

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

VOLKSWAGEN GROUP OF AMERICA, INC.

Petitioner

U.S. Patent No. 6,037,307

Issue Date: March 14, 2000

Title: CATALYST/SORBER FOR TREATING
SULFUR COMPOUND CONTAINING EFFLUENT

**PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 6,037,307
PURSUANT TO 35 U.S.C. §312 and 37 C.F.R. §42.104**

Case No. IPR2014-01554

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LISTING OF EXHIBITS

Exhibit 1001	U.S. Patent No. 6,037,307 to Campbell, et al.
Exhibit 1002	Prosecution History for U.S. Patent Application Ser. No. 12/610,067
Exhibit 1003	U.S. Patent No. 5,792,436 to Feeley, et al.
Exhibit 1004	U.S. Patent No. 4,760,044 to Joy, III et al.
Exhibit 1005	U.S. Patent No. 4,939,113 to Tauster, et al.
Exhibit 1006	Rieck, J.S., et al., “Development of Non-Nickel Additives for Reducing Hydrogen Sulfide Emissions from Three-Way Catalysts”, SAE Paper 892095 (1989)
Exhibit 1007	Declaration of Robert J. Farrauto, Ph.D.

I. Mandatory Notices (37 C.F.R. §42.8)

Real Party-in-Interest:

Volkswagen Group of America, Inc. (“VWGoA” or “Petitioner”) is the real party-in-interest.

Related Matters:

U.S. Patent No. 6,037,307 (“the ’307 patent,” Ex. 1001) is currently the subject of the following litigation: *EmeraChem Holdings, LLC v. Volkswagen Group of America, Inc., Volkswagen AG, and Volkswagen Group of America Chattanooga Operations, LLC*, No. 14-cv-132-TAV (E.D. Tenn), which was filed on March 31, 2014. Co-defendant Volkswagen Group of America Chattanooga Operations, LLC is a subsidiary of VWGoA. Volkswagen AG is the parent of VWGoA, and has not been served with the complaint yet.

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II. Grounds for Standing (37 C.F.R. §42.104(a))

Petitioner certifies that the '307 patent for which review is sought is available for *inter partes* review and that Petitioner is not barred or estopped from requesting an *inter partes* review challenging the patent claims on the grounds identified in this petition.

III. Identification of Challenge (37 C.F.R. §42.104(b)(1)-(3)) and Relief Requested (37 C.F.R. §42.22(a)(1))

Petitioner challenges claims 1-8 and 11 of the '307 patent under 35 U.S.C. §102, and cancellation of those claims is requested.

A. Background of the '307 Patent

The '307 patent issued on application ser. no. 09/113,258 (Ex. 1002), which was filed on July 10, 1998. The '307 patent does not claim the benefit of an earlier effective filing date under 35 U.S.C. §§119 or 120.

1. The Disclosure Of The '307 Patent

The '307 patent discloses a system for removing H₂S and SO₂, and oxidizing CO from the exhaust of an industrial process or combustion source. See Ex. 1001 at Abstract and col. 1, ln. 43-44. The system uses a catalytic oxidative sorption process for removing the gaseous sulfur compounds, particularly SO₂ and H₂S from the exhaust stream by contacting that exhaust stream with a catalyst/sorber which stores those gaseous sulfur compounds. See Abstract and col. 1, ln. 66 - col. 2, ln. 9. Under regeneration conditions, the sorbed sulfur compounds are

desorbed (i.e., released) from the catalyst/sorber as mainly H₂S and/or SO₂ in higher concentrations in a separate, isolated flow stream. See Id. at Abstract, and col. 2, ln. 9-16. The ratio of H₂S to SO₂ in the desorbed sulfur components can be adjusted by adding a modifier to the catalyst/sorber. See Id. at col. 4, ln. 59-67.

More particularly, the catalyst/sorber includes a noble metal component comprising “Pt, Pd, Rh, Ru or mixtures thereof, preferably Pt.” Id. at Col. 2, ln. 30-32. The catalyst/sorber further includes a metal oxide sorber comprising “an oxide of Ti, Zr, Hf, Ce, Al, Si or mixtures thereof.” Id. at Col. 2, ln. 32-34. The modifier may be deposited directly onto the catalyst/sorber or deposited within. Id. at Col. 5, ln. 7-8. The modifier comprises “an oxide of Ag, Cu, Bi, Sb, Sn, As, In, Pb, Au or mixtures thereof, preferably Cu, Ag, Bi and mixtures thereof.” Id. at Col. 2, ln. 34-37. “[T]he modifier is preferably present as from 1 to 10 wt % of the catalyst/sorber.” Id. at Col. 2, ln. 46-48.

Preferably, a carrier is used to distribute the catalyst/sorber and the modifier. The carrier may be characterized as a ceramic or metal monolith having a honeycomb structure. See Id. at col. 3, ln. 57-60. “The composition of the ceramic carrier can be any oxide or combination of oxides. Suitable oxide carriers include the oxides of Al, Zr, Ca, Mg, Hf, Ti and various mixtures of the oxides, such as cordierite and mullite.” Id. at Col. 3, ln. 61-65.

The '307 patent expresses uncertainty about the mechanism by which the gaseous sulfur compounds are absorbed by the catalyst/sorber.

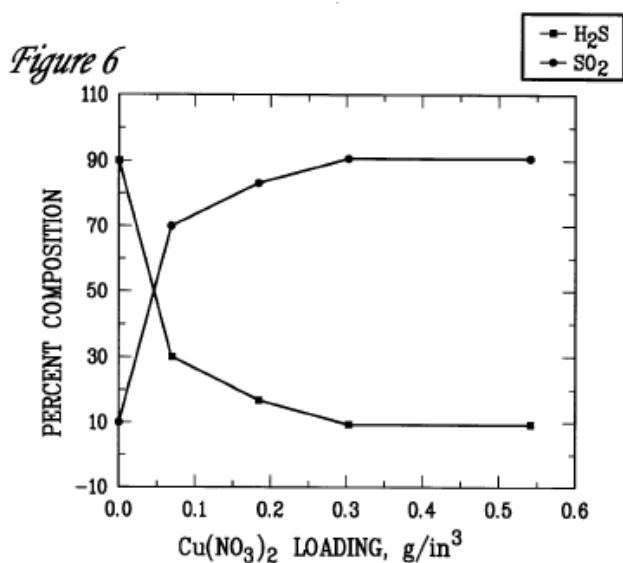
Although the sulfur compounds are removed from a gaseous stream on and/or onto the catalyst/sorber according to the present invention, it is not known in what form or by what mechanism the sulfur is associated with the catalyst/sorber. It is the invention that the sulfur compounds in the gaseous stream are in some manner releasably associated with the catalyst/sorber in an oxidizing atmosphere. It is believed that the sulfur is associated with the catalyst/sorber as a compound, most likely as an oxide, but not in the elemental form. Elemental sulfur has not been observed.

Ex. 1001 at col. 2, ln. 49-58.

“[S]ulfur can be captured and released by the catalyst/sorber, for example, a TiO_2/Pt system at temperatures as low as 300°F , however, the desorbed components released during regeneration consisted mainly of a mixture of H_2S and SO_2 .” Id. at Col. 4, ln. 59-63. After the catalyst/sorber becomes saturated with sulfur compounds, regeneration can be effectuated by passing a gaseous reducing agent over the saturated catalyst/sorber or by raising the temperature of the saturated catalyst/sorber (i.e., “thermal desorption”). See Id. at col. 2, ln. 9-29; col. 7, ln. 42-44; col. 9, ln. 15-45. “The ratio of $\text{H}_2\text{S}/\text{SO}_2$ depended on residence time and/or the presence of modifiers. In some applications the H_2S would not be

desirable; hence, it would be preferable [sic] to release the sulfur components as SO₂.” Id. at Col. 4, ln. 63-67.

“It was found that the addition of modifiers to the catalyst/sorber increased the release of sulfur as SO₂ and diminish or inhibit the formation of H₂S A variety of modifiers were determined to work; however, the most efficient were found to be copper, bismuth, and silver.” Ex. 1001 at Col. 5, ln. 4-10. Figure 6 of the ‘307 patent, which is reproduced below, illustrates the effect of the amount of a Cu(NO₃)₂ modifier has on the proportion of sulfur released as SO₂ and H₂S (see Id. at col. 5, ln. 29-31).



“This figure demonstrates that in the vicinity of 0.3 g/in³ and greater, all the sulfur compounds released during the regenerations was released as SO₂; however, below 0.3 g/in³ H₂S is released and the amount of H₂S released increases with decreasing Cu (NO₃)₃ loading. This effect was also observed with other TiO₂/Pt/X (where X

is the metal modifier as defined) modifiers such as the bismuth and silver.”

Ex. 1001 at Col. 5, ln. 31-38.

Claim 1 of the issued ‘307 patent is reproduced below:

1. A regenerable catalyst/sorber for removing gaseous sulfur compounds from gaseous streams comprising a noble metal catalyst component, a metal oxide sorber component selected from Ti, Zr, Hf, Ce, Al, Si or mixtures thereof and up to 0.3 g/in³ of a modifier component consisting of an oxide of Ag, Cu, Bi, Sb, Sn, As, In, Pb, Au or mixtures thereof.

Claims 2-10 depend from claim 1.

Claim 11 of the issued ‘307 patent is reproduced below:

11. A catalytic structure comprising a monolith carrier and a regenerable catalyst/sorber for removing gaseous sulfur compounds from gaseous streams comprising a noble metal catalyst component, a metal oxide sorber component selected from Ti, Zr, Hf, Ce, Al, Si or mixtures thereof and up to 0.3 g/in³ of a modifier component consisting of an oxide of Ag, Cu, Bi, Sb, Sn, As, In, Pb, Au or mixtures thereof deposited on said carrier.

Claims 12-15 depend from claim 11.

2. Prosecution History of the ‘307 Patent

As originally filed, the ‘307 patent included 40 claims. Ex. 1002 at pp. 21-24. Original application claim 1 recited a process for removing gaseous sulfur compounds from gaseous streams, and claims 2-23 depended from claim 1. Ex. 1002 at pp. 21-22. Original application claim 39 recited a method for adjusting

the amount of H₂S and SO₂ in a regeneration stream, and claim 40 depended from claim 39. Ex. 1002 at p. 24. In response to a telephonic restriction requirement, the patentee withdrew claims 1-23 and 39-40 from further consideration by the Examiner (see Ex. 1002 at pp. 67 and 79) and later canceled those claims (see Ex. 1002 at p. 78).

Original application claim 24, which recites a catalyst/sorber, is reproduced below:

24. A catalyst/sorber comprising a noble metal catalyst component, a metal oxide sorber component selected from Ti, Zr, Hf, Ce, Al, Si or mixtures thereof and a modifier consisting of an oxide of Ag, Cu, Bi, Sb, Sn, As, In, Pb, Au or mixtures thereof.

Ex. 1002 at p. 23. Claims 25-33 depended from claim 24. Original application claim 34, which recites a catalytic structure comprising a monolith carrier and a catalyst/sorber, is reproduced below:

34. A catalytic structure comprising a monolith carrier and a catalyst/sorber comprising a noble metal catalyst component, a metal oxide sorber component selected from Ti, Zr, Hf, Ce, Al, Si or mixtures thereof and a modifier consisting of an oxide of Ag, Cu, Bi, Sb, Sn, As, In, Pb, Au or mixtures thereof deposited on said carrier.

Ex. 1002 at p. 23.

On May 19, 1999, a non-final office action was issued rejecting claims 24-38. Ex. 1002 at pp. 64-65. In the office action, claims 24-31 and 34-38

were rejected under 35 U.S.C. §102(e) as being anticipated by Feeley et al. U.S. Patent No. 5,792,436 (“Feeley,” Ex. 1003). With respect to independent application claims 24 and 34, the Examiner explained:

The Feeley pat. discloses a sorbent/catalyst composition (please see col. 1 lns. 59-63) comprising:

a platinum group metal component, including platinum, rhodium, palladium, ruthenium, iridium and osmium (please see col. 2 ln. 65 to col. 3 ln. 1 and col. 4 lns. 6-8);

a sorbent material that may include oxides of cerium, titanium and copper (please see col. 3 lns. 19-23), and

a support, such as alumina (please see col. 10 lns. 10-18).

Additionally, note that col. 6 lns. 19-26 and fig. 1 fairly suggests that a monolith is used to support the composition, as required in applicants’ claim 34.

Ex. 1002 at p. 70. Claims 24-38 were rejected under 35 U.S.C. §103 as being unpatentable over Feeley in view of Japan 63-264,137 A and Ernest U.S. Patent No. 4,977,129. Ex. 1002 at pp. 71.

On October 15, 1999, the patentee filed an Amendment Under 37 C.F.R. §1.111 that amended independent claims 24 and 34, as follows:

24. (AMENDED) A regenerable catalyst/sorber for removing gaseous sulfur compounds from gaseous streams comprising a noble metal catalyst component, a metal oxide sorber component selected from Ti, Zr, Hf, Ce, Al, Si or mixtures thereof and 0.3 g/in³ of a

modifier component consisting of an oxide of Ag, Cu, Bi, Sb, Sn, As, In, Pb, Au or mixtures thereof.

34. (AMENDED) A catalytic structure comprising a monolith carrier and a regenerable catalyst/sorber for removing gaseous sulfur compounds from gaseous streams comprising a noble metal catalyst component, a metal oxide sorber component selected from Ti, Zr, Hf, Ce, Al, Si or mixtures thereof and 0.3 g/in³ of a modifier component consisting of an oxide of Ag, Cu, Bi, Sb, Sn, As, In, Pb, Au or mixtures thereof deposited on said carrier.

Ex. 1002 at pp. 77-78. In pertinent part, the patentee amended application claims 24 and 34 to recite the maximum amount of the modifier component that can be present in the catalyst/sorber.

In the “Remarks” section, in view of the relatively low maximum amount for the modifier compound recited in application claims 24 and 34, the patentee stated that “Feeley et al. do not disclose a modifier, although the sorber of Feeley et al. may include a Cu oxide.” Ex. 1002 at p. 80. More simply put, the patentee argued that the Cu oxide in Feeley was present in too great of a weight percentage to qualify as the recited modifier component. That is, based on Examples 1-3 of Feeley, the patentee calculated that “Cu oxide as a sorbent component would be present in the area at from 0.95 g/in³ (50%) to 1.8 g/in³ (95%) (col. 3, lines 19-25).” Id. The patentee then distinguished its amended claims over Feeley based on the now recited amount of the modifier:

In the present examples the amount of modifier used was from 0 to 0.3 g/in³. See examples general but specifically Example 5, 6, 7, 9, 10 and Specification Page 10 at line 21. Since the present claims recite the presence of a modifier they have been limited to 0.3 g/in³ which is supported at page 10 line 21 and generally. The Feeley et al., reference would not suggest the use of less than about 0.95 g/in³ Cu (see also specification at page 9, lines 1-18). Thus the maximum amount of modifier disclosed by Feeley et al., is at least three times the amount routinely recited in the present claims. The claims as amended overcome the anticipation.

Ex. 1002 at p. 81.

On November 18, 1999, a Notice of Allowance was issued. Ex. 1002 at p. 88. In the corresponding Notice of Allowability, by Examiner's Amendment, the "0.3 g/in³ of a modifier component" limitation recited in independent application claims 24 and 34 was amended to read -- up to 0.3 g/in³ of a modifier component --. Ex. 1002 at pp. 89-90. The patentee authorized this amendment in a telephonic interview on November 12, 1999. See Ex. 1002 at p. 95. On March 14, 2000, the '307 patent issued. Ex. 1001 at p. 1.

B. Patents and Printed Publications Relied On

Petitioner relies on the following patents and publications:

1. U.S. Patent No. 4,760,044 ("Joy," Ex. 1004) issued July 26, 1988 and therefore constitutes prior art against the '307 patent under 35 U.S.C. §102(b).

2. U.S. Patent No. 4,939,113 (“Tauster,” Ex. 1005) issued July 3, 1990 and therefore constitutes prior art against the ‘307 patent under 35 U.S.C. §102(b).

3. Rieck, J.S., et al., “Development of Non-Nickel Additives for Reducing Hydrogen Sulfide Emissions from Three-Way Catalysts,” SAE Paper 892095 (“Rieck”, Ex. 1006) published in 1989 and therefore constitutes prior art against the ‘307 patent under 35 U.S.C. §102(b).

C. Statutory Grounds for Challenge (37 C.F.R. §42.104(b)(1)-(2))

Cancellation of claims 1-8 and 11 of the ‘307 patent is requested on the following grounds:

1. Claims 1-8 and 11 are anticipated under 35 U.S.C. §102(b) by Joy.
2. Claims 1-8 and 11 are anticipated under 35 U.S.C. §102(b) by Tauster.
3. Claims 1-7 and 11 are anticipated under 35 U.S.C. §102(b) by Rieck.

D. Claim Construction (37 C.F.R. §42.104(b)(3))

The claim terms should be given their broadest reasonable construction in view of the specification. 37 C.F.R. §42.100(b). The claim terms are generally presumed to take on their ordinary and customary meaning. The prosecution history of the ‘307 patent does not include any claim construction arguments.

Petitioner proposes the following claim construction for the purposes of this Petition only.

1. “regenerable” (Claims 1 and 11)

Claims 1 and 11 of the ‘307 patent recite a “regenerable catalyst/sorber for removing gaseous sulfur compounds from gaseous streams”. As of the July 10, 1998 filing date of the ‘307 patent, a person of ordinary skill in the art¹ would understand that the term “regenerable” denotes that the catalyst/sorber is capable of releasing (i.e., “desorbing”) a gaseous sulfur compound that had been previously absorbed by the catalyst / sorber. See Ex. 1007, Farrauto ¶16. This proposed construction comports with the ‘307 patent specification which states:

In a preferred embodiment of the present process the gaseous sulfur compound containing stream is terminated and the sorbed sulfur is desorbed from said catalyst/sorber by contacting the catalyst/sorber with a regenerating gas stream under sulfur compound desorbing conditions whereby the catalyst/sorber is regenerated for reuse in the sorbing.

Ex. 1001 at col. 2, ln. 9-15; see also col. 4, ln. 59-63 (“According to the present invention sulfur can be captured and released by the catalyst/sorber....”).

¹ As of the July 10, 1998 filing date of the ‘307 patent, a person of ordinary skill in the art of catalysis would have about 5 years of work experience regarding the chemical aspects of catalysis, and at least a Masters of Science degree in chemical engineering, mechanical engineering, or chemistry. See Ex. 1007, Farrauto ¶13.

IV. HOW CHALLENGED CLAIMS ARE UNPATENTABLE (37 C.F.R. §42.104(b)(4)-(5))

A. Claims 1-8 and 11 Are Anticipated By Joy

Claims 1-8 and 11 of the ‘307 patent are anticipated under 35 U.S.C. §102(b) by Joy (Ex. 1004). Joy discloses a regenerable catalytic composite that minimizes the H₂S emissions from automotive exhaust during regeneration operations. The catalytic composite comprises a mixture of (i) cerium oxide dispersed on a primary refractory inorganic oxide support; (ii) copper (“Cu”) or lead (“Pb”) in the form of an oxide dispersed on a secondary support consisting of zirconia, titania or cerium oxide; and (iii) a catalytic metal selected from the platinum family group. See Ex. 1004 at Abstract. The disclosed amount of Cu or Pb in the catalytic composite lies within the “up to 0.3 g/in³” range recited in independent claims 1 and 11 of the ‘307 patent. See Id. at col. 7, ln. 21-24; col. 16, ln. 53-55 (claim 15); see also Ex. 1007, Farrauto ¶23. Joy explains that the Cu and Pb should not be dispersed on an alumina (i.e., aluminum oxide) support because a reduction in activity would otherwise occur under elevated temperatures. See Ex. 1004 at col. 2, ln. 45-62.

More particularly, Joy discloses that the catalytic composite includes “a primary refractory inorganic oxide having dispersed thereon at least one of a first active component selected from the group consisting of the rare earth oxides”. Id. at col. 4, ln. 46-49. “The primary refractory inorganic oxide may be selected

from the group consisting of alumina, silica, aluminosilicates, zirconia, titania or mixtures thereof with alumina being preferred.” Id. at col. 4, ln. 58-61.

This preferred alumina support is impregnated “with a water soluble decomposable compound of the particular first active component selected from the group consisting of the rare earths.” Id. at col. 6, ln. 5-9. The Joy patent discloses the process of impregnating this primary alumina support with cerium oxide, as follows:

Thus when cerium is the desired first active component, cerium acetate can be dissolved in water and a high surface area alumina can be added to the solution. This mixture can then be dried and calcined in air at a temperature of about 400° to about 700° C. for a time of about one to three hours. ***This results in the formation of cerium oxide which is uniformly distributed throughout the alumina.***

Id. at col. 6, ln. 19-26 (emphasis added).

During the combustion of gasoline in an automobile engine, gaseous sulfur compounds, such as SO₂ and SO₃, are produced. See Id. at col. 9, ln. 24-28. “In order to completely combust the gasoline fuel, at least a stoichiometric weight amount of air is required.” Id. at col. 9, ln. 28-30. Under either stoichiometric or “lean” (i.e., having an excess amount of oxygen) conditions, the gaseous sulfur compounds are absorbed by the cerium oxide by forming sulfates of cerium such as Ce₂(SO₄)₃. See Id. at col. 9, ln. 24-47. During “fuel rich” conditions (i.e., having fuel in excess of oxygen), the catalytic composite releases the previously

absorbed gaseous sulfur compounds, partly in the form of H_2S , thereby regenerating the catalytic composite.

The resultant sulfates formed on the catalytic composite at the conditions described above are unstable under fuel rich conditions. Therefore, when the air/fuel ratio becomes fuel rich, the solid sulfates will begin to decompose with the subsequent formation of hydrogen sulfide (H_2S), which will be emitted from the exhaust at concentrations that may be noxious. The reason that the concentrations of H_2S may be excessively high is that large amounts of sulfates can be stored on the catalytic composite under periods of stoichiometric or fuel lean operations and then released during periods of fuel rich operation.

Ex. 1004 at col. 9, ln. 47-58.

“Since the odor has become more noticeable and objectionable, a need exists to minimize the hydrogen sulfide emissions from catalyst equipped automobiles. [Joy] cures this problem by providing a catalyst composite which contains a metal that forms stable metal sulfides (hereinafter referred to as a second active component) under rich conditions and therefore minimizes the release of hydrogen sulfide under rich conditions. Some of the metals which are very effective in this regard are *lead*, zinc, *copper*, nickel, and cobalt.” Ex. 1004 at col. 2, ln. 20-29 (emphasis supplied).

Joy further explains that these metals, such as copper and lead, should not be dispersed on an alumina support:

However, when these catalysts are exposed to high temperatures (>750° C.), the second active components can interact with the alumina support to form metal aluminates. These aluminates are very stable and are not active for the desired reactions. This means that the catalytic composite will lose activity upon exposure to such high temperatures, due to changes in the second active components.

Ex. 1004 at col. 2, ln. 49-57. Joy “cures this problem by depositing the second active component on a secondary refractory inorganic oxide such as zirconia, ceria, titania, etc.” Id. at col. 2, ln. 63-66.

This secondary refractory inorganic oxide support is impregnated “with a water soluble salt of the second active component.” Id. at col. 6, ln. 44-47. The Joy patent discloses the process of impregnating the secondary support with the oxide form of the selected metal, as follows:

Thus, if ceria is the desired secondary refractory oxide support and nickel is the desired second active component then the ceria may be impregnated with an aqueous solution of nickel nitrate. After the ceria is impregnated with the nickel salt, the mixture is dried, and then calcined in the air at a temperature of about 400° to about 700° C. for about one to about 3 hours. This results in a uniform distribution of ***nickel oxide*** on the cerium oxide.

Ex. 1004 at col. 6, ln. 55-63 (emphasis added). Indeed, issued claim 1 of Joy recites “a secondary support ... having dispersed thereon at least one of a second active component which is an oxide of a metal...” Id. at col. 15, ln. 61-65.

If the secondary refractory oxide support would be impregnated with the aqueous solution of copper nitrate, copper chloride or copper acetate (as expressly disclosed in Joy at col. 6, ln. 49-54), and then calcined² in the same manner, the result would be a uniform distribution of copper oxide on the secondary support. Ex. 1007, Farrauto ¶¶19-20. Likewise, if the secondary refractory oxide support would be impregnated with the aqueous solution of lead nitrate, lead chloride or lead acetate (as expressly disclosed in Joy at col. 6, ln. 49-54) and then calcined in the same manner, the result would be a uniform distribution of lead oxide on the secondary support. Ex. 1007, Farrauto ¶¶19 & 21.

Next, the primary alumina support containing cesium oxide and the secondary support containing copper oxide or lead oxide would then be mixed, via a slurry, and applied to a monolithic carrier.

In the next step of this example of the method of preparation, the appropriate amounts of the primary refractory inorganic oxide support containing a first active component is mixed with the secondary refractory oxide support containing a second active component and a slurry is prepared using the combined powders. The slurry can be prepared by means known in the art such as combining the

² Calcination is a process of heating a compound at high temperature in the presence of air or oxygen to bring about a thermal decomposition of that compound. Ex. 1007, Farrauto ¶22.

appropriate amounts of oxide powders with water and an acid such as nitric, hydrochloric, sulfuric acid, etc. The resultant slurry is milled for about 2 to 6 hours to form a usable slurry. This slurry can now be used to deposit a thin film or washcoat onto the monolithic carrier.

Ex. 1004 at col. 6, ln. 64 - col. 7, ln. 8. The slurry coated monolithic carrier is then calcined. See Id. at col. 13, ln. 9-10 (Example III); col. 13, ln. 52-53 (Example IV); col. 14, ln. 26-27 (Example V).

Lastly, the catalytic metal such as platinum and/or rhodium is applied to the coated monolithic carrier.

The final step in this example of the method of preparation comprises depositing at least one main catalytic element onto the mixed inorganic oxide layer. The main catalytic metal may be chosen from the group consisting of platinum, iridium, rhodium, palladium, ruthenium and mixtures thereof. The main catalytic metal may be incorporated into the mixed inorganic oxide support material in any suitable manner. The preferred method of dispersing the main catalytic metal onto the mixed inorganic oxide support containing a first and second active component involves the utilization of a water soluble decomposable compound of the particular main catalytic metal for impregnation of the monolithic carrier which has been coated with, for example, the cerium oxide/alumina plus nickel/ceria supports.

Ex. 1004 at col. 6, ln. 25-39. The catalytic metal-impregnated monolithic carrier is then calcined. See Id. at col. 13, ln. 20-22 (Example III); col. 13, ln. 63-65 (Example IV); col. 14, ln. 37-39 (Example V).

Joy expressly discloses that “the second active component, such as nickel or cobalt, is preferred to be present in an amount in the range of about 0.7 to about 15 g per liter of monolithic carrier volume.” Id. at col. 7, ln. 21-24. Issued claim 15 of Joy states “the metal is copper present in a concentration of about 0.7 to about 15 g per liter of carrier volume.” Id. at col. 16, ln. 53-55. Given that a liter is 61.024 in³, this stated loading range converts to 0.011 to about 0.246 grams per in³. Ex. 1007, Farrauto ¶23.

Claim charts identifying specific portions of Joy that support a showing that claims 1-8 and 11 of the ‘307 patent are anticipated by Joy are provided below:

	Claims of Campbell, et al. U. S. Patent No. 6,037,307	Joy, III et al. U.S. Patent No. 4,760,044
1	A regenerable catalyst/sorber for removing gaseous sulfur compounds from gaseous streams comprising	“During the time that the exhaust gas is stoichiometric or net oxidizing, certain components of the catalyst are capable of reacting with the gaseous sulfur compounds in the exhaust gas (SO ₂ and SO ₃) and with O ₂ in the exhaust gas to form stable sulfates. For example, alumina would be expected to form sulfates of aluminum such as Al ₂ (SO ₄) ₃ at temperatures below about 400° C. and at a gaseous sulfur oxides (SO _x) concentration of 20 ppm; cerium oxide will similarly form sulfates of cerium such as Ce ₂ (SO ₄) ₃ at the same gaseous

	Claims of Campbell, et al. U. S. Patent No. 6,037,307	Joy, III et al. U.S. Patent No. 4,760,044
		<p>SO_x level at temperatures below about 500° C.” Ex. 1004 at col. 9, ln. 35-45.</p> <p>“The resultant sulfates formed on the catalytic composite at the conditions described above are unstable under fuel rich conditions. Therefore, when the air/fuel ratio becomes fuel rich, the solid sulfates will begin to decompose with the subsequent formation of hydrogen sulfide (H₂S), which will be emitted from the exhaust at concentrations that may be noxious.” Ex. 1004 at col. 9, ln. 48-54 (describing regeneration of catalyst/sorber).</p> <p>“[T]hese metals will scavenge any hydrogen sulfide that is released by the decomposition of sulfates of the primary support or first active component or other sources of H₂S. Therefore, release of hydrogen sulfide is minimized.” Ex. 1004 at col. 10, ln. 44-48.</p>
	a noble metal catalyst component,	<p>“The main catalytic metal may be chosen from the group consisting of platinum, iridium, rhodium, palladium, ruthenium and mixtures thereof. The main catalytic metal may be incorporated into the mixed inorganic oxide support material in any suitable manner.” Ex. 1004 at col. 7, ln. 27-32.</p>
	a metal oxide sorber component selected from Ti, Zr, Hf, Ce, Al, Si or mixtures thereof and	<p>“Thus when cerium is the desired first active component, cerium acetate can be dissolved in water and a high surface area alumina can be added to the solution. This mixture can then be dried and</p>

	Claims of Campbell, et al. U. S. Patent No. 6,037,307	Joy, III et al. U.S. Patent No. 4,760,044
		calcined in air at a temperature of about 400° to about 700° C. for a time of about one to three hours. This results in the formation of cerium oxide which is uniformly distributed throughout the alumina.” Ex. 1004 at col. 6, ln. 19-26.
	up to 0.3 g/in ³ of a modifier component consisting of an oxide of Ag, Cu, Bi, Sb, Sn, As, In, Pb, Au or mixtures thereof.	<p>“[A] secondary support ... having dispersed thereon at least one of a second active component which is an oxide of a metal, the metal selected from the group consisting of metals which form a stable sulfide under rich fuel conditions....” Ex. 1004 at col. 15, ln. 61-67 (claim 1). “Some of the metals which are very effective in this regard are <i>lead</i>, zinc, <i>copper</i>, nickel, and cobalt.” Ex. 1004 at col. 2, ln. 28-29 (emphasis added); <u>see also</u> Ex. 1004 at col. 6, ln. 44-63 (listing water soluble salts of copper and lead); Ex. 1007, Farrauto ¶¶19-21.</p> <p>“[T]he second active component ... is preferred to be present in an amount in the range of about 0.7 to about 15 g per liter [0.011 to about 0.246 grams per in³] of monolithic carrier volume.” Ex. 1004 at col. 7, ln. 21-24; Ex. 1004 at col. 16, ln. 53-55 (claim 15) (“the metal is copper present in a concentration of about 0.7 to about 15 g per liter of carrier volume.”); Ex. 1007, Farrauto ¶23 (converting “0.7 to about 15” grams per liter to “0.011 to about 0.246” grams per cubic inch).</p>
2	The catalyst/sorber according to claim 1 wherein said noble	“The main catalytic metal may be chosen from the group consisting of <i>platinum</i> ,

	Claims of Campbell, et al. U. S. Patent No. 6,037,307	Joy, III et al. U.S. Patent No. 4,760,044
	metal component is Pt, Pd, Rh, Ru or mixtures thereof.	iridium, <i>rhodium, palladium, ruthenium</i> and mixtures thereof. The main catalytic metal may be incorporated into the mixed inorganic oxide support material in any suitable manner.” Ex. 1004 at col. 7, ln. 27-32 (emphasis added).
3	The catalyst/sorber according to claim 2 wherein the noble metal component is Pt.	“The main catalytic metal may be chosen from the group consisting of <i>platinum</i> , iridium, rhodium, palladium, ruthenium and mixtures thereof. The main catalytic metal may be incorporated into the mixed inorganic oxide support material in any suitable manner.” Ex. 1004 at col. 7, ln. 27-32 (emphasis added).
4	The catalyst/sorber according to claim 1 wherein the metal oxide sorber component is an oxide of Ti, Zr, Hf, Ce or mixtures thereof.	“Thus when cerium is the desired first active component, cerium acetate can be dissolved in water and a high surface area alumina can be added to the solution. This mixture can then be dried and calcined in air at a temperature of about 400° to about 700° C. for a time of about one to three hours. This results in the formation of <i>cerium oxide</i> which is uniformly distributed throughout the alumina.” Ex. 1004 at col. 6, ln. 19-26 (emphasis added).
5	The catalyst/sorber according to claim 2 wherein the metal oxide sorber component is an oxide of Ti, Zr, Hf, Ce or mixtures thereof.	“Thus when cerium is the desired first active component, cerium acetate can be dissolved in water and a high surface area alumina can be added to the solution. This mixture can then be dried and

	Claims of Campbell, et al. U. S. Patent No. 6,037,307	Joy, III et al. U.S. Patent No. 4,760,044
		calcined in air at a temperature of about 400° to about 700° C. for a time of about one to three hours. This results in the formation of <i>cerium oxide</i> which is uniformly distributed throughout the alumina.” Ex. 1004 at col. 6, ln. 19-26 (emphasis added).

6	The catalyst/sorber according to claim 1 wherein the modifier component is an oxide of Cu, Ag, Bi or mixtures thereof.	<p>“[A] secondary support ... having dispersed thereon at least one of a second active component which is an oxide of a metal, the metal selected from the group consisting of metals which form a stable sulfide under rich fuel conditions...” Ex. 1004 at col. 15, ln. 61-67 (claim 1). “Some of the metals which are very effective in this regard are lead, zinc, <i>copper</i>, nickel, and cobalt.” Ex. 1004 at col. 2, ln. 28-29 (emphasis added); <u>see also</u> Ex. 1004 at col. 6, ln. 44-63 (listing water soluble salts of copper); Ex. 1007, Farrauto ¶¶19-20.</p>
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7	The catalyst/sorber according to claim 2 wherein the modifier component is an oxide of Cu, Ag, Bi or mixtures thereof.	<p>“[A] secondary support ... having dispersed thereon at least one of a second active component which is an oxide of a metal, the metal selected from the group consisting of metals which form a stable sulfide under rich fuel conditions...” Ex. 1004 at col. 15, ln. 61-67 (claim 1). “Some of the metals which are very effective in this regard are lead, zinc, <i>copper</i>, nickel, and cobalt.” Ex. 1004 at col. 2, ln. 28-29 (emphasis added); <u>see also</u> Ex. 1004 at col. 6, ln. 44-63 (listing water soluble salts of copper); Ex. 1007, Farrauto ¶¶19-20.</p>
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	Claims of Campbell, et al. U. S. Patent No. 6,037,307	Joy, III et al. U.S. Patent No. 4,760,044
8	The catalyst/sorber according to claim 1 wherein the modifier component is Cu oxide.	<p>“[A] secondary support ... having dispersed thereon at least one of a second active component which is an oxide of a metal, the metal selected from the group consisting of metals which form a stable sulfide under rich fuel conditions....” Ex. 1004 at col. 15, ln. 61-67 (claim 1). “Some of the metals which are very effective in this regard are lead, zinc, <i>copper</i>, nickel, and cobalt.” Ex. 1004 at col. 2, ln. 28-29 (emphasis added); <u>see also</u> Ex. 1004 at col. 6, ln. 44-63 (listing water soluble salts of copper); Ex. 1007, Farrauto ¶¶19-20.</p>
11	A catalytic structure comprising a monolith carrier and	<p>“[T]he appropriate amounts of the primary refractory inorganic oxide support containing a first active component is mixed with the secondary refractory oxide support containing a second active component and a slurry is prepared using the combined powders...This slurry can now be used to deposit a thin film or washcoat onto the <i>monolithic carrier</i>.” Ex. 1004 at col. 6, ln. 64 - col. 7, ln. 8 (emphasis added).</p> <p>“The preferred method of dispersing the main catalytic metal onto the mixed inorganic oxide support containing a first and second active component involves the utilization of a water soluble decomposable compound of the particular main catalytic metal for impregnation of the <i>monolithic carrier</i> which has been coated with, for</p>

	Claims of Campbell, et al. U. S. Patent No. 6,037,307	Joy, III et al. U.S. Patent No. 4,760,044
		<p>example, the cerium oxide/alumina plus nickel/ceria supports.” Ex. 1004 at col. 7, ln. 32-39 (emphasis added).</p>
	<p>a regenerable catalyst/sorber for removing gaseous sulfur compounds from gaseous streams comprising</p>	<p>“During the time that the exhaust gas is stoichiometric or net oxidizing, certain components of the catalyst are capable of reacting with the gaseous sulfur compounds in the exhaust gas (SO_2 and SO_3) and with O_2 in the exhaust gas to form stable sulfates. For example, alumina would be expected to form sulfates of aluminum such as $\text{Al}_2(\text{SO}_4)_3$ at temperatures below about 400°C. and at a gaseous sulfur oxides (SO_x) concentration of 20 ppm; cerium oxide will similarly form sulfates of cerium such as $\text{Ce}_2(\text{SO}_4)_3$ at the same gaseous SO_x level at temperatures below about 500°C.” Ex. 1004 at col. 9, ln. 35-45.</p> <p>“The resultant sulfates formed on the catalytic composite at the conditions described above are unstable under fuel rich conditions. Therefore, when the air/fuel ratio becomes fuel rich, the solid sulfates will begin to decompose with the subsequent formation of hydrogen sulfide (H_2S), which will be emitted from the exhaust at concentrations that may be noxious.” Ex. 1004 at col. 9, ln. 48-54 (describing regeneration of catalyst/sorber).</p> <p>“[T]hese metals will scavenge any hydrogen sulfide that is released by the decomposition of sulfates of the primary support or first active component or other</p>

	Claims of Campbell, et al. U. S. Patent No. 6,037,307	Joy, III et al. U.S. Patent No. 4,760,044
		sources of H ₂ S. Therefore, release of hydrogen sulfide is minimized.” Ex. 1004 at col. 10, ln. 44-48.
	a noble metal catalyst component,	“The main catalytic metal may be chosen from the group consisting of platinum, iridium, rhodium, palladium, ruthenium and mixtures thereof. The main catalytic metal may be incorporated into the mixed inorganic oxide support material in any suitable manner.” Ex. 1004 at col. 7, ln. 27-32.
	a metal oxide sorber component selected from Ti, Zr, Hf, Ce, Al, Si or mixtures thereof and	“Thus when cerium is the desired first active component, cerium acetate can be dissolved in water and a high surface area alumina can be added to the solution. This mixture can then be dried and calcined in air at a temperature of about 400° to about 700° C. for a time of about one to three hours. This results in the formation of cerium oxide which is uniformly distributed throughout the alumina.” Ex. 1004 at col. 6, ln. 19-26.
	up to 0.3 g/in ³ of a modifier component consisting of an oxide of Ag, Cu, Bi, Sb, Sn, As, In, Pb, Au or mixtures thereof deposited on said carrier.	“[A] secondary support ... having dispersed thereon at least one of a second active component which is an oxide of a metal, the metal selected from the group consisting of metals which form a stable sulfide under rich fuel conditions.” Ex. 1004 at col. 15, ln. 61-67 (claim 1). “Some of the metals which are very effective in this regard are <i>lead</i> , zinc, <i>copper</i> , nickel, and cobalt.” Ex. 1004 at col. 2, ln. 28-29 (emphasis added); <u>see also</u> Ex. 1004 at col. 6, ln. 44-63 (listing water soluble salts of copper and

	Claims of Campbell, et al. U. S. Patent No. 6,037,307	Joy, III et al. U.S. Patent No. 4,760,044
		lead); Ex. 1007, Farrauto ¶¶19-21. “[T]he second active component ... is preferred to be present in an amount in the range of about 0.7 to about 15 g per liter [0.011 to about 0.246 grams per in ³] of monolithic carrier volume.” Ex. 1004 at col. 7, ln. 21-24; Ex. 1004 at col. 16, ln. 53-55 (claim 15) (“the metal is copper present in a concentration of about 0.7 to about 15g per liter of carrier volume.”); Ex. 1007, Farrauto ¶23 (converting “0.7 to about 15” grams per liter to “0.011 to about 0.246” grams per cubic inch).

B. Claims 1-8 and 11 Are Anticipated By Tauster

Claims 1-8 and 11 of the ‘307 patent are anticipated under 35 U.S.C. §102(b) by Tauster (Ex. 1005). Tauster discloses a catalyst system that suppresses H₂S emissions from automotive exhaust during regeneration operations. See Ex. 1005 at col. 1, ln. 6-30. Tauster observes that “with relatively small amounts of copper oxide, almost total suppression of H₂S can be obtained”. Id. at col. 1, ln. 55-56. Similar to Joy (Ex. 1004), Tauster recognizes that “there is a potential for copper oxide to reduce the activity of the three-way catalyst if dispersed therewith.” Ex. 1005 at col. 1, ln. 62-64. Accordingly, Tauster’s catalyst system comprises a single refractory monolithic substrate having a first section and a

second section that is downstream of the first section relative to the exhaust flow. See Ex. 1005 at col. 1, ln. 64-68 & col. 2, ln. 30-32.

A three-way catalyst, which is capable of handling hydrocarbons, carbon monoxide and nitrogen oxides, is dispersed on the first section of the refractory monolithic substrate. See Ex. 1005 at col. 1, ln. 6-12 & col. 2, ln. 9-17. The three-way catalyst comprises a catalyst metal and bulk ceria (i.e., cerium oxide). See Id. at col. 2, ln. 9-17 & 48-51. In an alternative embodiment, “CuO may be applied *throughout* the three way catalyst in carefully controlled amounts of from about 0.01 to about 0.04 [grams per in³ of monolith] without unduly degrading the three way activity but it is preferred to prevent deterioration of three way activity by confining the CuO to a downstream portion of the monolith.” Id. at Col. 4, ln. 58-63 (emphasis supplied). “Amounts of as little as about 0.005 grams or 0.25 m-moles of H₂S suppressing materials per cu in of monolith can be effective in suppressing formation of H₂S.” Id. at col. 4, ln. 48-51.

Tauster prepared a series of exemplary three way catalyst (“TWC”) cores referred to as TWC-II. See Ex. 1005 at col. 5, ln. 40 - col. 6, ln. 7. In preparing the TWC-II cores, platinum and ceria were first applied to a monolith. See col. 5, ln. 41-55; Ex. 1007, Farrauto ¶26. Ceria is, in fact, cerium oxide. Ex. 1007, Farrauto ¶27. Next, rhodium was applied to that previously coated monolith. See Ex. 1005 at col. 5, ln. 56 - col. 6, ln. 7.

During “fuel-lean” conditions (i.e., having an excess amount of oxygen), the gaseous sulfur compounds are absorbed by the catalyst.

The Storage Test for H₂S was carried out by exposing the catalyst to the exhaust of an engine. The latter was operated under fuel-lean (i.e., oxidizing) conditions for approximately 30 minutes, during which time sulfur was stored, presumably as sulfate radicals, on the catalyst surface.

Ex. 1005 at Col. 6, ln. 34-39. During “fuel-rich” conditions (i.e., having fuel in excess of oxygen), the catalyst releases the previously absorbed sulfur compounds, partly in the form of H₂S, thereby regenerating the catalyst.

The engine was then abruptly switched to fuel-rich (i.e., reducing) conditions, which causes a significant fraction of the stored sulfur to be emitted as H₂S.

Ex. 1005 at Col. 6, ln. 39-42.

CuO was applied to samples of the TWC-II cores by immersing the cores into a solution of Cu(NO₃)₂. See Id. at col. 9, ln. 44-58. “In some instances the entire core was immersed while in others CuO was added only to the downstream end.” Id. at Col. 9, ln. 56-58. Table IX, which is reproduced below, shows data pertaining to the CuO-promoted TWC-II samples (col. 10, ln. 32-33):

TABLE IX

PREPARATION OF CuO - PROMOTED TWC-II CORES: FIRST SET				
CORE #	SOLUTION CONCENTRATION*	WET-WEIGHT GAIN (gm)	CuO LOADING gm/in ³	PERCENT OF CORE PROMOTED WITH CuO
1	0	9.9	0	—
2	6.26	10.0	0.020	100
3	12.78	9.9	0.041	100
4	12.78	2.0	0.041	20
5	6.33	2.8	0.020	28
6	25.57	11.3	0.093	100
7	26.10	3.4	0.095	30
8	50.61	2.9	0.188 ⁺	25

*Units are gm Cu(NO₃)₂ 2.5 H₂O per 200 gm solution

⁺It is assumed that the wet-weight gain for complete immersion in this solution would be 11.5 gm. (based on density measurement on slightly less concentrated solution).

See Ex. 1005 at p. 8. “Cores 4, 5, 7 and 8 contained various loadings of CuO on their downstream ends, ranging from 20 to 30% of their length.” *Id.* at Col. 10, ln. 49-51.

These CuO-promoted TWC-II samples were subjected to testing to determine their effectiveness in suppressing H₂S during “fuel-rich” operations (col. 6, ln. 33-46 & col. 10, ln. 39-42), and the results are presented in Table XI which is reproduced below:

TABLE XI

STORAGE TESTING (TEST PROCEDURE I) WITH CuO - PROMOTED AND UNPROMOTED TWC-II CORES		
CORE #	CuO PROMOTION, gm/in ³	TRANSITION-H ₂ S, ppm
1	None	>200
2	0.020 on entire core	20
3	0.041 on entire core	0
4	0.041 on 20% of core	25
5	0.020 on 28% of core	60
6	0.093 on entire core	0
7	0.095 on 30% of core	0
8	0.19 on 25% of core	0

Ex. 1005 at col. 15, ln. 11-23. “Unpromoted TWC-II proved to be a prolific H₂S emitter, scoring greater than 200 ppm. For those samples in which CuO was added

to the entire core (2, 3, and 6) it is seen that a CuO loading of only 0.020 gm/in³ reduced transition - H₂S more than 90%, to 20 ppm.” Id. at Col. 10, ln. 42-47. A similar CuO loading of 0.019 gm/in³ over the entire length was shown to have no adverse effect on TWC activity. See Id. at col. 11, ln. 20-36; see also col. 4, ln. 58-61 (“CuO may be applied throughout the three way catalyst in carefully controlled amounts of from about 0.01 to about 0.04 [gm/in³] without unduly degrading the three way activity....”).

Claim charts identifying specific portions of Tauster that support a showing that claims 1-8 and 11 of the ‘307 patent are anticipated by Tauster are provided below.

	Claims of Campbell, et al. U. S. Patent No. 6,037,307	Tauster U.S. Patent No. 4,939,113
1	A regenerable catalyst/sorber for removing gaseous sulfur compounds from gaseous streams comprising	“The Storage Test for H ₂ S was carried out by exposing the catalyst to the exhaust of an engine. The latter was operated under fuel-lean (i.e., oxidizing) conditions for approximately 30 minutes, during which time sulfur was stored, presumably as sulfate radicals, on the catalyst surface. The engine was then abruptly switched to fuel-rich (i.e., reducing) conditions, which causes a significant fraction of the stored sulfur to be emitted as H ₂ S.” Ex. 1005 at col. 6, ln. 34-42 (describing regeneration of catalyst). “For those samples in which CuO was added to the entire core (2, 3, and 6) it is seen that a CuO loading of only 0.020 gm/in ³ reduced transition-H ₂ S more than 90%, to 20 ppm.” Ex. 1005 at col. 10, ln. 43-47.

	Claims of Campbell, et al. U. S. Patent No. 6,037,307	Tauster U.S. Patent No. 4,939,113
	a noble metal catalyst component,	“In general, these catalysts comprise platinum and rhodium dispersed on support particles of a high surface area ceramic oxide, typically gamma aluminum oxide borne on a refractory substrate such as beads, pellets, or a monolithic substrate which may be either a refractory oxide or a high temperature oxidation resistant metal such as Fecralloy or the like.” Ex. 1005 at col. 3, ln. 21-27. In the exemplary TWC-II core, alumina was impregnated with platinum and rhodium, and then applied to a monolith. Ex. 1005 at col. 5, ln. 39 - col. 6, ln. 7; Ex. 1007, Farrauto ¶26.
	a metal oxide sorber component selected from Ti, Zr, Hf, Ce, Al, Si or mixtures thereof and	“In another preferred embodiment, bulk ceria dispersed on the first section of refractory monolithic substrate will be additionally included in the three way catalyst means.” Ex. 1005 at col. 2, ln. 47-51. In the exemplary TWC-II core, alumina was impregnated with ceria and then applied to the monolith. Ex. 1005 at col. 5, ln. 39-55; <u>see also</u> Ex. 1007, Farrauto ¶¶26-27.
	up to 0.3 g/in ³ of a modifier component consisting of an oxide of Ag, Cu, Bi, Sb, Sn, As, In, Pb, Au or mixtures thereof.	CuO was applied to samples of the TWC-II cores by immersing the cores into a solution of Cu(NO ₃) ₂ . <u>See</u> Ex. 1005 at col. 9, ln. 44-58. “In some instances the entire core was immersed while in others CuO was added only to the downstream end.” Ex. 1005 at col. 9, ln. 56-58. “For those samples in which CuO was added to the entire core (2, 3, and 6) it is seen that a CuO loading of

	Claims of Campbell, et al. U. S. Patent No. 6,037,307	Tauster U.S. Patent No. 4,939,113
		only 0.020 gm/in ³ reduced transition-H ₂ S more than 90%, to 20 ppm.” Ex. 1005 at col. 10, ln. 43-47; <u>see also</u> <u>id.</u> at p. 8 (Table XI).
2	The catalyst/sorber according to claim 1 wherein said noble metal component is Pt, Pd, Rh, Ru or mixtures thereof.	In the exemplary TWC-II core, alumina was impregnated with platinum and rhodium, and then applied to a monolith. Ex. 1005 at col. 5, ln. 39 - col. 6, ln. 7; Ex. 1007, Farrauto ¶26.
3	The catalyst/sorber according to claim 2 wherein the noble metal component is Pt.	In the exemplary TWC-II core, alumina was impregnated with platinum and rhodium, and then applied to a monolith. Ex. 1005 at col. 5, ln. 39 - col. 6, ln. 7; Ex. 1007, Farrauto ¶26.
4	The catalyst/sorber according to claim 1 wherein the metal oxide sorber component is an oxide of Ti, Zr, Hf, Ce or mixtures thereof.	“In another preferred embodiment, bulk ceria dispersed on the first section of refractory monolithic substrate will be additionally included in the three way catalyst means.” Ex. 1005 at col. 2, ln. 47-51. In the exemplary TWC-II core, alumina was impregnated with ceria and then applied to the monolith. Ex. 1005 at col. 5, ln. 39-55; <u>see also</u> Ex. 1007, Farrauto ¶¶26-27.
5	The catalyst/sorber according to claim 2 wherein the metal oxide sorber component is an oxide of Ti, Zr, Hf, Ce or mixtures thereof.	“In another preferred embodiment, bulk ceria dispersed on the first section of refractory monolithic substrate will be additionally included in the three way catalyst means.” Ex. 1005 at col. 2, ln. 47-51. In the exemplary TWC-II core, alumina was impregnated with ceria and

	Claims of Campbell, et al. U. S. Patent No. 6,037,307	Tauster U.S. Patent No. 4,939,113
		then applied to the monolith. Ex. 1005 at col. 5, ln. 39-55; <u>see also</u> Ex. 1007, Farrauto ¶¶26-27.

6	The catalyst/sorber according to claim 1 wherein the modifier component is an oxide of Cu, Ag, Bi or mixtures thereof.	CuO was applied to samples of the TWC-II cores by immersing the cores into a solution of Cu(NO ₃) ₂ . <u>See</u> Ex. 1005 at col. 9, ln. 44-58. “In some instances the entire core was immersed while in others CuO was added only to the downstream end.” Ex. 1005 at col. 9, ln. 56-58. “For those samples in which CuO was added to the entire core (2, 3, and 6) it is seen that a CuO loading of only 0.020 gm/in ³ reduced transition-H ₂ S more than 90%, to 20 ppm.” Ex. 1005 at col. 10, ln. 43-47; <u>see also id.</u> at p. 8 (Table XI).
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7	The catalyst/sorber according to claim 2 wherein the modifier component is an oxide of Cu, Ag, Bi or mixtures thereof.	CuO was applied to samples of the TWC-II cores by immersing the cores into a solution of Cu(NO ₃) ₂ . <u>See</u> Ex. 1005 at col. 9, ln. 44-58. “In some instances the entire core was immersed while in others CuO was added only to the downstream end.” Ex. 1005 at col. 9, ln. 56-58. “For those samples in which CuO was added to the entire core (2, 3, and 6) it is seen that a CuO loading of only 0.020 gm/in ³ reduced transition-H ₂ S more than 90%, to 20 ppm.” Ex. 1005 at col. 10, ln. 43-47; <u>see also id.</u> at p. 8 (Table XI).
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8	The catalyst/sorber according to claim 1 wherein the modifier	CuO was applied to samples of the TWC-II cores by immersing the cores
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	Claims of Campbell, et al. U. S. Patent No. 6,037,307	Tauster U.S. Patent No. 4,939,113
	component is Cu oxide.	into a solution of $\text{Cu}(\text{NO}_3)_2$. See Ex. 1005 at col. 9, ln. 44-58. “In some instances the entire core was immersed while in others CuO was added only to the downstream end.” Ex. 1005 at col. 9, ln. 56-58. “For those samples in which CuO was added to the entire core (2, 3, and 6) it is seen that a CuO loading of only 0.020 gm/in^3 reduced transition- H_2S more than 90%, to 20 ppm.” Ex. 1005 at col. 10, ln. 43-47; see also <i>id.</i> at p. 8 (Table XI).
11	A catalytic structure comprising a monolith carrier and	“In general, these catalysts comprise platinum and rhodium dispersed on support particles of a high surface area ceramic oxide, typically gamma aluminum oxide borne on a refractory substrate such as beads, pellets, or <i>a monolithic substrate</i> which may be either a refractory oxide or a high temperature oxidation resistant metal such as Fecralloy or the like.” Ex. 1005 at col. 3, ln. 21-27 (emphasis added).
	a regenerable catalyst/sorber for removing gaseous sulfur compounds from gaseous streams comprising	“The Storage Test for H_2S was carried out by exposing the catalyst to the exhaust of an engine. The latter was operated under fuel-lean (i.e., oxidizing) conditions for approximately 30 minutes, during which time sulfur was stored, presumably as sulfate radicals, on the catalyst surface. The engine was then abruptly switched to fuel-rich (i.e., reducing) conditions, which causes a significant fraction of the stored sulfur to be emitted as H_2S .” Ex. 1005 at col. 6, ln. 34-42 (describing regeneration of catalyst). “For those samples in which

	Claims of Campbell, et al. U. S. Patent No. 6,037,307	Tauster U.S. Patent No. 4,939,113
		CuO was added to the entire core (2, 3, and 6) it is seen that a CuO loading of only 0.020 gm/in ³ reduced transition-H ₂ S more than 90%, to 20 ppm.” Ex. 1005 at col. 10, ln. 43-47.
	a noble metal catalyst component,	In the exemplary TWC-II core, alumina was impregnated with platinum and rhodium, and then applied to the monolith. Ex. 1005 at col. 5, ln. 39 - col. 6, ln. 7; Ex. 1007, Farrauto ¶26.
	a metal oxide sorber component selected from Ti, Zr, Hf, Ce, Al, Si or mixtures thereof and	“In another preferred embodiment, bulk ceria dispersed on the first section of refractory monolithic substrate will be additionally included in the three way catalyst means.” Ex. 1005 at col. 2, ln. 47-51. In the exemplary TWC-II core, alumina was impregnated with ceria and then applied to the monolith. Ex. 1005 at col. 5, ln. 39-55; <u>see also</u> Ex. 1007, Farrauto ¶¶26-27.
	up to 0.3 g/in ³ of a modifier component consisting of an oxide of Ag, Cu, Bi, Sb, Sn, As, In, Pb, Au or mixtures thereof deposited on said carrier.	CuO was applied to samples of the TWC-II cores by immersing the cores into a solution of Cu(NO ₃) ₂ . <u>See</u> Ex. 1005 at col. 9, ln. 44-58. “In some instances the entire core was immersed while in others CuO was added only to the downstream end.” Ex. 1005 at col. 9, ln. 56-58. “For those samples in which CuO was added to the entire core (2, 3, and 6) it is seen that a CuO loading of only 0.020 gm/in ³ reduced transition-H ₂ S more than 90%, to 20 ppm.” Ex. 1005 at col. 10, ln. 43-47; <u>see also id.</u> at p. 8 (Table XI).

C. Claims 1-7 and 11 Are Anticipated By Rieck

Claims 1-7 and 11 of the '307 patent are anticipated under 35 U.S.C. §102(b) by Rieck (Ex. 1006). Rieck discloses a three-way catalyst that reduces hydrogen sulfide emissions from automotive exhaust, by including a copper ferrite (i.e., CuFe_2O_4) additive to the three-way catalyst. Ex. 1006 at p. 3; Ex. 1007, Farrauto ¶29.

The three-way catalyst comprises catalytic platinum (Pt) and rhodium (Rh) metals and the rare earth cerium oxide (CeO_2) compound dispersed on a γ -alumina carrier borne by a monolith substrate, along with the copper ferrite additive.

CATALYST PREPARATION - Pt/Rh three-way catalysts were prepared by washcoating cordierite and metal monolith substrates (62 and 50 cells/cm², respectively) with a lanthana-stabilized, γ -alumina-based washcoat. The noble metal and rare earth contents of the coated monoliths are given in Table 1. The catalysts in Table 1 include base case Pt/Rh washcoats and Pt/Rh washcoats incorporating Ni and ferrite additives. *The Ni and ferrite additives were added to the washcoat as bulk oxides.* The levels of these additives in the coated monoliths are also included in Table 1. The catalysts will be referred to according to the sample numbers given in Table 2.

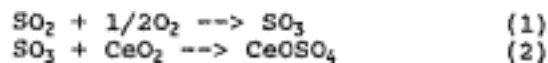
Ex. 1006 at p. 4 (emphasis added). Table 1 of Rieck, which is reproduced below, shows the loading amounts for each component of the three-way catalyst.

Table 1: Loadings of Catalyst Components ^(a)				
Substrate	Pt	Rh	Rare Earths ^(b)	H ₂ S Additives
M-metal	0.587	0.118	34.8	6.2
C-cordierite	1.47	0.294	17.7	14.4
C*-cordierite	1.47	0.294	34.8	14.4

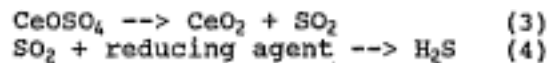
(a) Loadings are given in g/liter.
(b) Rare earth loadings are sum of La₂O₃ and CeO₂.

Ex. 1006 at p. 4.

“The mechanism for the H₂S emissions associated with odor production is due to the storage and release of sulfur on the surface of three-way catalysts,” more particularly by the cerium oxide (CeO₂) component. Ex. 1006 at p. 3. Rieck discloses that “[W]hile the engine runs under lean conditions (i.e., more oxygen than fuel), sulfur can be stored on the catalyst surface by the following mechanism.”



Ex. 1006 at p. 3. “Following a change in exhaust composition to a rich stoichiometry (i.e., more fuel than oxygen), the stored sulfur can be reduced to H₂S by the following reactions.”



Id. This removal of the stored sulfur from the three-way catalyst during “rich” operations regenerates the three-way catalyst. See Ex. 1007, Farrauto ¶¶31-32.

Table 2 of Rieck shows that in sample three-way catalyst C6, the H₂S additive is CuFe₂O₄. Ex. 1006 at p. 4. Copper ferrite, CuFe₂O₄, is “an oxide of Cu” as recited in claims 1 and 11 of the ‘307 patent because this Cu-based additive

is a binary oxide. See Ex. 1007, Farrauto ¶30. Table 1 of Rieck shows that in sample C6, which has a cordierite substrate, the loading of the CuFe_2O_4 additive is 14.4 g/liter. Ex. 1006 at p. 4. Given that a liter is 61.024 in^3 , this stated loading converts to 0.236 grams per in^3 . Ex. 1007, Farrauto ¶33.

The C6 sample containing the CuFe_2O_4 additive achieved significant reductions in H_2S emissions compared to a three-way catalyst with no additive (i.e., the C1 sample).

The CoFe_2O_4 (C2) and CuFe_2O_4 (C6) additive systems exhibit H_2S emission levels similar to that of the NiO-containing catalyst. Both CoFe_2O_4 - and CuFe_2O_4 -containing washcoats produce significant reductions in peak H_2S emissions versus the base case three-way catalyst.

Ex. 1006 at p. 6. Figure 3 of Rieck, which is reproduced below, compares, inter alia, H_2S emissions achieved with the C6 sample containing CuFe_2O_4 and the base case sample three-way catalyst C1.

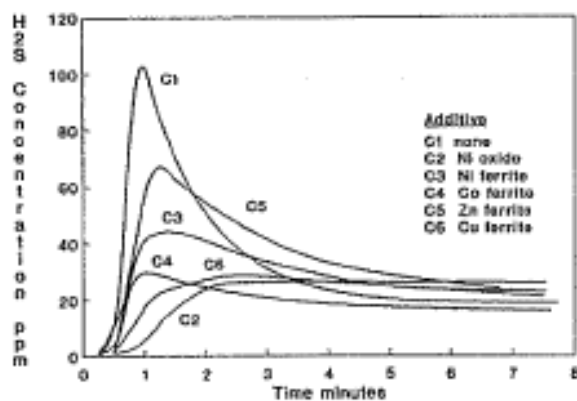


Figure 3: Effect of additives on hydrogen sulfide emissions; cordierite substrate.

Ex. 1006 at p. 6.

Claim charts identifying specific portions of Rieck that support a showing that claims 1-7 and 11 of the 307 patent are anticipated by Rieck follow:

	Claims of Campbell, et al. U. S. Patent No. 6,037,307	Rieck, J.S., et al. SAE Paper 892095 (1989)
1	A regenerable catalyst/sorber for removing gaseous sulfur compounds from gaseous streams comprising	“While the engine runs under lean conditions, sulfur can be stored on the catalyst surface.... Following a change in exhaust composition to a rich stoichiometry, the stored sulfur can be reduced to H ₂ S....” Ex. 1006 at p. 3 (describing regeneration of catalyst).
	a noble metal catalyst component,	<i>“Pt/Rh three-way catalysts</i> were prepared by washcoating cordierite and metal monolith substrates (62 and 50 cells/cm ² , respectively) with a lanthana-stabilized, γ-alumina-based washcoat. The noble metal and rare earth contents of the coated monoliths are given in Table 1. The catalysts in Table 1 include base case Pt/Rh washcoats and Pt/Rh washcoats incorporating Ni and ferrite additives. The Ni and ferrite additives were added to the washcoat as bulk oxides. The levels of these additives in the coated monoliths are also included in Table 1.” Ex. 1006 at p. 4 (emphasis added)
	a metal oxide sorber component selected from Ti, Zr, Hf, Ce, Al, Si or mixtures thereof and	“Pt/Rh three-way catalysts were prepared by washcoating cordierite and metal monolith substrates (62 and 50 cells/cm ² , respectively) with a lanthana-stabilized, γ-alumina-based washcoat. The noble metal and <i>rare earth contents of the coated monoliths are given in Table 1.</i> The catalysts in Table 1 include base case

	Claims of Campbell, et al. U. S. Patent No. 6,037,307	Rieck, J.S., et al. SAE Paper 892095 (1989)
		<p>Pt/Rh washcoats and Pt/Rh washcoats incorporating Ni and ferrite additives. The Ni and ferrite additives were added to the washcoat as bulk oxides. The levels of these additives in the coated monoliths are also included in Table 1.” Ex. 1006 at p. 4 (emphasis added).</p> <p>Table 1 shows that the rare earth contents include CeO₂. Ex. 1006 at p. 4 (Table 1, note (b)).</p>
	up to 0.3 g/in ³ of a modifier component consisting of an oxide of Ag, Cu, Bi, Sb, Sn, As, In, Pb, Au or mixtures thereof.	<p>“Pt/Rh three-way catalysts were prepared by washcoating cordierite and metal monolith substrates (62 and 50 cells/cm², respectively) with a lanthana-stabilized, γ-alumina-based washcoat. The noble metal and rare earth contents of the coated monoliths are given in Table 1. The catalysts in Table 1 include base case Pt/Rh washcoats and Pt/Rh washcoats incorporating Ni and <i>ferrite additives</i>. <i>The Ni and ferrite additives were added to the washcoat as bulk oxides.</i> The levels of these additives in the coated monoliths are also included in Table 1.” Ex. 1006 at p. 4 (emphasis added).</p> <p>Tables 1 and 2 show that sample catalyst C6 has a CuFe₂O₄ additive in the amount of 14.4 g/liter [0.236 gm/in³]. Ex. 1006 at p. 4; <u>see also</u> Ex. 1007, Farrauto ¶33 (converting “grams per liter” to “grams per cubic inch”).</p>
2	The catalyst/sorber according to claim 1 wherein said noble	“Pt/Rh three-way catalysts were prepared....” Ex. 1006 at p. 4; <u>see also</u>

	Claims of Campbell, et al. U. S. Patent No. 6,037,307	Rieck, J.S., et al. SAE Paper 892095 (1989)
	metal component is Pt, Pd, Rh, Ru or mixtures thereof.	Table 1.
3	The catalyst/sorber according to claim 2 wherein the noble metal component is Pt.	“Pt/Rh three-way catalysts were prepared....” Ex. 1006 at p. 4; <u>see also</u> Table 1.
4	The catalyst/sorber according to claim 1 wherein the metal oxide sorber component is an oxide of Ti, Zr, Hf, Ce or mixtures thereof.	The metal oxide sorber for sample catalyst C6 is CeO ₂ . Ex. 1006 at p. 4 (Table 1, note (b)).
5	The catalyst/sorber according to claim 2 wherein the metal oxide sorber component is an oxide of Ti, Zr, Hf, Ce or mixtures thereof.	The metal oxide sorber for sample catalyst C6 is CeO ₂ . Ex. 1006 at p. 4 (Table 1, note (b)).
6	The catalyst/sorber according to claim 1 wherein the modifier component is an oxide of Cu, Ag, Bi or mixtures thereof.	The H ₂ S additive for sample catalyst C6 is CuFe ₂ O ₄ . Ex. 1006 at p. 4 (Table 2).
7	The catalyst/sorber according to claim 2 wherein the modifier component is an oxide of Cu, Ag, Bi or mixtures thereof.	The H ₂ S additive for sample catalyst C6 is CuFe ₂ O ₄ . Ex. 1006 at p. 4 (Table 2).
11	A catalytic structure comprising a monolith carrier and	<i>“Pt/Rh three-way catalysts were prepared by washcoating cordierite and metal monolith substrates (62 and 50 cells/cm², respectively) with a lanthana-stabilized, γ-alumina-based washcoat. The noble metal and rare earth contents of the coated monoliths are given in Table 1. The catalysts in Table 1 include base case</i>

	Claims of Campbell, et al. U. S. Patent No. 6,037,307	Rieck, J.S., et al. SAE Paper 892095 (1989)
		Pt/Rh washcoats and Pt/Rh washcoats incorporating Ni and ferrite additives.” Ex. 1006 at p. 4 (emphasis added)
	a regenerable catalyst/sorber for removing gaseous sulfur compounds from gaseous streams comprising	“While the engine runs under lean conditions, sulfur can be stored on the catalyst surface.... Following a change in exhaust composition to a rich stoichiometry, the stored sulfur can be reduced to H ₂ S....” Ex. 1006 at p. 3 (describing regeneration of catalyst).
	a noble metal catalyst component,	<i>“Pt/Rh three-way catalysts</i> were prepared by washcoating cordierite and metal monolith substrates (62 and 50 cells/cm ² , respectively) with a lanthana-stabilized, γ-alumina-based washcoat. The noble metal and rare earth contents of the coated monoliths are given in Table 1. The catalysts in Table 1 include base case Pt/Rh washcoats and <i>Pt/Rh washcoats incorporating Ni and ferrite additives.</i> The Ni and ferrite additives were added to the washcoat as bulk oxides. The levels of these additives in the coated monoliths are also included in Table 1.” Ex. 1006 at p. 4 (emphasis added)
	a metal oxide sorber component selected from Ti, Zr, Hf, Ce, Al, Si or mixtures thereof and	“Pt/Rh three-way catalysts were prepared by washcoating cordierite and metal monolith substrates (62 and 50 cells/cm ² , respectively) with a lanthana-stabilized, γ-alumina-based washcoat. The noble metal and <i>rare earth contents of the coated monoliths are given in Table 1.</i> The catalysts in Table 1 include base case Pt/Rh washcoats and Pt/Rh washcoats incorporating Ni and ferrite additives.

	Claims of Campbell, et al. U. S. Patent No. 6,037,307	Rieck, J.S., et al. SAE Paper 892095 (1989)
		<p>The Ni and ferrite additives were added to the washcoat as bulk oxides. The levels of these additives in the coated monoliths are also included in Table 1.” Ex. 1006 at p. 4 (emphasis added).</p> <p>Table 1 shows that the rare earth contents include CeO₂. Ex. 1006 at p. 4 (Table 1, note (b)).</p>
	up to 0.3 g/in ³ of a modifier component consisting of an oxide of Ag, Cu, Bi, Sb, Sn, As, In, Pb, Au or mixtures thereof deposited on said carrier.	<p>“Pt/Rh three-way catalysts were prepared by washcoating cordierite and metal monolith substrates (62 and 50 cells/cm², respectively) with a lanthana-stabilized, γ-alumina-based washcoat. The noble metal and rare earth contents of the coated monoliths are given in Table 1. The catalysts in Table 1 include base case Pt/Rh washcoats and Pt/Rh washcoats incorporating Ni and <i>ferrite additives</i>. <i>The Ni and ferrite additives were added to the washcoat as bulk oxides.</i> The levels of these additives in the coated monoliths are also included in Table 1.: Ex. 1006 at p. 4 (emphasis added).</p> <p>Tables 1 and 2 show that sample catalyst C6 has a CuFe₂O₄ additive in the amount of 14.4 g/liter [0.236 gm/in³]. Ex. 1006 at p. 4; <u>see also</u> Ex. 1007, Farrauto ¶33 (converting “grams per liter” to “grams per cubic inch”).</p>

V. CONCLUSION

For all of the foregoing reasons, the Petition for *Inter Partes* Review should be granted.

Respectfully submitted,

Dated: September 30, 2014

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CERTIFICATE OF SERVICE

Pursuant to 37 C.F.R. §§42.6(e)(4) and 42.105(a), the undersigned hereby certifies that on September 30, 2014 a complete copy of the foregoing **PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 6,037,307** including all exhibits thereto was served in its entirety via EXPRESS MAIL on the official correspondence address for the '307 patent shown in PAIR, as follows:

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as well as on the attorneys of record in the related litigation, as follows:

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