [0054].

Olson-646 explains that "hydrogen bromide *reacts* with the unsaturated structure of the activated carbon.[1692] Olson-646 teaches that the reaction may take place at "a carbene species on the edge of the graphene sheet structures of the carbon."[1693] Further, Olson-646 explains that "[m]olecular bromine or a bromine compound reacts to form a similar structure, with a positive carbon that is active for oxidizing the mercury with subsequent capture by the sorbent."[1694] Fig. 2 of Olson-646 discloses that once the bromine/activated carbon complex contacts mercury, it chemically reacts with (e.g., adsorbs) the mercury.

322. A POSITA would have looked to the Olson-646 reference to further understand the relationship between the bromine-containing promoter and activated carbon disclosed by Sjostrom. Specifically, a POSITA would have understood that the activated-carbon sorbent of Sjostrom would have chemically reacted with the "Br" promoter. A POSITA would have understood that by using the particular bromine-containing species disclosed in Olson-646 ("HBr or Br_2") as the source of "Br" disclosed in Sjostrom, then at least a portion of the bromine and activated sorbent would have reacted with each other.

1692 Ex. 1014 (Olson-646) at ¶ [0054] (emphasis added).

1693 Ex. 1014 (Olson-646) at ¶ [0054].

1694 Ex. 1014 (Olson-646) at ¶ [0054].

3. Claim 1: Element 1(a)(2) —"wherein the bromine containing promoter is in gaseous form, vapor form, or non-aqueous liquid form,"

323. This limitation is obvious over Sjostrom in view of Olson-646. Addition Location 2 of Sjostrom discloses injecting bromine into the boiler.[1695] Although Sjostrom is silent about the form that the bromine should take, a POSITA would understood that it would have been obvious to inject bromine in a gaseous phase as in Olson-646. A POSITA would have been motivated to use acid halides to aid in Sjostrom's mercury removal because it was known since the 1930s that acid halides improve the effectiveness of activated carbon in mercury removal.[1696] Among the various acid halides, such as HCl, HI, and HBr, a POSITA would be motivated to use HBr because Olson-646 discloses it as promoting activated carbon. Because the boiling point of HBr is -67 °C,[1697] a POSITA would have recognized that using HBr in any practical application in a coal plant would have involved HBr in a gaseous phase.

324. Olson-646 also describes that the bromine-containing promoter is in gaseous or vapor form. While Olson-646 does not disclose adding HBr or Br_2 to the

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1695 Ex. 1010 (Sjostrom) at 4.

1696 *See* State of the Art, §XII.C.3, XII.G.2.

1697 Ex. 1041 (Greenwood), exhibit p. 66

combustion chamber, a POSITA would have looked to Sjostrom for the injection location and Olson-646 for the specific chemical to be injected (e.g., HBr(g) or Br_2(g)) and to identify the effectiveness of HBr and Br_2 in promoting activated carbon. Specifically, Olson-646 teaches embodiments "wherein the halogen/halide promoter is in gaseous or vapor form" that comprises "gaseous HBr or Br_2."[1698] Olson-646 explains that "[i]n some preferred embodiments, the halogen or halide promoter that is added to, and reacts with, the base activated carbon may preferably comprise, by way of illustration and not limitation, a molecular halogen in vapor or gaseous form."[1699] As described above in Reasons to Combine, a POSITA would have been motivated, with a reasonable expectation of success, to apply the teachings of Olson-646 (e.g., the addition of HBr or Br_2 in a gaseous or vapor form) to the system of Sjostrom.

325. A POSITA would have understood that at combustion temperatures found within the boiler any gaseous or vapor HBr or Br_2 added at Addition Location 2 of Sjostrom would have remained in the gaseous or vapor phase during subsequent contact with activated-carbon sorbent.

[1698] Ex. 1014 (Olson-646) at ¶ [0066].

[1699] Ex. 1014 (Olson-646) at ¶ [0052].

4. Claim 1: Element 1(a)(3) —"and wherein the activated carbon contains graphene sheets having carbene species edge sites"

326. This limitation is obvious over Sjostrom in view of Olson-646. As discussed for Element 1(a)(1), Sjostrom teaches injection of a particulate sorbent material manufactured by Norit with the brand name "DARCO FGD.[1700] A POSITA would have understood that Darco FGD was a well-known type of PAC used for mercury capture.[1701]

327. For example, Olson-646 also teaches the use of the same sorbent as Sjostrom "powdered activated carbon" such as "NORIT Darco FGD."[1702] Fig. 2 of Olson-646, reproduced below, shows "a theory developed from scientific evidence to explain the nature of the promoting compounds."[1703] The carbene sites found in graphene sheets are shown in Figure 2 of Olson-646, labeled "Carbon Basic Zig-Zag Site."

1700 Ex. 1010 (Sjostrom) at 16.

1701 *See, e.g.*, State of the Art, above, § § XII.C.1, XII.G.2.

1702 Ex. 1014 (Olson-646) at ¶ [0095].

1703 Ex. 1014 (Olson-646) at ¶ [0054].

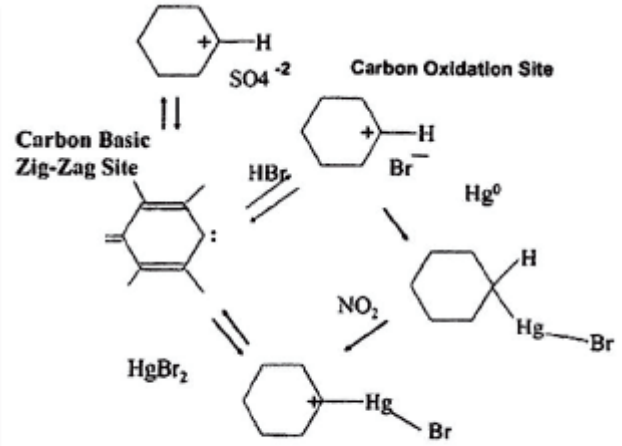
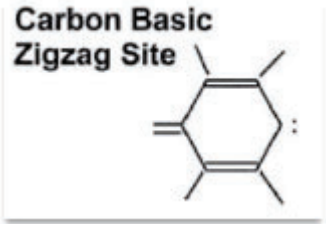


FIG. 2

Olson-646 explains that "hydrogen bromide reacts with the unsaturated structure of the activated carbon."[1704] Olson-646 teaches that the reaction with bromine-containing promoter may take place at "a carbene species on the edge of the graphene sheet structures of the carbon."[1705] In the above figure, each vertex represents a carbon atom; each hexagon represents an aromatic ring, and graphene is a structure with sheets of such aromatic rings stacked in layers upon one another. The "carbene species edge site" is excerpted below:



1704 Ex. 1014 (Olson-646) at ¶ [0054].

1705 Ex. 1014 (Olson-646) at [0054].

The carbene species is shown as a neutral carbon atom that is bonded to two other carbon atoms and that has two unshared valence electrons (indicated by the >:).

328. A person of skill in the art would have looked to the Olson-646 reference to further understand the surface chemistry of the activated-carbon sorbent disclosed by Sjostrom. Specifically, a POSITA would have understood, based on the models proposed by Olson-646, that the activated-carbon sorbent of Sjostrom would have included one or more carbene species located on the edge of the graphene sheet structures of the carbon, as explained by Olson-646.

5. Claim 1: Element 1(a)(4) —"which react with the bromine containing promoter to form a carbocation paired with a bromide anion in the promoted brominated sorbent for oxidation of the mercury:"

329. This limitation is obvious over Sjostrom in view of Olson-646. Olson-646 proposes that [a]ccording to our model, adding the bromine from the bromine reagent or a proton from a hydrogen halide acid to ***a basic carbene site on the carbon edge structure forms a carbocation that accepts electrons from the neutral mercury atom forming the oxidized mercury species that is bound to the sorbent surface.***"[1706] Olson-646 further explains that the reaction "may also generate reactive bromine radicals or carbon radicals at the active sites on the carbon."[1707]

[1706] Ex. 1014 (Olson-646) at ¶ [0093] (emphasis added).

[1707] Ex. 1014 (Olson-646) at ¶ [0093].

Specifically, Olson-646 explains that "the brominated carbon contains both covalent carbon-bound (organic) bromide as well as ***anionic bromide***."[1708] Olson-646 discloses that this reaction "provides a highly reactive bromine-containing reagent that can oxidize the mercury and promote its capture on the activated carbon."[1709] As described in the Reasons to Combine section, a POSITA would have looked to the Olson-646 reference to further provide a theory for the reaction mechanisms taking place when a bromine-containing promoter (as in Sjostrom) contacts activated carbon.

6. Claim 1: Element 1(b) —"chemically reacting elemental mercury in the mercury containing gas with the promoted brominated sorbent to form a mercury/sorbent chemical composition; and"

330. This limitation is obvious in view of Sjostrom. As discussed above, Sjostrom teaches injection of bromine as well as injection of a sorbent.[1710] As discussed above for Element 1(a)(1), a POSITA would have understood that the bromine-containing promoter and activated carbon of Sjostrom would have formed a promoted brominated sorbent. A POSITA would also have understood that the promoted brominated sorbent formed by the bromine-containing promoter and

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1708 Ex. 1014 (Olson-646) at ¶ [0096] (emphasis added).

1709 Ex. 1014 (Olson-646) at ¶ [0093].

1710 Ex. 1010 (Sjostrom) at 4.

activated-carbon sorbent of Sjostrom would have chemically reacted with elemental mercury in the mercury containing gas (e.g., flue gas) to form a mercury/sorbent chemical composition."[1711] For example, Sjostrom discloses removing more than 90% of mercury, which would have included a quantity of elemental mercury.[1712] A POSITA would have understood that it was well-known that halogens promoted activated-carbon sorbents by increasing their capacity and effectiveness for mercury removal.[1713]

331. This limitation is also obvious over Sjostrom in view of Olson-646. Olson-646 describes that elemental mercury and activated carbon in the flue gas would react to form a mercury/sorbent composition. Indeed, Olson-646 discloses a promoted activated-carbon sorbent "that capture[s] mercury via mercury-sorbent surface reactions."[1714] Olson-646 further describes "AC mercury binding sites" (i.e., sites where mercury contacts the sorbent and forms a mercury/sorbent chemical

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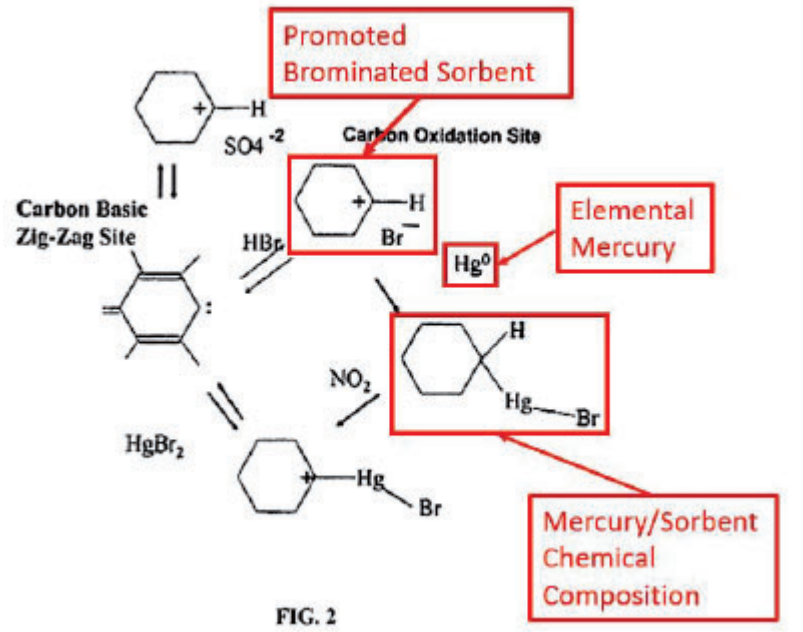
1711 *See* State of the Art, above, § § XII.C.3, XII.G.2.

1712 Ex. 1010 (Sjostrom) at 16.

1713 *See* State of the Art, above, § § XII.C.3, XII.G.2.

1714 Ex. 1014 (Olson-646) at ¶ [0043].

composition)[1715] and shows a mercury-sorbent chemical composition in Fig. 2.[1716] Specifically, Fig. 2 of Olson-646, annotated below, shows elemental mercury (Hg°) reacting with the promoted brominated sorbent to form a mercury/sorbent chemical composition."[1717]



Thus, Olson-646 discloses chemically reacting the promoted brominated sorbent with elemental mercury in the flue gas to form a mercury/sorbent chemical composition.

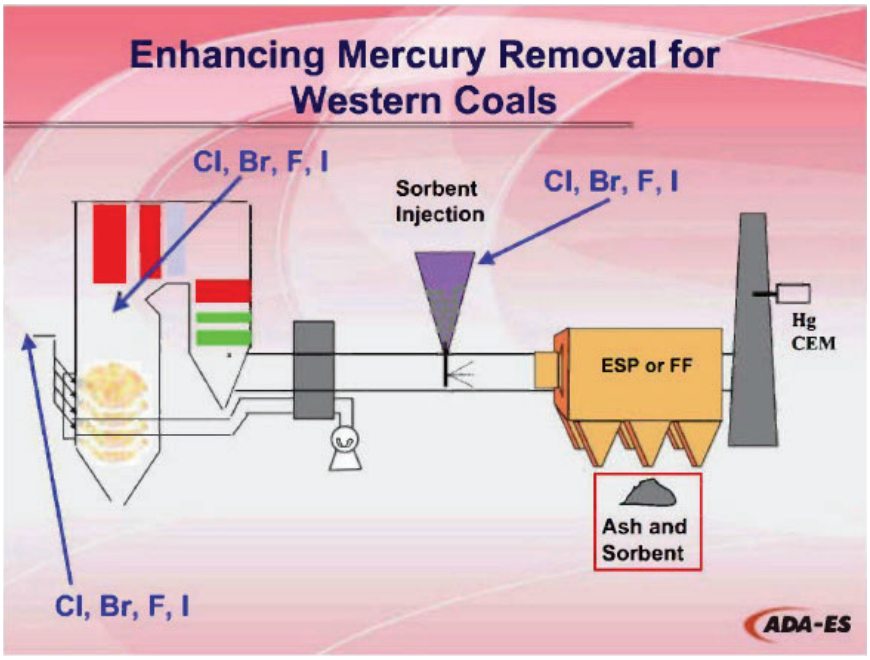
[1715] Ex. 1014 (Olson-646) at ¶ [0128].

[1716] Ex. 1014 (Olson-646) at Fig. 2.

[1717] Ex. 1014 (Olson-646) at Fig. 2 (annotations in red).

7. Claim 1: Element 1(c) —"separating particulates from the mercury containing gas, the particulates including ash and the mercury/sorbent chemical composition."

332. This limitation is disclosed by Sjostrom. As shown in the annotated figure below, Sjostrom describes passing the flue gas through an electrostatic precipitator (ESP) or fabric filter (FF) after the bromine and sorbent injection, each of which separate mercury/sorbent particulates and fly ash."[1718]



333. This annotated figure in Sjostrom specifically shows that the sorbent composition would have been removed by the ESP or FF. Further, a POSITA would have understood that it was well-known that the ESP or FF would have removed

[1718] Ex. 1010 (Sjostrom) at 4 (annotations in red).

solid material, including the mercury/sorbent composition."[1719] Thus, Sjostrom teaches separating particulates from the mercury containing gas, the particulates including ash and the mercury/sorbent chemical composition.

334. I also note that the '147 Patent admits 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.*[1720]

B. DEPENDENT CLAIMS

1. Claim 17

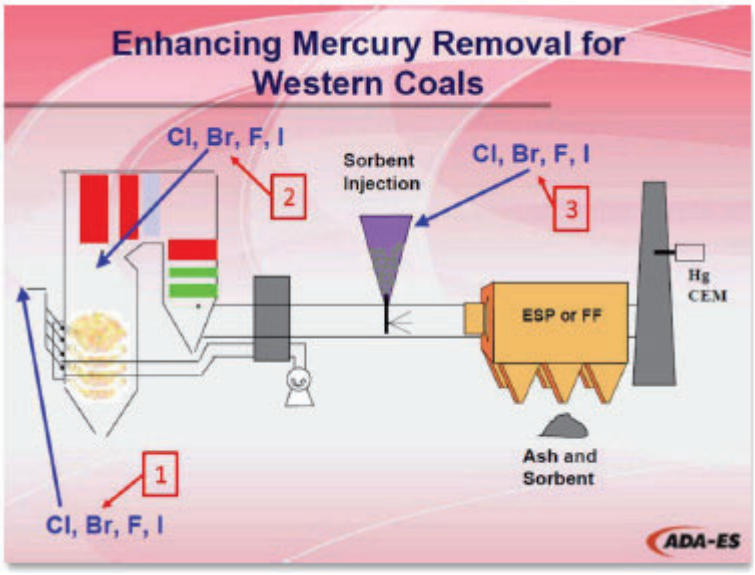
a. Claim 17: Element 17(a)—"A method according to claim 1, further comprising injecting the particulate sorbent material at a sorbent material injection rate and injecting separately the bromine containing promoter into a gas stream"

335. The annotated figure below shows that Sjostrom teaches introducing "Br" into the system."[1721]

[1719] See State of the Art, above, § XII.B.5.a

[1720] Ex. 1001 ('147 Patent) at 8:61-66.

[1721] Ex. 1010 (Sjostrom) at 4 (annotations in red).

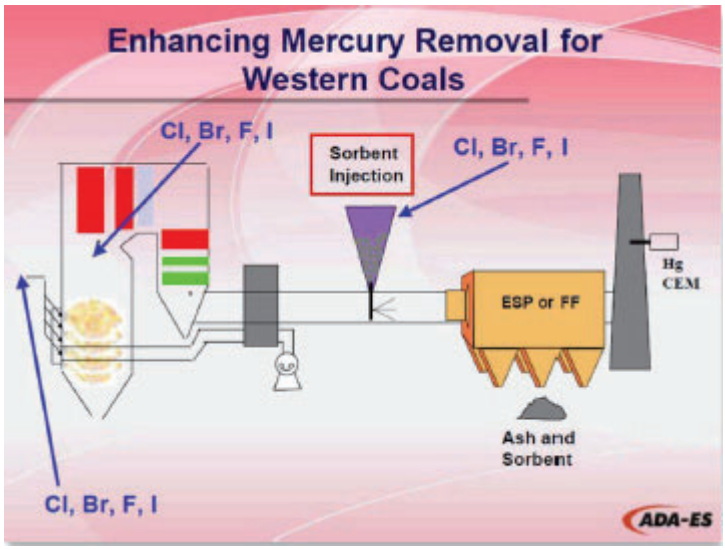


Addition Location 2 of Sjostrom teaches injecting bromine into the boiler, upstream of the sorbent injection point.[1722]

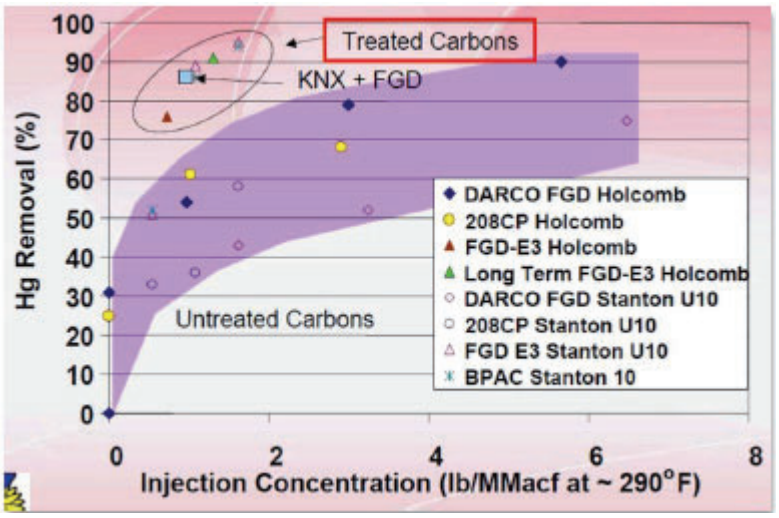
336. As shown in the annotated figure below, Sjostrom described separate sorbent injection at a location that is downstream of the boiler.[1723]

[1722] Ex. 1010 (Sjostrom) at 4.

[1723] Ex. 1010 (Sjostrom) at 4 (annotations in red).



As shown below, Sjostrom discloses injecting the sorbent at a "sorbent injection rate," provided in lb/MMacf (pounds per million actual cubic feet of flue gas):[1724]



A POSITA would have understood that for certain tests (e.g., "KNX + FGD"), the halogen injection would be occurring at Addition Location 2, while an untreated carbon is injected into the flue gas. Indeed, the above graph discloses using an

[1724] Ex. 1010 (Sjostrom) at 16 (annotations in red).

activated carbon such as "Darco FGD," which a POSITA would have known refers to an activated carbon that had not been pre-treated with bromine due to it being plotted in the purple range above labeled "untreated carbons." Further, a POSITA would have been motivated to try untreated (plain) activated carbon, because it was known that the "cost per mass unit of impregnated AC [activated carbon] may, however, be significantly greater than that of unmodified AC."[1725] In other words, where cost was a driving factor in designing a mercury-removal system, a POSITA would have been motivated to use a less expensive untreated activated carbon and inject bromine at Addition Location 2 to assist with mercury removal. Accordingly, it is obvious in view of Sjostrom to inject bromine at Addition Location 2 and separately inject untreated activated carbon at a point downstream of the bromine injection.

337. Regardless, even if a POSITA were to include bromine at both Addition Location 2 and Addition Location 3 (i.e., creating a brominated sorbent), this brominated sorbent is still a "sorbent material comprising activated carbon," which means that sorbent can include other components besides activated-carbon, such as

[1725] Ex. 1009 (EPA-Proposal) at 4676.

halogens.[1726] Second, Sjostrom teaches injecting pre-brominated sorbent, as shown in the graph above with using "BPAC" which a POSITA would have known refers to brominated PAC (i.e., pre-treated activated carbon). The additional bromine injected at Addition Location 2 would have further promoted the pre-brominated sorbent of Addition Location 3.

b. **Claim 17: Element 17(b)—"whereby in-flight reaction produces the promoted brominated sorbent,"**

c. **Claim 17: Element 17(c)—"wherein the promoter is reacted in the gas phase or as a vapor,"**

338. These limitations are obvious over Sjostrom alone as well as in view of Olson-646. As described above for Element 1(a)(1), a POSITA would have understood that the bromine and activated carbon would have reacted in the flue gas to form at least a quantity of promoted brominated sorbent. Olson-646 "provides a cost-effective way to capture pollutants by utilizing exceptionally reactive halogen/halide promoted carbon sorbents using a bromide (or other halogen/halide) treatment of the carbon, that capture mercury via mercury-sorbent surface reactions, at very short contact times of seconds or less.[1727] Olson-646 teaches embodiments

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[1726] Ex. 1001 ('147 Patent) at 7:44-46, 10:34-57 (describing multiple halogenation steps).

[1727] Ex. 1014 (Olson-646) at ¶ [0043].

"wherein the halogen/halide promoter is in gaseous or vapor form" that comprises "gaseous HBr or Br_2."[1728] As described above in the Reasons to Combine section, a POSITA would have been motivated, with a reasonable expectation of success, to apply the teachings of Olson-646 (e.g., the injection of gaseous or vapor HBr or Br_2) to the system of Sjostrom.

339. A POSITA would have understood that at combustion temperatures found within the boiler the gaseous HBr or Br_2 added at Addition Location 2 of Sjostrom, especially in the amounts and locations disclosed in Olson-646 (about 1-30g of promoter per 100g of activated carbon)) would have remained in the vapor phase within the flue gas leaving the boiler.[1729] A POSITA would have understood that at combustion temperatures found within the boiler any gaseous HBr or Br_2 added at Addition Location 2 of Sjostrom would have remained in the vapor phase within the flue gas leaving the boiler. At the temperature and pressure conditions present within standard flue gas systems, the HBr or Br_2 would have remained in the gaseous or vapor phase. Accordingly, a POSITA would have understood that at least a quantity of bromine gas or bromine vapors would have made contact with the activated-carbon sorbent of Sjostrom at the sorbent injection location within the flue

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[1728] Ex. 1014 (Olson-646) at 41 [0066].

[1729] Ex. 1014 (Olson-646) at ¶ [0027].

gas stream. Thus, Sjostrom in view of Olson-646 renders obvious an "in-flight" reaction as described in the '147 Patent.

340. Further, Olson-646 repeatedly describes an "in-flight" reaction between bromine and activated-carbon sorbents.[1730] Olson-646 explains that an "in-flight" reaction "is accomplished by ... contacting the vapors of any combination of halogens ... with very fine carbon particles."[1731] A POSITA viewing the teachings of Sjostrom and Olson-646 would have looked to Sjostrom to describe the location at which bromine-containing promoter and activated-carbon sorbent contact one another (i.e., in a mercury-containing gas), and would have looked to Olson-646 to understand that such contact is an in-flight reaction.

d. Claim 17: Element 17(d)—"wherein the promoter is added at from about 1 to about 30 grams per 100 grams of the sorbent material."

341. This limitation is obvious over Sjostrom in view of Olson-646. Olson-646 discloses this ratio of the promoter to the sorbent, using identical language from Element 17(d). For example, Olson-646 states that "the promoter is added at from

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[1730] Ex. 1014 (Olson-646) at Abstract, ¶¶ [0011], [0022], [0024], [0027], [0062], [0077], [0078].

[1731] Ex. 1014 (Olson-646) at ¶ [0077].

about 1 to about 30 grams per 100 grams of activated carbon.[1732] This limitation also appears repeatedly in the claims of Olson-646.[1733] Olson-646 also discloses an embodiment wherein "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."[1734] In that embodiment, Olson-646 explains that "the promoter is added at from about 1 to about 30 grams per 100 grams of activated carbon."[1735]

342. A person of skill in the art would have looked to the Olson-646 reference to provide the implementation details for the system of Sjostrom. Sjostrom describes the sorbent injection rate and the location for injecting "Br", and a POSITA would have looked to Olson-646 to identify the specific chemical to inject (e.g., HBr and/or Br_2) and the amount of that chemical to inject.[1736]

343. Furthermore, element 17(d) is merely an attempt to claim the optimum or workable range for a process of combining a particular conventional halogen

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[1732] Ex. 1014 (Olson-646) at ¶ [0023].

[1733] Ex. 1014 (Olson-646) at claims 3, 17, 37, 47.

[1734] Ex. 1014 (Olson-646) at ¶ [0027].

[1735] Ex. 1014 (Olson-646) at ¶ [0027].

[1736] Ex. 1010 (Sjostrom) at 4, 16.

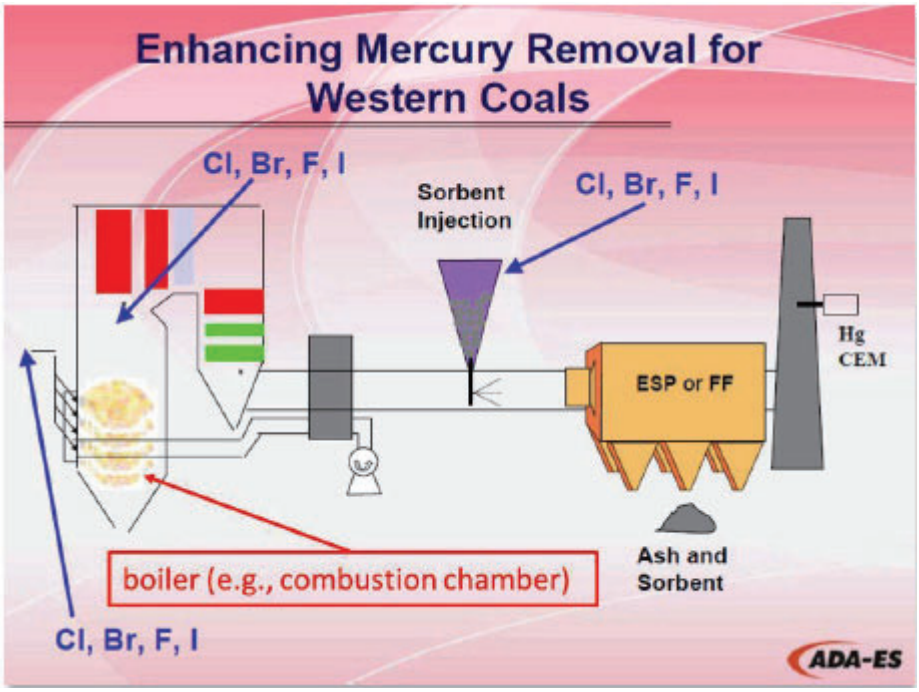
(bromine) being used in a conventional way (halogens are inherent to coal, and both oxidize mercury and promote activated carbon) with a conventional sorbent (activated carbon). Nothing about the particular range of 1 g to about 30 g of the halide promoter per 100 g of the sorbent would lead to an unexpected result from what was already known to one of skill in the art. As described in the State of the Art,[1737] it was known that the saturation limit of activated carbon for bromine (i.e., how much bromine the activated carbon can actually adsorb at equilibrium), was up to 31 to 38 grams per 100 grams of activated carbon. Through routine process optimization and routine experimentation, a POSITA would have adjusted the rate of addition of bromine-containing species and/or activated carbon injection rate to achieve about 1 g to about 30 g of halide promoter per 100g of sorbent.

2. Claim 18: "A method according to claim 17, wherein the gas stream is a mercury containing gas."

344. This limitation is disclosed by Sjostrom. As I describe for claim 17, Sjostrom in view of Olson-646 discloses an in-flight reaction in the flue gas between bromine and activated carbon to form an improved sorbent. Sjostrom describes injecting "Br" promoter into a coal-fired boiler (e.g., combustion chamber), as shown in the annotated figure below.[1738]

[1737] *See* State of the Art, above, § XII.C.3.

[1738] Ex. 1010 (Sjostrom) at 4 (annotations in red).



A POSITA would have understood that this unit was a boiler based on the image used to represent the unit in the drawing, whose distinctive inverted fish hook cross section was a common and routine way to represent a coal-combustion chamber (boiler). Sjostrom explains that at the time of testing, both of the coal-fired power plants combusted PRB (Powder River Basin) coal having a mercury content of "0.04 — 0.1 ppm-dry."[1739] Accordingly, combusting such coal produced a mercury-containing gas in the combustion chamber, the location of promoter injection. Relying only on existing equipment at these plants, Sjostrom shows that the outlet

[1739] Ex. 1010 (Sjostrom) at 12, 18.

mercury content of the flue gas was 11.2 μg/dncm.[1740] Thus, the bromine injected at Addition Location 2 is injected into a mercury-containing gas.

345. In addition, the sorbent is also injected into a mercury-containing gas. Sjostrom shows injection of the sorbent into the flue-gas ductwork prior to the ESP or FF.[1741] A POSITA would have known that the flue gas prior to reaching the ESP or FF still contained all or substantially all of the mercury created by the coal-combustion process. Thus, the sorbent injected in the system of Sjostrom is injected into a mercury-containing gas.

3. Claim 19: "A method according to claim 18, wherein the gas stream is a transport gas."

346. This limitation is obvious over Sjostrom in view of Olson-646. As I describe for claims 17 and 18, Sjostrom discloses an in-flight reaction in the mercury-containing flue gas between bromine and activated carbon to form an improved sorbent. A POSITA would have understood that coal combustion produced a mercury-containing flue gas, and that the mercury-containing gas transported the bromine-containing promoter of Sjostrom to the activated-carbon sorbent.

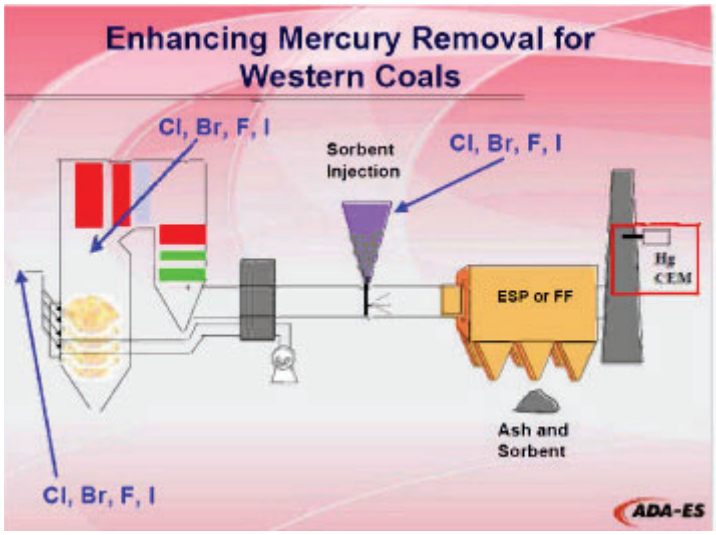
4. Claim 20. "A method according to claim 18, wherein the gas stream is a transport gas."A method according to claim 17,

[1740] Ex. 1010 (Sjostrom) at 3.

[1741] Ex. 1010 (Sjostrom) at 4.

wherein the promoter injection rate and the sorbent injection rate into the gas are determined at least in part on the monitored mercury content of the cleaned gas."

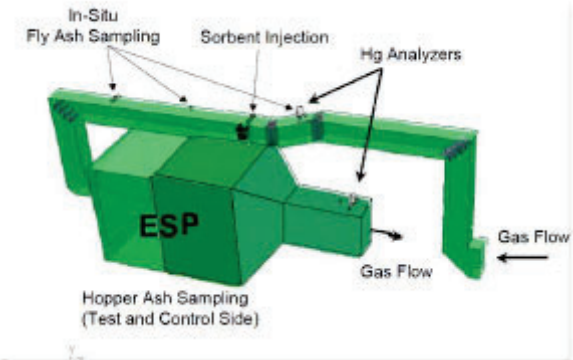
1032. This limitation is disclosed by Sjostrom. As shown in the annotated figure below, Sjostrom describes passing the treated flue gas through a stack with an attached Hg CEM (continuous emissions monitor) attached.[1742]



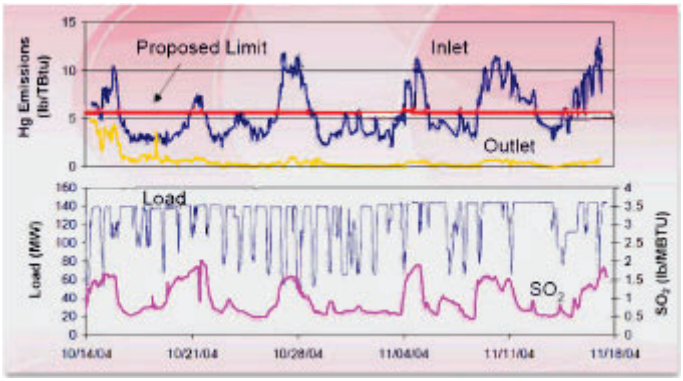
Further, Sjostrom discusses taking measurements of the Hg content at both the inlet and outlet of the ESP as shown below.[1743]

1742 Ex. 1010 (Sjostrom) at 4 (annotations in red).

1743 Ex. 1010 (Sjostrom) at 19.



Sjostrom includes the chart showing the Hg emissions as measured at the inlet and outlet of the ESP[1744]

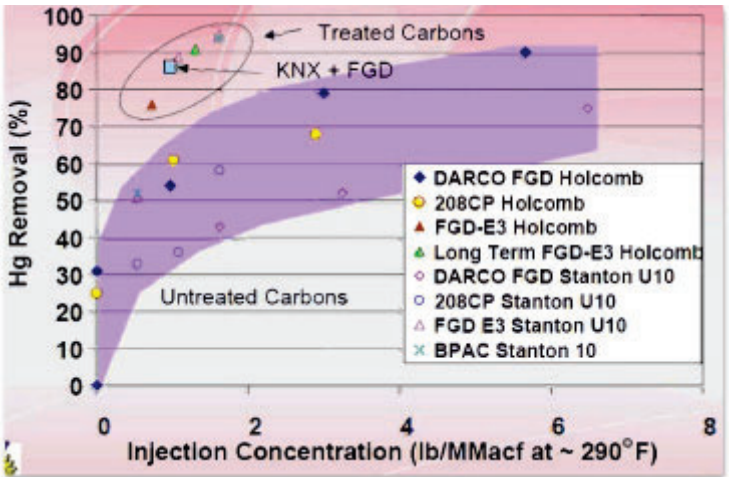


Thus, Sjostrom discloses monitoring the mercury content of the cleaned gas.

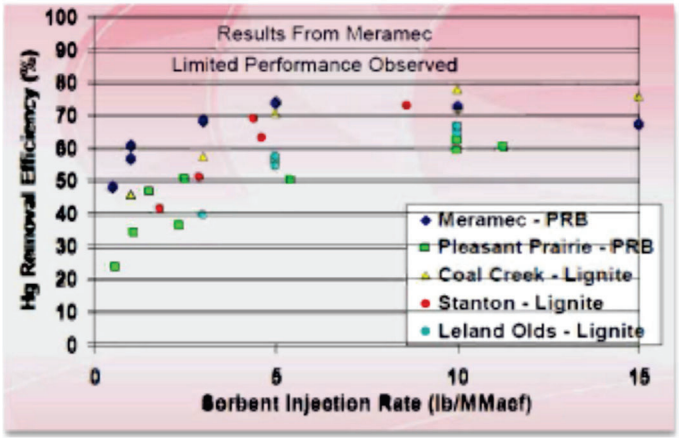
1033. Sjostrom includes numerous charts of measured mercury removals for various injection rates of activated-carbon sorbents. For example, the below chart shows the effects of activated carbon injection rates for testing using the system of Sjostrom.[1745]

1744 Ex. 1010 (Sjostrom) at 22.

1745 Ex. 1010 (Sjostrom) at 16.



Similarly, the below chart shows the effects of activated carbon injection rates for testing using the system of Sjostrom.[1746]



1034. The fact that there is a graph that has datapoints for different sorbent injection rates (the independent variable) and associated Hg removal percentages (the dependent variable) means that a POSITA would have understood that there is a relationship between the Hg removal % and the sorbent injection rate. Given that,

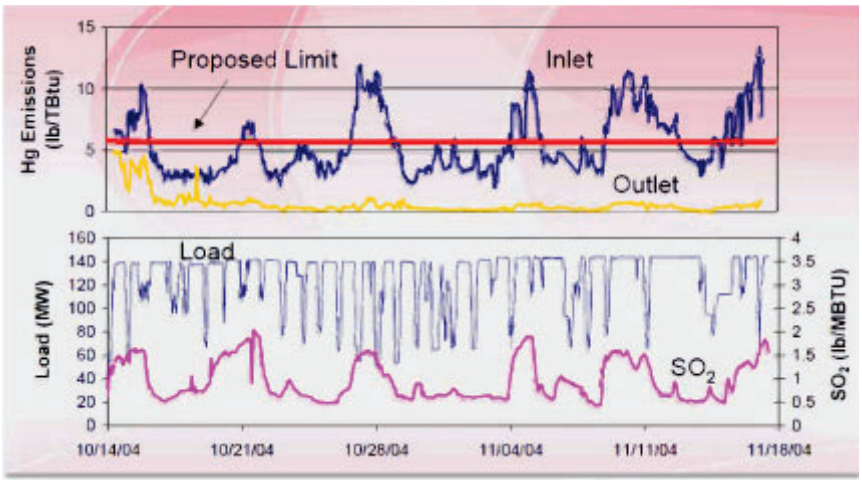
1746 Ex. 1010 (Sjostrom) at 20.

and a target Hg removal rate, a POSITA would have understood that the sorbent injection rate would be adjusted to result in a target mercury content.

1035. As discussed previously, a POSITA would have known that activated carbon was expensive, especially relative to costs of components such as "Br" in the form of HBr or an aqueous bromide salt solution. Thus, a POSITA would have been motivated to maintain the sorbent injection rate at the minimum level necessary to reach the desired level of mercury emissions. A POSITA viewing the charts of Sjostrom showing mercury removal versus sorbent injection rate would have been motivated to use the charts to control the sorbent injection rate at a level that minimized costs while reaching mercury removal targets. Thus, Sjostrom discloses controlling, in response to the monitored mercury content of the cleaned gas, an injection rate of the sorbent into the mercury-containing gas, the sorbent composition, or a combination thereof.

1036. The below figure from Sjostrom shows that the testing focused on a "Proposed Limit.[1747]

[1747] Ex. 1010 (Sjostrom) at 22.



347. Thus, Sjostrom teaches maintaining the mercury content of the cleaned gas "at or below a desired level" (e.g., the 'Proposed Limit."). A POSITA would have been motivated to determine the activated carbon injection rate to reach this desired level while minimizing the amount of activated carbon injected. A POSITA would have understood that injecting too much activated carbon would have increased the costs of the mercury removal process and injecting too little activated carbon may lead to mercury emissions rising above actionable levels. Thus, Sjostrom discloses controlling the system so that the mercury content of the cleaned gas is maintained at or below a desired level.

XXXV. GROUND Q: OBVIOUSNESS OF THE '147 PATENT OVER VOSTEEN IN VIEW OF GRANITE

607. It is my opinion that Vosteen either alone or in combination with the background knowledge of a POSITA or Granite renders obvious each of asserted claim of the '147 patent.

A. CLAIM 1

1. Claim 1: Preamble —"A method for separating mercury from a mercury containing gas comprising:"

608. Vosteen discloses the preamble. The title of Vosteen is, "Process for removing mercury from flue gases."[1748] Flue gas is an example of a mercury-containing gas, and "removing mercury" refers to separating the mercury from a mercury-containing gas. Vosteen describes "removal of mercury from the flue gases in a flue gas emission control system downstream of the combustion," in plants such as "power stations, for example bituminous coal-fired or lignite-fired power stations.[1749] Claim 1 of Vosteen also discloses the preamble.[1750] Subjecting flue gas "to a cleanup for removing mercury from the flue gas" refers to separating mercury from a mercury-containing gas.

2. Claim 1: Element 1(a)(1) —"promoting at least a portion of a particulate sorbent material comprising activated carbon by chemically reacting the sorbent material with a bromine containing promoter to form a promoted brominated sorbent"

609. This limitation is disclosed by Vosteen. Vosteen explains that the addition of the bromine compound can be to coal can be made at the plant, upstream of the furnace.[1751] Vosteen describes that a mercury/sorbent/bromine composition

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[1748] Ex. 1008 (Vosteen) at Title.

[1749] Ex. 1008 (Vosteen) at 2:16-20, 2:35-37.

[1750] Ex. 1008 (Vosteen) at Claim 1.

[1751] Ex. 1008 (Vosteen) at 3:66-4:19; see also id. at 2:54-3:2, 3:66-4:33, 6:65-7:32.

is formed (which thus includes a mercury/sorbent composition), in that the "mercury bromide ($HgBr_2$) adsorbs to the activated carbon."[1752] When bromine and carbon come into contact with each other, (e.g., upon adsorption as in Vosteen), a POSITA would have understood that the two react with one another and a promoted sorbent is formed.[1753]

610. By 2003, it was well-known that halides "improve[d] 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."[1754] A POSITA would have known that the introduction of halogens helped remove mercury by increasing the ability of the activated carbon to bind with the mercury. Thus, a POSITA would have known that the sorbent/halogen complex would have been referred to as a "promoted" sorbent.

611. Vosteen discloses a variety of bromine species that can be supplied, including hydrogen bromide.[1755] Hydrogen bromide is specifically identified in the '147 patent as a bromine containing promoter.[1756]

a. **Particulate sorbent material comprising activated carbon**

[1752] Ex. 1008 (Vosteen) at 5:35-39.

[1753] See, e.g., State of the Art, Sections XII.C.3, XII.G.2.

[1754] Ex. 1062 (Crocker) at 2-3.

[1755] Ex. 1008 (Vosteen) at 2:54-67.

[1756] Ex. 1001 ('147 Patent) at 7:61-8:20.

612. This claim element is disclosed by Vosteen and would be obvious in light of Vosteen in combination with the activated carbon systems such as those disclosed in Granite.

613. Vosteen discloses a dry-emission control system that includes injecting an activated-carbon sorbent for adsorbing mercury into a mercury-containing gas. Vosteen describes "cloth filters which are impinged with a blown-in finely pulverulent slaked lime/ *activated carbon* or slaked lime/lignite coal coke mixture."[1757]

614. As I describe in the State of the Art regarding Components Downstream of the Combustion Chamber, fabric filters have been a component of downstream emissions control that contain fabric bags. The mercury-containing flue gas with fly ash pass through the bags, and particle materials are filtered out of the gas. Vosteen describes adding bromine-containing species to the coal (and/or or to the combustion chamber) to introduce HBr and other bromine-containing species into the mercury-containing flue gas generated in the combustion chamber, and also describes injecting a mixture of lime and activated carbon onto fabric filters downstream of the combustion chamber.[1758] This treatment configuration spontaneously brominates the activated carbon (sorbent) in the mercury-containing flue gas as both the

[1757] Ex. 1008 (Vosteen) at 5:27-30.
[1758] Ex. 1008 (Vosteen) at 5:27-30.

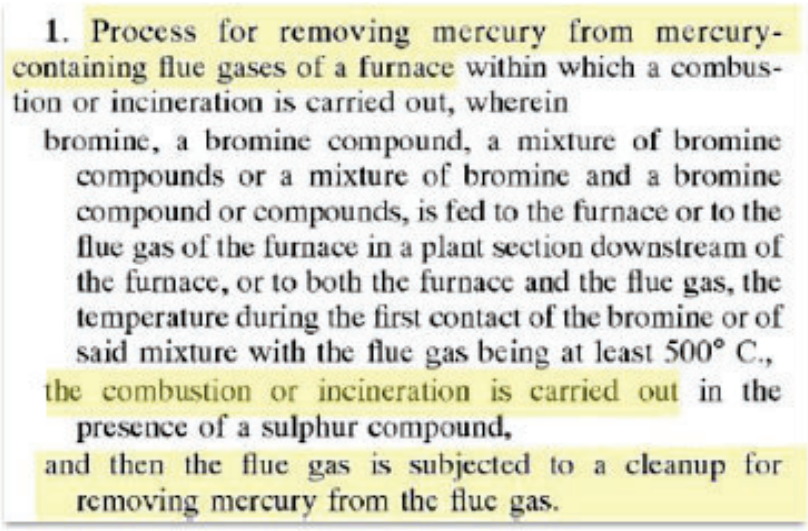
activated-carbon sorbent and the bromine-containing species move towards the fabric filter unit. The bromination also occurs in the dust cakes of fly ash, activated carbon, and lime on the outer bag surfaces. In turn, the brominated activated carbon captures elemental and oxidized mercury at extremely high efficiency, due to the large concentration of brominated sites in the activated carbon in a dust cake.

615. Vosteen further describes that the emission control system is downstream of the combustion chamber, in that his process performs the "removal of mercury from the flue gases in a flue gas emission control system downstream of the combustion . . . ."[1759] The flue gas was formed as a result of combustion of coal in the combustion chamber.

616. The claims of Vosteen also confirm that the use of the activated-carbon sorbent occurs downstream of the combustion chamber. For example, claim 1 states that "the combustion . . . is carried out . . . *and then* the flue gas is subjected to a cleanup for removing mercury from the flue gas."[1760]

[1759] Ex. 1008 (Vosteen) at 2:17-18.

[1760] Ex. 1008 (Vosteen) at Claim 1; *see also* Ex. 1008 (Vosteen) at Claim 12.



1. Process for removing mercury from mercury-containing flue gases of a furnace within which a combustion or incineration is carried out, wherein

bromine, a bromine compound, a mixture of bromine compounds or a mixture of bromine and a bromine compound or compounds, is fed to the furnace or to the flue gas of the furnace in a plant section downstream of the furnace, or to both the furnace and the flue gas, the temperature during the first contact of the bromine or of said mixture with the flue gas being at least 500° C.,

the combustion or incineration is carried out in the presence of a sulphur compound,

and then the flue gas is subjected to a cleanup for removing mercury from the flue gas.

617. It would have also been obvious to combine Vosteen's addition of bromine compounds to coal for combustion with activated carbon injection systems in use at the time that the Vosteen reference was published. For example, Vosteen's bromine additive would have been obvious to use in the plants described in the Granite reference. Granite explains that control technologies for removing mercury from flue gas at the time include the use of activated carbon sorbents injected into the gas stream.[1761] Granite describes, for example, the activated carbon duct injection systems used for mercury control for industrial combustors.[1762] A POSITA would understand that injection of activated carbon downstream of the combustion chamber was the more common and readily available method of using activated carbon for mercury control instead of the impinged fabric filters of Vosteen.

[1761] Ex. 2003 (Granite 2000) at 1020, 1022.

[1762] Ex. 2003 (Granite 2000) at 1026.

Furthermore, a POSITA would have been motivated by Granites teaching that the promotion of activated carbon using halogens such as chlorine and iodine to combine the teachings of Vosteen regarding bromine with the state of the art activated carbon systems it describes.[1763]

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b. **Promoting at least a portion of a particulate sorbent material by chemically reacting the sorbent material with a bromine containing promoter to form a promoted brominated sorbent**

618. This claim element is disclosed by Vosteen. A POSITA reading Vosteen would have understood that there would be excess bromine that would react to promote the sorbent material to form a promoted brominated sorbent. The POSITA would understand that not all bromine added to the coal or combustion chamber in Vosteen is used to oxidize mercury, because there is an excess (a ratio of 10^2 to 10^4) of bromine compared to mercury.[1764] Accordingly, a POSITA would have understood that excess bromine would be available to contact the activated carbon in the mercury-containing gas to form a promoted sorbent.

619. Granite likewise teaches the importance of promoting activated carbon with halogens.[1765]

1763 Ex. 2003 (Granite 2000) at 1020.
1764 Ex. 1008 (Vosteen) at 4:34-45.
1765 Ex. 2003 (Granite 2000) at 1020.

620. Finally, I understand that according to the Plaintiffs' own contentions infringement, the bromine containing precursor would react with the activated carbon to form the promoted sorbent through the claimed mechanism.

3. Claim 1: Element 1(a)(2) —"wherein the bromine containing promoter is in gaseous form, vapor form, or non-aqueous liquid form,"

621. This claim element is disclosed by Vosteen. Vosteen discloses mixing bromide compounds in with the coal in liquid form, either as an aqueous form or non-aqueous liquid.[1766] Furthermore, under Plaintiffs contentions of infringement, this claim element is met where the high temperatures of the flue gas vaporizes the bromine containing promoter.

4. Claim 1: Element 1(a)(3) —"and wherein the activated carbon contains graphene sheets having carbene species edge sites"

622. According to the Plaintiffs' own contentions of infringement, activated carbon includes graphene sheets having carbene edge sites.

5. Claim 1: Element 1(a)(4) —"which react with the bromine containing promoter to form a carbocation paired with a bromide anion in the promoted brominated sorbent for oxidation of the mercury:"

623. According to the Plaintiffs' own contentions of infringement, activated carbon includes graphene sheets having carbene edge sites.

6. Claim 1: Element 1(b) —"chemically reacting elemental mercury in the mercury containing gas with the promoted

[1766] Ex. 1008 (Vosteen) at 44-19.

brominated sorbent to form a mercury/sorbent chemical composition; and"

624. This limitation is disclosed by Vosteen. Vosteen states regarding the dry emission control system that bromine oxidizes mercury to form $HgBr_2$, and "Mercury bromide $HgBr_2$ *adsorbs more strongly to dry sorbents* than mercury chloride $HgCl_2$."[1767] Accordingly, this composition is a "mercury/sorbent" composition, as required in claims 23-25, in that it contains both mercury and sorbent. This composition also comprises the element bromine, the sorbent, and mercury, as required by claim 30.

625. Granite likewise describes the mechanism whereby mercury can react with the promoted sorbent: "Granite describes the mechanisms by which mercury adsorbs to the promoted activated carbon sorbent: "For a chemically promoted carbon, such as sulfur-impregnated carbon, chemisorption/reaction between the physically adsorbed mercury and sulfur promoter to form mercuric sulfide could be the second step in the mechanism of mercury removal."[1768]

626. Furthermore, according to the Plaintiffs' own contentions of infringement, the presence of the bromine containing precursor that has been introduced by addition to the coal in a coal combustion system results in the claimed

[1767] Ex. 1008 (Vosteen) at 2:20-31, 5:35-39.

[1768] Ex. 2003 (Granite 2000) at 1025.

chemical reaction to form the mercury/sorbent chemical composition. includes graphene sheets having carbene edge sites.

7. Claim 1: Element 1(c) —"separating particulates from the mercury containing gas, the particulates including ash and the mercury/sorbent chemical composition."

627. Vosteen discloses this claim element. Vosteen describes numerous components that are used to separate the mercury/sorbent composition from the mercury-containing (flue) gas, to form a cleaned gas. Such components include a spray-dryer adsorber (SDA), electrostatic precipitator (ESP), or fabric filter.[1769] These are also discussed in claims of Vosteen:[1770]

> **10.** The process according to claim **8**, wherein said emission control system comprises filtration, electrostatic separation or both.

628. Vosteen repeatedly refers to a flue gas *cleaning* system.[1771] Vosteen refers to "clean gas downstream of the wet and/or dry flue gas emission system."[1772] This is because, as Vosteen discloses, an "object of the invention to provide a process for removing mercury, in particular for the substantially complete removal of mercury (Hg)."[1773] The claims of Vosteen further disclose a process of "cleanup" of

1769 Ex. 1008 (Vosteen) at 5:15-30.
1770 Ex. 1008 (Vosteen) at Claim 10.
1771 See, e.g., Ex. 1008 (Vosteen) at Abstract, 2:12-15, 5:1-5.
1772 Ex. 1008 (Vosteen) at 6:2-4.
1773 Ex. 1008 (Vosteen) at 1:50-53.

the flue gas.[1774] The "dry cleanup stage" and "dry sorbent" includes, for example, the activated carbon injected into the mercury-containing flue gas that is separated by the fabric filter.[1775] The "cleanup" and "removal" referred to by Vosteen in the passages above refer to separating the mercury/sorbent composition from the mercury-containing flue gas.

629. Granite likewise describes the systems in place at the time as including a particulate collection device.[1776] A POSITA would understand that a particulate collection device would be necessary to remove the particulates in the flue gas, as well as the mercury absorbed on the particulates.

B. DEPENDENT CLAIMS

1. Claim 17

a. Claim 17: Element 17(a)—"A method according to claim 1, further comprising injecting the particulate sorbent material at a sorbent material injection rate and injecting separately the bromine containing promoter into a gas stream"

630. Vosteen discloses a dry-emission control system that includes injecting an activated-carbon sorbent for adsorbing mercury into a mercury-containing gas. Vosteen describes "cloth filters which are impinged with a blown-in finely

[1774] Ex. 1008 (Vosteen) at Claims 1, 18.

[1775] Ex. 1008 (Vosteen) at 5:27-30.

[1776] Ex. 2003 (Granite 2000) at 1024.

pulverulent slaked lime/ *activated carbon* or slaked lime/lignite coal coke mixture."[1777]

631. As I describe in the State of the Art regarding Components Downstream of the Combustion Chamber, fabric filters have been a component of downstream emissions control that contain fabric bags. The mercury-containing flue gas with fly ash pass through the bags, and particle materials are filtered out of the gas. Vosteen describes adding bromine-containing species to the coal (and/or or to the combustion chamber) to introduce HBr and other bromine-containing species into the mercury-containing flue gas generated in the combustion chamber, and also describes injecting a mixture of lime and activated carbon onto fabric filters downstream of the combustion chamber.[1778] This treatment configuration spontaneously brominates the activated carbon (sorbent) in the mercury-containing flue gas as both the activated-carbon sorbent and the bromine-containing species move towards the fabric filter unit. The bromination also occurs in the dust cakes of fly ash, activated carbon, and lime on the outer bag surfaces. In turn, the brominated activated carbon captures elemental and oxidized mercury at extremely high efficiency, due to the large concentration of brominated sites in the activated carbon in a dust cake.

[1777] Ex. 1008 (Vosteen) at 5:27-30.

[1778] Ex. 1008 (Vosteen) at 5:27-30.

632. It would have also been obvious to combine Vosteen's addition of bromine compounds to coal for combustion with activated carbon injection systems in use at the time that the Vosteen reference was published. For example, Vosteen's bromine additive would have been obvious to use in the plants described in the Granite reference. Vosteen explains that its teachings are particularly applicable to dry emission control systems,[1779] which would include systems that inject activated carbon sorbents. Granite explains that control technologies for removing mercury from flue gas at the time include the use of activated carbon sorbents injected into the gas stream.[1780] Granite describes, for example, the activated carbon duct injection systems used for mercury control for industrial combustors.[1781] A POSITA would understand that injection of activated carbon downstream of the combustion chamber was the more common and readily available method of using activated carbon for mercury control instead of the impinged fabric filters of Vosteen. Furthermore, a POSITA would have been motivated by Granites teaching that the promotion of activated carbon using halogens such as chlorine and iodine to combine the teachings of Vosteen regarding bromine with the state of the art activated carbon systems it describes.[1782]

1779 Ex. 1008 (Vosteen) at 5:19-21.
1780 Ex. 2003 (Granite 2000) at 1020, 1022.
1781 Ex. 2003 (Granite 2000) at 1026.
1782 Ex. 2003 (Granite 2000) at 1020.

b. **Claim 17: Element 17(b)—"whereby in-flight reaction produces the promoted brominated sorbent,"**

c. **Claim 17: Element 17(c)—"wherein the promoter is reacted in the gas phase or as a vapor,"**

633. These limitations are obvious over Vosteen alone as well as in view of Granite. As described above for Claim 1, a POSITA would have understood that the bromine and activated carbon would have reacted in the flue gas to form at least a quantity of promoted brominated sorbent.

634. At the temperature and pressure conditions present within standard flue gas systems, the HBr or Br_2 would have remained in the gaseous or vapor phase. Accordingly, a POSITA would have understood that at least a quantity of bromine gas or bromine vapors would have made contact with the activated-carbon sorbent within the flue gas stream, as I described above. Thus, Vosteen alone or in combination with the activated carbon injection systems known at the time and described in Granite renders obvious an "in-flight" reaction as described in the '147 patent.

635. Furthermore, according to the Plaintiffs' own contentions of infringement, the presence of the bromine containing precursor that has been introduced by addition to the coal in a coal combustion system would produce a promoted brominated sorbent through an in-flight reaction.

d. Claim 17: Element 17(d)—"wherein the promoter is added at from about 1 to about 30 grams per 100 grams of the sorbent material."

636. This claim would have been obvious over Vosteen. Claim 29 would have been obvious over Vosteen. In Figure 6 of Vosteen, the Y-axis represents the percentage by weight of elemental mercury (labeled Hg_{met} for metallic mercury) compared to total mercury (labeled Hg_{tot}). On the X-axis, Vosteen plots the total bromine concentration in the mercury-containing gas (Br_{tot}), which is the sharper curve.[1783]

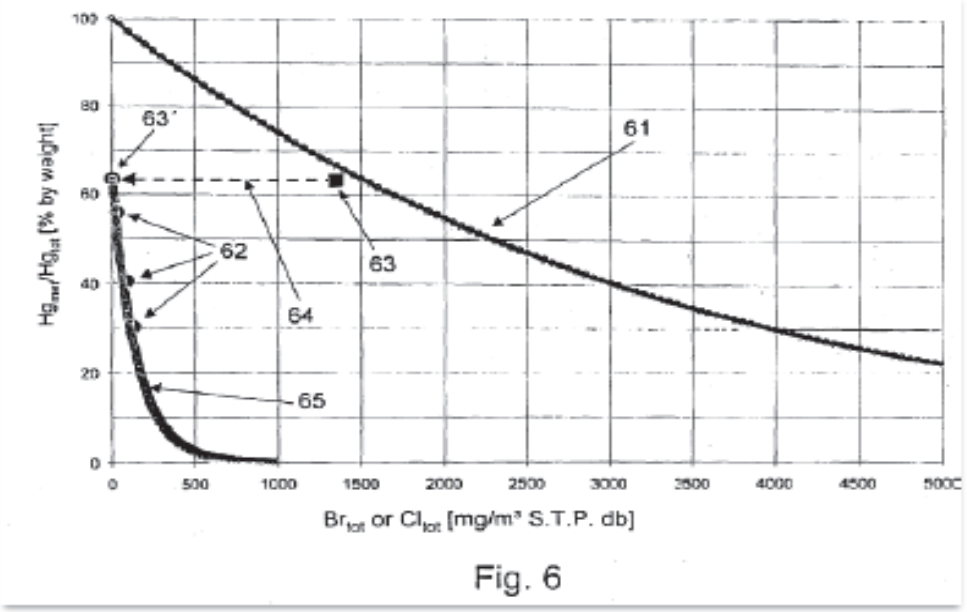


Fig. 6

The values on the X-axis are presented as mg/m^3 S.T.P. db, which is milligrams Br per cubic meter of mercury-containing flue gas, on a dry basis'[1784] at standard temperature (25 °C) and standard pressure (1 atm). Vosteen also

1783 Ex. 1008 (Vosteen) at 10:58-61.

1784 Ex. 1008 (Vosteen) at 1:18.

describes that activated carbon is used in his system,[1785] but does not expressly state the injection rate of activated carbon into the system downstream of the combustion chamber.

637. A person of ordinary skill in the art would have known to use, or at least start with as a first approximation, widely accepted values for injection rates of activated carbon. As described above,[1786] it was routine in the industry to use injection rates of activated carbon of around 10 pounds/MMacf (million actual cubic feet of flue gas) to capture mercury. Based on the data presented by Vosteen of 50 mg bromine per m^3 of flue gas S.T.P. db (the first datapoint described by Vosteen),[1787] and a standard and well-known injection rate of activated carbon of around 10 pounds/MMacf, a person of ordinary skill in the art would have used, or at least tried using, a mercury-containing gas that comprises about 20 grams of the element bromine per 100 grams of sorbent, which is within the claimed range of 1-30 grams bromine per 100 grams sorbent. I explain my calculations below.

638. 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 or pounds per million actual cubic feet. Vosteen

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1785 Ex. 1008 (Vosteen) at 5:23-29, 5:37.
1786 State of the Art, § XII.C.5, XII.G
1787 Ex. 1008 (Vosteen) at 10:37-45.

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 (MACF) of flue gas. Converting between the two would have been a routine calculation at a power plant to a person of ordinary skill in the art and would have involved such basic concepts as the ideal gas law (to convert concentrations between temperatures and pressures), which was taught in first semester undergraduate chemistry to a person of skill in the art.[1788] Such unit conversion would have also involved basic engineering knowledge of a power-plant operation, such as a typical flue gas temperature, pressure, and moisture content. Each of these would have been well-known to a person of skill in the art.

639. A person of skill in the art 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 lignites and subbituminous can produce flue gas with 15 % moisture or greater, and anthracites can produce as little as 5 % moisture or less. [1789] For

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[1788] See, e.g., State of the Art, § XII.A.9.

[1789] Ex. 1027 (B&W Steam) at 8-5 to 8-6.

example, estimates for a low volatile bituminous coal gave 8.1 % moisture in flue gas.[1790]

640. Regarding the second conversion, a person of skill in the art would have understood from the ideal gas law that the density of a gas is proportional to pressure and inversely proportional to temperature. A person of skill in the art would have learned from undergraduate chemistry that standard temperature and pressure (STP) refers to 25 °C (298 K) and 1 atm, respectively, and 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. 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[1791] This dewpoint range restricts the outlet temperatures to somewhat hotter values like 150 °C. Last, a person of ordinary skill in the art would have found in readily available tables of unit conversions that 1 m^3 = 35.3^6 ft^3.

[1790] Ex. 1008 (Vosteen) at 2:36-38 ("bituminous coal-fired or lignite-fired power stations").

[1791] Ex. 1027 (B&W Steam) at 19-11.

641. Accordingly, 50 mg / m^3 S.T.P. db (as disclosed by Vosteen) converts to the following in terms of grams bromine / million actual cubic feet.

$$\frac{50\ mgBr}{m^3_{STP.DB}} \times \left(\frac{0.9m^3_{STP.DB}}{1.0m^3_{STP}}\right) \times \left(\frac{1g}{1000\ mg}\right) \times \left(\frac{1\ atm}{1\ atm}\right) \times \left(\frac{298K}{413K}\right) \times \left(\frac{1m^3}{35.3ft^3}\right)$$
$$\times \left(\frac{10^6 ACF}{1\ MACF}\right) \times 919.8 \frac{g\ Br}{MACF}$$

642. A person of ordinary skill in the art would have also been readily able to convert pounds activated carbon to grams activated carbon through the well-known unit conversion that there are 453.592 grams per pound. Accordingly, at a typical activated-carbon injection rate of 10 pounds per MACF, the injection rate of activated carbon would equal:

$$10 \frac{pounds\ PAC}{MACF} \times \frac{453.592\ grams}{pounds} = 4{,}535 \frac{grams\ Activated\ Carbon}{MACF}$$

643. Dividing the two injection rates provides a mercury-containing gas that comprises about 20 grams bromine per 100 grams of activated-carbon sorbent, which is within the range of 1 gram to 30 grams.

644. Furthermore, this claim element is merely an attempt to claim a workable range for combining a conventional halogen (bromine) being used in a conventional way (to oxidize mercury and promote activated carbon) with a conventional sorbent (activated carbon). Nothing in the ’147 patent specification attributes significance to the claimed range, or establishes that the claimed range

"achieves unexpected results." The range presents nothing more than optimization of "result-effective" variables that would have been obvious to a POSITA

2. Claim 18: "A method according to claim 17, wherein the gas stream is a mercury containing gas."

645. This limitation is disclosed by Vosteen as well as Granite.

646. Vosteen describes that the combustion chamber (sometimes referred to as "furnace" or "boiler" in Vosteen) comprises added aqueous hydrogen bromide [HBr(aq)], bromide compounds in solid or aqueous form (e.g., sodium bromide [NaBr(s) or NaBr(aq)], molecular bromine (Br2), and mixtures thereof. The gas coming from the combustion chamber would be mercury-containing gas from the combustion of coal. For example, Vosteen describes experiments conducted on "a *coal-fired power station* of Bayer AG in Uerdingen, which essentially consists of *a slag-tap fired boiler* . . "[1792] Vosteen also describes a *"coal-fired* power station of Bayer AG in Uerdingen (see FIG.9)" with "two parallel slag-tap fired boilers 91, 92 having temperatures in the *combustion chamber* around 1450°C."[1793]

3. Claim 19: "A method according to claim 18, wherein the gas stream is a transport gas."

647. This limitation is obvious over Vosteen alone as well as in view of Granite. As I describe for claims 17 and 18, Vosteen and Granite each disclose the

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[1792] Ex. 1008 (Vosteen) at 7:25-28.

[1793] Ex. 1008 (Vosteen) at 10:63-11:6.

addition of a bromine species and activated carbon sorbent in the mercury-containing flue gas. A POSITA would have understood that coal combustion produced a mercury-containing flue gas, and that the mercury-containing gas transported the bromine-containing promoter of Vosteen to the activated-carbon sorbent described above.

4. Claim 20. "A method according to claim 18, wherein the gas stream is a transport gas."A method according to claim 17, wherein the promoter injection rate and the sorbent injection rate into the gas are determined at least in part on the monitored mercury content of the cleaned gas."

648. Vosteen discloses this claim element. Vosteen discloses this claim element. Vosteen describes that "*the mercury content of the flue gas*, in particular the content of metallic [i.e., elemental] mercury, *is measured continuously* downstream of the flue gas emission control system."[1794] Measurements of the mercury content are depicted in Figures 2-8 of Vosteen,[1795] and are also recited in claim 9 of Vosteen.[1796]

649. Vosteen monitors the mercury content of the cleaned gas, and in response, controls the rate of addition to the coal and/or combustion chamber of the added bromine-containing species.

1794 Ex. 1008 (Vosteen) at 5:48-50.
1795 Ex. 1008 (Vosteen) at Figs. 2-8.
1796 Ex. 1008 (Vosteen) at Claims 9.

> Preferably, in the inventive process, *the mercury content of the flue gas*, in particular the content of metallic mercury, *is measured continuously* downstream of the flue gas emission control system and *on the basis of the measured mercury content the amount of bromine fed and/or bromine compounds and/or the mixture of bromine compounds* and if appropriate sulphur and/or sulphur substances and/or the mixture of sulphur substances *is controlled.*[1797]

As explained above for Claim 1, the bromine-containing species include aqueous hydrogen bromide [HBr(aq)], bromide compounds in solid or aqueous form (e.g., sodium bromide [NaBr(s) or NaBr(aq)], molecular bromine (Br_2), and mixtures thereof, and these bromine-containing species are added to either the coal or to the combustion chamber. Claim 20 is also disclosed by claim 9 of Vosteen.[1798]

XXXVI. GROUND R: OBVIOUSNESS OF THE '517 PATENT OVER SJOSTROM IN VIEW OF ECKBERG AND/OR OLSON-646

1037. It is my opinion that Sjostrom in view of Eckberg and/or Olson-646 render obvious each of claims 1-11, 13-15, 17-19, 21-26, 28-30 of the '517 Patent.

A. INDEPENDENT CLAIM 1

1. Claim 1: Element 1a: "A method for reducing mercury in a mercury-containing gas, the method comprising:"

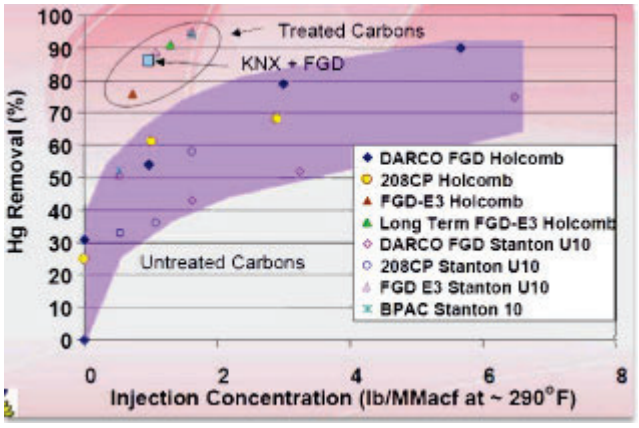
1038. The preamble is disclosed by Sjostrom. Sjostrom, either alone or in combination with Eckberg, anticipates or renders this limitation obvious.

1797 Ex. 1008 (Vosteen) at 5:48-55.

1798 Ex. 1008 (Vosteen) at Claims 9.

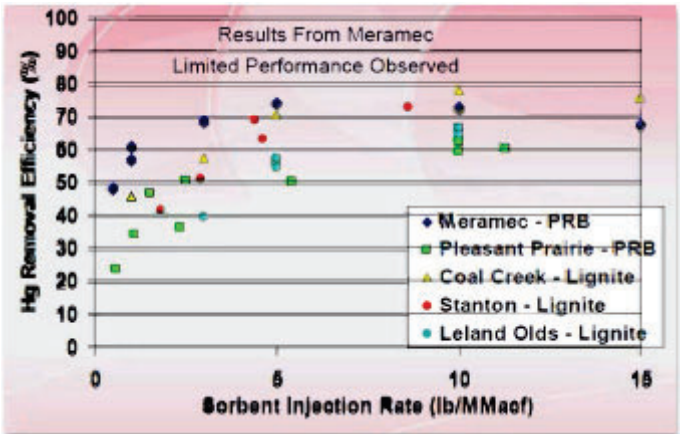
1039. Sjostrom is a presentation titled "Full Scale Evaluations of Mercury Control Technologies with PRB Coals."[1799] Sjostrom provides an overall process schematic showing the injection of halogens and activated-carbon sorbents for mercury removal in coal-fired flue gas. Sjostrom quantifies mercury separation from a mercury-containing gas in the form of charts showing "Hg Removal (%)"[1800] and "Hg Removal Efficiency (%)".[1801]

1040. Sjostrom includes numerous charts showing greater than 70 % removal of mercury from the flue gas. For example, the below chart shows the mercury removal from testing at a plant using the system of Sjostrom.[1802]



Similarly, the below chart shows the mercury removal from testing at a plant using the system of Sjostrom.[1803]

1799 Ex. 1010 (Sjostrom) at 1.
1800 Ex. 1010 (Sjostrom) at 8, 15-17.
1801 Ex. 1010 (Sjostrom) at 20-21.
1802 Ex. 1010 (Sjostrom) at 16.
1803 Ex. 1010 (Sjostrom) at 20.

1041. 

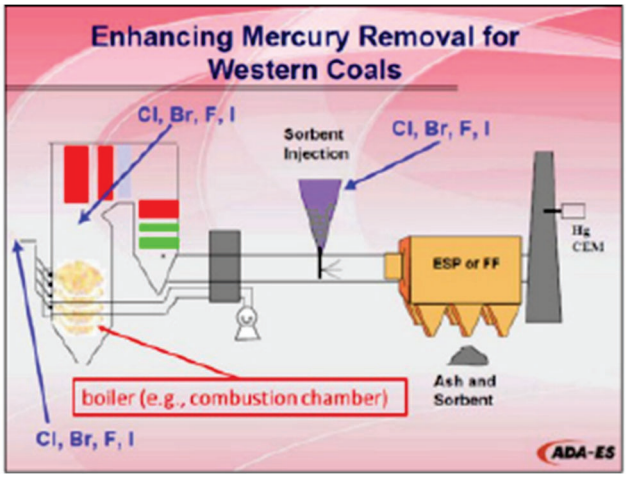
2. Claim 1: Element 1b: "combusting coal in a combustion chamber, the coal comprising an additive comprising Br2, HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas; and"

1042. Sjostrom, either alone or in combination with Eckberg, anticipates or renders this limitation obvious. Sjostrom discloses combusting coal in a combustion chamber to form the mercury-containing gas, wherein the coal comprises an additive comprising Br2, HBr, a bromide compound, or a combination thereof, by teaching combusting coal in a combustion chamber.

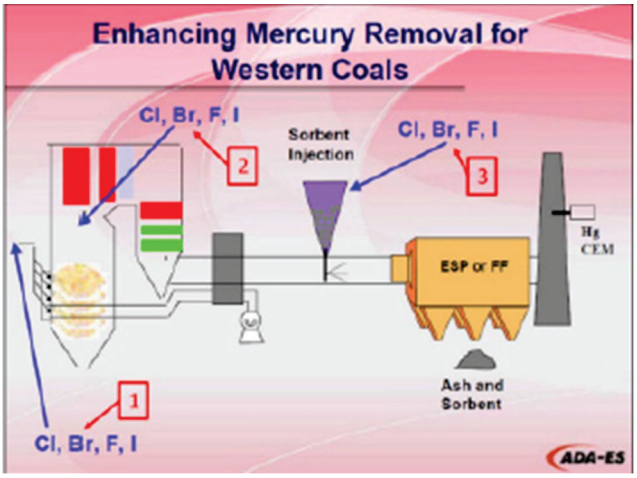
1043. Sjostrom discloses combustion of PRB (Powder River Basin) coal having a mercury content of "0.04 – 0.1 ppm-dry."[1804] The combustion generated a concentration of mercury in the flue gas of 11.2 µg/dncm.[1805]

1804 Ex. 1010 (Sjostrom) at 12, 18.

1805 Ex. 1010 (Sjostrom) at 3, 4 (annotated below).



1044. Further, Sjostrom discloses that "Br" could be added to the combustion chamber at Addition Location 2 or before the combustion chamber at Addition Location 1.[1806]



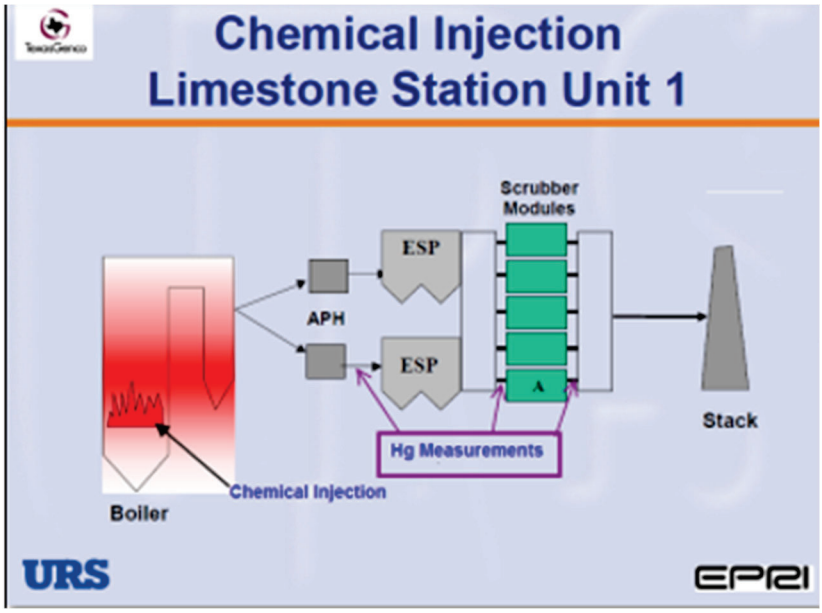
1045. A POSITA having read Sjostrom, would understand that Sjostrom's "Br" source would have been widely available bromine-containing materials suitable for injection at the disclosed locations in a coal-fired plant, such as HBr or an aqueous solution of a bromide compound, such as $CaBr_2$. A POSITA would also

1806 Ex. 1010 (Sjostrom) at 4 (annotated below).

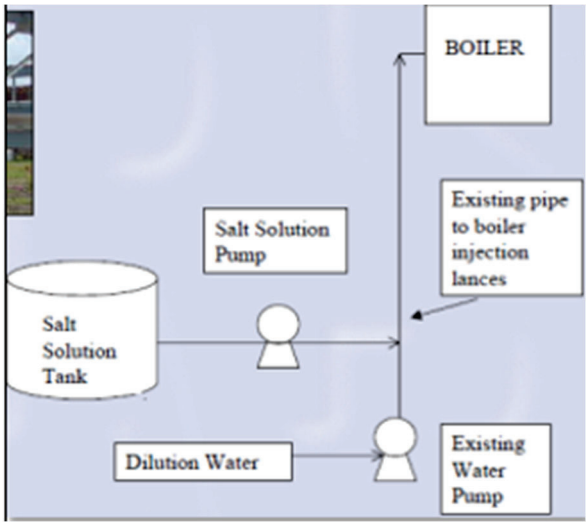
have understood that a calcium bromide in an aqueous solution would dissociate to form Br– (bromide ions). Indeed, Sjostrom refers adding "KNX (Alstom Power)"—a known aqueous solution of bromide salt for enhancing mercury control.[1807] At least a portion of the bromide species resulting from the addition of a bromide compound at either Addition Location 1 or Addition Location 2 of Sjostrom would have evaporated at the temperatures inside the boiler and left the combustion chamber in the vapor phase of the flue gas.[1808]

1046. Eckberg teaches using halogens to remove mercury from coal-fired plants. Eckberg is entitled, "Mercury Control Evaluation of Halogen Injection into a Texas Lignite-Fired Boiler." Eckberg describes "Chemical Injection" of a halogen directly into a coal-fired boiler.[1809] Eckberg further teaches that the "salt solution" added to the "boiler" was either "CaCl2 (25 wt%)" or "CaBr2 (52 wt%)."[1810] Eckberg also teaches the ratio of bromine to coal, the feed rate of the aqueous salt solution, and the bromine concentration in flue gas.[1811]

1807 Ex. 1010 (Sjostrom) at 23.
1808 *See* Ex. 1010 (Sjostrom) at 4.
1809 *See* Ex. 1011 (Eckberg) at 5 (provided below).
1810 *See* Ex. 1011 (Eckberg) at 9.
1811 *See* Ex. 1011 (Eckberg) at 9.



1047. Eckberg also discloses the equipment used for halogen addition.[1812]



1048. A POSITA would have been motivated to combine the teachings of Sjostrom and Eckberg to utilize calcium bromide, a widely obtainable and relatively cheap form of bromine.

1812 *See* Ex. 1011 (Eckberg) at 8.

3. Claim 1: Element 1c: "collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon."

1049. Sjostrom discloses this element. Sjostrom discloses injecting a sorbent material comprising activated carbon into the mercury-containing gas downstream of the combustion chamber (*e.g.*, boiler) as shown in the figure on page 4 at the "Sorbent Injection" feature.[1813] Exemplary activated-carbon sorbents for mercury capture include powdered activated carbon, including "DARCO FGD."[1814]

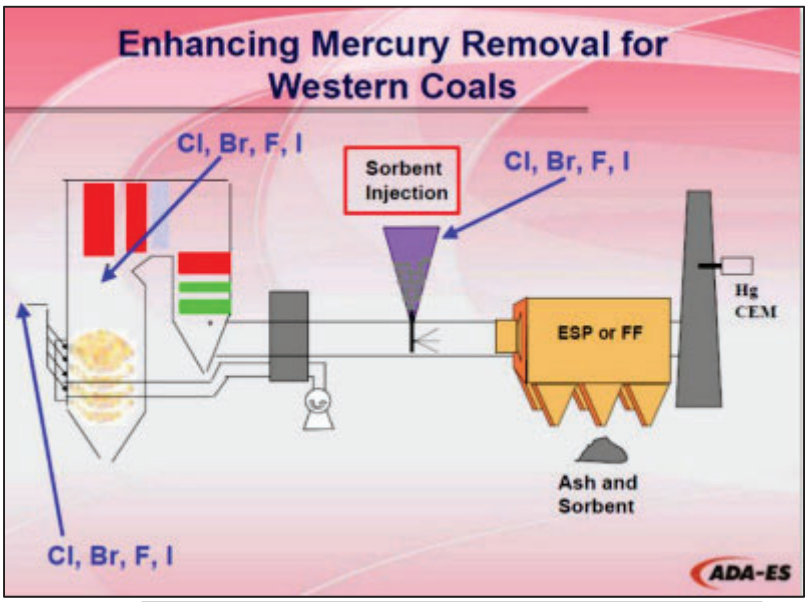
1050. The mercury in the flue gas of Sjostrom is contacted with activated carbon to form a mercury/sorbent composition because the mercury is adsorbed by the activated carbon.[1815] Adsorption is a form of contact. Norit DARCO FGD and other activated carbons were referred to as "sorbents" because when they contacted certain materials in the gas phase such as mercury, they adsorbed them. A POSITA would understand that in an adsorption process, adsorbate (e.g., mercury) from a fluid (e.g., flue gas) are adhered to the surface of a sorbent upon contact.

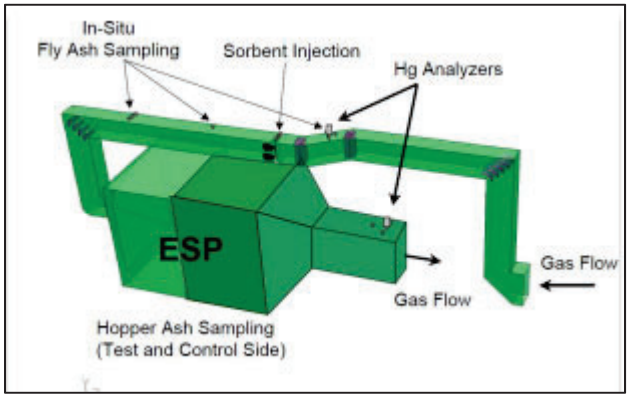
1051. Sjostrom discloses separating the mercury/sorbent composition from the mercury-containing gas, to form a cleaned gas with an ESP or FF.[1816] Specifically, Sjostrom shows that "ash and sorbent" are removed in an ESP or FF,

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1813 Ex. 1010 (Sjostrom) at 4 (annotated below).
1814 Ex. 1010 (Sjostrom) at 10-11, 15-16, 21.
1815 Ex. 1010 (Sjostrom) at 4 (annotated below).
1816 Ex. 1010 (Sjostrom) at 4 (annotated below).

which were well-known particulate control devices to separate particles (e.g., the mercury/sorbent material) from a mercury-containing gas.[1817]





B. CLAIMS DEPENDING FROM CLAIM 1

1. Claim 2: "The method of claim 1, further comprising injecting an alkaline sorbent into the mercury-containing gas stream."

[1817] Ex. 1010 (Sjostrom) at 4 (annotated below), 19.

1052. Sjostrom, either alone or in light of Olson-646, renders this limitation obvious. Sjostrom discloses injecting sorbent in the mercury-containing gas.[1818]

1053. In addition, Olson-646 explains that a "promoted carbon sorbent and/or an optional alkali component is injected into contaminated flue gas stream 15," to remove mercury from flue gas.[1819] A POSITA would have been motivated to combine the teachings of Sjostrom and Olson-646 to utilize a known, suitable sorbent for mercury removal.

2. Claim 3: "The method of claim 2, wherein the alkaline sorbent is selected from the group consisting of alkali elements, alkaline earth elements, alkali salts, alkaline earth salts, and combinations thereof."

1054. The language of this claim element discusses similar elements as claim 2. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

3. Claim 4: "The method of claim 1, wherein the activated carbon is chosen from powdered activated carbon, granular activated carbon, carbon black, carbon fiber, aerogel carbon, pyrolysis char, and combinations thereof."

1055. This limitation is disclosed by Sjostrom. Sjostrom repeatedly discusses the use of activated carbon.[1820] Further, Sjostrom includes test results of "Untreated

[1818] Ex. 1010 (Sjostrom) at 4.

[1819] Ex. 1014 (Olson-646) ¶ 61.

[1820] Ex. 1010 (Sjostrom) at 10, 20, 34.

PAC Injection into ESP" for "PRB and Lignite Coals."[1821] A POSITA would have known that PAC stood for "powdered activated carbon." Sjostrom also discusses testing done with the injection of "DARCO FGD" sorbent.[1822] A POSITA would have known that DARCO FGD was a well-known type of powdered activated-carbon sorbent.[1823]

4. Claim 5: "The method of claim 1, wherein the sorbent has a composition comprising from about 1 to about 30 grams of the element bromine per 100 grams of activated carbon."

1056. This limitation is obvious over Sjostrom in view of Olson-646. Claim 5 is merely an attempt to claim the optimum or workable range for a process of combining a particular conventional halogen (bromine) being used in a conventional way (halogens are inherent to coal, and both oxidize mercury and promote activated carbon) with a conventional sorbent (activated carbon). Nothing about the particular range of 1 g to about 30 g of the halide promoter per 100 g of the sorbent would lead to an unexpected result from what was already known to one of skill in the art.

1057. As described in the State of the Art,[1824] it was known that the saturation limit of activated carbon for bromine (i.e., how much bromine the activated carbon can actually adsorb at equilibrium), was up to 31 to 38 grams per 100 grams of

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1821 Ex. 1010 (Sjostrom) at 20.

1822 Ex. 1010 (Sjostrom) at 15, 16, 20-21.

1823 See, e.g., State of the Art, Sections XII.C.3, XII.G.2.

1824 State of the Art, § XII.C.3.

activated carbon. Given the residence times in flue gas, and other inefficiencies, a person of ordinary skill in the art would have understood that the actual bromine loaded onto activated carbon would have been less than the saturation limit.

1058. Through routine process optimization and routine experimentation, a person of ordinary skill in the art would have adjusted the bromine injection rate and/or activated carbon injection rate to achieve halide promoter on the activated-carbon sorbent from about 1 g to about 30 g.

1059. Olson-646 includes repeated discussion of this ratio of the halogen or halide promoter to the sorbent material in the mercury-containing gas. For example, Olson-646 discloses that in certain embodiments "the sorbent comprises from about 1 to about 30 grams promoter per 100 grams of base activated carbon."[1825]

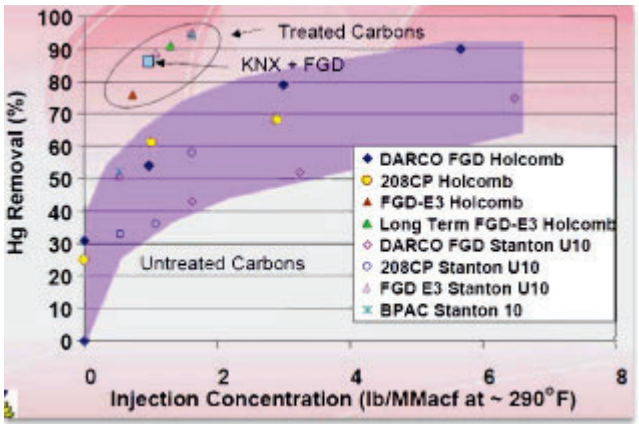
1060. A person of skill in the art would have looked to the Olson-646 reference to further understand the relationship between the halogen and activated carbon disclosed by Sjostrom. Specifically, a POSITA would have understood that the activated-carbon sorbent of Sjostrom would have "comprise[d] from about 1 to about 30 grams promoter per 100 grams of base activated carbon" after the activated-carbon sorbent made contact with the "Br" promoter. To the extent that Sjostrom does not explicitly state that the sorbent includes this ratio of promoter:activated carbon, Olson-646 provides this explanation. A POSITA would have understood

[1825] Ex. 1014 (Olson-646) at ¶ [0014]; *see also* ¶ [0018] and Claims 3, 17.

that by using the particular bromine-containing species disclosed in Olson ("HBr or Br_2") as the source of "Br" disclosed in Sjostrom, then "the sorbent comprises from about 1 to about 30 grams promoter per 100 grams of base activated carbon."

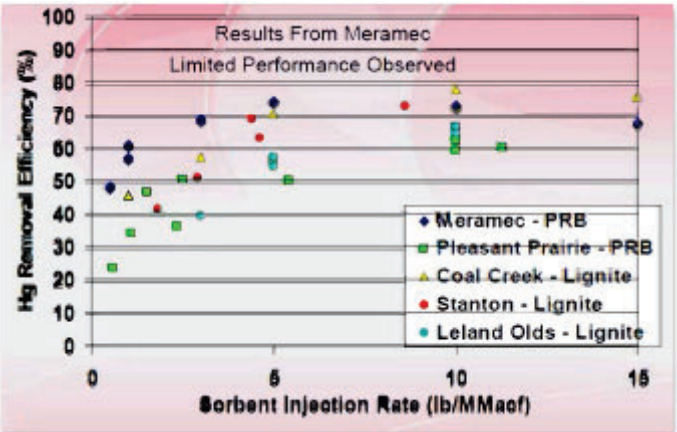
5. Claim 6: "The method of claim 1, comprising collecting greater than 70 wt % of the mercury in the mercury-containing gas."

1061. This limitation is disclosed by Sjostrom. Sjostrom includes numerous charts showing greater than 70 % removal of mercury from the flue gas. For example, the below chart shows the mercury removal from testing at a plant using the system of Sjostrom.[1826]



Similarly, the below chart shows the mercury removal from testing at a plant using the system of Sjostrom.[1827]

[1826] Ex. 1010 (Sjostrom) at 16.
[1827] Ex. 1010 (Sjostrom) at 20.



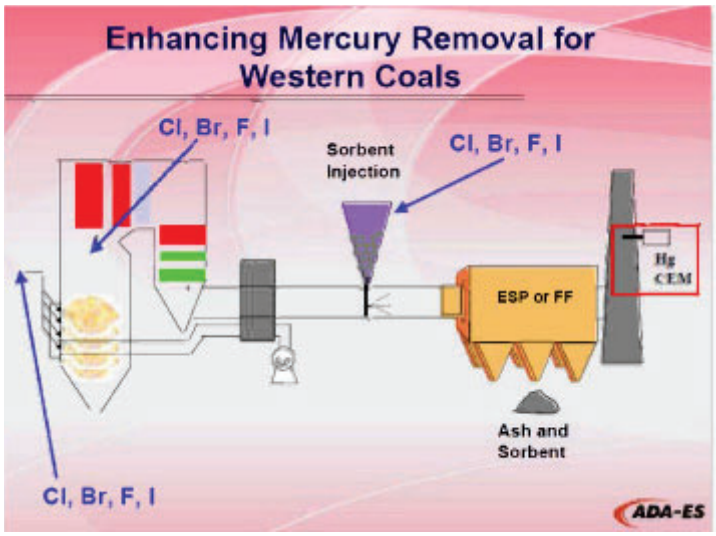
6. Claim 7: "The method of claim 1, comprising collecting greater than 70 wt % of the mercury in the mercury-containing gas with the sorbent."

1062. The language of this claim element includes elements that are similar to those in claim 6. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

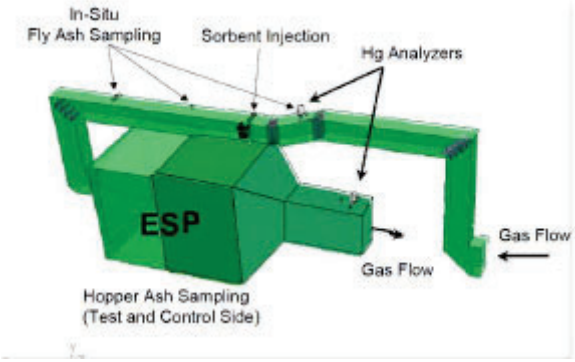
7. Claim 8: "The method of claim 1, further comprising: measuring mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content, an injection rate of injecting the sorbent comprising activated carbon into the mercury-containing gas, an amount of the additive comprising the Br2, HBr, bromide compound, or a combination thereof, added to the coal, or a combination thereof."

1063. This limitation is disclosed by Sjostrom alone and/or in view of Eckberg. As shown in the annotated figure below, Sjostrom describes passing the treated flue gas through a stack with an attached Hg CEM (continuous emissions monitor) attached.[1828]

[1828] Ex. 1010 (Sjostrom) at 4 (annotations in red).

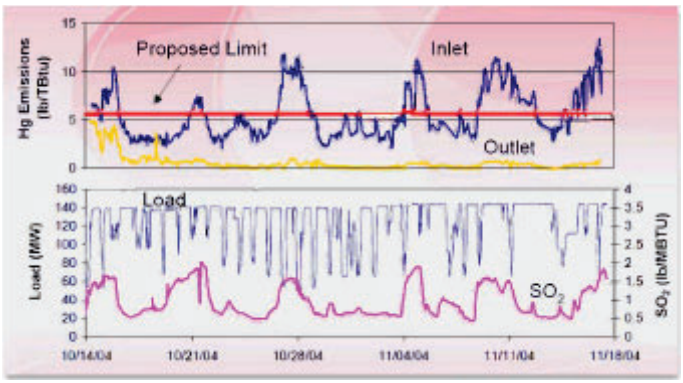


Further, Sjostrom discusses taking Hg measurements at both the inlet and outlet of the ESP as shown below.[1829]

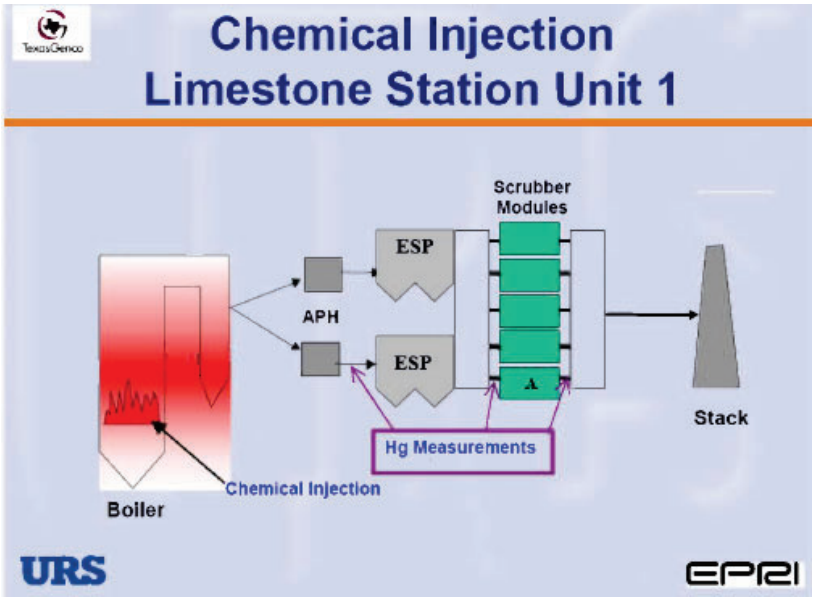


Sjostrom includes the chart showing the Hg emissions as measured at the inlet and outlet of the ESP.[1830]

1829 Ex. 1010 (Sjostrom) at 19.
1830 Ex. 1010 (Sjostrom) at 22.



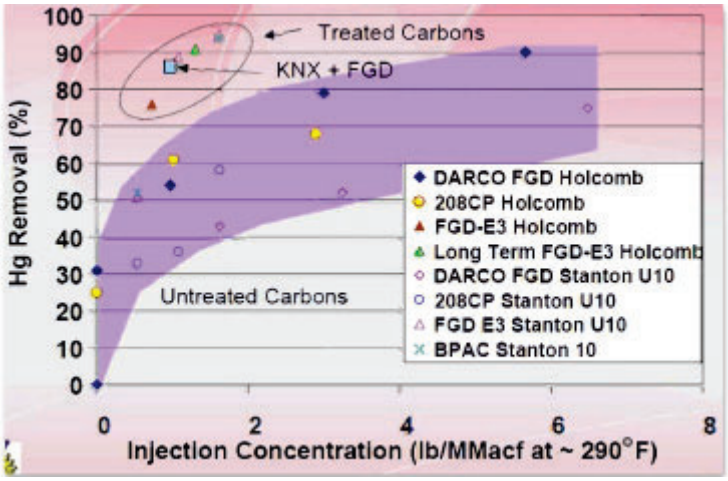
1064. As shown in the figure below, and similar to Sjostrom, Eckberg also describes testing the mercury removal effects of halogen injection directly into a coal-fired boiler.[1831]



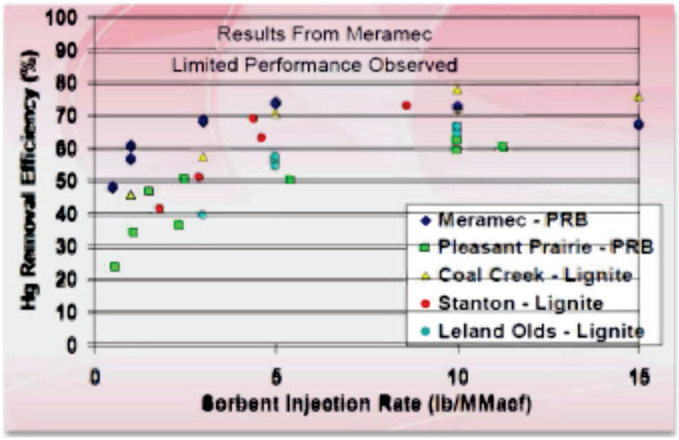
1065. Sjostrom includes numerous charts of measured mercury removals for various injection rates of activated-carbon sorbents. For example, the below chart

1831 Ex. 1011 (Eckberg) at 5.

shows the effects of activated carbon injection rates for testing using the system of Sjostrom.[1832]



Similarly, the below chart shows the effects of activated carbon injection rates for testing using the system of Sjostrom.[1833]



1066. The fact that there is a graph that has datapoints for different sorbent injection rates (the independent variable) and associated Hg removal percentages

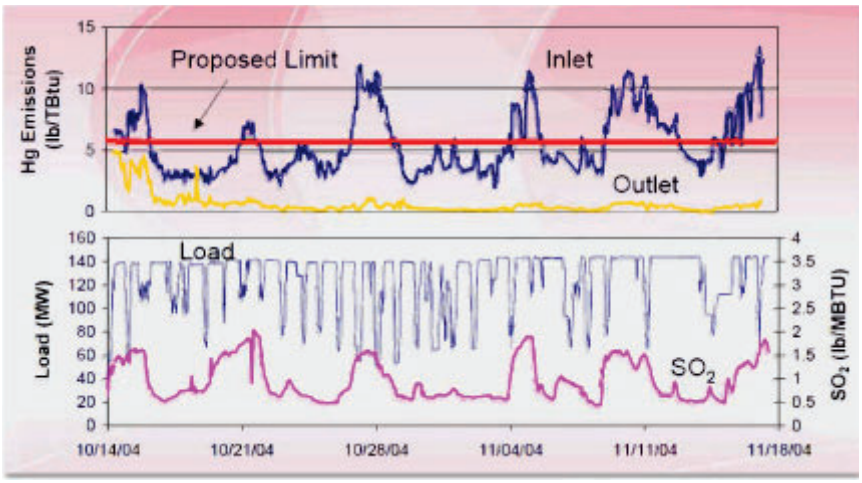
1832 Ex. 1010 (Sjostrom) at 16.
1833 Ex. 1010 (Sjostrom) at 20.

(the dependent variable) means that a POSITA would have understood that there is a relationship between the Hg removal % and the sorbent injection rate. Given that, and a target Hg removal rate, a POSITA would have understood that the sorbent injection rate would be adjusted to result in a target removal %.

1067. As discussed previously, a POSITA would have known that activated carbon was expensive, especially relative to costs of components such as "Br" in the form of HBr or an aqueous bromide salt solution. Thus, a POSITA would have been motivated to maintain the sorbent injection rate at the minimum level necessary to reach the desired level of mercury emissions. A POSITA viewing the charts of Sjostrom showing mercury removal versus sorbent injection rate would have been motivated to use the charts to control the sorbent injection rate at a level that minimized costs while reaching mercury removal targets. Thus, Sjostrom discloses modifying, in response to the measured mercury content, an injection rate of the sorbent into the mercury-containing gas, the amount of additive in the mixture, or a combination thereof.

1068. The below figure from Sjostrom shows that the testing focused on a "Proposed Limit.[1834]

[1834] Ex. 1010 (Sjostrom) at 22.



Thus, Sjostrom teaches maintaining the mercury content of the cleaned gas "at or below a desired level" (e.g., the 'Proposed Limit."). A POSITA would have been motivated to control the activated carbon injection rate to reach this desired level while minimizing the amount of activated carbon injected. A POSITA would have understood that injecting too much activated carbon would have increased the costs of the mercury removal process and injecting too little activated carbon may lead to mercury emissions rising above actionable levels.

1069. Eckberg also suggest further testing to balance the amount of additive injection to limit effects such as boiler corrosion and air heater plugging.[1835]

8. Claim 9: "The method of claim 8, wherein the measuring of the mercury content of the mercury-containing gas is performed substantially continuously."

[1835] Ex. 1011 (Eckberg) at 16.

1070. ME2C did not provide infringement contentions for this claim. ME2C's infringement contentions cross reference claim 24 of the '225 patent. ME2C's infringement contentions do not include claim 24 of the '225 patent. ME2C's final contentions hew to this position, and thus ME2C is apparently not asserting this claim. Therefore, no analysis regarding this element is required.

9. Claim 10: "The method of claim 1, further comprising: modifying, in response to a measured mercury content, an injection rate of injecting the sorbent comprising activated carbon into the mercury-containing gas, an amount of the Br2, HBr, bromide compound, or a combination thereof, added to the coal, or a combination thereof."

1071. The language of this claim element includes elements that are similar to those in claim 8. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

10. Claim 11: "The method of claim 1, wherein the coal comprises a subbituminous coal."

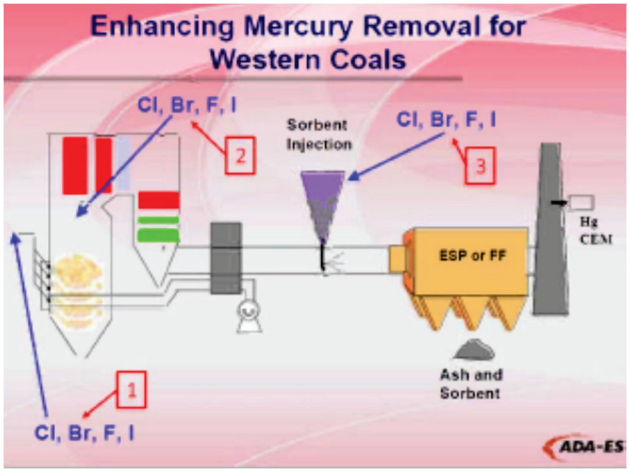
1072. This limitation is disclosed by Sjostrom. Sjostrom described using coal that included subbituminous coal.[1836]

11. Claim 13: "The method of claim 1, wherein the coal comprises the added Br2, HBr, the bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber."

1073. This limitation is disclosed by Sjostrom. This limitation is also obvious over Sjostrom in view of Eckberg.

[1836] Ex. 1010 (Sjostrom) at 3.

1074. This limitation is disclosed by Sjostrom, and obvious over Sjostrom in view of Eckberg under either interpretation. Sjostrom described testing mercury removal from flue gas of coal-fired power plants involving sorbent injection, halogen injection, and both sorbent and halogen injection.[1837] Specifically, the annotated figure below shows that Sjostrom teaches injection of bromine in at least three locations throughout the coal power process."[1838]



Addition Location 1 of Sjostrom renders obvious injecting bromine upstream of the combustion chamber, such as by adding it to the coal entering the boiler.[1839] Addition Location 2 of Sjostrom discloses injecting bromine into the boiler.[1840] Location 3 of Sjostrom discloses adding bromine to the mercury sorbent that is injected into the flue gas.[1841]

1837 Ex. 1010 (Sjostrom) at 4.
1838 Ex. 1010 (Sjostrom) at 4 (annotations in red).
1839 Ex. 1010 (Sjostrom) at 4 (annotations in red).
1840 Ex. 1010 (Sjostrom) at 4 (annotations in red).
1841 Ex. 1010 (Sjostrom) at 4 (annotations in red).

1075. A POSITA would have found it obvious that the "Br" of Sjostrom would be a widely available bromine-containing material, such as HBr or an aqueous solution of a bromide salt, such as CaBr2, for Addition Location 1 and Addition Location 2. Further, Sjostrom teaches the addition of "KNX (Alstom Power)."[1842] KNX was a known aqueous solution of a bromide salt additive developed for enhanced mercury control. A POSITA would have found it obvious that an aqueous bromide salt solution, such as $CaBr_2$, would dissociate to form Br^- ions. As discussed above, Addition Location 1 of Sjostrom renders obvious adding bromine-containing species upstream of the combustion chamber, such as by adding it to the coal entering the boiler.[1843] Thus, Sjostrom renders obvious wherein the coal comprises added Br_2, HBr, Br^-, or a combination thereof, added to the coal upstream of the combustion chamber.

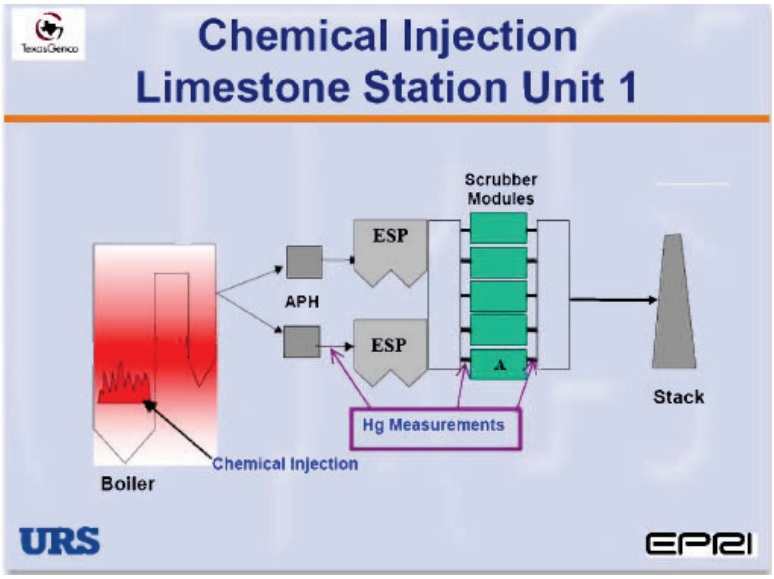
1076. As discussed above, Addition Location 2 of Sjostrom teaches adding bromine-containing species into the combustion chamber. [1844] Thus, Sjostrom discloses wherein the combustion chamber comprises added Br_2, HBr, Br^-, or a combination thereof, or a combination thereof. For at least this reason, Sjostrom discloses this limitation under the first, broader interpretation.

1842 Ex. 1010 (Sjostrom) at 23.
1843 Ex. 1010 (Sjostrom) at 4 (annotations in red).
1844 Ex. 1010 (Sjostrom) at 4 (annotations in red).

1077. A POSITA would have understood the "Br" addition of Sjostrom would also have entered the mercury-containing flue gas. Specifically, a POSITA would have understood the "Br" added at either Addition Location 1 before the combustion chamber or Addition Location 2 within the combustion chamber would have resulted in "Br" entering the flue gas stream. A POSITA would have found it obvious that the "Br" of Sjostrom could be an aqueous solution of a bromide salt, such as $CaBr_2$, for Addition Location 1 and Addition Location 2. Further, Sjostrom teaches the addition of "KNX (Alstom Power)" as the bromine-containing ingredient.[1845] KNX was a known aqueous solution of a bromide salt additives developed for enhanced mercury control. A POSITA would have found it obvious that an aqueous bromide salt solution, such as $CaBr_2$, would dissociate to form Br ions. A POSITA would have understood that at combustion temperatures found within the boiler, at least a portion of the Br^- ions injected at either Addition Location 1 or Addition Location 2 would have evaporated, leaving the boiler as HBr in the vapor phase. Thus, Sjostrom discloses wherein the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br, or a combination thereof.

[1845] Ex. 1010 (Sjostrom) at 23.

1078. To the extent that Sjostrom does not explicitly identify the bromine-containing species, Eckberg teaches this limitation. As shown in the figure below, Eckberg teaches "chemical injection" to the boiler.[1846]



Specifically, Eckberg teaches injection of "$CaCl_2$ (25 wt%)" and "$CaBr_2$ (52 wt%)" into the boiler.[1847] A POSITA would have understood that calcium bromide was an example of a "bromide compound," and that a 52 wt% aqueous solution of $CaBr_2$ would have dissociated in water to form a quantity of Br^- ions. A POSITA would have found it obvious that an aqueous bromide salt solution, such as $CaBr_2$, would dissociate to form Br ions. A POSITA would have further understood the bromide ion (Br^-) added to the combustion chamber of Eckberg would also have entered the mercury containing flue gas. As described above in the "Reasons to Combine"

1846 Ex. 1011 (Eckberg) at 5.
1847 Ex. 1011 (Eckberg) at 9.

section, a POSITA would have been motivated, and expected a reasonable chance of success, to apply the teachings of Eckberg (e.g., the injection of $CaBr_2$) to the combustion chamber of Sjostrom.

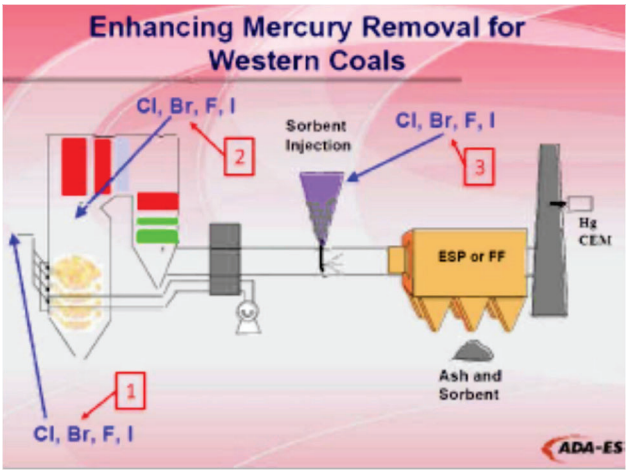
12. Claim 14: "The method of claim 1, wherein the combustion chamber comprises the added Br2, HBr, the bromide compound, or a combination thereof."

1079. This limitation is disclosed by Sjostrom. This limitation is also obvious over Sjostrom in view of Eckberg.

1080. This limitation is disclosed by Sjostrom, and obvious over Sjostrom in view of Eckberg under either interpretation. Sjostrom described testing mercury removal from flue gas of coal-fired power plants involving sorbent injection, halogen injection, and both sorbent and halogen injection.[1848] Specifically, the annotated figure below shows that Sjostrom teaches injection of bromine in at least three locations throughout the coal power process."[1849]

[1848] Ex. 1010 (Sjostrom) at 4.

[1849] Ex. 1010 (Sjostrom) at 4 (annotations in red).



Addition Location 1 of Sjostrom renders obvious injecting bromine upstream of the combustion chamber, such as by adding it to the coal entering the boiler.[1850] Addition Location 2 of Sjostrom discloses injecting bromine into the boiler.[1851] Location 3 of Sjostrom discloses adding bromine to the mercury sorbent that is injected into the flue gas.[1852]

1081. A POSITA would have found it obvious that the "Br" of Sjostrom would be a widely available bromine-containing material, such as HBr or an aqueous solution of a bromide salt, such as CaBr2, for Addition Location 1 and Addition Location 2. Further, Sjostrom teaches the addition of "KNX (Alstom Power)."[1853] KNX was a known aqueous solution of a bromide salt additive developed for enhanced mercury control. A POSITA would have found it obvious that an

1850 Ex. 1010 (Sjostrom) at 4 (annotations in red).
1851 Ex. 1010 (Sjostrom) at 4 (annotations in red).
1852 Ex. 1010 (Sjostrom) at 4 (annotations in red).
1853 Ex. 1010 (Sjostrom) at 23.

aqueous bromide salt solution, such as $CaBr_2$, would dissociate to form Br^- ions. As discussed above, Addition Location 1 of Sjostrom renders obvious adding bromine-containing species upstream of the combustion chamber, such as by adding it to the coal entering the boiler.[1854] Thus, Sjostrom renders obvious wherein the coal comprises added Br_2, HBr, Br^-, or a combination thereof, added to the coal upstream of the combustion chamber.

1082. As discussed above, Addition Location 2 of Sjostrom teaches adding bromine-containing species into the combustion chamber. [1855] Thus, Sjostrom discloses wherein the combustion chamber comprises added Br_2, HBr, Br^-, or a combination thereof, or a combination thereof. For at least this reason, Sjostrom discloses this limitation under the first, broader interpretation.

1083. A POSITA would have understood the "Br" addition of Sjostrom would also have entered the mercury-containing flue gas. Specifically, a POSITA would have understood the "Br" added at either Addition Location 1 before the combustion chamber or Addition Location 2 within the combustion chamber would have resulted in "Br" entering the flue gas stream. A POSITA would have found it obvious that the "Br" of Sjostrom could be an aqueous solution of a bromide salt, such as $CaBr_2$, for Addition Location 1 and Addition Location 2. Further, Sjostrom

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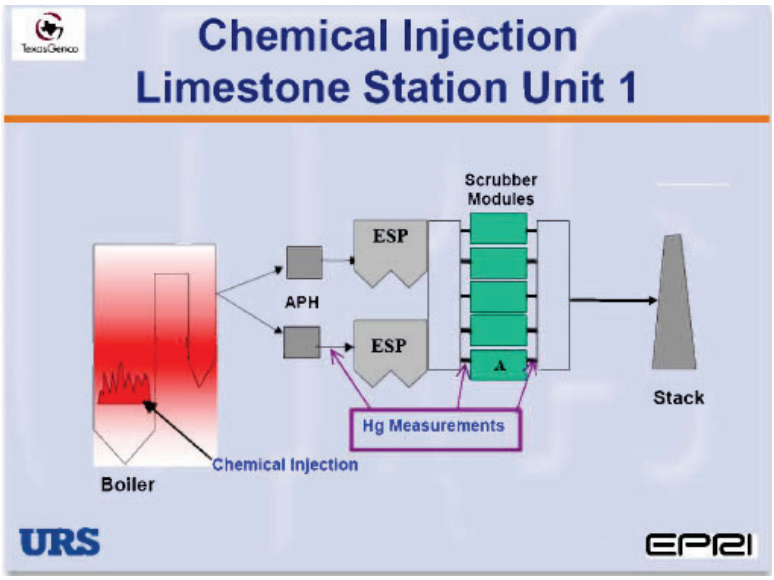
[1854] Ex. 1010 (Sjostrom) at 4 (annotations in red).

[1855] Ex. 1010 (Sjostrom) at 4 (annotations in red).

teaches the addition of "KNX (Alstom Power)" as the bromine-containing ingredient.[1856] KNX was a known aqueous solution of a bromide salt additives developed for enhanced mercury control. A POSITA would have found it obvious that an aqueous bromide salt solution, such as $CaBr_2$, would dissociate to form Br ions. A POSITA would have understood that at combustion temperatures found within the boiler, at least a portion of the Br^- ions injected at either Addition Location 1 or Addition Location 2 would have evaporated, leaving the boiler as HBr in the vapor phase. Thus, Sjostrom discloses wherein the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br, or a combination thereof.

1084. To the extent that Sjostrom does not explicitly identify the bromine-containing species, Eckberg teaches this limitation. As shown in the figure below, Eckberg teaches "chemical injection" to the boiler.[1857]

[1856] Ex. 1010 (Sjostrom) at 23.
[1857] Ex. 1011 (Eckberg) at 5.



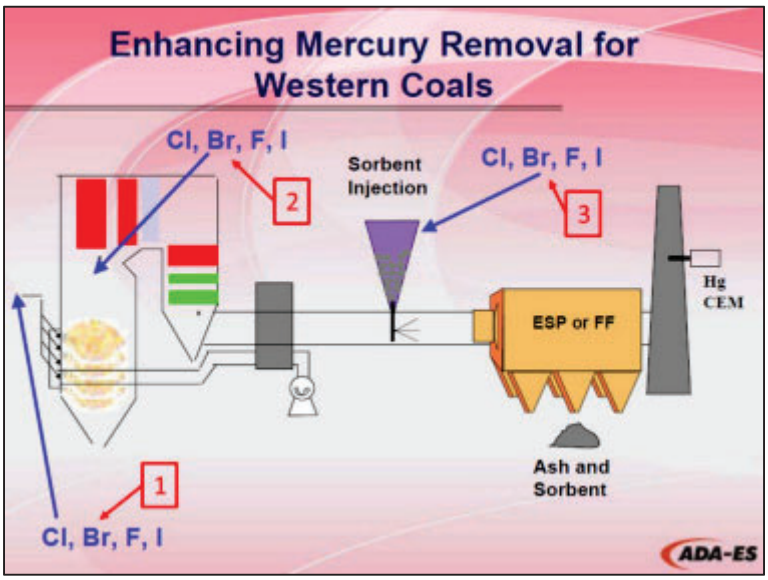
Specifically, Eckberg teaches injection of "$CaCl_2$ (25 wt%)" and "$CaBr_2$ (52 wt%)" into the boiler.[1858] A POSITA would have understood that calcium bromide was an example of a "bromide compound," and that a 52 wt% aqueous solution of $CaBr_2$ would have dissociated in water to form a quantity of Br^- ions. A POSITA would have found it obvious that an aqueous bromide salt solution, such as $CaBr_2$, would dissociate to form Br ions. A POSITA would have further understood the bromide ion (Br^-) added to the combustion chamber of Eckberg would also have entered the mercury containing flue gas. As described above in the "Reasons to Combine" section, a POSITA would have been motivated, and expected a reasonable chance of success, to apply the teachings of Eckberg (e.g., the injection of $CaBr_2$) to the combustion chamber of Sjostrom.

[1858] Ex. 1011 (Eckberg) at 9.

13. Claim 15: "The method of claim 1, wherein the coal is combusted in the combustion chamber at a coal-combustion facility, wherein the Br2, HBr, bromide compound, or combination thereof, is added to the coal before the coal enters the combustion chamber, wherein the addition of the Br2, HBr, bromide compound, or combination thereof, to the coal is performed at the coal-combustion facility."

1085. Sjostrom, either alone or in combination with Eckberg, anticipates or renders obvious this limitation. Sjostrom discloses adding a halide or halogen upstream of the combustion chamber. Specifically, Sjostrom discloses that "Br" could be added to the combustion chamber at Addition Location 2 or before the combustion chamber at Addition Location 1.[1859] The process is carried out at coal-combustion facilities.[1860]

1086.



1859 Ex. 1010 (Sjostrom) at 4 (annotated, provided below).

1860 Ex. 1010 (Sjostrom) at 3-5, 10, 27-32.

1087. A POSITA would understand that Sjostrom's "Br" source would have been widely available bromine-containing materials suitable for injection at the disclosed locations in a coal-fired plant, such as HBr, or an aqueous solution of a bromide compound, such as CaBr2. A POSITA would have further understood that the HBr, $CaBr_2$, or a known bromide compound could be added to the coal upstream of the boiler at the facility as a matter of obvious design choice.

1088. A POSITA would have been motivated to modify Sjostrom to add HBr, $CaBr_2$, or a known bromide compound to coal upstream of the combustion chamber at the facility to utilize a widely obtainable and relatively cheap form of bromine.

1089. The language of this claim element includes elements that are similar to those in claim 13. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

14. Claim 17: "The method of claim 1, wherein the combustion chamber is an electric utility coal combustion chamber."

1090. Sjostrom discloses the combustion chamber is an electric utility coal combustion chamber. Sjostrom discloses that testing was performed at "Sunflower Electric Holcomb Station PRB Coal SDA/FF," an electric utility.

15. Claim 18: "The method of claim 1, further comprising: measuring mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content, an injection rate of injecting the sorbent comprising activated carbon into the mercury-containing gas."

1091. The language of this claim element includes elements that are similar to those in claim 8. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

16. Claim 19: "The method of claim 1, wherein the mercury-containing gas comprises about 1 g to about 30 g of the element bromine per 100 g of the sorbent."

1092. The language of this claim element includes elements that are similar to those in claim 5. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

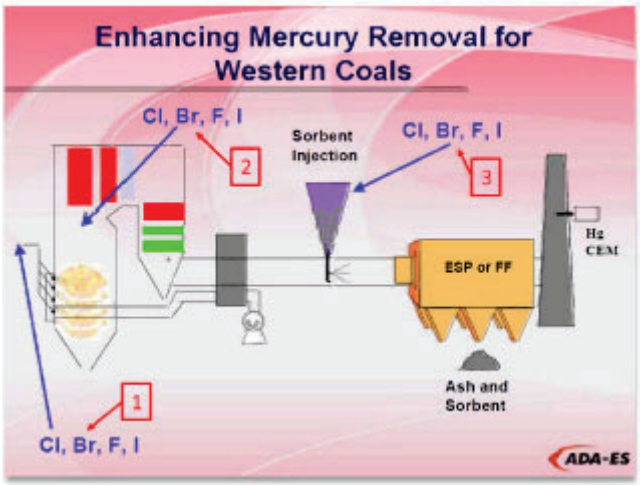
17. Claim 21: "The method of claim 1, wherein the sorbent in the mercury-containing gas comprises about 1 g to about 30 g of the added Br2, HBr, the bromide compound, or a combination thereof, per 100 g of the sorbent."

1093. The language of this claim element includes elements that are similar to those in claim 5. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

18. Claim 22: "The method of claim 1, wherein the Br2, HBr, or the bromide compound is contacted with the sorbent in vapor form, gaseous form, liquid form, or in an organic solvent."

1094. This limitation is obvious over Sjostrom in view of Eckberg. Sjostrom described testing mercury removal from flue gas of coal-fired power plants involving sorbent injection, halogen injection, and both sorbent and halogen

injection.[1861] Specifically, the annotated figure below shows that Sjostrom teaches injection of bromine in at least three locations throughout the coal power process.[1862]

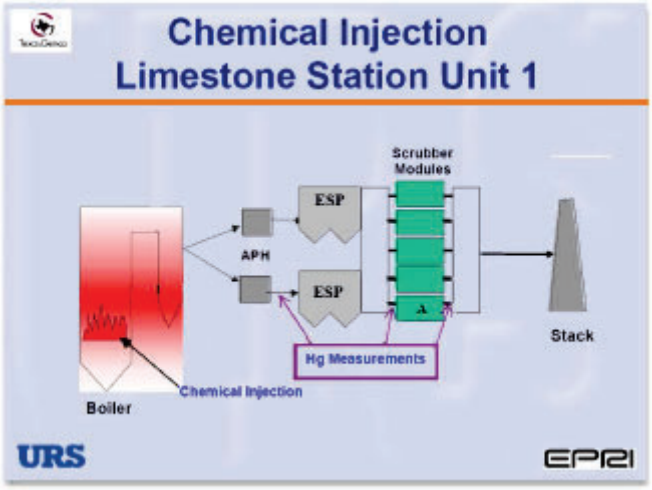


1095. Addition Location 1 of Sjostrom renders obvious injecting bromine upstream of the combustion chamber, such as by adding it to the coal entering the boiler.[1863] Addition Location 2 of Sjostrom discloses injecting bromine into the boiler.[1864] A POSITA would have found it obvious that the "Br" of Sjostrom could be a widely available bromine-containing material, such as HBr or an aqueous solution of a bromide salt, such as $CaBr_2$, for Addition Location 1 and Addition Location 2. Further, Sjostrom teaches the addition of "KNX (Alstom Power)."[1865] KNX was a known aqueous solution of a bromide salt additive developed for

1861 Ex. 1010 (Sjostrom) at 4.
1862 Ex. 1010 (Sjostrom) at 20
1863 Ex. 1010 (Sjostrom) at 4 (annotations in red).
1864 Ex. 1010 (Sjostrom) at 4 (annotations in red).
1865 Ex. 1010 (Sjostrom) at 23.

enhanced mercury control. A POSITA would have found it obvious that an aqueous bromide salt solution, such as $CaBr_2$, would dissociate to form Br^- ions.

1096. As shown in the figure below, Eckberg teaches "chemical injection" to the boiler.[1866]



1097. Specifically, Eckberg teaches injection of "$CaCl_2$ (25 wt%)" and "$CaBr_2$ (52 wt%)" into the boiler.[1867] Further, Eckberg explains that the $CaBr_2$ salt is injected at a "Liquid Salt Feed Rate (gpm)."[1868]

1098. A POSITA would have known that the Br injected in Sjostrom would have been in the form of an aqueous bromide salt solution as taught by Eckberg. A POSITA would have understood that at combustion temperatures found within the boiler, at least a portion of the Br^- ions injected at either Addition Location 1 or Addition Location 2 would have evaporated leaving the boiler as HBr in the vapor

1866 Ex. 1011 (Eckberg) at 5.
1867 Ex. 1011 (Eckberg) at 9.
1868 Ex. 1011 (Eckberg) at 9.

phase. Once the HBr reached the sorbent injection location, it would make contact with the injected sorbent.

19. Claim 23: "The method of claim 1, wherein the sorbent injected into the mercury-containing gas is a sorbent obtained by contacting a base sorbent with a halogen or halide promoter prior to injection of the sorbent to the mercury-containing gas."

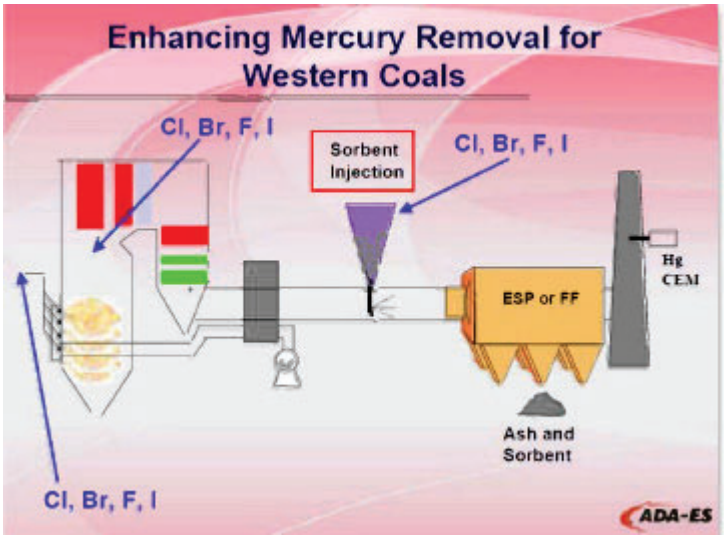
1099. ME2C did not provide infringement contentions for this claim. ME2C's infringement contentions cross reference claim 14 of the '114 patent. ME2C's infringement contentions do not include claim 14 of the '114 patent. ME2C's final contentions hew to this position, and thus ME2C is apparently not asserting this claim. Therefore, no analysis regarding this element is required.

20. Claim 24: "The method of claim 1, wherein the sorbent injected into the mercury-containing gas is free of contact with a halogen or halide promoter prior to injection of the sorbent into the mercury-containing gas."

1100. ME2C did not provide infringement contentions for this claim. ME2C's infringement contentions cross reference claim 13 of the '114 patent. ME2C's infringement contentions do not include claim 13 of the '114 patent. ME2C's final contentions hew to this position, and thus ME2C is apparently not asserting this claim. Therefore, no analysis regarding this element is required.

21. Claim 25: "The method of claim 1, wherein the injection of the sorbent into the mercury-containing gas occurs upstream of a particulate separator or a scrubber."

1101. This limitation is disclosed by Sjostrom. As shown in the annotated figure below, Sjostrom described certain tests involving sorbent injection downstream of the boiler.[1869]



The sorbent injection system of Sjostrom is shown upstream of an ESP or FF.[1870] A POSITA would have understood that ESPs and FFs were well-known particulate separators and would be used to collect the mercury-sorbent composition (and thus be downstream of where the mercury-sorbent composition is formed).[1871]

22. Claim 26: "The method of claim 25, wherein the particulate separator comprises an electrostatic precipitator, a baghouse, a fabric filter, or a combination thereof."

1869 Ex. 1010 (Sjostrom) at 4 (annotations in red).
1870 Ex. 1010 (Sjostrom) at 4.
1871 State of the Art, § XII.B.5.a

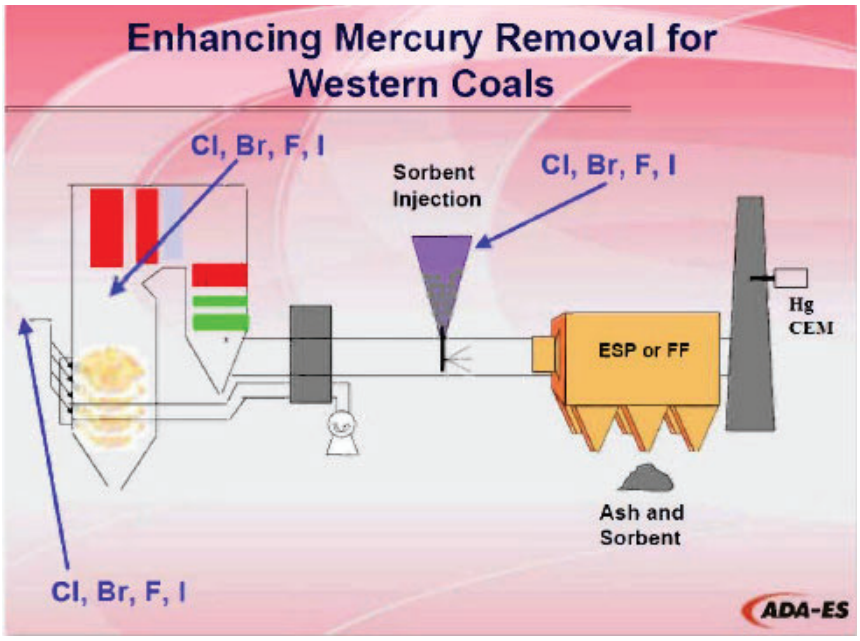
1102. Sjostrom discloses this claim. The explanation I provide above for claim 25 applies equally to these claim elements. Sjostrom further discloses the method of claim 25, which is described in the above section.

C. INDEPENDENT CLAIM 29

1. Claim 29: Element 29a: "A method of separating mercury from a mercury-containing gas, the method comprising:"

1103. The preamble is disclosed by Sjostrom. Sjostrom teaches separating mercury from a mercury-containing gas. The title of Sjostrom is "Full Scale Evaluations of ***Mercury Control Technologies*** with PRB Coals."[1872] Specifically, Sjostrom described various mercury control tests conducted at coal-fired power plants.[1873] Sjostrom described testing mercury removal from flue gas of coal-fired power plants involving sorbent injection and halogen addition, as detailed below.[1874]

[1872] Ex. 1010 (Sjostrom) at 1 (emphasis added).
[1873] Ex. 1010 (Sjostrom) at 12, 18.
[1874] Ex. 1010 (Sjostrom) at 4.



Sjostrom includes numerous charts detailing the "Hg Removal (%)" and "Hg Removal Efficiency (%)" achieved throughout the testing performed on coal flue gas.[1875] This annotated figure in Sjostrom specifically shows that particulate matter, including the mercury-sorbent composition, would have been separated from the flue gas by the ESP or FF, because a POSITA would have understood that it was well-known to use an ESP or FF to remove such solid materials.[1876]

2. Claim 29: Element 29b: "combusting coal in a combustion chamber, wherein"

1104. The language of this claim element is identical to that of claim 1b. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

1875 Ex. 1010 (Sjostrom) at 8, 15-17, 20, and 21.

1876 State of the Art, § XII.B.5.a

3. Claim 29: Element 29c: "the coal comprises added Br2, HBr, bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber, or the combustion chamber comprises added Br2, HBr, bromide compound, or a combination thereof, or a combination thereof; and"

1105. The language of this claim element is identical to that of claim 1b. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

4. Claim 29: Element 29d: "collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon."

1106. The language of this claim element is identical to that of claim 1c. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

D. INDEPENDENT CLAIM 30

1. Claim 30: Element 30a: "A method of separating mercury from a mercury-containing gas, the method comprising:"

1107. The language of this claim element is identical to that of claim 29a and contains elements of 1a. Accordingly, the explanation I provide above for those claim elements apply equally to these claim elements.

2. Claim 30: Element 30b: "combusting coal in a combustion chamber, to provide the mercury-containing gas, wherein the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br−, or a combination thereof, wherein"

1108. The language of this claim element is identical to that of the first portion of claim element 29b and contains elements of claim 23. Accordingly, the explanation I provide above for those claims applies equally to these claim elements.

3. Claim 30: Element 30c: "the coal comprises added Br2, HBr, bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber, or the combustion chamber comprises added Br2, HBr, bromide compound, or a combination thereof, or a combination thereof"

1109. The language of this claim element is identical to that of claims 13 and 14, and contains elements of claim 1b. Accordingly, the explanation I provide above for those claims applies equally to these claim elements.

4. Claim 30: Element 30d: "collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon;"

1110. The language of this claim element is identical to that of claims 1c and 29d. Accordingly, the explanation I provide above for those claims applies equally to these claim elements.

5. Claim 30: Element 30e: "separating the sorbent contacted with the mercury from the mercury-containing gas;"

1111. The language of this claim element is identical to that of claims 1c and 29d. Accordingly, the explanation I provide above for those claims applies equally to these claim elements.

6. Claim 30: Element 30f: "measuring the mercury content of the mercury-containing gas; and modifying, in response to

the measured mercury content of the mercury-containing gas, an injection rate of injecting the sorbent into the mercury-containing gas, an amount of the Br2, HBr, bromide compound, or a combination thereof, added to the coal or the combustion chamber, or a combination thereof."

1112. The language of this claim element is similar to that of claims 8 and 18. Accordingly, the explanation I provide above for those claims applies equally to these claim elements.

XXXVII. GROUND S: OBVIOUSNESS OF THE '517 PATENT OVER SJOSTROM IN VIEW OF OLSON-646

1113. It is my opinion that Sjostrom in view of Olson-646 render obvious each of claims 1-11, 13-15, 17-19, 21-26, 28-30 of the '517 Patent.

A. INDEPENDENT CLAIM 1

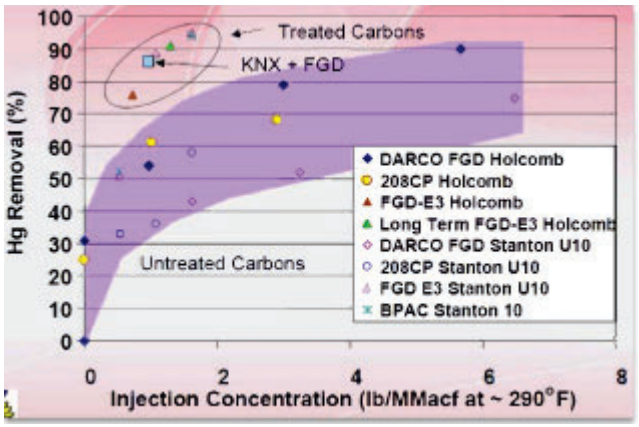
1. Claim 1: Element 1a: "A method for reducing mercury in a mercury-containing gas, the method comprising:"

1114. The preamble is disclosed by Sjostrom. Sjostrom is a presentation titled "Full Scale Evaluations of Mercury Control Technologies with PRB Coals."[1877] Sjostrom provides an overall process schematic showing the injection of halogens and activated-carbon sorbents for mercury removal in coal-fired flue gas. Sjostrom

[1877] Ex. 1010 (Sjostrom) at 1.

quantifies mercury separation from a mercury-containing gas in the form of charts showing "Hg Removal (%)"[1878] and "Hg Removal Efficiency (%)".[1879]

1115. Sjostrom includes numerous charts showing greater than 70 % removal of mercury from the flue gas. For example, the below chart shows the mercury removal from testing at a plant using the system of Sjostrom.[1880]



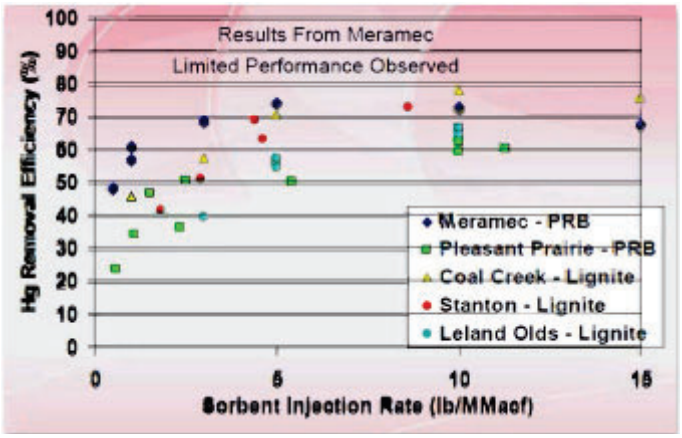
Similarly, the below chart shows the mercury removal from testing at a plant using the system of Sjostrom.[1881]

1878 Ex. 1010 (Sjostrom) at 8, 15-17.

1879 Ex. 1010 (Sjostrom) at 20-21.

1880 Ex. 1010 (Sjostrom) at 16.

1881 Ex. 1010 (Sjostrom) at 20.



2. Claim 1: Element 1b: "combusting coal in a combustion chamber, the coal comprising an additive comprising Br2, HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas; and"

1116. Sjostrom, either alone or in combination with Olson-646, anticipates or renders this limitation obvious. As discussed regarding claim element 1b, in Ground R above, claim 1b is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground R applies equally here.

1117. In addition, Olson-646 teaches using halogens to remove mercury from coal-fired plants. Olson-646 is entitled "Sorbents for the Oxidation and Removal of Mercury." Olson-646 "provides a cost-effective way to capture pollutants by utilizing exceptionally reactive halogen/halide promoted carbon sorbents using a bromide (or other halogen/halide) treatment of the carbon, that capture mercury via mercury-sorbent surface reactions."[1882] Olson-646 teaches using gaseous HBr or Br2

[1882] Ex. 1014 (Olson-646) at ¶ [0043].

to accomplish this.[1883] Olson-646 discloses the reaction of hydrogen bromide with activated carbon occurs at carbene species on "the edge of graphene sheets structures of the carbon."[1884] Olson-646 also discloses a mercury control system 100 wherein activated carbon (from base activated carbon reservoir 110) is reacted with a bromine-containing reagent (from halogen/halide promoter reservoir 130) to form promoted activated carbon, and then injecting the promoted activated carbon into the mercury-containing flue gas stream 15 at injection point 116 resulting in a reduced mercury flue gas 25.[1885]

1883 Ex. 1014 (Olson-646) at ¶ [0066].
1884 Ex. 1014 (Olson-646) at ¶ [0054].
1885 Ex. 1014 (Olson-646) at ¶¶ [0056], [0057], [0061], Fig. 3.

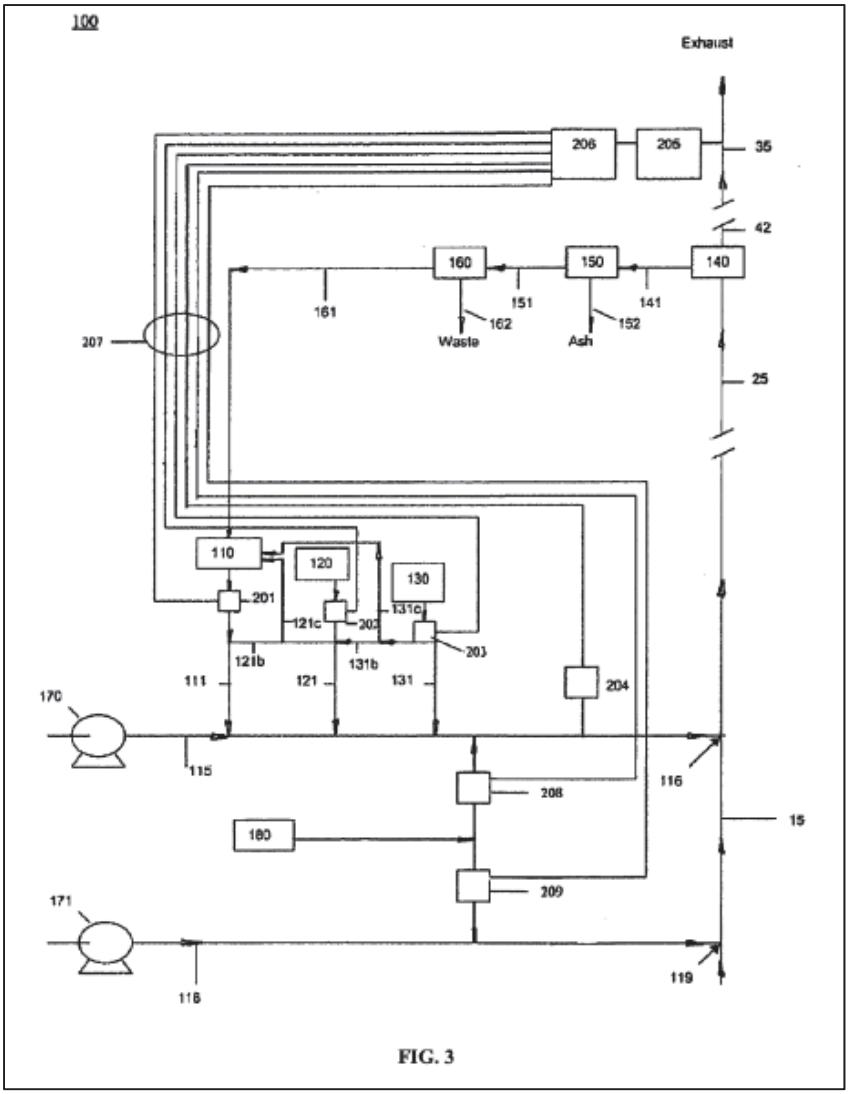


FIG. 3

1118. Olson-646's disclosed embodiments reduce "mercury in flue gas comprising providing a sorbent, injecting the sorbent into a mercury-containing flue gas stream, collecting greater than 70 wt-% of the mercury in the flue gas on the sorbent to produce a cleaned flue gas, and substantially recovering the sorbent from the cleaned flue gas."[1886]

[1886] Ex. 1014 (Olson-646) at ¶ [0022].

1119. Therefore, a POSITA would have been motivated to combine the teachings of Sjostrom and Olson-646 to utilize HBr and/or Br_2 (widely obtainable, affordable forms of bromine), implement known process techniques to reduce mercury in flue gas.

3. Claim 1: Element 1c: "collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon."

1120. Sjostrom discloses this element. As discussed regarding claim element 1c, in Ground R above, claim 1c is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground R applies equally here.

B. CLAIMS DEPENDING FROM CLAIM 1

1. Claim 2: "The method of claim 1, further comprising injecting an alkaline sorbent into the mercury-containing gas stream."

1121. Sjostrom, either alone or in light of Olson-646, renders this limitation obvious. As discussed regarding claim 2, in Ground R above, claim 2 is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground R applies equally here. Sjostrom discloses injecting sorbent in the mercury-containing gas.[1887]

[1887] Ex. 1010 (Sjostrom) at 4.

1122. In addition, Olson-646 explains that a "promoted carbon sorbent and/or an optional alkali component is injected into contaminated flue gas stream 15," to remove mercury from flue gas.[1888] A POSITA would have been motivated to combine the teachings of Sjostrom and Olson-646 to utilize a known, suitable sorbent for mercury removal.

2. Claim 3: "The method of claim 2, wherein the alkaline sorbent is selected from the group consisting of alkali elements, alkaline earth elements, alkali salts, alkaline earth salts, and combinations thereof."

1123. The language of this claim element discusses similar elements as claim 2. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

3. Claim 4: "The method of claim 1, wherein the activated carbon is chosen from powdered activated carbon, granular activated carbon, carbon black, carbon fiber, aerogel carbon, pyrolysis char, and combinations thereof."

1124. This limitation is disclosed by Sjostrom. Sjostrom discloses this element. As discussed regarding claim 4, in Ground R above, claim 4 is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground R applies equally here.

4. Claim 5: "The method of claim 1, wherein the sorbent has a composition comprising from about 1 to about 30 grams of the element bromine per 100 grams of activated carbon."

[1888] Ex. 1014 (Olson-646) ¶ 61.

1125. As discussed regarding claim element 5 in Ground R above, claim 5 is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground R applies equally here. This limitation is obvious over Sjostrom in view of Olson-646.

5. Claim 6: "The method of claim 1, comprising collecting greater than 70 wt % of the mercury in the mercury-containing gas."

1126. Sjostrom discloses this element. As discussed regarding claim element 6, in Ground R above, claim 6 is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground R applies equally here.

6. Claim 7: "The method of claim 1, comprising collecting greater than 70 wt % of the mercury in the mercury-containing gas with the sorbent."

1127. The language of this claim element includes elements that are similar to those in claim 6. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

7. Claim 8: "The method of claim 1, further comprising: measuring mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content, an injection rate of injecting the sorbent comprising activated carbon into the mercury-containing gas, an amount of the additive comprising the Br2, HBr, bromide compound, or a combination thereof, added to the coal, or a combination thereof."

1128. Sjostrom discloses this element. As discussed regarding claim element 8, in Ground R above, claim 8 is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground R applies equally here.

8. Claim 9: "The method of claim 8, wherein the measuring of the mercury content of the mercury-containing gas is performed substantially continuously."

1129. ME2C did not provide infringement contentions for this claim. ME2C's infringement contentions cross reference claim 24 of the '225 patent. ME2C's infringement contentions do not include claim 24 of the '225 patent. ME2C's final contentions hew to this position, and thus ME2C is apparently not asserting this claim. Therefore, no analysis regarding this element is required.

9. Claim 10: "The method of claim 1, further comprising: modifying, in response to a measured mercury content, an injection rate of injecting the sorbent comprising activated carbon into the mercury-containing gas, an amount of the Br2, HBr, bromide compound, or a combination thereof, added to the coal, or a combination thereof."

1130. The language of this claim element includes elements that are similar to those in claim 8. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

10. Claim 11: "The method of claim 1, wherein the coal comprises a subbituminous coal."

1131. This limitation is disclosed by Sjostrom. Sjostrom described using coal that included subbituminous coal.[1889]

11. Claim 13: "The method of claim 1, wherein the coal comprises the added Br2, HBr, the bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber."

1132. This limitation is disclosed by Sjostrom, and obvious over Sjostrom in view of Olson-646 under either interpretation. As discussed regarding claim element 13, in Ground R above, claim 13 is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground R applies equally here.

1133. Further, Olson-646 teaches using gaseous HBr or Br_2 as a halide promotor.[1890]

1134. A POSITA would have been motivated to modify Sjostrom to add HBr, $CaBr_2$, or a known bromide compound to coal upstream of the combustion chamber to utilize a widely obtainable and relatively cheap form of bromine, as a matter of obvious design choice.

12. Claim 14: "The method of claim 1, wherein the combustion chamber comprises the added Br2, HBr, the bromide compound, or a combination thereof."

1889 Ex. 1010 (Sjostrom) at 3.

1890 Ex. 1014 (Olson-646) ¶ 66.

1135. This limitation is disclosed by Sjostrom, and obvious over Sjostrom in view of Olson-646 under either interpretation. As discussed regarding claim element 14, in Ground R above, claim 14 is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground R applies equally here.

1136. Olson-646 "provides a cost-effective way to capture pollutants by utilizing exceptionally reactive halogen/halide promoted carbon sorbents using a bromide (or other halogen/halide) treatment of the carbon, that capture mercury via mercury-sorbent surface reactions, at very short contact times of seconds or less."[1891] Olson-646 teaches embodiments "wherein the halogen/halide promoter is in gaseous or vapor form" that comprises "gaseous HBr or Br_2."[1892]

1137. Olson-646 also discloses a mercury control system 100 wherein activated carbon (from base activated carbon reservoir 110) is reacted with a bromine-containing reagent (from halogen/halide promoter reservoir 130) to form promoted activated carbon, and then injecting the promoted activated carbon into the mercury-containing flue gas stream 15 at injection point 116 resulting in a reduced mercury flue gas 25.[1893]

1891 Ex. 1014 (Olson-646) at ¶ [0043].
1892 Ex. 1014 (Olson-646) at ¶ [0066].
1893 Ex. 1014 (Olson-646) at ¶¶ [0056], [0057], [0061], Fig. 3.

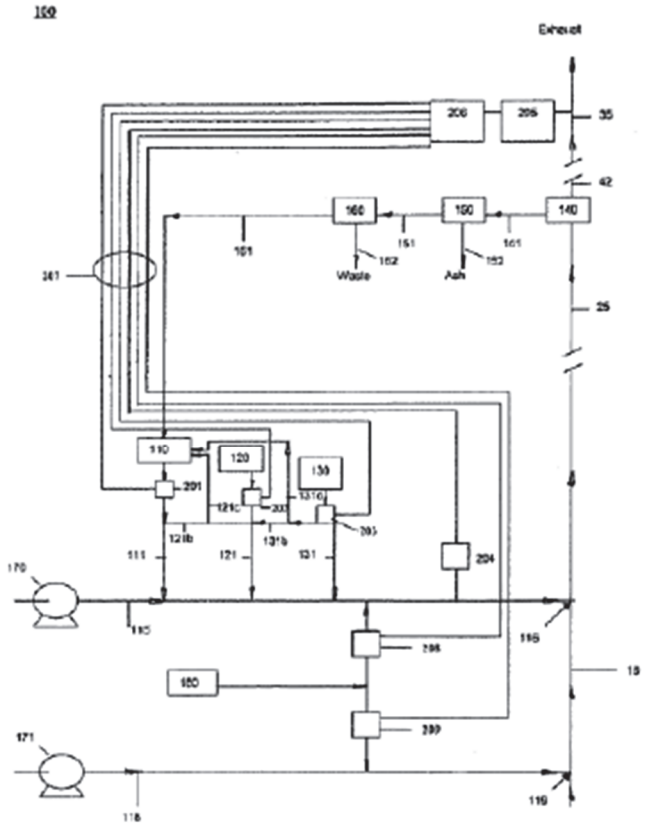


FIG. 3

1138. Olson-646's disclosed embodiments reduce "mercury in flue gas comprising providing a sorbent, injecting the sorbent into a mercury-containing flue gas stream collecting greater than 70 wt-% of the mercury in the flue gas on the sorbent to produce a cleaned flue gas, and substantially recovering the sorbent from the cleaned flue gas."[1894]

1139. As described above in the Reasons to Combine section, a POSITA would have been motivated, and expected a reasonable chance of success, to apply the teachings of Olson-646 (e.g., to utilize HBr and/or Br2, which are widely

[1894] Ex. 1014 (Olson-646) at ¶ [0022]

obtainable and affordable forms of bromine, to implement known process techniques to reduce mercury in flue gas) to the system of Sjostrom.

13. Claim 15: "The method of claim 1, wherein the coal is combusted in the combustion chamber at a coal-combustion facility, wherein the Br2, HBr, bromide compound, or combination thereof, is added to the coal before the coal enters the combustion chamber, wherein the addition of the Br2, HBr, bromide compound, or combination thereof, to the coal is performed at the coal-combustion facility."

1140. This limitation is disclosed by Sjostrom, and obvious over Sjostrom in view of Olson-646 under either interpretation. As discussed regarding claim element 15, in Ground R above, claim 15 is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground R applies equally here.

1141. Olson-646 teaches using gaseous HBr or Br_2 as a halide promotor. *Olson-646* ¶ 66. A POSITA would have been motivated to modify Sjostrom to add HBr, $CaBr_2$, or a known bromide compound to coal upstream of the combustion chamber at the facility to utilize a widely obtainable and relatively cheap form of bromine, as a matter of obvious design choice and efficiency.

1142. The language of this claim element includes elements that are similar to those in claim 13. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

14. Claim 17: "The method of claim 1, wherein the combustion chamber is an electric utility coal combustion chamber."

1143. Sjostrom discloses the combustion chamber is an electric utility coal combustion chamber. Sjostrom discloses that testing was performed at "Sunflower Electric Holcomb Station PRB Coal SDA/FF," an electric utility.

15. Claim 18: "The method of claim 1, further comprising: measuring mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content, an injection rate of injecting the sorbent comprising activated carbon into the mercury-containing gas."

1144. The language of this claim element includes elements that are similar to those in claim 8. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

16. Claim 19: "The method of claim 1, wherein the mercury-containing gas comprises about 1 g to about 30 g of the element bromine per 100 g of the sorbent."

1145. The language of this claim element includes elements that are similar to those in claim 5. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

17. Claim 21: "The method of claim 1, wherein the sorbent in the mercury-containing gas comprises about 1 g to about 30 g of the added Br2, HBr, the bromide compound, or a combination thereof, per 100 g of the sorbent."

1146. The language of this claim element includes elements that are similar to those in claim 5. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

18. Claim 22: "The method of claim 1, wherein the Br2, HBr, or the bromide compound is contacted with the sorbent in vapor form, gaseous form, liquid form, or in an organic solvent."

1147. This limitation is disclosed by Sjostrom, and obvious over Sjostrom in view of Olson-646 under either interpretation. As discussed regarding claim element 15, in Ground R above, claim 15 is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground R applies equally here.

1148. In addition, Olson-646 discloses utilizing HBr or Br2 promoters.[1895]

1149. The language of this claim element includes elements that are similar to those in claim 1b. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

19. Claim 23: "The method of claim 1, wherein the sorbent injected into the mercury-containing gas is a sorbent obtained by contacting a base sorbent with a halogen or halide promoter prior to injection of the sorbent to the mercury-containing gas."

[1895] Ex. 1014 (Olson-646) at ¶ [0066]

1150. ME2C did not provide infringement contentions for this claim. ME2C's infringement contentions cross reference claim 14 of the '114 patent. ME2C's infringement contentions do not include claim 14 of the '114 patent. ME2C's final contentions hew to this position, and thus ME2C is apparently not asserting this claim. Therefore, no analysis regarding this element is required.

20. Claim 24: "The method of claim 1, wherein the sorbent injected into the mercury-containing gas is free of contact with a halogen or halide promoter prior to injection of the sorbent into the mercury-containing gas."

1151. ME2C did not provide infringement contentions for this claim. ME2C's infringement contentions cross reference claim 13 of the '114 patent. ME2C's infringement contentions do not include claim 13 of the '114 patent. ME2C's final contentions hew to this position, and thus ME2C is apparently not asserting this claim. Therefore, no analysis regarding this element is required.

21. Claim 25: "The method of claim 1, wherein the injection of the sorbent into the mercury-containing gas occurs upstream of a particulate separator or a scrubber."

1152. Sjostrom discloses this element alone and/or in view of Olson-646. As discussed regarding claim element 25, in Ground R above, claim 25 is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground R applies equally here.

1153. In addition, Olson-646 further describes injecting sorbent upstream of a particular separator or scrubber. Olson-646 discloses that "[d]ownstream from

injection point 116 and 119 is provided particulate separator 140. 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."[1896]

22. Claim 26: "The method of claim 25, wherein the particulate separator comprises an electrostatic precipitator, a baghouse, a fabric filter, or a combination thereof."

1154. Sjostrom discloses this claim. The explanation I provide above for claim 25 applies equally to these claim elements. Sjostrom further discloses the method of claim 25, which is described in the above section.

C. INDEPENDENT CLAIM 29

1. Claim 29: Element 29a: "A method of separating mercury from a mercury-containing gas, the method comprising:"

1155. Sjostrom discloses this element. As discussed regarding claim element 29, in Ground R above, claim 29 is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground R applies equally here.

2. Claim 29: Element 29b: "combusting coal in a combustion chamber, wherein"

[1896] Ex. 1014 (Olson-646) at ¶ [0059]

1156. The language of this claim element is identical to that of claim 1b. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

3. Claim 29: Element 29c: "the coal comprises added Br2, HBr, bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber, or the combustion chamber comprises added Br2, HBr, bromide compound, or a combination thereof, or a combination thereof; and"

1157. The language of this claim element is identical to that of claim 1b. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

4. Claim 29: Element 29d: "collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon."

1158. The language of this claim element is identical to that of claim 1c. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

D. INDEPENDENT CLAIM 30

1. Claim 30: Element 30a: "A method of separating mercury from a mercury-containing gas, the method comprising:"

1159. The language of this claim element is identical to that of claim 29a and contains elements of 1a. Accordingly, the explanation I provide above for those claim elements apply equally to these claim elements.

2. Claim 30: Element 30b: "combusting coal in a combustion chamber, to provide the mercury-containing gas, wherein the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br−, or a combination thereof, wherein"

1160. The language of this claim element is identical to that of the first portion of claim element 29b and contains elements of claim 23. Accordingly, the explanation I provide above for those claims applies equally to these claim elements.

3. Claim 30: Element 30c: "the coal comprises added Br2, HBr, bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber, or the combustion chamber comprises added Br2, HBr, bromide compound, or a combination thereof, or a combination thereof"

1161. The language of this claim element is identical to that of claims 13 and 14, and contains elements of claim 1b. Accordingly, the explanation I provide above for those claims applies equally to these claim elements.

4. Claim 30: Element 30d: "collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon;"

1162. The language of this claim element is identical to that of claims 1c and 29d. Accordingly, the explanation I provide above for those claims applies equally to these claim elements.

5. Claim 30: Element 30e: "separating the sorbent contacted with the mercury from the mercury-containing gas;"

1163. The language of this claim element is identical to that of claims 1c and 29d. Accordingly, the explanation I provide above for those claims applies equally to these claim elements.

6. Claim 30: Element 30f: "measuring the mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content of the mercury-containing gas, an injection rate of injecting the sorbent into the mercury-containing gas, an amount of the Br2, HBr, bromide compound, or a combination thereof, added to the coal or the combustion chamber, or a combination thereof."

1164. The language of this claim element is similar to that of claims 8 and 18. Accordingly, the explanation I provide above for those claims applies equally to these claim elements.

XXXVIII. GROUND T: ANTICIPATION OF THE '517 PATENT AND/OR OBVIOUS OVER DOWNS-BOILER

1165. It is my opinion that Downs-Boiler anticipates each of claims 1-11, 13-15, 17-19, 21-26, 28-30 of the '517 Patent. In the subsections below, I rely on the disclosure of Downs-Boiler. The material I rely on was also disclosed and supported by Downs-Boiler-Provisional, so parallel citations to Downs-Boiler-Provisional are also included.

A. INDEPENDENT CLAIM 1

1. Claim 1: Element 1a: "A method for reducing mercury in a mercury-containing gas, the method comprising:"

1166. Downs-Boiler discloses this claim element. Downs-Boiler is a published patent application entitled "Bromine Addition for the Improved Removal

of Mercury From Flue Gas."[1897] Downs-Boiler explains that bromine-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."[1898]

2. Claim 1: Element 1b: "combusting coal in a combustion chamber, the coal comprising an additive comprising Br2, HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas; and"

1167. Downs-Boiler discloses this claim element. The primary application taught by Downs-Boiler is with "[c]oal-fired utility boilers [that] are a known major source of anthropogenic mercury emissions in the United States.[1899] Downs-Boiler illustrates a conventional coal-fired utility boiler used for the purpose of combusting coal, as represented by the arrow into combustion chamber 14. Representative Figure 4 is reproduced below:[1900]

[1897] Downs-Boiler at 1.

[1898] Downs-Boiler at Abstract, ¶ 7.

[1899] Ex. 1006 (Downs-Boiler) ¶ [0001]; *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [002].

[1900] Ex. 1006 (Downs-Boiler) ¶ [0007], Figures 4; *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [009], Figures 4.

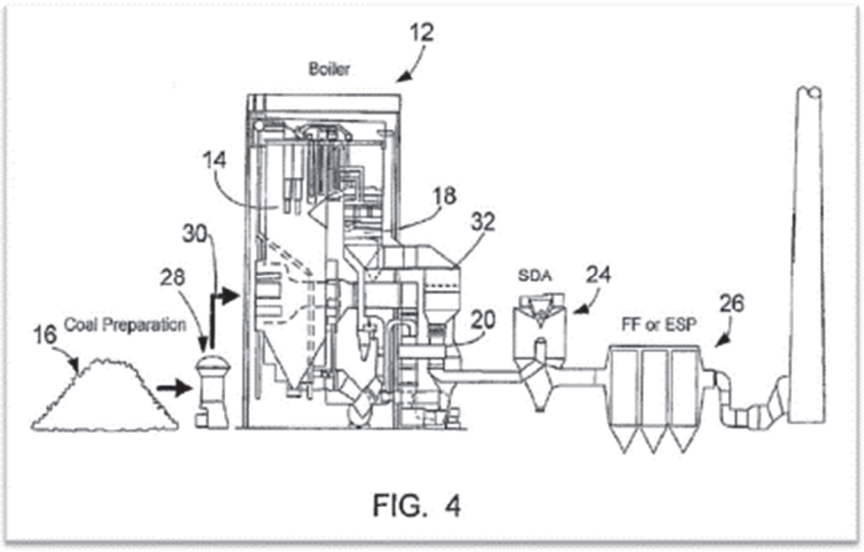


FIG. 4

1168. Downs-Boiler goes on to describe such a combustion of coal together with an added bromine-containing reagent, which occurs within combustion chamber 14, as illustrated in Figures 4-6:[1901]

> A bromine containing reagent 10 is *added to the boiler* 12 combustion furnace 14, either directly or by *premixing with the incoming coal* 16. Bromine species released *during the combustion process* enhance the oxidation of *mercury as* the *combustion gases* pass through the furnace 14 and, in particular, through the *cooler sections of the boiler* convection pass 18 and combustion air preheater 20.

1169. Downs-Boiler describes combusting common ranks of coal used by the electric utility industry and, specifically, that "the coal-fired boiler fuel 16 may include bituminous, subbituminous, and lignite coals and blends, thereof."[1902]

[1901] Ex. 1006 (Downs-Boiler) ¶ [0015] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [0018].

[1902] Ex. 1006 (Downs-Boiler) ¶ [0020]; *see also* Ex. 1007 (Downs-Boiler-Provisional) IT [0023].

Finally, Downs-Boiler explicitly describes that "[m]ercury appears in coal combustion flue gases in both solid and gas phases."[1903] This flue gas referred to by Downs-Boiler is an example of a mercury-containing gas, and was generated from the combustion of coal.

3. Claim 1: Element 1c: "collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon."

1170. Downs-Boiler discloses this claim element.

1171. Downs-Boiler discloses "injection of a carbonaceous sorbent (e.g., powdered activated carbon, or PAC) into the flue gas upstream of the dust collector to adsorb vapor-phase mercury."[1904] Downs-Boiler also describes "PAC injection systems" as a component of "downstream pollution control systems," as they are "downstream" of the combustion chamber.[1905] Downs-Boiler also discloses using a sorbent injection system and "powdered activated carbon (PAC)" as a carbonaceous sorbent.[1906]

1172. Downs-Boiler uses "powdered activated carbon, or PAC…to adsorb vapor-phase mercury."[1907]Downs-Boiler also teaches that the mercury in the

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1903 Ex. 1006 (Downs-Boiler) ¶ [0002] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [003].

1904 Ex. 1006 (Downs-Boiler) ¶ [0004].

1905 Ex. 1006 (Downs-Boiler) ¶ [0015].

1906 Ex. 1006 (Downs-Boiler) ¶ [0025].

1907 Ex. 1006 (Downs-Boiler) ¶ [0004].

mercury-containing gas contacts the sorbent, as evidenced by Downs's disclosure of the "sorbent, and its burden of adsorbed mercury," and the creation of "particulate-bound mercury" due to the increased "reactivity of oxidized mercury with PAC."[1908]

1173. Moreover, Downs-Boiler also discloses collecting the mercury/sorbent composition from the mercury-containing gas, to form a cleaned gas with an ESP or FF.[1909] Specifically, Downs-Boiler discloses that the activated-carbon "sorbent, and its burden of adsorbed mercury, are subsequently removed from the flue gases in a downstream particulate collector" by SDA 24 and/or particulate collector 26 (FF or ESP), which separates the mercury/sorbent composition by removing it from the mercury-containing (flue) gas resulting in a cleaned gas.[1910]

B. CLAIMS DEPENDING FROM CLAIM 1

1. Claim 2: "The method of claim 1, further comprising injecting an alkaline sorbent into the mercury-containing gas stream."

1174. Downs-Boiler discloses this claim element. Downs-Boiler discloses HBr or a bromide compound, or a combination thereof, as its bromine-containing reagent that is added to the coal upstream of the combustion chamber. Downs-Boiler explains that its bromine-containing reagent may comprise, "but is not limited to, *alkali metal* and *alkaline earth*

1908 Ex. 1006 (Downs-Boiler) ¶¶ [0003]-[0004], [0015]-[0016].
1909 Ex. 1006 (Downs-Boiler) Fig. 4.
1910 Ex. 1006 (Downs-Boiler) ¶¶ [0004], [0015], [0017], [0023].

metal bromides, hydrogen bromide (HBr) or *bromine (Br_2).*"[1911] Downs-Boiler also specifically discloses *calcium bromide ($CaBr_2$)* as another bromide compound suitable for use as the bromine-containing reagent.[1912]

1175. The bromine-containing reagent is applied to the coal upstream of the combustion chamber and thus the coal and reagent would be part of the mixture being combusted. Downs-Boiler teaches that a "bromine containing reagent 10 is added to the boiler 12 combustion furnace 14, either directly or by premixing with the incoming coal 16."[1913] According to the preferred embodiment of Downs-Boiler, ***"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*" such that the *"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."[1914] Thus, upstream of the combustion

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[1911] Ex. 1006 (Downs-Boiler) 41] [0021] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) 'll [0024].

[1912] Ex. 1006 (Downs-Boiler) 11 [0018-19] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) l] [0021-22].

[1913] Ex. 1006 (Downs-Boiler) 11 [0015]; *see also* Ex. 1007 (Downs-Boiler-Provisional) 11 [0018].

[1914] Ex. 1006 (Downs-Boiler) ¶ [0019], Figure 2; *see also* Ex. 1007 (Downs-Boiler-Provisional) III [0022], Figure 2.

chamber, such as in the coal pulverizers and the pulverized coal conveying system, at least one or a combination of HBr and a bromide compound (e.g., calcium bromide ($CaBr_2$)) has been added on the coal.

2. Claim 3: "The method of claim 2, wherein the alkaline sorbent is selected from the group consisting of alkali elements, alkaline earth elements, alkali salts, alkaline earth salts, and combinations thereof."

1176. Downs-Boiler discloses this claim element. The language of this claim element discusses similar elements as claim 2. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

3. Claim 4: "The method of claim 1, wherein the activated carbon is chosen from powdered activated carbon, granular activated carbon, carbon black, carbon fiber, aerogel carbon, pyrolysis char, and combinations thereof."

1177. Downs-Boiler discloses this claim element. Downs-Boiler discloses adding a particulate sorbent material comprising activated carbon, referring to the example of "powdered activated carbon (PAC)."[1915] Powdered activated carbon is activated carbon in particulate form. Downs-Boiler explains that the use of a conventional PAC injection process is improved by the addition of bromine, in that the bromine-containing reagent "enhances the removal of mercury across a ***PAC***

[1915] Ex. 1006 (Downs-Boiler) ¶ [0025]; *see also* Ex. 1007 (Downs-Boiler-Provisional) IT [0028].

injection process."[1916] Downs-Boiler repeats in other places that the bromine-containing reagent saves costs by making more efficient use of the activated-carbon sorbent material that is "inject[ed]."[1917] As explained by Downs-Boiler, the disclosed injected activated-carbon sorbent materials (e.g., sorbent injection systems using PAC) are part of *"downstream* pollution control systems such as . . . PAC injection systems."[1918] Here, "downstream" is relative to the location of the combustion chamber, and thus after generation of the mercury-containing gas. The activated-carbon sorbent material is injected into a mercury-containing gas: "injection of a carbonaceous *sorbent* (e.g., powdered *activated carbon,* or PAC) *into the flue gas* upstream of the dust collector to *adsorb vapor-phase mercury.*"[1919] Downs-Boiler discloses the use of a "sorbent injection system" for the purpose of injecting a "carbonaceous sorbent" including at least "powdered activated carbon (PAC), carbons and chars produced from coal and other organic materials, and unburned carbon produced by the combustion process itself."[1920]

[1916] Ex. 1006 (Downs-Boiler) ¶ [0016] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [0019].

[1917] Ex. 1006 (Downs-Boiler) ¶ [0015] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) II [0018].

[1918] Ex. 1006 (Downs-Boiler) ¶ [0004]; see also Ex. 1007 (Downs-Boiler-Provisional)¶ [005].

[1919] Ex. 1006 (Downs-Boiler) ¶¶ [0004], [0015], [0016], and [0025]; *see also* Ex. 1007 (Downs-Boiler-Provisional) in [005], [0018], [0019], and [0028].

[1920] Ex. 1006 (Downs-Boiler) ¶ [0025]; *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [0028].

4. Claim 5: "The method of claim 1, wherein the sorbent has a composition comprising from about 1 to about 30 grams of the element bromine per 100 grams of activated carbon."

1178. Downs-Boiler discloses this claim element. While Downs-Boiler discloses injecting hydrogen bromide (HBr) or bromine (Br_2)[1921] upstream of or within the combustion chamber, it does not explicitly disclose the claimed element bromine-sorbent ratio in the mercury containing gas (*i.e.*, about 1 gram to about 30 grams the element bromine per 100 g of the activated carbon).

1179. However, this limitation merely recites a workable range of promoter using known, conventional techniques. The range combines a conventional halogen (bromine) being used in a conventional way with a conventional sorbent (activated carbon). Nothing in the '517 patent specification attributes any particular significance to the claimed range or establishes that the claimed range "achieves unexpected results" in mercury removal. Rather, the range presents nothing more than optimization of "result-effective" variables, which would have been obvious to a POSITA.

5. Claim 6: "The method of claim 1, comprising collecting greater than 70 wt % of the mercury in the mercury-containing gas."

[1921] Ex. 1006 (Downs-Boiler) ¶¶ [0015], [0021], Fig. 2; *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [0028].

1180. This limitation is disclosed by Downs-Boiler. According to Figure 3, reproduced below as annotated, Downs-Boiler indicates that the disclosed method for removing mercury from the flue gas resulted in mercury emissions at the outlet of the fabric filter of approximately 2 µg/dscm (blue) as compared to an initial value *(i.e.,* the mercury inventory of the system) at the inlet of the fabric filter of approximately 9 µg/dscm (red).[1922]

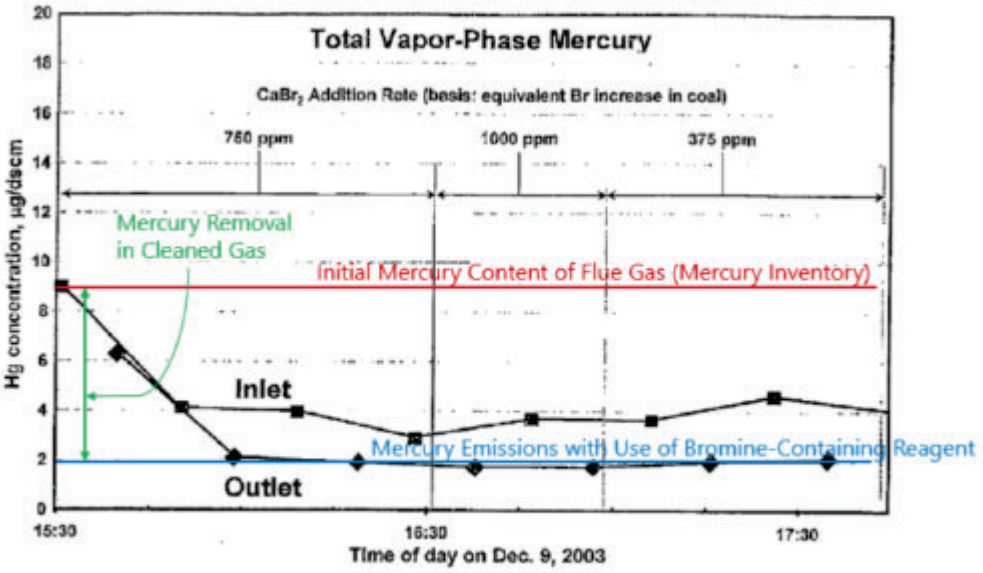


FIG. 3

Therefore, the use of the method disclosed by Downs-Boiler in conjunction with a fabric filter resulted in a system mercury removal of approximately 7 µg/dscm (green). This removal of the mercury in the mercury containing gas (7 µ g/dscm) as compared to the mercury inventory of the system (9 µg/dscm) may also be expressed

[1922] Ex. 1006 (Downs-Boiler) Figure 3 (annotated); *see also* Ex. 1007 (Downs-Boiler-Provisional) Figure 3.

as a percentage: at least 77 wt% of the mercury in the mercury-containing gas was removed—or in other words: removing greater than 70 wt% of the mercury in the mercury-containing gas.

1181. Furthermore, as described in the State of the Art,[1923] a POSITA would have known that by 2004, the EPA had already put the industry on notice of upcoming laws and regulations requiring 70% mercury removal, including the EPA's Clean Air Mercury Rule (CAMR). Downs-Boiler further teaches compliance with EPA standards regulating mercury emissions from coal-fired plants.[1924] Notice of these regulations exerted a strong outside impetus on the industry to adjust processes to comply with the regulations' eventual implementation. Through routine process optimization and routine experimentation, a POSITA would have adjusted the rate of addition of bromine-containing species and/or activated carbon injection rate to meet and exceed (for purposes of safety margin) the EPA's proposed rules requiring a 70% removal of mercury.

6. Claim 7: "The method of claim 1, comprising collecting greater than 70 wt % of the mercury in the mercury-containing gas with the sorbent."

1182. This limitation is obvious in view of Downs-Boiler. As described above regarding Claim 6, Downs-Boiler discloses removing greater than 77 wt% of

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1923 State of the Art, XII.D — XII.F.

1924 Ex. 1006 (Downs-Boiler) ¶ [0001]; *see also* Ex. 1007 (Downs-Boiler-Provisional) 11 [002].

the mercury in the flue gas. In addition to the reasons for Claim 6, a POSITA would understand that that the mercury removal on the sorbent alone would meet or exceed 70%. Downs-Boiler discloses that only "25% of the coal-fired power plants in the U.S. are equipped with wet FGD systems" (scrubbers), and discloses "PAC injection systems" (activated carbon) as an alternative to "downstream pollution control systems such as wet [scrubbers] 22 and SDA 24 FGD systems."[1925] This impact would be particularly pronounced for coal-fired utility plants using lignites or blends of high volatility coals that would produce minimal unburned carbon (*e.g.,* loss on ignition) particulate in the flue gas stream,[1926] resulting in a higher proportion of the mercury in the mercury-containing gas to bind to the sorbent.

1183. Downs-Boiler notes that "the presence of unburned carbon" is a factor that has "been shown to affect the conversion of elemental mercury to oxidized mercury species" and this unburned carbon *(i.e.,* LOI) would scavenge mercury from the flue gas, thereby affecting the percentage of mercury on the sorbent.[1927] Specifically, Downs-Boiler discloses that power stations burning western lignite coals, which produce a lower "percentage of oxidized mercury" and "have low

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[1925] Ex. 1006 (Downs-Boiler), ¶¶ [0007, 0015]; Ex. 1007 (Downs-Boiler-Provisional) ¶¶ [009, 0018].

[1926] *See* State of the Art, § XII.B.1.

[1927] Ex. 1006 (Downs-Boiler) ¶ [0005]; Ex. 1007 (Downs-Boiler-Provisional) 4111 [006].

chloride content" would benefit from the disclosed Hg control methods.[1928] Such plants typically exhibit very low levels of LOI in addition to suffering from very low concentrations of inherent chlorine in their flue gas. Under such circumstances, Hg capture on inherent unburned carbon would have been minimal in plants using western lignite coals and would therefore not have a significant effect on the percentage of mercury on the sorbent. Consequently, adding bromine-containing species to the furnace of coal-fired utility plants burning lignite and related coals, and that are not configured with a scrubber or a spray dryer absorber while injecting a sorbent ahead of the particle collection device, as Downs-Boiler teaches, ensures that virtually all the Hg captured in a particle collection device would be bound to the sorbent. Furthermore, Downs-Boiler also teaches how to adjust the bromine addition level to achieve highly efficient Hg removal, including greater than 70% removal.

1184. Additionally, a POSITA would have understood that that the mercury removal on the sorbent alone would meet or exceed 70%. Downs-Boiler discloses that only "25% of the coal-fired power plants in the U.S. are equipped with wet FGD systems" (scrubbers), and discloses "PAC injection systems" (activated carbon) as an alternative to "downstream pollution control systems such as wet 22 and SDA 24

[1928] Ex. 1006 (Downs-Boiler) ¶ [0005]; *see also* Ex. 1007 (Downs-Boiler-Provisional) 11 [006].

FGD systems."[1929] Downs-Boiler also discloses a plant that burns "lignite coals," which produces a lower "percentage of oxidized mercury" on account of "low chloride content."[1930] A POSITA would have understood that plants burning lignite, without a scrubber or spray-dryer adsorber, as taught by Downs-Boiler adding bromine in conjunction with activated carbon, the activated carbon would be the component that accounts for almost all of the mercury removal.

7. Claim 8: "The method of claim 1, further comprising: measuring mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content, an injection rate of injecting the sorbent comprising activated carbon into the mercury-containing gas, an amount of the additive comprising the Br2, HBr, bromide compound, or a combination thereof, added to the coal, or a combination thereof."

1185. This limitation is obvious in view of Downs-Boiler. Downs-Boiler teaches measuring the mercury content of the cleaned gas, as depicted in Figure 3, wherein the Y-axis indicates the reduction in mercury concentration in flue gas at the outlet upon the injection of calcium bromide.[1931]

[1929] Ex. 1006 (Downs-Boiler) 111 [0007, 0015, 0025]; *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶¶ [009, 0018, 0028].

[1930] Ex. 1006 (Downs-Boiler) ¶¶ [0005, 0020]; *see also* Ex. 1007 (Downs-Boiler-Provisional) im [006, 0023].

[1931] *Id.* ¶¶ 11, 18, Fig. 3.

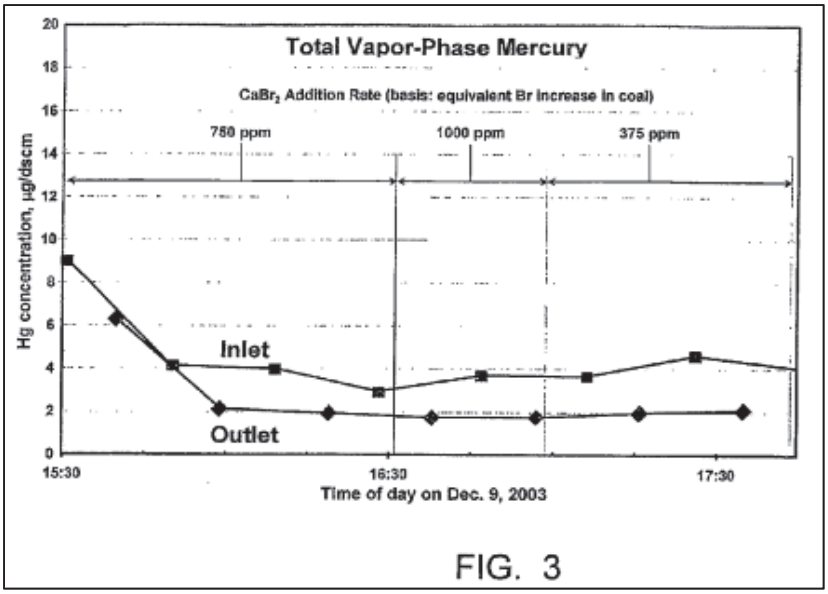


FIG. 3

1186. Downs-Boiler explains that, in response to the mercury content of the cleaned gas (Y-axis of Fig. 3), Downs-Boiler modifies the promoter feed rate of CaBr2 between 375-1000 ppm.[1932]

A POSITA, reviewing the measured data as presented by Figure 3 of Downs-Boiler, would have been motivated to modify the amount of bromine in response to fluctuations in mercury content, such as by selecting a given addition rate (e.g., one of the four rates provided: 0, 375, 750, and 1000 ppm) and/or by interpolating an intermediate value in response to the measured mercury content.

In addition, a POSITA would have known that by modifying the feed rate of bromine (e.g., the $CaBr_2$), the sorbent (which in the flue gas contains bromine and activated carbon) is also modified.

1187. A POSITA would have known to modify the rate of injecting the sorbent at least because Downs-Boiler explains that, although activated-carbon

[1932] *Id.* ¶¶ 11, 18, Fig. 3.

sorbents were effective for removing mercury, the "economics of high injection rates can be prohibitive."[1933] Accordingly, a POSITA would have been motivated to modify, in response to the measured mercury content, the sorbent injection rate to optimize sorbent injection while maintaining adequate mercury removal. A POSITA would have further understood that coal composition varies in native mercury and halogen content and would have adjusted the sorbent injection rate as part of routine optimization and process control to account for the fluctuating coal content, with a reasonable expectation of success. Downs-Boiler discloses EPA standards regulating mercury emissions from coal-fired plants,[1934] and such standards act as a "desired level," for which a POSITA would have controlled mercury content of the cleaned gas to meet or exceed. A POSITA would have sought to comply with such standards to avoid fines and other penalties.

8. Claim 9: "The method of claim 8, wherein the measuring of the mercury content of the mercury-containing gas is performed substantially continuously."

1188. ME2C did not provide infringement contentions for this claim. ME2C's infringement contentions cross reference claim 24 of the '225 patent. ME2C's infringement contentions do not include claim 24 of the '225 patent. ME2C's final

1933 *Id.* at ¶ 4.

1934 *Id.* ¶ 1.

contentions hew to this position, and thus ME2C is apparently not asserting this claim. Therefore, no analysis regarding this element is required.

9. Claim 10: "The method of claim 1, further comprising: modifying, in response to a measured mercury content, an injection rate of injecting the sorbent comprising activated carbon into the mercury-containing gas, an amount of the Br2, HBr, bromide compound, or a combination thereof, added to the coal, or a combination thereof."

1189. The language of this claim element includes elements that are similar to those in claim 8. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

10. Claim 11: "The method of claim 1, wherein the coal comprises a subbituminous coal."

1190. This limitation is disclosed by Downs-Boiler. Downs-Boiler describes combusting common ranks of coal used by the electric utility industry and, specifically, that "the coal-fired boiler fuel 16 may include bituminous, subbituminous, and lignite coals and blends, thereof."

11. Claim 13: "The method of claim 1, wherein the coal comprises the added Br2, HBr, the bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber."

1191. Downs-Boiler discloses this claim element. Although the claim only requires one to be shown, Downs-Boiler discloses both: 1) adding Br_2, HBr, and/or a bromide compound to the coal upstream of the combustion chamber, and 2) adding

Br_2, HBr, and/or a bromide compound to the combustion chamber; as well as the combination of the two.

1192. First, Downs-Boiler discloses Br_2, HBr, a bromide compound, or a combination thereof, added to the coal upstream of the combustion chamber. Downs-Boiler explains that the bromine-containing reagent may comprise, "but is not limited to, ***alkali metal*** and ***alkaline earth metal bromides, hydrogen bromide (HBr)*** or ***bromine (Br_2).***"[1935] Downs-Boiler also specifically discloses ***calcium bromide ($CaBr_2$)*** as another suitable bromide compound for use as the bromine-containing reagent.[1936]

1193. This bromine-containing reagent is applied to the coal upstream of the combustion chamber. Downs-Boiler teaches that a "bromine containing reagent 10 is added to the boiler 12 combustion furnace 14, either directly or by premixing with the incoming coal 16."[1937] According to the preferred embodiment of Downs-Boiler, ***"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*" such that the *"coal pulverizers 28 intimately*

[1935] Ex. 1006 (Downs-Boiler) 41] [0021] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) 'll [0024].

[1936] Ex. 1006 (Downs-Boiler) 11 [0018-19] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) l] [0021-22].

[1937] Ex. 1006 (Downs-Boiler) 11 [0015]; *see also* Ex. 1007 (Downs-Boiler-Provisional) 11 [0018].

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."[1938] Thus, upstream of the combustion chamber, such as in the coal pulverizers and the pulverized coal conveying system, at least one or a combination of Br_2, HBr, and a bromide compound (e.g., calcium bromide ($CaBr_2$)) has been added on the coal.

1194. Second, Downs-Boiler discloses "the combustion chamber comprises added Br_2, HBr, a bromide compound, or a combination thereof" As described above—where the bromine-containing reagent is disclosed as added to the coal and/or the coal conveying system—this further discloses that the combustion chamber comprises added bromine-containing reagent *(e.g.,* Br_2, HBr, a bromide compound, or a combination thereof). As explained by Downs-Boiler, as a result of adding the bromine-containing reagent to the coal and/or the coal conveying system, the "***[b]romine species released during the combustion process*** enhance the oxidation of mercury as the combustion gases pass ***through the furnace 14***."[1939] That the bromine-containing reagent is "sprayed on the crushed coal 16 before the coal is pulverizedfor *combustion"* additionally "ensures even distribution of the

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[1938] Ex. 1006 (Downs-Boiler) ¶ [0019], Figure 2; *see also* Ex. 1007 (Downs-Boiler-Provisional) III [0022], Figure 2.

[1939] Ex. 1006 (Downs-Boiler) 11 [0015] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [0018].

[bromine-containing] reagent 10 ***across the boiler furnace*** *(i.e.,* in the combustion chamber).[1940]

1195. Downs-Boiler also discloses introduction of Br_2, HBr, and/or a bromide compound *(i.e.,* the bromine-containing reagent) directly into the combustion chamber. Downs-Boiler teaches that a "bromine containing reagent 10 is added to the boiler 12 combustion furnace 14, either directly or by premixing with the incoming coal 16"[1941]. Downs-Boiler describes that the inventors successfully tested direct introduction of the bromine-containing reagent—specifically, a bromide compound of calcium bromide ($CaBr_2$)—"injected into the combustion chamber 14 through a coal burner."[1942] Downs-Boiler further recognizes that "the bromine-containing reagent 10 may be fed to the boiler combustion zone 14 in gaseous, liquid, or solid form."[1943] Thus, the combustion chamber comprises at least one or a combination of Br_2, HBr, and a bromide compound *(e.g.,* calcium bromide ($CaBr_2$)).

1196. Third, Downs-Boiler discloses adding a bromine-containing reagent to both the coal and the combustion chamber. As described above, Downs-Boiler

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[1940] Ex. 1006 (Downs-Boiler) ¶ [0019] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) II [0022].

[1941] Ex. 1006 (Downs-Boiler) ¶ [0015]; *see also* Ex. 1007 (Downs-Boiler-Provisional) 11 [0018].

[1942] Ex. 1006 (Downs-Boiler) 11 [0019]; *see also* Ex. 1007 (Downs-Boiler-Provisional) IT [0021].

[1943] Ex. 1006 (Downs-Boiler) ¶ [0022]; *see also* Ex. 1007 (Downs-Boiler-Provisional) IT [0025].

describes applying the bromine-containing reagent to the coal upstream of the combustion chamber in such a way that added Br_2, HBr, and/or a bromide compound *(e.g.,* calcium bromide ($CaBr_2$)) is both on the coal *and* in the combustion chamber.

1197. Furthermore, as illustrated in Figure 2, reproduced below as annotated, Downs-Boiler illustrates that the bromine-containing reagent may be introduced "to addition points A, B, C" including "coal preparation," "the pulverized coal conveying system 30," and "the boiler furnace 14."[1944]

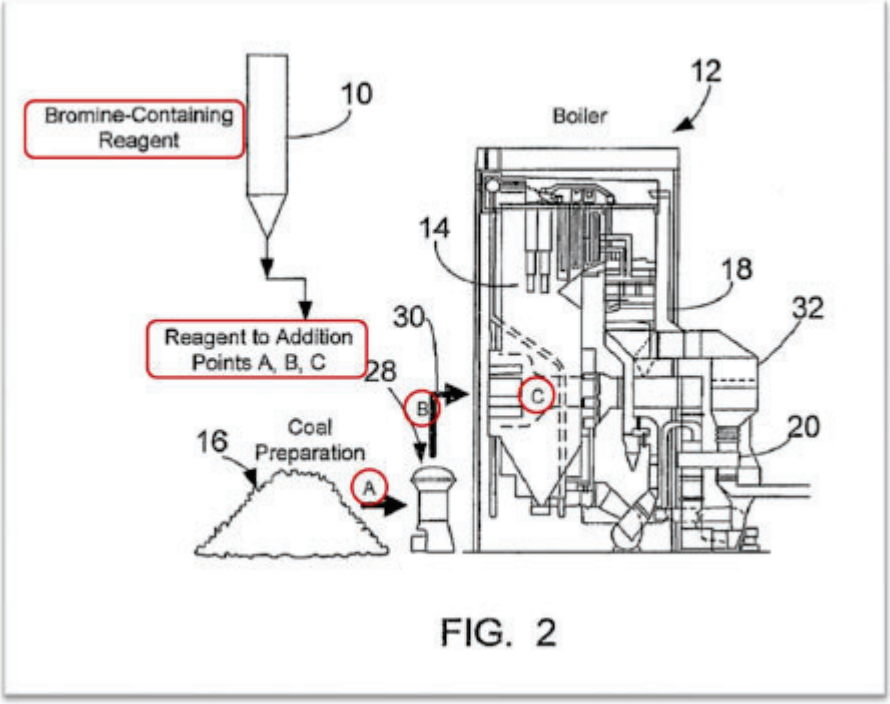


FIG. 2

1198. Downs-Boiler in no way restricts simultaneous introduction to each of points A, B, and C. Rather, as described above, Downs-Boiler invites, if not

[1944] Ex. 1006 (Downs-Boiler) ¶ [0019], Figure 2 (annotated); *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [0022], Figure 2.

encourages, simultaneous introduction to each of points A, B, and C or some combination of A/B and C to "intimately mix the bromide reagent 10 with the coal" so as to achieve a more "even distribution of the reagent 10 across the boiler furnace 14."[1945] Accordingly, Downs-Boiler discloses each and every limitation of Claim Element 13.

12. Claim 14: "The method of claim 1, wherein the combustion chamber comprises the added Br2, HBr, the bromide compound, or a combination thereof."

1199. Downs-Boiler discloses both: 1) adding Br_2, HBr, and/or a bromide compound to the coal upstream of the combustion chamber, and 2) adding Br_2, HBr, and/or a bromide compound to the combustion chamber; as well as the combination of the two.

1200. First, Downs-Boiler discloses Br_2, HBr, a bromide compound, or a combination thereof, added to the coal upstream of the combustion chamber. Downs-Boiler explains that the bromine-containing reagent may comprise, "but is not limited to, ***alkali metal*** and ***alkaline earth metal bromides, hydrogen bromide (HBr)*** or ***bromine (Br_2).***"[1946] Downs-Boiler also specifically discloses ***calcium***

[1945] Ex. 1006 (Downs-Boiler) ¶ [0019]; *see also* Ex. 1007 (Downs-Boiler-Provisional) 11 [0022].

[1946] Ex. 1006 (Downs-Boiler) 41] [0021] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) 'll [0024].

bromide ($CaBr_2$) as another suitable bromide compound for use as the bromine-containing reagent.[1947]

1201. This bromine-containing reagent is applied to the coal upstream of the combustion chamber. Downs-Boiler teaches that a "bromine containing reagent 10 is added to the boiler 12 combustion furnace 14, either directly or by premixing with the incoming coal 16."[1948] According to the preferred embodiment of Downs-Boiler, ***"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*" such that the *"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."[1949] Thus, upstream of the combustion chamber, such as in the coal pulverizers and the pulverized coal conveying system, at least one or a combination of Br_2, HBr, and a bromide compound (e.g., calcium bromide ($CaBr_2$)) has been added on the coal.

[1947] Ex. 1006 (Downs-Boiler) 11 [0018-19] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) l] [0021-22].

[1948] Ex. 1006 (Downs-Boiler) 11 [0015]; *see also* Ex. 1007 (Downs-Boiler-Provisional) 11 [0018].

[1949] Ex. 1006 (Downs-Boiler) ¶ [0019], Figure 2; *see also* Ex. 1007 (Downs-Boiler-Provisional) III [0022], Figure 2.

1202. Second, Downs-Boiler discloses "the combustion chamber comprises added Br_2, HBr, a bromide compound, or a combination thereof" As described above—where the bromine-containing reagent is disclosed as added to the coal and/or the coal conveying system—this further discloses that the combustion chamber comprises added bromine-containing reagent *(e.g.,* Br_2, HBr, a bromide compound, or a combination thereof). As explained by Downs-Boiler, as a result of adding the bromine-containing reagent to the coal and/or the coal conveying system, the "***[b]romine species released during the combustion process*** enhance the oxidation of mercury as the combustion gases pass ***through the furnace 14***."[1950] That the bromine-containing reagent is "sprayed on the crushed coal 16 before the coal is pulverizedfor *combustion"* additionally "ensures even distribution of the [bromine-containing] reagent 10 ***across the boiler furnace****" (i.e.,* in the combustion chamber).[1951]

1203. Downs-Boiler also discloses introduction of Br_2, HBr, and/or a bromide compound *(i.e.,* the bromine-containing reagent) directly into the combustion chamber. Downs-Boiler teaches that a "bromine containing reagent 10 is added to the boiler 12 combustion furnace 14, either directly or by premixing with the

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[1950] Ex. 1006 (Downs-Boiler) 11 [0015] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [0018].

[1951] Ex. 1006 (Downs-Boiler) ¶ [0019] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) II [0022].

incoming coal 16"[1952]. Downs-Boiler describes that the inventors successfully tested direct introduction of the bromine-containing reagent—specifically, a bromide compound of calcium bromide ($CaBr_2$)—"injected into the combustion chamber 14 through a coal burner."[1953] Downs-Boiler further recognizes that "the bromine-containing reagent 10 may be fed to the boiler combustion zone 14 in gaseous, liquid, or solid form."[1954] Thus, the combustion chamber comprises at least one or a combination of Br_2, HBr, and a bromide compound *(e.g.,* calcium bromide ($CaBr_2$)).

1204. Third, Downs-Boiler discloses adding a bromine-containing reagent to both the coal and the combustion chamber.

13. Claim 15: "The method of claim 1, wherein the coal is combusted in the combustion chamber at a coal-combustion facility, wherein the Br2, HBr, bromide compound, or combination thereof, is added to the coal before the coal enters the combustion chamber, wherein the addition of the Br2, HBr, bromide compound, or combination thereof, to the coal is performed at the coal-combustion facility."

1205. Downs-Boiler discloses that the coal is combusted in the combustion chamber at a coal-combustion facility, wherein the Br_2, HBr, bromide compound, or combination thereof, is added to the coal before the coal enters the combustion

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[1952] Ex. 1006 (Downs-Boiler) ¶ [0015]; see also Ex. 1007 (Downs-Boiler-Provisional) 11 [0018].

[1953] Ex. 1006 (Downs-Boiler) 11 [0019]; *see also* Ex. 1007 (Downs-Boiler-Provisional) IT [0021].

[1954] Ex. 1006 (Downs-Boiler) ¶ [0022]; *see also* Ex. 1007 (Downs-Boiler-Provisional) IT [0025].

chamber, wherein the addition of the Br_2, HBr, bromide compound, or combination thereof, to the coal is performed at the coal-combustion facility.

1206. Downs-Boiler discloses bromine-containing reagents—including "alkali metal and alkaline earth metal bromides, hydrogen bromide (HBr) or bromine (Br_2)," and "an aqueous solution of calcium bromide ($CaBr_2$)."[1955]

1207. Downs-Boiler teaches adding a bromine-containing reagent "to the boiler 12 combustion furnace 14, either directly or by premixing with the incoming coal 16."[1956] Downs-Boiler further teaches that "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."[1957]

1208. The language of this claim element includes elements that are similar to those in claim 13. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

14. Claim 17: "The method of claim 1, wherein the combustion chamber is an electric utility coal combustion chamber."

1955 *Id.* ¶ 18, 21.

1956 *Id.* ¶ 15.

1957 *Id.* ¶ 19*; see also* ¶ 17, Figs. 2, 4-6.

1209. This limitation is disclosed by Downs-Boiler. Downs-Boiler describes combusting common ranks of coal used by the electric utility industry and, specifically, that "the coal-fired boiler fuel 16 may include bituminous, subbituminous, and lignite coals and blends, thereof."[1958] Downs-Boiler acknowledges that the "removal of elemental mercury from coal combustion gases generated by electric utility plants through the application of a ***conventional PAC injection process****"* is well known and understood in the industry but concedes that that use of these systems is "very expensive" when not used in combination with the disclosed invention.[1959]

1210. Furthermore, as illustrated in Figures 4-6 of Downs-Boiler, a coal-fired utility boiler is shown as having a number of pollution control devices: "the electric utility plant configurations may include plants equipped with an SDA 24 and particulate collector 26 (FF or ESP) (FIG. 4), a particulate collector 26 (FF or ESP) (FIG. 5), or a wet 22 FGD and particulate collector 26 (FF or ESP) (FIG. 6)."[1960]

15. Claim 18: "The method of claim 1, further comprising: measuring mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content, an injection rate of injecting the sorbent

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[1958] Ex. 1006 (Downs-Boiler) ¶ [0020]; *see also* Ex. 1007 (Downs-Boiler-Provisional) IT [0023].

[1959] Ex. 1006 (Downs-Boiler) ¶ [0016] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) II [0019].

[1960] Ex. 1006 (Downs-Boiler) Figures 4-6; *see also* Ex. 1007 (Downs-Boiler-Provisional) Figures 4-6.

comprising activated carbon into the mercury-containing gas."

1211. The language of this claim element includes elements that are similar to those in claim 8. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

16. Claim 19: "The method of claim 1, wherein the mercury-containing gas comprises about 1 g to about 30 g of the element bromine per 100 g of the sorbent."

1212. This claim would have been obvious over Downs-Boiler. Claim 4 is merely an attempt to claim the optimum or workable range for a process of combining a particular conventional halogen (bromine) being used in a conventional way (halogens are inherent to coal, and has the dual-benefit of oxidizing mercury and promoting activated carbons) with a conventional sorbent (activated carbon). Nothing about the particular range of 1 g to about 30 g of the halide promoter per 100 g of the sorbent would have led to an unexpected result from what was already known to one of skill in the art.

1213. As described in the State of the Art,[1961] it was known that the saturation limit of activated carbon for bromine (i.e., how much bromine the activated carbon can actually adsorb at equilibrium), was up to 31 to 38 grams per 100 grams of activated carbon. Given the residence times in flue gas, and other inefficiencies, a

[1961] State of the Art, § XII.C.3.

person of ordinary skill in the art would have understood that the actual bromine loaded onto activated carbon would have been less than the saturation limit.

1214. A POSITA would have recognized that there would be sufficient bromine in the flue gas, according to the processes disclosed by Downs-Boiler, to provide a ratio of between 1 g to 30 g of bromine per 100 g of activated carbon. A POSITA would have been motivated to use near the bromine-saturation limit of the activated carbon because, in addition to the enhanced removal of mercury on sorbent with the use of halogens as disclosed by Downs-Boiler,[1962] it was known in the art that mercury oxidized by a halide, as "in the form of mercuric chloride, is soluble in water, making it amenable to removal in sulfur dioxide scrubbers," as discussed by Downs-Boiler.[1963] The fact that halides both contribute to the solubility of mercury in water rendering it trivial to remove in a scrubber and also enhance reactivity between mercury and activated carbons is confirmed as well-known in the art, which indicates that halides "improve[d] 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."[1964]

[1962] Ex. 1006 (Downs-Boiler) TT [0016], [0006]; *see also* Ex. 1007 (Downs-Boiler-Provisional) ill [0019], [007].

[1963] Ex. 1006 (Downs-Boiler) ¶ [0003]; *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [004].

[1964] Ex. 1062 (Crocker) at 2-3.

1215. Through natural process optimization and routine experimentation, a POSITA would have adjusted the rate of addition of bromine-containing species and/or activated carbon injection rate to achieve halide promoter on the activated-carbon sorbent from about 1 g to about 30 g.

17. Claim 21: "The method of claim 1, wherein the sorbent in the mercury-containing gas comprises about 1 g to about 30 g of the added Br2, HBr, the bromide compound, or a combination thereof, per 100 g of the sorbent."

1216. The language of this claim element includes elements that are similar to those in claim 5. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

18. Claim 22: "The method of claim 1, wherein the Br2, HBr, or the bromide compound is contacted with the sorbent in vapor form, gaseous form, liquid form, or in an organic solvent."

1217. Downs-Boiler teaches that the bromine-containing reagent "may be fed to the boiler combustion zone 14 in gaseous, liquid, or solid form."[1965]

1218. In addition, a POSITA would have known that Br_2 has a boiling point of 58.8 ºC and HBr has a boiling point of -67 ºC. Upon exposing the bromine-containing reagent to the relatively high combustion temperatures and subsequent

[1965] *Id.* ¶ 22.

flue gas, the bromine-containing reagent would remain in gaseous form when contacting the sorbent.

1219. The language of this claim element includes elements that are similar to those in claim 1b. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

19. Claim 23: "The method of claim 1, wherein the sorbent injected into the mercury-containing gas is a sorbent obtained by contacting a base sorbent with a halogen or halide promoter prior to injection of the sorbent to the mercury-containing gas."

1220. ME2C did not provide infringement contentions for this claim. ME2C's infringement contentions cross reference claim 14 of the '114 patent. ME2C's infringement contentions do not include claim 14 of the '114 patent. ME2C's final contentions hew to this position, and thus ME2C is apparently not asserting this claim. Therefore, no analysis regarding this element is required.

20. Claim 24: "The method of claim 1, wherein the sorbent injected into the mercury-containing gas is free of contact with a halogen or halide promoter prior to injection of the sorbent into the mercury-containing gas."

1221. ME2C did not provide infringement contentions for this claim. ME2C's infringement contentions cross reference claim 13 of the '114 patent. ME2C's infringement contentions do not include claim 13 of the '114 patent. ME2C's final contentions hew to this position, and thus ME2C is apparently not asserting this claim. Therefore, no analysis regarding this element is required.

21. Claim 25: "The method of claim 1, wherein the injection of the sorbent into the mercury-containing gas occurs upstream of a particulate separator or a scrubber."

1222. Downs-Boiler discloses a coal-fired utility boiler with an air preheater 20 (blue), a particulate separator device 26 (purple), and a scrubber (yellow).[1966] Downs-Boiler discloses that "sorbent, and its burden of adsorbed mercury, are subsequently removed from the flue gases in a downstream particulate collector," which means that the sorbent must have been injected upstream of that particulate collector in order to be removed by it.[1967]

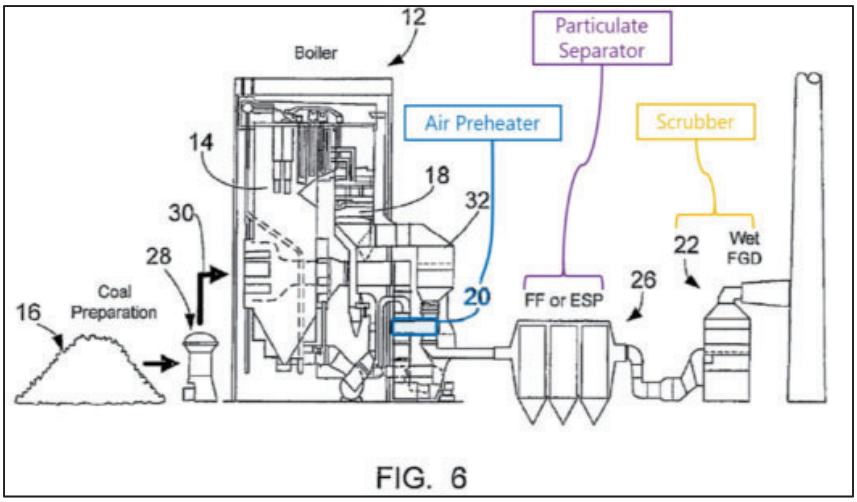


FIG. 6

Specifically, Downs-Boiler explains that a particular advantage of the disclosed invention is that it "enhances removal of mercury across ***particulate collectors 26***

1966 *See id.* at Fig. 6 (annotated version below).

1967 *Id.* ¶ 4, Fig. 6.

such as fabric filters (FF) and electrostatic precipitators (ESP)."[1968] As further explained by Downs-Boiler, the upstream injection of a sorbent means that the "sorbent, and its burden of adsorbed mercury, are subsequently removed from the flue gases ***in a downstream particulate collector***."[1969]

1223. The concept of using a particulate separator or a scrubber in conjunction with sorbent injection is further confirmed by the EPA, explaining that for "direct sorbent injection, after sorbent is introduced into the flue gas, it adsorbs Hg and other contaminants and is ***captured downstream*** in an existing or sorbent-specific [(particulate matter)] control device."[1970] Therefore, to the extent Downs-Boiler fails to explicitly disclose injection of the sorbent material into the mercury-containing gas occurring upstream of a particulate separator or a scrubber this would have been obvious to a POSITA at the time.

22. Claim 26: "The method of claim 25, wherein the particulate separator comprises an electrostatic precipitator, a baghouse, a fabric filter, or a combination thereof."

1224. Downs-Boiler discloses this claim element. Downs-Boiler explains that the desired removal of mercury from the flue gas is by a separation of the particulate-bound mercury. Separation of the particulate-bound mercury

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1968 Ex. 1006 (Downs-Boiler) ¶ [0015] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) II [0018].

1969 Ex. 1006 (Downs-Boiler) ¶ [0004] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [005].

1970 Ex. 1009 (EPA-Proposal) at 4676 (emphasis added).

(mercury/sorbent composition), which includes the oxidized mercury adsorbed onto the PAC as discussed above regarding claim element 25(c)(2), is removed from the mercury-containing gas by a particulate collector as a way to clean the flue gas:[1971]

> The sorbent, and its burden of adsorbed mercury, are subsequently removed from the flue gases in a downstream particulate collector. Adsorption is a technique that has often been successfully applied for the separation and removal of trace quantities of undesirable components.

Downs-Boiler illustrates a number of example particulate collection devices that may be used to separate the mercury-sorbent composition to produce a cleaned gas, each of which were well known to a POSITA. These particulate collectors include "electrostatic precipitators (ESP) or fabric filters (FF), sometimes called baghouses" that "provide high-efficiency removal of particulate-bound mercury."[1972]

1225. Downs-Boiler further discloses the method of claim 25, which is described in the above section.

C. INDEPENDENT CLAIM 29

1. Claim 29: Element 29a: "A method of separating mercury from a mercury-containing gas, the method comprising:"

[1971] Ex. 1006 (Downs-Boiler) ¶ [0004]; see also Ex. 1007 (Downs-Boiler-Provisional) il [005].

[1972] Ex. 1006 (Downs-Boiler) ¶¶ [0003] [0023], Figures 4-6; *see also* Ex. 1007 (Downs-Boiler-Provisional) '111 [004] [0026], Figures 4-6.

1226. Downs-Boiler discloses the preamble. The title of Downs-Boiler is "Bromine Addition for the Improved Removal of Mercury from Flue Gas.[1973] Flue gas is an example of a mercury-containing gas, and "removal of mercury" refers to separating the mercury from a mercury-containing gas. Downs-Boiler repeatedly characterizes the disclosed process as for removing *(i.e.,* separating) mercury from flue gas (i.e., a mercury-containing gas):

> [T]he 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.[1974]

1227. Claim 1 of Downs-Boiler also recites a similar preamble: "1. A method of removing a portion of the elemental mercury in a flue gas"[1975] The removal of mercury from the flue gas as described by Downs-Boiler is by separating the mercury along with a sorbent:[1976]

> The sorbent, and its burden of adsorbed mercury, are subsequently removed from the flue gases in a downstream particulate collector. Adsorption is a technique that has often

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[1973] Ex. 1006 (Downs-Boiler) at Title; Ex. 1007 (Downs-Boiler-Provisional) at Title

[1974] pg completed formatting/need to do QCEx. 1006 (Downs-Boiler) ¶ [0007]; Ex. 1007 (Downs-Boiler-Provisional) ¶ [0013].

[1975] Ex. 1006 (Downs-Boiler) at Claim 1; see also Ex. 1007 (Downs-Boiler-Provisional) at Claim 1 ("1. A method of reducing the mercury concentration of a flue gas comprising.").

[1976] Ex. 1006 (Downs-Boiler) ¶ [0004] (emphasis added); Ex. 1007 (Downs-Boiler-Provisional) IT [005].

been successfully applied for the *separation and removal* of trace quantities of undesirable components.

1228. Downs-Boiler characterizes its disclosed "invention" as "a cost-effective method of removing elemental mercury from coal combustion flue gases."[1977]

2. Claim 29: Element 29b: "combusting coal in a combustion chamber, wherein"

1229. The language of this claim element is identical to that of claim 1b. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

3. Claim 29: Element 29c: "the coal comprises added Br2, HBr, bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber, or the combustion chamber comprises added Br2, HBr, bromide compound, or a combination thereof, or a combination thereof; and"

1230. The language of this claim element is identical to that of claim 1b. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

4. Claim 29: Element 29d: "collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon."

[1977] Ex. 1006 (Downs-Boiler) ¶ [0018]; Ex. 1007 (Downs-Boiler-Provisional) ¶ [021].

1231. The language of this claim element is identical to that of claim 1c. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

D. INDEPENDENT CLAIM 30

1. Claim 30: Element 30a: "A method of separating mercury from a mercury-containing gas, the method comprising:"

1232. The language of this claim element is identical to that of claim 29. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

2. Claim 30: Element 30b: "combusting coal in a combustion chamber, to provide the mercury-containing gas, wherein the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br−, or a combination thereof, wherein"

1233. The language of this claim element is identical to that of the first portion of claim element 29b and contains elements of claim 23. Accordingly, the explanation I provide above for those claims applies equally to these claim elements.

1234. In addition, Downs-Boiler discloses adding Br2, HBr, or an "aqueous solution of calcium bromide" (CaBr2) to the coal and/or combustion chamber.[1978] HBr and Br– are examples of a "halogen or halide promoter." Downs-Boiler expressly discloses HBr and aqueous solutions of calcium bromide that dissociate in

[1978] *Id.* ¶¶ 18-, 21, Fig. 2.

water to form bromide ions (Br–).[1979] Downs-Boiler also confirms that the bromine-containing species are present in the mercury-containing flue gas, stating that they are responsible for "enhanc[ing] the removal of mercury."[1980]

3. Claim 30: Element 30c: "the coal comprises added Br2, HBr, bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber, or the combustion chamber comprises added Br2, HBr, bromide compound, or a combination thereof, or a combination thereof"

1235. The language of this claim element is identical to that of claims 13 and 14, and contains elements of claim 1b. Accordingly, the explanation I provide above for those claims applies equally to these claim elements.

4. Claim 30: Element 30d: "collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon;"

1236. The language of this claim element is identical to that of claims 1c and 29d. Accordingly, the explanation I provide above for those claims applies equally to these claim elements.

5. Claim 30: Element 30e: "separating the sorbent contacted with the mercury from the mercury-containing gas;"

1979 *Id.* ¶¶ 18-19.
1980 *Id.* ¶¶ 15-16.

1237. The language of this claim element is identical to that of claims 1c and 29d. Accordingly, the explanation I provide above for those claims applies equally to these claim elements.

6. Claim 30: Element 30f: "measuring the mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content of the mercury-containing gas, an injection rate of injecting the sorbent into the mercury-containing gas, an amount of the Br2, HBr, bromide compound, or a combination thereof, added to the coal or the combustion chamber, or a combination thereof."

1238. The language of this claim element is similar to that of claims 8 and 18. Accordingly, the explanation I provide above for those claims applies equally to these claim elements.

XXXIX. GROUND U: OBVIOUSNESS OF THE '517 PATENT OVER DOWNS-BOILER IN VIEW OF EPA-PROPOSAL

1239. It is my opinion that Downs-Boiler in view of the EPA-Proposal renders obvious each of the claims 1c and 6. Elements and claims not mentioned below are disclosed and/or obvious for the reasons stated above in Ground T.

A. INDEPENDENT CLAIM 1

1. Claim 1: Element 1c: "collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon."

1240. In addition to the reasons described in Ground T, claim element 1(c) would have been obvious over Downs-Boiler in view of the EPA-Proposal.

1241. EPA-Proposal also discloses introducing sorbents into the flue gas for mercury removal by direct sorbent injection. *EPA-Proposal* at 4676. EPA-Proposal teaches that "[w]ith direct sorbent injection, after sorbent is introduced into the flue gas, it adsorbs Hg and other contaminants and is captured downstream in an existing or sorbent-specific PM control device."[1981] EPA-Proposal discloses activated carbon (regular and impregnated) as a type of sorbent for use in sorbent injection.[1982]

1242. EPA-Proposal further teaches that the mercury in the mercury-containing gas contacts the sorbent, as evidenced by EPA-Proposal's disclosure of activated carbon having an internal pore structure that allows the activated carbon to "adsorb a broad range of contaminants," including "good to excellent Hg removal with the injection of AC."[1983]

B. CLAIMS DEPENDING FROM CLAIM 1

1. Claim 6: "The method of claim 1, comprising collecting greater than 70 wt % of the mercury in the mercury-containing gas."

1243. In addition to the reasons described in Ground T, claim 6 would have been obvious over Downs-Boiler in view of the EPA-Proposal.

1981 *Id.*

1982 *Id.*

1983 Ex. 1009 (EPA-Proposal*)* at 4676.

1244. As described in Ground T, Downs-Boiler discloses removing at least 77 wt% of the mercury in the mercury-containing gas.[1984] Downs-Boiler also discloses removing mercury to meet advancing EPA standards regulating mercury emissions from coal-fired plants.[1985] The EPA proposed rules stated that a "primary goal in this rulemaking is to reduce power plant emissions of Hg by 70 percent from today's levels by 2018" with more near-term caps built in.[1986] EPA-Proposal discloses targeting 70% mercury removal by introducing activated carbon (including halogen-impregnated varieties) into the flue gas and utilizing other known methods. At least by January 2004, the EPA announced to the coal-fired industry that upcoming regulations would require an eventual 70% reduction in mercury emissions, motivating researchers to adopt processes that would achieve those limits.[1987] EPA-Proposal also discusses enforcement mechanisms, including "automatic…financial penalties" for mercury emissions exceeding the desired levels.[1988] Relatedly, Downs-Boiler discusses EPA standards regulating mercury emissions from coalfired plants.[1989] Thus, Downs-Boiler discloses the need to

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1984 Ex. 1006 (Downs-Boiler) Figure 3 (annotated); *see also* Ex. 1007 (Downs-Boiler-Provisional) Figure 3.

1985 Ex. 1006 (Downs-Boiler) ¶ [0001]; *see also* Ex. 1007 (Downs-Boiler-Provisional) 11 [002].

1986 Ex. 1009 (EPA-Proposal) at 4698.

1987 Ex. 1009 (EPA-Proposal) at Cover, 4652, 4698.

1988 Ex. 1009 (EPA-Proposal) at 4701.

1989 Ex. 1006 (Downs-Boiler) ¶ [0001].

comply with regulatory requirements for mercury emissions, such as those set forth in EPA-Proposal.

1245. Furthermore, EPA-Proposal discusses several ways to reduce mercury emissions to a desired level, including by injecting activated-carbon sorbent material (bare or halogen-impregnated), and controlling the activated-carbon injection rate.[1990] A POSITA would have had a reasonable expectation of success in combining Downs-Boiler with EPA-Proposal because, like Downs-Boiler, EPA Proposal describes "sorbent injection" into the flue gas.[1991] "[A]fter sorbent is introduced into the flue gas, it adsorbs Hg and other contaminants and is captured downstream in an existing or sorbent-specific PM [particulate matter] control device."[1992] EPA-Proposal describes "activated carbon" as an exemplary sorbent for injection into flue gas.[1993]

1246. Therefore, a POSITA would have been motivated to combine the teachings of Down-Boiler and EPA-Proposal to operate their coal-fired plants in a manner compliant with the EPA-Proposal to avoid eventual regulatory fines for emissions violations, to try the remediation methods described by the EPA-Proposal.

1990 Ex. 1009 (EPA-Proposal) at 4698.
1991 Ex. 1009 (EPA-Proposal) at 4698.
1992 Ex. 1009 (EPA-Proposal) at 4698.
1993 Ex. 1009 (EPA-Proposal) at 4698.

XL. GROUND V: OBVIOUSNESS OF THE '517 PATENT OVER DOWNS-BOILER IN VIEW OF NELSON

1247. It is my opinion that Downs-Boiler in view of Nelson renders obvious each of claims 5-6. Elements and claims not mentioned below are disclosed and/or obvious for the reasons stated above in Ground T.

A. CLAIMS DEPENDING FROM CLAIM 1

1. Claim 5: "The method of claim 1, wherein the sorbent has a composition comprising from about 1 to about 30 grams of the element bromine per 100 grams of activated carbon."

1248. In addition to the reasons described in Ground T, claim 5 would have been obvious over Downs-Boiler in view of Nelson.

1249. Nelson describes a promoted activated-carbon sorbent formed from about 1 g to about 30 g of bromide per 100 g of sorbent. Specifically, Nelson explains that "[w]hile over 30 wt % of Br_2(g) can be adsorbed into some powdered activated carbons, for example, significant increases in mercury reactivity will be observed with only about 1 wt % Br_2(g) in the PAC."[1994]

1250. A POSITA would have been motivated to combine the teachings of Downs-Boiler, Nelson, and/or knowledge in the art to use about 1 to about 30 grams of element bromine per 100 g of activated carbon to load the sorbent, e.g., activated

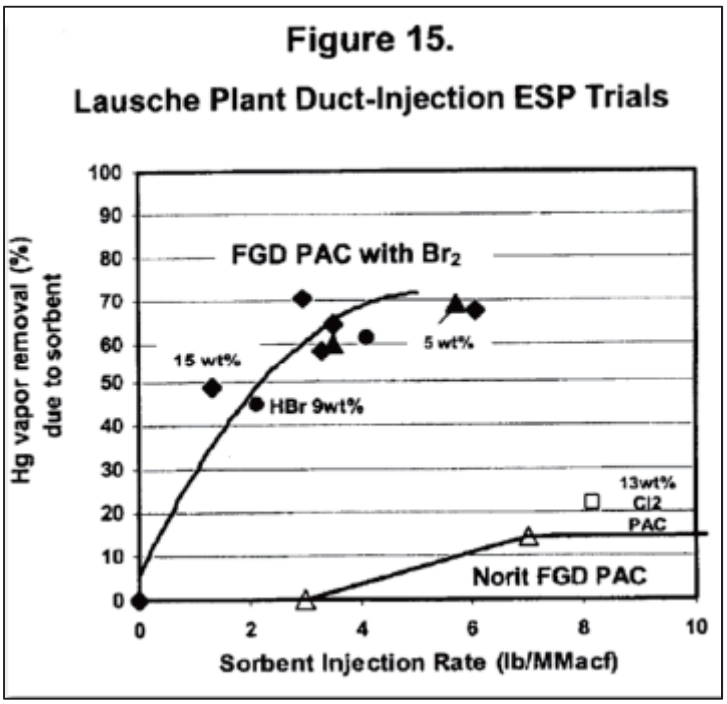
[1994] Ex. 1012 (Nelson) at 8:35-40.

carbon, sufficiently to increase its reactivity and ability to adsorb mercury and to optimize the use of the bromine and mercury removal.

2. Claim 6: "The method of claim 1, comprising collecting greater than 70 wt % of the mercury in the mercury-containing gas."

1251. In addition to the reasons described in Ground T, claim 6 would have been obvious over Downs-Boiler in view of Nelson.

1252. Nelson provides additional motivation to achieve 70% mercury removal on the sorbent itself. For example, Figure 15 of Nelson plots the "Hg vapor removal (%) due to sorbent," as opposed to other components such as unburnt carbon or a scrubber.[1995]



[1995] Ex. 1012 (Nelson) at 15:5-39, Fig. 15.

1253. At a sorbent injection rate of approximately 4 lbs/MMacf, Nelson achieves above 70% removal on the sorbent.[1996] At a sorbent injection rate of 5 lbs/MMacf, the sorbent itself would have removed even more mercury. Accordingly, a POSITA would have been motivated to, and capable of, removing 70% or more mercury from the mercury-containing flue gas, including on the sorbent.

1254. Therefore, a POSITA would have been motivated to combine the teachings of Down-Boiler and Nelson to operate coal-fired plants in a manner compliant with EPA guidelines to avoid eventual regulatory fines for emissions violations.

XLI. GROUND W: ANTICIPATION OF THE '517 PATENT OVER VOSTEEN AND/OR OBVIOUSNESS OVER VOSTEEN IN VIEW OF GRANITE

A. INDEPENDENT CLAIM 1

1. Claim 1: Element 1a: "A method for reducing mercury in a mercury-containing gas, the method comprising:"

1255. Claim element 1a is obvious over Vosteen alone and/or in view of Granite. Vosteen discloses processes for "removing mercury from flue gases of high-temperature plants, in particular from power stations and waste incineration

[1996] *Id.* at 15:35-38.

plants."[1997] Granite is concerned with the control of anthropogenic mercury emissions.[1998]

2. Claim 1: Element 1b: "combusting coal in a combustion chamber, the coal comprising an additive comprising Br2, HBr, a bromide compound, or a combination thereof, to form the mercury-containing gas; and"

1256. Vosteen discloses this element. Vosteen discloses "a process for removing mercury from flue gases of high-temperature plants, in particular from power stations and waste incineration plants."[1999] Vosteen describes adding HBr (hydrogen bromide) and bromide compounds to the coal, or to the combustion chamber, or both. Sodium bromide is an example of a bromide compound. Vosteen describes that bromine-containing ingredients are added to the combustion chamber (also referred to by Vosteen as a furnace), and can also be added to the coal upstream of the combustion chamber.

> The 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*

[1997] Ex. 1008 (Vosteen) at 1:66-2:1; see also Ex. 1008 (Vosteen) at 1:6-8.
[1998] Ex. 2003 (Granite 2000) at 1020.
[1999] Ex. 1008 (Vosteen) at 1:66-2:1.

multistage furnace and/or to the flue gas in a plant section downstream of the furnace.[2000]

Particularly preferably, an *aqueous solution of hydrogen bromide or an alkali metal bromide,* in particular sodium bromide, or an aqueous solution of the alkali metal bromide is used.[2001]

The *bromine compound*, for example, *sodium bromide, can be added in solid form, for example as salt, or in 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 a pyrolysis drum, which serves, for example, for the thermal breakdown of co-incinerated waste materials, or *to a coal mill*. *The compound can also be fed during the combustion process*. . . .*[T] he bromine compound can be introduced*, likewise in solid or liquid form, *into one or both combustion chambers*, for example into the rotary kiln and/or the afterburning chamber. Preferably, an aqueous solution of the compound is *sprayed into one of the combustion chambers*.[2002]

2000 Ex. 1008 (Vosteen) at 1:65-2:5.
2001 Ex. 1008 (Vosteen) at 2:58-61.
2002 Ex. 1008 (Vosteen) at 4:4-19.

> [I]t is also possible to feed the bromine compound, for example an *aqueous solution of hydrogen bromide or sodium bromide*, at a fine dispersion *to the combustion* air and/or if appropriate to a recirculated substream, in particular recirculated flue gas, recirculated ash and recirculated fly ash.[2003]

1257. The "bromine and/or a bromine compound" identified above in Vosteen refers to molecular bromine (Br_2) and/or a compound containing the element bromine (Br) bonded to other chemical elements.

1258. This claim element is also disclosed by claims 1 and 2 of Vosteen, highlighted below, which recite adding a bromine compound or mixture of compounds (including hydrogen bromide) to the combustion chamber (furnace):[2004]

[2003] Ex. 1008 (Vosteen) at 4:28-33.

[2004] Ex. 1008 (Vosteen) at Claims 1, 2.

1. Process for removing mercury from mercury-containing flue gases of a furnace within which a combustion or incineration is carried out, wherein

bromine, a bromine compound, a mixture of bromine compounds or a mixture of bromine and a bromine compound or compounds, is fed to the furnace or to the flue gas of the furnace in a plant section downstream of the furnace, or to both the furnace and the flue gas, the temperature during the first contact of the bromine or of said mixture with the flue gas being at least 500° C.,

the combustion or incineration is carried out in the presence of a sulphur compound,

and then the flue gas is subjected to a cleanup for removing mercury from the flue gas.

2. Process according to claim 1, wherein the bromine compound is an aqueous solution of hydrogen bromide, an alkali metal bromide, or a mixture thereof.

1259. This claim element is also disclosed by claim 18 of Vosteen, highlighted below:[2005]

18. A process for removing mercury from mercury-containing flue gases of a furnace, comprising:

carrying out a combustion or incineration process, within the furnace, in the presence of a sulphur compound;

feeding bromine, a bromine compound, a mixture of bromine compounds, or a mixture of bromine and one or more bromine compounds to at least one of the furnace

* * *

[2005] Ex. 1008 (Vosteen) at Claim 18.

wherein feeding the bromine, bromine compound, mixture of bromine compounds, or mixture of bromine and one or more bromine compounds to the furnace comprises:
applying the bromine, bromine compound, mixture of bromine compounds, or mixture of bromine and one or more bromine compounds in an aqueous solution of the bromine, bromine compound, mixture of bromine compounds, or a mixture of bromine and one or more bromine compounds to a coal; and
feeding the coal to the furnace,

3. Claim 1: Element 1c: "collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon."

1260. Vosteen, either alone or in combination with Granite, anticipates or renders obvious this limitation.

1261. [2006] Vosteen discloses adding particulate sorbent material comprising activated carbon by the introduction of cloth filters with granulated activated carbon into the mercury-containing flue gas stream as part of the flue gas emission control system downstream of the combustion chamber.[2007]

1262. Alternatively, it would have been obvious to a person of skill in the art to use the teachings of Vosteen concerning the use of a bromine additive with a flue gas control system typical of a coal burning power plant.[2008] A POSITA would understand that injection of activated carbon into the ductwork downstream of the combustion furnace was the more common and readily available method of using

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2006 Ex. 1008 (Vosteen) at 1:35-45, 5:19-30.
2007 Ex. 1008 (Vosteen) at 5:19-30.
2008 Ex. 1008 (Vosteen) at 7:25-32.

activated carbon for mercury control instead of the impinged fabric filters of Vosteen.

1263. It would have also been obvious to combine Vosteen's addition of bromine compounds to coal for combustion with activated carbon injection systems in use at the time that the Vosteen reference was published. For example, Vosteen's bromine additive would have been obvious to use in the plants described in the Granite reference. Granite explains that control technologies for removing mercury from flue gas at the time include the use of activated carbon sorbents injected into the gas stream.[2009] Granite describes, for example, the activated carbon duct injection systems used for mercury control for industrial combustors.[2010] A POSITA would understand that injection of activated carbon into the ductwork downstream of the combustion furnace was the more common and readily available method of using activated carbon for mercury control instead of the impinged fabric filters of Vosteen. Furthermore, a POSITA would have been motivated by Granite's teaching that the promotion of activated carbon using halogens such as chlorine and iodine to combine the teachings of Vosteen regarding bromine with the state of the art activated carbon systems it describes.[2011]

[2009] Ex. 2003 (Granite 2000) at 1020, 1022.
[2010] Ex. 2003 (Granite 2000) at 1026.
[2011] Ex. 2003 (Granite 2000) at 1020.

B. CLAIMS DEPENDING FROM CLAIM 1

1. Claim 2: "The method of claim 1, further comprising injecting an alkaline sorbent into the mercury-containing gas stream."

1264. Vosteen, either alone or in combination with Granite, anticipates or renders obvious this limitation. Vosteen teaches that the flue gas control system can be used with addition of alkaline sorbents such as granular lime, such as in a mixture with adsorbers such as activated carbon.[2012] Vosteen discloses adding particulate sorbent material comprising activated carbon by the introduction of cloth filters with granulated activated carbon into the mercury-containing flue gas stream as part of the flue gas emission control system downstream of the combustion chamber.

1265. Alternatively, it would have been obvious to a person of skill in the art to use the teachings of Vosteen concerning the use of a bromine additive with a flue gas control system typical of a coal burning power plant.[2013] A POSITA would understand that injection of activated carbon into the ductwork downstream of the combustion furnace was the more common and readily available method of using activated carbon for mercury control instead of the impinged fabric filters of Vosteen.

[2012] See Ex. 1008 (Vosteen) at 5:15-49; 7:25-31.

[2013] Ex. 1008 (Vosteen) at 7:25-32.

1266. It would have also been obvious to combine Vosteen's addition of bromine compounds to coal for combustion with activated carbon injection systems in use at the time that the Vosteen reference was published. For example, Vosteen's bromine additive would have been obvious to use in the plants described in the Granite reference. Granite explains that control technologies for removing mercury from flue gas at the time include the use of activated carbon sorbents injected into the gas stream.[2014] Granite describes, for example, the activated carbon duct injection systems used for mercury control for industrial combustors.[2015] A POSITA would understand that injection of activated carbon into the ductwork downstream of the combustion furnace was the more common and readily available method of using activated carbon for mercury control instead of the impinged fabric filters of Vosteen. Furthermore, a POSITA would have been motivated by Granites teaching that the promotion of activated carbon using halogens such as chlorine and iodine to combine the teachings of Vosteen regarding bromine with the state of the art activated carbon systems it describes.[2016]

2. Claim 3: "The method of claim 2, wherein the alkaline sorbent is selected from the group consisting of alkali elements, alkaline earth elements, alkali salts, alkaline earth salts, and combinations thereof."

2014 Ex. 2003 (Granite 2000) at 1020, 1022.
2015 Ex. 2003 (Granite 2000) at 1026.
2016 Ex. 2003 (Granite 2000) at 1020.

1267. Vosteen alone and/or in view of Granite discloses this claim element. The language of this claim element discusses similar elements as claim 2. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

3. Claim 4: "The method of claim 1, wherein the activated carbon is chosen from powdered activated carbon, granular activated carbon, carbon black, carbon fiber, aerogel carbon, pyrolysis char, and combinations thereof."

1268. Vosteen alone and/or in view of Granite discloses this claim element. As described above, Vosteen discloses injecting activated carbon into a mercury-containing flue gas downstream of the combustion chamber and contacting mercury with the sorbent to form a mercury/sorbent composition. Vosteen discloses activated carbon as a sorbent. Vosteen further specifies "granulated activated carbon" as the sorbent.[2017] A person of skill in the art would have recognized that "granular" activated carbon and "granulated" activated carbon are two words for the same material.

1269. Granite also discloses a number of different types of activated carbon.

4. Claim 5: "The method of claim 1, wherein the sorbent has a composition comprising from about 1 to about 30 grams of the element bromine per 100 grams of activated carbon."

[2017] Ex. 1008 (Vosteen) at 5:24-25.

1270. Vosteen, either alone or in view of knowledge of the art, discloses this limitation. This limitation merely recites a workable range of bromine using known, conventional techniques. The range combines a conventional halogen (bromine) being used in a conventional way with a conventional sorbent (activated carbon). Nothing in the '430 patent specification attributes any particular significance to the claimed range or establishes that the claimed range "achieves unexpected results" in mercury removal. Rather, the range presents nothing more than optimization of "result-effective" variables, which would have been obvious to a POSITA.

1271. Further, a POSITA would have been motivated to load the activated carbon with up to nearly its saturation limit to increase its reactivity and ability to adsorb mercury. And, a POSITA would have known that the saturation limit of activated carbon for bromine (i.e., the amount of bromine activated carbon can actually hold at equilibrium), was about 31-38 grams per 100 grams of activated carbon. Given the residence times in flue gas, a POSITA would have understood that the bromine loaded onto activated carbon would be less than the saturation limit.

1272. Therefore, a POSITA would have been motivated to combine the teachings of Vosteen and knowledge in the art to use about 1 gram to about 30 grams of element bromine per 100 g of sorbent to load the sorbent, e.g., activated carbon, sufficiently to increase its reactivity and ability to adsorb mercury and to optimize the use of the bromine and mercury removal

5. Claim 6: "The method of claim 1, comprising collecting greater than 70 wt % of the mercury in the mercury-containing gas."

1273. Vosteen renders this claim obvious in combination with the background knowledge of a POSITA. Vosteen discloses maintaining mercury levels below those needed to comply with legal and regulatory requirements.[2018] Vosteen describes measuring the mercury content and then, in response to that measurement, controlling process parameters (e.g., rates of addition of bromine-containing components) to achieve those limits. Measurements of the mercury content are depicted in Figures 2-8 of Vosteen,[2019] and also recited in claim 9 of Vosteen.[2020] Vosteen further describes maintaining mercury content of the cleaned gas below desired levels, including those imposed by regulatory authorities. For example, Vosteen mentions that "strict limiting values exist for the legally permissible emission of mercury, for example from incineration plants and power stations."[2021] Vosteen discusses the need that his invention provided a solution for "further reduction of the currently permitted limiting values" of mercury emissions.[2022]

1274. As I discuss in the State of the Art, the EPA and other regulatory bodies proposed rules that, upon implementation, would have required mercury emissions

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2018 Ex. 1008 (Vosteen) at 1:10-13, 1:20-22.
2019 Ex. 1008 (Vosteen) at Figs. 2-8.
2020 Ex. 1008 (Vosteen) at Claims 9.
2021 Ex. 1008 (Vosteen) at 1:10-13.
2022 Ex. 1008 (Vosteen) at 1:20-22.

reductions by 70%. In trying to ensure their plants were compliant upon eventual implementation and promulgation of the EPA rules, a person of skill in the art would have been motivated, and it would have been obvious, to keep mercury emissions below the desired levels proposed by the EPA in order to avoid paying regulatory fines and other penalties that would incur upon rule implementation.

6. Claim 7: "The method of claim 1, comprising collecting greater than 70 wt % of the mercury in the mercury-containing gas with the sorbent."

1275. Claim 7 would have been obvious to a person of skill in the art over Vosteen. For example, as described for Claim 6 above, Vosteen discloses removing more than 98% of the mercury from the mercury-containing gas.[2023] Vosteen discloses that his invention is particularly suited "for those high-temperature plants *which do not have a wet flue gas emission control system*, but solely have a dry emission control system having a mercury *sorption* stage."[2024] Such plants with "solely" a dry emission control system, and without a scrubber, would be dependent on the activated carbon for mercury removal. Moreover, the Hg removals on sorbents alone would meet or exceed the 70% removal threshold under the configurations disclosed by Vosteen. Specifically, Vosteen discloses that "lignite-fired power stations"[2025] would benefit from his Hg control methods. A person of

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2023 Ex. 1008 (Vosteen) at 6:35-40 (describing Figure 5).
2024 Ex. 1008 (Vosteen) at 5:32-36.
2025 Ex. 1008 (Vosteen) at 2:36-37.

ordinary skill in the art would have understood that such plants typically have very low concentrations of inherent chlorine in their flue gas as well as very low LOI levels in their flyash. Under such circumstances, Hg capture on inherent unburned carbon is minimal. Consequently, a person of ordinary skill in the art would have understood that adding bromine to the furnace of a plant with "solely" a dry emission control system, and without a scrubber, while injecting a sorbent ahead of the particle collection device, as Vosteen teaches, ensures that virtually all the Hg captured in a particle collection device would be bound to the sorbent. Furthermore, Vosteen also teaches how to adjust the bromine addition level to achieve Hg removal up to essentially complete removal, including 70 % removal.

1276. As described in the State of the Art,[2026] a person of skill in the art would have known that by 2004, the EPA had already put the industry on notice of upcoming laws and regulations surrounding announced regulations requiring 70% mercury removal, such as the EPA's Clean Air Mercury Rule (CAMR). Notice of these regulations exerted a strong outside impetus on the industry to adjust processes to comply with the regulations' eventual implementation. Through routine process optimization and routine experimentation, a person of ordinary skill in the art would have adjusted the bromine injection rate and/or activated carbon injection rate in a plant he described as preferred (one that relied solely on a dry emission control

[2026] State of the Art, XII.D —XII.F.

system having a mercury sorption stage) to meet and exceed (for purposes of safety margin) the EPA's proposed rules requiring a 70% removal of mercury.

7. Claim 8: "The method of claim 1, further comprising: measuring mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content, an injection rate of injecting the sorbent comprising activated carbon into the mercury-containing gas, an amount of the additive comprising the Br2, HBr, bromide compound, or a combination thereof, added to the coal, or a combination thereof."

1277. This limitation is disclosed by Vosteen. Vosteen discloses measuring the mercury content of the mercury-containing gas. Vosteen describes that "*the mercury content of the flue gas*, in particular the content of metallic [i.e., elemental] mercury, *is measured continuously* downstream of the flue gas emission control system."[2027] Measurements of the mercury content are depicted in Figures 2-8 of Vosteen,[2028] and are also recited in claim 9 of Vosteen:[2029]

> **9.** Process according to claim **8**, wherein the mercury content of the flue gas is measured continuously downstream of the flue gas emission control system and the amount of bromine, bromine compounds fed and any sulphur or sulphur compounds fed is controlled on the basis of the measured mercury content.

Measuring mercury content of the cleaned gas is a form of monitoring the mercury.

2027 Ex. 1008 (Vosteen) at 5:48-50.
2028 Ex. 1008 (Vosteen) at Figs. 2-8.
2029 Ex. 1008 (Vosteen) at Claims 9.

1278. Vosteen monitors the mercury content of the cleaned gas, and in response, controls the amount of addition to the coal and/or combustion chamber of the added bromine-containing species.

> Preferably, in the inventive process, *the mercury content of the flue gas*, in particular the content of metallic mercury, *is measured continuously* downstream of the flue gas emission control system and *on the basis of the measured mercury content the amount of bromine fed and/or bromine compounds and/or the mixture of bromine compounds* and if appropriate sulphur and/or sulphur substances and/or the mixture of sulphur substances *is controlled.*[2030]

1279. As explained above, the bromine-containing species include aqueous hydrogen bromide [HBr(aq)], bromide compounds in solid or aqueous form (e.g., sodium bromide [NaBr(s) or NaBr(aq)], molecular bromine (Br_2), and mixtures thereof, and these bromine-containing species are added to either the coal or to the combustion chamber. This claim element is also disclosed by claim 9 of Vosteen.[2031]

1280. In addition, Vosteen continuously monitors the mercury content of the cleaned gas, and, in response, continuously adjusts the rate of addition to the coal or combustion chamber of the added bromine-containing species.[2032] The bromine-containing species include aqueous hydrogen bromide [HBr(aq)], bromide compounds in solid or aqueous form (e.g., sodium bromide [NaBr(s) or NaBr(aq)],

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2030 Ex. 1008 (Vosteen) at 5:48-55.

2031 Ex. 1008 (Vosteen) at Claims 9.

2032 Ex. 1008 (Vosteen) at 5:48-55, Claim 9.

molecular bromine (Br_2), and mixtures thereof, and these bromine-containing species are added to either the coal or to the combustion chamber.

1281. A POSITA would have understood that adjusting the rate of addition of bromine-containing species would have affected the sorbent composition (e.g., the amount of bromine and/or adsorbed mercury on the sorbent). A POSITA reviewing the figures of Vosteen would have known to use the monitored mercury content to control the injection rate of bromine-containing promoter, and thereby controlled the activated-carbon sorbent composition, in response to the monitored mercury content of the cleaned gas. Therefore, A POSITA would have known that by controlling the feed rate of bromine-containing species, the sorbent composition in the mercury-containing gas would have also been controlled.

1282. A POSITA would have known that activated carbon was expensive, especially relative to costs of components such as HBr or sodium bromide. Thus, a POSITA would have been motivated to adjust the addition rate of bromine-containing species to remove sufficient mercury while minimizing the sorbent injection rate. A POSITA viewing the figures of Vosteen (e.g., Figs. 5-8) showing bromine injection versus mercury removal would have been motivated, and thus it would have been obvious, to at least try using the charts to control the sorbent injection rate at a level that minimized costs while reaching mercury removal targets. Furthermore, due to the variability of the composition of coal as a fuel source

(including for example, native mercury and halogen content), as described in the State of the Art,[2033] it would have been obvious that some amount of adjustment to the rate of injection of the sorbent into the flue gas would be performed as part of routine process control and optimization to account for variances in the coal.

8. Claim 9: "The method of claim 8, wherein the measuring of the mercury content of the mercury-containing gas is performed substantially continuously."

1283. ME2C did not provide infringement contentions for this claim. ME2C's infringement contentions cross reference claim 24 of the '225 patent. ME2C's infringement contentions do not include claim 24 of the '225 patent. ME2C's final contentions hew to this position, and thus ME2C is apparently not asserting this claim. Therefore, no analysis regarding this element is required.

9. Claim 10: "The method of claim 1, further comprising: modifying, in response to a measured mercury content, an injection rate of injecting the sorbent comprising activated carbon into the mercury-containing gas, an amount of the Br2, HBr, bromide compound, or a combination thereof, added to the coal, or a combination thereof."

1284. The language of this claim element includes elements that are similar to those in claim 8. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

10. Claim 11: "The method of claim 1, wherein the coal comprises a subbituminous coal."

[2033] State of the Art, § XII.B.1.

1285. This claim element is obvious in light of Vosteen and the background knowledge of a POSITA and/or Granite. Vosteen teaches that its invention can be applied to coal-fired power stations using a variety of coals. In addition, a POSITA would understand that methods of mercury removal from coal combustion gas disclosed in Granite would be applicable to coal comprising subbituminous coal.

11. Claim 13: "The method of claim 1, wherein the coal comprises the added Br2, HBr, the bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber."

1286. Vosteen renders this claim obvious. Vosteen discloses mixing bromide compounds in with the coal or added to the combustion furnace:

> The bromine compound, for example, sodium bromide, can be added in solid form, for example as salt, or in 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 a pyrolysis drum, which serves, for example, for the thermal breakdown of co-incinerated waste materials, or to a coal mill. The compound can also be fed during the combustion process. If the furnace comprises a plurality of stages, for example a primary and a secondary furnace, the bromine compound can be introduced, likewise in solid or liquid form, into one or both combustion chambers, for example into the rotary kiln and/or the afterburning chamber. Preferably, an aqueous solution of the compound is sprayed into one of the combustion chambers.[2034]

[2034] Ex. 1008 (Vosteen) at 4:4-19; *see also id.* at 2:54-3:2, 3:66-4:33, 6:65-7:32.

1287. Vosteen discloses that mercury containing gas results from high temperature processes such as combustion in power plants and waste incineration plants.[2035]

12. Claim 14: "The method of claim 1, wherein the combustion chamber comprises the added Br2, HBr, the bromide compound, or a combination thereof."

1288. Vosteen discloses this claim element. Vosteen describes that the combustion chamber (sometimes referred to as "furnace" or "boiler" in Vosteen) comprises added aqueous hydrogen bromide [HBr(aq)], bromide compounds in solid or aqueous form (e.g., sodium bromide [NaBr(s) or NaBr(aq)], molecular bromine (Br2), and mixtures thereof. Specifically, Vosteen describes adding HBr (hydrogen bromide) and bromide compounds to the coal, or to the combustion chamber, or both. Sodium bromide is an example of a bromide compound. Vosteen describes that bromine-containing ingredients are added to the combustion chamber (also referred to by Vosteen as a furnace), and can also be added to the coal upstream of the combustion chamber.

> The 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* <u>*fed to the if appropriate*</u>

[2035] Ex. 1008 (Vosteen) at 1:66-2:1; *see also, id*. at 1:10-22.

multistage furnace and/or to the flue gas in a plant section downstream of the furnace.[2036]

Particularly preferably, an *aqueous solution of hydrogen bromide or an alkali metal bromide,* in particular sodium bromide, or an aqueous solution of the alkali metal bromide is used.[2037]

The *bromine compound*, for example, *sodium bromide, can be added in solid form, for example as salt, or in 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 a pyrolysis drum, which serves, for example, for the thermal breakdown of co-incinerated waste materials, or *to a coal mill*. *The compound can also be fed during the combustion process*. . . .*[T] he bromine compound can be introduced*, likewise in solid or liquid form, *into one or both combustion chambers*, for example into the rotary kiln and/or the afterburning chamber. Preferably, an aqueous solution of the compound is *sprayed into one of the combustion chambers*.[2038]

2036 Ex. 1008 (Vosteen) at 1:65-2:5.
2037 Ex. 1008 (Vosteen) at 2:58-61.
2038 Ex. 1008 (Vosteen) at 4:4-19.

> [I]t is also possible to feed the bromine compound, for example an *aqueous solution of hydrogen bromide or sodium bromide*, at a fine dispersion *to the combustion* air and/or if appropriate to a recirculated substream, in particular recirculated flue gas, recirculated ash and recirculated fly ash.[2039]

1289. The "bromine and/or a bromine compound" identified above in Vosteen refers to molecular bromine (Br_2) and/or a compound containing the element bromine (Br) bonded to other chemical elements.

1290. This claim element is also disclosed by claims 1 and 2 of Vosteen, highlighted below, which recite adding a bromine compound or mixture of compounds (including hydrogen bromide) to the combustion chamber (furnace):[2040]

[2039] Ex. 1008 (Vosteen) at 4:28-33.

[2040] Ex. 1008 (Vosteen) at Claims 1, 2.

1. Process for removing mercury from mercury-containing flue gases of a furnace within which a combustion or incineration is carried out, wherein

bromine, a bromine compound, a mixture of bromine compounds or a mixture of bromine and a bromine compound or compounds, is fed to the furnace or to the flue gas of the furnace in a plant section downstream of the furnace, or to both the furnace and the flue gas, the temperature during the first contact of the bromine or of said mixture with the flue gas being at least 500° C.,

the combustion or incineration is carried out in the presence of a sulphur compound,

and then the flue gas is subjected to a cleanup for removing mercury from the flue gas.

2. Process according to claim 1, wherein the bromine compound is an aqueous solution of hydrogen bromide, an alkali metal bromide, or a mixture thereof.

1291. This claim element is also disclosed by claim 18 of Vosteen, highlighted below:[2041]

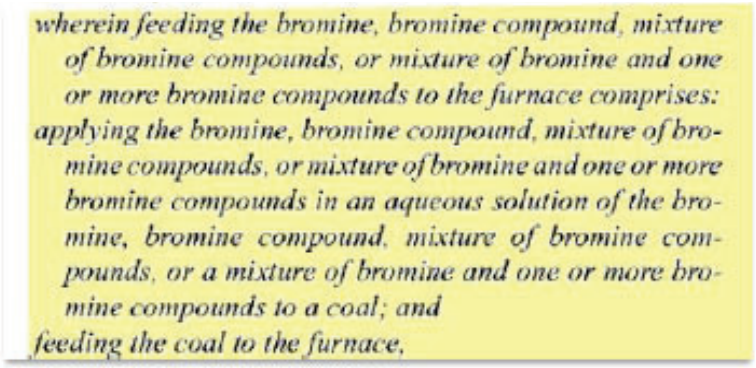
18. A process for removing mercury from mercury-containing flue gases of a furnace, comprising:

carrying out a combustion or incineration process, within the furnace, in the presence of a sulphur compound;

feeding bromine, a bromine compound, a mixture of bromine compounds, or a mixture of bromine and one or more bromine compounds to at least one of the furnace

* * *

[2041] Ex. 1008 (Vosteen) at Claim 18.



wherein feeding the bromine, bromine compound, mixture of bromine compounds, or mixture of bromine and one or more bromine compounds to the furnace comprises:
applying the bromine, bromine compound, mixture of bromine compounds, or mixture of bromine and one or more bromine compounds in an aqueous solution of the bromine, bromine compound, mixture of bromine compounds, or a mixture of bromine and one or more bromine compounds to a coal; and
feeding the coal to the furnace.

13. Claim 15: "The method of claim 1, wherein the coal is combusted in the combustion chamber at a coal-combustion facility, wherein the Br2, HBr, bromide compound, or combination thereof, is added to the coal before the coal enters the combustion chamber, wherein the addition of the Br2, HBr, bromide compound, or combination thereof, to the coal is performed at the coal-combustion facility."

1292. Vosteen and Granite disclose this claim element. Both Vosteen and Granite disclose that their methods for mercury control are applicable at coal-combustion facilities.[2042]

1293. The language of this claim element includes elements that are similar to those in claim 13 and 1. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

14. Claim 17: "The method of claim 1, wherein the combustion chamber is an electric utility coal combustion chamber."

[2042] Ex. 1008 (Vosteen) at 1:4-21; Ex. 2003 (Granite 2000) at 1026.

1294. Vosteen and Granite disclose this claim element. Both Vosteen and Granite disclose that their methods for mercury control are applicable in an electric utility coal-combustion chamber.[2043]

15. Claim 18: "The method of claim 1, further comprising: measuring mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content, an injection rate of injecting the sorbent comprising activated carbon into the mercury-containing gas."

1295. The language of this claim element includes elements that are similar to those in claim 8. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

16. Claim 19: "The method of claim 1, wherein the mercury-containing gas comprises about 1 g to about 30 g of the element bromine per 100 g of the sorbent."

1296. The language of this claim element includes elements that are similar to those in claim 5. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

17. Claim 21: "The method of claim 1, wherein the sorbent in the mercury-containing gas comprises about 1 g to about 30 g of the added Br2, HBr, the bromide compound, or a combination thereof, per 100 g of the sorbent."

[2043] Ex. 1008 (Vosteen) at 1:4-21, 4:6-23; Ex. 2003 (Granite 2000) at 1026.

1297. The language of this claim element includes elements that are similar to those in claim 5. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

18. Claim 22: "The method of claim 1, wherein the Br2, HBr, or the bromide compound is contacted with the sorbent in vapor form, gaseous form, liquid form, or in an organic solvent."

1298. Vosteen renders this claim obvious. Vosteen discloses mixing bromide compounds in with the coal or added to the combustion furnace:

> The bromine compound, for example, sodium bromide, can be added in solid form, for example as salt, or in 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 a pyrolysis drum, which serves, for example, for the thermal breakdown of co-incinerated waste materials, or to a coal mill. The compound can also be fed during the combustion process. If the furnace comprises a plurality of stages, for example a primary and a secondary furnace, the bromine compound can be introduced, likewise in solid or liquid form, into one or both combustion chambers, for example into the rotary kiln and/or the afterburning chamber. Preferably, an aqueous solution of the compound is sprayed into one of the combustion chambers.[2044]

1299. Vosteen discloses that mercury containing gas results from high temperature processes such as combustion in power plants and waste incineration plants.[2045]

[2044] Ex. 1008 (Vosteen) at 4:4-19; *see also id.* at 2:54-3:2, 3:66-4:33, 6:65-7:32.

[2045] Ex. 1008 (Vosteen) at 1:66-2:1; *see also, id*. at 1:10-22.

1300. The language of this claim element includes elements that are similar to those in claim 1b. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

19. Claim 23: "The method of claim 1, wherein the sorbent injected into the mercury-containing gas is a sorbent obtained by contacting a base sorbent with a halogen or halide promoter prior to injection of the sorbent to the mercury-containing gas."

1301. ME2C did not provide infringement contentions for this claim. ME2C's infringement contentions cross reference claim 14 of the '114 patent. ME2C's infringement contentions do not include claim 14 of the '114 patent. ME2C's final contentions hew to this position, and thus ME2C is apparently not asserting this claim. Therefore, no analysis regarding this element is required.

20. Claim 24: "The method of claim 1, wherein the sorbent injected into the mercury-containing gas is free of contact with a halogen or halide promoter prior to injection of the sorbent into the mercury-containing gas."

1302. ME2C did not provide infringement contentions for this claim. ME2C's infringement contentions cross reference claim 13 of the '114 patent. ME2C's infringement contentions do not include claim 13 of the '114 patent. ME2C's final contentions hew to this position, and thus ME2C is apparently not asserting this claim. Therefore, no analysis regarding this element is required.

21. Claim 25: "The method of claim 1, wherein the injection of the sorbent into the mercury-containing gas occurs upstream of a particulate separator or a scrubber."

1303. Vosteen, either alone or in combination with Granite, anticipates or renders obvious this limitation. As described above, Vosteen discloses injecting activated carbon into a mercury-containing flue gas downstream of the combustion chamber and contacting mercury with the sorbent to form a mercury/sorbent composition. Vosteen discloses activated carbon as a sorbent. Vosteen further specifies "granulated activated carbon" as the sorbent.[2046] A person of skill in the art would have recognized that "granular" activated carbon and "granulated" activated carbon are two words for the same material.

1304. Alternatively, it would have been obvious to a person of skill in the art to use the teachings of Vosteen concerning the use of a bromine additive with a flue gas control system typical of a coal burning power plant.[2047] Granite explains that control technologies for removing mercury from flue gas include scrubbing solutions and activated carbon sorbents.[2048] Granite also discloses a number of different types of activated carbon. A POSITA would understand that a sorbent would need to be added upstream of the scrubber or particulate control system to be useful for removal of adsorbed mercury.[2049]

[2046] Ex. 1008 (Vosteen) at 5:24-25.

[2047] See Ex. 1008 (Vosteen) at 7:25-32.

[2048] Ex. 2003 (Granite 2000) at 1020, 1022, 1024, 1026.

[2049] See also, Ex. 1038 (Granite-1998) at 4.

22. Claim 26: "The method of claim 25, wherein the particulate separator comprises an electrostatic precipitator, a baghouse, a fabric filter, or a combination thereof."

1305. The language of this claim element includes elements that are similar to those in claim 25. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

C. INDEPENDENT CLAIM 29

1. Claim 29: Element 29a: "A method of separating mercury from a mercury-containing gas, the method comprising:"

1306. Vosteen discloses the preamble. The title of Vosteen is, "Process for removing mercury from flue gases."[2050] Flue gas is an example of a mercury-containing gas, and "removing mercury" refers to separating the mercury from a mercury-containing gas. Vosteen describes "removal of mercury from the flue gases in a flue gas emission control system downstream of the combustion," in plants such as "power stations, for example bituminous coal-fired or lignite-fired power stations.[2051] Claim 1 of Vosteen also discloses the preamble, as shown in the highlighting below:[2052]

2050 Ex. 1008 (Vosteen) at Title.

2051 Ex. 1008 (Vosteen) at 2:16-20, 2:35-37.

2052 Ex. 1008 (Vosteen) at Claim 1.

1. Process for removing mercury from mercury-containing flue gases of a furnace within which a combustion or incineration is carried out, wherein

bromine, a bromine compound, a mixture of bromine compounds or a mixture of bromine and a bromine compound or compounds, is fed to the furnace or to the flue gas of the furnace in a plant section downstream of the furnace, or to both the furnace and the flue gas, the temperature during the first contact of the bromine or of said mixture with the flue gas being at least 500° C.,

the combustion or incineration is carried out in the presence of a sulphur compound,

and then the flue gas is subjected to a cleanup for removing mercury from the flue gas.

Subjecting flue gas "to a cleanup for removing mercury from the flue gas" refers to separating mercury from a mercury-containing gas. Claim 18 of Vosteen also discloses the preamble, as shown in the highlighting below.

18. A process for removing mercury from mercury-containing flue gases of a furnace, comprising:

carrying out a combustion or incineration process, within the furnace, in the presence of a sulphur compound;

feeding bromine, a bromine compound, a mixture of bromine compounds, or a mixture of bromine and one or more bromine compounds to at least one of the furnace or a flue gas of the furnace in a plant section downstream from the furnace, a temperature at first contact of the bromine, bromine compound, mixture of bromine compounds, or mixture of bromine and one or more bromine compounds with the mercury-containing flue gas being at least 800° C.; and

subjecting the mercury-containing flue gas to a cleanup for substantially removing mercury from the mercury-containing flue gas, wherein the cleanup for substantially removing mercury from the mercury-containing flue gas includes a dry cleanup stage comprising at least one sorbent, and

2. Claim 29: Element 29b: "combusting coal in a combustion chamber, wherein"

1307. The language of this claim element is identical to that of claim 1b. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

3. Claim 29: Element 29c: "the coal comprises added Br2, HBr, bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber, or the combustion chamber comprises added Br2, HBr, bromide compound, or a combination thereof, or a combination thereof; and"

1308. The language of this claim element is identical to that of claim 1b. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

4. Claim 29: Element 29d: "collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon."

1309. The language of this claim element is identical to that of claim 1c. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

D. INDEPENDENT CLAIM 30

1. Claim 30: Element 30a: "A method of separating mercury from a mercury-containing gas, the method comprising:"

1310. The language of this claim element is identical to that of claim 29. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

2. Claim 30: Element 30b: "combusting coal in a combustion chamber, to provide the mercury-containing gas, wherein the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br−, or a combination thereof, wherein"

1311. The language of this claim element is identical to that of the first portion of claim element 29b and contains elements of claim 23. Accordingly, the explanation I provide above for those claims applies equally to these claim elements.

1312.

3. Claim 30: Element 30c: "the coal comprises added Br2, HBr, bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber, or the combustion chamber comprises added Br2, HBr, bromide compound, or a combination thereof, or a combination thereof"

1313. The language of this claim element is identical to that of claims 13 and 14, and contains elements of claim 1b. Accordingly, the explanation I provide above for those claims applies equally to these claim elements.

4. Claim 30: Element 30d: "collecting mercury in the mercury-containing gas with a sorbent added to the mercury-containing gas, the sorbent comprising activated carbon;"

1314. The language of this claim element is identical to that of claims 1(c) and 29(d). Accordingly, the explanation I provide above for those claims applies equally to these claim elements.

5. Claim 30: Element 30e: "separating the sorbent contacted with the mercury from the mercury-containing gas;"

1315. The language of this claim element is identical to that of claims 1c and 29d. Accordingly, the explanation I provide above for those claims applies equally to these claim elements.

6. Claim 30: Element 30f: "measuring the mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content of the mercury-containing gas, an injection rate of injecting the sorbent into the mercury-containing gas, an amount of the Br2, HBr, bromide compound, or a combination thereof, added to the coal or the combustion chamber, or a combination thereof."

1316. The language of this claim element is similar to that of claims 8 and 18. Accordingly, the explanation I provide above for those claims applies equally to these claim elements.

XLII. GROUND X: OBVIOUSNESS OF THE '430 PATENT OVER SJOSTROM IN VIEW OF ECKBERG

1317. It is my opinion that Sjostrom in view of Eckberg render obvious each of claims 1-4, 6- 8, 10-25, 28-29 of the '430 Patent.

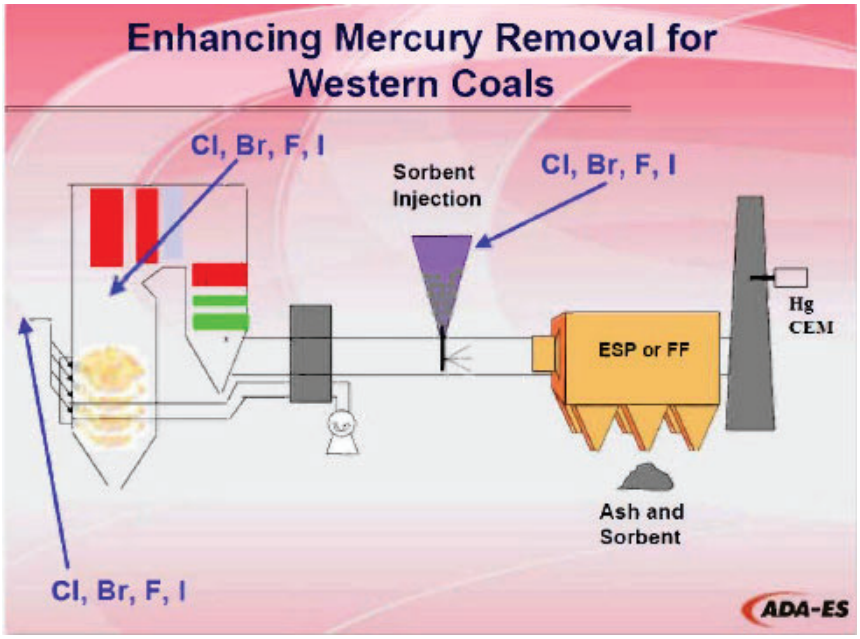
A. INDEPENDENT CLAIM 28

1. Claim 28: Element 28(a): "A method of separating mercury from a mercury-containing as [sic], the method comprising:"

1318. The preamble is disclosed by Sjostrom. Sjostrom teaches separating mercury from a mercury-containing gas. The title of Sjostrom is "Full Scale Evaluations of ***Mercury Control Technologies*** with PRB Coals."[2053] Specifically,

[2053] Ex. 1010 (Sjostrom) at 1 (emphasis added).

Sjostrom described various mercury control tests conducted at coal-fired power plants.[2054] Sjostrom described testing mercury removal from flue gas of coal-fired power plants involving sorbent injection and halogen addition, as detailed below.[2055]

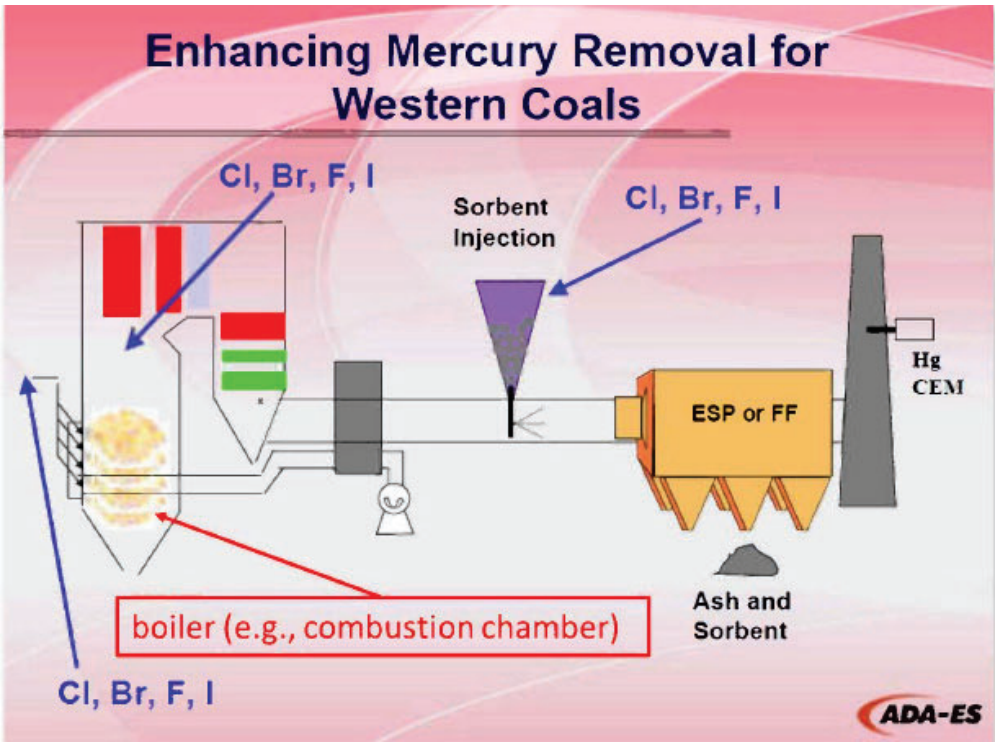


Sjostrom includes numerous charts detailing the "Hg Removal (%)" and "Hg Removal Efficiency (%)" achieved throughout the testing performed on coal flue gas.[2056] This annotated figure in Sjostrom specifically shows that particulate matter, including the mercury-sorbent composition, would have been separated from the flue gas by the ESP or FF, because a POSITA would have understood that it was well-known to use an ESP or FF to remove such solid materials.[2057]

2054 Ex. 1010 (Sjostrom) at 12, 18.
2055 Ex. 1010 (Sjostrom) at 4.
2056 Ex. 1010 (Sjostrom) at 8, 15-17, 20, and 21.
2057 State of the Art, § XII.B.5.a

2. Claim 28: Element 28(b): "combusting coal in a combustion chamber, to provide the mercury-containing gas, wherein the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br−, or a combination thereof, wherein"

1319. This limitation is disclosed by Sjostrom. This limitation is also obvious over Sjostrom in view of Eckberg. As discussed above, Sjostrom described various mercury control tests conducted at coal-fired power plants.[2058] These plants combustion of coal in a coal-fired boiler (e.g., combustion chamber) as shown in the annotated figure below.[2059]



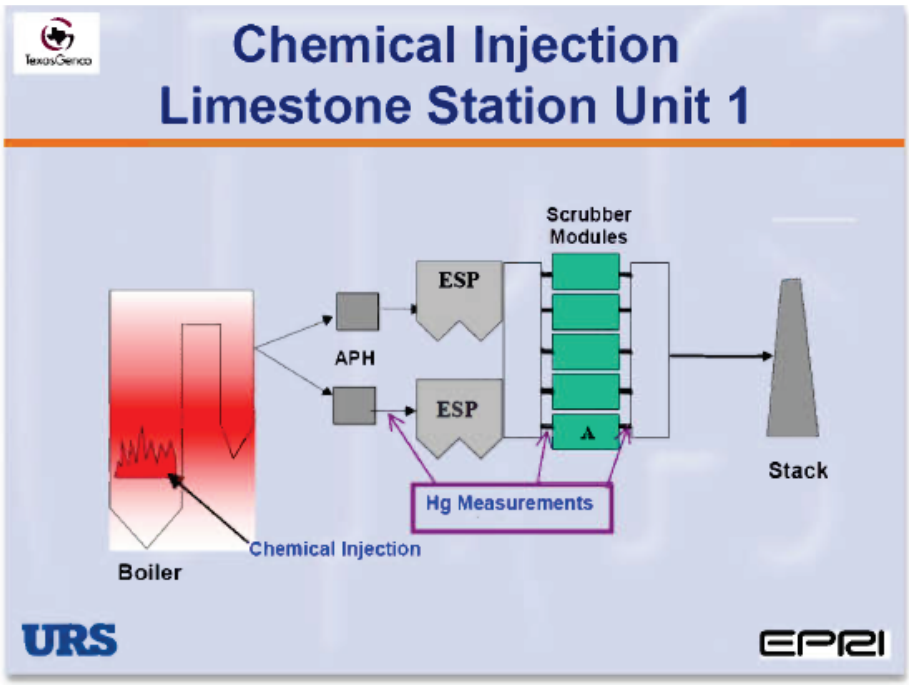
2058 Ex. 1010 (Sjostrom) at 12, 18.

2059 Ex. 1010 (Sjostrom) at 4 (annotations in red).

A POSITA would have understood that this unit was a boiler based on the image used to represent the unit in the drawing, which was a common and routine way to represent a coal-combustion chamber (boiler). Sjostrom explains that at the time of testing, both of the coal-fired power plants tested combusted PRB (Powder River Basin) coal having a mercury content of "0.04 — 0.1 ppm-dry.[2060] Relying only on existing equipment at these plants, Sjostrom shows that the outlet mercury content of the flue gas was 11.2 µg/dncm.[2061] Thus, Sjostrom discloses combusting coal in a combustion chamber (e.g., boiler) to form a mercury containing flue gas stream.

1320. To the extent that Sjostrom is found to not explicitly disclose a combustion chamber that is a boiler, Eckberg discloses this limitation. As shown in the figure below, Eckberg explicitly describes combusting coal in a boiler.[2062]

2060 Ex. 1010 (Sjostrom) at 12, 18.
2061 Ex. 1010 (Sjostrom) at 3.
2062 Ex. 1011 (Eckberg) at 5.



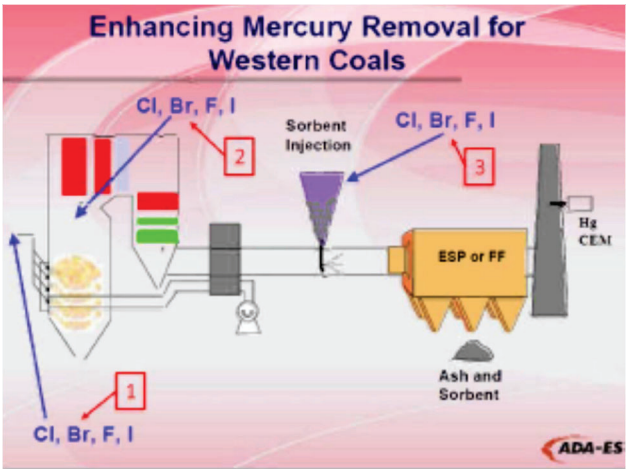
The image in Eckberg identified as a "boiler" is substantially similar to the image found in Sjostrom. Thus, Sjostrom in view of Eckberg discloses combusting coal in a combustion chamber (e.g., boiler) to form a mercury containing flue gas stream.

3. Claim 28: Elements 28(c)-(e): "the coal comprises an additive comprising Br2, HBr, a bromide compound, or a combination thereof, wherein the additive is added to the coal before the coal enters the combustion chamber, or the combustion chamber comprises an additive comprising Br2, HBr, a bromide compound, or a combination thereof, or a combination thereof,"

1321. This limitation is disclosed by Sjostrom. This limitation is also obvious over Sjostrom in view of Eckberg.

1322. This limitation is disclosed by Sjostrom, and obvious over Sjostrom in view of Eckberg under either interpretation. Sjostrom described testing mercury removal from flue gas of coal-fired power plants involving sorbent injection,

halogen injection, and both sorbent and halogen injection.[2063] Specifically, the annotated figure below shows that Sjostrom teaches injection of bromine in at least three locations throughout the coal power process."[2064]



Addition Location 1 of Sjostrom renders obvious injecting bromine upstream of the combustion chamber, such as by adding it to the coal entering the boiler.[2065] Addition Location 2 of Sjostrom discloses injecting bromine into the boiler.[2066] Location 3 of Sjostrom discloses adding bromine to the mercury sorbent that is injected into the flue gas.[2067]

1323. A POSITA would have found it obvious that the "Br" of Sjostrom would be a widely available bromine-containing material, such as HBr or an aqueous solution of a bromide salt, such as CaBr2, for Addition Location 1 and Addition

2063 Ex. 1010 (Sjostrom) at 4.
2064 Ex. 1010 (Sjostrom) at 4 (annotations in red).
2065 Ex. 1010 (Sjostrom) at 4 (annotations in red).
2066 Ex. 1010 (Sjostrom) at 4 (annotations in red).
2067 Ex. 1010 (Sjostrom) at 4 (annotations in red).

Location 2. Further, Sjostrom teaches the addition of "KNX (Alstom Power)."[2068] KNX was a known aqueous solution of a bromide salt additive developed for enhanced mercury control. A POSITA would have found it obvious that an aqueous bromide salt solution, such as $CaBr_2$, would dissociate to form Br^- ions. As discussed above, Addition Location 1 of Sjostrom renders obvious adding bromine-containing species upstream of the combustion chamber, such as by adding it to the coal entering the boiler.[2069] Thus, Sjostrom renders obvious wherein the coal comprises added Br_2, HBr, Br^-, or a combination thereof, added to the coal upstream of the combustion chamber.

1324. As discussed above, Addition Location 2 of Sjostrom teaches adding bromine-containing species into the combustion chamber. [2070] Thus, Sjostrom discloses wherein the combustion chamber comprises added Br_2, HBr, Br^-, or a combination thereof, or a combination thereof. For at least this reason, Sjostrom discloses this limitation under the first, broader interpretation.

1325. A POSITA would have understood the "Br" addition of Sjostrom would also have entered the mercury-containing flue gas. Specifically, a POSITA would have understood the "Br" added at either Addition Location 1 before the combustion chamber or Addition Location 2 within the combustion chamber would

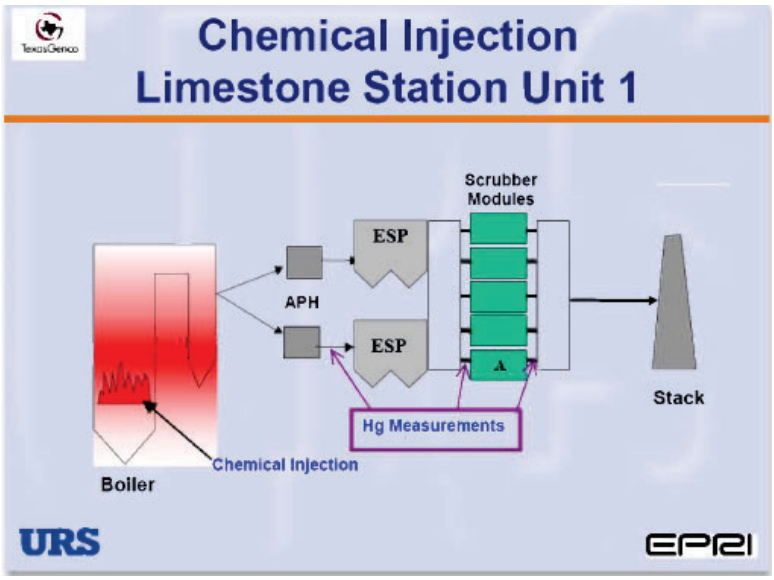
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2068 Ex. 1010 (Sjostrom) at 23.
2069 Ex. 1010 (Sjostrom) at 4 (annotations in red).
2070 Ex. 1010 (Sjostrom) at 4 (annotations in red).

have resulted in "Br" entering the flue gas stream. A POSITA would have found it obvious that the "Br" of Sjostrom could be an aqueous solution of a bromide salt, such as $CaBr_2$, for Addition Location 1 and Addition Location 2. Further, Sjostrom teaches the addition of "KNX (Alstom Power)" as the bromine-containing ingredient.[2071] KNX was a known aqueous solution of a bromide salt additives developed for enhanced mercury control. A POSITA would have found it obvious that an aqueous bromide salt solution, such as $CaBr_2$, would dissociate to form Br ions. A POSITA would have understood that at combustion temperatures found within the boiler, at least a portion of the Br^- ions injected at either Addition Location 1 or Addition Location 2 would have evaporated, leaving the boiler as HBr in the vapor phase. Thus, Sjostrom discloses wherein the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br, or a combination thereof.

1326. To the extent that Sjostrom does not explicitly identify the bromine-containing species, Eckberg teaches this limitation. As shown in the figure below, Eckberg teaches "chemical injection" to the boiler.[2072]

[2071] Ex. 1010 (Sjostrom) at 23.
[2072] Ex. 1011 (Eckberg) at 5.

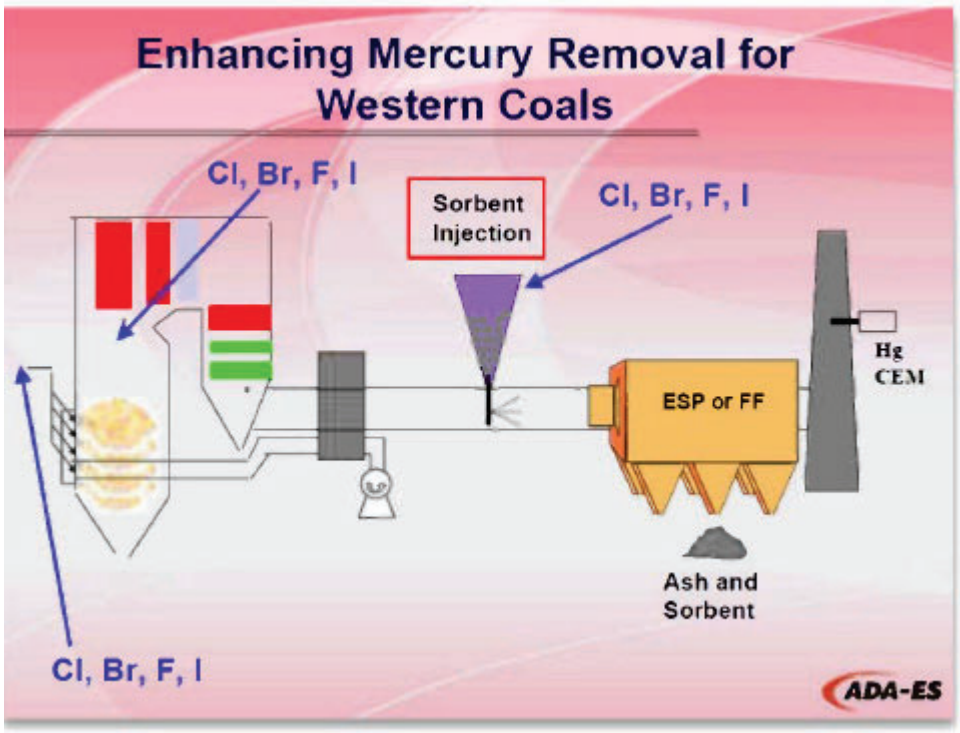


Specifically, Eckberg teaches injection of "$CaCl_2$ (25 wt%)" and "$CaBr_2$ (52 wt%)" into the boiler.[2073] A POSITA would have understood that calcium bromide was an example of a "bromide compound," and that a 52 wt% aqueous solution of $CaBr_2$ would have dissociated in water to form a quantity of Br^- ions. A POSITA would have found it obvious that an aqueous bromide salt solution, such as $CaBr_2$, would dissociate to form Br ions. A POSITA would have further understood the bromide ion (Br^-) added to the combustion chamber of Eckberg would also have entered the mercury containing flue gas. As described above in the "Reasons to Combine" section, a POSITA would have been motivated, and expected a reasonable chance of success, to apply the teachings of Eckberg (e.g., the injection of $CaBr_2$) to the combustion chamber of Sjostrom.

[2073] Ex. 1011 (Eckberg) at 9.

4. Claim 28: Elements 28(f): "injecting a sorbent comprising activated carbon into the mercury-containing gas downstream of the combustion chamber;"

1327. This limitation is disclosed by Sjostrom. As shown in the annotated figure below, Sjostrom described certain tests involving sorbent injection downstream of the boiler.[2074]



As shown in the above figure, the "Sorbent Injection" occurs downstream from a combustion chamber. Specifically, Sjostrom described testing performed with activated carbon injection, including injection of "DARCO FGD."[2075] A POSITA

2074 Ex. 1010 (Sjostrom) at 4 (annotations in red).
2075 Ex. 1010 (Sjostrom) at 10, 11, 16.

would have understood that DARCO FGD was a well-known type of activated carbon used for mercury capture.[2076]

5. Claim 28: Elements 28(g): "contacting mercury in the mercury-containing gas with the sorbent; and"

1328. The mercury in the flue gas is adsorbed, and thus contacted, with the sorbent to form a mercury/sorbent composition. A POSITA would have understood that Norit DARCO FGD and related materials were referred to as a "sorbent" specifically because they adsorbed (and thus contacted) materials in the gas phase. It was a well-known use of activated carbon for adsorbing and thus removing mercury from the flue-gas stream. Upon adsorption, the mercury and activated carbon in the flue gas would form a mercury/sorbent composition.[2077] Specifically, a POSITA would have understood that "sorbents" are used in a process called adsorption by which adsorbate (e.g., atoms, ions, or molecules) in a fluid (typically a gas) are bound to the surface of a sorbent, and thus by definition the sorbent is "contacting mercury in the mercury-containing gas," as per claim element 1(c).

1329. In addition, a person of skill in the art would have understood that the scope of a "mercury/sorbent composition" is broad enough to encompass a "mercury/sorbent/bromine" composition, because, for example, independent claim 25 of the '114 Patent recites a "mercury/sorbent composition" and its dependent

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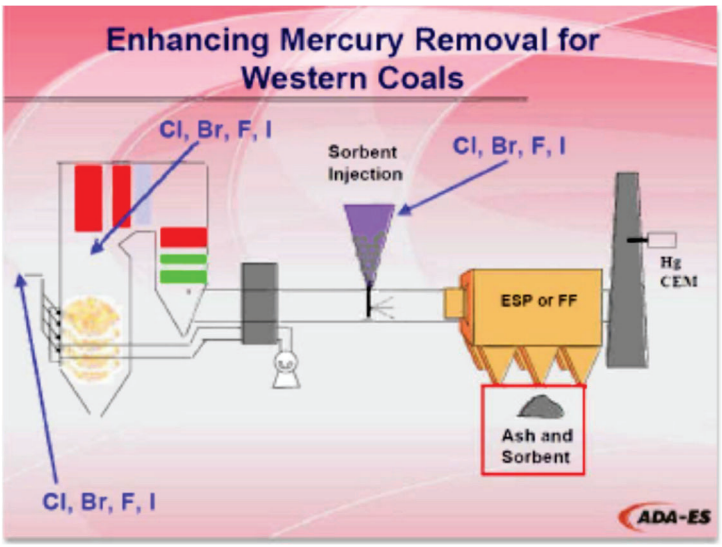
2076 See, e.g., State of the Art, Sections XII.C.3, XII.G.2.

2077 See, e.g., State of the Art, Sections XII.C.3, XII.G.2.

claim 30 recites that "the mercury/sorbent composition comprises the element bromine, the sorbent material, and mercury."[2078] Further, through enhanced reactivity between mercury and activated carbon because of the halogens (bromine), a POSITA would have known that the sorbent/halogen complex would have been referred to as a "promoted" sorbent.

6. Claim 28: Elements 28(h): "separating the sorbent contacted with the mercury from the mercury-containing gas."

1330. This limitation is disclosed by Sjostrom. As shown in the annotated figure below, Sjostrom describes passing the flue gas through an electrostatic precipitator (ESP) or fabric filter (FF) after the bromine and sorbent injection.[2079]



This annotated figure in Sjostrom specifically shows that the sorbent composition would have been removed by the ESP or FF. Further, a POSITA would have

2078 Ex. 1001 ('114 Patent) at Claims 25, 30.
2079 Ex. 1010 (Sjostrom) at 4 (annotations in red).

understood that it was well-known that the ESP or FF would have removed solid material, including the mercury/sorbent composition.[2080] Thus, Sjostrom teaches "separating the mercury/sorbent composition from the mercury-containing gas, to form a cleaned gas."

B. INDEPENDENT CLAIM 1

1. Claim 1: Preamble—"A method of separating mercury from a mercury-containing gas, the method comprising:"

1331. The language of the preamble of claim 1 is identical to the preamble of claims 28 and 29. Accordingly, the explanation I provide above for the preamble of claim 28 applies equally to the preamble of claim 1.

2. Claim 1: Element (1)(b)—"combusting coal in a combustion chamber, to provide the mercury-containing gas,"

1332. The language of claim element 1(b) is identical to the first portion of claim element 28(b) [which is identical to claim element 29(b)]. Accordingly, the explanation I provide above for those claim elements applies equally to claim element 1(b).

3. Claim 1: Element 1(c)—"the coal comprises an additive comprising Br2, HBr, a bromide compound, or a combination thereof, wherein the additive is added to the coal before the coal enters the combustion chamber, or"

[2080] State of the Art, § XII.B.5.a

1333. The language of claim element 1(c) is identical to the language of claim element 28(c) [which is identical to claim element 29(c)]. Accordingly, the explanation I provide above for those claim elements applies equally to claim element 1(c).

4. Claim 1: Element 1(d)—"the combustion chamber comprises an additive comprising Br2, HBr, a bromide compound, or a combination thereof or

1334. The language of claim element 1(d) is identical to the language of claim element 28(d) [which is identical to claim element 29(d)]. Accordingly, the explanation I provide above for those claim elements applies equally to claim element 1(d).

5. Claim 1: Element 1(e)—"a combination thereof;"

1335. The language of claim element 1(e) is identical to the language of claim element 28(e) [which is identical to claim element 29(e)]. Accordingly, the explanation I provide above for those claim elements applies equally to claim element 1(e).

6. Claim 1: Element 1(f)—"injecting a sorbent comprising activated carbon into the mercury-containing gas downstream of the combustion chamber;"

1336. The language of claim element 1(f) is identical to the language of claim element 28(f) [which is identical to the first portion of claim element 29(f)]. Accordingly, the explanation I provide above for those claim elements applies equally to claim element 1(b).

7. Claim 1: Element 1(g)—"contacting mercury in the mercury-containing gas with the sorbent; and"

1337. The language of claim element 1(g) is identical to the language of claim element 28(g) [which is identical to claim element 29(g)]. Accordingly, the explanation I provide above for those claim elements applies equally to claim element 1(g).

8. Claim 1: Element 1(h)—"separating the sorbent contacted with the mercury from the mercury-containing gas."

1338. The language of claim element 1(h) is identical to the language of claim element 28(h) [which is identical to claim element 29(h)]. Accordingly, the explanation I provide above for those claim elements applies equally to claim element 1(h).

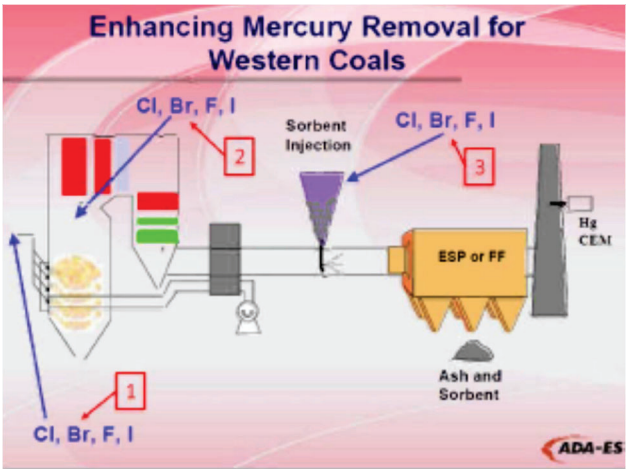
C. CLAIMS DEPENDING FROM CLAIM 1

1. Claim 2: "The method of claim 1, wherein the coal comprises the additive comprising the Br2, HBr, the bromide compound, or a combination thereof, wherein the additive is added to the coal before the coal enters the combustion chamber.

1339. This limitation is disclosed by Sjostrom. This limitation is also obvious over Sjostrom in view of Eckberg.

1340. This limitation is disclosed by Sjostrom, and obvious over Sjostrom in view of Eckberg under either interpretation. Sjostrom described testing mercury removal from flue gas of coal-fired power plants involving sorbent injection,

halogen injection, and both sorbent and halogen injection.[2081] Specifically, the annotated figure below shows that Sjostrom teaches injection of bromine in at least three locations throughout the coal power process."[2082]



Addition Location 1 of Sjostrom renders obvious injecting bromine upstream of the combustion chamber, such as by adding it to the coal entering the boiler.[2083] Addition Location 2 of Sjostrom discloses injecting bromine into the boiler.[2084] Location 3 of Sjostrom discloses adding bromine to the mercury sorbent that is injected into the flue gas.[2085]

1341. A POSITA would have found it obvious that the "Br" of Sjostrom would be a widely available bromine-containing material, such as HBr or an aqueous solution of a bromide salt, such as CaBr2, for Addition Location 1 and Addition

2081 Ex. 1010 (Sjostrom) at 4.
2082 Ex. 1010 (Sjostrom) at 4 (annotations in red).
2083 Ex. 1010 (Sjostrom) at 4 (annotations in red).
2084 Ex. 1010 (Sjostrom) at 4 (annotations in red).
2085 Ex. 1010 (Sjostrom) at 4 (annotations in red).

Location 2. Further, Sjostrom teaches the addition of "KNX (Alstom Power)."[2086] KNX was a known aqueous solution of a bromide salt additive developed for enhanced mercury control. A POSITA would have found it obvious that an aqueous bromide salt solution, such as $CaBr_2$, would dissociate to form Br^- ions. As discussed above, Addition Location 1 of Sjostrom renders obvious adding bromine-containing species upstream of the combustion chamber, such as by adding it to the coal entering the boiler.[2087] Thus, Sjostrom renders obvious wherein the coal comprises added Br_2, HBr, Br^-, or a combination thereof, added to the coal upstream of the combustion chamber.

1342. As discussed above, Addition Location 2 of Sjostrom teaches adding bromine-containing species into the combustion chamber. [2088] Thus, Sjostrom discloses wherein the combustion chamber comprises added Br_2, HBr, Br^-, or a combination thereof, or a combination thereof. For at least this reason, Sjostrom discloses this limitation under the first, broader interpretation.

1343. A POSITA would have understood the "Br" addition of Sjostrom would also have entered the mercury-containing flue gas. Specifically, a POSITA would have understood the "Br" added at either Addition Location 1 before the combustion chamber or Addition Location 2 within the combustion chamber would

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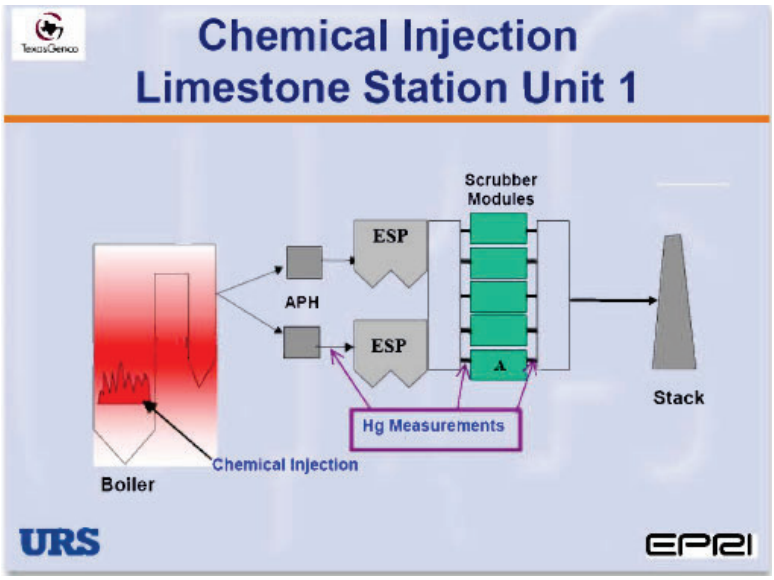
2086 Ex. 1010 (Sjostrom) at 23.
2087 Ex. 1010 (Sjostrom) at 4 (annotations in red).
2088 Ex. 1010 (Sjostrom) at 4 (annotations in red).

have resulted in "Br" entering the flue gas stream. A POSITA would have found it obvious that the "Br" of Sjostrom could be an aqueous solution of a bromide salt, such as $CaBr_2$, for Addition Location 1 and Addition Location 2. Further, Sjostrom teaches the addition of "KNX (Alstom Power)" as the bromine-containing ingredient.[2089] KNX was a known aqueous solution of a bromide salt additives developed for enhanced mercury control. A POSITA would have found it obvious that an aqueous bromide salt solution, such as $CaBr_2$, would dissociate to form Br ions. A POSITA would have understood that at combustion temperatures found within the boiler, at least a portion of the Br^- ions injected at either Addition Location 1 or Addition Location 2 would have evaporated, leaving the boiler as HBr in the vapor phase. Thus, Sjostrom discloses wherein the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br, or a combination thereof.

1344. To the extent that Sjostrom does not explicitly identify the bromine-containing species, Eckberg teaches this limitation. As shown in the figure below, Eckberg teaches "chemical injection" to the boiler.[2090]

[2089] Ex. 1010 (Sjostrom) at 23.

[2090] Ex. 1011 (Eckberg) at 5.



Specifically, Eckberg teaches injection of "$CaCl_2$ (25 wt%)" and "$CaBr_2$ (52 wt%)" into the boiler.[2091] A POSITA would have understood that calcium bromide was an example of a "bromide compound," and that a 52 wt% aqueous solution of $CaBr_2$ would have dissociated in water to form a quantity of Br^- ions. A POSITA would have found it obvious that an aqueous bromide salt solution, such as $CaBr_2$, would dissociate to form Br ions. A POSITA would have further understood the bromide ion (Br^-) added to the combustion chamber of Eckberg would also have entered the mercury containing flue gas. As described above in the "Reasons to Combine" section, a POSITA would have been motivated, and expected a reasonable chance of success, to apply the teachings of Eckberg (e.g., the injection of $CaBr_2$) to the combustion chamber of Sjostrom.

[2091] Ex. 1011 (Eckberg) at 9.

2. Claim 3: "The method of claim 1, wherein the combustion chamber comprises the additive comprising the Br2, HBr, the bromide compound, or a combination thereof."

1345. This limitation is disclosed by Sjostrom. As discussed above for claim element 1(b), Sjostrom discloses wherein the combustion chamber comprises added Br_2, HBr, Br–, or a combination thereof. A POSITA would have understood that bromine-containing species was a known halogen or halide promoter. [2092]Thus, Sjostrom discloses wherein the combustion chamber comprises the additive comprising the Br2, HBr, the bromide compound, or a combination thereof.

3. Claim 4: "The method of claim 1, wherein the coal is combusted in the combustion chamber at a coal-combustion facility, wherein the additive comprising the Br2, HBr, bromide compound, or combination thereof, is added to the coal before the coal enters the combustion chamber, wherein the addition of the additive comprising the Br2, HBr, bromide compound, or combination thereof, to the coal is performed at the coal-combustion facility."

1346. The language in claim 4 is comparable to the language in claim element 28(c). Accordingly, the explanation I provide above for that claim element applies equally to claim 4.

4. Claim 6: "The method of claim 1, wherein the combustion chamber is an electric utility coal combustion chamber."

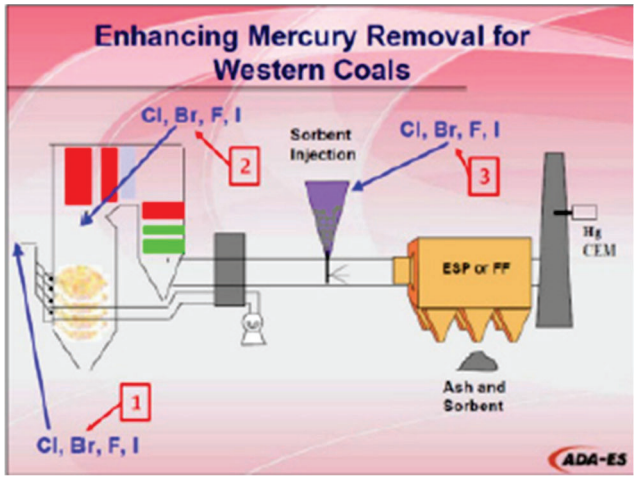
[2092] *See, e.g.,* State of the Art, Sections XII.C.3, XII.G.2.

1347. Sjostrom discloses the combustion chamber is an electric utility coal combustion chamber. Sjostrom discloses that testing was performed at "Sunflower Electric Holcomb Station PRB Coal SDA/FF," an electric utility.[2093]

5. Claim 7: "The method of claim 1, wherein the combustion chamber is a coal combustion furnace."

1348. Sjostrom discloses this claim element. The explanation I provide above for claims 4 and 6 are equally applicable to claim 7.

1349. Sjostrom discloses the combustion chamber is a coal combustion furnace at Addition Location 2.[2094]



6. Claim 8: "The method of claim 1, wherein the coal comprises a subbituminous coal."

1350. This limitation is disclosed by Sjostrom. Sjostrom described using coal that included subbituminous coal.[2095]

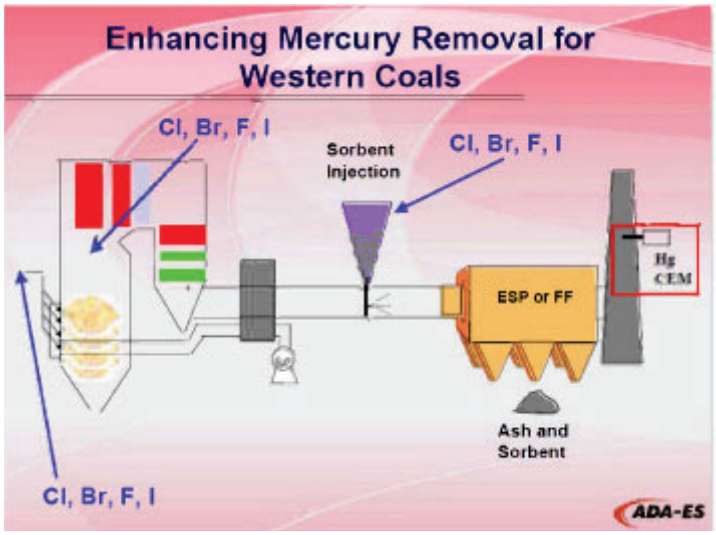
2093 Ex. 1010 (Sjostrom) at 1.

2094 Ex. 1010 (Sjostrom) at 1, 4.

2095 Ex. 1010 (Sjostrom) at 3.

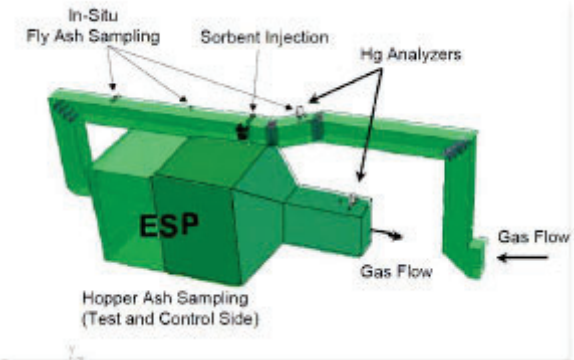
7. Claim 10: "The method of claim 1, further comprising measuring the mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content of the mercury-containing gas, an injection rate of injecting the sorbent into the mercury-containing gas, an amount of the Br_2, HBr, the bromide compound, or a combination thereof, added to the coal or the combustion chamber, or a combination thereof."

1351. This limitation is disclosed by Sjostrom. As shown in the annotated figure below, Sjostrom describes passing the treated flue gas through a stack with an attached Hg CEM (continuous emissions monitor) attached.[2096]

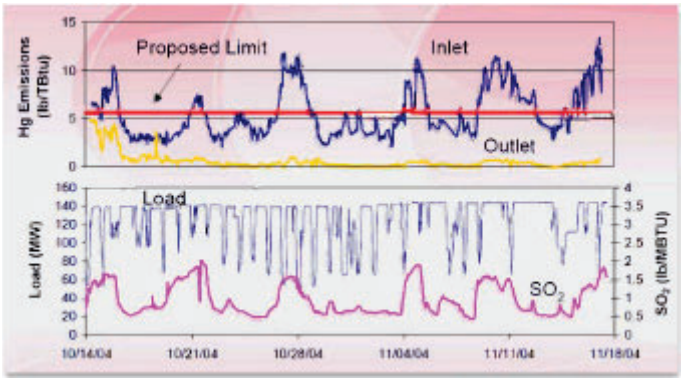


Further, Sjostrom discusses taking Hg measurements at both the inlet and outlet of the ESP as shown below.[2097]

2096 Ex. 1010 (Sjostrom) at 4 (annotations in red).
2097 Ex. 1010 (Sjostrom) at 19.



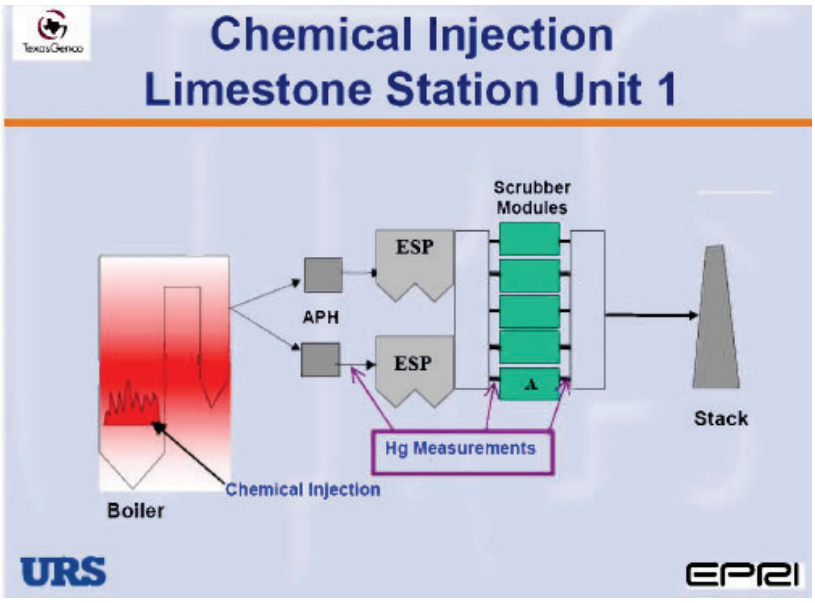
Sjostrom includes the chart showing the Hg emissions as measured at the inlet and outlet of the ESP.[2098]



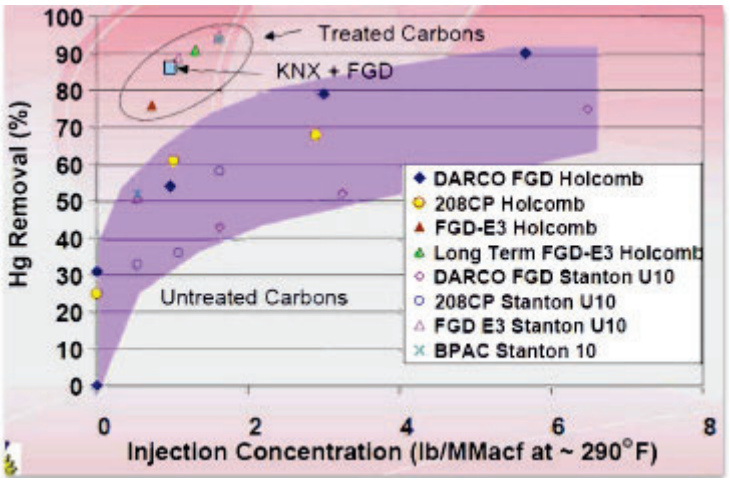
1352. As shown in the figure below, and similar to Sjostrom, Eckberg also describes testing the mercury removal effects of halogen injection directly into a coal-fired boiler.[2099]

[2098] Ex. 1010 (Sjostrom) at 22.

[2099] Ex. 1011 (Eckberg) at 5.

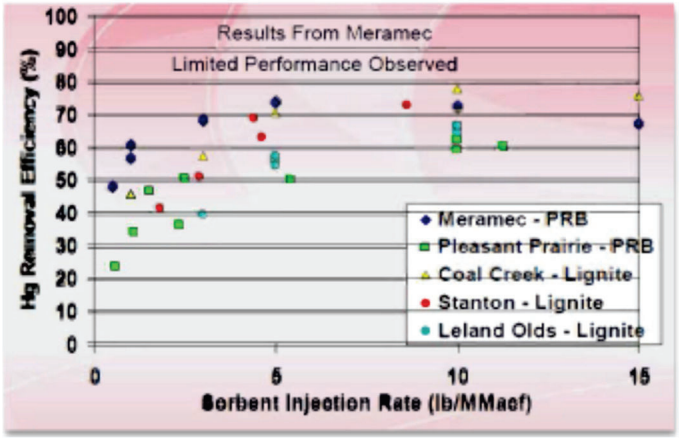


1353. Sjostrom includes numerous charts of measured mercury removals for various injection rates of activated-carbon sorbents. For example, the below chart shows the effects of activated carbon injection rates for testing using the system of Sjostrom.[2100]



2100 Ex. 1010 (Sjostrom) at 16.

Similarly, the below chart shows the effects of activated carbon injection rates for testing using the system of Sjostrom.[2101]



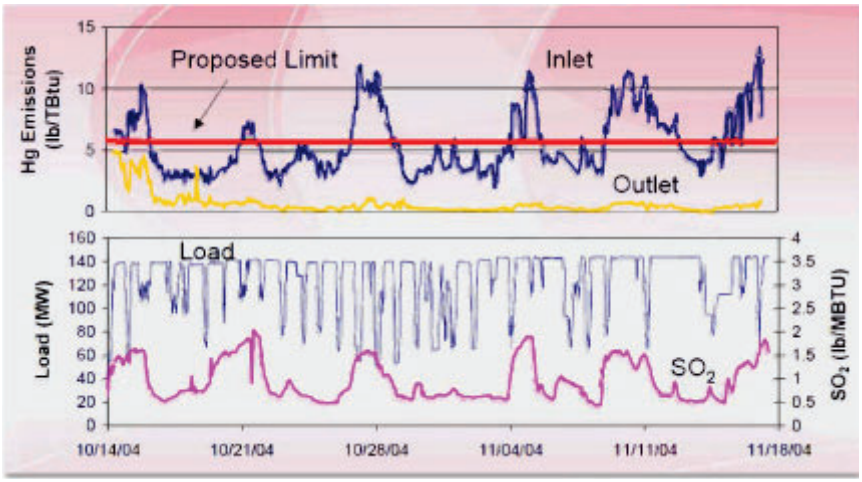
1354. The fact that there is a graph that has datapoints for different sorbent injection rates (the independent variable) and associated Hg removal percentages (the dependent variable) means that a POSITA would have understood that there is a relationship between the Hg removal % and the sorbent injection rate. Given that, and a target Hg removal rate, a POSITA would have understood that the sorbent injection rate would be adjusted to result in a target removal %.

1355. As discussed previously, a POSITA would have known that activated carbon was expensive, especially relative to costs of components such as "Br" in the form of HBr or an aqueous bromide salt solution. Thus, a POSITA would have been motivated to maintain the sorbent injection rate at the minimum level necessary to reach the desired level of mercury emissions. A POSITA viewing the charts of

[2101] Ex. 1010 (Sjostrom) at 20.

Sjostrom showing mercury removal versus sorbent injection rate would have been motivated to use the charts to control the sorbent injection rate at a level that minimized costs while reaching mercury removal targets. Thus, Sjostrom discloses modifying, in response to the measured mercury content, an injection rate of the sorbent into the mercury-containing gas, the amount of additive in the mixture, or a combination thereof.

1356. The below figure from Sjostrom shows that the testing focused on a "Proposed Limit.[2102]



Thus, Sjostrom teaches maintaining the mercury content of the cleaned gas "at or below a desired level" (e.g., the 'Proposed Limit."). A POSITA would have been motivated to control the activated carbon injection rate to reach this desired level while minimizing the amount of activated carbon injected. A POSITA would have understood that injecting too much activated carbon

[2102] Ex. 1010 (Sjostrom) at 22.

would have increased the costs of the mercury removal process and injecting too little activated carbon may lead to mercury emissions rising above actionable levels.

1357. Eckberg also suggest further testing to balance the amount of additive injection to limit effects such as boiler corrosion and air heater plugging.[2103]

1358.

8. Claim 11: "The method of claim 10, wherein the measuring of the mercury content comprises continuous measurement."

1359. ME2C did not provide infringement contentions for this claim. ME2C's infringement contentions cross reference claim 24 of the '225 patent. ME2C's infringement contentions do not include claim 24 of the '225 patent. ME2C's final contentions hew to this position, and thus ME2C is apparently not asserting this claim. Therefore, no analysis regarding this element is required.

9. Claim 12: "The method of claim 1, further comprising: modifying, in response to a measured mercury content, an injection rate of injecting the sorbent into the mercury-containing gas, an amount of the Br2, HBr, the bromide compound, or a combination thereof, added to the coal or the combustion chamber, or a combination thereof."

[2103] Ex. 1011 (Eckberg) at 16.

1360. The language of claim 12 is substantially identical to the language of claim 10. Accordingly, the explanation I provide above for claim 10 applies equally to claim 12.

10. Claim 13: "The method of claim 1, wherein the mercury-containing gas comprises about 1 g to about 30 g of the element bromine per 100 g of the sorbent."

1361. This limitation is obvious over Sjostrom in view of Eckberg. Claim 13 is merely an attempt to claim the optimum or workable range for a process of combining a particular conventional halogen (bromine) being used in a conventional way (halogens are inherent to coal, and both oxidize mercury and promote activated carbon) with a conventional sorbent (activated carbon). Nothing about the particular range of 1 g to about 30 g of the halide promoter per 100 g of the sorbent would lead to an unexpected result from what was already known to one of skill in the art.

1362. As described in the State of the Art,[2104] it was known that the saturation limit of activated carbon for bromine (i.e., how much bromine the activated carbon can actually adsorb at equilibrium), was up to 31 to 38 grams per 100 grams of activated carbon. Given the residence times in flue gas, and other inefficiencies, a person of ordinary skill in the art would have understood that the actual bromine loaded onto activated carbon would have been less than the saturation limit.

[2104] State of the Art, § XII.C.3.

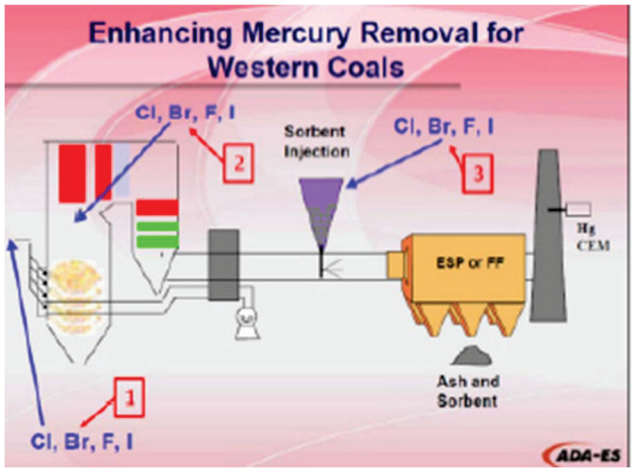
1363. A person of ordinary skill in the art would have recognized that there would be sufficient bromine in the flue gas, according to Sjostrom's processes, to provide a ratio of between 1 g to 30 g of bromine per 100 g of activated carbon. For example, Sjostrom teaches mercury-removal results similar to Eckberg, using an injection rate of 1 lb/MMacf activated carbon (FGD) at 290 °F in connection with an unspecified quantity of KNX (bromine)[2105] Eckberg discloses a bromine concentration in the flue gas for a nearly identical system was 48 ppm or 50 ppm that results in "81% overall removal" of mercury.[2106] A person of ordinary skill in the art would have been motivated to take advantage of the saturation limits of activated carbon, and seek to load the activated carbon with up to nearly its saturation limit, because it was known in the art that halides "improve[d] 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."[2107]

1364. Through routine process optimization and routine experimentation, a person of ordinary skill in the art would have adjusted the bromine injection rate and/or activated carbon injection rate to achieve an additive on the activated-carbon sorbent from about 1 g to about 30 g.

2105 Ex. 1010 (Sjostrom) at 16.
2106 Ex. 1011 (Eckberg) at 9, 14.
2107 Ex. 1062 (Crocker) at 2-3.

11. Claim 14: "The method of claim 1, wherein the sorbent contacted with the mercury comprises the element bromine and mercury."

1365. This limitation is disclosed by Sjostrom. For instance, Sjostrom discloses adding "Br" to the combustion chamber at Addition Location 2, before the combustion chamber at Addition Location 1, or at the sorbent injection device at Addition Location 3, where the sorbent comprises Br and PAC, as annotated below:[2108]

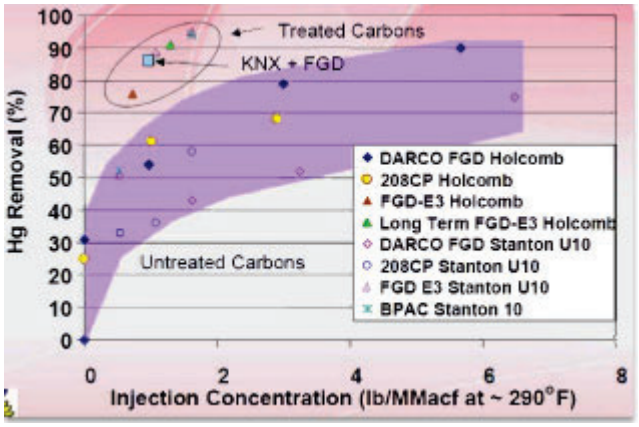


12. Claim 15: "The method of claim 1, comprising removing greater than 70 wt % of the mercury in the mercury-containing gas."

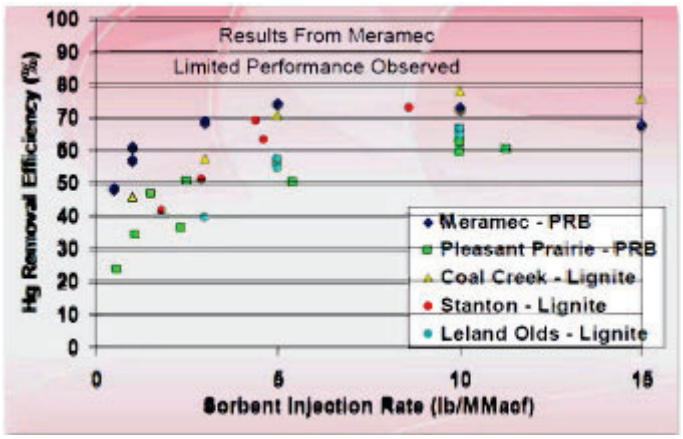
1366. This limitation is disclosed by Sjostrom. Sjostrom includes numerous charts showing greater than 70 % removal of mercury from the flue gas. For

[2108] Ex. 1010 (Sjostrom) at 4.

example, the below chart shows the mercury removal from testing at a plant using the system of Sjostrom.[2109]



Similarly, the below chart shows the mercury removal from testing at a plant using the system of Sjostrom.[2110]



13. Claim 16: "The method of claim 1, comprising removing greater than 70 wt % of the mercury in the mercury-containing gas with the sorbent."

2109 Ex. 1010 (Sjostrom) at 16.

2110 Ex. 1010 (Sjostrom) at 20.

1367. The language of this claim element is substantially similar to that of claim 15. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

14. Claim 17: "The method of claim 1, wherein the sorbent in the mercury-containing gas comprises about 1 g to about 30 g of the added Br2, HBr, the bromide compound, or a combination thereof, per 100 g of the sorbent."

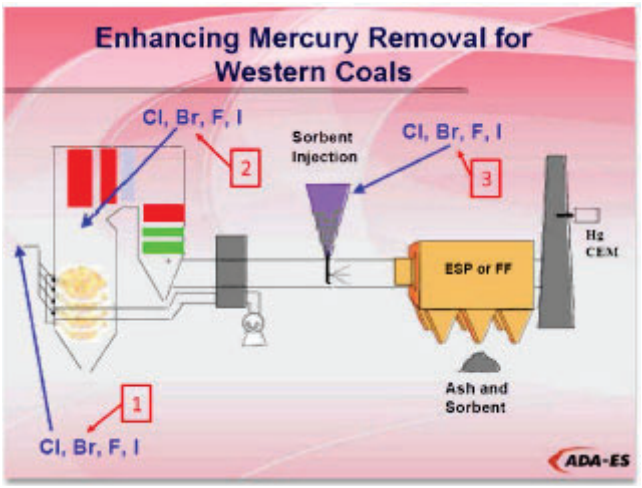
1368. The language of this claim element is substantially similar to that of claim 13. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

15. Claim 18: "The method of claim 1, wherein the Br2, HBr, or the bromide compound is contacted with the sorbent in vapor form, gaseous form, liquid form, or in an organic solvent."

1369. This limitation is obvious over Sjostrom in view of Eckberg. Sjostrom described testing mercury removal from flue gas of coal-fired power plants involving sorbent injection, halogen injection, and both sorbent and halogen injection.[2111] Specifically, the annotated figure below shows that Sjostrom teaches injection of bromine in at least three locations throughout the coal power process.[2112]

[2111] Ex. 1010 (Sjostrom) at 4.

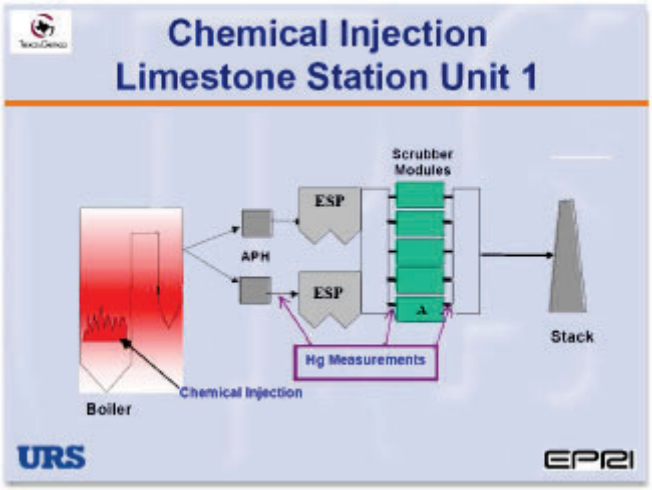
[2112] Ex. 1010 (Sjostrom) at 20



1370. Addition Location 1 of Sjostrom renders obvious injecting bromine upstream of the combustion chamber, such as by adding it to the coal entering the boiler.[2113] Addition Location 2 of Sjostrom discloses injecting bromine into the boiler.[2114] A POSITA would have found it obvious that the "Br" of Sjostrom could be a widely available bromine-containing material, such as HBr or an aqueous solution of a bromide salt, such as $CaBr_2$, for Addition Location 1 and Addition Location 2. Further, Sjostrom teaches the addition of "KNX (Alstom Power)."[2115] KNX was a known aqueous solution of a bromide salt additive developed for enhanced mercury control. A POSITA would have found it obvious that an aqueous bromide salt solution, such as $CaBr_2$, would dissociate to form Br^- ions.

2113 Ex. 1010 (Sjostrom) at 4 (annotations in red).
2114 Ex. 1010 (Sjostrom) at 4 (annotations in red).
2115 Ex. 1010 (Sjostrom) at 23.

1371. As shown in the figure below, Eckberg teaches "chemical injection" to the boiler.[2116]



1372. Specifically, Eckberg teaches injection of "$CaCl_2$ (25 wt%)" and "$CaBr_2$ (52 wt%)" into the boiler.[2117] Further, Eckberg explains that the $CaBr_2$ salt is injected at a "Liquid Salt Feed Rate (gpm)."[2118]

1373. A POSITA would have known that the Br injected in Sjostrom would have been in the form of an aqueous bromide salt solution as taught by Eckberg. A POSITA would have understood that at combustion temperatures found within the boiler, at least a portion of the Br^- ions injected at either Addition Location 1 or Addition Location 2 would have evaporated leaving the boiler as HBr in the vapor phase. Once the HBr reached the sorbent injection location, it would make contact with the injected sorbent.

2116 Ex. 1011 (Eckberg) at 5.
2117 Ex. 1011 (Eckberg) at 9.
2118 Ex. 1011 (Eckberg) at 9.

16. Claim 19: "The method of claim 1, wherein the activated carbon comprises powdered activated carbon, granular activated carbon, or a combination thereof."

1374. This limitation is disclosed by Sjostrom. Sjostrom repeatedly discusses the use of activated carbon.[2119] Further, Sjostrom includes test results of "Untreated PAC Injection into ESP" for "PRB and Lignite Coals."[2120] A POSITA would have known that PAC stood for "powdered activated carbon." Sjostrom also discusses testing done with the injection of "DARCO FGD" sorbent.[2121] A POSITA would have known that DARCO FGD was a well-known type of powdered activated-carbon sorbent.[2122]

17. Claim 20: "The method of claim 1, wherein the sorbent injected into the mercury-containing gas is a sorbent obtained by contacting a sorbent with a halogen or halide promoter prior to the injection of the sorbent into the mercury-containing gas."

1375. ME2C did not provide infringement contentions for this claim. ME2C's infringement contentions cross reference claim 14 of the '114 patent. ME2C's infringement contentions do not include claim 14 of the '114 patent. ME2C's final contentions hew to this position, and thus ME2C is apparently not asserting this claim. Therefore, no analysis regarding this element is required.

2119 Ex. 1010 (Sjostrom) at 10, 20, 34.
2120 Ex. 1010 (Sjostrom) at 20.
2121 Ex. 1010 (Sjostrom) at 15, 16,
2122 See, e.g., State of the Art, Sections XII.C.3, XII.G.2.

18. Claim 21: "The method of claim 1, wherein the sorbent injected into the mercury-containing gas is free of contact with a halogen or halide promoter prior to injection of the sorbent into the mercury-containing gas."

1376. ME2C did not provide infringement contentions for this claim. ME2C's infringement contentions cross reference claim 13 of the '114 patent. ME2C's infringement contentions do not include claim 13 of the '114 patent. ME2C's final contentions hew to this position, and thus ME2C is apparently not asserting this claim. Therefore, no analysis regarding this element is required.

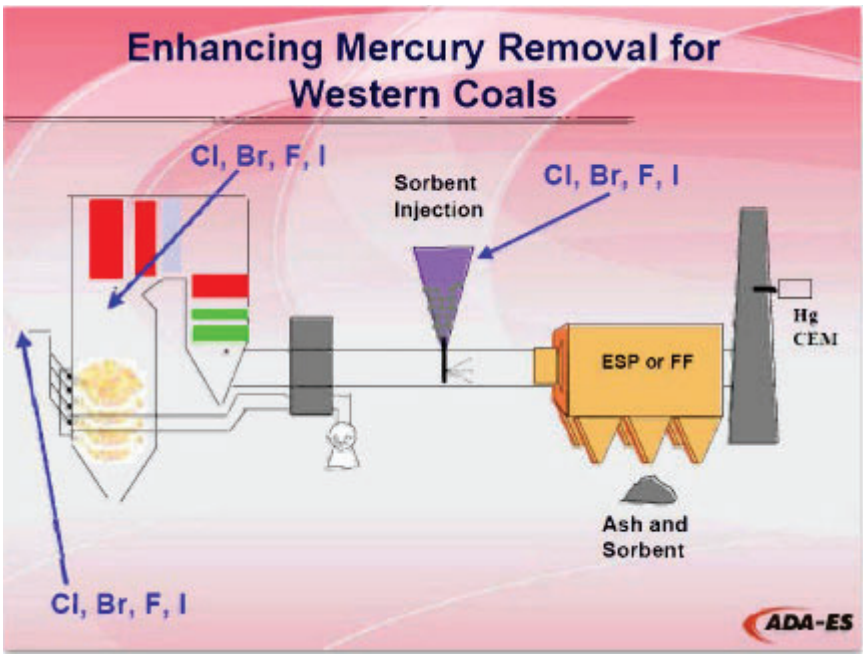
19. Claim 22: "The method of claim 1, wherein the combustion chamber comprises a boiler."

1377. This limitation is disclosed by Sjostrom. As discussed for claim element 28(a), Sjostrom discloses combusting coal in a combustion chamber (e.g., boiler) to form a mercury containing flue gas stream.

20. Claim 23: "The method of claim 1, wherein the mercury-containing gas is a flue gas."

1378. This limitation is disclosed by Sjostrom. Sjostrom discloses testing performed on the treatment of mercury-containing gas from a coal-fired power plant. A POSITA would have known that the mercury-containing exhaust gas from coal-fired power plants was commonly referred to as "flue gas." For example, Sjostrom discloses testing on coal-fired power plants according to the following schematic.[2123]

[2123] Ex. 1010 (Sjostrom) at 4.



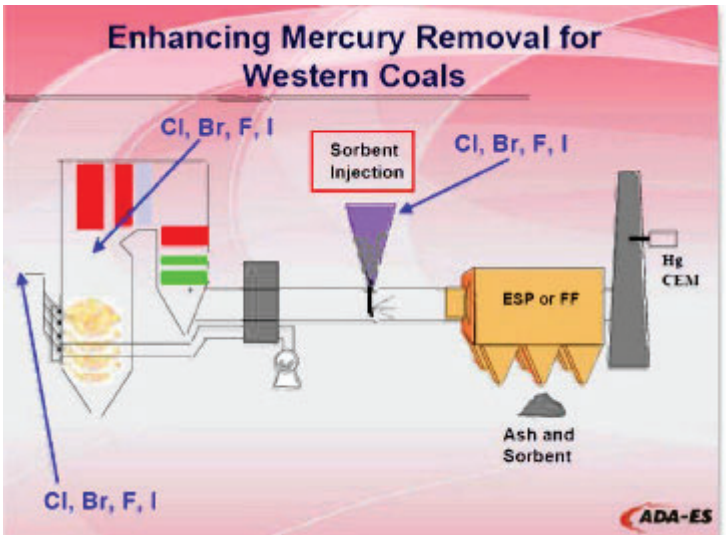
Further, Sjostrom expressly includes discussion of sampling and injection of "Flue Gas Flow."[2124]

21. Claim 24: "The method of claim 1, wherein the injection of the sorbent into the mercury-containing gas occurs upstream of a particulate separator, a scrubber, or a combination thereof."

1379. This limitation is disclosed by Sjostrom. As shown in the annotated figure below, Sjostrom described certain tests involving sorbent injection downstream of the boiler.[2125]

2124 Ex. 1010 (Sjostrom) at 19.

2125 Ex. 1010 (Sjostrom) at 4 (annotations in red).



The sorbent injection system of Sjostrom is shown upstream of an ESP or FF.[2126] A POSITA would have understood that ESPs and FFs were well-known particulate separators and would be used to collect the mercury-sorbent composition (and thus be downstream of where the mercury-sorbent composition is formed).[2127]

22. Claim 25: "The method of claim 24, wherein the particulate separator comprises a baghouse, an electrostatic precipitator, a fabric filter, or a combination thereof."

1380. Sjostrom discloses this claim. The explanation I provide above for claim 24 applies equally to these claim elements.

1381. Sjostrom further discloses the method of claim 24, which is described in the above section.

2126 Ex. 1010 (Sjostrom) at 4.

2127 State of the Art, § XII.B.5.a

D. INDEPENDENT CLAIM 29

1. Claim 29: Element 29(a): "A method of separating mercury from a mercury-containing gas, the method comprising:"

1382. The language of the preamble of claim 29 is identical to the preamble of claims 28 and 1. Accordingly, the explanation I provide above for the preamble of claim 28 applies equally to the preamble of claim 29.

2. Claim 29: Element 29(b): "combusting coal in a combustion chamber, to provide the mercury-containing gas, wherein the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br−, or a combination thereof, wherein"

1383. The language of this claim element is identical to claim element 28(b). Accordingly, the explanation I provide above for those claim elements applies equally to this claim element.

3. Claim 29: Element 29(c)-(e): "the coal comprises an additive comprising Br2, HBr, a bromide compound, or a combination thereof, wherein the additive is added to the coal before the coal enters the combustion chamber, or the combustion chamber comprises an additive comprising Br2, HBr, a bromide compound, or a combination thereof, or a combination thereof;"

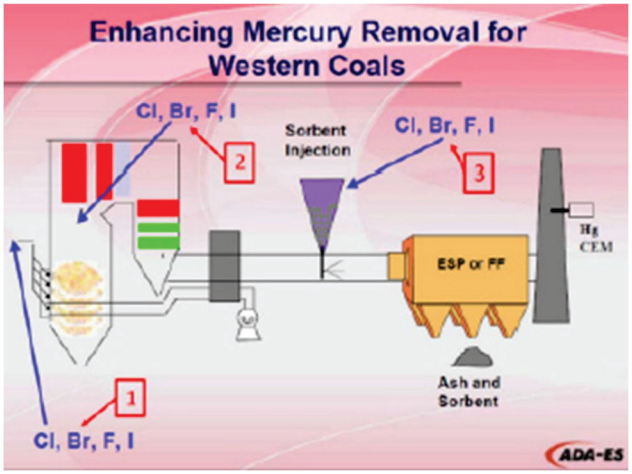
1384. The language of this claim element is identical to claim element 28(c)-(e). Accordingly, the explanation I provide above for those claim elements applies equally to this claim element.

4. Claim 29: Element 29(f): "injecting a sorbent comprising activated carbon into the mercury-containing gas downstream of the combustion chamber such that the activated carbon reacts with the halogen or halide promoter

in the mercury-containing gas to form a promoted sorbent;"

1385. The language of this claim element is identical to the first portion of claim element 28(f). Accordingly, the explanation I provide above for those claim elements applies equally to this claim element.

1386. In addition, the bromine added at Addition Location 1 or Addition Location 2 of Sjostrom would contact the sorbent in the flue gas at or downstream of the sorbent injection point at Addition Location 3.[2128]



1387. At least a quantity of promoted sorbent would have formed as a reaction between the sorbent and halogen upon contact. The reaction would take place at or after the sorbent injection point, at Addition Location 3. It was well-known in the art that halogens (including bromine) "promoted" activated carbon sorbents because

[2128] Ex. 1010 (Sjostrom) at 4.

they improved mercury removal by increasing the ability of the activated carbon to bind with the mercury.

5. Claim 29: Element 29(g): "contacting mercury in the mercury-containing gas with the promoted sorbent;"

1388. The language of this claim element is identical to claim element 28(g). Accordingly, the explanation I provide above for those claim elements applies equally to this claim element.

6. Claim 29: Element 29(h): "separating the promoted sorbent contacted with the mercury from the mercury-containing gas;"

1389. The language of this claim element is identical to claim element 28(h). Accordingly, the explanation I provide above for those claim elements applies equally to this claim element.

7. Claim 29: Element 29(i)-(m): "measuring the mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content, an injection rate of injecting the sorbent into the mercury-containing gas, an amount of the Br2, HBr, the bromide compound, or a combination thereof, added to the coal or the combustion chamber, or a combination thereof."

1390. The language of this claim element is identical to that of claim 10. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

XLIII. GROUND Y: OBVIOUSNESS OF THE '430 PATENT OVER SJOSTROM IN VIEW OF OLSON-646

1391. It is my opinion that Sjostrom in view of Olson-646 render obvious each of claims 1-4, 6- 8, 10-25, 28-29 of the '430 Patent.

A. INDEPENDENT CLAIM 28

1. Claim 28: Element 28(a): "A method of separating mercury from a mercury-containing as [sic], the method comprising:"

1392. As discussed regarding the preamble of claim 28 (element 28(a)), in Ground X above, the preamble is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground X applies equally here.

2. Claim 28: Element 28(b): "combusting coal in a combustion chamber, to provide the mercury-containing gas, wherein the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br−, or a combination thereof, wherein"

1393. As discussed in Ground X above, this limitation is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground X applies equally here.

3. Claim 28: Elements 28(c)-(e): "the coal comprises an additive comprising Br2, HBr, a bromide compound, or a combination thereof, wherein the additive is added to the coal before the coal enters the combustion chamber, or the combustion chamber comprises an additive comprising Br2, HBr, a bromide compound, or a combination thereof, or a combination thereof,"

1394. As discussed in Ground X above, this limitation is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground X applies equally here.

1395. In addition, this limitation is also obvious over Sjostrom in view of Olson-646. To the extent that Sjostrom does not explicitly identify the specific bromine-containing species used, Olson-646 teaches this limitation. Olson-646 "provides a cost-effective way to capture pollutants by utilizing exceptionally reactive halogen/halide promoted carbon sorbents using a bromide (or other halogen/halide) treatment of the carbon, that capture mercury via mercury-sorbent surface reactions, at very short contact times of seconds or less."[2129] Olson-646 teaches embodiments "wherein the halogen/halide promoter is in gaseous or vapor form" that comprises "gaseous HBr or Br_2."[2130]

1396. Olson-646 also discloses a mercury control system 100 wherein activated carbon (from base activated carbon reservoir 110) is reacted with a bromine-containing reagent (from halogen/halide promoter reservoir 130) to form promoted activated carbon, and then injecting the promoted activated carbon into the mercury-containing flue gas stream 15 at injection point 116 resulting in a reduced mercury flue gas 25.[2131]

2129 Ex. 1014 (Olson-646) at ¶ [0043].
2130 Ex. 1014 (Olson-646) at ¶ [0066].
2131 Ex. 1014 (Olson-646) at ¶¶ [0056], [0057], [0061], Fig. 3.

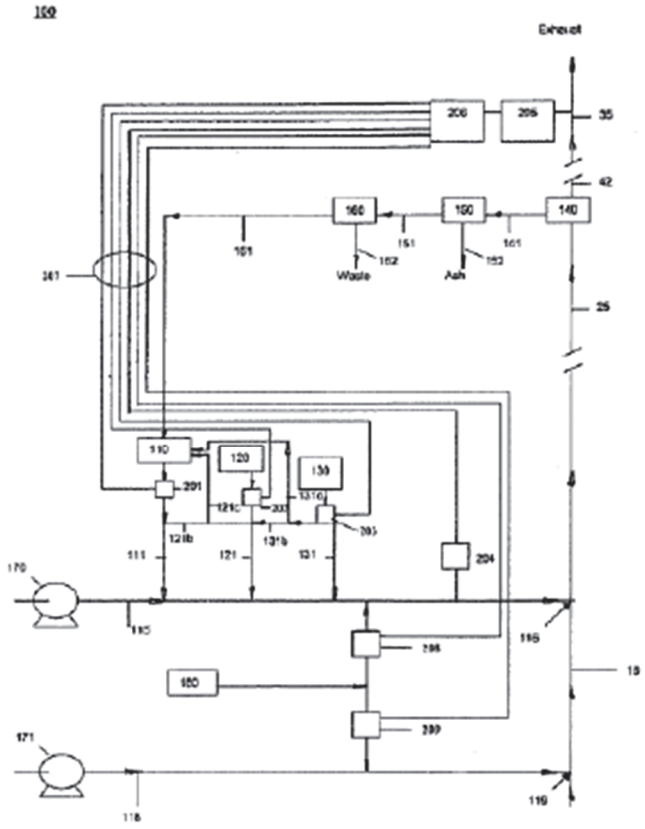


FIG. 3

1397. Olson-646's disclosed embodiments reduce "mercury in flue gas comprising providing a sorbent, injecting the sorbent into a mercury-containing flue gas stream collecting greater than 70 wt-% of the mercury in the flue gas on the sorbent to produce a cleaned flue gas, and substantially recovering the sorbent from the cleaned flue gas."[2132]

1398. As described above in the Reasons to Combine section, a POSITA would have been motivated, and expected a reasonable chance of success, to apply the teachings of Olson-646 (e.g., to utilize HBr and/or Br2, which are widely

[2132] Ex. 1014 (Olson-646) at ¶ [0022]

obtainable and affordable forms of bromine, to implement known process techniques to reduce mercury in flue gas) to the system of Sjostrom.

4. Claim 28: Elements 28(f): "injecting a sorbent comprising activated carbon into the mercury-containing gas downstream of the combustion chamber;"

1399. As discussed in Ground X above, this limitation is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground X applies equally here.

1400. In addition, Olson-646 also discloses injecting the promoted activated carbon into the mercury-containing flue gas stream 15 at injection point 116 resulting in a reduced mercury flue gas 25.[2133]

5. Claim 28: Elements 28(g): "contacting mercury in the mercury-containing gas with the sorbent; and"

1401. As discussed in Ground X above, this limitation is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground X applies equally here.

6. Claim 28: Elements 28(h): "separating the sorbent contacted with the mercury from the mercury-containing gas."

1402. As discussed in Ground X above, this limitation is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground X applies equally here.

[2133] Ex. 1014 (Olson-646) at ¶¶ [0056], [0057], [0061], Fig. 3.

B. INDEPENDENT CLAIM 1

1. Claim 1: Preamble—"A method of separating mercury from a mercury-containing gas, the method comprising:"

1403. The language of the preamble of claim 1 is identical to the preamble of claims 28 and 29. Accordingly, the explanation I provide above for the preamble of claim 28 applies equally to the preamble of claim 1.

2. Claim 1: Element (1)(b)—"combusting coal in a combustion chamber, to provide the mercury-containing gas,"

1404. The language of claim element 1(b) is identical to the first portion of claim element 28(b) [which is identical to claim element 29(b)]. Accordingly, the explanation I provide above for those claim elements applies equally to claim element 1(b).

3. Claim 1: Element 1(c)—"the coal comprises an additive comprising Br2, HBr, a bromide compound, or a combination thereof, wherein the additive is added to the coal before the coal enters the combustion chamber, or"

1405. The language of claim element 1(c) is identical to the language of claim element 28(c) [which is identical to claim element 29(c)]. Accordingly, the explanation I provide above for those claim elements applies equally to claim element 1(c).

4. Claim 1: Element 1(d)—"the combustion chamber comprises an additive comprising Br2, HBr, a bromide compound, or a combination thereof or

1406. The language of claim element 1(d) is identical to the language of claim element 28(d) [which is identical to claim element 29(d)]. Accordingly, the explanation I provide above for those claim elements applies equally to claim element 1(d).

5. Claim 1: Element 1(e)—"a combination thereof;"

1407. The language of claim element 1(e) is identical to the language of claim element 28(e) [which is identical to claim element 29(e)]. Accordingly, the explanation I provide above for those claim elements applies equally to claim element 1(e).

6. Claim 1: Element 1(f)—"injecting a sorbent comprising activated carbon into the mercury-containing gas downstream of the combustion chamber;"

1408. The language of claim element 1(f) is identical to the language of claim element 28(f) [which is identical to the first portion of claim element 29(f)]. Accordingly, the explanation I provide above for those claim elements applies equally to claim element 1(b).

7. Claim 1: Element 1(g)—"contacting mercury in the mercury-containing gas with the sorbent; and"

1409. The language of claim element 1(g) is identical to the language of claim element 28(g) [which is identical to claim element 29(g)]. Accordingly, the explanation I provide above for those claim elements applies equally to claim element 1(g).

8. Claim 1: Element 1(h)—"separating the sorbent contacted with the mercury from the mercury-containing gas."

1410. The language of claim element 1(h) is identical to the language of claim element 28(h) [which is identical to claim element 29(h)]. Accordingly, the explanation I provide above for those claim elements applies equally to claim element 1(h).

C. CLAIMS DEPENDING FROM CLAIM 1

1. Claim 2: "The method of claim 1, wherein the coal comprises the additive comprising the Br2, HBr, the bromide compound, or a combination thereof, wherein the additive is added to the coal before the coal enters the combustion chamber.

1411. As discussed in Ground X above, this limitation is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground X applies equally here.

1412. In addition, Olson-646 teaches using halogens to remove mercury from coal-fired plants. Olson-646 is entitled "Sorbents for the Oxidation and Removal of Mercury." Olson- 46 "provides a cost-effective way to capture pollutants by utilizing exceptionally reactive halogen/halide promoted carbon sorbents using a bromide (or other halogen/halide) treatment of the carbon, that capture mercury via mercury-sorbent surface reactions."[2134] Olson-646 teaches using gaseous HBr or Br2

[2134] Ex. 1014 (Olson-646) at ¶ [0043].

to accomplish this.[2135] Olson-646 discloses the reaction of hydrogen bromide with activated carbon occurs at carbene species on "the edge of graphene sheets structures of the carbon."[2136] Olson-646 also discloses a mercury control system 100 wherein activated carbon (from base activated carbon reservoir 110) is reacted with a bromine-containing reagent (from halogen/halide promoter reservoir 130) to form promoted activated carbon, and then injecting the promoted activated carbon into the mercury-containing flue gas stream 15 at injection point 116 resulting in a reduced mercury flue gas 25.[2137]

1413. A POSITA would have been motivated to modify Sjostrom to add HBr, CaBr2, or a known bromide compound to coal upstream of the combustion chamber to utilize a widely obtainable and relatively cheap form of bromine, as a matter of obvious design choice.

2. Claim 3: "The method of claim 1, wherein the combustion chamber comprises the additive comprising the Br2, HBr, the bromide compound, or a combination thereof."

1414. As discussed in Ground X above, this limitation is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground X applies equally here.

3. Claim 4: "The method of claim 1, wherein the coal is combusted in the combustion chamber at a coal-combustion

2135 Ex. 1014 (Olson-646) at ¶ [0066].
2136 Ex. 1014 (Olson-646) at ¶ [0054].
2137 Ex. 1014 (Olson-646) at ¶¶ [0056], [0057], [0061], Fig. 3.

facility, wherein the additive comprising the Br2, HBr, bromide compound, or combination thereof, is added to the coal before the coal enters the combustion chamber, wherein the addition of the additive comprising the Br2, HBr, bromide compound, or combination thereof, to the coal is performed at the coal-combustion facility."

1415. As discussed in Ground X above, this limitation is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground X applies equally here.

1416. The language in claim 4 is comparable to the language in claim element 28(c). Accordingly, the explanation I provide above for that claim element applies equally to claim 4.

4. Claim 6: "The method of claim 1, wherein the combustion chamber is an electric utility coal combustion chamber."

1417. As discussed in Ground X above, this limitation is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground X applies equally here.

5. Claim 7: "The method of claim 1, wherein the combustion chamber is a coal combustion furnace."

1418. As discussed in Ground X above, this limitation is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground X applies equally here.

1419. The explanation I provide above for claims 4 and 6 are equally applicable to claim 7.

6. Claim 8: "The method of claim 1, wherein the coal comprises a subbituminous coal."

1420. As discussed in Ground X above, this limitation is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground X applies equally here.

7. Claim 10: "The method of claim 1, further comprising measuring the mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content of the mercury-containing gas, an injection rate of injecting the sorbent into the mercury-containing gas, an amount of the Br_2, HBr, the bromide compound, or a combination thereof, added to the coal or the combustion chamber, or a combination thereof."

1421. As discussed in Ground X above, this limitation is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground X applies equally here.

1422. In addition, Olson-646 also explains that "[t]he reduced mercury 'clean' flue gas stream 142 is then monitored for mercury content by an optional CEM [continuous emissions monitor] 205, which provides corresponding signals to an optional computer/controller 206 . . . to maintain the mercury concentration in exhaust stream 35 within desired limits, according to control algorithms well known in the art."[2138]

[2138] Ex. 1014 (Olson-646) at ¶ [0061], Fig. 3.

1423. To the extent this limitation is not disclosed in Sjostrom, it would have been obvious to a POSITA to adjust the sorbent-injection rate in response to the monitored mercury content in order to satisfy a specific target Hg removal percentage. Because of the expense associated with activated carbon sorbents, especially relative to costs of cheaper components such as "Br," a POSITA would have been motivated to use the charts of Sjostrom as a guide to adjust the sorbent injection rate to minimize costs while reaching desired mercury removal levels. Also, a POSITA would have been motivated to remove at least the amount of mercury necessary to stay within the "Proposed Limit" while minimizing the amount of activated carbon injected to comply with Sjostrom's proven method.

8. Claim 11: "The method of claim 10, wherein the measuring of the mercury content comprises continuous measurement."

1424. ME2C did not provide infringement contentions for this claim. ME2C's infringement contentions cross reference claim 24 of the '225 patent. ME2C's infringement contentions do not include claim 24 of the '225 patent. ME2C's final contentions hew to this position, and thus ME2C is apparently not asserting this claim. Therefore, no analysis regarding this element is required.

9. Claim 12: "The method of claim 1, further comprising: modifying, in response to a measured mercury content, an injection rate of injecting the sorbent into the mercury-containing gas, an amount of the Br2, HBr, the bromide compound, or a combination thereof, added to the coal or the combustion chamber, or a combination thereof."

1425. As discussed in Ground X above, this limitation is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground X applies equally here.

1426. The language of claim 12 is substantially identical to the language of claim 10. Accordingly, the explanation I provide above for claim 10 applies equally to claim 12.

10. Claim 13: "The method of claim 1, wherein the mercury-containing gas comprises about 1 g to about 30 g of the element bromine per 100 g of the sorbent."

1427. As discussed in Ground X above, this limitation is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground X applies equally here.

1428. In addition, Olson-646 includes repeated discussion of this ratio of the halogen or halide promoter to the sorbent material in the mercury-containing gas. For example, Olson-646 discloses that in certain embodiments "the sorbent comprises from about 1 to about 30 grams promoter per 100 grams of base activated carbon."[2139]

1429. A person of skill in the art would have looked to the Olson-646 reference to further understand the relationship between the halogen and activated carbon disclosed by Sjostrom. Specifically, a POSITA would have understood that

[2139] Ex. 1014 (Olson-646) at ¶ [0014]; *see also* ¶ [0018] and Claims 3, 17.

the activated-carbon sorbent of Sjostrom would have "comprise[d] from about 1 to about 30 grams promoter per 100 grams of base activated carbon" after the activated-carbon sorbent made contact with the "Br" promoter. To the extent that Sjostrom does not explicitly state that the sorbent includes this ratio of promoter:activated carbon, Olson-646 provides this explanation. Therefore, a POSITA would have been motivated to combine the teachings of Sjostrom, Olson-646, and knowledge in the art to use 1 g - 30 g of halogen or halide promoter per 100 g of sorbent to optimize the use of promoter and mercury removal.

11. Claim 14: "The method of claim 1, wherein the sorbent contacted with the mercury comprises the element bromine and mercury."

1430. As discussed in Ground X above, this limitation is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground X applies equally here.

12. Claim 15: "The method of claim 1, comprising removing greater than 70 wt % of the mercury in the mercury-containing gas."

1431. As discussed in Ground X above, this limitation is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground X applies equally here.

1432. In addition, claims 2 and 3 are also obvious over Sjostrom in view of Olson-646. For example, Olson-646 explains that "a method is provided for

reducing mercury in flue gas comprising providing a sorbent, injecting the sorbent into a mercury-containing flue gas stream, collecting ***greater than 70 wt-% of the mercury in the flue gas on the sorbent*** to produce a cleaned flue gas, and substantially recovering the sorbent from the cleaned flue gas."[2140] Claim 30 of Olson-646 also discloses "comprising removing greater than 70 wt % of the mercury in the mercury-containing gas on the sorbent."[2141]

1433. A person of skill in the art would have looked to the Olson-646 reference to further understand the mechanisms for the mercury-removal disclosed by Sjostrom. Specifically, a POSITA would have understood that the activated carbon of Sjostrom removed "greater than 70 wt % of the mercury in the mercury-containing gas on the sorbent," as discussed in Ground I above. To the extent that Sjostrom does not explicitly state that the mercury is removed "on the sorbent," Olson-646 provides this explanation. A POSITA would have understood that by using the particular bromine-containing species disclosed in Olson ("HBr or Br_2") as the source of "Br" disclosed in Sjostrom, then "greater than 70 wt % of the mercury in the mercury-containing gas" would have been removed "on the sorbent," as confirmed by Olson-646.

2140 Ex. 1014 (Olson-646) at ¶ [0022] (emphasis added).

2141 Ex. 1014 (Olson-646) at Claim 30 (emphasis added).

13. Claim 16: "The method of claim 1, comprising removing greater than 70 wt % of the mercury in the mercury-containing gas with the sorbent."

1434. As discussed in Ground X above, this limitation is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground X applies equally here.

1435. In addition, the language of this claim element is substantially similar to that of claim 15. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

14. Claim 17: "The method of claim 1, wherein the sorbent in the mercury-containing gas comprises about 1 g to about 30 g of the added Br2, HBr, the bromide compound, or a combination thereof, per 100 g of the sorbent."

1436. As discussed in Ground X above, this limitation is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground X applies equally here.

1437. In addition, the language of this claim element contains concepts substantially similar to that of claim 13. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

15. Claim 18: "The method of claim 1, wherein the Br2, HBr, or the bromide compound is contacted with the sorbent in vapor form, gaseous form, liquid form, or in an organic solvent."

1438. As discussed in Ground X above, this limitation is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground X applies equally here.

1439. To the extent Sjostrom fails to explicitly disclose that the "Br" is added as HBr or Br2, a POSITA would have been motivated to look to Olson-646 for this information. Olson-646 discloses utilizing a gaseous HBR or Br2 promoter.[2142]

16. Claim 19: "The method of claim 1, wherein the activated carbon comprises powdered activated carbon, granular activated carbon, or a combination thereof."

1440. As discussed in Ground X above, this limitation is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground X applies equally here.

17. Claim 20: "The method of claim 1, wherein the sorbent injected into the mercury-containing gas is a sorbent obtained by contacting a sorbent with a halogen or halide promoter prior to the injection of the sorbent into the mercury-containing gas."

1441. ME2C did not provide infringement contentions for this claim. ME2C's infringement contentions cross reference claim 14 of the '114 patent. ME2C's infringement contentions do not include claim 14 of the '114 patent. ME2C's final contentions hew to this position, and thus ME2C is apparently not asserting this claim. Therefore, no analysis regarding this element is required.

[2142] Ex. 1014 (Olson-646) at ¶ [0066].

18. Claim 21: "The method of claim 1, wherein the sorbent injected into the mercury-containing gas is free of contact with a halogen or halide promoter prior to injection of the sorbent into the mercury-containing gas."

1442. ME2C did not provide infringement contentions for this claim. ME2C's infringement contentions cross reference claim 13 of the '114 patent. ME2C's infringement contentions do not include claim 13 of the '114 patent. ME2C's final contentions hew to this position, and thus ME2C is apparently not asserting this claim. Therefore, no analysis regarding this element is required.

19. Claim 22: "The method of claim 1, wherein the combustion chamber comprises a boiler."

1443. As discussed in Ground X above, this limitation is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground X applies equally here.

20. Claim 23: "The method of claim 1, wherein the mercury-containing gas is a flue gas."

1444. As discussed in Ground X above, this limitation is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground X applies equally here.

21. Claim 24: "The method of claim 1, wherein the injection of the sorbent into the mercury-containing gas occurs upstream of a particulate separator, a scrubber, or a combination thereof."

1445. As discussed in Ground X above, this limitation is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground X applies equally here.

1446. In addition, Olson-646 further describes injecting sorbent upstream of a particular separator or scrubber. Olson-646 discloses that "[d]ownstream from injection point 116 and 119 is provided particulate separator 140. 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."[2143]

22. Claim 25: "The method of claim 24, wherein the particulate separator comprises a baghouse, an electrostatic precipitator, a fabric filter, or a combination thereof."

1447. As discussed in Ground X above, this limitation is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground X applies equally here. Sjostrom discloses this claim.

1448. In addition, the explanation I provide above for claim 24 applies equally to these claim elements.

D. INDEPENDENT CLAIM 29

1. Claim 29: Element 29(a): "A method of separating mercury from a mercury-containing gas, the method comprising:"

[2143] Ex. 1014 (Olson-646) at ¶ [0059].

1449. The language of the preamble of claim 29 is identical to the preamble of claims 28 and 1. Accordingly, the explanation I provide above for the preamble of claim 28 applies equally to the preamble of claim 29.

2. Claim 29: Element 29(b): "combusting coal in a combustion chamber, to provide the mercury-containing gas, wherein the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br−, or a combination thereof, wherein"

1450. The language of this claim element is identical to claim element 28(b). Accordingly, the explanation I provide above for those claim elements applies equally to this claim element.

3. Claim 29: Element 29(c)-(e): "the coal comprises an additive comprising Br2, HBr, a bromide compound, or a combination thereof, wherein the additive is added to the coal before the coal enters the combustion chamber, or the combustion chamber comprises an additive comprising Br2, HBr, a bromide compound, or a combination thereof, or a combination thereof;"

1451. The language of this claim element is identical to claim element 28(c)-(e). Accordingly, the explanation I provide above for those claim elements applies equally to this claim element.

4. Claim 29: Element 29(f): "injecting a sorbent comprising activated carbon into the mercury-containing gas downstream of the combustion chamber such that the activated carbon reacts with the halogen or halide promoter in the mercury-containing gas to form a promoted sorbent;"

1452. The language of this claim element is identical to the first portion of claim element 28(f). Accordingly, the explanation I provide above for those claim elements applies equally to this claim element.

1453. In addition, as discussed in Ground X above, the remainder of this limitation is disclosed by Sjostrom. My analysis with regards to the disclosure of Sjostrom regarding this element for Ground X applies equally here.

5. Claim 29: Element 29(g): "contacting mercury in the mercury-containing gas with the promoted sorbent;"

1454. The language of this claim element is identical to claim element 28(g). Accordingly, the explanation I provide above for those claim elements applies equally to this claim element.

6. Claim 29: Element 29(h): "separating the promoted sorbent contacted with the mercury from the mercury-containing gas;"

1455. The language of this claim element is identical to claim element 28(h). Accordingly, the explanation I provide above for those claim elements applies equally to this claim element.

7. Claim 29: Element 29(i)-(m): "measuring the mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content, an injection rate of injecting the sorbent into the mercury-containing gas, an amount of the Br2, HBr, the bromide compound, or a combination thereof, added to the coal or the combustion chamber, or a combination thereof."

1456. The language of this claim element is identical to that of claim 10. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

XLIV. GROUND Z: ANTICIPATION AND OBVIOUSNESS OF THE '430 PATENT BY DOWNS-BOILER

1457. It is my opinion that Downs-Boiler anticipates each of claims 1-4, 6- 8, 10-25, 28-29 of the '430 Patent. In the subsections below, I rely on the disclosure of Downs-Boiler. The material I rely on was also disclosed and supported by Downs-Boiler-Provisional, so parallel citations to Downs-Boiler-Provisional are also included.

A. INDEPENDENT CLAIM 28

1. Claim 28: Element 28(a): "A method of separating mercury from a mercury-containing as [sic], the method comprising:"

1458. Downs-Boiler discloses the preamble. The title of Downs-Boiler is "Bromine Addition for the Improved Removal of Mercury from Flue Gas.[2144] Flue gas is an example of a mercury-containing gas, and "removal of mercury" refers to separating the mercury from a mercury-containing gas. Downs-Boiler repeatedly characterizes the disclosed process as for removing *(i.e.,* separating) mercury from flue gas (i.e., a mercury-containing gas):

[2144] Ex. 1006 (Downs-Boiler) at Title; Ex. 1007 (Downs-Boiler-Provisional) at Title

> [T]he 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.[2145]

1459. Claim 1 of Downs-Boiler also recites a similar preamble: "1. A method of removing a portion of the elemental mercury in a flue gas"[2146] The removal of mercury from the flue gas as described by Downs-Boiler is by separating the mercury along with a sorbent:[2147]

> The sorbent, and its burden of adsorbed mercury, are subsequently removed from the flue gases in a downstream particulate collector. Adsorption is a technique that has often been successfully applied for the *separation and removal* of trace quantities of undesirable components.

1460. Downs-Boiler characterizes its disclosed "invention" as "a cost-effective method of removing elemental mercury from coal combustion flue gases."[2148]

2. Claim 28: Element 28(b): "combusting coal in a combustion chamber, to provide the mercury-containing gas, wherein the mercury-containing gas comprises a

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[2145] pg completed formatting/need to do QCEx. 1006 (Downs-Boiler) ¶ [0007]; Ex. 1007 (Downs-Boiler-Provisional) ¶ [0013].

[2146] Ex. 1006 (Downs-Boiler) at Claim 1; see also Ex. 1007 (Downs-Boiler-Provisional) at Claim 1 ("1. A method of reducing the mercury concentration of a flue gas comprising.").

[2147] Ex. 1006 (Downs-Boiler) ¶ [0004] (emphasis added); Ex. 1007 (Downs-Boiler-Provisional) IT [005].

[2148] Ex. 1006 (Downs-Boiler) ¶ [0018]; Ex. 1007 (Downs-Boiler-Provisional) ¶ [021].

halogen or halide promoter comprising HBr, Br−, or a combination thereof, wherein"

1461. Downs-Boiler discloses this claim element. The primary application taught by Downs-Boiler is with "[c]oal-fired utility boilers [that] are a known major source of anthropogenic mercury emissions in the United States.[2149] Downs-Boiler illustrates a conventional coal-fired utility boiler used for the purpose of combusting coal, as represented by the arrow into combustion chamber 14. Representative Figure 4 is reproduced below:[2150]

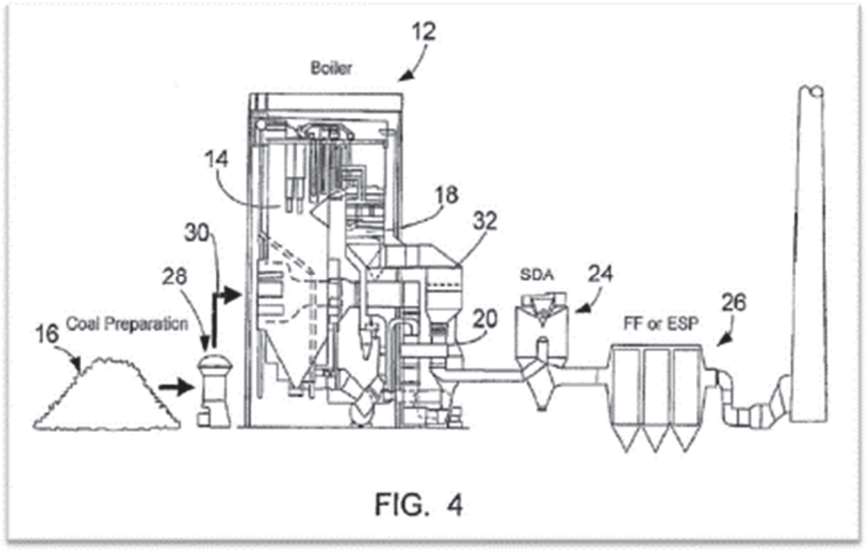


FIG. 4

[2149] Ex. 1006 (Downs-Boiler) ¶ [0001]; *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [002].

[2150] Ex. 1006 (Downs-Boiler) ¶ [0007], Figures 4; *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [009], Figures 4.

1462. Downs-Boiler goes on to describe such a combustion of coal together with an added bromine-containing reagent, which occurs within combustion chamber 14, as illustrated in Figures 4-6:[2151]

> A bromine containing reagent 10 is *added to the boiler* 12 combustion furnace 14, either directly or by *premixing with the incoming coal* 16. Bromine species released *during the combustion process* enhance the oxidation of *mercury as* the *combustion gases* pass through the furnace 14 and, in particular, through the *cooler sections of the boiler* convection pass 18 and combustion air preheater 20.

1463. Downs-Boiler describes combusting common ranks of coal used by the electric utility industry and, specifically, that "the coal-fired boiler fuel 16 may include bituminous, subbituminous, and lignite coals and blends, thereof."[2152] Finally, Downs-Boiler explicitly describes that "[m]ercury appears in coal combustion flue gases in both solid and gas phases."[2153] This flue gas referred to by Downs-Boiler is an example of a mercury-containing gas, and was generated from the combustion of coal.

3. Claim 28: Elements 28(c)-(e): "the coal comprises an additive comprising Br2, HBr, a bromide compound, or a combination thereof, wherein the additive is added to the coal before the coal enters the combustion chamber, or the combustion chamber comprises an additive comprising Br2,

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2151 Ex. 1006 (Downs-Boiler) ¶ [0015] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [0018].

2152 Ex. 1006 (Downs-Boiler) ¶ [0020]; *see also* Ex. 1007 (Downs-Boiler-Provisional) IT [0023].

2153 Ex. 1006 (Downs-Boiler) ¶ [0002] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [003].

HBr, a bromide compound, or a combination thereof, or a combination thereof,"

1464. Downs-Boiler discloses this claim element. Although the claim only requires one to be shown, Downs-Boiler discloses both: 1) adding Br_2, HBr, and/or a bromide compound to the coal upstream of the combustion chamber, and 2) adding Br_2, HBr, and/or a bromide compound to the combustion chamber; as well as the combination of the two.

1465. First, Downs-Boiler discloses Br_2, HBr, a bromide compound, or a combination thereof, added to the coal upstream of the combustion chamber. Downs-Boiler explains that the bromine-containing reagent may comprise, "but is not limited to, ***alkali metal*** and ***alkaline earth metal bromides, hydrogen bromide (HBr)*** or ***bromine (Br_2).***"[2154] Downs-Boiler also specifically discloses ***calcium bromide ($CaBr_2$)*** as another suitable bromide compound for use as the bromine-containing reagent.[2155]

1466. This bromine-containing reagent is applied to the coal upstream of the combustion chamber. Downs-Boiler teaches that a "bromine containing reagent 10 is added to the boiler 12 combustion furnace 14, either directly or by premixing with

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[2154] Ex. 1006 (Downs-Boiler) 41] [0021] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) 'll [0024].

[2155] Ex. 1006 (Downs-Boiler) 11 [0018-19] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) l] [0021-22].

the incoming coal 16."[2156] According to the preferred embodiment of Downs-Boiler, ***"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*" such that the *"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."[2157] Thus, upstream of the combustion chamber, such as in the coal pulverizers and the pulverized coal conveying system, at least one or a combination of Br_2, HBr, and a bromide compound (e.g., calcium bromide ($CaBr_2$)) has been added on the coal.

1467. Second, Downs-Boiler discloses "the combustion chamber comprises added Br_2, HBr, a bromide compound, or a combination thereof" As described above—where the bromine-containing reagent is disclosed as added to the coal and/or the coal conveying system—this further discloses that the combustion chamber comprises added bromine-containing reagent *(e.g.,* Br_2, HBr, a bromide compound, or a combination thereof). As explained by Downs-Boiler, as a result of adding the bromine-containing reagent to the coal and/or the coal conveying system,

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[2156] Ex. 1006 (Downs-Boiler) 11 [0015]; *see also* Ex. 1007 (Downs-Boiler-Provisional) 11 [0018].

[2157] Ex. 1006 (Downs-Boiler) ¶ [0019], Figure 2; *see also* Ex. 1007 (Downs-Boiler-Provisional) III [0022], Figure 2.

the "***[b]romine species released during the combustion process*** enhance the oxidation of mercury as the combustion gases pass ***through the furnace 14***."[2158] That the bromine-containing reagent is "sprayed on the crushed coal 16 before the coal is pulverizedfor *combustion"* additionally "ensures even distribution of the [bromine-containing] reagent 10 ***across the boiler furnace****" (i.e.,* in the combustion chamber).[2159]

1468. Downs-Boiler also discloses introduction of Br_2, HBr, and/or a bromide compound *(i.e.,* the bromine-containing reagent) directly into the combustion chamber. Downs-Boiler teaches that a "bromine containing reagent 10 is added to the boiler 12 combustion furnace 14, either directly or by premixing with the incoming coal 16"[2160]. Downs-Boiler describes that the inventors successfully tested direct introduction of the bromine-containing reagent—specifically, a bromide compound of calcium bromide ($CaBr_2$)—"injected into the combustion chamber 14 through a coal burner."[2161] Downs-Boiler further recognizes that "the bromine-containing reagent 10 may be fed to the boiler combustion zone 14 in gaseous, liquid,

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[2158] Ex. 1006 (Downs-Boiler) 11 [0015] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [0018].

[2159] Ex. 1006 (Downs-Boiler) ¶ [0019] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) II [0022].

[2160] Ex. 1006 (Downs-Boiler) ¶ [0015]; see also Ex. 1007 (Downs-Boiler-Provisional) 11 [0018].

[2161] Ex. 1006 (Downs-Boiler) 11 [0019]; *see also* Ex. 1007 (Downs-Boiler-Provisional) IT [0021].

or solid form."[2162] Thus, the combustion chamber comprises at least one or a combination of Br_2, HBr, and a bromide compound *(e.g.,* calcium bromide ($CaBr_2$)).

1469. Third, Downs-Boiler discloses adding a bromine-containing reagent to both the coal and the combustion chamber. As described above, Downs-Boiler describes applying the bromine-containing reagent to the coal upstream of the combustion chamber in such a way that added Br_2, HBr, and/or a bromide compound *(e.g.,* calcium bromide ($CaBr_2$)) is both on the coal *and* in the combustion chamber.

1470. Furthermore, as illustrated in Figure 2, reproduced below as annotated, Downs-Boiler illustrates that the bromine-containing reagent may be introduced "to addition points A, B, C" including "coal preparation," "the pulverized coal conveying system 30," and "the boiler furnace 14."[2163]

[2162] Ex. 1006 (Downs-Boiler) ¶ [0022]; *see also* Ex. 1007 (Downs-Boiler-Provisional) IT [0025].

[2163] Ex. 1006 (Downs-Boiler) ¶ [0019], Figure 2 (annotated); *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [0022], Figure 2.

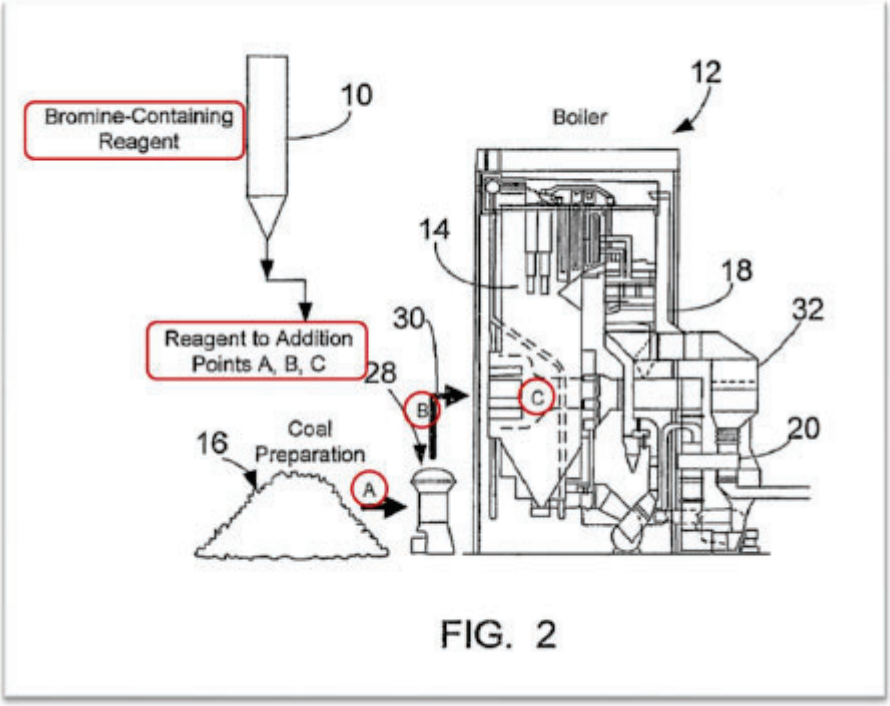


FIG. 2

Downs-Boiler in no way restricts simultaneous introduction to each of points A, B, and C. Rather, as described above, Downs-Boiler invites, if not encourages, simultaneous introduction to each of points A, B, and C or some combination of A/B and C to "intimately mix the bromide reagent 10 with the coal" so as to achieve a more "even distribution of the reagent 10 across the boiler furnace 14."[2164] Accordingly, Downs-Boiler discloses each and every limitation of Claim Element 25(b).

4. Claim 28: Elements 28(f): "injecting a sorbent comprising activated carbon into the mercury-containing gas downstream of the combustion chamber;"

[2164] Ex. 1006 (Downs-Boiler) ¶ [0019]; *see also* Ex. 1007 (Downs-Boiler-Provisional) 11 [0022].

1471. Downs-Boiler discloses that injecting a sorbent material comprising activated carbon, referring to the example of "powdered activated carbon (PAC)."[2165] Downs-Boiler explains that the use of a conventional PAC injection process is improved by the addition of bromine, in that the bromine-containing reagent "enhances the removal of mercury across a ***PAC injection*** process."[2166] Downs-Boiler repeats in other places that the bromine-containing reagent saves costs by making more efficient use of the activated-carbon sorbent material that is "inject[ed]."[2167] As explained by Downs-Boiler, the disclosed injected activated-carbon sorbent materials (e.g., sorbent injection systems using PAC) are part of *"downstream* pollution control systems such as . . . PAC injection systems."[2168] Here, "downstream" is relative to the location of the combustion chamber, and thus after generation of the mercury-containing gas. The activated-carbon sorbent material is injected into a mercury-containing gas: "injection of a carbonaceous

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[2165] Ex. 1006 (Downs-Boiler) ¶ [0025]; *see also* Ex. 1007 (Downs-Boiler-Provisional) IT [0028].

[2166] Ex. 1006 (Downs-Boiler) ¶ [0016] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [0019].

[2167] Ex. 1006 (Downs-Boiler) ¶ [0015] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) II [0018].

[2168] Ex. 1006 (Downs-Boiler) ¶ [0004]; see also Ex. 1007 (Downs-Boiler-Provisional)¶ [005].

sorbent (e.g., powdered *activated carbon,* or PAC) *into the flue gas* upstream of the dust collector to *adsorb vapor-phase mercury.*"[2169]

5. Claim 28: Elements 28(g): "contacting mercury in the mercury-containing gas with the sorbent; and"

1472. In the context of conventional mercury removal by PAC injection, Downs-Boiler explains that adsorption (*i.e.,* contact) of the mercury by the sorbent occurring in the mercury-containing (flue) gas system (*i.e.,* downstream of the combustion chamber) has been successfully shown to form a mercury/sorbent composition:[2170]

> injection of a carbonaceous *sorbent* (e.g., powdered *activated carbon,* or PAC) *into the flue gas* upstream of the dust collector to *adsorb vapor-phase mercury.* The *sorbent, and its burden of adsorbed mercury,* are subsequently removed from the flue gases in a downstream particulate collector. *Adsorption* is a technique that has often been successfully applied for the separation and removal of trace quantities of undesirable components.

The "sorbent, and its burden of adsorbed mercury" discloses a mercury/sorbent composition. For this process, described by Downs-Boiler as taking place in the dry emission control system such as an electrostatic precipitator or fabric filter, the "adsorption" of mercury refers to a process by which atoms, ions, or molecules in a fluid (typically a gas) are bound to the surface of a sorbent, and thus by definition

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[2169] Ex. 1006 (Downs-Boiler) ¶¶ [0004], [0015], [0016], and [0025]; *see also* Ex. 1007 (Downs-Boiler-Provisional) in [005], [0018], [0019], and [0028].

[2170] Ex. 1006 (Downs-Boiler) ¶ [0004]; *see also* Ex. 1007 (Downs-Boiler-Provisional) 11 [005]

the sorbent is "contacting mercury in the mercury-containing gas," as per claim element 25(c).

1473. Downs-Boiler recognizes that, when contacted with a sorbent, mercury in the mercury-containing gas forms a mercury/sorbent composition through the sorbent "bond[ing] with adsorbed mercury species" and that the strength of this bond is improved by halogens.[2171] In particular, Downs-Boiler explains that adding bromine in conjunction with activated carbon "results in an increased fraction of particulate-bound mercury," which includes an increase in the formation of sorbent-bound mercury.[2172] This increase in the fraction of particulate-bound mercury is explained as leading to a mercury/sorbent composition due to the increased "reactivity of oxidized mercury with PAC."[2173]

6. Claim 28: Elements 28(h): "separating the sorbent contacted with the mercury from the mercury-containing gas."

1474. Downs-Boiler discloses this claim element. Downs-Boiler explains that the desired removal of mercury from the flue gas is by a separation of the particulate-bound mercury. Separation of the particulate-bound mercury

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[2171] Ex. 1006 (Downs-Boiler) 11 [0004]; Ex. 1007 (Downs-Boiler-Provisional) 44 [005].

[2172] Ex. 1006 (Downs-Boiler) ¶ [0015]; Ex. 1007 (Downs-Boiler-Provisional) ¶ [0018].

[2173] Ex. 1006 (Downs-Boiler) ¶ [0016]; Ex. 1007 (Downs-Boiler-Provisional) ¶ [0019].

(mercury/sorbent composition), which includes the oxidized mercury adsorbed onto the PAC as discussed above regarding claim element 25(c)(2), is removed from the mercury-containing gas by a particulate collector as a way to clean the flue gas:[2174]

> The sorbent, and its burden of adsorbed mercury, are subsequently removed from the flue gases in a downstream particulate collector. Adsorption is a technique that has often been successfully applied for the separation and removal of trace quantities of undesirable components.

1475. Downs-Boiler illustrates a number of example particulate collection devices that may be used to separate the mercury-sorbent composition to produce a cleaned gas, each of which were well known to a POSITA. These particulate collectors include "electrostatic precipitators (ESP) or fabric filters (FF), sometimes called baghouses" that "provide high-efficiency removal of particulate-bound mercury."[2175]

B. INDEPENDENT CLAIM 1

1. Claim 1: Preamble—"A method of separating mercury from a mercury-containing gas, the method comprising:"

1476. The language of the preamble of claim 1 is identical to the preamble of claims 28 and 29. Accordingly, the explanation I provide above for the preamble of claim 28 applies equally to the preamble of claim 1.

[2174] Ex. 1006 (Downs-Boiler) ¶ [0004]; see also Ex. 1007 (Downs-Boiler-Provisional) il [005].

[2175] Ex. 1006 (Downs-Boiler) ¶¶ [0003] [0023], Figures 4-6; *see also* Ex. 1007 (Downs-Boiler-Provisional) '111 [004] [0026], Figures 4-6.

2. Claim 1: Element (1)(b)—"combusting coal in a combustion chamber, to provide the mercury-containing gas,"

1477. The language of claim element 1(b) is identical to the first portion of claim element 28(b) [which is identical to claim element 29(b)]. Accordingly, the explanation I provide above for those claim elements applies equally to claim element 1(b).

3. Claim 1: Element 1(c)—"the coal comprises an additive comprising Br2, HBr, a bromide compound, or a combination thereof, wherein the additive is added to the coal before the coal enters the combustion chamber, or"

1478. The language of claim element 1(c) is identical to the language of claim element 28(c) [which is identical to claim element 29(c)]. Accordingly, the explanation I provide above for those claim elements applies equally to claim element 1(c).

4. Claim 1: Element 1(d)—"the combustion chamber comprises an additive comprising Br2, HBr, a bromide compound, or a combination thereof or

1479. The language of claim element 1(d) is identical to the language of claim element 28(d) [which is identical to claim element 29(d)]. Accordingly, the explanation I provide above for those claim elements applies equally to claim element 1(d).

5. Claim 1: Element 1(e)—"a combination thereof;"

1480. The language of claim element 1(e) is identical to the language of claim element 28(e) [which is identical to claim element 29(e)]. Accordingly, the explanation I provide above for those claim elements applies equally to claim element 1(e).

6. Claim 1: Element 1(f)—"injecting a sorbent comprising activated carbon into the mercury-containing gas downstream of the combustion chamber;"

1481. The language of claim element 1(f) is identical to the language of claim element 28(f) [which is identical to the first portion of claim element 29(f)]. Accordingly, the explanation I provide above for those claim elements applies equally to claim element 1(b).

7. Claim 1: Element 1(g)—"contacting mercury in the mercury-containing gas with the sorbent; and"

1482. The language of claim element 1(g) is identical to the language of claim element 28(g) [which is identical to claim element 29(g)]. Accordingly, the explanation I provide above for those claim elements applies equally to claim element 1(g).

8. Claim 1: Element 1(h)—"separating the sorbent contacted with the mercury from the mercury-containing gas."

1483. The language of claim element 1(h) is identical to the language of claim element 28(h) [which is identical to claim element 29(h)]. Accordingly, the explanation I provide above for those claim elements applies equally to claim element 1(h).

C. CLAIMS DEPENDING FROM CLAIM 1

1. Claim 2: "The method of claim 1, wherein the coal comprises the additive comprising the Br2, HBr, the bromide compound, or a combination thereof, wherein the additive is added to the coal before the coal enters the combustion chamber.

1484. Downs-Boiler discloses this claim element. Downs-Boiler discloses HBr or a bromide compound, or a combination thereof, as its bromine-containing reagent that is added to the coal upstream of the combustion chamber. Downs-Boiler explains that its bromine-containing reagent may comprise, "but is not limited to, *alkali metal* and *alkaline earth metal bromides, hydrogen bromide (HBr)* or *bromine (Br_2).*"[2176] Downs-Boiler also specifically discloses *calcium bromide ($CaBr_2$)* as another bromide compound suitable for use as the bromine-containing reagent.[2177]

1485. The bromine-containing reagent is applied to the coal upstream of the combustion chamber and thus the coal and reagent would be part of the mixture being combusted. Downs-Boiler teaches that a "bromine containing reagent 10 is added to the boiler 12 combustion furnace 14, either directly or

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2176 Ex. 1006 (Downs-Boiler) 41] [0021] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) 'll [0024].

2177 Ex. 1006 (Downs-Boiler) 11 [0018-19] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) l] [0021-22].

by premixing with the incoming coal 16."[2178] According to the preferred embodiment of Downs-Boiler, ***"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*" such that the *"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."[2179] Thus, upstream of the combustion chamber, such as in the coal pulverizers and the pulverized coal conveying system, at least one or a combination of HBr and a bromide compound (e.g., calcium bromide ($CaBr_2$)) has been added on the coal.

1486. Downs-Boiler also discloses "the combustion chamber comprises added Br_2, HBr, a bromide compound, or a combination thereof." As described above—where the bromine-containing reagent is disclosed as added to the coal and/or the coal conveying system—this further discloses that the mixture being combusted comprises coal and the added bromine-containing reagent *(e.g.,* Br_2, HBr, a bromide compound, or a combination

[2178] Ex. 1006 (Downs-Boiler) 11 [0015]; *see also* Ex. 1007 (Downs-Boiler-Provisional) 11 [0018].

[2179] Ex. 1006 (Downs-Boiler) ¶ [0019], Figure 2; *see also* Ex. 1007 (Downs-Boiler-Provisional) III [0022], Figure 2.

thereof). As explained by Downs-Boiler, as a result of adding the bromine-containing reagent to the coal and/or the coal conveying system, the "***[b]romine species released during the combustion process*** enhance the oxidation of mercury as the combustion gases pass ***through the furnace 14***."[2180] That the bromine-containing reagent is "sprayed on the crushed coal 16 before the coal is pulverizedfor *combustion"* additionally "ensures even distribution of the [bromine-containing] reagent 10 ***across the boiler furnace"*** *(i.e.,* in the combustion chamber).[2181]

1487. Downs-Boiler also discloses introduction of HBr, and/or a bromide compound *(i.e.,* the bromine-containing reagent) directly into the combustion chamber. Downs-Boiler teaches that a "bromine containing reagent 10 is added to the boiler 12 combustion furnace 14, either directly or by premixing with the incoming coal 16"[2182]. Downs-Boiler describes that the inventors successfully tested direct introduction of the bromine-containing reagent—specifically, a bromide compound of calcium bromide ($CaBr_2$)—

[2180] Ex. 1006 (Downs-Boiler) 11 [0015] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [0018].

[2181] Ex. 1006 (Downs-Boiler) ¶ [0019] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) II [0022].

[2182] Ex. 1006 (Downs-Boiler) ¶ [0015]; see also Ex. 1007 (Downs-Boiler-Provisional) 11 [0018].

"injected into the combustion chamber 14 through a coal burner."[2183] Downs-Boiler further recognizes that "the bromine-containing reagent 10 may be fed to the boiler combustion zone 14 in gaseous, liquid, or solid form."[2184] Thus, the mixture that is being combusted comprises at least one or a combination of HBr and a bromide compound *(e.g.,* calcium bromide ($CaBr_2$)).

1488. Third, Downs-Boiler discloses adding a bromine-containing reagent to both the coal and the combustion chamber. As described above, Downs-Boiler describes applying the bromine-containing reagent to the coal upstream of the combustion chamber in such a way that added HBr and/or a bromide compound *(e.g.,* calcium bromide ($CaBr_2$)) is both on the coal *and* in the combustion chamber.

1489. Furthermore, as illustrated in Figure 2, reproduced below as annotated, Downs-Boiler illustrates that the bromine-containing reagent may be introduced "to addition points A, B, C" including "coal preparation," "the pulverized coal conveying system 30," and "the boiler furnace 14."[2185]

[2183] Ex. 1006 (Downs-Boiler) 11 [0019]; *see also* Ex. 1007 (Downs-Boiler-Provisional) IT [0021].

[2184] Ex. 1006 (Downs-Boiler) ¶ [0022]; *see also* Ex. 1007 (Downs-Boiler-Provisional) IT [0025].

[2185] Ex. 1006 (Downs-Boiler) ¶ [0019], Figure 2 (annotated); *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [0022], Figure 2.

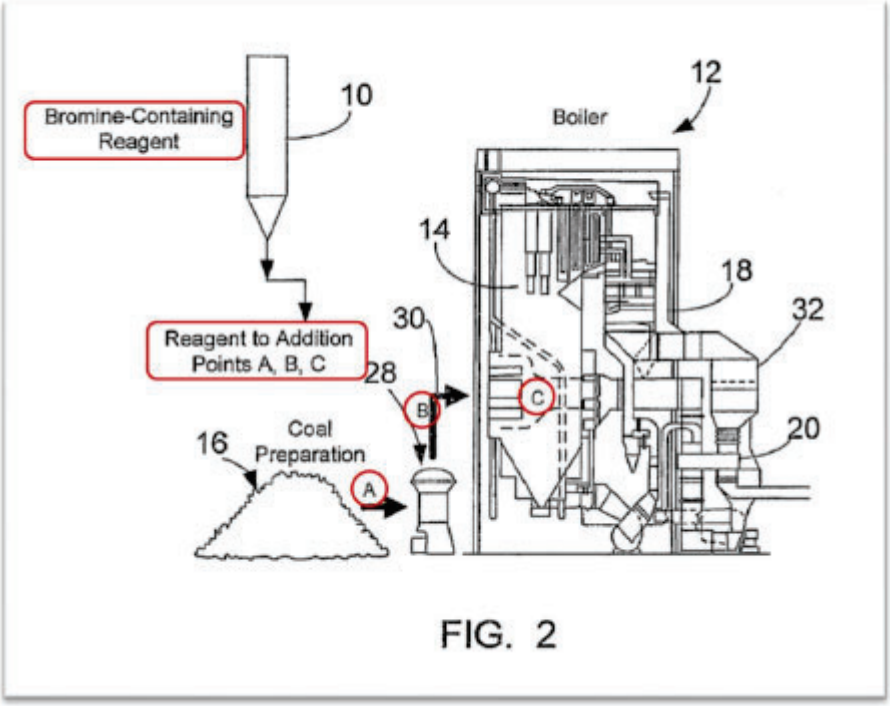


FIG. 2

1490. Downs-Boiler invites, if not encourages, introduction to each of points A, B, and C or some combination of A/B and C to "intimately mix the bromide reagent 10 with the coal" so as to achieve a more "even distribution of the reagent 10 across the boiler furnace 14."[2186]

2. <u>Claim 3: "The method of claim 1, wherein the combustion chamber comprises the additive comprising the Br2, HBr, the bromide compound, or a combination thereof."</u>

1491. This limitation is disclosed by Downs-Boiler and would otherwise be obvious based on the background knowledge of a POSITA. Downs-Boiler illustrates a conventional coal-fired facility with a boiler used

[2186] Ex. 1006 (Downs-Boiler) ¶ [0019]; *see also* Ex. 1007 (Downs-Boiler-Provisional) 11 [0022].

for the purpose of combusting coal, as represented by the arrow into combustion chamber 14. Representative Figure 4 is reproduced below:[2187]

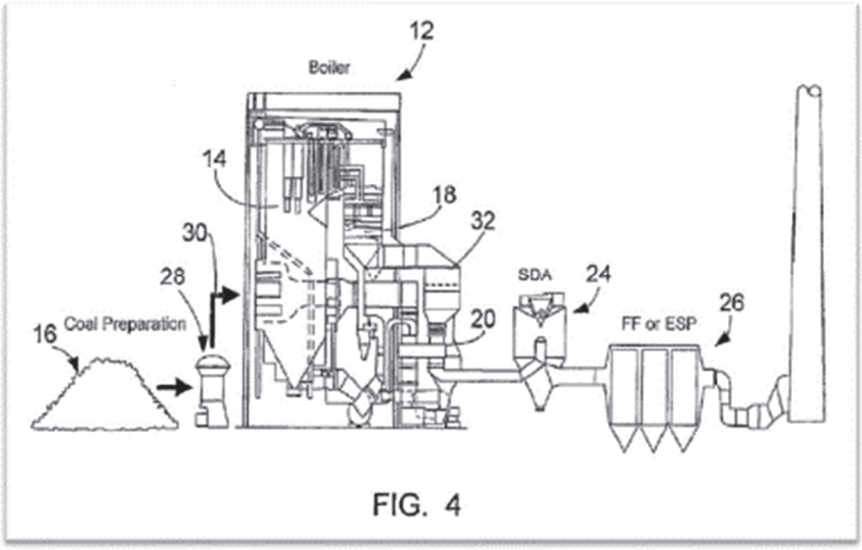


FIG. 4

1492. Downs-Boiler goes on to describe such a combustion of coal together with an added bromine-containing reagent, which occurs within combustion chamber 14, as illustrated in Figures 4-6:[2188]

1493. Downs-Boiler illustrates that the bromine-containing reagent may be introduced "to addition points A, B, C" including "coal preparation," "the pulverized coal conveying system 30," and "the boiler furnace 14."[2189]

2187 Ex. 1006 (Downs-Boiler) ¶ [0007], Figures 4; *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [009], Figures 4.

2188 Ex. 1006 (Downs-Boiler) ¶ [0015] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [0018].

2189 Ex. 1006 (Downs-Boiler) ¶ [0019], Figure 2 (annotated); *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [0022], Figure 2.

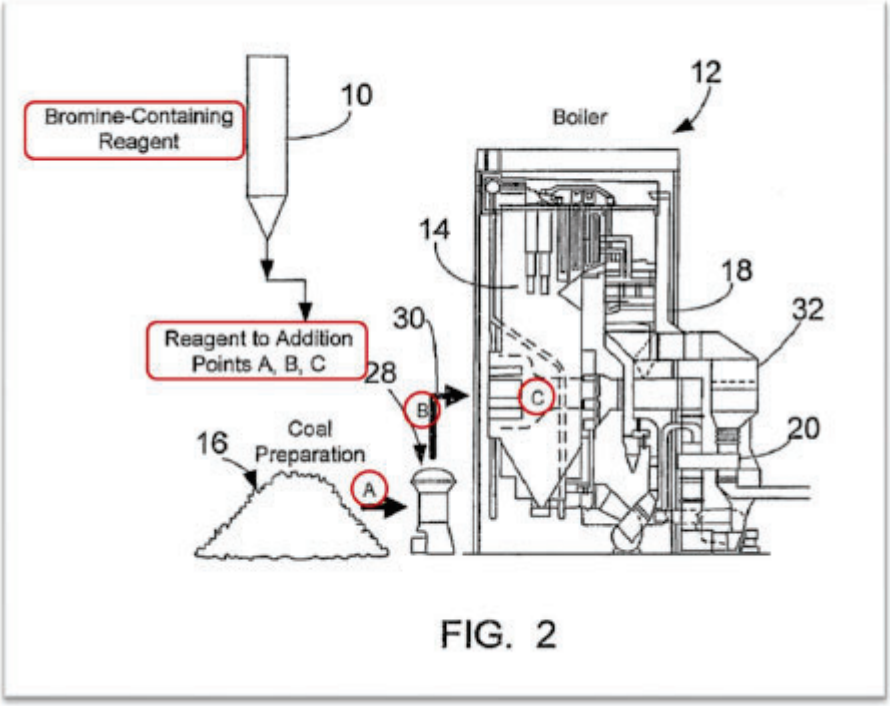


FIG. 2

3. Claim 4: "The method of claim 1, wherein the coal is combusted in the combustion chamber at a coal-combustion facility, wherein the additive comprising the Br2, HBr, bromide compound, or combination thereof, is added to the coal before the coal enters the combustion chamber, wherein the addition of the additive comprising the Br2, HBr, bromide compound, or combination thereof, to the coal is performed at the coal-combustion facility."

1494. The language in claim 4 is reflective of the language in claim elements 28(c) and 3. Accordingly, the explanation I provide above for that claim element applies equally to claim 4.

4. Claim 6: "The method of claim 1, wherein the combustion chamber is an electric utility coal combustion chamber."

1495. This limitation is disclosed by Downs-Boiler. Downs-Boiler describes combusting common ranks of coal used by the electric utility industry and,

specifically, that "the coal-fired boiler fuel 16 may include bituminous, subbituminous, and lignite coals and blends, thereof."[2190] Downs-Boiler acknowledges that the "removal of elemental mercury from coal combustion gases generated by electric utility plants through the application of a ***conventional PAC injection process****"* is well known and understood in the industry but concedes that that use of these systems is "very expensive" when not used in combination with the disclosed invention.[2191]

1496. Furthermore, as illustrated in Figures 4-6 of Downs-Boiler, a coal-fired utility boiler is shown as having a number of pollution control devices: "the electric utility plant configurations may include plants equipped with an SDA 24 and particulate collector 26 (FF or ESP) (FIG. 4), a particulate collector 26 (FF or ESP) (FIG. 5), or a wet 22 FGD and particulate collector 26 (FF or ESP) (FIG. 6)."[2192]

5. Claim 7: "The method of claim 1, wherein the combustion chamber is a coal combustion furnace."

1497. Downs-Boiler discloses this claim element. The explanation I provide above for claims 4 and 6 are equally applicable to claim 7.

[2190] Ex. 1006 (Downs-Boiler) ¶ [0020]; *see also* Ex. 1007 (Downs-Boiler-Provisional) IT [0023].

[2191] Ex. 1006 (Downs-Boiler) ¶ [0016] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) II [0019].

[2192] Ex. 1006 (Downs-Boiler) Figures 4-6; *see also* Ex. 1007 (Downs-Boiler-Provisional) Figures 4-6.

1498. The primary application taught by Downs-Boiler is with "[c]oal-fired utility boilers [that] are a known major source of anthropogenic mercury emissions in the United States.[2193] Downs-Boiler illustrates a conventional coal-fired utility boiler used for the purpose of combusting coal, as represented by the arrow into combustion chamber 14. Representative Figure 4 is reproduced below:[2194]

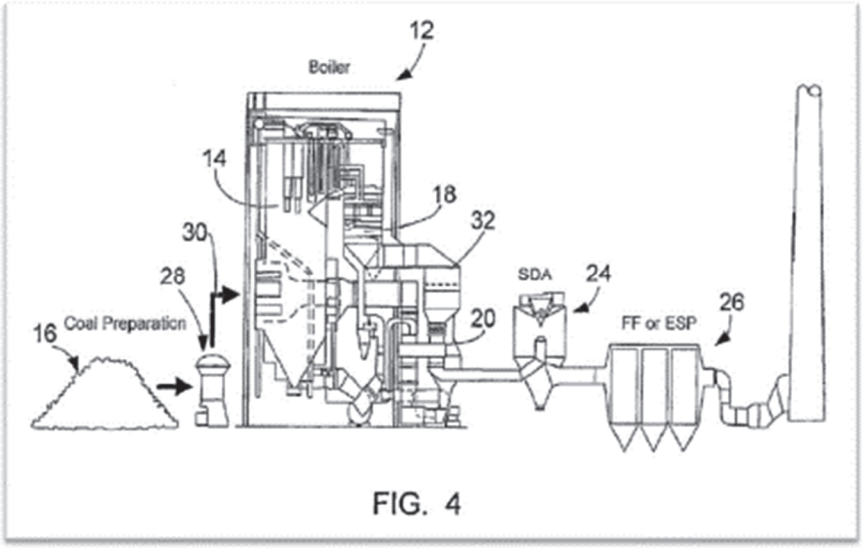


FIG. 4

6. Claim 8: "The method of claim 1, wherein the coal comprises a subbituminous coal."

1499. This limitation is disclosed by Downs-Boiler. Downs-Boiler describes combusting common ranks of coal used by the electric utility industry and,

[2193] Ex. 1006 (Downs-Boiler) ¶ [0001]; *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [002].

[2194] Ex. 1006 (Downs-Boiler) ¶ [0007], Figures 4; *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [009], Figures 4.

specifically, that "the coal-fired boiler fuel 16 may include bituminous, subbituminous, and lignite coals and blends, thereof."[2195]

7. Claim 10: "The method of claim 1, further comprising measuring the mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content of the mercury-containing gas, an injection rate of injecting the sorbent into the mercury-containing gas, an amount of the Br_2, HBr, the bromide compound, or a combination thereof, added to the coal or the combustion chamber, or a combination thereof."

1500. This limitation is disclosed by Downs-Boiler. The mercury content is monitored, as depicted by the Y-axis of Figure 3 *(i.e.,* the "Hg concentration" in µg/dscm).[2196] The units "µg/dscm" refer to micrograms of mercury per standard cubic meter of flue gas on a dry basis.

[2195] Ex. 1006 (Downs-Boiler) ¶ [0020]; *see also* Ex. 1007 (Downs-Boiler-Provisional) IT [0023].

[2196] Ex. 1006 (Downs-Boiler) Figure 3 (annotated); *see also* Ex. 1007 (Downs-Boiler-Provisional) Figure 3.

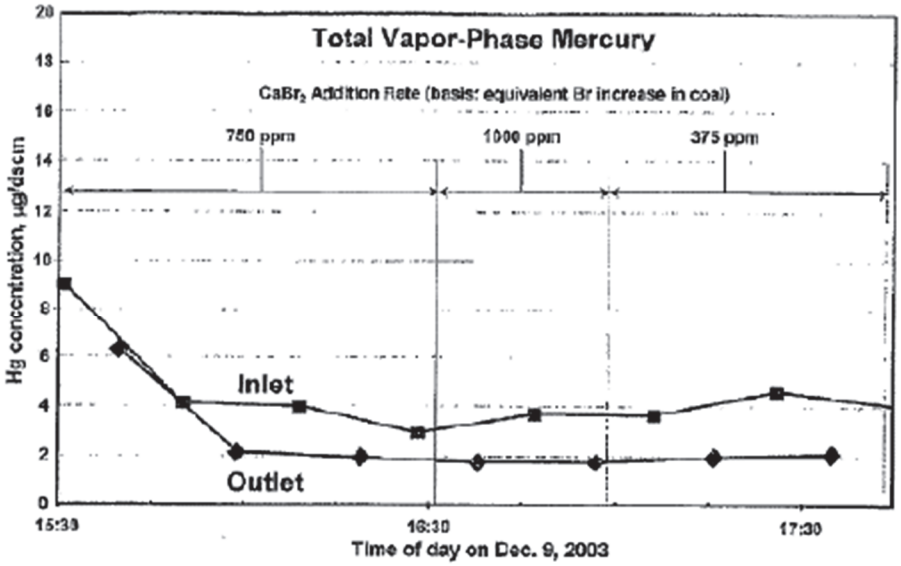


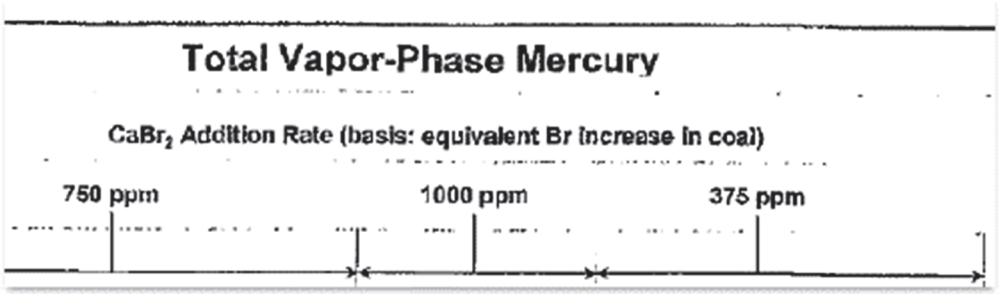
FIG. 3

In particular, Figure 3 shows that the mercury content of the cleaned gas (the data set provided by diamond markers for the outlet of the particulate collector) is monitored for a period of over two hours.[2197]

1501. As illustrated by Figure 3 of Downs-Boiler, excerpted below, in response to continuously monitoring the mercury content of the cleaned gas, the amount of additive (in this case the bromide compound $CaBr_2$) added into the mixture for combustion was continuously adjusted between a range of 375 to 1000

[2197] Ex. 1006 (Downs-Boiler) Figure 3; *see also* Ex. 1007 (Downs-Boiler-Provisional) Figure 3.

parts per million of a bromine-containing reagent ($CaBr_2$).[2198] By adjusting the amount of bromine-containing reagent applied, it would have been understood by a



POSITA that this would modify the amount of additive in the mixture. A POSITA reviewing the monitored data as presented by Figure 3 of Downs-Boiler would have understood that the monitored mercury content at the outlet of the particulate collector could be used to modify the addition rate of the bromine-containing reagent thereby controlling the amount of the additive in the mixture.

1502. It would have also been obvious to control the sorbent injection rate. As described above, Downs-Boiler discloses that the injection of sorbents was effective for the removal of mercury but as the rate of injecting the sorbent into the mercury-containing gas increases, the "economics of high injection rates can be prohibitive" due to the costs of the consumable sorbent material.[2199] The normal desire of a POSITA to improve on a given process would have been to adjust the

[2198] Ex. 1006 (Downs-Boiler) Figure 3 (annotated); *see also* Ex. 1007 (Downs-Boiler-Provisional) Figure 3.

[2199] Ex. 1006 (Downs-Boiler) ¶ [0004]; *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [005].

result-effective variable of the injection rate of the sorbent so as not to wastefully inject excessive sorbent once sufficient mercury removal was demonstrated, in order to minimize costs associated with operating the sorbent injection system. Furthermore, due to the variability of the composition of coal as a fuel source (including for example, native mercury and halogen content), as described in the State of the Art,[2200] it would have been obvious that some amount of adjustment to the rate of injection of the sorbent into the flue gas would be performed as part of routine process control and optimization to account for variances in the coal.

8. Claim 11: "The method of claim 10, wherein the measuring of the mercury content comprises continuous measurement."

1503. ME2C did not provide infringement contentions for this claim. ME2C's infringement contentions cross reference claim 24 of the '225 patent. ME2C's infringement contentions do not include claim 24 of the '225 patent. ME2C's final contentions hew to this position, and thus ME2C is apparently not asserting this claim. Therefore, no analysis regarding this element is required.

9. Claim 12: "The method of claim 1, further comprising: modifying, in response to a measured mercury content, an injection rate of injecting the sorbent into the mercury-containing gas, an amount of the Br2, HBr, the bromide compound, or a combination thereof, added to the coal or the combustion chamber, or a combination thereof."

[2200] State of the Art, § XII.B.1.

1504. The language of claim 12 is substantially identical to the language of claim 10. Accordingly, the explanation I provide above for claim 10 applies equally to claim 12.

10. Claim 13: "The method of claim 1, wherein the mercury-containing gas comprises about 1 g to about 30 g of the element bromine per 100 g of the sorbent."

1505. This claim would have been obvious over Downs-Boiler. Claim 4 is merely an attempt to claim the optimum or workable range for a process of combining a particular conventional halogen (bromine) being used in a conventional way (halogens are inherent to coal, and has the dual-benefit of oxidizing mercury and promoting activated carbons) with a conventional sorbent (activated carbon). Nothing about the particular range of 1 g to about 30 g of the halide promoter per 100 g of the sorbent would have led to an unexpected result from what was already known to one of skill in the art.

1506. As described in the State of the Art,[2201] it was known that the saturation limit of activated carbon for bromine (i.e., how much bromine the activated carbon can actually adsorb at equilibrium), was up to 31 to 38 grams per 100 grams of activated carbon. Given the residence times in flue gas, and other inefficiencies, a person of ordinary skill in the art would have understood that the actual bromine loaded onto activated carbon would have been less than the saturation limit.

[2201] State of the Art, § XII.C.3.

1507. A POSITA would have recognized that there would be sufficient bromine in the flue gas, according to the processes disclosed by Downs-Boiler, to provide a ratio of between 1 g to 30 g of bromine per 100 g of activated carbon. A POSITA would have been motivated to use near the bromine-saturation limit of the activated carbon because, in addition to the enhanced removal of mercury on sorbent with the use of halogens as disclosed by Downs-Boiler,[2202] it was known in the art that mercury oxidized by a halide, as "in the form of mercuric chloride, is soluble in water, making it amenable to removal in sulfur dioxide scrubbers," as discussed by Downs-Boiler.[2203] The fact that halides both contribute to the solubility of mercury in water rendering it trivial to remove in a scrubber and also enhance reactivity between mercury and activated carbons is confirmed as well-known in the art, which indicates that halides "improve[d] 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."[2204]

1508. Through natural process optimization and routine experimentation, a POSITA would have adjusted the rate of addition of bromine-containing species

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[2202] Ex. 1006 (Downs-Boiler) TT [0016], [0006]; *see also* Ex. 1007 (Downs-Boiler-Provisional) ill [0019], [007].

[2203] Ex. 1006 (Downs-Boiler) ¶ [0003]; *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [004].

[2204] Ex. 1062 (Crocker) at 2-3.

and/or activated carbon injection rate to achieve halide promoter on the activated-carbon sorbent from about 1 g to about 30 g.

11. Claim 14: "The method of claim 1, wherein the sorbent contacted with the mercury comprises the element bromine and mercury."

1509. Downs-Boiler discloses this claim. Downs-Boiler discloses that injecting a sorbent material comprising activated carbon, referring to the example of "powdered activated carbon (PAC)."[2205] Downs-Boiler explains that the use of a conventional PAC injection process is improved by the addition of bromine, in that the bromine-containing reagent "enhances the removal of mercury across a ***PAC injection*** process."[2206] Downs-Boiler repeats in other places that the bromine-containing reagent saves costs by making more efficient use of the activated-carbon sorbent material that is "inject[ed]."[2207] As explained by Downs-Boiler, the disclosed injected activated-carbon sorbent materials (e.g., sorbent injection systems using PAC) are part of *"downstream* pollution control systems such as . . . PAC injection systems."[2208] Here, "downstream" is relative to the location of the combustion

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[2205] Ex. 1006 (Downs-Boiler) ¶ [0025]; *see also* Ex. 1007 (Downs-Boiler-Provisional) IT [0028].

[2206] Ex. 1006 (Downs-Boiler) ¶ [0016] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [0019].

[2207] Ex. 1006 (Downs-Boiler) ¶ [0015] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) II [0018].

[2208] Ex. 1006 (Downs-Boiler) ¶ [0004]; see also Ex. 1007 (Downs-Boiler-Provisional)¶ [005].

chamber, and thus after generation of the mercury-containing gas. The activated-carbon sorbent material is injected into a mercury-containing gas: "injection of a carbonaceous *sorbent* (e.g., powdered *activated carbon,* or PAC) *into the flue gas* upstream of the dust collector to *adsorb vapor-phase mercury*."[2209]

1510. Downs-Boiler discloses that mercury in the flue gas is oxidized by the bromine-containing species and subsequently adsorbed onto activated carbon. Downs-Boiler describes that the use of the bromine-containing halogen in the presence of mercury results in an "increased fraction of mercury appearing in the oxidized form"—the oxidized form being that of mercuric bromide ($HgBr_2$).[2210] Downs-Boiler explains that the mercury forms a composition that comprises the element bromine, the sorbent material, and mercury owing to the "higher reactivity of oxidized mercury with PAC."[2211] Thus, the composition includes mercury and the element bromine (in the form of $HgBr_2$), together adsorbed onto activated carbon.

12. Claim 15: "The method of claim 1, comprising removing greater than 70 wt % of the mercury in the mercury-containing gas."

[2209] Ex. 1006 (Downs-Boiler) ¶¶ [0004], [0015], [0016], and [0025]; *see also* Ex. 1007 (Downs-Boiler-Provisional) in [005], [0018], [0019], and [0028].

[2210] Ex. 1006 (Downs-Boiler) 11 [0021]; *see also* Ex. 1007 (Downs-Boiler-Provisional) IT [0024].

[2211] Ex. 1006 (Downs-Boiler) ¶ [0016]; *see also* Ex. 1007 (Downs-Boiler-Provisional)¶ [0019].

1511. This limitation is disclosed by Downs-Boiler. According to Figure 3, reproduced below as annotated, Downs-Boiler indicates that the disclosed method for removing mercury from the flue gas resulted in mercury emissions at the outlet of the fabric filter of approximately 2 µg/dscm (blue) as compared to an initial value *(i.e.,* the mercury inventory of the system) at the inlet of the fabric filter of approximately 9 µg/dscm (red).[2212]

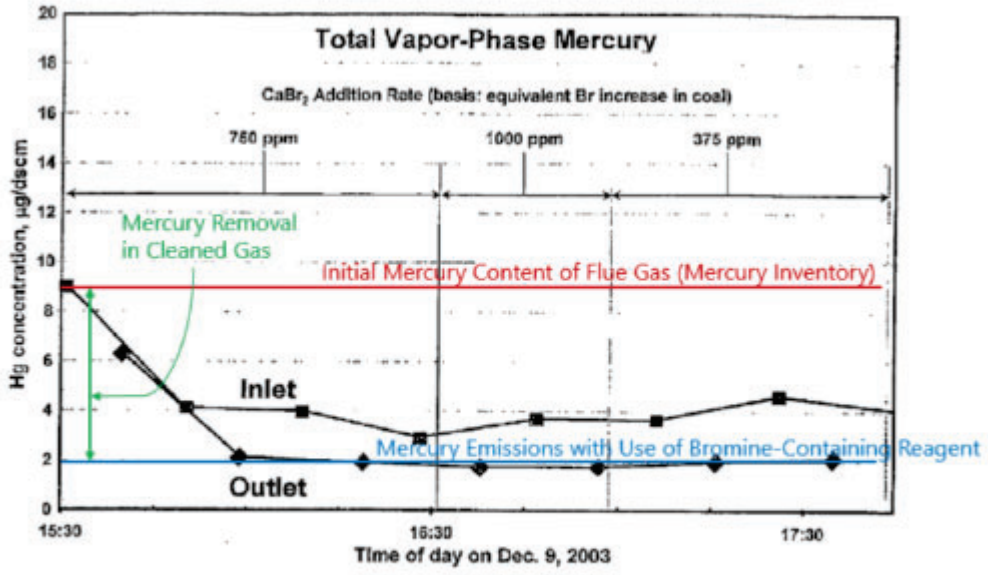


FIG. 3

Therefore, the use of the method disclosed by Downs-Boiler in conjunction with a fabric filter resulted in a system mercury removal of approximately 7 µg/dscm (green). This removal of the mercury in the mercury containing gas (7 µ g/dscm) as compared to the mercury inventory of the system (9 µg/dscm) may also be expressed

[2212] Ex. 1006 (Downs-Boiler) Figure 3 (annotated); *see also* Ex. 1007 (Downs-Boiler-Provisional) Figure 3.

as a percentage: at least 77 wt% of the mercury in the mercury-containing gas was removed—or in other words: removing greater than 70 wt% of the mercury in the mercury-containing gas.

1512. Furthermore, as described in the State of the Art,[2213] a POSITA would have known that by 2004, the EPA had already put the industry on notice of upcoming laws and regulations requiring 70% mercury removal, including the EPA's Clean Air Mercury Rule (CAMR). Downs-Boiler further teaches compliance with EPA standards regulating mercury emissions from coal-fired plants.[2214] Notice of these regulations exerted a strong outside impetus on the industry to adjust processes to comply with the regulations' eventual implementation. Through routine process optimization and routine experimentation, a POSITA would have adjusted the rate of addition of bromine-containing species and/or activated carbon injection rate to meet and exceed (for purposes of safety margin) the EPA's proposed rules requiring a 70% removal of mercury.

13. Claim 16: "The method of claim 1, comprising removing greater than 70 wt % of the mercury in the mercury-containing gas with the sorbent."

1513. This limitation is obvious in view of Downs-Boiler. As described above regarding Claim 15, Downs-Boiler discloses removing greater than 77 wt%

2213 State of the Art, XII.D — XII.F.

2214 Ex. 1006 (Downs-Boiler) ¶ [0001]; *see also* Ex. 1007 (Downs-Boiler-Provisional) 11 [002].

of the mercury in the flue gas. In addition to the reasons for Claim 2, a POSITA would understand that that the mercury removal on the sorbent alone would meet or exceed 70%. Downs-Boiler discloses that only "25% of the coal-fired power plants in the U.S. are equipped with wet FGD systems" (scrubbers), and discloses "PAC injection systems" (activated carbon) as an alternative to "downstream pollution control systems such as wet [scrubbers] 22 and SDA 24 FGD systems."[2215] This impact would be particularly pronounced for coal-fired utility plants using lignites or blends of high volatility coals that would produce minimal unburned carbon (*e.g.,* loss on ignition) particulate in the flue gas stream,[2216] resulting in a higher proportion of the mercury in the mercury-containing gas to bind to the sorbent.

1514. Downs-Boiler notes that "the presence of unburned carbon" is a factor that has "been shown to affect the conversion of elemental mercury to oxidized mercury species" and this unburned carbon *(i.e.,* LOI) would scavenge mercury from the flue gas, thereby affecting the percentage of mercury on the sorbent.[2217] Specifically, Downs-Boiler discloses that power stations burning western lignite coals, which produce a lower "percentage of oxidized mercury" and "have low

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[2215] Ex. 1006 (Downs-Boiler), ¶¶ [0007, 0015]; Ex. 1007 (Downs-Boiler-Provisional) ¶¶ [009, 0018].

[2216] *See* State of the Art, § XII.B.1.

[2217] Ex. 1006 (Downs-Boiler) ¶ [0005]; Ex. 1007 (Downs-Boiler-Provisional) 4111 [006].

chloride content" would benefit from the disclosed Hg control methods.[2218] Such plants typically exhibit very low levels of LOI in addition to suffering from very low concentrations of inherent chlorine in their flue gas. Under such circumstances, Hg capture on inherent unburned carbon would have been minimal in plants using western lignite coals and would therefore not have a significant effect on the percentage of mercury on the sorbent. Consequently, adding bromine-containing species to the furnace of coal-fired utility plants burning lignite and related coals, and that are not configured with a scrubber or a spray dryer absorber while injecting a sorbent ahead of the particle collection device, as Downs-Boiler teaches, ensures that virtually all the Hg captured in a particle collection device would be bound to the sorbent. Furthermore, Downs-Boiler also teaches how to adjust the bromine addition level to achieve highly efficient Hg removal, including greater than 70% removal.

1515. Additionally, a POSITA would have understood that that the mercury removal on the sorbent alone would meet or exceed 70%. Downs-Boiler discloses that only "25% of the coal-fired power plants in the U.S. are equipped with wet FGD systems" (scrubbers), and discloses "PAC injection systems" (activated carbon) as an alternative to "downstream pollution control systems such as wet 22 and SDA 24

[2218] Ex. 1006 (Downs-Boiler) ¶ [0005]; *see also* Ex. 1007 (Downs-Boiler-Provisional) 11 [006].

FGD systems."[2219] Downs-Boiler also discloses a plant that burns "lignite coals," which produces a lower "percentage of oxidized mercury" on account of "low chloride content."[2220] A POSITA would have understood that plants burning lignite, without a scrubber or spray-dryer adsorber, as taught by Downs-Boiler adding bromine in conjunction with activated carbon, the activated carbon would be the component that accounts for almost all of the mercury removal.

14. Claim 17: "The method of claim 1, wherein the sorbent in the mercury-containing gas comprises about 1 g to about 30 g of the added Br2, HBr, the bromide compound, or a combination thereof, per 100 g of the sorbent."

1516. This claim would have been obvious over Downs-Boiler. Claim 17 is merely an attempt to claim the optimum or workable range for a process of combining a particular conventional additive (Br2, HBr, the bromide compound, or a combination thereof) being used in a conventional way (this type of additive is inherent to coal, and has the dual-benefit of oxidizing mercury and promoting activated carbons) with a conventional sorbent (activated carbon). Nothing about the particular range of 1 g to about 30 g of the additive per 100 g of the sorbent would have led to an unexpected result from what was already known to one of skill in the art.

[2219] Ex. 1006 (Downs-Boiler) 111 [0007, 0015, 0025]; *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶¶ [009, 0018, 0028].

[2220] Ex. 1006 (Downs-Boiler) ¶¶ [0005, 0020]; *see also* Ex. 1007 (Downs-Boiler-Provisional) im [006, 0023].

1517. As described in the State of the Art,[2221] it was known that the saturation limit of activated carbon for bromine (i.e., how much bromine the activated carbon can actually adsorb at equilibrium), was up to 31 to 38 grams per 100 grams of activated carbon. Given the residence times in flue gas, and other inefficiencies, a person of ordinary skill in the art would have understood that the actual bromine loaded onto activated carbon would have been less than the saturation limit.

1518. A POSITA would have recognized that there would be sufficient bromine in the flue gas, according to the processes disclosed by Downs-Boiler, to provide a ratio of between 1 g to 30 g of bromine per 100 g of activated carbon. A POSITA would have been motivated to use near the bromine-saturation limit of the activated carbon because, in addition to the enhanced removal of mercury on sorbent with the use of halogens as disclosed by Downs-Boiler,[2222] it was known in the art that mercury oxidized by a halide, as "in the form of mercuric chloride, is soluble in water, making it amenable to removal in sulfur dioxide scrubbers," as discussed by Downs-Boiler.[2223] The fact that halides both contribute to the solubility of mercury in water rendering it trivial to remove in a scrubber and also enhance reactivity between mercury and activated carbons is confirmed as well-known in the art, which

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2221 State of the Art, § XII.C.3.

2222 Ex. 1006 (Downs-Boiler) TT [0016], [0006]; *see also* Ex. 1007 (Downs-Boiler-Provisional) ill [0019], [007].

2223 Ex. 1006 (Downs-Boiler) ¶ [0003]; *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [004].

indicates that halides "improve[d] 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."[2224]

1519. Through natural process optimization and routine experimentation, a POSITA would have adjusted the rate of addition of bromine-containing species and/or activated carbon injection rate to achieve an additive on the activated-carbon sorbent from about 1 g to about 30 g.

15. Claim 18: "The method of claim 1, wherein the Br2, HBr, or the bromide compound is contacted with the sorbent in vapor form, gaseous form, liquid form, or in an organic solvent."

1520. This limitation is obvious in view of Downs-Boiler. Downs-Boiler teaches that the bromine-containing reagent "may be fed to the boiler combustion zone 14 in gaseous, liquid, or solid form."[2225] In addition, a POSITA would have known that Br2 has a boiling point of 58.8 ºC and HBr has a boiling point of -67 ºC. Upon exposing the bromine-containing reagent to the relatively high combustion temperatures and subsequent flue gas, the bromine-containing reagent would remain in gaseous form when contacting the sorbent.

1521. The explanation I provide above for claim 28(c) is equally applicable to claim 18.

2224 Ex. 1062 (Crocker) at 2-3.

2225 Ex. 1006 (Downs-Boiler) ¶ [0022].

16. Claim 19: "The method of claim 1, wherein the activated carbon comprises powdered activated carbon, granular activated carbon, or a combination thereof."

1522. Downs-Boiler discloses adding a particulate sorbent material comprising activated carbon, referring to the example of "powdered activated carbon (PAC)."[2226] Powdered activated carbon is activated carbon in particulate form. Downs-Boiler explains that the use of a conventional PAC injection process is improved by the addition of bromine, in that the bromine-containing reagent "enhances the removal of mercury across a ***PAC injection*** process."[2227] Downs-Boiler repeats in other places that the bromine-containing reagent saves costs by making more efficient use of the activated-carbon sorbent material that is "inject[ed]."[2228] As explained by Downs-Boiler, the disclosed injected activated-carbon sorbent materials (e.g., sorbent injection systems using PAC) are part of *"downstream* pollution control systems such as . . . PAC injection systems."[2229] Here, "downstream" is relative to the location of the combustion chamber, and thus after generation of the mercury-containing gas. The activated-carbon sorbent

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[2226] Ex. 1006 (Downs-Boiler) ¶ [0025]; *see also* Ex. 1007 (Downs-Boiler-Provisional) IT [0028].

[2227] Ex. 1006 (Downs-Boiler) ¶ [0016] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [0019].

[2228] Ex. 1006 (Downs-Boiler) ¶ [0015] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) II [0018].

[2229] Ex. 1006 (Downs-Boiler) ¶ [0004]; see also Ex. 1007 (Downs-Boiler-Provisional)¶ [005].

material is injected into a mercury-containing gas: "injection of a carbonaceous *sorbent* (e.g., powdered *activated carbon,* or PAC) *into the flue gas* upstream of the dust collector to *adsorb vapor-phase mercury.*"[2230] Downs-Boiler discloses the use of a "sorbent injection system" for the purpose of injecting a "carbonaceous sorbent" including at least "powdered activated carbon (PAC), carbons and chars produced from coal and other organic materials, and unburned carbon produced by the combustion process itself."[2231]

17. Claim 20: "The method of claim 1, wherein the sorbent injected into the mercury-containing gas is a sorbent obtained by contacting a sorbent with a halogen or halide promoter prior to the injection of the sorbent into the mercury-containing gas."

1523. ME2C did not provide infringement contentions for this claim. ME2C's infringement contentions cross reference claim 14 of the '114 patent. ME2C's infringement contentions do not include claim 14 of the '114 patent. ME2C's final contentions hew to this position, and thus ME2C is apparently not asserting this claim. Therefore, no analysis regarding this element is required.

18. Claim 21: "The method of claim 1, wherein the sorbent injected into the mercury-containing gas is free of contact with a halogen or halide promoter prior to injection of the sorbent into the mercury-containing gas."

[2230] Ex. 1006 (Downs-Boiler) ¶¶ [0004], [0015], [0016], and [0025]; *see also* Ex. 1007 (Downs-Boiler-Provisional) in [005], [0018], [0019], and [0028].

[2231] Ex. 1006 (Downs-Boiler) ¶ [0025]; *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [0028].

1524. ME2C did not provide infringement contentions for this claim. ME2C's infringement contentions cross reference claim 13 of the '114 patent. ME2C's infringement contentions do not include claim 13 of the '114 patent. ME2C's final contentions hew to this position, and thus ME2C is apparently not asserting this claim. Therefore, no analysis regarding this element is required.

19. Claim 22: "The method of claim 1, wherein the combustion chamber comprises a boiler."

1525. Downs-Boiler discloses this limitation. Downs-Boiler discloses a combustion chamber (i.e. a "combustion furnace 14") that comprises a "boiler 12."[2232] Furthermore, in Figures 2 and 4-6 Downs-Boiler illustrates a combustion chamber 14 (red) comprising a boiler 12 (green), as indicated by representative Figure 5 reproduced below as annotated:[2233]

[2232] Ex. 1006 (Downs-Boiler) 11 [0015]; *see also* Ex. 1007 (Downs-Boiler-Provisional) IT [0018].

[2233] Ex. 1006 (Downs-Boiler) Figures 2, 4-6; *see also* Ex. 1007 (Downs-Boiler-Provisional) Figures 2, 4-6.

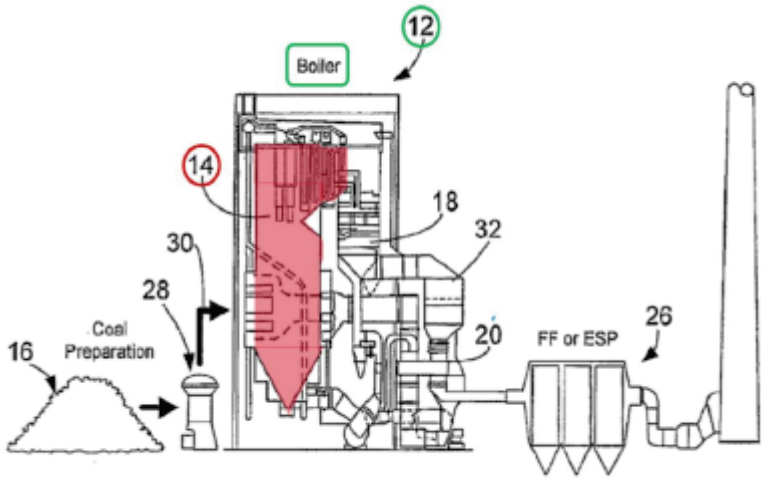


FIG. 5

20. Claim 23: "The method of claim 1, wherein the mercury-containing gas is a flue gas."

1526. Downs-Boiler discloses this limitation. Downs-Boiler specifically describes various forms of mercury as being present within a flue gas:[2234]

> Mercury appears in coal combustion flue gases in both solid and gas phases (particulate-bound mercury and vapor-phase mercury, respectively). The so called particulate-bound mercury is really vapor-phase mercury adsorbed onto the surface of ash or carbon particles. Due to the high volatility of mercury and many of its compounds, most of the mercury found in flue gases is vapor-phase mercury. Vapor-phase mercury can appear as elemental mercury (elemental, metallic mercury vapor) or as oxidized mercury (vapor-phase species of various compounds of mercury).

The invention taught by Downs-Boiler promises an effective low-cost solution for "mercury removal" from the flue gases "at coal-fired electric plants."[2235] The

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[2234] Ex. 1006 (Downs-Boiler) ¶ [0002]; *see also* Ex. 1007 (Downs-Boiler-Provisional) III [003].

[2235] Ex. 1006 (Downs-Boiler) 11 [0016]; *see also* Ex. 1007 (Downs-Boiler-Provisional) IT [0019].

preamble of claim 1 of Downs-Boiler also identifies "a flue gas" as being such a mercury-containing gas from which to remove mercury.[2236]

21. Claim 24: "The method of claim 1, wherein the injection of the sorbent into the mercury-containing gas occurs upstream of a particulate separator, a scrubber, or a combination thereof."

1527. Downs-Boiler discloses this limitation. As illustrated by Figures 4-6 of Downs-Boiler, representative Figure 6 reproduced below as annotated, Downs-Boiler describes a coal-fired electric utility plant that can have a number of downstream pollution control devices including particulate collection systems (*e.g.,* a fabric filter (FF) system and/or an electrostatic precipitator (ESP) system) (purple) and a scrubber (*e.g.,* wet flue gas desulfurization (FGD) system) (yellow).[2237]

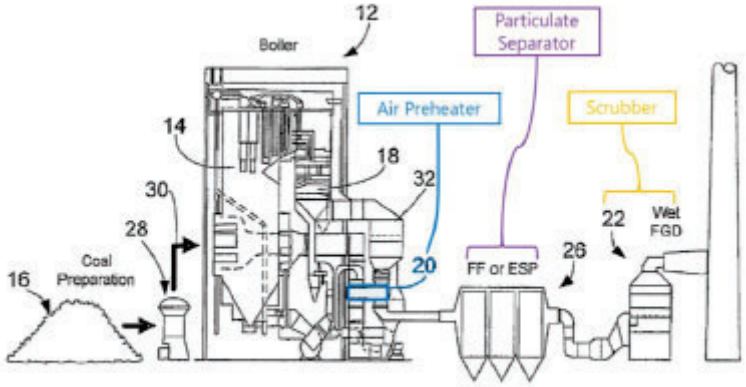


FIG. 6

[2236] Ex. 1006 (Downs-Boiler) Claim 1; *see also* Ex. 1007 (Downs-Boiler-Provisional) Claim 1.

[2237] Ex. 1006 (Downs-Boiler) Figure 6 (annotated; *see also* Ex. 1006 (Downs-Boiler) Figures 4-5; Ex. 1007 (Downs-Boiler-Provisional) Figures 4-6.

The use of the bromine-containing reagent as disclosed by Downs-Boiler "thereby enhance[es] the overall removal of mercury in ***downstream pollution control devices***."[2238] Specifically, Downs-Boiler explains that a particular advantage of the disclosed invention is that it "enhances removal of mercury across ***particulate collectors 26*** such as fabric filters (FF) and electrostatic precipitators (ESP)."[2239] As further explained by Downs-Boiler, the upstream injection of a sorbent means that the "sorbent, and its burden of adsorbed mercury, are subsequently removed from the flue gases ***in a downstream particulate collector***."[2240]

1528. The concept of using a particulate separator or a scrubber in conjunction with sorbent injection is further confirmed by the EPA, explaining that for "direct sorbent injection, after sorbent is introduced into the flue gas, it adsorbs Hg and other contaminants and is ***captured downstream*** in an existing or sorbent-specific [(particulate matter)] control device."[2241] Therefore, to the extent Downs-Boiler fails to explicitly disclose injection of the sorbent material into the mercury-containing gas occurring upstream of a particulate separator or a scrubber this would have been obvious to a POSITA at the time.

2238 Ex. 1006 (Downs-Boiler) 11 [0007] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [009].

2239 Ex. 1006 (Downs-Boiler) ¶ [0015] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) II [0018].

2240 Ex. 1006 (Downs-Boiler) ¶ [0004] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [005].

2241 Ex. 1009 (EPA-Proposal) at 4676 (emphasis added).

22. Claim 25: "The method of claim 24, wherein the particulate separator comprises a baghouse, an electrostatic precipitator, a fabric filter, or a combination thereof."

1529. Downs-Boiler discloses this claim element. Downs-Boiler explains that the desired removal of mercury from the flue gas is by a separation of the particulate-bound mercury. Separation of the particulate-bound mercury (mercury/sorbent composition), which includes the oxidized mercury adsorbed onto the PAC as discussed above regarding claim element 25(c)(2), is removed from the mercury-containing gas by a particulate collector as a way to clean the flue gas:[2242]

> The sorbent, and its burden of adsorbed mercury, are subsequently removed from the flue gases in a downstream particulate collector. Adsorption is a technique that has often been successfully applied for the separation and removal of trace quantities of undesirable components.

Downs-Boiler illustrates a number of example particulate collection devices that may be used to separate the mercury-sorbent composition to produce a cleaned gas, each of which were well known to a POSITA. These particulate collectors include "electrostatic precipitators (ESP) or fabric filters (FF), sometimes called baghouses" that "provide high-efficiency removal of particulate-bound mercury."[2243]

[2242] Ex. 1006 (Downs-Boiler) ¶ [0004]; see also Ex. 1007 (Downs-Boiler-Provisional) il [005].

[2243] Ex. 1006 (Downs-Boiler) ¶¶ [0003] [0023], Figures 4-6; *see also* Ex. 1007 (Downs-Boiler-Provisional) '111 [004] [0026], Figures 4-6.

1530. Downs-Boiler further discloses the method of claim 24, which is described in the above section.

D. INDEPENDENT CLAIM 29

1. Claim 29: Element 29(a): "A method of separating mercury from a mercury-containing gas, the method comprising:"

1531. The language of the preamble of claim 29 is identical to the preamble of claims 28 and 1. Accordingly, the explanation I provide above for the preamble of claim 28 applies equally to the preamble of claim 29.

2. Claim 29: Element 29(b): "combusting coal in a combustion chamber, to provide the mercury-containing gas, wherein the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br−, or a combination thereof, wherein"

1532. The language of this claim element is identical to claim element 28(b). Accordingly, the explanation I provide above for those claim elements applies equally to this claim element.

3. Claim 29: Element 29(c)-(e): "the coal comprises an additive comprising Br2, HBr, a bromide compound, or a combination thereof, wherein the additive is added to the coal before the coal enters the combustion chamber, or the combustion chamber comprises an additive comprising Br2, HBr, a bromide compound, or a combination thereof, or a combination thereof;"

1533. The language of this claim element is identical to claim element 28(c)-(e). Accordingly, the explanation I provide above for those claim elements applies equally to this claim element.

4. Claim 29: Element 29(f): "injecting a sorbent comprising activated carbon into the mercury-containing gas downstream of the combustion chamber such that the activated carbon reacts with the halogen or halide promoter in the mercury-containing gas to form a promoted sorbent;"

1534. The language of this claim element is identical to claim element 28(f). Accordingly, the explanation I provide above for those claim elements applies equally to this claim element.

1535. In addition, Downs-Boiler discloses adding Br2, HBr, or an "aqueous solution of calcium bromide" (CaBr2) to the coal and/or combustion chamber.[2244] HBr and Br– are examples of a "halogen or halide promoter." Downs-Boiler expressly discloses HBr and aqueous solutions of calcium bromide that dissociate in water to form bromide ions (Br–).[2245] Downs-Boiler also confirms that the bromine-containing species are present in the mercury-containing flue gas, stating that they are responsible for "enhanc[ing] the removal of mercury."[2246]

1536. Downs-Boiler also discloses "injection of a carbonaceous sorbent (e.g., powdered activated carbon, or PAC) into the flue gas upstream of the dust collector to adsorb vapor-phase mercury."[2247]. Downs-Boiler describes "PAC injection

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2244 Ex. 1006 (Downs-Boiler) [0018]-[0021], Fig. 2.
2245 Ex. 1006 (Downs-Boiler) [0018]-[0019].
2246 Ex. 1006 (Downs-Boiler) [0015]-[0016].
2247 Ex. 1006 (Downs-Boiler) [0004].

systems" as a component of "downstream pollution control systems," as they are "downstream" of the combustion chamber.[2248]

1537. A POSITA would have understood that activated carbon and the halide promoter (bromide) would have reacted to form at least a quantity of promoted sorbent. For example, it was well known that halides form chemical bonds directly with activated carbon, and improve mercury capture not only by oxidizing elemental mercury (Hg0) to the more easily removed Hg2+ form, but also by enhancing the reactivity of Hg0 with activated carbons. Indeed, Downs-Boiler teaches that halogens may be "incorporated into the carbonaceous sorbent" to "yield sorbents that more strongly bond with adsorbed mercury species" (i.e., forming a promoted sorbent).[2249] A POSITA would have also known that on account of the enhanced reactivity of activated carbon to mercury, the sorbent/halogen composition would have been considered a "promoted" sorbent.

5. Claim 29: Element 29(g): "contacting mercury in the mercury-containing gas with the promoted sorbent;"

1538. The language of this claim element is identical to claim element 28(g). Accordingly, the explanation I provide above for those claim elements applies equally to this claim element.

2248 Ex. 1006 (Downs-Boiler) [0015].

2249 Ex. 1006 (Downs-Boiler) [0004].

6. Claim 29: Element 29(h): "separating the promoted sorbent contacted with the mercury from the mercury-containing gas;"

1539. The language of this claim element is identical to claim element 28(h). Accordingly, the explanation I provide above for those claim elements applies equally to this claim element.

7. Claim 29: Element 29(i)-(m): "measuring the mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content, an injection rate of injecting the sorbent into the mercury-containing gas, an amount of the Br2, HBr, the bromide compound, or a combination thereof, added to the coal or the combustion chamber, or a combination thereof."

1540. The language of this claim element is identical to that of claim 10. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

XLV. GROUND AA: OBVIOUSNESS OF THE '430 PATENT OVER DOWNS-BOILER IN VIEW OF EPA-PROPOSAL

1541. It is my opinion that Downs-Boiler in view of the EPA-Proposal renders obvious each of claims 1, 10, 15, 16, and 28-29. Elements and claims not mentioned below are disclosed and/or obvious for the reasons stated above in Ground Z.

8. Claims 1, 28, and 29: Claim Elements 1(f), 28(f), and 29(f)

1542. From the disclosure of Downs-Boiler, POSITA would have found claims 1, 24, and 28 (and claims depending from them) obvious in view of EPA-Proposal.

a. **Element 1(f)—"injecting a sorbent comprising activated carbon into the mercury-containing gas downstream of the combustion chamber;"**

b. **Element 28(f)—"injecting a sorbent comprising activated carbon into the mercury-containing gas downstream of the combustion chamber;"**

c. **Element 29(f)—"injecting a sorbent comprising activated carbon into the mercury-containing gas downstream of the combustion chamber such that the activated carbon reacts with the halogen or halide promoter in the mercury-containing gas to form a promoted sorbent;"**

1543. In addition to the reasons described in Ground Z, claim elements 1(f), 28(f), and 29(f) would have been obvious over Downs-Boiler in view of the EPA-Proposal.

1544. EPA-Proposal also discloses introducing sorbents into the flue gas for mercury removal by direct sorbent injection.[2250] EPA-Proposal teaches that "[w]ith direct sorbent injection, after sorbent is introduced into the flue gas, it adsorbs Hg and other contaminants and is captured downstream in an existing or sorbent-specific PM control device."[2251] EPA-Proposal discloses activated carbon (regular and impregnated) as a type of sorbent for use in sorbent injection.[2252]

9. Claims 1, 28, and 29: Claim Elements 1(g), 28(g), and 29(g)

2250 Ex. 1009 (EPA-Proposal) at 4676.
2251 Ex. 1009 (EPA-Proposal) at 4676.
2252 Ex. 1009 (EPA-Proposal) at 4676.

a. **Element 1(g)—"contacting mercury in the mercury-containing gas with the sorbent; and"**

b. **Element 28(g): "contacting mercury in the mercury-containing gas with the sorbent; and"**

c. **Element 29(g): "contacting mercury in the mercury-containing gas with the promoted sorbent;"**

1545. In addition to the reasons described in Ground Z, claim elements 1(g), 28(g), and 29(g) would have been obvious over Downs-Boiler in view of the EPA-Proposal.

1546. EPA-Proposal also teaches that the mercury in the mercury-containing gas contacts the sorbent, as evidenced by EPA-Proposal's disclosure of activated carbon having an internal pore structure that allows the activated carbon to "adsorb a broad range of contaminants," including "good to excellent Hg removal with the injection of AC."[2253]

10. Claim 10: "The method of claim 1, further comprising measuring the mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content of the mercury-containing gas, an injection rate of injecting the sorbent into the mercury-containing gas, an amount of the Br_2, HBr, the bromide compound, or a combination thereof, added to the coal or the combustion chamber, or a combination thereof."

1547. In addition to the reasons described in Ground Z, claim 10 would have been obvious over Downs-Boiler in view of the EPA-Proposal. When starting from

[2253] Ex. 1009 (EPA-Proposal) at 4676.

Downs-Boiler, a POSITA would have found it obvious to control the sorbent injection rate in view of EPA-Proposal in achieving mercury emissions targets. As described above, Downs-Boiler monitors mercury content and controls the addition rate of bromine and/or bromine compound. EPA-Proposal discusses an additional control variable that can be adjusted based on mercury content in the mercury-containing gas. EPA-Proposal explains that when using activated carbon, the "extent of potential Hg removal is dependent on: (1) Efficient distribution of the sorbent (e.g., activated carbon) in the flue gas; (2) *the amount of sorbent needed* to achieve a specific level of Hg removal which will vary depending on the fuel being burned."[2254] Accordingly, in operating a dry-emission control system, such as the electrostatic precipitator and/or fabric filter as in Downs-Boiler, a POSITA would have been motivated to continuously adjust an injection rate of the sorbent into the mercury-containing gas, in response to the continuous monitoring of the mercury level, to provide the desired amount of sorbent needed to remove mercury.

1548. Accordingly, a POSITA would have been motivated to combine the teachings of Downs-Boiler and EPA-Proposal to modify, in response to the measured mercury content, the sorbent injection rate to optimize sorbent injection while maintaining adequate mercury removal. A POSITA would have further understood that coal composition varies in native mercury and halogen content and

[2254] Ex. 1009 (EPA-Proposal) at 4676 (emphasis added).

would have adjusted the sorbent injection rate as part of routine optimization and process control to account for the fluctuating coal content, with a reasonable expectation of success.

11. Claims 15 and 16

a. Claim 15: "The method of claim 1, comprising removing greater than 70 wt % of the mercury in the mercury-containing gas."

b. Claim 16: "The method of claim 1, comprising removing greater than 70 wt % of the mercury in the mercury-containing gas with the sorbent."

1549. In addition to the reasons described in Ground Z, claim 15 would have been obvious over Downs-Boiler in view of the EPA-Proposal. As described in Ground Z, Downs-Boiler discloses removing at least 77 wt% of the mercury in the mercury-containing gas.[2255] Downs-Boiler also discloses removing mercury to meet advancing EPA standards regulating mercury emissions from coal-fired plants.[2256] The EPA proposed rules stated that a "primary goal in this rulemaking is to reduce power plant emissions of Hg by 70 percent from today's levels by 2018" with more near-term caps built in.[2257] EPA-Proposal discloses targeting 70% mercury removal by introducing activated carbon (including halogen-impregnated varieties) into the

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[2255] Ex. 1006 (Downs-Boiler) Figure 3 (annotated); *see also* Ex. 1007 (Downs-Boiler-Provisional) Figure 3.

[2256] Ex. 1006 (Downs-Boiler) ¶ [0001]; *see also* Ex. 1007 (Downs-Boiler-Provisional) 11 [002].

[2257] Ex. 1009 (EPA-Proposal) at 4698.

flue gas and utilizing other known methods. At least by January 2004, the EPA announced to the coal-fired industry that upcoming regulations would require an eventual 70% reduction in mercury emissions, motivating researchers to adopt processes that would achieve those limits.[2258] EPA-Proposal also discusses enforcement mechanisms, including "automatic…financial penalties" for mercury emissions exceeding the desired levels.[2259] Relatedly, Downs-Boiler discusses EPA standards regulating mercury emissions from coalfired plants.[2260] Thus, Downs-Boiler discloses the need to comply with regulatory requirements for mercury emissions, such as those set forth in EPA-Proposal.

1550. Furthermore, EPA-Proposal discusses several ways to reduce mercury emissions to a desired level, including by injecting activated-carbon sorbent material (bare or halogen-impregnated), and controlling the activated-carbon injection rate.[2261] A POSITA would have had a reasonable expectation of success in combining Downs-Boiler with EPA-Proposal because, like Downs-Boiler, EPA Proposal describes "sorbent injection" into the flue gas.[2262] "[A]fter sorbent is introduced into the flue gas, it adsorbs Hg and other contaminants and is captured downstream in an existing or sorbent-specific PM [particulate matter] control

2258 Ex. 1009 (EPA-Proposal) at Cover, 4652, 4698.
2259 Ex. 1009 (EPA-Proposal) at 4701.
2260 Ex. 1006 (Downs-Boiler) ¶ [0001].
2261 Ex. 1009 (EPA-Proposal) at 4698.
2262 Ex. 1009 (EPA-Proposal) at 4698.

device."[2263] EPA-Proposal describes "activated carbon" as an exemplary sorbent for injection into flue gas.[2264]

1551. Therefore, a POSITA would have been motivated to combine the teachings of Down-Boiler and EPA-Proposal to operate their coal-fired plants in a manner compliant with the EPA-Proposal to avoid eventual regulatory fines for emissions violations, to try the remediation methods described by the EPA-Proposal.

XLVI. GROUND AB: OBVIOUSNESS OF THE '430 PATENT OVER DOWNS-BOILER IN VIEW OF NELSON

1552. It is my opinion that Downs-Boiler in view of Nelson renders obvious each of claims 1, 13-15, 28, 29. Elements and claims not mentioned below are disclosed and/or obvious for the reasons stated above in Ground Z and Ground AA above.

12. Claims 1, 28, and 29

1553. From the disclosure of Downs-Boiler, POSITA would have found claims 1, 24, and 28 (and claims depending from them) obvious in view of Nelson.

a. **Element 1(f)—"injecting a sorbent comprising activated carbon into the mercury-containing gas downstream of the combustion chamber;"**

b. **Element 28(f): "injecting a sorbent comprising activated carbon into the mercury-containing gas downstream of the combustion chamber;"**

2263 Ex. 1009 (EPA-Proposal) at 4698.

2264 Ex. 1009 (EPA-Proposal) at 4698.

c. Element 29(f): "injecting a sorbent comprising activated carbon into the mercury-containing gas downstream of the combustion chamber such that the activated carbon reacts with the halogen or halide promoter in the mercury-containing gas to form a promoted sorbent;"

1554. In addition to the reasons described above in Grounds Z and AA, claim elements 1(f), 28(f), and 29(f) would have been obvious over Downs-Boiler in view of Nelson. Downs-Boiler describes "particulate collectors" including electro static precipitators (ESP) and ***fabric filters (FF)*** that "provide high-efficiency removal of particulate-bound mercury."[2265] Particularly, Downs-Boiler states that "[f]abric filters tend to exhibit better particulate laden mercury removal."[2266] Downs-Boiler discloses that the activated-carbon sorbent is injected into the mercury-containing flue gas such that it is subsequently "removed from the flue gases in a downstream particulate collector,"[2267] as described in Ground Z.

1555. Similarly, Nelson also discloses an embodiment in which "sorbent flows with flue gas to a fabric filter 31 and is deposited on the filter bags in a filter cake along with the fly ash and other gas-stream particulates," which also causes "intimate contact between the sorbents and the remaining mercury in the flue

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[2265] Ex. 1006 (Downs-Boiler) 11 [0003]; *see also* Ex. 1007 (Downs-Boiler-Provisional) ¶ [004].

[2266] Ex. 1006 (Downs-Boiler) ¶ [0003]; *see also* Ex. 1007 (Downs-Boiler-Provisional) ill [004].

[2267] Ex. 1006 (Downs-Boiler) ¶ [0004] (emphasis added); *see also* Ex. 1007 (Downs-Boiler-Provisional) 411 [005].

gas."[2268] The "mercury sorbents in the filter cake" are removed, and "[c]leansed of its mercury content and particulates, the flue gas exits the fabric filter."[2269] Accordingly, Nelson clarifies the disclosure of Downs-Boiler, explaining that the activated-carbon sorbent would have been injected upstream of a particulate separator (such as a fabric filter).

1556. Downs-Boiler also describes an embodiment in which an electrostatic precipitator (ESP) is used as a particulate separator.[2270] However, Downs-Boiler does not expressly state the injection location of activated-carbon sorbent for such an embodiment. A POSITA would have used the disclosure of Nelson to clarify the disclosure of Downs-Boiler, particularly, where to inject the activated-carbon sorbent for coal-fired utility plant configured with an ESP. Nelson describes injecting "sorbents to a plant which has a 'hot-side' ESP, a particularly difficult situation for mercury control.[2271] In this equipment arrangement, the air preheater 22 follows the ESP 32.[2272]

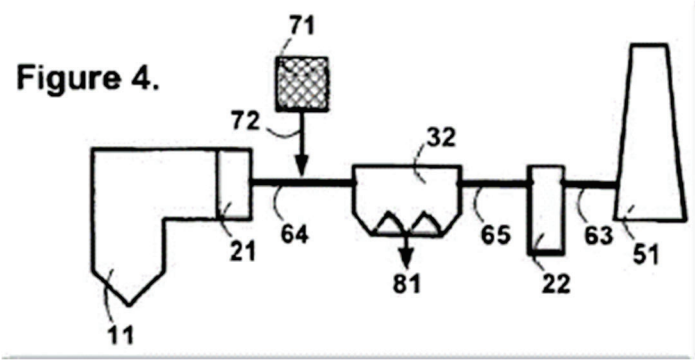
[2268] Ex. 1012 (Nelson) at 9:36-42

[2269] Ex. 1012 (Nelson) at 9:43-50

[2270] Ex. 1006 (Downs-Boiler) ¶ [0003]; *see also* Ex. 1007 (Downs-Boiler-Provisional) III [004].

[2271] Ex. 1012 (Nelson) at 10:9-11.

[2272] Ex. 1012 (Nelson) at Figure 4, 10:9-13



1557. Nelson discloses that in such a configuration, as shown in Figure 4, the activated carbon is injected "from bin 71," which is upstream from the air-preheater (item 22) and upstream from a particulate separator (item 32).[2273] Accordingly, Nelson clarifies the disclosure of Downs-Boiler in that for a plant with a hot-side ESP followed by a pre-heater, the injection of activated carbon would have been upstream of both.

13. Claim 13: "The method of claim 1, wherein the mercury-containing gas comprises about 1 g to about 30 g of the element bromine per 100 g of the sorbent."

1558. In addition to the reasons described in Grounds Z and AA for claim 13, claim 13 would have been obvious over Downs-Boiler in view of Nelson. Nelson describes preparation of a promoted activated-carbon sorbent formed from about 1 g to about 30 g of bromide per 100 g of sorbent:

> Any level of bromination of carbonaceous substrates appears to increase their mercury-removal performance. While over 30 wt % of Br_2 (g) can be adsorbed into some powdered activated carbons, for example, significant increases in mercury reactivity

[2273] Ex. 1012 (Nelson) at 10:20-22.

> will be observed with only about 1 wt % Br_2 (g) in the PAC. Greater degrees of bromination do correlate with greater maximum mercury capacities for a particular carbonaceous substrate.[2274]

1559. While Downs-Boiler discloses injecting hydrogen bromide (HBr) or bromine (Br2)[2275]upstream of or within the combustion chamber, it does not explicitly disclose the claimed ratio in the mercury containing gas (i.e., about 1 to about 30 grams the element bromine per 100 g of the sorbent, e.g., activated carbon).

1560. A POSITA would have been motivated to load the activated carbon with up to nearly its saturation limit to increase its reactivity and ability to adsorb mercury. And a POSITA would have known that the saturation limit of activated carbon for bromine (i.e., the amount of bromine activated carbon can actually hold at equilibrium), was about 31-38 grams per 100 grams of activated carbon. Given the residence times in flue gas, a POSITA would have understood that the bromine loaded onto activated carbon would be less than the saturation limit.

1561. In addition, Nelson describes a promoted activated-carbon sorbent formed from about 1 g to about 30 g of bromide per 100 g of sorbent. Specifically, Nelson explains that "[w]hile over 30 wt % of Br2(g) can be adsorbed into some

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2274 Ex. 1012 (Nelson) at 8:35-42.

2275 Ex. 1006 (Downs-Boiler) at [0015], [0021], Fig. 2.

powdered activated carbons, for example, significant increases in mercury reactivity will be observed with only about 1 wt % Br2(g) in the PAC."[2276]

1562. Therefore, a POSITA would have been motivated to combine the teachings of Downs-Boiler, Nelson, and/or knowledge in the art to use about 1 to about 30 grams of element bromine per 100 g of sorbent (activated carbon) to load the sorbent, e.g., activated carbon, sufficiently to increase its reactivity and ability to adsorb mercury and to optimize the use of the bromine and mercury removal.

14. Claim 14: "The method of claim 1, wherein the sorbent contacted with the mercury comprises the element bromine and mercury."

1563. As described above for Grounds Z and AA, the mercury in the flue gas is adsorbed, and thus contacted, with the sorbent to form a mercury/sorbent composition that comprises the element bromine, the sorbent material, and mercury. Downs-Boiler states that this adsorption occurs "due to the higher reactivity of oxidized mercury with PAC."[2277] In addition to the reasons provided in Ground E and Ground F, related to—forming a "promoted sorbent"—and—forming a "mercury/sorbent composition compris[ing] the element bromine, the sorbent material, and mercury"—the "contacting" limitations would have been obvious in view of Downs-Boiler over Nelson. A POSITA would have understood that at least

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[2276] Ex. 1012 (Nelson) at 8:35-40.

[2277] Ex. 1006 (Downs-Boiler) ¶ [0016]; Ex. 1007 (Downs-Boiler-Provisional) IT [0019].

a portion of the bromine would be available to promote the activated carbon to form a promoted sorbent.

1564. The bromine-containing gas in Nelson is explained as acting as a promoter in that it "increase[s] the ability of the carbonaceous substrate [activated carbon] to adsorb mercury and mercury-containing compounds."[2278] When the promoted sorbent is present in the mercury containing flue gas, Nelson describes that the mercury in the mercury-containing gas reacts (and thus contacts) the activated carbon and bonds to it to form a mercury/sorbent composition that contains mercury, halide promoter (bromide), and sorbent (activated carbon). Nelson describes that this takes place for both elemental mercury and oxidized mercury:

> While not intending to be limited by hypothesized chemistry, it appears that in exposing PAC to concentrated bromine gas, a relatively large quantity of the bromine reacts with the carbon, forming surface compounds on the large surface-area of 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 that were created and are held fast.* When the carbon particles are removed from the flue gas along with the fly ash by the electrostatic precipitator (ESP) or fabric filter, the mercury is removed with them. The mercury sorbents are then disposed of with the fly ash. *Because the mercury has been chemically adsorbed, rather than just physically adsorbed,* the captured mercury appears to be very stable and does not revolatilize or leach.[2279]

2278 Ex. 1012 (Nelson) at Abstract; *see also* Ex. 1012 (Nelson) at Claim 1.

2279 Ex. 1012 (Nelson) at 6:26-41.

> Mixing with the flue gas, the *sorbent adsorbs its elemental mercury and oxidized mercury species.*[2280]

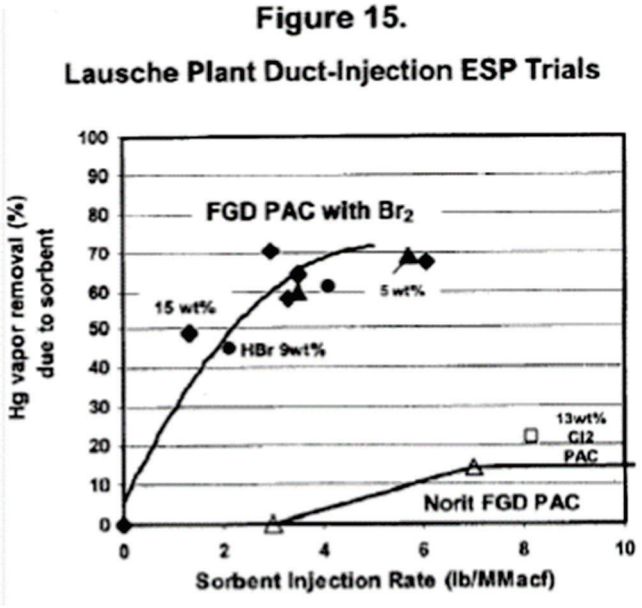
1565. Accordingly, in view of Downs-Boiler's disclosure of mercury bromide adsorbing onto activated carbon, and Nelson's description of the mercury-carbon-bromine reaction, a POSITA would have understood that a mercury/sorbent composition would be formed that includes mercury, sorbent, and bromine.

15. Claim 15: "The method of claim 1, comprising removing greater than 70 wt % of the mercury in the mercury-containing gas."

1566. In addition to the reasons described above from the disclosures in Downs-Boiler, Claim 15 would have been obvious over Downs-Boiler in view of Nelson. For example, as explained above with respect to claim 15, Downs-Boiler illustrates removing at least 77% of the mercury from the mercury-containing gas in Figure 3. Through routine process optimization, a POSITA would have been able to adjust the bromine:sorbent ratio such that at least 70% of the mercury is in the mercury-containing gas is removed on the sorbent. Downs-Boiler recognizes that there are a number of factors, such as "combustion air preheater temperature profiles, flue gas composition, fly ash characteristics and composition, and the presence of unburned carbon have all been shown to affect the conversion of elemental mercury

[2280] Ex. 1012 (Nelson) at 9:35-37

to oxidized mercury species."[2281] A POSITA would have looked to Nelson to answer a number of these factors, for example, Nelson also conducted a study to determine the mercury removed by the sorbent itself, as opposed to other components such as unburnt carbon or a scrubber. Figure 15 of Nelson plots the "Hg vapor removal (%) *due to sorbent,"* and the X-axis plots the sorbent injection rate.



1567. At a sorbent injection rate of approximately 4 lb/MMacf, Nelson achieves above 70% removal by the sorbent itself.[2282] And based on the trending curve, a POSITA would have recognized that at a sorbent injection rate of 5 lb/MMacf, the sorbent itself would have removed even more than 70% mercury. Accordingly, a POSITA would have been motivated to, and capable of, using the

[2281] Ex. 1006 (Downs-Boiler) ll [0005]; *see also* Ex. 1007 (Downs-Boiler-Provisional) ll [006].

[2282] Ex. 1012 (Nelson) at 15:35-38.

processes disclosed in Nelson and Downs-Boiler to remove 70% or more mercury from the mercury-containing flue gas, including on the sorbent.

XLVII. GROUND AC: ANTICIPATION OF THE '430 PATENT OVER VOSTEEN AND/OR OBVIOUSNESS OVER VOSTEEN IN VIEW OF GRANITE

A. INDEPENDENT CLAIM 28

1. Claim 28: Element 28(a): "A method of separating mercury from a mercury-containing as [sic], the method comprising:"

1568. Vosteen discloses the preamble. The title of Vosteen is, "Process for removing mercury from flue gases."[2283] Flue gas is an example of a mercury-containing gas, and "removing mercury" refers to separating the mercury from a mercury-containing gas. Vosteen describes "removal of mercury from the flue gases in a flue gas emission control system downstream of the combustion," in plants such as "power stations, for example bituminous coal-fired or lignite-fired power stations.[2284] Claim 1 of Vosteen also discloses the preamble, as shown in the highlighting below:[2285]

2283 Ex. 1008 (Vosteen) at Title.
2284 Ex. 1008 (Vosteen) at 2:16-20, 2:35-37.
2285 Ex. 1008 (Vosteen) at Claim 1.

1. Process for removing mercury from mercury-containing flue gases of a furnace within which a combustion or incineration is carried out, wherein

bromine, a bromine compound, a mixture of bromine compounds or a mixture of bromine and a bromine compound or compounds, is fed to the furnace or to the flue gas of the furnace in a plant section downstream of the furnace, or to both the furnace and the flue gas, the temperature during the first contact of the bromine or of said mixture with the flue gas being at least 500° C.,

the combustion or incineration is carried out in the presence of a sulphur compound,

and then the flue gas is subjected to a cleanup for removing mercury from the flue gas.

Subjecting flue gas "to a cleanup for removing mercury from the flue gas" refers to separating mercury from a mercury-containing gas. Claim 18 of Vosteen also discloses the preamble, as shown in the highlighting below.

18. A process for removing mercury from mercury-containing flue gases of a furnace, comprising:

carrying out a combustion or incineration process, within the furnace, in the presence of a sulphur compound;

feeding bromine, a bromine compound, a mixture of bromine compounds, or a mixture of bromine and one or more bromine compounds to at least one of the furnace or a flue gas of the furnace in a plant section downstream from the furnace, a temperature at first contact of the bromine, bromine compound, mixture of bromine compounds, or mixture of bromine and one or more bromine compounds with the mercury-containing flue gas being at least 800° C.; and

subjecting the mercury-containing flue gas to a cleanup for substantially removing mercury from the mercury-containing flue gas, wherein the cleanup for substantially removing mercury from the mercury-containing flue gas includes a dry cleanup stage comprising at least one sorbent, and

2. Claim 28: Element 28(b): "combusting coal in a combustion chamber, to provide the mercury-containing gas, wherein the

mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br−, or a combination thereof, wherein"

1569. Vosteen discloses this claim element. Vosteen discloses that one of the applications for his process is in removing mercury from a mercury-containing gas generated from the combustion of coal in a combustion chamber. For example, Vosteen describes experiments conducted on "a *coal-fired power station* of Bayer AG in Uerdingen, which essentially consists of *a slag-tap fired boiler* . . "[2286] Vosteen also describes a *"coal-fired* power station of Bayer AG in Uerdingen (see FIG.9)" with "two parallel slag-tap fired boilers 91, 92 having temperatures in the *combustion chamber* around 1450°C."[2287] Vosteen describes his results in Figures 7 and 8 regarding the experiments conducted on "coal combustion (bituminous coal)."[2288] This limitation is also disclosed in claims 1 and 18 of Vosteen, highlighted below:[2289]

2286 Ex. 1008 (Vosteen) at 7:25-28.
2287 Ex. 1008 (Vosteen) at 10:63-11:6.
2288 Ex. 1008 (Vosteen) at 11:23-24.
2289 Ex. 1008 (Vosteen) at Claims 1, 18.

1. Process for removing mercury from mercury-containing flue gases of a furnace within which a combustion or incineration is carried out, wherein

bromine, a bromine compound, a mixture of bromine compounds or a mixture of bromine and a bromine compound or compounds, is fed to the furnace or to the flue gas of the furnace in a plant section downstream of the furnace, or to both the furnace and the flue gas, the temperature during the first contact of the bromine or of said mixture with the flue gas being at least 500° C.,

the combustion or incineration is carried out in the presence of a sulphur compound,

and then the flue gas is subjected to a cleanup for removing mercury from the flue gas.

18. A process for removing mercury from mercury-containing flue gases of a furnace, comprising:

carrying out a combustion or incineration process, within the furnace, in the presence of a sulphur compound;

* * *

feeding the coal to the furnace,

the process further comprising feeding sulphur, a sulphur compound or a mixture of sulphur compounds to said furnace based on measuring mercury content of the mercury-containing flue gas.

1570. Vosteen describes adding HBr (hydrogen bromide) and bromide compounds to the coal, or to the combustion chamber, or both. Sodium bromide is an example of a bromide compound. Vosteen describes that bromine-containing ingredients are added to the combustion chamber (also referred to by Vosteen as a furnace), and can also be added to the coal upstream of the combustion chamber.

The 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 and/or to the flue gas in a plant section downstream of the furnace.[2290]

Particularly preferably, an *aqueous solution of hydrogen bromide or an alkali metal bromide,* in particular sodium bromide, or an aqueous solution of the alkali metal bromide is used.[2291]

The *bromine compound*, for example, *sodium bromide, can be added in solid form, for example as salt, or in 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 a pyrolysis drum, which serves, for example, for the thermal breakdown of co-incinerated waste materials, or *to a coal mill*. *The compound can also be fed during the combustion process*. . . .*[T] he bromine compound can be introduced*, likewise in solid or liquid form, *into one or both combustion chambers*, for example into the rotary kiln and/or the afterburning chamber. Preferably, an aqueous solution of the compound is *sprayed into one of the combustion chambers*.[2292]

2290 Ex. 1008 (Vosteen) at 1:65-2:5.
2291 Ex. 1008 (Vosteen) at 2:58-61.
2292 Ex. 1008 (Vosteen) at 4:4-19.

> [I]t is also possible to feed the bromine compound, for example an *aqueous solution of hydrogen bromide or sodium bromide*, at a fine dispersion *to the combustion* air and/or if appropriate to a recirculated substream, in particular recirculated flue gas, recirculated ash and recirculated fly ash.[2293]

The "bromine and/or a bromine compound" identified above in Vosteen refers to molecular bromine (Br_2) and/or a compound containing the element bromine (Br) bonded to other chemical elements.

1571. This claim element is also disclosed by claims 1 and 2 of Vosteen, highlighted below, which recite adding a bromine compound or mixture of compounds (including hydrogen bromide) to the combustion chamber (furnace):[2294]

[2293] Ex. 1008 (Vosteen) at 4:28-33.

[2294] Ex. 1008 (Vosteen) at Claims 1, 2.

1. Process for removing mercury from mercury-containing flue gases of a furnace within which a combustion or incineration is carried out, wherein

bromine, a bromine compound, a mixture of bromine compounds or a mixture of bromine and a bromine compound or compounds, is fed to the furnace or to the flue gas of the furnace in a plant section downstream of the furnace, or to both the furnace and the flue gas, the temperature during the first contact of the bromine or of said mixture with the flue gas being at least 500° C.,

the combustion or incineration is carried out in the presence of a sulphur compound,

and then the flue gas is subjected to a cleanup for removing mercury from the flue gas.

2. Process according to claim 1, wherein the bromine compound is an aqueous solution of hydrogen bromide, an alkali metal bromide, or a mixture thereof.

This claim element is also disclosed by claim 18 of Vosteen, highlighted below:[2295]

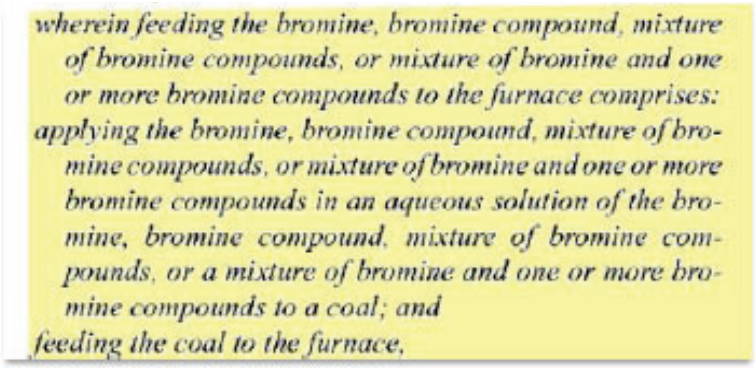
18. A process for removing mercury from mercury-containing flue gases of a furnace, comprising:

carrying out a combustion or incineration process, within the furnace, in the presence of a sulphur compound;

feeding bromine, a bromine compound, a mixture of bromine compounds, or a mixture of bromine and one or more bromine compounds to at least one of the furnace

* * *

[2295] Ex. 1008 (Vosteen) at Claim 18.



wherein feeding the bromine, bromine compound, mixture of bromine compounds, or mixture of bromine and one or more bromine compounds to the furnace comprises:
applying the bromine, bromine compound, mixture of bromine compounds, or mixture of bromine and one or more bromine compounds in an aqueous solution of the bromine, bromine compound, mixture of bromine compounds, or a mixture of bromine and one or more bromine compounds to a coal; and
feeding the coal to the furnace,

1572. Vosteen discloses adding an "aqueous solution of hydrogen bromide" to the coal and/or combustion chamber.[2296] Vosteen continuously monitors the mercury content of the cleaned gas, and, in response, continuously adjusts the rate of addition to the coal or combustion chamber of the added bromine-containing species.'[2297] The bromine-containing species include aqueous hydrogen bromide [HBr(aq)], bromide compounds in solid or aqueous form (e.g., sodium bromide [NaBr(s) or NaBr(aq)], molecular bromine (Br_2), and mixtures thereof, and these bromine-containing species are added to either the coal or to the combustion chamber. HBr and Br– are examples of a "halogen or halide promoter." A POSITA would have known that at the high temperatures of the combustion system, the HBr and Br– would be gaseous.

3. Claim 28: Elements 28(c)-(e): "the coal comprises an additive comprising Br2, HBr, a bromide compound, or a combination thereof, wherein the additive is added to the coal before the coal enters the combustion chamber, or the combustion chamber

2296 Ex. 1008 (Vosteen) at 2:54-3:2.
2297 Ex. 1008 (Vosteen) at 5:48-55, Claim 9.

comprises an additive comprising Br2, HBr, a bromide compound, or a combination thereof, or a combination thereof,"

1573. Vosteen discloses this claim element. Vosteen describes adding HBr (hydrogen bromide) and bromide compounds to the coal, or to the combustion chamber, or both. Sodium bromide is an example of a bromide compound. Vosteen describes that bromine-containing ingredients are added to the combustion chamber (also referred to by Vosteen as a furnace), and can also be added to the coal upstream of the combustion chamber.

> The 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* and/or to the flue gas in a plant section downstream of the furnace.[2298]
>
> Particularly preferably, an *aqueous solution of hydrogen bromide or an alkali metal bromide,* in particular sodium bromide, or an aqueous solution of the alkali metal bromide is used.[2299]

[2298] Ex. 1008 (Vosteen) at 1:65-2:5.
[2299] Ex. 1008 (Vosteen) at 2:58-61.

The *bromine compound*, for example, *sodium bromide, can be added in solid form, for example as salt, or in 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 a pyrolysis drum, which serves, for example, for the thermal breakdown of co-incinerated waste materials, or *to a coal mill*. *The compound can also be fed during the combustion process*. . . .*[T] he bromine compound can be introduced*, likewise in solid or liquid form, *into one or both combustion chambers*, for example into the rotary kiln and/or the afterburning chamber. Preferably, an aqueous solution of the compound is *sprayed into one of the combustion chambers*.[2300]

[I]t is also possible to feed the bromine compound, for example an *aqueous solution of hydrogen bromide or sodium bromide*, at a fine dispersion *to the combustion* air and/or if appropriate to a recirculated substream, in particular recirculated flue gas, recirculated ash and recirculated fly ash.[2301]

2300 Ex. 1008 (Vosteen) at 4:4-19.

2301 Ex. 1008 (Vosteen) at 4:28-33.

1574. The "bromine and/or a bromine compound" identified above in Vosteen refers to molecular bromine (Br_2) and/or a compound containing the element bromine (Br) bonded to other chemical elements.

1575. This claim element is also disclosed by claims 1 and 2 of Vosteen, highlighted below, which recite adding a bromine compound or mixture of compounds (including hydrogen bromide) to the combustion chamber (furnace):[2302]

1. Process for removing mercury from mercury-containing flue gases of a furnace within which a combustion or incineration is carried out, wherein

bromine, a bromine compound, a mixture of bromine compounds or a mixture of bromine and a bromine compound or compounds, is fed to the furnace or to the flue gas of the furnace in a plant section downstream of the furnace, or to both the furnace and the flue gas, the temperature during the first contact of the bromine or of said mixture with the flue gas being at least 500° C.,

the combustion or incineration is carried out in the presence of a sulphur compound,

and then the flue gas is subjected to a cleanup for removing mercury from the flue gas.

2. Process according to claim 1, wherein the bromine compound is an aqueous solution of hydrogen bromide, an alkali metal bromide, or a mixture thereof.

1576. This claim element is also disclosed by claim 18 of Vosteen, highlighted below:[2303]

2302 Ex. 1008 (Vosteen) at Claims 1, 2.

2303 Ex. 1008 (Vosteen) at Claim 18.

18. A process for removing mercury from mercury-containing flue gases of a furnace, comprising:
carrying out a combustion or incineration process, within the furnace, in the presence of a sulphur compound;
feeding bromine, a bromine compound, a mixture of bromine compounds, or a mixture of bromine and one or more bromine compounds to at least one of the furnace

* * *

wherein feeding the bromine, bromine compound, mixture of bromine compounds, or mixture of bromine and one or more bromine compounds to the furnace comprises:
applying the bromine, bromine compound, mixture of bromine compounds, or mixture of bromine and one or more bromine compounds in an aqueous solution of the bromine, bromine compound, mixture of bromine compounds, or a mixture of bromine and one or more bromine compounds to a coal; and
feeding the coal to the furnace,

4. Claim 28: Elements 28(f): "injecting a sorbent comprising activated carbon into the mercury-containing gas downstream of the combustion chamber;"

1577. This claim element is disclosed by Vosteen. Vosteen discloses injecting activated carbon into a mercury-containing flue gas downstream of the combustion chamber and contacting mercury with the sorbent to form a mercury/sorbent composition[2304] Vosteen discloses adding particulate sorbent material comprising activated carbon by the introduction of cloth filters with granulated activated carbon into the mercury-containing flue gas stream as part of the flue gas emission control system downstream of the combustion chamber.[2305]

2304 Ex. 1008 (Vosteen) at 1:35-45, 5:19-30.
2305 Ex. 1008 (Vosteen) at 5:19-30.

1578. Alternatively, it would have been obvious to a person of skill in the art to use the teachings of Vosteen concerning the use of a bromine additive with a flue gas control system typical of a coal burning power plant.[2306] A POSITA would understand that injection of activated carbon into the ductwork downstream of the combustion furnace was the more common and readily available method of using activated carbon for mercury control instead of the impinged fabric filters of Vosteen.

1579. It would have also been obvious to combine Vosteen's addition of bromine compounds to coal for combustion with activated carbon injection systems in use at the time that the Vosteen reference was published. For example, Vosteen's bromine additive would have been obvious to use in the plants described in the Granite reference. Granite explains that control technologies for removing mercury from flue gas at the time include the use of activated carbon sorbents injected into the gas stream.[2307] Granite describes, for example, the activated carbon duct injection systems used for mercury control for industrial combustors.[2308] A POSITA would understand that injection of activated carbon into the ductwork downstream of the combustion furnace was the more common and readily available method of using activated carbon for mercury control instead of the impinged fabric filters of

[2306] Ex. 1008 (Vosteen) at 7:25-32.
[2307] Ex. 2003 (Granite 2000) at 1020, 1022.
[2308] Ex. 2003 (Granite 2000) at 1026.

Vosteen. Furthermore, a POSITA would have been motivated by Granites teaching that the promotion of activated carbon using halogens such as chlorine and iodine to combine the teachings of Vosteen regarding bromine with the state of the art activated carbon systems it describes.[2309]

5. Claim 28: Elements 28(g): "contacting mercury in the mercury-containing gas with the sorbent; and"

1580. This claim element is disclosed by Vosteen. Vosteen discloses a method of mercury removal which includes the contact (and adsorption) of mercury by the sorbent.[2310]

6. Claim 28: Elements 28(h): "separating the sorbent contacted with the mercury from the mercury-containing gas."

1581. This claim element is disclosed by Vosteen. Vosteen describes numerous components that are used to separate the mercury/sorbent composition from the mercury-containing (flue) gas, to form a cleaned gas. Such components include a spray-dryer adsorber (SDA), electrostatic precipitator (ESP), or fabric filter.[2311] These are also discussed in claims of Vosteen:[2312]

> **10.** The process according to claim **8**, wherein said emission control system comprises filtration, electrostatic separation or both.

[2309] Ex. 2003 (Granite 2000) at 1020.

[2310] Ex. 1008 (Vosteen) at 5:19-39; 2:17-31.

[2311] Ex. 1008 (Vosteen) at 5:15-30.

[2312] Ex. 1008 (Vosteen) at Claim 10.

1582. Vosteen repeatedly refers to a flue gas *cleaning* system.[2313] Vosteen refers to "clean gas downstream of the wet and/or dry flue gas emission system."[2314] This is because, as Vosteen discloses, an "object of the invention to provide a process for removing mercury, in particular for the substantially complete removal of mercury (Hg)."[2315] The claims of Vosteen further disclose a process of "cleanup" of the flue gas:[2316]

1. Process for removing mercury from mercury-containing flue gases of a furnace within which a combustion or incineration is carried out, wherein

bromine, a bromine compound, a mixture of bromine compounds or a mixture of bromine and a bromine compound or compounds, is fed to the furnace or to the flue gas of the furnace in a plant section downstream of the furnace, or to both the furnace and the flue gas, the temperature during the first contact of the bromine or of said mixture with the flue gas being at least 500° C.,

the combustion or incineration is carried out in the presence of a sulphur compound,

and then the flue gas is subjected to a cleanup for removing mercury from the flue gas.

2313 See, e.g., Ex. 1008 (Vosteen) at Abstract, 2:12-15, 5:1-5.
2314 Ex. 1008 (Vosteen) at 6:2-4.
2315 Ex. 1008 (Vosteen) at 1:50-53.
2316 Ex. 1008 (Vosteen) at Claims 1, 18.

18. A process for removing mercury from mercury-containing flue gases of a furnace, comprising:

carrying out a combustion or incineration process, within the furnace, in the presence of a sulphur compound;

feeding bromine, a bromine compound, a mixture of bromine compounds, or a mixture of bromine and one or more bromine compounds to at least one of the furnace or a flue gas of the furnace in a plant section downstream from the furnace, a temperature at first contact of the bromine, bromine compound, mixture of bromine compounds, or mixture of bromine and one or more bromine compounds with the mercury-containing flue gas being at least 800° C.; and

subjecting the mercury-containing flue gas to a cleanup for substantially removing mercury from the mercury-containing flue gas, wherein the cleanup for substantially removing mercury from the mercury-containing flue gas includes a dry cleanup stage comprising at least one sorbent, and

1583. The "dry cleanup stage" and "dry sorbent" includes, for example, the activated carbon injected into the mercury-containing flue gas that is separated by the fabric filter.[2317] The "cleanup" and "removal" referred to by Vosteen in the passages above refer to separating the mercury/sorbent composition from the mercury-containing flue gas.

1584. Granite also discloses a number of different types of activated carbon.

B. INDEPENDENT CLAIM 1

1585. As shown in the redlines below, claim 1 is nearly identical to claims 28 and 29, with minor changes.

[2317] Ex. 1008 (Vosteen) at 5:27-30.

~~28~~1. A method of separating mercury from a mercury-containing gas, the method comprising:

combusting coal in a combustion chamber, to provide the mercury-containing gas, wherein ~~the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br⁻, or a combination thereof, wherein~~

the coal comprises an additive comprising Br_2, HBr, a bromide compound, or a combination thereof, wherein the additive is added to the coal before the coal enters the combustion chamber, or

the combustion chamber comprises an additive comprising Br_2, HBr, a bromide compound, or a combination thereof, or

a combination thereof,

injecting a sorbent comprising activated carbon into the mercury-containing gas downstream of the combustion chamber;

contacting mercury in the mercury-containing gas with the sorbent; and

separating the sorbent contacted with the mercury from the mercury-containing gas.

~~29~~1. A method of separating mercury from a mercury-containing gas, the method comprising:

combusting coal in a combustion chamber, to provide the mercury-containing gas, wherein ~~the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br⁻, or a combination thereof, wherein~~

the coal comprises an additive comprising Br_2, HBr, a bromide compound, or a combination thereof, wherein the additive is added to the coal before the coal enters the combustion chamber, or

the combustion chamber comprises an additive comprising Br_2, HBr, a bromide compound, or a combination thereof, or

a combination thereof;

injecting a sorbent comprising activated carbon into the mercury-containing gas downstream of the combustion ~~chamber such that the activated carbon reacts with the halogen or halide promoter in the mercury-containing gas to form a promoted sorbent~~;

contacting mercury in the mercury-containing gas with the promoted sorbent; and

separating the promoted sorbent contacted with the mercury from the mercury-containing gas~~;~~

~~measuring the mercury content of the mercury-containing gas; and~~

~~modifying, in response to the measured mercury content,~~

~~an injection rate of injecting the sorbent into the mercury-containing gas,~~

~~an amount of the Br_2, HBr, the bromide compound, or a combination thereof, added to the coal or the combustion chamber, or~~

~~a combination thereof~~.

1586. Accordingly, my analysis provided for claims 28 and 29 also applies to claim 1. Vosteen anticipates and also renders obvious these claims. Claim 1 differs from these claims in there are fewer limitations listed in Claim 1. Fewer limitations would have been obvious to a POSITA.

1. Claim 1: Preamble—"A method of separating mercury from a mercury-containing gas, the method comprising:"

1587. The language of the preamble of claim 1 is identical to the preamble of claims 28 and 29. Accordingly, the explanation I provide above for the preamble of claim 28 applies equally to the preamble of claim 1.

2. Claim 1: Element (1)(b)—"combusting coal in a combustion chamber, to provide the mercury-containing gas,"

1588. The language of claim element 1(b) is identical to the first portion of claim element 28(b) [which is identical to claim element 29(b)]. Accordingly, the explanation I provide above for those claim elements applies equally to claim element 1(b).

3. Claim 1: Element 1(c)—"the coal comprises an additive comprising Br2, HBr, a bromide compound, or a combination thereof, wherein the additive is added to the coal before the coal enters the combustion chamber, or"

1589. The language of claim element 1(c) is identical to the language of claim element 28(c) [which is identical to claim element 29(c)]. Accordingly, the explanation I provide above for those claim elements applies equally to claim element 1(c).

4. Claim 1: Element 1(d)—"the combustion chamber comprises an additive comprising Br2, HBr, a bromide compound, or a combination thereof or

1590. The language of claim element 1(d) is identical to the language of claim element 28(d) [which is identical to claim element 29(d)]. Accordingly, the explanation I provide above for those claim elements applies equally to claim element 1(d).

5. Claim 1: Element 1(e)—"a combination thereof;"

1591. The language of claim element 1(e) is identical to the language of claim element 28(e) [which is identical to claim element 29(e)]. Accordingly, the explanation I provide above for those claim elements applies equally to claim element 1(e).

6. Claim 1: Element 1(f)—"injecting a sorbent comprising activated carbon into the mercury-containing gas downstream of the combustion chamber;"

1592. The language of claim element 1(f) is identical to the language of claim element 28(f) [which is identical to the first portion of claim element 29(f)]. Accordingly, the explanation I provide above for those claim elements applies equally to claim element 1(b).

7. Claim 1: Element 1(g)—"contacting mercury in the mercury-containing gas with the sorbent; and"

1593. The language of claim element 1(g) is identical to the language of claim element 28(g) [which is identical to claim element 29(g)]. Accordingly, the explanation I provide above for those claim elements applies equally to claim element 1(g).

8. Claim 1: Element 1(h)—"separating the sorbent contacted with the mercury from the mercury-containing gas."

1594. The language of claim element 1(h) is identical to the language of claim element 28(h) [which is identical to claim element 29(h)]. Accordingly, the

explanation I provide above for those claim elements applies equally to claim element 1(h).

C. CLAIMS DEPENDING FROM CLAIM 1

1. Claim 2: "The method of claim 1, wherein the coal comprises the additive comprising the Br2, HBr, the bromide compound, or a combination thereof, wherein the additive is added to the coal before the coal enters the combustion chamber.

1595. Claim 2 is disclosed by Vosteen. Vosteen discloses mixing bromide compounds in with the coal before entering the combustion chamber:

> The *bromine compound*, for example, *sodium bromide, can be added in solid form, for example as salt, or in 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 a pyrolysis drum, which serves, for example, for the thermal breakdown of co-incinerated waste materials, or *to a coal mill*. *The compound can also be fed during the combustion process*. . . .*[T] he bromine compound can be introduced*, likewise in solid or liquid form, *into one or both combustion chambers*, for example into the rotary kiln and/or the afterburning chamber. Preferably, an aqueous solution of the compound is *sprayed into one of the combustion chambers*.[2318]

[2318] Ex. 1008 (Vosteen) at 4:4-19.

> [I]t is also possible to feed the bromine compound, for example an *aqueous solution of hydrogen bromide or sodium bromide*, at a fine dispersion *to the combustion* air and/or if appropriate to a recirculated substream, in particular recirculated flue gas, recirculated ash and recirculated fly ash.[2319]

The "bromine and/or a bromine compound" identified above in Vosteen refers to molecular bromine (Br_2) and/or a compound containing the element bromine (Br) bonded to other chemical elements.

1596. This claim element is also disclosed by claims 1 and 2 of Vosteen, highlighted below, which recite adding a bromine compound or mixture of compounds (including hydrogen bromide) to the combustion chamber (furnace):[2320]

[2319] Ex. 1008 (Vosteen) at 4:28-33 (emphasis added); *see also id*. at 2:54-3:2, 3:66-4:33, 6:65-7:32.

[2320] Ex. 1008 (Vosteen) at Claims 1, 2.

1. Process for removing mercury from mercury-containing flue gases of a furnace within which a combustion or incineration is carried out, wherein

bromine, a bromine compound, a mixture of bromine compounds or a mixture of bromine and a bromine compound or compounds, is fed to the furnace or to the flue gas of the furnace in a plant section downstream of the furnace, or to both the furnace and the flue gas, the temperature during the first contact of the bromine or of said mixture with the flue gas being at least 500° C.,

the combustion or incineration is carried out in the presence of a sulphur compound,

and then the flue gas is subjected to a cleanup for removing mercury from the flue gas.

2. Process according to claim 1, wherein the bromine compound is an aqueous solution of hydrogen bromide, an alkali metal bromide, or a mixture thereof.

1597. This claim element is also disclosed by claim 18 of Vosteen, highlighted below:[2321]

18. A process for removing mercury from mercury-containing flue gases of a furnace, comprising:

carrying out a combustion or incineration process, within the furnace, in the presence of a sulphur compound;

feeding bromine, a bromine compound, a mixture of bromine compounds, or a mixture of bromine and one or more bromine compounds to at least one of the furnace

* * *

[2321] Ex. 1008 (Vosteen) at Claim 18.

wherein feeding the bromine, bromine compound, mixture of bromine compounds, or mixture of bromine and one or more bromine compounds to the furnace comprises:
applying the bromine, bromine compound, mixture of bromine compounds, or mixture of bromine and one or more bromine compounds in an aqueous solution of the bromine, bromine compound, mixture of bromine compounds, or a mixture of bromine and one or more bromine compounds to a coal; and
feeding the coal to the furnace,

2. Claim 3: "The method of claim 1, wherein the combustion chamber comprises the additive comprising the Br2, HBr, the bromide compound, or a combination thereof."

1598. Vosteen discloses this claim. As I explain regarding claim element 28(d), Vosteen describes that the combustion chamber (sometimes referred to as "furnace" or "boiler" in Vosteen) comprises added aqueous hydrogen bromide [HBr(aq)], bromide compounds in solid or aqueous form (e.g., sodium bromide [NaBr(s) or NaBr(aq)], molecular bromine (Br_2), and mixtures thereof.

3. Claim 4: "The method of claim 1, wherein the coal is combusted in the combustion chamber at a coal-combustion facility, wherein the additive comprising the Br2, HBr, bromide compound, or combination thereof, is added to the coal before the coal enters the combustion chamber, wherein the addition of the additive comprising the Br2, HBr, bromide compound, or combination thereof, to the coal is performed at the coal-combustion facility."

1599. Vosteen discloses this claim element. Vosteen discloses that its methods for mercury control are applicable at coal-combustion facilities.[2322]

[2322] Ex. 1008 (Vosteen) at 1:4-21..

1600. The language in claim 4 is comparable to the language in claim element 28(c). Accordingly, the explanation I provide above for that claim element applies equally to claim 4.

4. Claim 6: "The method of claim 1, wherein the combustion chamber is an electric utility coal combustion chamber.

1601. Vosteen discloses this claim element. Vosteen discloses that its methods for mercury control are applicable at an electric utility coal-combustion chamber.[2323]

5. Claim 7: "The method of claim 1, wherein the combustion chamber is a coal combustion furnace.

1602. Vosteen discloses this claim element. The explanation I provide above for claims 4 and 6 are equally applicable to claim 7.

6. Claim 8: "The method of claim 1, wherein the coal comprises a subbituminous coal.

1603. This claim element is obvious in light of Vosteen and the background knowledge of a POSITA. Vosteen teaches that its invention can be applied to coal-fired power stations using a variety of coals.[2324]

7. Claim 10: "The method of claim 1, further comprising measuring the mercury content of the mercury-containing gas; and modifying, in response to the measured mercury content of the mercury-containing gas, an injection rate of injecting the sorbent into the mercury-containing gas, an amount of the Br_2, HBr, the

[2323] Ex. 1008 (Vosteen) at 1:4-21..

[2324] Ex. 1008 (Vosteen) at 2:32-53.

bromide compound, or a combination thereof, added to the coal or the combustion chamber, or a combination thereof."

1604. This limitation is disclosed by Vosteen. Vosteen discloses measuring the mercury content of the mercury-containing gas. Vosteen describes that "*the mercury content of the flue gas*, in particular the content of metallic [i.e., elemental] mercury, *is measured continuously* downstream of the flue gas emission control system."[2325] Measurements of the mercury content are depicted in Figures 2-8 of Vosteen,[2326] and are also recited in claim 9 of Vosteen:[2327]

> **9**. Process according to claim **8**, wherein the mercury content of the flue gas is measured continuously downstream of the flue gas emission control system and the amount of bromine, bromine compounds fed and any sulphur or sulphur compounds fed is controlled on the basis of the measured mercury content.

Measuring mercury content of the cleaned gas is a form of monitoring the mercury.

1605. Vosteen monitors the mercury content of the cleaned gas, and in response, controls the amount of addition to the coal and/or combustion chamber of the added bromine-containing species.

> Preferably, in the inventive process, *the mercury content of the flue gas*, in particular the content of metallic mercury, *is measured continuously* downstream of the flue gas emission control system and *on the basis of the measured mercury content the amount of bromine fed and/or bromine compounds and/or the mixture of bromine compounds* and if appropriate sulphur and/or sulphur

2325 Ex. 1008 (Vosteen) at 5:48-50.
2326 Ex. 1008 (Vosteen) at Figs. 2-8.
2327 Ex. 1008 (Vosteen) at Claims 9.

substances and/or the mixture of sulphur substances *is controlled*.[2328]

1606. As explained above, the bromine-containing species include aqueous hydrogen bromide [HBr(aq)], bromide compounds in solid or aqueous form (e.g., sodium bromide [NaBr(s) or NaBr(aq)], molecular bromine (Br_2), and mixtures thereof, and these bromine-containing species are added to either the coal or to the combustion chamber. Claim Element 10(c) is also disclosed by claim 9 of Vosteen.[2329]

1607. As discussed above in Claim Element 10(c), Vosteen continuously monitors the mercury content of the cleaned gas, and, in response, continuously adjusts the rate of addition to the coal or combustion chamber of the added bromine-containing species.[2330] The bromine-containing species include aqueous hydrogen bromide [HBr(aq)], bromide compounds in solid or aqueous form (e.g., sodium bromide [NaBr(s) or NaBr(aq)], molecular bromine (Br_2), and mixtures thereof, and these bromine-containing species are added to either the coal or to the combustion chamber.

1608. A POSITA would have understood that adjusting the rate of addition of bromine-containing species would have affected the sorbent composition (e.g., the

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2328 Ex. 1008 (Vosteen) at 5:48-55.

2329 Ex. 1008 (Vosteen) at Claims 9.

2330 Ex. 1008 (Vosteen) at 5:48-55, Claim 9.

amount of bromine and/or adsorbed mercury on the sorbent). A POSITA reviewing the figures of Vosteen would have known to use the monitored mercury content to control the injection rate of bromine-containing promoter, and thereby controlled the activated-carbon sorbent composition, in response to the monitored mercury content of the cleaned gas. Therefore, A POSITA would have known that by controlling the feed rate of bromine-containing species, the sorbent composition in the mercury-containing gas would have also been controlled.

1609. A POSITA would have known that activated carbon was expensive, especially relative to costs of components such as HBr or sodium bromide. Thus, a POSITA would have been motivated to adjust the addition rate of bromine-containing species to remove sufficient mercury while minimizing the sorbent injection rate. A POSITA viewing the figures of Vosteen (e.g., Figs. 5-8) showing bromine injection versus mercury removal would have been motivated, and thus it would have been obvious, to at least try using the charts to control the sorbent injection rate at a level that minimized costs while reaching mercury removal targets. Furthermore, due to the variability of the composition of coal as a fuel source (including for example, native mercury and halogen content), as described in the State of the Art,[2331] it would have been obvious that some amount of adjustment to

[2331] State of the Art, § XII.B.1.

the rate of injection of the sorbent into the flue gas would be performed as part of routine process control and optimization to account for variances in the coal.

8. Claim 11: "The method of claim 10, wherein the measuring of the mercury content comprises continuous measurement."

1610. ME2C did not provide infringement contentions for this claim. ME2C's infringement contentions cross reference claim 24 of the '225 patent. ME2C's infringement contentions do not include claim 24 of the '225 patent. ME2C's final contentions hew to this position, and thus ME2C is apparently not asserting this claim. Therefore, no analysis regarding this element is required.

9. Claim 12: "The method of claim 1, further comprising: modifying, in response to a measured mercury content, an injection rate of injecting the sorbent into the mercury-containing gas, an amount of the Br2, HBr, the bromide compound, or a combination thereof, added to the coal or the combustion chamber, or a combination thereof."

1611. The language of claim 12 is substantially identical to the language of claim 10. Accordingly, the explanation I provide above for claim 10 applies equally to claim 12.

10. Claim 13: "The method of claim 1, wherein the mercury-containing gas comprises about 1 g to about 30 g of the element bromine per 100 g of the sorbent."

1612. Claim 13 would have been obvious over Vosteen. In Figure 6 of Vosteen, the Y-axis represents the percentage by weight of elemental mercury (labeled Hg_{met} for metallic mercury) compared to total mercury (labeled Hg_{tot}). On

the X-axis, Vosteen plots the total bromine concentration in the mercury-containing gas (Br_{tot}), which is the sharper curve.[2332]

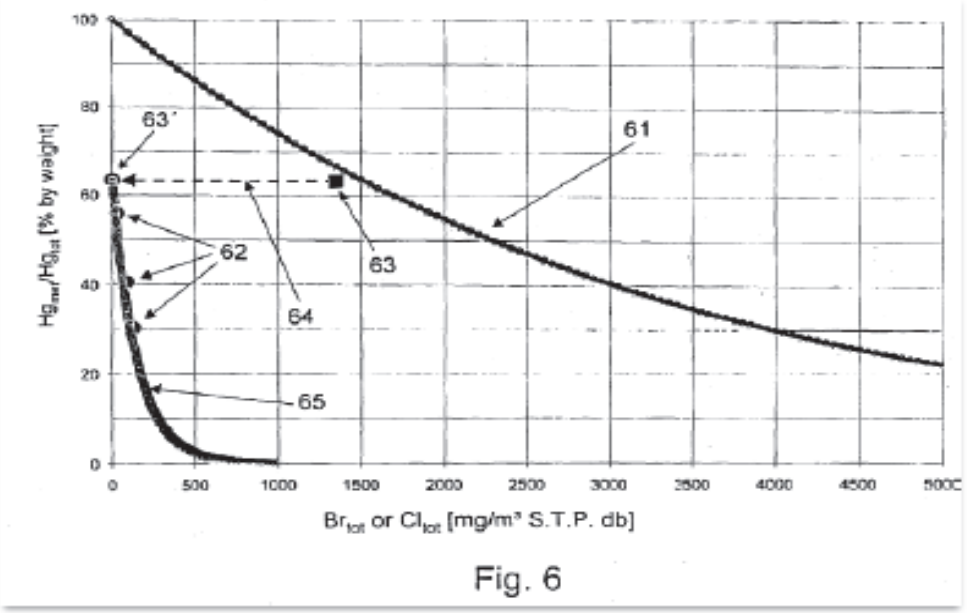


Fig. 6

1613. The values on the X-axis are presented as mg/m^3 S.T.P. db, which is milligrams Br per cubic meter of mercury-containing flue gas, on a dry basis'[2333] at standard temperature (25 °C) and standard pressure (1 atm). Vosteen also describes that activated carbon is used in his system,[2334] but does not expressly state the injection rate of activated carbon into the system downstream of the combustion chamber.

1614. A person of ordinary skill in the art would have known to use, or at least start with as a first approximation, widely accepted values for injection rates of

2332 Ex. 1008 (Vosteen) at 10:58-61.
2333 Ex. 1008 (Vosteen) at 1:18.
2334 Ex. 1008 (Vosteen) at 5:23-29, 5:37.

activated carbon. As described above,[2335] it was routine in the industry to use injection rates of activated carbon of around 10 pounds/MMacf (million actual cubic feet of flue gas) to capture mercury. Based on the data presented by Vosteen of 50 mg bromine per m^3 of flue gas S.T.P. db (the first datapoint described by Vosteen),[2336] and a standard and well-known injection rate of activated carbon of around 10 pounds/MMacf, a person of ordinary skill in the art would have used, or at least tried using, a mercury-containing gas that comprises about 20 grams of the element bromine per 100 grams of sorbent, which is within the claimed range of 1-30 grams bromine per 100 grams sorbent. I explain my calculations below.

1615. 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 or pounds per million actual cubic feet. 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 (MACF) of flue gas. Converting between the two would have been a routine calculation at a power plant to a person of ordinary skill in the art and would have involved such basic concepts as the ideal gas law (to convert concentrations between

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2335 State of the Art, § XII.C.5, XII.G

2336 Ex. 1008 (Vosteen) at 10:37-45.

temperatures and pressures), which was taught in first semester undergraduate chemistry to a person of skill in the art.[2337] Such unit conversion would have also involved basic engineering knowledge of a power-plant operation, such as a typical flue gas temperature, pressure, and moisture content. Each of these would have been well-known to a person of skill in the art.

1616. A person of skill in the art 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 lignites and subbituminous can produce flue gas with 15 % moisture or greater, and anthracites can produce as little as 5 % moisture or less. [2338] For example, estimates for a low volatile bituminous coal gave 8.1 % moisture in flue gas.[2339]

1617. Regarding the second conversion, a person of skill in the art would have understood from the ideal gas law that the density of a gas is proportional to pressure and inversely proportional to temperature. A person of skill in the art would have

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2337 See, e.g., State of the Art, § XII.A.9.

2338 Ex. 1027 (B&W Steam) at 8-5 to 8-6.

2339 Ex. 1008 (Vosteen) at 2:36-38 ("bituminous coal-fired or lignite-fired power stations").

learned from undergraduate chemistry that standard temperature and pressure (STP) refers to 25 °C (298 K) and 1 atm, respectively, and 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. 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[2340] This dewpoint range restricts the outlet temperatures to somewhat hotter values like 150 °C. Last, a person of ordinary skill in the art would have found in readily available tables of unit conversions that 1 m^3 = 35.3[6] ft^3.

1618. Accordingly, 50 mg / m^3 S.T.P. db (as disclosed by Vosteen) converts to the following in terms of grams bromine / million actual cubic feet.

$$\frac{50\ mgBr}{m^3_{STP.DB}} \times \left(\frac{0.9m^3_{STP.DB}}{1.0m^3_{STP}}\right) \times \left(\frac{1g}{1000\ mg}\right) \times \left(\frac{1\ atm}{1\ atm}\right) \times \left(\frac{298K}{413K}\right) \times \left(\frac{1m^3}{35.3ft^3}\right) \times \left(\frac{10^6 ACF}{1\ MACF}\right) \times 919.8 \frac{g\ Br}{MACF}$$

1619. A person of ordinary skill in the art would have also been readily able to convert pounds activated carbon to grams activated carbon through the well-

[2340] Ex. 1027 (B&W Steam) at 19-11.

known unit conversion that there are 453.592 grams per pound. Accordingly, at a typical activated-carbon injection rate of 10 pounds per MACF, the injection rate of activated carbon would equal:

$$10\frac{pounds\ PAC}{MACF} \times \frac{453.592\ grams}{pounds} = 4{,}535\frac{grams\ Activated\ Carbon}{MACF}$$

1620. Dividing the two injection rates provides a mercury-containing gas that comprises about 20 grams bromine per 100 grams of activated-carbon sorbent, which is within the range of 1 gram to 30 grams.

1621. Claim 13 is merely an attempt to claim a workable range for combining a conventional halogen (bromine) being used in a conventional way (to oxidize mercury and promote activated carbon) with a conventional sorbent (activated carbon). Nothing in the '430 Patent specification attributes significance to the claimed range, or establishes that the claimed range "achieves unexpected results." The range presents nothing more than optimization of "result-effective" variables that would have been obvious to a POSITA.

11. Claim 14: "The method of claim 1, wherein the sorbent contacted with the mercury comprises the element bromine and mercury."

1622. Vosteen renders this claim obvious. A POSITA would have understood that not all bromine added to the coal/chamber in Vosteen is used to oxidize mercury. Vosteen added an excess of bromine compared to mercury, specifically describing that "the bromine compound is preferably added in a mass ratio of bromine to

mercury in the range of 102 to 104."[2341] Accordingly, a POSITA would have understood that excess bromine would be available to contact the activated carbon to form a promoted sorbent.

12. Claim 15: "The method of claim 1, comprising removing greater than 70 wt % of the mercury in the mercury-containing gas."

1623. Vosteen renders this claim obvious in combination with the background knowledge of a POSITA. Vosteen discloses maintaining mercury levels below those needed to comply with legal and regulatory requirements.[2342] Vosteen describes measuring the mercury content and then, in response to that measurement, controlling process parameters (e.g., rates of addition of bromine-containing components) to achieve those limits. Measurements of the mercury content are depicted in Figures 2-8 of Vosteen,[2343] and also recited in claim 9 of Vosteen.[2344] Vosteen further describes maintaining mercury content of the cleaned gas below desired levels, including those imposed by regulatory authorities. For example, Vosteen mentions that "strict limiting values exist for the legally permissible emission of mercury, for example from incineration plants and power stations."[2345]

2341 Ex. 1008 (Vosteen) at 4:34-45.
2342 Ex. 1008 (Vosteen) at 1:10-13, 1:20-22.
2343 Ex. 1008 (Vosteen) at Figs. 2-8.
2344 Ex. 1008 (Vosteen) at Claims 9.
2345 Ex. 1008 (Vosteen) at 1:10-13.

Vosteen discusses the need that his invention provided a solution for "further reduction of the currently permitted limiting values" of mercury emissions.[2346]

1624. As I discuss in the State of the Art, the EPA and other regulatory bodies proposed rules that, upon implementation, would have required mercury emissions reductions by 70%. In trying to ensure their plants were compliant upon eventual implementation and promulgation of the EPA rules, a person of skill in the art would have been motivated, and it would have been obvious, to keep mercury emissions below the desired levels proposed by the EPA in order to avoid paying regulatory fines and other penalties that would incur upon rule implementation.

13. Claim 16: "The method of claim 1, comprising removing greater than 70 wt % of the mercury in the mercury-containing gas with the sorbent."

1625. Claim 16 would have been obvious to a person of skill in the art over Vosteen. For example, as described for Claim 15 above, Vosteen discloses removing more than 98% of the mercury from the mercury-containing gas.[2347]Vosteen discloses that his invention is particularly suited "for those high-temperature plants *which do not have a wet flue gas emission control system*, but solely have a dry emission control system having a mercury *sorption* stage."[2348] Such plants with "solely" a dry emission control system, and without a scrubber, would

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2346 Ex. 1008 (Vosteen) at 1:20-22.

2347 Ex. 1008 (Vosteen) at 6:35-40 (describing Figure 5).

2348 Ex. 1008 (Vosteen) at 5:32-36.

be dependent on the activated carbon for mercury removal. Moreover, the Hg removals on sorbents alone would meet or exceed the 70% removal threshold under the configurations disclosed by Vosteen. Specifically, Vosteen discloses that "lignite-fired power stations"[2349] would benefit from his Hg control methods. A person of ordinary skill in the art would have understood that such plants typically have very low concentrations of inherent chlorine in their flue gas as well as very low LOI levels in their flyash. Under such circumstances, Hg capture on inherent unburned carbon is minimal. Consequently, a person of ordinary skill in the art would have understood that adding bromine to the furnace of a plant with "solely" a dry emission control system, and without a scrubber, while injecting a sorbent ahead of the particle collection device, as Vosteen teaches, ensures that virtually all the Hg captured in a particle collection device would be bound to the sorbent. Furthermore, Vosteen also teaches how to adjust the bromine addition level to achieve Hg removal up to essentially complete removal, including 70 % removal.

1626. As described in the State of the Art,[2350] a person of skill in the art would have known that by 2004, the EPA had already put the industry on notice of upcoming laws and regulations surrounding announced regulations requiring 70% mercury removal, such as the EPA's Clean Air Mercury Rule (CAMR). Notice of

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2349 Ex. 1008 (Vosteen) at 2:36-37.

2350 State of the Art, XII.D —XII.F.

these regulations exerted a strong outside impetus on the industry to adjust processes to comply with the regulations' eventual implementation. Through routine process optimization and routine experimentation, a person of ordinary skill in the art would have adjusted the bromine injection rate and/or activated carbon injection rate in a plant he described as preferred (one that relied solely on a dry emission control system having a mercury sorption stage) to meet and exceed (for purposes of safety margin) the EPA's proposed rules requiring a 70% removal of mercury.

14. Claim 17: "The method of claim 1, wherein the sorbent in the mercury-containing gas comprises about 1 g to about 30 g of the added Br2, HBr, the bromide compound, or a combination thereof, per 100 g of the sorbent."

1627. This claim would have been obvious over Vosteen. Claim 4 is merely an attempt to claim the optimum or workable range for a process of combining a particular conventional halogen (bromine) being used in a conventional way (halogens are inherent to coal, and both oxidize mercury and promote activated carbon) with a conventional sorbent (activated carbon). Nothing about the particular range of 1 g to about 30 g of the halide promoter per 100 g of the sorbent would have led to an unexpected result from what was already known to one of skill in the art.

1628. As described in the State of the Art,[2351] it was known that the saturation limit of activated carbon for bromine (i.e., how much bromine the activated carbon

[2351] State of the Art, § XII.C.3.

can actually adsorb at equilibrium), was up to 31 to 38 grams per 100 grams of activated carbon. Given the residence times in flue gas, and other inefficiencies, a person of ordinary skill in the art would have understood that the actual bromine loaded onto activated carbon would have been less than the saturation limit.

1629. A person of ordinary skill in the art would have recognized that there would have been sufficient bromine in the flue gas, according to Vosteen's processes, to provide a ratio of between 1 g to 30 g of bromine per 100 g of activated carbon. A person of ordinary skill in the art operating a plant with solely a dry emission control system (i.e., without a wet scrubber), would have been motivated to seek to load the activated carbon with up to nearly its saturation limit, because it was known in the art that halides "improve[d] 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."[2352] Vosteen expressly discloses the former,[2353] and the latter was well-known in the art.

1630. Through routine process optimization and routine experimentation, a person of ordinary skill in the art would have adjusted the rate of addition of bromine-containing species and/or activated carbon injection rate to achieve halide promoter on the activated-carbon sorbent from about 1 g to about 30 g.

[2352] Ex. 1062 (Crocker) at 2-3.

[2353] Ex. 1008 (Vosteen) at 4:46-50.

15. Claim 18: "The method of claim 1, wherein the Br2, HBr, or the bromide compound is contacted with the sorbent in vapor form, gaseous form, liquid form, or in an organic solvent."

1631. Vosteen renders this claim obvious. Vosteen discloses mixing bromide compounds in with the coal or added to the combustion furnace:

The bromine compound, for example, sodium bromide, can be added in solid form, for example as salt, or in 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 a pyrolysis drum, which serves, for example, for the thermal breakdown of co-incinerated waste materials, or to a coal mill. The compound can also be fed during the combustion process. If the furnace comprises a plurality of stages, for example a primary and a secondary furnace, the bromine compound can be introduced, likewise in solid or liquid form, into one or both combustion chambers, for example into the rotary kiln and/or the afterburning chamber. Preferably, an aqueous solution of the compound is sprayed into one of the combustion chambers.[2354]

1632. Vosteen discloses that mercury containing gas results from high temperature processes such as combustion in power plants and waste incineration plants.[2355]

16. Claim 19: "The method of claim 1, wherein the activated carbon comprises powdered activated carbon, granular activated carbon, or a combination thereof."

1633. This limitation is disclosed by Vosteen. As described above, Vosteen discloses injecting activated carbon into a mercury-containing flue gas downstream of the combustion chamber and contacting mercury with the sorbent to form a

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[2354] Ex. 1008 (Vosteen) at 4:4-19; *see also id.* at 2:54-3:2, 3:66-4:33, 6:65-7:32.

[2355] Ex. 1008 (Vosteen) at 1:66-2:1; *see also, id*. at 1:10-22.

mercury/sorbent composition. Vosteen discloses activated carbon as a sorbent. Vosteen further specifies "granulated activated carbon" as the sorbent.[2356] A person of skill in the art would have recognized that "granular" activated carbon and "granulated" activated carbon are two words for the same material.

1634. Granite also discloses a number of different types of activated carbon.

17. Claim 20: "The method of claim 1, wherein the sorbent injected into the mercury-containing gas is a sorbent obtained by contacting a sorbent with a halogen or halide promoter prior to the injection of the sorbent into the mercury-containing gas."

1635. ME2C did not provide infringement contentions for this claim. ME2C's infringement contentions cross reference claim 14 of the '114 patent. ME2C's infringement contentions do not include claim 14 of the '114 patent. ME2C's final contentions hew to this position, and thus ME2C is apparently not asserting this claim. Therefore, no analysis regarding this element is required.

18. Claim 21: "The method of claim 1, wherein the sorbent injected into the mercury-containing gas is free of contact with a halogen or halide promoter prior to injection of the sorbent into the mercury-containing gas."

1636. ME2C did not provide infringement contentions for this claim. ME2C's infringement contentions cross reference claim 13 of the '114 patent. ME2C's infringement contentions do not include claim 13 of the '114 patent. ME2C's final

[2356] Ex. 1008 (Vosteen) at 5:24-25.

contentions hew to this position, and thus ME2C is apparently not asserting this claim. Therefore, no analysis regarding this element is required.

19. Claim 22: "The method of claim 1, wherein the combustion chamber comprises a boiler."

1637. This claim is disclosed by Vosteen. Vosteen discloses that one of the applications for his process is in removing mercury from a mercury-containing gas generated from the combustion of coal in a combustion chamber. Vosteen discloses adding the bromine-containing species to a combustion chamber. Vosteen further specifies that the bromine-containing species "can be added after combustion, for example in a downstream waste-heat boiler."[2357] Vosteen further refers to "boiler flue gas" in reference to the figures.[2358] Vosteen explains that the boilers are part of the combustion chamber: "The power station [of Figure 9] comprises two parallel slag-tap fired boilers 91, 91' having temperatures in the combustion chamber around 1450 °C. The slag-tap fired boilers 91, 91' are charged with coal 92, 92'."[2359] Vosteen further discloses components from a boiler in Figures 2-4.[2360]

20. Claim 23: "The method of claim 1, wherein the mercury-containing gas is a flue gas."

[2357] Ex. 1008 (Vosteen) at 4:20-21; see also Ex. 1008 (Vosteen) at 7:5-8.

[2358] Ex. 1008 (Vosteen) at 11:11; see also Ex. 1008 (Vosteen) at 6:15-62, Figure 9.

[2359] Ex. 1008 (Vosteen) at 11:3-6.

[2360] Ex. 1008 (Vosteen) at 6:15-34; Figs. 2-4.

1638. This claim is disclosed by Vosteen. For example, the title of Vosteen is "Process for Removing Mercury from Flue Gases," and the Abstract refers to "removing mercury from flue gases of high-temperature plants, in particular power stations."[2361] This element is also disclosed by the claims of Vosteen:[2362]

1. Process for removing mercury from mercury-containing flue gases of a furnace within which a combustion or incineration is carried out, wherein

bromine, a bromine compound, a mixture of bromine compounds or a mixture of bromine and a bromine compound or compounds, is fed to the furnace or to the flue gas of the furnace in a plant section downstream of the furnace, or to both the furnace and the flue gas, the temperature during the first contact of the bromine or of said mixture with the flue gas being at least 500° C.,

the combustion or incineration is carried out in the presence of a sulphur compound,

and then the flue gas is subjected to a cleanup for removing mercury from the flue gas.

18. A process for removing mercury from mercury-containing flue gases of a furnace, comprising:

carrying out a combustion or incineration process, within the furnace, in the presence of a sulphur compound;

feeding bromine, a bromine compound, a mixture of bromine compounds, or a mixture of bromine and one or more bromine compounds to at least one of the furnace or a flue gas of the furnace in a plant section downstream from the furnace, a temperature at first contact of the bromine, bromine compound, mixture of bromine compounds, or mixture of bromine and one or more bromine compounds with the mercury-containing flue gas being at least 800° C.; and

subjecting the mercury-containing flue gas to a cleanup for substantially removing mercury from the mercury-containing flue gas, wherein the cleanup for substantially removing mercury from the mercury-containing flue gas includes a dry cleanup stage comprising at least one sorbent, and

2361 Ex. 1008 (Vosteen) at Title, Abstract.

2362 Ex. 1008 (Vosteen) at Claims 1, 18.

1639. Vosteen further discloses the method of claim 1, which is described above.

21. Claim 24: "The method of claim 1, wherein the injection of the sorbent into the mercury-containing gas occurs upstream of a particulate separator, a scrubber, or a combination thereof."

1640. Vosteen discloses this claim element. Vosteen discloses that one of the applications for his process is in removing mercury from a mercury-containing gas generated from the combustion of coal in a combustion chamber. For example, Vosteen describes experiments conducted on "a *coal-fired power station* of Bayer AG in Uerdingen, which essentially consists of *a slag-tap fired boiler* . . "[2363] Vosteen also describes a *"coal-fired* power station of Bayer AG in Uerdingen (see FIG.9)" with "two parallel slag-tap fired boilers 91, 92 having temperatures in the *combustion chamber* around 1450°C."[2364] Vosteen describes his results in Figures 7 and 8 regarding the experiments conducted on "coal combustion (bituminous coal)."[2365] This limitation is also disclosed in claims 1 and 18 of Vosteen, highlighted below:[2366]

2363 Ex. 1008 (Vosteen) at 7:25-28.
2364 Ex. 1008 (Vosteen) at 10:63-11:6.
2365 Ex. 1008 (Vosteen) at 11:23-24.
2366 Ex. 1008 (Vosteen) at Claims 1, 18.

1. Process for removing mercury from mercury-containing flue gases of a furnace within which a combustion or incineration is carried out, wherein

bromine, a bromine compound, a mixture of bromine compounds or a mixture of bromine and a bromine compound or compounds, is fed to the furnace or to the flue gas of the furnace in a plant section downstream of the furnace, or to both the furnace and the flue gas, the temperature during the first contact of the bromine or of said mixture with the flue gas being at least 500° C.,

the combustion or incineration is carried out in the presence of a sulphur compound,

and then the flue gas is subjected to a cleanup for removing mercury from the flue gas.

18. A process for removing mercury from mercury-containing flue gases of a furnace, comprising:

carrying out a combustion or incineration process, within the furnace, in the presence of a sulphur compound;

* * *

feeding the coal to the furnace,

the process further comprising feeding sulphur, a sulphur compound or a mixture of sulphur compounds to said furnace based on measuring mercury content of the mercury-containing flue gas.

1641. Vosteen further discloses the method of claim 1, which is described above.

22. Claim 25: "The method of claim 24, wherein the particulate separator comprises a baghouse, an electrostatic precipitator, a fabric filter, or a combination thereof."

1642. Vosteen discloses this claim element. Vosteen describes a fabric filter ("cloth filter"), which is an example of a particulate separator. Vosteen discloses

that the activated-carbon sorbent is injected upstream of the fabric filter, in that the fabric filter separates the mercury-sorbent composition from the gas stream.[2367]

1643. Vosteen describes numerous components that are used to separate the mercury/sorbent composition from the mercury-containing (flue) gas, to form a cleaned gas. Such components include a spray-dryer adsorber (SDA), electrostatic precipitator (ESP), or fabric filter.[2368] These are also discussed in claims of Vosteen:[2369]

> **10.** The process according to claim **8**, wherein said emission control system comprises filtration, electrostatic separation or both.

1644. Vosteen repeatedly refers to a flue gas *cleaning* system.[2370] Vosteen refers to "clean gas downstream of the wet and/or dry flue gas emission system."[2371] This is because, as Vosteen discloses, an "object of the invention to provide a process for removing mercury, in particular for the substantially complete removal of mercury (Hg)."[2372] The claims of Vosteen further disclose a process of "cleanup" of the flue gas:[2373]

2367 Ex. 1008 (Vosteen) at 5:24-29.
2368 Ex. 1008 (Vosteen) at 5:15-30.
2369 Ex. 1008 (Vosteen) at Claim 10.
2370 See, e.g., Ex. 1008 (Vosteen) at Abstract, 2:12-15, 5:1-5.
2371 Ex. 1008 (Vosteen) at 6:2-4.
2372 Ex. 1008 (Vosteen) at 1:50-53.
2373 Ex. 1008 (Vosteen) at Claims 1, 18.

1. Process for removing mercury from mercury-containing flue gases of a furnace within which a combustion or incineration is carried out, wherein

bromine, a bromine compound, a mixture of bromine compounds or a mixture of bromine and a bromine compound or compounds, is fed to the furnace or to the flue gas of the furnace in a plant section downstream of the furnace, or to both the furnace and the flue gas, the temperature during the first contact of the bromine or of said mixture with the flue gas being at least 500° C.,

the combustion or incineration is carried out in the presence of a sulphur compound,

and then the flue gas is subjected to a cleanup for removing mercury from the flue gas.

18. A process for removing mercury from mercury-containing flue gases of a furnace, comprising:

carrying out a combustion or incineration process, within the furnace, in the presence of a sulphur compound;

feeding bromine, a bromine compound, a mixture of bromine compounds, or a mixture of bromine and one or more bromine compounds to at least one of the furnace or a flue gas of the furnace in a plant section downstream from the furnace, a temperature at first contact of the bromine, bromine compound, mixture of bromine compounds, or mixture of bromine and one or more bromine compounds with the mercury-containing flue gas being at least 800° C.; and

subjecting the mercury-containing flue gas to a cleanup for substantially removing mercury from the mercury-containing flue gas, wherein the cleanup for substantially removing mercury from the mercury-containing flue gas includes a dry cleanup stage comprising at least one sorbent, and

1645. The "dry cleanup stage" and "dry sorbent" includes, for example, the activated carbon injected into the mercury-containing flue gas that is separated by the fabric filter.[2374] The "cleanup" and "removal" referred to by Vosteen in the passages above refer to separating the mercury/sorbent composition from the mercury-containing flue gas.

[2374] Ex. 1008 (Vosteen) at 5:27-30.

1646. Vosteen also discloses that the "dry cleanup" (fabric filter) can be used in conjunction with a "wet scrubber."[2375] A person of ordinary skill in the art would have understood that a scrubber is one of the last units in an emissions control system, as shown in item 97 of Figure 9,[2376] and that activated sorbent would have been injected before the scrubber.

1647. Vosteen discloses an alternative embodiment, which makes use of an electrostatic precipitator (ESP),[2377] which is a type of particulate separator. Vosteen explains that "mercury adsorption intensifies on the fly ash of ESPs."[2378] Vosteen also explains that "[m]ercury bromide $HgBr_2$ adsorbs more strongly to dry sorbents than mercury chloride $HgCl_2$."[2379] The dry sorbents disclosed by Vosteen include "granulated activated carbon" and "pulverulent slaked lime/activated carbon."[2380] A person of ordinary skill in the art would have understood that, as taught by Vosteen, adsorption of $HgBr_2$ by activated carbon occurs with direct contact between $HgBr_2$ and the activated carbon particles in the flue gas. A POSITA would have known that, once entrained in flue gas, the activated carbon would have been transported downstream to a particle collection device (PCD), such as a fabric filter or ESP.[2381]

2375 Ex. 1008 (Vosteen) at Abstract.
2376 Ex. 1008 (Vosteen) at 11:1-14, Figure 9.
2377 Ex. 1008 (Vosteen) at 11:5-10, Figure 9 (item 96); see also 5:26-39.
2378 Ex. 1008 (Vosteen) at 5:38-39.
2379 Ex. 1008 (Vosteen) at 5:36-38.
2380 Ex. 1008 (Vosteen) at 5:24-25, 5:28-29.
2381 State of the Art, § XII.B.5.a.

A POSITA would have known that air pre-heaters are located immediately upstream of the PCDs in a conventional flue gas system, and that, much like the activated carbon would have been injected upstream of a fabric filter or ESP—so that the mercury-sorbent composition can be separated from the flue gas by the fabric filter or ESP—the activated carbon would likewise have been injected upstream of the air preheater. A POSITA would have been further motivated to inject the activated carbon upstream of the air preheater in order to extend the residence time during which the activated carbon can contact the mercury in the flue gas, thereby increasing the amount of mercury removal.

1648. Granite also describes scrubbing solutions for removal of sorbents.[2382] A POSITA would understand that the addition of a sorbent must occur before scrubber or particulate control system, as the purpose of the sorbent is to adsorb gaseous waste such as mercury so that the waste can be removed on the particulates by the scrubber or particulate control system.

1649. Vosteen further discloses the method of claim 24, which is described in the above section.

D. INDEPENDENT CLAIM 29

1. Claim 29: Element 29(a): "A method of separating mercury from a mercury-containing gas, the method comprising:"

[2382] Ex. 2003 (Granite 2000) at 1020, 1026.

1650. The language of the preamble of claim 29 is identical to the preamble of claims 28 and 1. Accordingly, the explanation I provide above for the preamble of claim 28 applies equally to the preamble of claim 29.

2. Claim 29: Element 29(b): "combusting coal in a combustion chamber, to provide the mercury-containing gas, wherein the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br−, or a combination thereof, wherein"

1651. The language of this claim element is identical to claim element 28(b). Accordingly, the explanation I provide above for those claim elements applies equally to this claim element.

3. Claim 29: Element 29(c)-(e): "the coal comprises an additive comprising Br2, HBr, a bromide compound, or a combination thereof, wherein the additive is added to the coal before the coal enters the combustion chamber, or the combustion chamber comprises an additive comprising Br2, HBr, a bromide compound, or a combination thereof, or a combination thereof;"

1652. The language of this claim element is identical to claim element 28(c)-(e). Accordingly, the explanation I provide above for those claim elements applies equally to this claim element.

4. Claim 29: Element 29(f): "injecting a sorbent comprising activated carbon into the mercury-containing gas downstream of the combustion chamber such that the activated carbon reacts with the halogen or halide promoter in the mercury-containing gas to form a promoted sorbent;"

1653. The language of this claim element is identical to claim element 28(f). Accordingly, the explanation I provide above for those claim elements applies equally to this claim element.

1654. In addition, the sorbent material used by Vosteen is granular activated carbon: "fixed-bed adsorbers, for example based on granulated activated carbon" or ""cloth filters which are impinged with a blown-in finely pulverulent slaked lime/activated carbon or slaked lime/lignite coal coke mixture."[2383]

1655. It would have also been obvious to combine Vosteen's addition of bromine compounds to coal for combustion with activated carbon injection systems in use at the time that the Vosteen reference was published. For example, Vosteen's bromine additive would have been obvious to use in the plants described in the Granite reference. Granite explains that control technologies for removing mercury from flue gas at the time include the use of activated carbon sorbents injected into the gas stream.[2384] Granite describes, for example, the activated carbon duct injection systems used for mercury control for industrial combustors.[2385] A POSITA would understand that sorbent would need to be added upstream of the scrubber or particulate control system to be useful for removal of adsorbed mercury.[2386]

2383 Ex. 1008 (Vosteen) at 5:19-30.
2384 Ex. 2003 (Granite 2000) at 1020, 1022.
2385 Ex. 2003 (Granite 2000) at 1026.
2386 Ex. 1038 (Granite-1998) at 4.

1656. A POSITA would have understood that not all bromine added to the coal/chamber in Vosteen is used to oxidize mercury. Vosteen teaches added an excess of bromine compared to mercury. Vosteen discloses preferably adding the bromine compound "in a mass ratio of bromine to mercury in the range of 102 to 104."[2387] Accordingly, a POSITA would have understood that excess bromine would be available to contact the activated carbon to form a promoted sorbent. Granite teaches the importance of promoting activated carbon with halogens.[2388]

5. Claim 29: Element 29(g): "contacting mercury in the mercury-containing gas with the promoted sorbent;"

1657. The language of this claim element is identical to claim element 28(g). Accordingly, the explanation I provide above for those claim elements applies equally to this claim element.

6. Claim 29: Element 29(h): "separating the promoted sorbent contacted with the mercury from the mercury-containing gas;"

1658. The language of this claim element is identical to claim element 28(h). Accordingly, the explanation I provide above for those claim elements applies equally to this claim element.

7. Claim 29: Element 29(i)-(m): "measuring the mercury content of the mercury-containing gas; and modifying, in

[2387] Ex. 1008 (Vosteen) at 4:34-45 .

[2388] Ex. 2003 (Granite 2020) at 1020; *see also* Ex. 1038 (Granite-1998) at 8-9 (listing halides as known promoters of activated carbon to increase its capacity for the removal of mercury).

response to the measured mercury content, an injection rate of injecting the sorbent into the mercury-containing gas, an amount of the Br2, HBr, the bromide compound, or a combination thereof, added to the coal or the combustion chamber, or a combination thereof."

1659. The language of this claim element is identical to that of claim 10. Accordingly, the explanation I provide above for that claim applies equally to these claim elements.

XLVIII. ADDITIONAL OPINIONS RELATING TO INEQUITABLE CONDUCT

348. I understand that Defendants in this matter have alleged that the patent applicants, including the inventors, committed "inequitable conduct" during their prosecution of the applications that led to the asserted patents. I understand that inequitable conduct requires a finding that applicants misrepresented or omitted material information to the patent office, and that they did so with an intent to deceive. While I am not offering an ultimate opinion on whether or not the applicants committed inequitable conduct, I have been asked to provide my opinion with respect to several underlying issues.

A. ACTIVATED CARBON PROPERTIES

349. First, I have reviewed the article "The Multiple Site Model for Flue Gas-Mercury Interactions on Activated Carbons: the Basic Site ("Site Model

Paper")."[2389] I also understand that there was an accompanying presentation at the 225th American Chemical Society ("ACS") National Meeting, New Orleans, LA, which occurred March 23-27, 2003, and I have confirmed this by reviewing the program listing from that meeting. While I was not at this meeting, I have attended ACS meetings many times, both before and after 2003. I was and still am a member of the American Chemical Society Division of Fuel Chemistry and received copies of the preprints of the papers presented at all meetings.

350. The Site Model Paper pertains to poisoning of the active sites for Hg chemistry on PAC by sulfur species. The authors were all personnel from the EERC at the time, including two named inventors on the asserted patents, Ed Olson and John Pavlish. I recall discussing the authors' findings in this paper with other experts at other conferences at the time.

351. The Site Model Paper is cited as "Fuel Chemistry Division Preprints, 2003, 48(1), 30." This preprint would have been available to the public in 2003 at the ACS Meeting. Based on my experience with ACS National Meetings, the American Chemical Society National Meeting would have been attended by thousands of scientists, and the presentations for the Division of Fuel Chemistry were usually attended by several dozen researchers in the field. This preprint would

[2389] Fuel Chemistry Division Preprints 2003, 48(a), 30.

normally have been distributed via mail to all attendees and all dues paying members of the Division soon before or soon after the presentation at the conference, and sold to other interested researchers. At that time there were a few hundred members in the Division of Fuel Chemistry.

352. The Site Model Paper contains two figures: Figure 1 illustrates the proposed mechanism for mercury capture on Norit FGD sorbent, and Figure 2 provides more detail on the site on FGD carbon that binds oxidized mercury (Hg(II)) to the sorbent. The Site Model Paper presents a postulated description of the binding sites available on activated carbon. This description envisions two sites for heterogeneous (i.e., reactions between a gas and surface, rather than between two gaseous species) mercury chemistry, one in which a solid surface adsorbs elemental mercury from surrounding gases and oxidizes it on the carbon surface, and another that binds the oxidized mercury until it is further oxidized by chlorine and eventually released as $HgCl_2$ into the surrounding gases. The primary focus in the Site Model Paper is on the carbon basic binding sites for Hg(II). These sites are envisioned as zig-zag carbene structures that are located at the edges of graphene layers in the solid-phase carbon sorbent. It is at these carbene edge sites that the oxidized mercury would react with acid anions such as Cl^- and NO_2^-, according to the model. Other species such as halides and sulfate compounds would also react at the carbene edge sites without contacting bound mercury.

353. As I discuss elsewhere in this report, all of the claims of the ’147 patent that are being asserted in this case include a claim element requiring an activated carbon sorbent having zig-zag carbene edge sites on graphene layers. Claim 1 of the ’147 patent requires that the added bromine species react at these edge sites. Claim 1 is essentially requiring that substances behave according to the model presented in the Site Model Paper. In my opinion, the Site Model Paper is directly relevant to Claim 1 of the ’147 patent, and should have been provided to the Patent Office as prior art. I do not know why the inventors Ed Olson and John Pavlish would have omitted this reference from the Patent Office. Without that paper, I am not aware of any material that the Patent Office would have had at the time disclosing a public presentation or public disclosure of the carbene edge site model in Claim 1.

354. The particular powdered activated carbon discussed in the Site Model Paper is a commercially available sorbent called Norit Darco FGD. I am very familiar with FGD, going back to at least 2003, because it was used in essentially all field tests to demonstrate sorbent injection for mercury control at coal-fired power plants sponsored by DoE’s National Energy Technology Laboratory. My company, Niksa Energy Associates LLC, was funded for several years to quantitatively interpret the results of these field tests with our postulated reaction mechanisms for mercury transformations along utility gas cleaning systems, and these interpretations included dozens of datasets for FGD injection. The prominence of the FGD sorbent

in the mercury controls community is illustrated by Nelson's statement in his patent that "Norit's Darco FGD® is a common PAC frequently used by other researchers as a comparative yardstick."[2390] The various field test teams sponsored by NETL included FGD in their test specifications so that the findings from different teams could be compared without the complications of different sorbent properties. And since so many test teams used the same sorbent, FGD is the most well-known and well characterized activated carbon in the literature for mercury emissions control, and was so back in 2003. The asserted patents refer to Norit Darco FGD in their discussion of powdered activated carbon.[2391] Norit Darco FGD is the same sorbent as the Norit FGD referred to in the Site Model Paper. There are experimental examples in the asserted patents that use Norit FGD, in both brominated and unbrominated forms.[2392]

355. During the prosecution of the '147 patent, the patent examiner distinguished the prior art reference to Nelson Jr., based on the applicant's

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[2390] Ex. 1012 (Nelson) at 11:17-19

[2391] 147 Patent (Ex. 1001) at 5:35-67 (describing the figures in the patent including experimental results for non-halogenated NORIT Darco FGD or brominated NORIT FGD sorbent).

[2392] *See* 147 Patent (Ex. 1001) at 14:40-46; 15:39-51.

arguments, because Nelson Jr. "does not disclose the activated carbon being graphene sheets and the binding sites being carbene species edge sites." The patent examiner made that statement in 2011, and the applicants continued to rely on it. Nelson Jr. explicitly discloses experiments concerning the bromination of Norit FGD:

> The gas-phase bromine treatment of this invention has been tested on many different commercially-available powdered activated carbons (PACs). Each has been found to be easily brominated to at least 15 wt % Br, including PACs from …Norit. Norit's Darco FGD® is a common PAC yardstick frequently used by other researches as a competitive yardstick.[2393]

356. As demonstrated in their Site Model Paper, Ed Olson and John Pavlish knew as far back as 2003 that Norit FGD was an activated carbon that contained graphene sheets whose binding sites were zig-zag carbene structures on the edges of the sheets. I know this because it was well-known in the community, and specifically because they disclosed this understanding to the mercury control community in 2003 through the Site Model Paper and at the accompanying conference.

357. In 2011, the patent examiner allowed the applicants to overcome a rejection of their patent claims over the Nelson reference because the Nelson reference "does not disclose the activated carbon being graphene sheets and the

[2393] Ex. 1013 at ¶ 69.

binding sites being carbene species edge sites." That statement was not correct, and persons of knowledge in the field would have known at the time that it was not correct. This was confirmed by Ed Olson during his deposition.[2394] For example, Olsen and Pavlish would have known that statement to be incorrect, and would also have known that a person of skill aware of their Site Model Paper would know that statement to be incorrect. I have no found no other references in the file history of the '147 patent that contains this same information. If Ed Olson and John Pavlish, or their attorneys, had provided the 2003 Site Model Paper, I believe the examiner would have found that Paper material to the patentability of the patent claims, and would have understood that the powdered activated carbon used by Nelson Jr. had the claimed graphene sheets with reactive carbene edge sites.

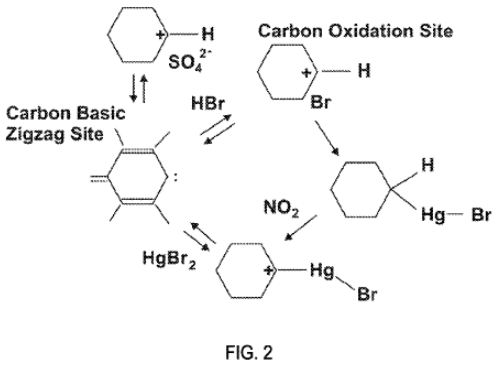
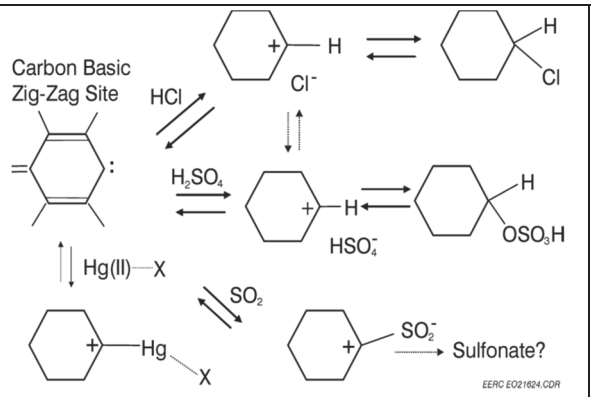
B. IMPROVED MECHANISM MODEL

358. The inventors of the asserted patents also presented their research at two other conferences in 2003. At the XIIth International Conference on Heavy Metals in the Environment in Grenoble, France, May 26-30, they presented the paper "Chemical mechanisms in mercury emission control technologies." J. Phys. IV France 107 (2003).[2395] Likewise, at the Combined Power Plant Air Pollutant Control

[2394] Ex. 2007 at 201:21-202:8

[2395] Ex. 1079

MEGA Symposium, in Washington, DC, May 19-22, they presented "An Improved Model for Flue Gas-Mercury Interactions on Activated Carbons."[2396] I understand that neither reference was provided to the Patent Office during the prosecution of the applications that became the '114 or '147 patents. Both of these papers as well as the Site Model Paper include a figure that is substantially the same as the figure that is Fig. 2 in the '114 and '147 patents.

	
Fig. 2 of the 114 and 147 patents	Fig. 2 in An Improved Model for Flue Gas–Mercury Interactions on Activated Carbons[2397]

359. These figures disclose the same key information but with respect to different halogens. The figure as presented in the patents shows bromine promotion of activated carbon, while the figures in the omitted references uses chlorine

[2396] Ex. 2008

[2397] Ex. 2008

promotion of activated carbon. But a POSITA would expect that bromine would react with activated carbon is a way similar to chlorine, as both are halogens. This similarity is tacitly indicated in the figure from the Site Model Paper by the symbol "X" which denotes different acid anions including Cl^-, Br^-, and NO_2^- in this particular illustration. Both figures show identical Carbon Basic Zigzag Sites. In the figure from the patents, these sites participate in three reaction channels involving SO_2, HBr, and $HgBr_2$. In the figure from the Site Model Paper, the zigzag sites participate in these same three reactions, plus a fourth channel involving H_2SO_4 which is irrelevant to mercury conversion. The version of the figure from the MEGA Symp. Paper shows the same four channels, and that from the French Conf. presentation omits the channel involving SO_2 but includes that involving H_2SO_4.

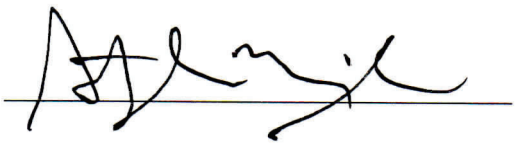
360. Most important, all three figures from papers that were not disclosed to the examiners show the binding step for oxidized mercury (indicated as either $HgBr_2$ in the patents or as Hg(II)-X in the papers) and also show the channel involving HX (indicated as either HBr in the patents or as HCl in the papers). At the very least, the patent examiner should have been provided with the publicly presented model from the 2003 references, so that the examiner could evaluate if the teaching in the '114 and '147 patents had been previously disclosed. Rather than provide these disclosures, the patent applicants wrote that "an entirely new model is presented for

the reactivity of the bromine-treated carbon with mercury shown in Fig. 2."[2398] That statement is false in light of the 2003 references disclosing the carbon edge site model. And as I have already described, the carbon edge site model is an element of the promotion of activated carbon as claimed in Claim 1 of the '147 patent. I am unaware of any publications that were disclosed to the patent office in connection with the '147 patent that contained this same information. In my opinion, if the applicants, including the inventors and their attorneys, wanted to provide the Patent Examiner with references material to the claimed model, they would have provided these references.

[2398] Ex. 1002 ('114 Patent) at 17:25-27.

XLIX. CONCLUSION

Executed on October 25, 2022

By: 

Dr. Stephen Niksa

CERTIFICATE OF SERVICE

I hereby certify that on October 25, 2022, copies of the foregoing were caused to be served upon the following in the manner indicated:

James M. Lennon, Esquire — *VIA ELECTRONIC MAIL*
DEVLIN LAW FIRM LLC
1526 Gilpin Avenue
Wilmington, DE 19806
Attorneys for Plaintiffs

Bradley W. Caldwell, Esquire — *VIA ELECTRONIC MAIL*
Jason D. Cassady, Esquire
John Austin Curry, Esquire
Justin T. Nemunaitis, Esquire
Adrienne R. Dellinger, Esquire
CALDWELL CASSADY CURRY PC
2010 Cedar Springs Road, Suite 1000
Dallas, TX 75201
Attorneys for Plaintiffs

Robert S. Saunders, Esquire — *VIA ELECTRONIC MAIL*
Nicole A. DiSalvo, Esquire
Jessica R. Kunz, Esquire
Daniel S. Atlas, Esquire
SKADDEN, ARPS, SLATE, MEAGHER & FLOM LLP
One Rodney Square
P.O. Box 636
Wilmington, DE 19899-0636
Attorneys for Defendant Alistar Enterprises, LLC

/s/ David Glandorf