

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Mercedes-Benz USA, LLC

Petitioner,

v.

Michigan Motor Technologies, LLC

Patent Owner.

IPR2023-01113

PETITION FOR *INTER PARTES* REVIEW OF

U.S. PATENT NO. 6,561,166

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LIST OF EXHIBITS

Exhibit	Description
1001	U.S. Patent No. 6,561,166 to Halleron et al. (“’166 Patent”)
1002	Prosecution File History of U.S. Patent No. 6,561,166 (“’166 File History”)
1003	Expert Declaration of Glenn R. Bower, Ph.D.
1004	Curriculum Vitae of Glenn R. Bower, Ph.D.
1005	U.S. Patent No. 5,910,096 to Hepburn et al. (“Hepburn”)
1006	U.S. Patent No. 6,192,672 to Kerns (“Kerns”)
1007	U.S. Patent No. 6,227,033 to Kainz (“Kainz”)
1008	U.S. Patent No. 6,341,487 to Takahashi et al. (“Takahashi”)

I. CLAIM LISTING

A. Claim 1

1[pre]	A method of controlling a direct injection spark ignited internal combustion engine that is capable of operating in a stratified mode where fuel is injected during a compression stroke of the engine and a homogeneous mode where fuels is injected during an intake stroke of the engine, the internal combustion engine having a catalytic converter and an NOx trap, comprising:
1[a]	measuring a first temperature of an NOx trap that is in contact with an exhaust gas exhausted from a combustion chamber while the engine is operating in the stratified mode;
1[b]	enabling evaporated fuel vapors to enter the combustion chamber at a flow rate while the engine is operating in the stratified mode;
1[c]	measuring a second temperature of the NOx trap while the engine is operating in the stratified mode; and
1[d]	adjusting the flow rate of the evaporated fuel vapors as a function of the second temperature when the second temperature is within a lower temperature threshold and an upper temperature threshold.

B. Claim 2

2	The method of claim 1, further comprising: switching the engine to the homogeneous mode when the second temperature is below the lower temperature threshold.
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C. Claim 3

3	The method of claim 2, further comprising: measuring a fuel level of the evaporated fuel vapors after the switching the engine to the homogeneous mode.
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D. Claim 4

4	The method of claim 3, wherein the measuring the fuel level comprises measuring the fuel level via an exhaust gas oxygen sensor.
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E. Claim 5

5	The method of claim 4, wherein the measuring the fuel level comprises measuring the fuel level with an universal exhaust gas oxygen sensor.
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II. INTRODUCTION

Mercedes-Benz USA, LLC (“MBUSA”) hereby petitions for *Inter Partes* Review (IPR) and cancellation of claims 1-5 of U.S. Patent No. 6,561,166 (“the ’166 patent”) (Ex. 1001). The challenged claims generally relate to a method for controlling a direct injection spark ignited internal combustion engine.

The ’166 patent claims nothing more than conventional methods for controlling an engine’s fuel injection to manage temperature. For example, the claims recite well-known components of an engine, such as a catalytic converter, an NOx trap, an exhaust gas oxygen sensor, and an engine controller. These components were prolific in the prior art—for example, Hepburn and Kerns each disclose each of these components.

The alleged improvement of the ’166 patent is merely a recitation of adjusting the flow rate of evaporated fuel vapors based on the temperature of an engine’s NOx trap—a concept expressly taught by Hepburn and Kerns as discussed below.

In addition, the prior art discloses each and every trivial addition added by the dependent claims.¹ Accordingly, Petitioner requests that the challenged claims be held unpatentable.

III. REQUIREMENTS UNDER 37 C.F.R. 42.104

A. Grounds for Standing

Petitioner respectfully requests *inter partes* review (“IPR”) of Claims 1-5 (“Challenged Claims”) of the ’166 patent (Ex. 1001), which is indicated as assigned to Michigan Motor Technologies LLC (“MMT”). Petitioner certifies that the ’166 patent is available for *inter partes* review and Petitioner is not barred or estopped from requesting review of the Challenged Claims on the grounds identified in this Petition.

B. Precise Relief Requested

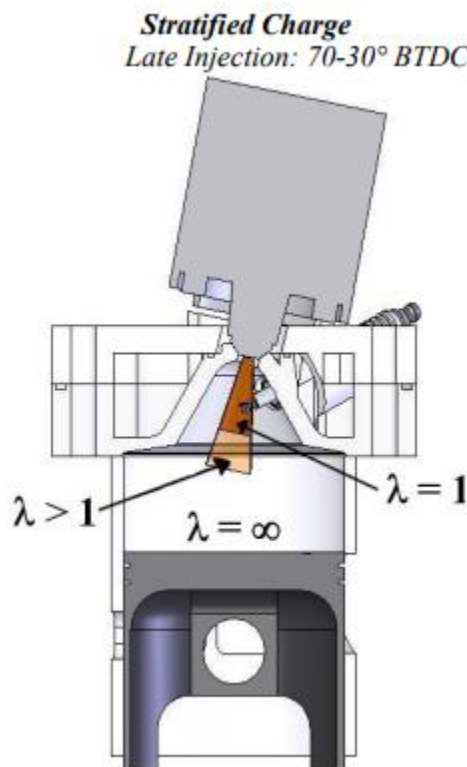
The relief requested is cancellation of the challenged claims, as follows:

Ground	’166 Patent Claims	References	Basis
1	1-3	Hepburn, Kerns	§103
2	4-5	Hepburn, Kerns, Kainz	§103
3	1-5	Kerns, Takahashi	§103

¹ As discussed more fully below, the PTAB previously found it was reasonably likely that the combination of Hepburn, Kainz, and another reference Price (U.S. Patent No. 5,806,304) and Kerns alone invalidated all claims of the ’166 patent. *Volkswagen Group of America, Inc. v. Michigan Motor Technologies LLC*, IPR2020-00452, Paper 12 at 26-27, 39 (PTAB Sept. 9, 2020).

IV. OVERVIEW OF THE '166 PATENT

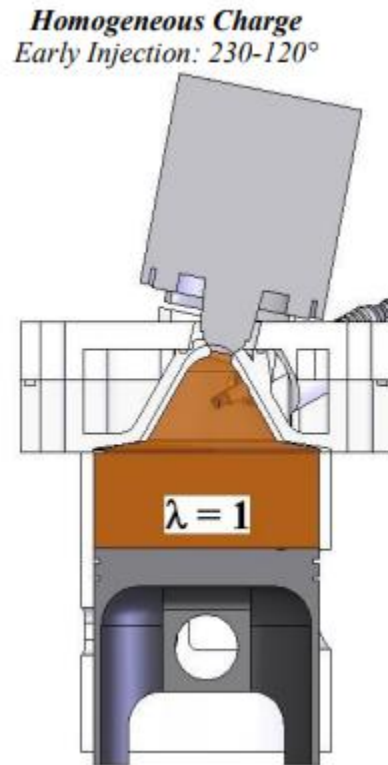
The claims of the '166 patent disclose methods for controlling fuel injection for a direct injection spark ignition (“DISI”) engine that is capable of operating in a stratified mode and a homogeneous mode. Ex. 1001 at Abstract. In particular, DISI engines operate in either *homogeneous* or *stratified* mode. *Id.* at 1:27-30. When in *stratified* mode, the combustion chambers of the engine contain stratified layers with different air/fuel concentrations. *Id.* This is shown, for example, in the figure below, where the air/fuel ratio λ of the layers of fuel is represented by the opacity of the fuel charge:



Justin W. Johnson, *Comparison of Stratified and Homogeneous Combustion in a Direct-Injected Two-Stroke Engine for Snowmobile Applications*, M.S. Thesis,

Dept. Mech. Eng., University of Idaho, Moscow, ID, 2007 at FIG. 17.

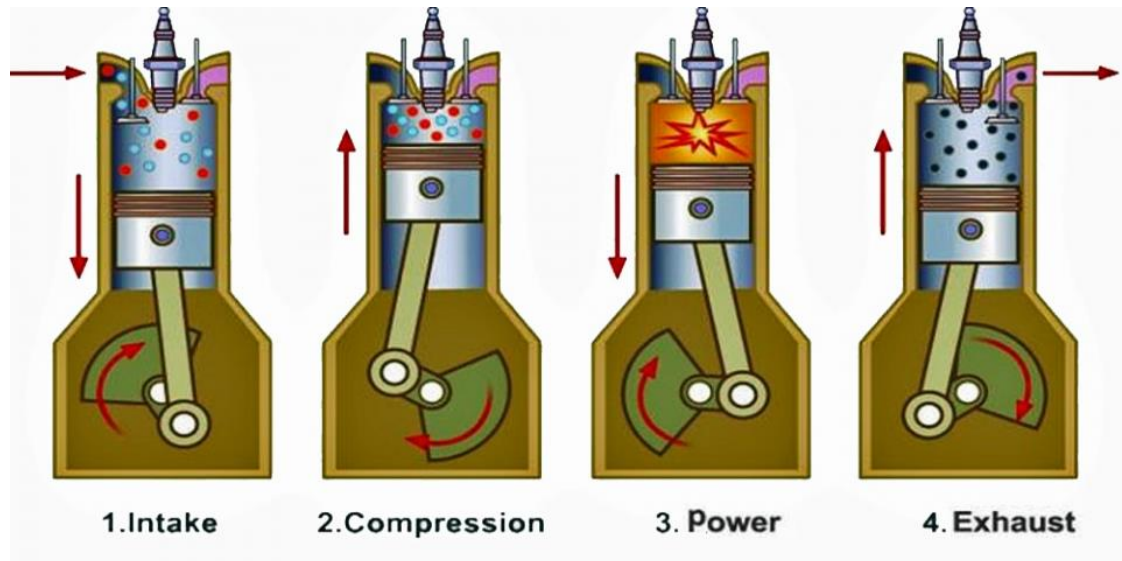
When the engine is in **homogeneous** mode, a homogeneous mixture of air and fuel is injected into the combustion chamber. Ex. 1001 at 1:33-35. This is shown, for example, in the figure below:



Justin W. Johnson, *Comparison of Stratified and Homogeneous Combustion in a Direct-Injected Two-Stroke Engine for Snowmobile Applications*, M.S. Thesis, Dept. Mech. Eng., University of Idaho, Moscow, ID, 2007 at FIG. 17.

This engine combustion mode determines when fuel is injected into the engine. In stratified mode, fuel is injected during the compression stroke of the engine. *Id.* at 2:35-40. In homogeneous mode, fuel is injected during the intake stroke of the

engine. *Id.* These two engine strokes, and the subsequent power and exhaust strokes, are depicted below:



Haynes, *Beginner's guide: what is a four stroke engine and how does it work* (Dec. 24, 2020), <https://haynes.com/en-us/tips-tutorials/beginners-guide-what-four-stroke-engine>.

The amount and timing of the fuel injection impacts an engine's emissions, including nitrous oxide (NOx). Engines that can operate in a stratified combustion mode include an NOx trap to capture NOx generated during stratified combustion. The temperature of the NOx trap impacts its performance and ability to efficiently handle emissions. The timing and amount of fuel injected into the combustion chamber directly impacts the NOx trap's temperature and its ability to regulate emissions.

The '166 patent claims nothing more than adjusting the flow rate of evaporative emissions to maintain NOx trap temperature. In particular, the '166

patent discloses testing the temperature of an NOx trap (also called a “catalyst”) using a catalyst temperature sensor. *Id.* at 4:51-53. The ’166 patent teaches that if the engine is operating in homogenous mode, and the NOx trap temperature is within a predetermined, acceptable range then the engine is switched to stratified mode to lower fuel consumption. *Id.* at 4:55-67. Once the engine is switched to stratified mode, fuel vapors from the engine’s carbon cannister are allowed to enter the intake manifold. *Id.* at 5:1-5. Once the vapors have entered the combustion chamber, the temperature of the NOx trap is measured again. *Id.* at 5:6-9.

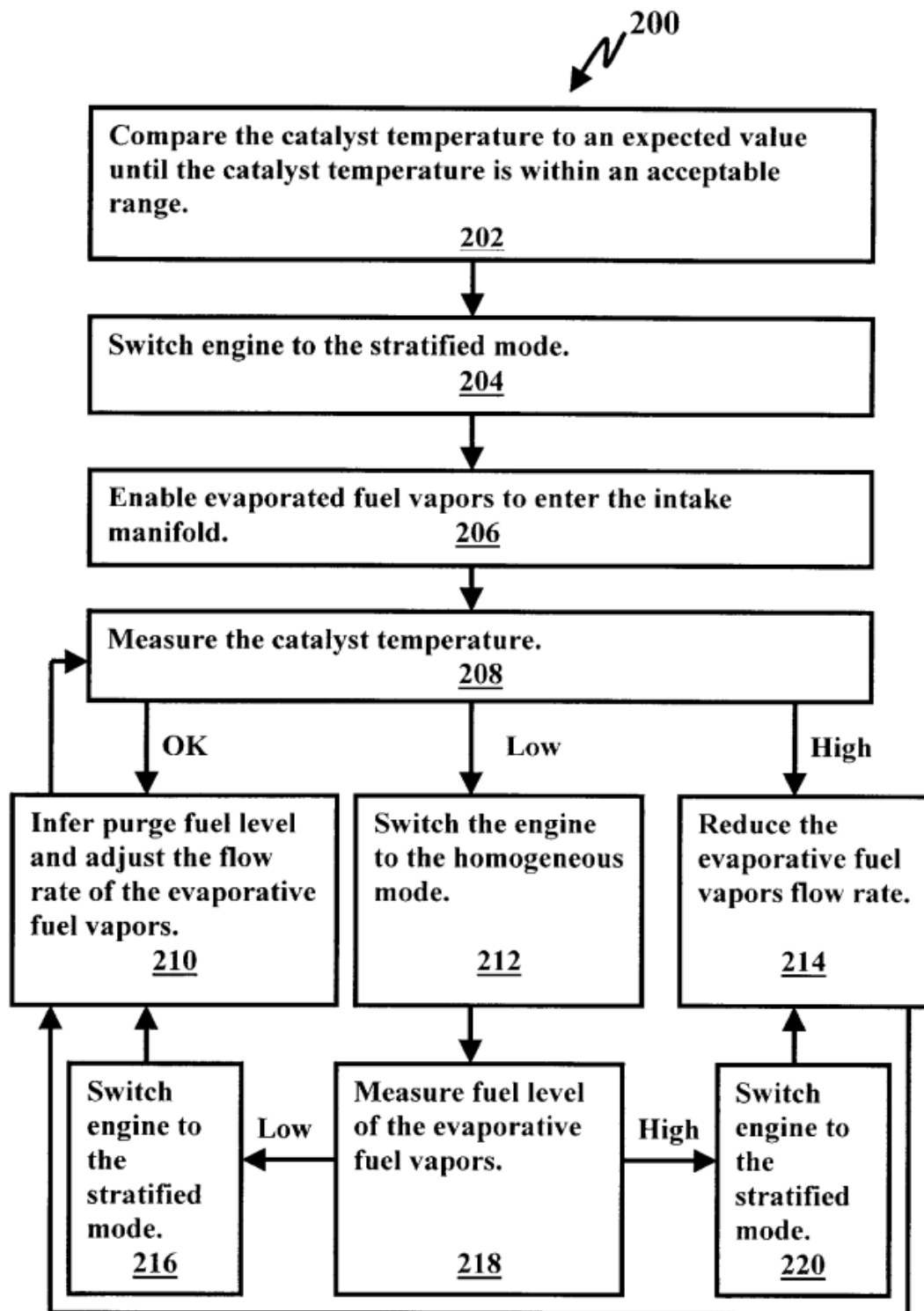
If the change in temperature after the introduction of fuel vapors is within an acceptable range, then there is sufficient heat from the engine to keep the NOx trap at an operational temperature and additional fuel need not be injected to increase engine temperature. *Id.* at 5:16-21. Because additional fuel need not be injected, the engine will remain in stratified mode to conserve fuel consumption. *Id.* at 5:16-21.

On the other hand, if the catalyst temperature change in stratified mode is above the acceptable range, this indicates that the evaporated fuel vapors introduced to the combustion chamber contain too much fuel—therefore, the flow rate of fuel vapors is reduced until the catalyst temperature is within the acceptable range. *Id.* at 5:24-31.

Further, if the catalyst temperature change is below the acceptable range, this could indicate that fuel level in the evaporated fuel vapors is either low or very high.

Id. at 5:36-43. To determine whether the fuel vapors are lean or very rich, the engine is switched back into homogeneous mode. *Id.* While in homogeneous mode, the fuel level in the fuel vapors is measured using an exhaust gas oxygen sensor. *Id.* at 5:44-50. If the fuel vapors are determined to be lean, the engine is switched back to stratified mode and the flow of evaporated fuel vapors is increased. *Id.* at 5:44-56. On the other hand, if the fuel vapors are very rich, the engine is switched back to stratified mode and the flow rate of fuel vapors is reduced until the temperature change is within the acceptable range. *Id.* at 5:56-63.

The flow of this claimed process is shown, for example, in Figure 2:



Thus, the '166 patent claims nothing more than increasing or decreasing evaporative fuel vapors flow rate based on whether the measured NOx trap temperature is too high or too low.

V. PROSECUTION HISTORY

The '166 patent was issued May 13, 2003, from U.S. Application No. 09/861,983 (“the '983 application”), which was filed on May 16, 2001. See Ex. 1001, field (22). The '166 patent claims priority to Provisional Application No. 60/211,085, filed June 13, 2000. Thus, the '166 patent's earliest possible priority date is June 13, 2000.

The examiner issued two office actions before ultimately allowing the '983 application. The original '983 application contained method claims 1-11 and device claims 12-24. Ex. 1002 at 39-43. On July 10, 2002, the Examiner issued a Non-Final Rejection rejecting all twenty-four claims as anticipated by Kerns. *Id.* at 55-58. The Examiner rejected the claims based on the embodiments of Kerns described in Figures 8-10:

“Kerns teaches a method of controlling a direct injection spark ignited internal combustion engine comprising a step of adjusting a flow rate of evaporated fuel vapors as a function of a temperature of a catalyst (see figures 8-10, col. 11 line 42 through col. 13 line 10).”

Id. at 58 (emphasis added).

In response to the July 10, 2002 Rejection, the Applicant cancelled claims 14-15, and amended claim 1 as follows:

1. A method of controlling a direct injection spark ignited internal combustion engine that is capable of operating in a stratified mode where fuel is injected during a compression stroke of the engine and a homogeneous mode where fuels is injected during an intake stroke of the engine, the internal combustion engine having a catalytic converter and an NOx trap, comprising:

measuring a first temperature of an NOx trap [[a catalyst]] that is in contact with an exhaust gas exhausted from a combustion chamber while the engine is operating in the stratified mode;

enabling evaporated fuel vapors to enter the combustion chamber at a flow rate while the engine is operating in the stratified mode;

measuring a second temperature of the NOx trap [[catalyst]] while the engine is operating in the stratified mode; and

adjusting the flow rate of the evaporated fuel vapors as a function of the second temperature when the second temperature is within a lower temperature threshold and an upper temperature threshold.

Id. at 76.

After these amendments on December 30, 2002, the Examiner issued a Final Rejection allowing method claims 1-11, but maintaining the rejection of device

claims 12-13 and 16-24 based on Kerns. *Id.* at 78-82. The examiner rejected device claims 12-13 and 16-24 based on the embodiment of Kerns described in Figure 5:

Kerns teaches an engine control that switches the engine between the stratified and homogeneous modes and adjust a flow rate of evaporated fuel vapors as a function of a temperature of a NOx trap (see **Figure 5 step 513**).

Id. at 80.

In response to the Final Office Action, the applicant canceled the rejected claims. *Id.* at 86. On February 13, 2003, the examiner issued a Notice of Allowance allowing claims 1-11. *Id.* at 87-91.

Notably, at no point during the examination of the '166 patent did the Examiner discuss or cite Figure 7 of Kerns or its description within Kerns' specification.² Figure 7 and its corresponding description discloses an NOx trap and upper and lower temperature limitations for the trap. Ex. 1006 at 11:1-8 ("Continuing with FIG. 7, in step 716 a determination is made as to whether temperature T_{trap} of NOx trap 72 is between threshold values $T1'$ and $T2'$).

² The PTAB previously found that neither the examiner nor the applicant addressed the Figure 7 embodiment of Kerns during the prosecution of the '166 patent. *Volkswagen Group of America, Inc. v. Michigan Motor Technologies LLC*, IPR2020-00452, Paper 12 at 33 (PTAB Sept. 9, 2020).

Threshold value T2’ represents an upper level above which NOx trap 72 is operating a peak efficiency. Temperature Threshold T1’ represents a lower level below which NOx trap 72 cannot support an exothermic reaction between unburned fuel vapors and excess oxygen ”). As explained below in § X.A, *infra*, the Examiner and applicant overlooked Figure 7 and its express disclosure of evaluating whether an NOx trap temperature falls within a predetermined temperature range—the same limitations the applicant argued was not taught by Kerns’ Figure 5. Ex. 1003 at ¶¶ 70-73.

VI. THE HYUNDAI AND VOLKSWAGEN IPRS

Hyundai Motor Company (“Hyundai”) and Volkswagen Group of America, Inc. (“VW”) each previously filed a petition for *inter partes* review of the ’166 patent, both challenging claims 1-5. See IPR Nos. IPR2018-01075 and IPR2020-00452. The petitions in IPR2018-01075 and IPR2020-0452 both relied on combinations including Hepburn and Kainz, and Kerns alone. See IPR No. IPR2018-01075 at Paper 2 (Petition); IPR No. IPR2018-01075 at Paper 2 (Petition). These references are also relied upon by MBUSA in this Petition. Neither the petition in IPR2018-01075 nor the petition in IPR2020-0452 relied on the combination of Kerns and Takahashi relied upon by MBUSA in this Petition. See IPR No. IPR2018-01075 at Paper 2 (Petition); IPR No. IPR2018-01075 at Paper 2 (Petition).

In IPR2018-01075, Patent Owner settled its litigation with Hyundai and moved for termination of the IPR before the PTAB issued an institution decision.

The PTAB granted the termination request.

In IPR2020-0452, the PTAB instituted the petition, finding a reasonable likelihood of success that the prior art—including a combination including Hepburn and Kainz, and Kerns alone—invalidated the challenged claims. IPR No. IPR2018-01075 at Paper 12. However, Patent Owner settled its litigation with VW and moved for termination of IPR2020-0452 IPR before the post-institution briefing was completed. The PTAB granted the termination request.

Accordingly, the PTAB has not had an opportunity to render a patentability determination regarding claims 1-5 of the '166 patent.

VII. LEVEL OF ORDINARY SKILL IN THE ART

A POSITA at the time of the alleged invention would have had a B.S. degree in Electrical Engineering or Mechanical Engineering (or equivalent), as well as at least 2-3 years of industry experience or, alternatively, at least an M.S. degree in Electrical Engineering or Mechanical Engineering and 1-2 years of industrial experience. Ex. 1003 at ¶ 54.

VIII. CLAIM CONSTRUCTION

Petitioner submits that express interpretations of the Challenged Claims are not necessary. Ex. 1003 at ¶ 75. Petitioner takes no position in this Petition as to whether the claims are indefinite, and no statements herein should be interpreted to mean that the terms are definite.

The PTAB previously found it was not necessary to expressly construe any

claim language to determine the '166 claims' patentability. *Volkswagen Group of America, Inc. v. Michigan Motor Technologies LLC*, IPR2020-00452, Paper 12 at 10-11 (PTAB Sept. 9, 2020).

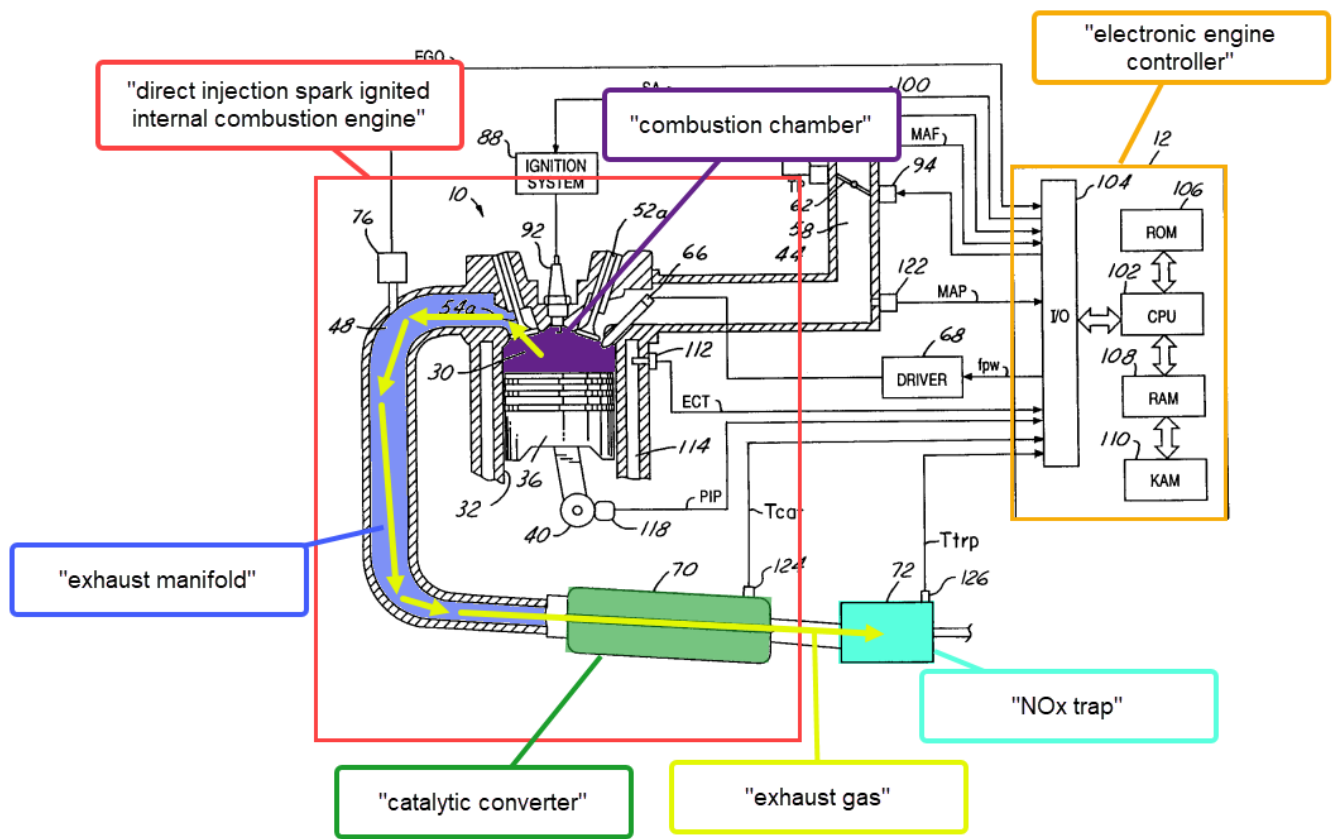
IX. SUMMARY OF PRIOR ART

A. Hepburn

U.S. Patent No. 5,910,096 to Hepburn et al., “Temperature control system for emission device coupled to direct injection engines” (Ex. 1005, “Hepburn”), issued June 8, 1999, more than one year before the '166 patent's earliest possible priority date. Therefore, Hepburn is prior art at least under 35 U.S.C. §102(b) (pre-AIA).

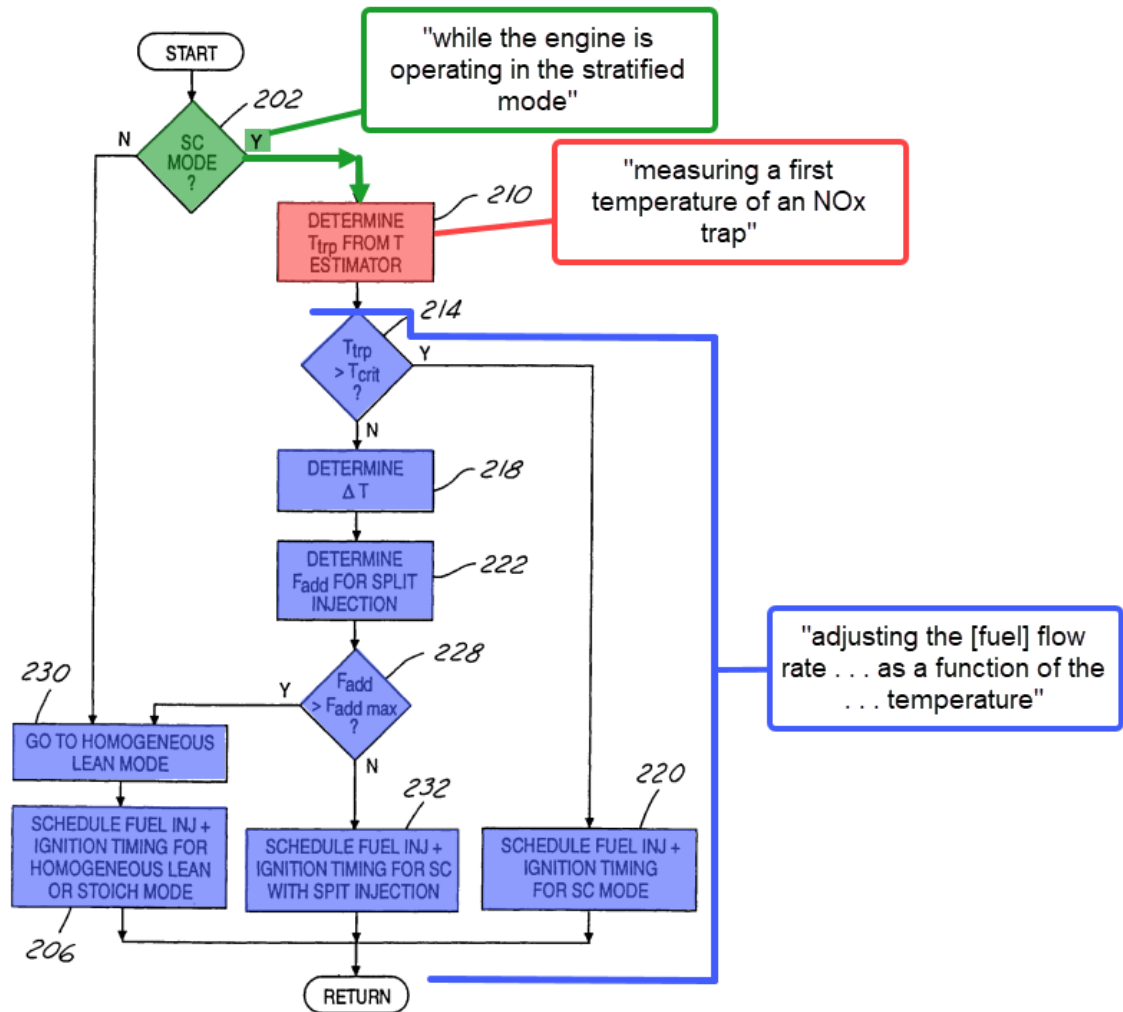
Like the '166 patent, Hepburn discloses a “[d]irect injection spark ignited [(“DISI”)] internal combustion engine 10” capable of operating in a stratified and homogeneous combustion mode and a method for controlling the engine's fuel injection to provide heating for the engine's NOx trap. Ex. 1005 at Abstract.

As shown in the annotated version of Hepburn's Figure 1 below, Hepburn discloses the common components of any DISI engine: “a plurality of combustion chambers” connected to an “exhaust manifold 48” and “controlled by electronic engine controller 12.” Ex. 1005 at Abstract; 2:55-67. Hepburn's DISI engine further comprises two emissions control devices, also commonly used in the prior art: “catalytic converter 70” and “Nitrogen oxide (NOx) absorbent or trap 72.” *Id.*, 3:21-22, 3:61-67.



Id. at FIG. 1 (annotations added).

Hepburn uses these components to practice the same engine control method as the '166 patent. In particular, as shown in the annotated version of Hepburn's Figure 2 below, Hepburn teaches first determining whether the engine is operating in stratified mode, as indicated in step 202 of Figure 2 below. *Id.* at 4:27-38.



Id. at FIG. 2 (annotations added).

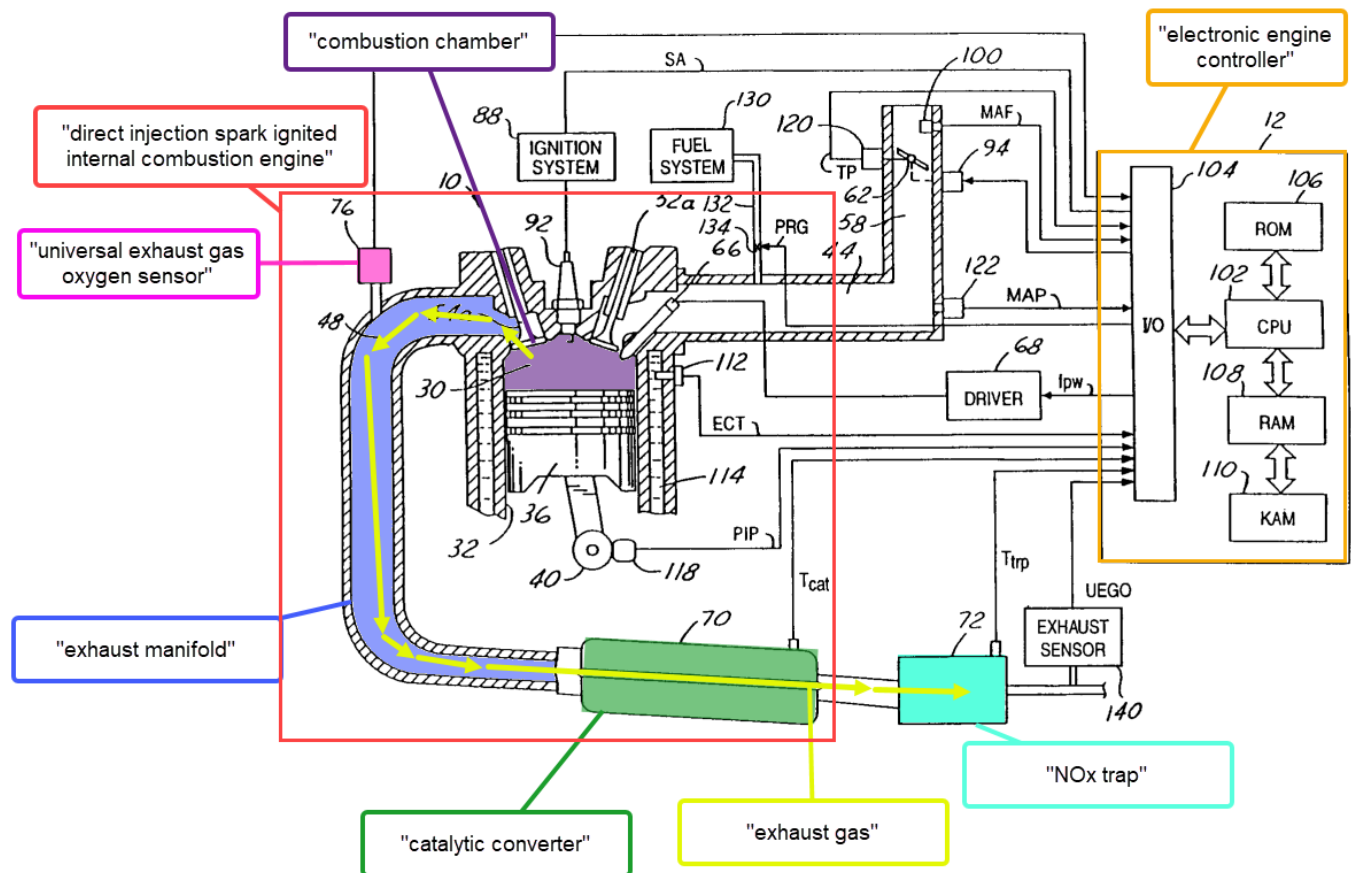
“When engine 10 is operating in the stratified mode . . . temperature of NOx trap 72 (T_{trp}) is determined.” *Id.* at 4:38-40. Just like the ’166 patent, if the NOx trap temperature is too low, Hepburn calculates and injects a quantity of fuel required to raise the NOx trap temperature. *Id.* at 4:52-63 (“If NOx trap temperature . . . is less than critical temperature T_{crit} ” “difference in temperature ΔT is determined” and a “quantity of fuel F_{add} is injected during the exhaust stroke of each combustion chamber . . . to heat catalytic converter 70 and NOx trap 72”). If the NOx trap

temperature is low enough that the amount of fuel required to raise the temperature is greater than the amount of fuel saved by operating in stratified mode, Hepburn switches its engine to homogeneous mode, just like the '166 patent. *Id.* at 4:63-67. If NO_x temperature is within the temperature range required for the NO_x trap to operate effectively, just like the '166 patent, Hepburn remains in stratified mode. *Id.* at 4:46-51.

B. Kerns

U.S. Patent No. 6,192,672 to Kerns, “Engine control method with multiple emission control devices” (Ex. 1006, “Kerns”), was filed on August 2, 1999, before the '166 patent's earliest possible priority date. Therefore, Kerns is prior art at least under 35 U.S.C. §102(e) (pre-AIA).

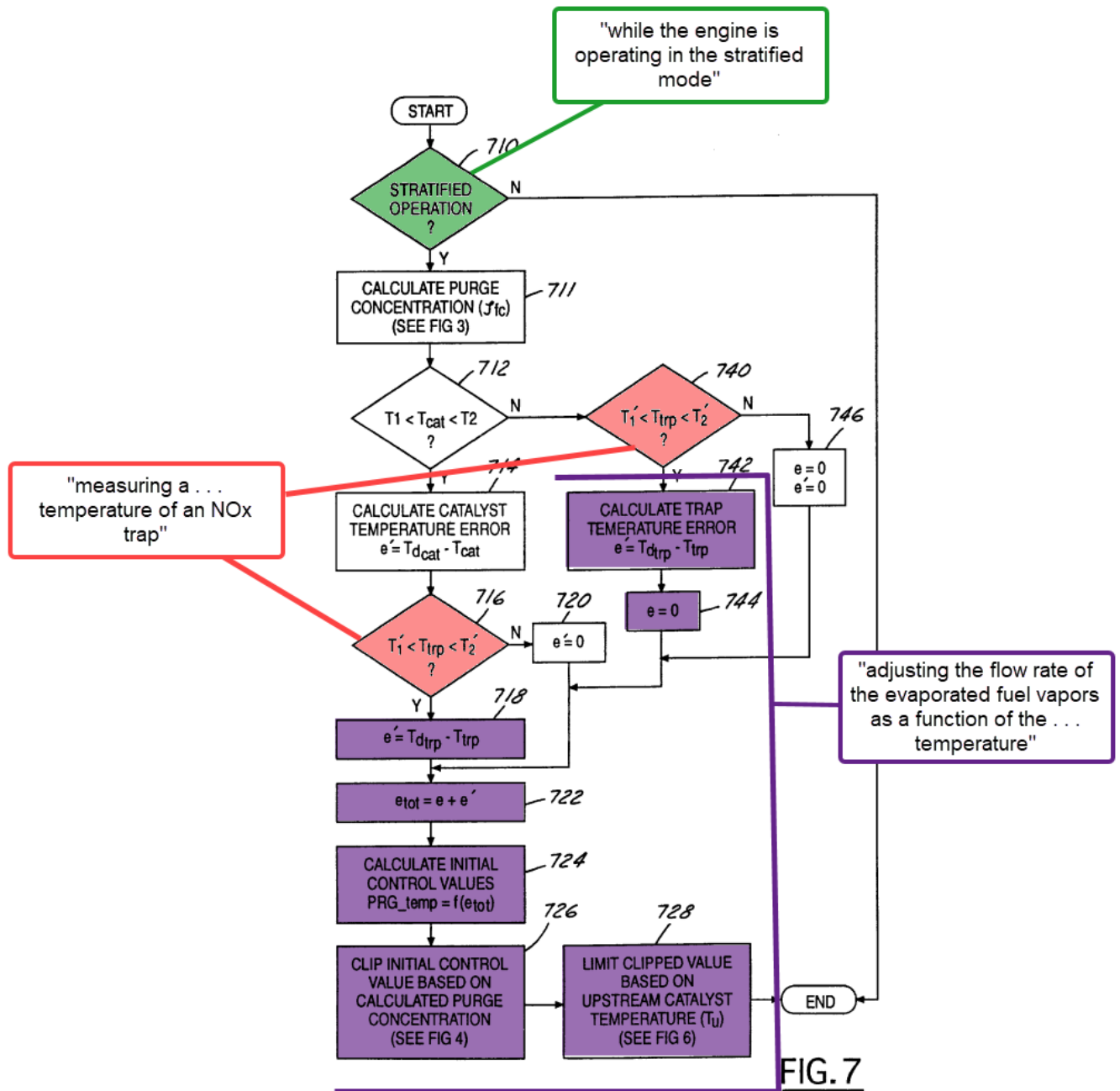
Like the '166 patent and as shown in the annotated version of Kerns' Figure 1 below, Kerns discloses the common components of any DISI engine: a plurality of combustion chambers connected to an exhaust manifold 48 and controlled by electronic engine controller 12. Ex. 1006 at Abstract, 1:26-20. Kerns' DISI engine further comprises two emissions control devices also commonly used in the prior art: “catalytic converter 70” and an “NO_x trap 72,” and a “UEGO,” or universal “[e]xhaust gas oxygen sensor 76.” *Id.* at 3:21-65.



Id. at FIG. 1 (annotations added).

Kerns uses these components to practice the same engine control method as the '166 patent. In particular, Kerns' engine control method teaches "[f]irst . . . a determination is made as to whether engine 10 is operating in a stratified mode."

Id. at 10:51-53.



Id. at FIG. 2 (annotations added).

When engine 10 is operating in the stratified mode, Kerns measures the temperature of the NOx trap and determines whether it is between lower threshold temperature $T1'$ and upper temperature threshold $T2'$. *Id.* at 11:1-3 (“in step 716 a determination is made as to whether temperature $Ttrp$ of NOx trap 72 is between

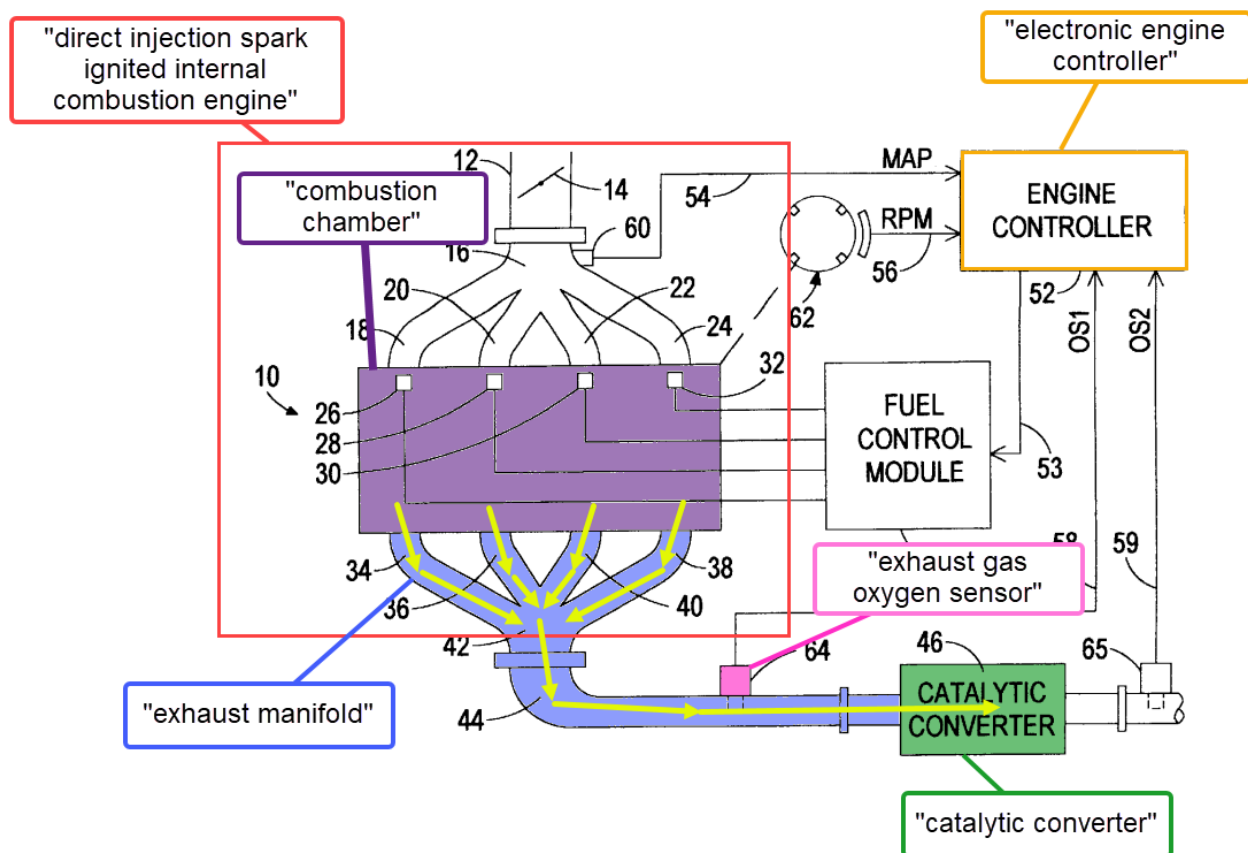
threshold values $T1'$ and $T2'$.”). Just like the '166 patent, if the NOx trap temperature is low enough that the amount of fuel required to raise the temperature is greater than the amount of fuel saved by operating in stratified mode, Kerns switches its engine to homogeneous mode. *Id.* at 7:62-8:5 (“when the stratified mode no longer provides a fuel savings because of the additional fuel vapor injected to maintain temperature of the emission control device, the engine air/fuel operating mode is switched to the homogeneous mode thereby maximizing fuel economy.”).

When the NOx trap temperature is between the lower and upper threshold, Kerns determines the difference between the NOx trap temperature and the desired NOx trap temperature. *Id.* at 11:8-11 (“When the answer to step 716 is YES, a trap temperature error (e') is calculated in step 718 based on a desired trap temperature (T_{dtrp}) of NOx trap 72 and the actual temperature (Trp) of NOx trap 72.”). Just like the '166 patent, Kerns calculates the flow rate of fuel vapors needed to adjust the NOx trap temperature to the desired temperature and enables that amount of fuel vapors to enter the combustion chamber. *Id.* at 9:10-15 (“ . . . a total error ($etot$) is calculated from both trap temperature error (e') and catalyst temperature error (e)” and “an initial control value (PRG_temp) is calculated based on a function (f) of total error ($etot$).”), 11:12-16 (PRG_temp is eventually converted to control signal PRG , where PRG controls the flow rate of fuel vapors into the combustion chamber, $\dot{m}_p$).

C. Kainz

U.S. Patent No. 6,227,033 to Kainz, “Auto-calibration method for a wide range exhaust gas oxygen sensor” (Ex. 1007, “Kainz”), was filed on March 11, 1999, before the ’166 patent’s earliest possible priority date. Therefore, Kainz is prior art at least under 35 U.S.C. §102(e) (pre-AIA).

Kainz, like Hepburn, Kerns, and the ’166 patent, discloses methods for controlling engine fueling based on aspects of the engine exhaust. Ex. 1007 at Abstract. Kainz particularly discloses an engine having the common components of an engine controller, an exhaust manifold, a catalytic converter, and a universal exhaust gas oxygen sensor. Ex. 1007 at 2:36-3:13.



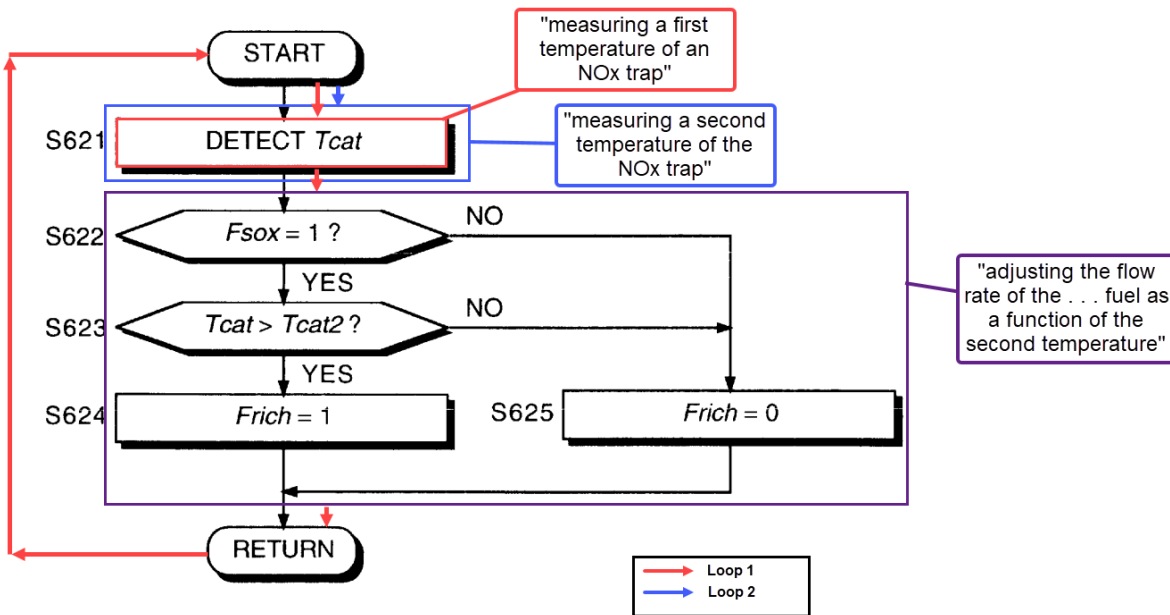
Ex. 1007 at FIG. 1 (annotations added).

Kainz teaches that its exhaust gas oxygen sensor may be “a universal, or wide-range oxygen sensor.” Ex. 1007 at 1:27-31 (“The other type of oxygen sensor, referred to as a universal exhaust gas oxygen sensor, or wide-range oxygen sensor”).

D. Takahashi

U.S. Patent No. 6,341,487 to Takahashi, “Catalyst temperature control device and method of internal combustion engine” (Ex. 1008, “Takahashi”), was filed on March 29, 2000, before the ’166 patent’s earliest possible priority date. Therefore, Takahashi is prior art at least under 35 U.S.C. §102(e) (pre-AIA).

Like the ’166 patent, Takahashi discloses a DISI engine having an NO_x trap and a method for controlling the temperature of the NO_x trap. Ex. 1007 at Abstract, 2:54-64. As shown below in annotated Figure 6, like the ’166 patent, Takahashi teaches a method that measures NO_x trap temperature, determines whether the temperature is below a desired temperature threshold and, if it is, increases the fuel added to the engine’s combustion chamber to raise the NO_x trap temperature. *Id.* at 10:30-57.



Id. at FIG. 6 (annotations added).

X. DISCRETIONARY FACTORS

As discussed in detail below, the Board should not exercise its discretion to deny this IPR petition.

A. The Board Should Not Deny Institution Under Section 325(d)

The Board uses a two-part framework to analyze denial under § 325(d). *Advanced Bionics, LLC v. MED-EL Elektromedizinische Geräte GmbH*, IPR2019-01469, Paper 6 at 7 (PTAB Feb. 13, 2020) (precedential). For the first prong, the Board considers whether the same or substantially the same prior art or arguments were presented during the prosecution of the patent, and any post-issuance proceedings. *Id.* at 7-8. As to the second prong, the Board considers whether the office materially erred in determining patentability of the challenged claims,

including by overlooking a specific teaching of the relevant prior art or an error of law, such as misconstruing a claim term. *Id.* at n. 9. If the first prong is not met, the Board does not need to address the second prong. *Godbersen-Smith Constr. Co. v. Guntert & Zimmerman Const. Div., Inc.*, IPR2021-00050, Paper 24 at 21 (PTAB May 7, 2021). The *Advanced Bionics* analysis weighs in favor of institution here.

An analysis of the prosecution history and Hyundai and VW's prior IPR petitions favors institution. First, this Petition relies on different art and different combinations not considered during prosecution of the '166 patent. In particular, this Petition cites Takahashi, which discloses “measuring a second temperature of the NOx trap” and “adjusting the flow rate of . . . fuel . . . as a function of the second temperature”—Takahashi was not before the examiner during prosecution. This Petition also relies on the combination of Hepburn, Kerns, and Kainz, which was not considered during prosecution or the prior IPR petitions. Accordingly, Section 325(d) concerns are not implicated here because this Petition addresses new arguments based on prior art not addressed during prosecution or any post-issuance proceeding. *Advanced Bionics, LLC v. MED-EL Elektromedizinische Geräte GmbH*, Paper 6 at 7 (PTAB Feb. 13, 2020) (considering whether the same or substantially the same art previously was presented to the Office or whether the same or substantially the same arguments previously were presented to the Office.); *Becton, Dickinson & Co. v. B. Braun Melsungen AG*, IPR2017-01586, Paper 8 at 28

(PTAB Dec. 15, 2017) (informative) (finding that a cited reference was cumulative when the same base reference was substantively evaluated during prosecution).

Moreover, even if the first prong were met, as the PTAB observed, the Office committed a material error by overlooking specific teachings of Kerns that disclose the limitations of claim 1. *Volkswagen Group of America, Inc. v. Michigan Motor Technologies LLC*, IPR2020-00452, Paper 12 at 32-33 (PTAB Sept. 9, 2020) (“We find that Petitioner has sufficiently shown how the Examiner erred in a material manner during prosecution of the application resulting in the ’166 patent by failing to fully consider the embodiment illustrated in Kerns’s Figure 7”).

The applicant attempted to distinguish the ’166 patent claims from Kerns by amending claim 1 and 11 to require measuring the temperature of an NO_x trap and determine whether the temperature of the NO_x trap is between a lower and upper temperature threshold. Ex. 1002 at 76. But Figure 7 of Kerns’ or its description within Kerns’ specification. Figure 7 and its corresponding description discloses an NO_x trap and upper and lower temperature limitations for the trap. Ex. 1006 at 11:1-8. Kerns’ teaches that “continuing with FIG. 7, in step 716 a determination is made as to whether temperature T_{trp} of NO_x trap 72 is between threshold values $T1'$ and $T2'$. Threshold value $T2'$ represents an upper level above which NO_x trap 72 is operating a peak efficiency. Temperature Threshold $T1'$ represents a lower level below which NO_x trap 72 cannot support an exothermic reaction between unburned fuel vapors and excess oxygen.” *Id.*

At no point during the examination of the '166 patent did the examiner discuss or cite Figure 7 of Kerns' or its description within Kerns' specification and overlooked its express disclosure of evaluating whether an NOx trap temperature falls within a predetermined temperature range. See Ex. 1002; Ex. 1003 at ¶¶ 70-73. Thus, under prong 2, the examiner erred in a manner material to patentability, and § 325(d) does not counsel in favor of a discretionary denial. *Advanced Bionics, LLC v. MED-EL Elektromedizinische Geräte GmbH*, Paper 6 at n. 9 (PTAB Feb. 13, 2020) (“overlooking specific teachings of the relevant prior art where those teachings impact patentability of the challenged claims” constitutes a “material error”); *Volkswagen Group of America, Inc. v. Michigan Motor Technologies LLC*, IPR2020-00452, Paper 12 at 32-33 (PTAB Sept. 9, 2020).

The VW IPR challenges also do not warrant denial under § 325(d). While VW IPR challenge included a combination with the Hepburn and Kainz references cited in this Petition, the PTAB never issued a final written decision in the '452 IPR. The PTAB did issue an institution decision, but such a preliminary determination “is not a sufficient demonstration that the reference was previously considered” under prong 1 of *Advanced Bionics*. *Google LLC v. Uniloc 2017 LLC*, IPR2019-01584 (PTAB Mar. 24, 2020) paper 7 at 11-12 (“it is unwarranted to apply our discretion under 35 U.S.C. § 325(d) to deny the instant Petition simply because it relies on the same or similar references that we considered in an institution decision in a prior petition”). Accordingly, the '425 IPR proceeding does not warrant denial under §

325(d).

Likewise, the same art was relied upon in the '1075 IPR petition. But there, the parties settled before the PTAB even issued an institution decision. IPR2018-01075, Paper 7 at 2. Accordingly, 325(d) is not implicated by the '1075 proceeding either.

As such § 325(d) does not counsel in favor of a discretionary denial. Therefore, the Board does not have to address the second prong of the analysis.

B. The General Plastic Factors Weigh In Favor Of Institution

Factor 1: whether the same petitioner previously filed a petition directed to the same claims of the same patent. This is the first post-grant proceeding brought against the '166 patent by MBUSA. Neither VW nor Hyundai's prior IPR bear a "significant relationship" such that Factor 1 would favor discretionary denial. *Twitter v. Palo Alto Research Center Inc.*, IPR2021-01398, Paper 12 at 40-41 (PTAB Mar. 15, 2022). MBUSA was sued separately from Hyundai and VW: MMT sued Hyundai in the Eastern District of Michigan in 2017; MMT sued VW in the Eastern District of Michigan in two years later in 2019; and MMT sued MBUSA in the Northern District of Illinois three years later in 2022. *See Michigan Motor Technologies LLC v. Hyundai Motor Company*, No. 2:17-cv12901 (E.D. Mich.); *Michigan Motor Technologies LLC v. Volkswagen AG*, No. 2:19-cv10485 (E.D. Mich.); *Michigan Motor Technologies, LLC v. Mercedes-Benz USA, LLC*, Case 1:22-cv-03957 (N.D. Ill.). Accordingly, there is no relationship between the IPRs,

let alone a significant one.

Moreover, there is no overlap between MBUSA's accused products and the accused products that were at issue in the litigation with Hyundai or VW. MMT's complaint against MBUSA accuses three Mercedes-AMG engine types and the Mercedes-Benz GLC 350e of infringement. *Michigan Motor Technologies, LLC v. Mercedes-Benz USA, LLC*, Case 1:22-cv-03957 (N.D. Ill.), Dkt. 1 at ¶¶ 13-17. MMT's complaint against Hyundai accused multiple Hyundai vehicles of infringement. *Michigan Motor Technologies LLC v. Hyundai Motor Company*, No. 2:17-cv12901 (E.D. Mich.), Dkt. 1 at ¶13, 181. MMT's complaint against VW accused multiple VW and Audi engines and vehicles of infringement. *Michigan Motor Technologies LLC v. Volkswagen AG*, No. 2:19-cv10485 (E.D. Mich.), Dkt. 1 at ¶¶ 11, 17, 23, 29, 35, 43, 49, 55, 62, 68, 76, 88, 96, 102, 110, 116, 122, 128, 134, 146.

Furthermore, MBUSA did not coordinate with Hyundai or VW in the preparation of this Petition, Hyundai's petition in IPR2018-01075, or VW's petition in IPR2020-00452. In these circumstances, the Board has found Factor 1 weighs in favor of institution. IPR2021-01398, Paper 12 at 40-41.

Factor 2: whether at the time of filing of the first petition the petitioner knew of the prior art asserted in the second petition or should have known of it. This factor does not apply because MBUSA did not file a previous petition. Moreover, as explained with regard to Factor 1 above, MBUSA had no reason to know of the

prior art asserted in this Petition at the time of Hyundai or VW's petitions at least because MMT had not yet sued MBUSA. Likewise, there is no significant relationship between MBUSA and Hyundai or VW. Thus, Factor 2 weighs in favor of institution. IPR2021-01398, Paper 12 at 41-42.

Factor 3: whether at the time of filing of the second petition the petitioner already received the patent owner's preliminary response to the first petition or received the Board's decision on whether to institute review in the first petition.

This factor does not apply because MBUSA did not file a previous petition. Likewise, there was no delay by MBUSA in filing its IPR petition after being sued by MMT. Accordingly, Factor 3 weighs in favor of institution.

Factor 4: the length of time that elapsed between the time the petitioner learned of the prior art asserted in the second petition and the filing of the second petition. This factor does not apply because MBUSA did not file a previous petition. Further, MBUSA did not learn of the prior art asserted in this Petition until after MBUSA received service of MMT's complaint in the district court litigation. MBUSA's IPR petition is timely filed before the statutory bar date and, thus, there is also no delay. Accordingly, Factor 4 also weighs in favor of institution.

Factor 5: whether the petitioner provides adequate explanation for the time elapsed between the filings of multiple petitions directed to the same claims of the same patent. For the same reasons discussed with respect to Factor 4, Factor 5 is

also irrelevant. Accordingly, Factor 5 weighs in favor of institution.

Factor 6: *the finite resources of the Board.* The petition is not a “follow-on” petition like those discussed in *General Plastic* or a “serial attack” on the ’166 patent by the same petitioner. Moreover, MBUSA is not attempting to “strategically stage their prior art and arguments in multiple petitions”—this Petition was filed as a direct response to MMT’s new complaint against MBUSA filed more than two years after VW’s petition of the ’166 patent and more than four years after Hyundai’s petition, both of which were filed in response to MMT’s complaints against Hyundai and VW, respectively. *Ameristar Perimeter Sec. Usa, Inc. v. Rsa Protective Techs., LLC*, No. IPR2020-01369, Paper 11 at 15 (PTAB Feb. 5, 2021) (finding *General Plastics* factors weighed in favor of institution where petitioner was not involved in prior petitions, was not attempting to strategically stage prior art, and instead searched for prior art in response to the commencement of litigation); *Samsung Elecs. Co. v. Iron Oak Techs., LLC*, IPR2018-01554, Paper 9 at 31 (PTAB Feb. 13, 2019) (board will “decline to wield [the patent owner’s] own litigation activities as a shield in [an] inter partes review” and complaint about serial petitions unpersuasive where “the volume [of petitions] appears to be a direct result of [the patent owner’s] own litigation activity”).

Thus, this Petition does not waste the finite resources of the Board and, accordingly, this factor weighs in favor of institution.

Factor 7: *the requirement that the Board issue a final determination within*

1 year. The filing of this Petition will in no way adversely impact the PTAB’s 1 year deadline to issue a Final Written Decision. Accordingly, Factor 7 weighs in favor of institution.

For the foregoing reasons, the *General Plastic* factors weigh in favor of institution. Indeed, this is not the type of serial attack on a patent that the *General Plastics* factors are designed to prevent. *General Plastic Industrial Co., Ltd. v. Canon Kabushiki Kaisha*, Case IPR2016-01357 at 8-11 (Paper 19) (Precedential) (setting forth seven factors directed towards “follow-on” petitions).

C. Institution Should Not Be Denied Under *Fintiv*

Discretionary denial under § 314 is analyzed under the *Fintiv* factors, and those factors weigh in favor of institution. *Apple Inc. v. Fintiv, Inc.*, IPR2020-00019, Paper 11 (PTAB Mar. 20, 2020) (precedential).

1. A Final Written Decision Will Issue Before Any Trial

A schedule has not yet been issued in the corresponding district court litigation. No trial date has been set. This petition is being filed on June 21, 2023. Thus, the approximate date of the PTAB hearing would be October 2024, whereas the trial date for the district court case (which has not been set) will likely not be until 2025. Accordingly, the PTAB trial will pre-date the district court trial, perhaps by many months.

Even if the trial occurs shortly before the PTAB hearing, the PTAB has held that such close proximity of a district court trial date weighs in favor of institution.

See, e.g., MediaTek Inc. et al. v. Nippon Telegraph and Telephone Corp., IPR2020-01607, Paper 12 at 14 (PTAB April 2, 2021).

2. The Merits of the Petition Support Institution

As discussed in more detail below, the prior art teaches every element of the challenged claims. Accordingly, the challenged claims should be held unpatentable. The merits of the petition weigh strongly in favor of institution. Likewise, as noted by the Director, “the PTAB will not rely on the *Fintiv* factors to discretionarily deny institution . . . where a petition presents compelling evidence of unpatentability.” USPTO Interim Procedure for Discretionary Denials, at 2.

3. Stipulation Not To Rely On The Petition’s Grounds In District Court

Petitioner stipulates that, if the Board institutes inter partes review, Petitioner will not seek resolution in the District Court of any ground of invalidity for the ’166 Patent that utilizes the same combination of prior art reference relied upon in the grounds of the instant petition. Petitioner’s proposal addresses the concern of narrowing the issues, as this stipulation ensures there is no overlap between the ’166 Patent invalidity theories before the Board and at issue in the District Court. Accordingly, this factor weighs in favor of institution.

XI. GROUND 1: THE COMBINATION OF HEPBURN AND KERNS RENDERS OBVIOUS CLAIMS 1-3.

A POSITA at the time of the alleged invention would have found claims 1-3 obvious over Hepburn in view of Kerns.

1. Motivation to Combine Hepburn with Kerns

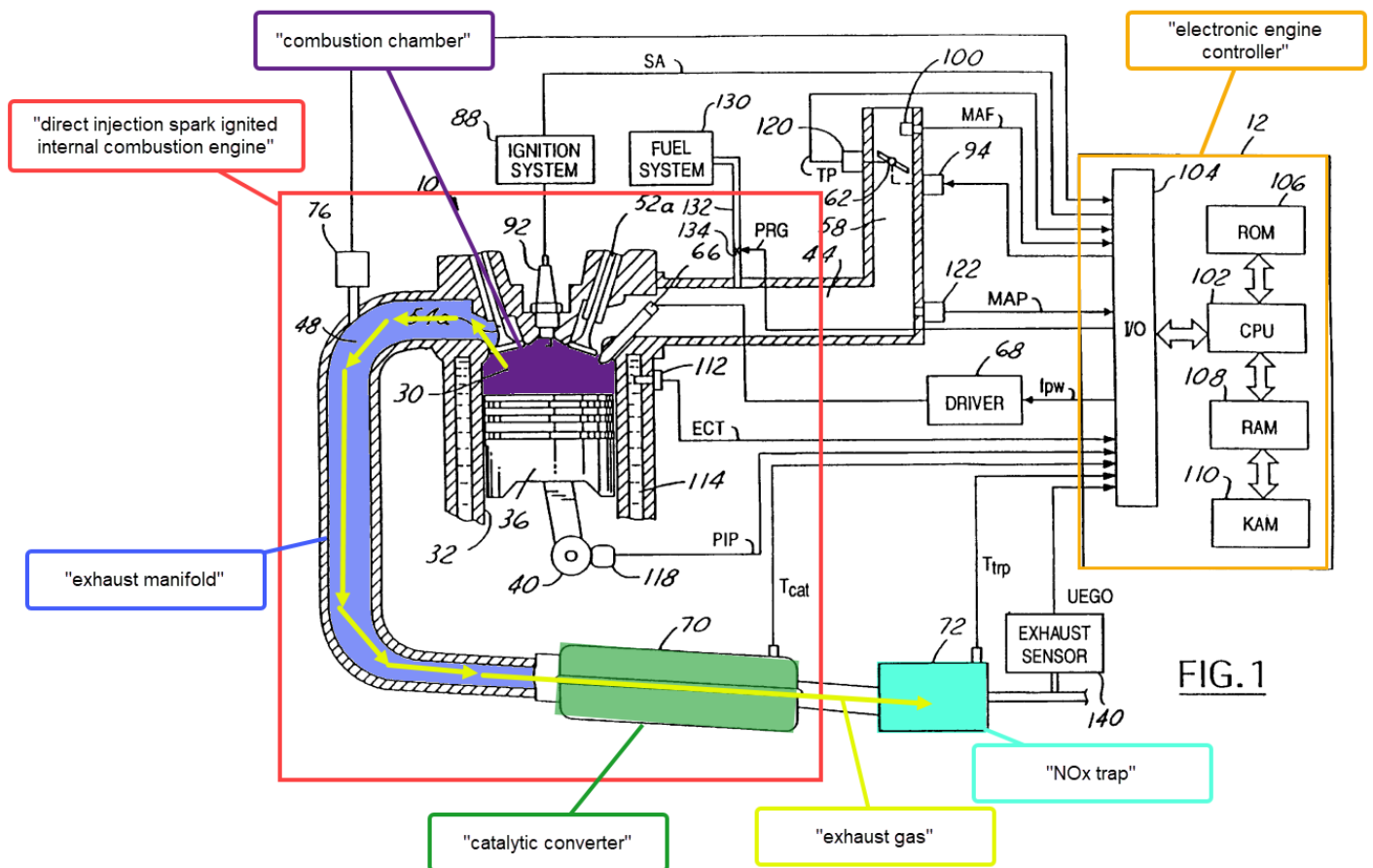
A POSITA viewing Hepburn's fuel injection methods would have been motivated to enable fuel vapors to enter the combustion chamber and particularly adjust the flow of evaporated fuel vapors when the NOx trap temperature is within a lower and upper temperature threshold, because, as Kerns teaches, doing so would decrease emissions, increase fuel economy, and allow smooth transitions into and out of vapor purge operations. Ex. 1006 at 2:33-42; Ex. 1003 at ¶¶ 88-92.

As Kerns teaches, its fuel injection technique increases the amount of time the engine is operating in stratified mode, and "therefore increase[s] fuel economy." *Id.* at 2:33-42. Thus, a POSITA would have been motivated to combine the use of fuel vapors as taught by Kerns with Hepburn's engine and emissions control system to increase Hepburn's fuel economy. Ex. 1003 at ¶¶ 88-92. A POSITA would have been further motivated to seek out teachings like those in Kerns because Hepburn's explicit goal is "to control temperature of emission control devices . . . with minimal effect on fuel economy"—the exact benefits of Kerns' teachings. Ex. 1005 at 1:44-48, Ex. 1003 at ¶¶ 88-92.

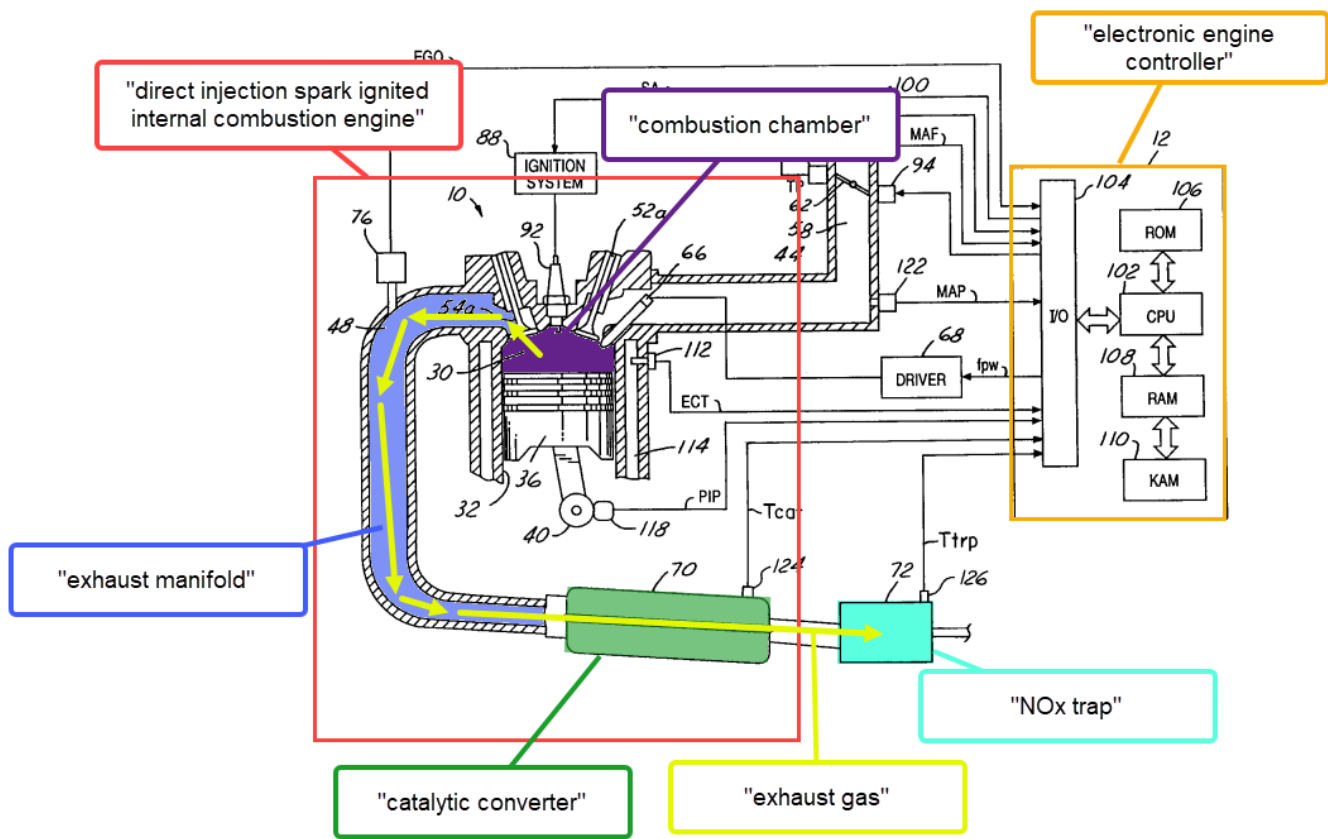
Moreover, Kerns teaches that its use of fuel vapors and adjustment of fuel flow based on temperature "decreases emissions." Ex. 1006 at 2:33-42; Ex. 1003 at ¶¶ 88-92. Thus, a POSITA would have been motivated to adjust the flow rate of evaporative fuel vapors to control the NOx trap temperature in Hepburn's engine and emissions control system as taught by Kerns to reduce engine emissions. Ex.

1003 at ¶¶ 88-92.

A POSITA would likewise be motivated to combine the teachings of Hepburn and Kerns because they are both in the *same field of endeavor* as the '166 patent, controlling fuel injection to maintain the temperature of an NOx trap and/or catalytic converter. Ex. 1001 at Abstract; Ex. 1005 at Abstract; Ex. 1006 at Abstract. As discussed below, both Hepburn and Kerns use *similar techniques to solve the same problem* as the '166 patent—indeed, Hepburn discloses nearly all of the limitations of claims 1-3 of the '166 patent, and Kerns discloses the use of fuel vapors and temperature thresholds claimed in claim 1. Moreover, a POSITA would have had a *reasonable expectation of success* of applying Kern's teachings regarding the use of fuel vapors and temperature thresholds to Hepburn's engine control system at least because Hepburn already teaches using fuel vapor purging and measuring the temperature of an NOx trap and adjusting fuel injection based on that temperature. Ex. 1005 at 4:35-45, Ex. 1003 at ¶¶ 88-92. A POSITA would understand that the code in Hepburn's electronic engine controller, which is a conventional microcomputer, could be modified to implement Kern's method of adjusting fueling based on temperature thresholds and fuel vapor purging. Ex. 1003 at ¶¶ 88-92. Moreover, as shown in Kerns' Figure 1 and Hepburn's Figure 1 below, Kerns and Hepburn disclose nearly identical engine systems and controllers for those systems.



Ex. 1006 at FIG. 1 (annotations added).



Ex. 1005 at FIG. 1 (annotations added).

Thus, a POSITA would understand that Hepburn's system could be modified to include a fuel system coupled to the intake manifold and having a tube and purge valve for introducing evaporated fuel vapors to the combustion chamber as taught by Kerns. Ex. 1003 at ¶¶ 88-92.

A POSITA would have therefore been motivated to combine the known elements of Kern's use of fuel vapors with Hepburn's engine control method using known methods because the modification would decrease emissions and improve fuel economy. Ex. 1003 at ¶¶ 88-92; *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 416 (2007) ("The combination of familiar elements according to known methods is

likely to be obvious when it does no more than yield predictable results.”).

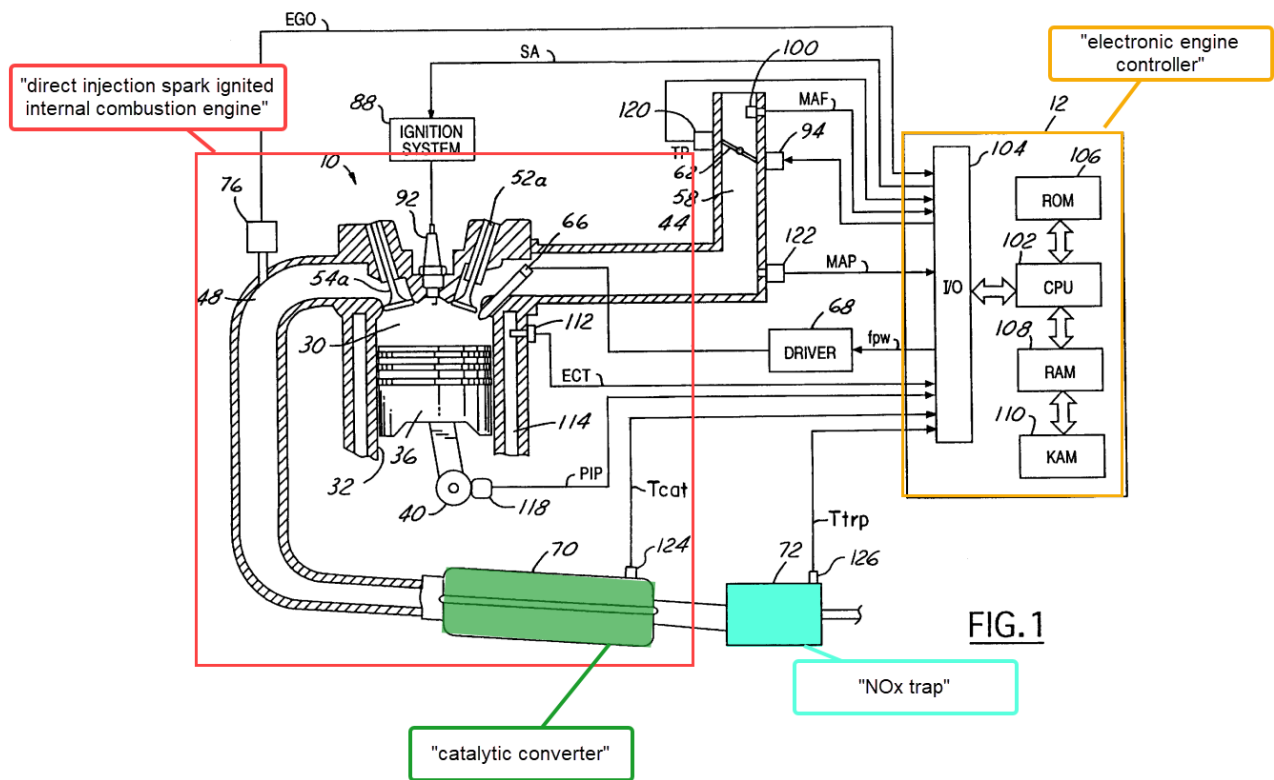
2. Claim 1:

- a. 1[pre] *“A method of controlling a direct injection spark ignited internal combustion engine that is capable of operating in a stratified mode where fuel is injected during a compression stroke of the engine and a homogeneous mode where fuels is injected during an intake stroke of the engine, the internal combustion engine having a catalytic converter and an NOx trap, comprising:”*

Hepburn discloses the preamble of claim 1. Ex. 1003 at ¶¶ 93-95.³

Hepburn teaches a “direct injection spark ignition engine” that “is fueled during a compression stroke . . . for stratified mode operation” and “in a homogeneous mode of operation” injects fuel “during [the] intake stroke.” Ex. 1005 at Abstract, 1:9-27. As shown below in Figure 1, Hepburn also discloses a direct injection spark ignition engine with a “catalytic converter 70” and an “NOx trap 72.”

³ The PTAB previously found it was reasonably likely that Hepburn discloses this claim limitation. *Volkswagen Group of America, Inc. v. Michigan Motor Technologies LLC*, IPR2020-00452, Paper 12 at 16-17 (PTAB Sept. 9, 2020).



Id. at FIG. 1 (annotations added).

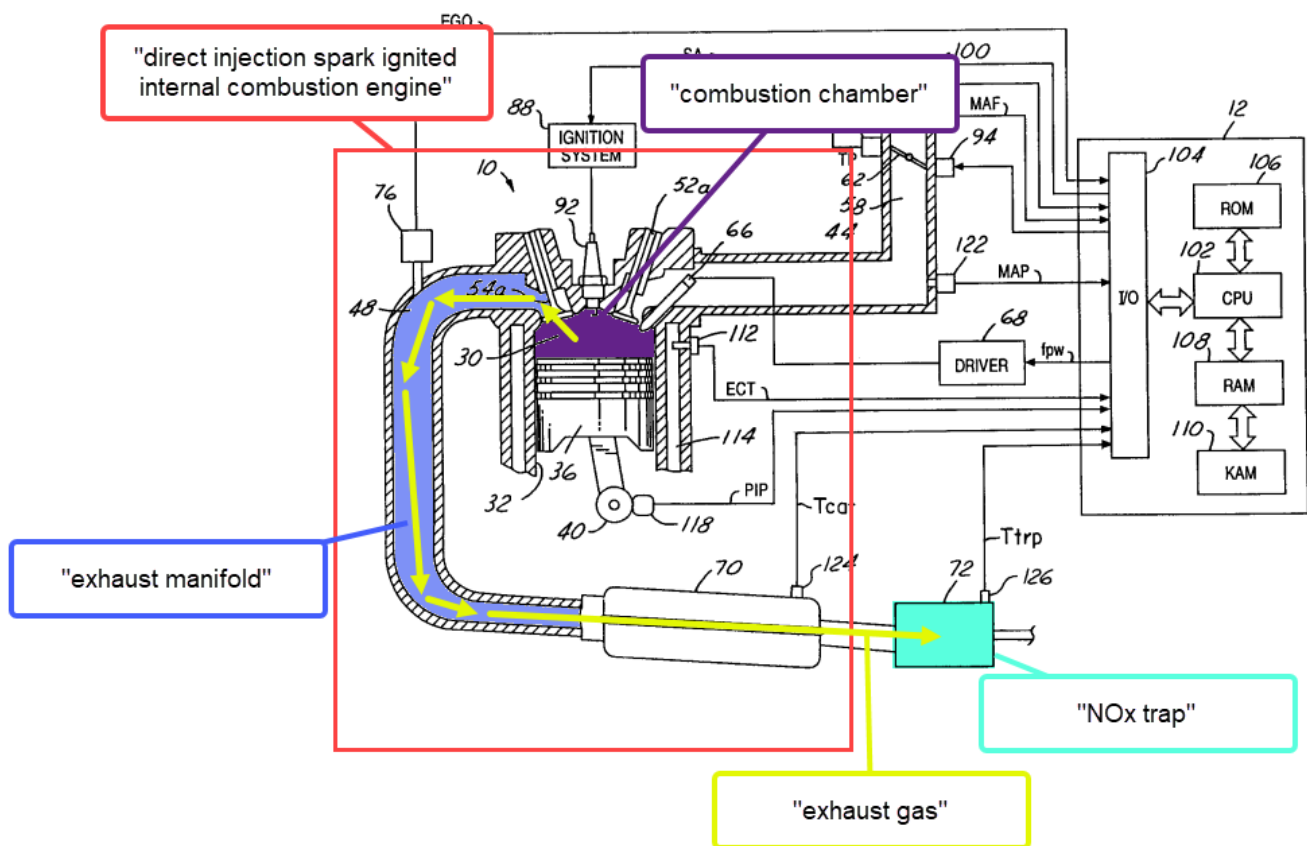
Moreover, Hepburn discloses that its invention includes “a control method . . . for a spark ignited” engine. *Id.* at 1:49-53.

Thus, Hepburn discloses the preamble of claim 1. Ex. 1003 at ¶¶ 93-95.

- b. *1[a] “measuring a first temperature of an NOx trap that is in contact with an exhaust gas exhausted from a combustion chamber while the engine is operating in the stratified mode;”*

Hepburn discloses measuring a first temperature of an NOx trap that is in contact with an exhaust gas exhausted from a combustion chamber while the engine

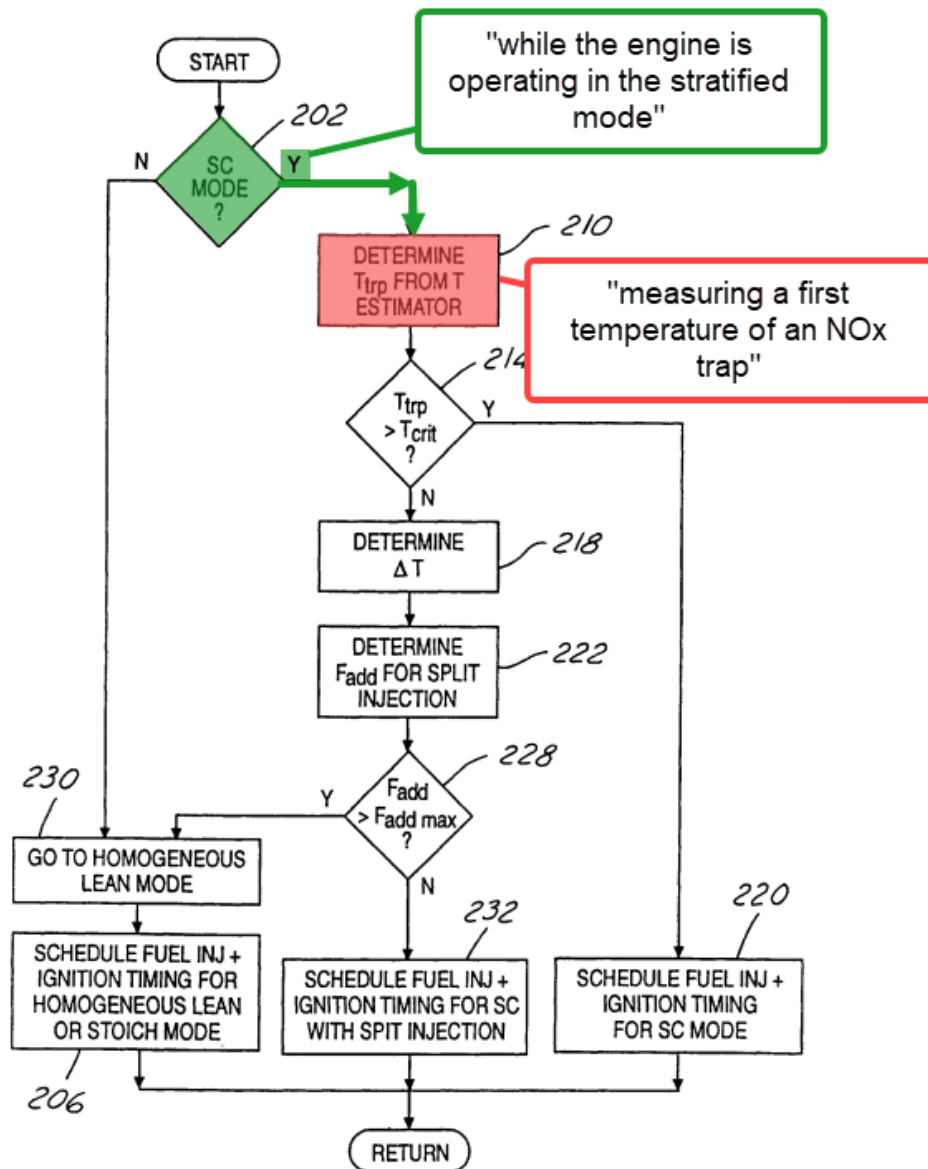
is operating in the stratified mode.⁴ Ex. 1003 at ¶¶ 96-98. As shown below in Figure 1, Hepburn teaches an NOx trap 72 that is downstream from an “exhaust manifold 48” that is connected to “[c]ombustion chamber 30” such that exhaust gas from the combustion chamber is directed through the exhaust manifold to the NOx trap. Ex. 1005 at 2:56-66; Ex. 1003 at ¶¶ 96-98.



Ex. 1005 at FIG. 1 (annotations added).

⁴ The PTAB previously found it was reasonably likely that Hepburn discloses this claim limitation. *Volkswagen Group of America, Inc. v. Michigan Motor Technologies LLC*, IPR2020-00452, Paper 12 at 17-18 (PTAB Sept. 9, 2020).

Moreover, as shown below in Figure 2, “[w]hen engine 10 is operating in the stratified mode (step 202) temperature of NOx trap (T_{trp}),” i.e., a first temperature, “is determined from the Temperature estimator” or, “[a]lternatively the temperature of NOx trap 72 may be provided by [a] temperature sensor 126.” Ex. 1005 at 4:38-44.



Id. at FIG. 2 (annotations added).

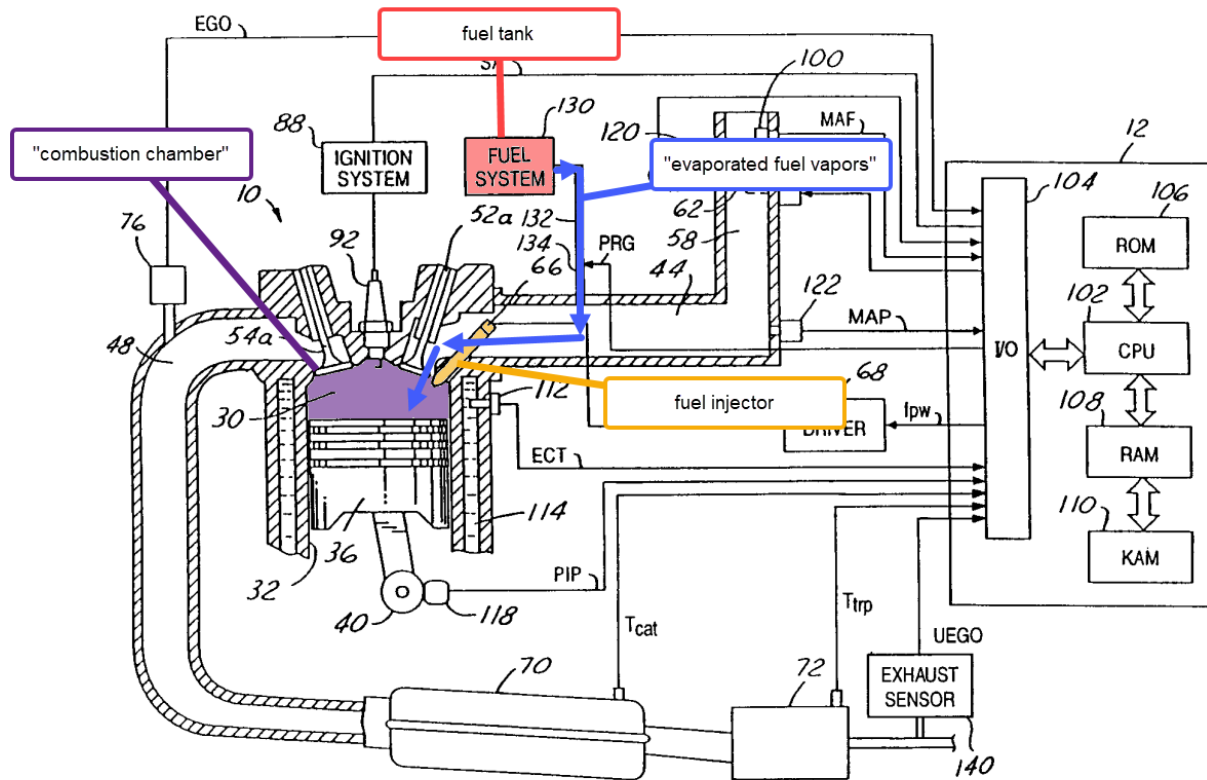
Thus, Hepburn discloses the claim limitation 1[a]. Ex. 1003 at ¶¶ 96-98

- c. *1[b]: “enabling evaporated fuel vapors to enter the combustion chamber at a flow rate while the engine is operating in the stratified mode;”*

Hepburn in view of Kerns discloses enabling evaporated fuel vapors to enter the combustion chamber at a flow rate while the engine is operating in the stratified mode. Ex. 1003 at ¶¶ 99-104. Hepburn discloses that “when [the] engine 10 is operating in the stratified mode” and “NOx trap temperature T_{trp} is less than critical temperature . . . [a]dditional quantity of fuel F_{add} . . . is injected during the exhaust stroke of each combustion chamber.” *Id.* at 4:38-58. Hepburn’s fuel injector delivers fuel at a flow rate “proportion[al] to the pulse width of signal fpw .” *Id.* at 2:66-3:8.

Likewise, Kerns discloses enabling evaporated fuel vapors to enter the combustion chamber at a flow rate while the engine is operating in the stratified mode.⁵ Ex. 1003 at ¶¶ 99-104. Kerns teaches “purging fuel vapors into the combustion chamber,” and particularly “purging fuel vapors during stratified operation.” Ex. 1006 at 2:6-23.

⁵ The PTAB previously found it was reasonably likely that Kerns alone invalidates this claim limitation. *Volkswagen Group of America, Inc. v. Michigan Motor Technologies LLC*, IPR2020-00452, Paper 12 at 35-36 (PTAB Sept. 9, 2020).



Id. at FIG. 1 (annotations added).

Kerns further teaches a “purge flow rate” $\dot{m}_p$, *i.e.*, a flow rate at which the evaporated fuel vapors enter the combustion chamber. *Id.* at 9:10-48.

A POSITA would have understood that modifying Hepburn’s engine control method to use evaporated fuel vapors based on the teachings of Kerns would both increase fuel economy and decrease engine emissions. Ex. 1006 at 2:33-42; Ex. 1003 at ¶¶ 99-104.

A POSITA would have been able to easily implement Kerns’ teachings by modifying the code in Hepburn’s electronic engine controller to enable fuel vapors to enter the combustion chamber, including at least because Hepburn discloses that

its controller is already capable of enabling fuel vapor purging and Kerns and Hepburn's engine systems are nearly identical. Ex. 1005 at 4:35-45, FIG. 1; Ex. 1006 at FIG. 1, Ex. 1003 at ¶¶ 99-104. Thus, a POSITA would understand that Hepburn's system could be modified to include a fuel system coupled to the intake manifold and having a tube and purge valve for introducing evaporated fuel vapors to the combustion chamber as taught by Kerns. Ex. 1003 at ¶¶ 88-92.

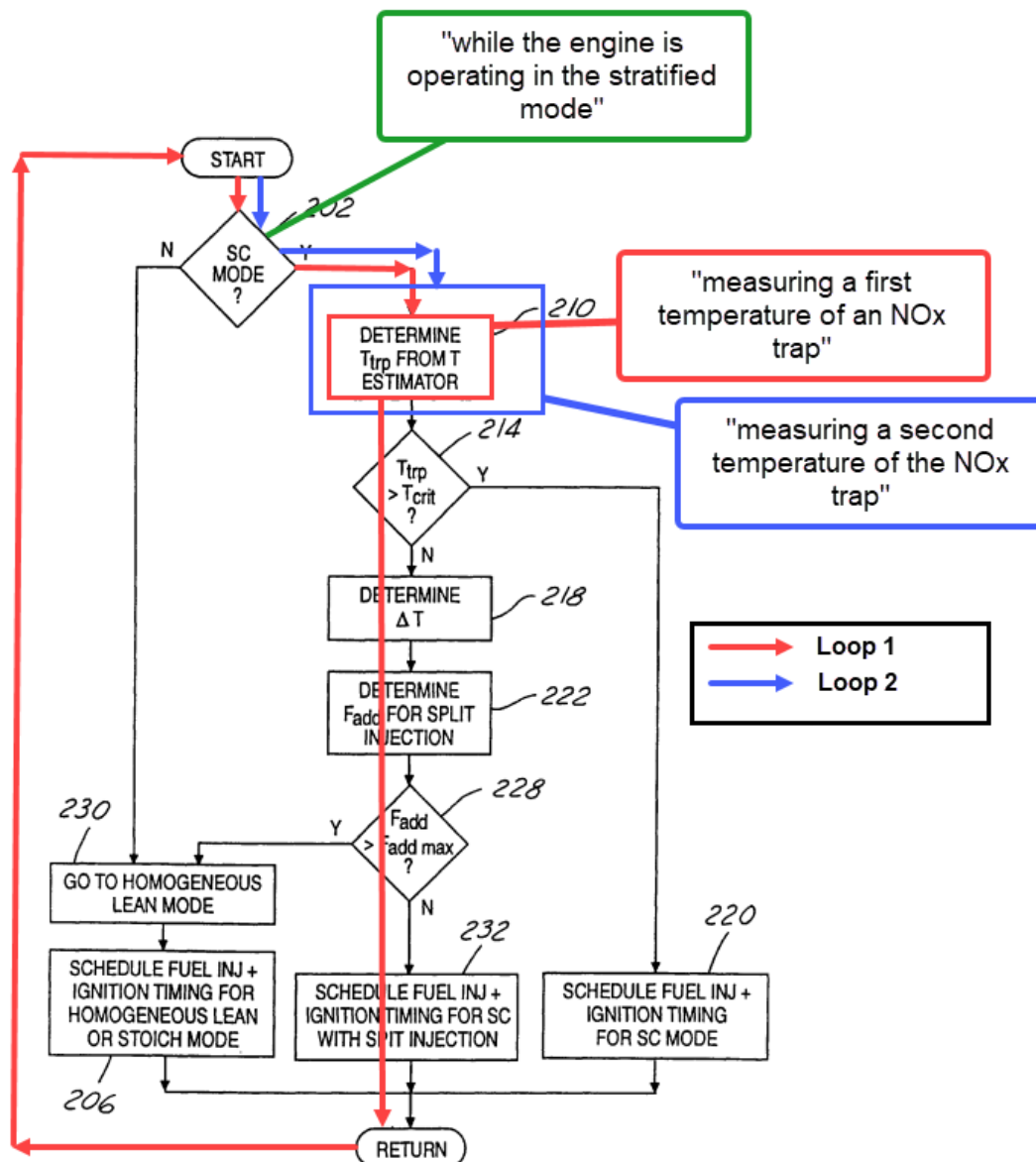
Thus, Hepburn in view of Kerns renders obvious claim limitation 1[b]. Ex. 1003 at ¶¶ 99-104.

- d. *1[c]: "measuring a second temperature of the NOx trap while the engine is operating in the stratified mode; and"*

Hepburn discloses measuring a second temperature of the NOx trap while the engine is operating in the stratified mode.⁶ Ex. 1003 at ¶¶ 105-106. As shown below in Figure 2, Hepburn discloses a method that is a continuous loop in which 1) the engine controller determines whether the engine is operating in stratified mode and 2) the temperature of the NOx trap is measured. Ex. 1005 at 4:38-41. As explained in § XI.2.b, *supra*, on the first loop of Hepburn's method, the controller determines whether the engine is operating in stratified mode and measures a first temperature of the NOx trap. Ex. 1005 at 4:38-41; Ex. 1003 at ¶¶ 105-106. On

⁶ The PTAB previously found it was reasonably likely that Hepburn discloses this claim limitation. *Volkswagen Group of America, Inc. v. Michigan Motor Technologies LLC*, IPR2020-00452, Paper 12 at 22-23 (PTAB Sept. 9, 2020).

the second loop of Hepburn's method, Hepburn's system again determines whether the engine is operating in stratified mode and again measures the temperature of the NOx trap, *i.e.*, measures a second temperature of the NOx trap. Ex. 1005 at 4:38-41; Ex. 1003 at ¶¶ 105-106.



Ex. 1005 at FIG. 2 (annotations added).

Thus, Hepburn discloses the claim limitation 1[c]. Ex. 1003 at ¶¶ 105-106.

- e. *1[d]: “adjusting the flow rate of the evaporated fuel vapors as a function of the second temperature when the second temperature is within a lower temperature threshold and an upper temperature threshold.”*

Hepburn in view of Kerns discloses adjusting the flow rate of the evaporated fuel vapors as a function of the second temperature when the second temperature is within a lower temperature threshold and an upper temperature threshold.⁷ Ex. 1003 at ¶¶ 107-116. Hepburn discloses adjusting the flow of fuel as a function of the second temperature. Ex. 1003 at ¶¶ 107-116. Hepburn’s teaches, on the second loop of its method, determining whether the engine is operating in stratified mode, determining the second temperature of NOx trap 72 and, “[i]f NOx trap temperature . . . is less than critical temperature Tcrit” “difference in temperature ΔT is determined” and a “quantity of fuel Fadd, which is proportional to ΔT ” “is injected during the exhaust stroke of each combustion chamber,” *i.e.*, the flow rate of fuel is adjusted. Ex. 1005 at 4:39-62.

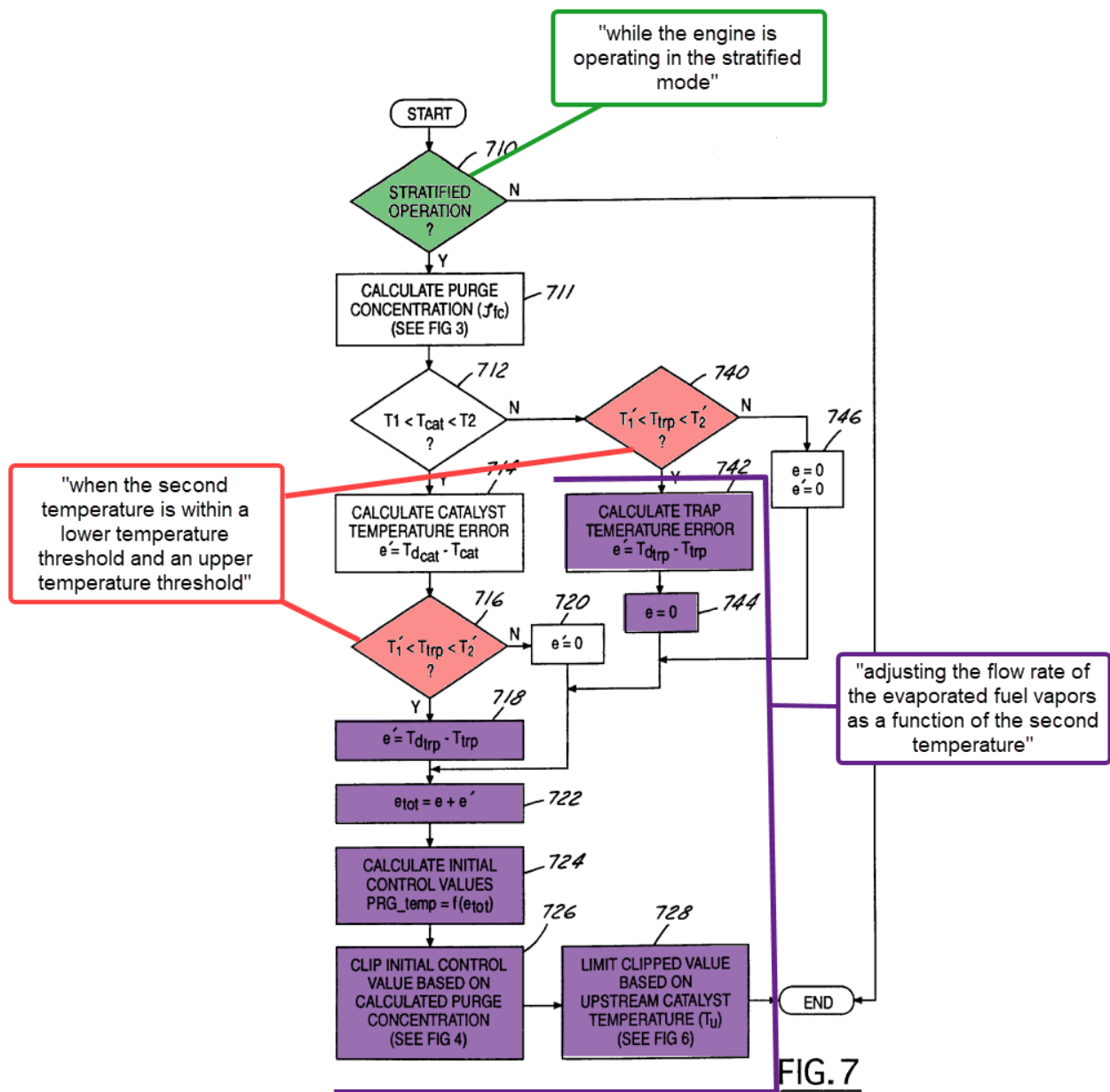
⁷ The PTAB previously found it was reasonably likely that Kerns alone discloses this claim limitation. *Volkswagen Group of America, Inc. v. Michigan Motor Technologies LLC*, IPR2020-00452, Paper 12 at 37-39 (PTAB Sept. 9, 2020).

$$\dot{m}_p = g(PRG)$$

Id. at 9:10-15 (showing fuel vapor flow rate $\dot{m}_p$ is calculated as a function of control signal PRG).

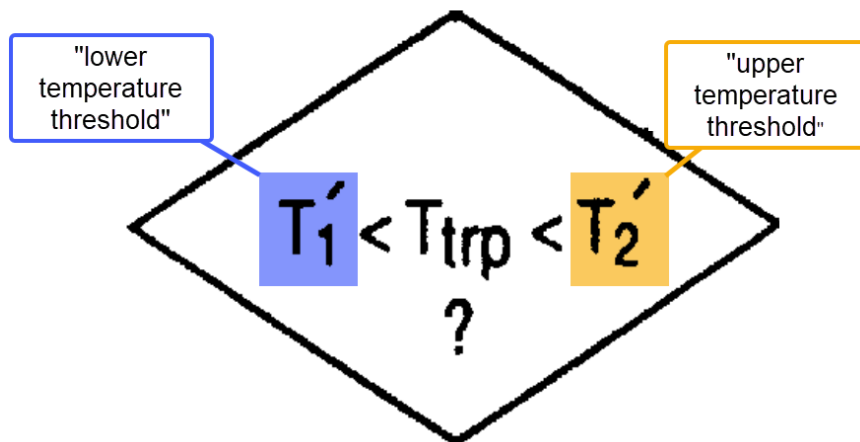
Control signal PRG is calculated based on a NOx trap temperature error e' .

Id. at 11:8-11. NOx trap temperature error e' is the difference between desired NOx trap temperature T_{dtrp} and actual NOx trap temperature T_{trp} , *i.e.*, it is a function of the NOx trap temperature. As shown below in Figure 7, e' —and subsequently control signal PRG and evaporated fuel vapor flow rate $\dot{m}_p$ —are recalculated when (1) the engine is operating in stratified mode and (2) NOx trap temperature T_{trp} is between lower threshold value $T1'$ and upper threshold value $T2'$. *Id.* at 11:1-38. Moreover, Kerns' methods, including the one disclosed in Figure 7, run in a continuous loop such that on the second loop of the method a second temperature of the NOx trap would be measured. Ex. 1003 at ¶¶ 107-116.



Id. at FIG. 7 (annotations added).⁸

⁸ Figure 7 of Kerns incorrectly labels the output temperature error of step 714 as "e'." The output of step 714 is a catalyst temperature "e." Ex. 1006 at 10:64-67.



Id.

Thus, Kerns discloses adjusting the flow rate of the evaporated fuel vapors as a function of the second temperature when the second temperature is within a lower temperature threshold and an upper temperature threshold.

A POSITA would have understood that modifying Hepburn's engine control method to use evaporated fuel vapors and adjustment of fuel flow based on a lower and upper temperature threshold based on the teachings of Kerns would increase fuel economy and decrease emissions. Ex. 1006 at 2:33-42; Ex. 1003 at ¶¶ 107-116.

A POSITA would have been able to easily implement Kerns' teachings by modifying the code in Hepburn's electronic engine controller to enable fuel vapors to enter the combustion chamber and to adjust fuel flow based on whether an NOx temperature is between an upper and lower threshold, including at least because Hepburn discloses that its controller is already capable of enabling fuel vapor purging and measuring the temperature of an NOx trap and adjusting fuel injection

based on that temperature. Ex. 1005 at 4:35-45, Ex. 1003 at ¶¶ 107-116. A POSITA would understand that the code in Hepburn's electronic engine controller, which is a conventional microcomputer, could be modified to implement the method of adjusting fueling based on temperature thresholds and fuel vapor purging based on the teachings of Kerns. Ex. 1003 at ¶¶ 107-116. Moreover, a POSITA would have understood that any modifications to Hepburn based on the teachings of Kerns would have had a reasonable expectation of success, including because Hepburn and Kerns disclose nearly identical engine systems. See Ex. 1005 at FIG. 1; Ex. 1006 at FIG. 1. Thus, a POSITA would understand that Hepburn's system could be modified to include a fuel system coupled to the intake manifold and having a tube and purge valve for introducing evaporated fuel vapors to the combustion chamber as taught by Kerns. Ex. 1003 at ¶¶ 88-92.

Thus, Hepburn in view of Kerns renders obvious claim limitation 1[d]. Ex. 1003 at ¶¶ 107-116.

3. Claim 2:

- a. *"The method of claim 1, further comprising: switching the engine to the homogeneous mode when the second temperature is below the lower temperature threshold."*

Hepburn in view of Kerns discloses the method of claim 1 further comprising switching the engine to the homogeneous mode when the second temperature is below the lower temperature threshold. Ex. 1003 at ¶¶ 117-120. As explained in § XI.2, *supra*, Hepburn in view of Kerns discloses the method of claim 1. Ex. 1003

at ¶¶ 117-120. Further, Hepburn teaches “[w]hen additional fuel Fadd needed to raise NOx trap 72 temperature to the desired temperature is greater than the fuel savings associated with stratified engine operations,” i.e., when the NOx trap temperature is below a lower threshold, “engine 10 is switched from the stratified mode to the homogeneous mode.” Ex. 1005 at 4:63-67.

Thus, Hepburn in view of Kerns renders obvious claim 2. Ex. 1003 at ¶¶ 117-120.

4. Claim 3:

- a. *The method of claim 2, further comprising: measuring a fuel level of the evaporated fuel vapors after the switching the engine to the homogeneous mode.*

Hepburn in view of Kerns discloses the method of claim 2 further comprising measuring a fuel level of the evaporated fuel vapors after switching the engine to the homogeneous mode. Ex. 1003 at ¶¶ 121-127. As explained in §§ XI.2-3, *supra*, Hepburn in view of Kerns discloses the method of claim 2. Ex. 1003 at ¶¶ 121-127. Kerns further teaches that “[a]s the engine switches to the homogeneous mode, the new fuel flow rate from the fuel injectors ($\dot{m}_{fh}$) is found as:

$$\dot{m}_{fh} = \dot{m}_{f_{stoich}} - \rho_f \dot{V}_p$$

when fuel vapor purge is continued in the homogeneous mode.” Ex. 1006 at 8:15-22.

As shown in the above formula taught by Kerns, to calculate the new fuel flow

rate $\dot{m}_{fh}$ Kerns teaches first calculating the input ρ_f , the “fuel vapor concentration.”

Id. at 5:5-8, 8:15-22. Kerns teaches that the fuel vapor concentration ρ_f is calculated based on the following formula:

$$\rho_f = \frac{\dot{m}_p + \dot{m}_a - \lambda S \dot{m}_f}{\dot{m}_p(1 + \lambda S)}$$

Id. at 5:10-14. Kerns teaches that in the above formula used to calculate fuel vapor concentration when the engine switches to homogeneous mode, λ “is measured relative air/fuel ratio in the exhaust,” *i.e.*, a measured fuel level of the evaporated fuel vapors. *Id.* at 5:14-24. Kerns teaches measuring λ via a “UEGO” (universal exhaust gas oxygen sensor). *Id.* at 3:21-28. Thus, Kerns discloses after switching the engine to the homogeneous mode, measuring relative air/fuel ratio λ , *i.e.*, a measured fuel level, to calculate fuel vapor concentration and the new flow rate. Ex. 1003 at ¶¶ 121-127.

A POSITA would have understood that modifying Hepburn’s engine control method to use evaporated fuel vapors and a UEGO sensor based on the teachings of Kerns, including measuring the level of fuel vapors available when operating the engine in a homogeneous mode, would increase fuel economy and decrease emissions. Ex. 1006 at 2:33-42; Ex. 1003 at ¶¶ 121-127.

A POSITA would have been able to easily implement Kerns’ teachings by modifying Hepburn’s system to use a UEGO sensor, and modifying the code in

Hepburn's electronic engine controller to both receive λ measurements from the UEGO sensor and enable fuel vapors to enter the combustion chamber, including at least because Hepburn discloses that its controller is already capable of enabling fuel vapor purging, Hepburn already discloses that its system includes an exhaust gas oxygen sensor, and Hepburn's system is nearly identical to Kerns' such that a POSITA would easily be able to include fuel vapor purging hardware into Hepburn's system based on the teachings of Kerns. Ex. 1005 at 3:20-21 ("Exhaust gas oxygen sensor 76 is shown coupled to exhaust manifold 48"), 4:35-45, FIG. 1; Ex. 1006 at FIG. 1; Ex. 1003 at ¶¶ 121-127.

Thus, Hepburn in view of Kerns renders obvious claim 3. Ex. 1003 at ¶¶ 121-127.

XII. GROUND 2: THE COMBINATION OF HEPBURN, KERNS, AND KAINZ RENDERS OBVIOUS CLAIMS 4 AND 5.

A POSITA at the time of the alleged invention would have found claims 4 and 5 obvious over Hepburn in view of Kerns and Kainz.

1. Motivation to Combine Hepburn, Kerns, and Kainz

A POSITA would have been motivated to modify the system and methods combining Hepburn and Kerns as described in § XI.1 *supra*, to include a method of continuous calibration of a universal exhaust gas oxygen sensor based on the teachings of Kainz because, as explicitly taught by Kainz, the sensor provides "improved fuel control performance." Ex. 1007 at 1:27-34; Ex. 1003 at ¶¶ 128-

133.

Kainz discloses a fuel control system using a universal exhaust gas oxygen sensor that “enables improved fuel control performance.” Ex. 1007 at 1:27-34. Similarly, Kerns discloses a universal exhaust gas oxygen sensor. Ex. 1006 at 3:22-28. Kainz also teaches a method for “automatically and periodically learn[ing] or re-learn[ing]” a “transfer function” of the universal exhaust gas oxygen sensor. Ex. 1007, Abstract. Automatically and continuously updating the UEGO sensor transfer function as taught by Kainz would maximize the amount of time the engine is operating in the stratified mode, which would maximize fuel economy and minimize emissions. Ex. 1003 at ¶¶ 128-133. A POSITA would therefore be motivated to modify the Hepburn-Kerns combination to use a UEGO sensor having a transfer function as taught by Kainz to improve fuel control performance, maximize fuel economy, and minimize emissions. Ex. 1003 at ¶¶ 128-133.

Additionally, a POSITA would be motivated to modify Hepburn’s systems to include a universal exhaust gas oxygen sensor because use of such an accurate sensor would enable improved control of fuel economy and NOx trap temperature. Ex. 1003 at ¶¶ 128-133.

A POSITA would likewise be motivated to combine the Hepburn-Kerns combination with Kainz because they are all in the *same field of endeavor* as the ’166 patent, controlling fuel injection based on NOx trap temperature. Ex. 1001 at Abstract; Ex. 1005 at Abstract; Ex. 1006 at Abstract; Ex. 1007 at Abstract. As

discussed throughout this Petition, Hepburn, Kerns, and Kainz use ***similar techniques to solve the same problem*** as the '166 patent—for example, Hepburn discloses nearly all of the limitations of claims 1-5 of the '166 patent; Kerns discloses the use of fuel vapors and temperature thresholds claimed in claim 1, measuring fuel levels as claimed in claim 3, and the universal exhaust gas oxygen sensor of claim 5; and Kainz discloses a function for using a universal exhaust gas oxygen sensor to measure fuel levels, as claimed in claim 5. Moreover, a POSITA would have had a ***reasonable expectation of success*** of applying Kainz's teachings regarding a universal gas oxygen sensor to Hepburn's engine control system at least because Hepburn already teaches using an exhaust gas oxygen sensor coupled to its exhaust manifold upstream of its catalytic converter, the same type of sensor and location disclosed by Kainz. Ex. 1005 at 3:20-31, FIG. 1; Ex. 1007 at 2:64-3:5, FIG. 1; Ex. 1003 at ¶¶ 128-133.

A POSITA would understand that the Hepburn-Kerns combination's system could easily be modified to use a universal exhaust gas oxygen sensor having a transfer function as taught by Kainz because Hepburn already teaches a system with an exhaust gas oxygen sensor, Kerns already teaches a system with a universal exhaust gas oxygen sensor, and the code in Hepburn's electronic engine controller could be modified to read signals and data from the sensor and perform the transfer function calibration as taught by Kainz. Ex. 1003 at ¶¶ 128-133.

A POSITA would have therefore been motivated to combine the known

elements of Kainz’s use of a universal exhaust gas oxygen sensor with Hepburn’s engine control method using known methods because the modification would enable improved fuel control performance. Ex. 1003 at ¶¶ 128-133; *KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 416 (2007) (“The combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results.”).

2. Claim 4:

- a. *“The method of claim 3, wherein the measuring the fuel level comprises measuring the fuel level via an exhaust gas oxygen sensor.”*

Hepburn in view of Kerns and Kainz discloses the method of claim 3, wherein the measuring the fuel level comprises measuring the fuel level via an exhaust gas oxygen sensor. Ex. 1003 at ¶¶ 134-139. As explained in § XI.4, *supra*, Hepburn in view of Kerns renders obvious claim 3. Ex. 1003 at ¶¶ 134-139. Kerns further teaches an “[e]xhaust gas oxygen sensor 76” “coupled to exhaust manifold 48” that measures “a relative air fuel ratio λ ,” *i.e.*, the fuel level. Ex. 1006 at 3:22-28.

Like Kerns, Kainz teaches a “wide-range exhaust gas oxygen sensor,” *i.e.*, a universal gas oxygen sensor, and a method for “automatically and periodically learn[ing] or re-learn[ing]” a “transfer function” for measuring fuel level via the sensor. Ex. 1007, Abstract; 1:27-31, 2:64-3:5.

A POSITA would have understood that modifying Hepburn’s engine control method to use evaporated fuel vapors and a UEGO sensor based on the teachings of

Kerns, and learning/using an accurate UEGO transfer function as taught by Kainz when operating the engine in a homogeneous mode, would increase fuel economy and decrease emissions. Ex. 1006 at 2:33-42; Ex. 1003 at ¶¶ 134-139.

A POSITA would have been able to easily modify Hepburn's system based on the teachings of Kerns and Kainz. A POSITA would understand that Hepburn's system could be easily modified to use a UEGO sensor, including at least because Hepburn's system already includes an exhaust gas oxygen sensor. Ex. 1005 at 3:20-21 ("Exhaust gas oxygen sensor 76 is shown coupled to exhaust manifold 48"); Ex. 1003 at ¶¶ 134-139. Further, a POSITA would be able to easily modify the code in Hepburn's electronic engine controller to receive fuel level measurements from the UEGO sensor, as taught by Kerns, and update its transfer function accordingly, as taught by Kainz. Ex. 1003 at ¶¶ 134-139.

Thus, Hepburn in view of Kerns and Kainz renders obvious claim 4. Ex. 1003 at ¶¶ 134-139.

3. Claim 5:

- a. *"The method of claim 4, wherein the measuring the fuel level comprises measuring the fuel level with an universal exhaust gas oxygen sensor."*

Hepburn in view of Kerns and Kainz discloses the method of claim 4, wherein the measuring the fuel level comprises measuring the fuel level with a universal exhaust gas oxygen sensor. Ex. 1003 at ¶¶ 140-144. As explained in § XII.2-5, *supra*, Hepburn in view of Kerns discloses the method of claim 4. Ex. 1003 at ¶¶

140-144. Kerns discloses that its exhaust gas oxygen sensor 76 provides “signal UEGO,” *i.e.*, it is a universal exhaust gas oxygen sensor. Ex. 1006 at 3:22-28; Ex. 1003 at ¶¶ 192-195. Likewise, Kainz discloses a fuel emissions system that incorporates a “universal exhaust gas oxygen sensor,” and transfer function for calibrating the sensor to measure fuel levels. Ex. 1007 at Abstract, 1:27-31, 2:64-3:5.

A POSITA would have been motivated to modify the Hepburn-Kerns combination to use a method to learn an accurate transfer function for a universal exhaust gas oxygen sensor, as taught by Kainz, to perform an accurate measurement of fuel levels of the evaporative fuel vapors, as Kainz explicitly teaches, its universal exhaust gas oxygen sensor “enables improved fuel control performance.” Ex. 1007 at 1:27-34.

A POSITA would understand that Hepburn’s system could easily be modified to use a universal exhaust gas oxygen sensor as taught by Kainz because Hepburn already teaches a system with an exhaust gas oxygen sensor. Ex. 1003 at ¶¶ 140-144. Moreover, a POSITA would be able to modify the code in Hepburn’s electronic engine controller to read signals and data from the sensor and automatically and periodically update the sensor’s transfer function as taught by Kainz. Ex. 1003 at ¶¶ 140-144.

Thus, Hepburn in view of Kerns and Kainz renders obvious claim 5. Ex. 1003 at ¶¶ 140-144.

XIII. GROUND 3: THE COMBINATION OF KERNS AND TAKAHASHI RENDERS OBVIOUS CLAIMS 1-5

A POSITA at the time of the alleged invention would have found claims 1-5 obvious over Kerns in view of Takahashi.⁹

1. Motivation to Combine Kerns with Takahashi

A POSITA viewing Kerns' fuel injection methods would have been motivated to modify Kerns' method to operate a continuous loop that measures a first and second temperature of an NOx trap based on the teachings of Takahashi. Ex. 1003 at ¶¶ 146-150.

A POSITA would have been motivated to make these modifications to Kerns based on the teachings of Takahashi because, as explicitly taught by Takahashi, continuous monitoring of the temperature of devices used for catalytic treatment, such as a catalytic converter or NOx trap, and adjusting fuel injection based on such temperatures enables the catalyst to discharge oxides without impairing the durability of the catalyst. Ex. 1008 at 1:49-54; Ex. 1003 at ¶¶ 146-150. Takahashi teaches a routine that repeatedly measures catalyst temperature, determines whether the temperature exceeds a threshold, and then, based on whether the temperature exceeds the threshold, adjusts the flow of fuel. *Id.* at 10:30-57.

⁹ The PTAB previously found it was reasonably likely that Kerns alone invalidates claims 1-5. *Volkswagen Group of America, Inc. v. Michigan Motor Technologies LLC*, IPR2020-00452, Paper 12 at 33-40 (PTAB Sept. 9, 2020).

Thus, a POSITA would be motivated to increase Kerns' catalyst durability by modifying Kerns' method to repeatedly monitor catalyst temperature as taught by Takahashi. Ex. 1003 at ¶¶ 146-150.

A POSITA would likewise be motivated to combine the teachings of Kerns and Takahashi because they are both in the *same field of endeavor* as the '166 patent, controlling fuel injection to maintain the temperature of an NOx trap and/or catalytic converter. Ex. 1001 at Abstract; Ex. 1006 at Abstract; Ex. 1008 at Abstract. As discussed below, both Kerns and Takahashi use *similar techniques to solve the same problem* as the '166 patent—indeed, Kerns discloses nearly all of the limitations of claim 1-5 of the '166 patent, and Takahashi discloses measuring a second temperature of an NOx trap and adjusting fuel flow as a function of that temperature as claimed in claim 1. Moreover, a POSITA would have had a *reasonable expectation of success* of applying Takahashi's continuous catalyst temperature monitoring to Kerns' engine control system at least because Kerns already teaches methods for adjusting fuel flow based on the temperature of an NOx trap. Ex. 1006 at FIG. 7; Ex. 1003 at ¶¶ 146-150.

A POSITA would understand that the code in Kerns' electronic engine controller, which is a conventional microcomputer, could be modified to repeatedly measure the NOx trap temperature and adjust fueling based on the temperature as taught by Takahashi by repeating the methods already disclosed by Kerns. Ex. 1003 at ¶¶ 146-150.

A POSITA would have therefore been motivated to combine the known elements of Takahashi's use of continuous NOx trap temperature monitoring with Kerns' engine control method using known methods because the modification would increase Kerns' catalyst durability. Ex. 1003 at ¶¶ 146-150; *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 416 (2007) ("The combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results.").

2. Claim 1

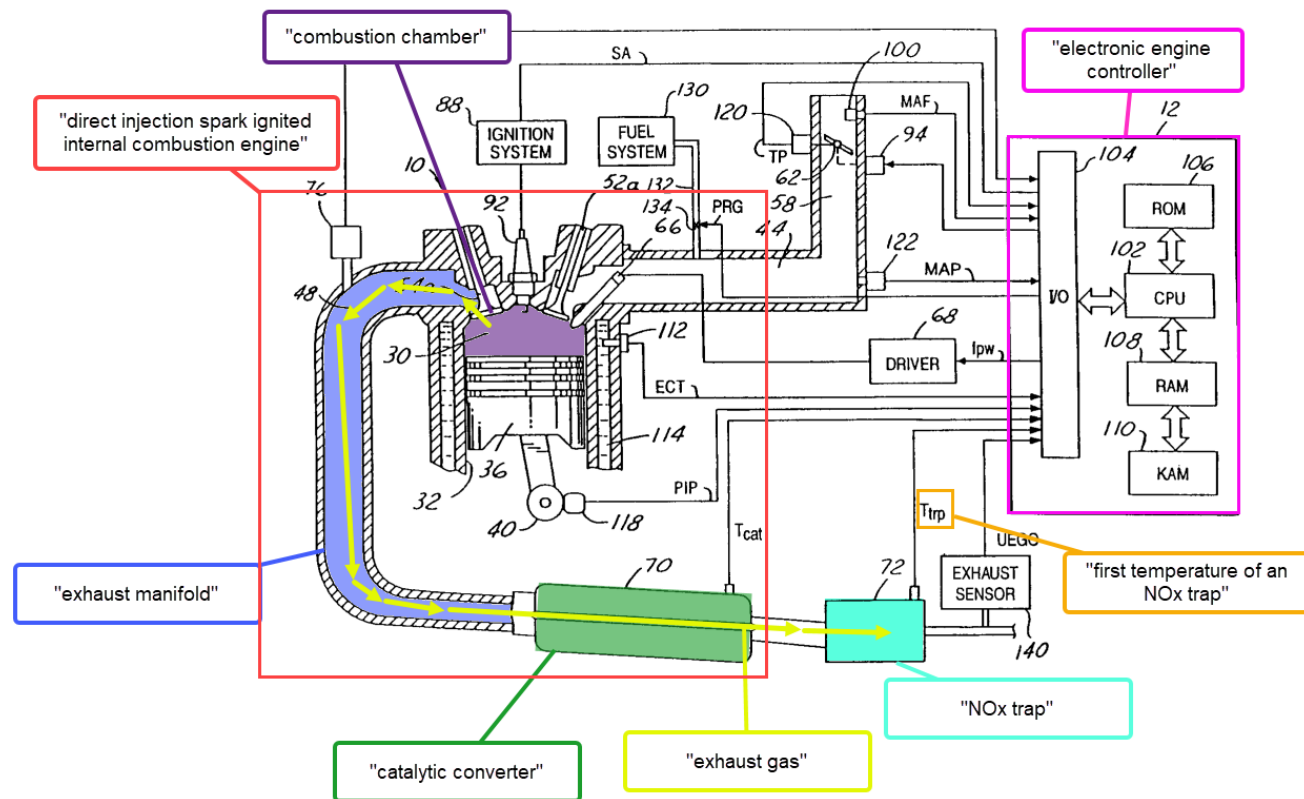
- a. *1[pre] "A method of controlling a direct injection spark ignited internal combustion engine that is capable of operating in a stratified mode where fuel is injected during a compression stroke of the engine and a homogeneous mode where fuels is injected during an intake stroke of the engine, the internal combustion engine having a catalytic converter and an NOx trap, comprising:"*

Kerns discloses the preamble of claim 1.¹⁰ Ex. 1003 at ¶¶ 151-154.

Kerns teaches a "direct injection spark ignition engine" that can "operat[e] in a stratified mode where fuel is injected directly into cylinder 30 during a compression stroke" and in a "homogeneous mode" where "controller 12 activates fuel injector 66 during the intake stroke." Ex. 1006 at Abstract, 1:26-2:20, 3:41-42, 9:52-55. As shown below in Figure 1, Kerns also discloses a direct injection

¹⁰ The PTAB previously found it was reasonably likely that Kerns invalidates this claim limitation. *Volkswagen Group of America, Inc. v. Michigan Motor Technologies LLC*, IPR2020-00452, Paper 12 at 33-34 (PTAB Sept. 9, 2020).

spark ignition engine with a “catalytic converter 70” and an “NOx trap 72.” 3:21-65.



Id. at FIG. 1 (annotations added).

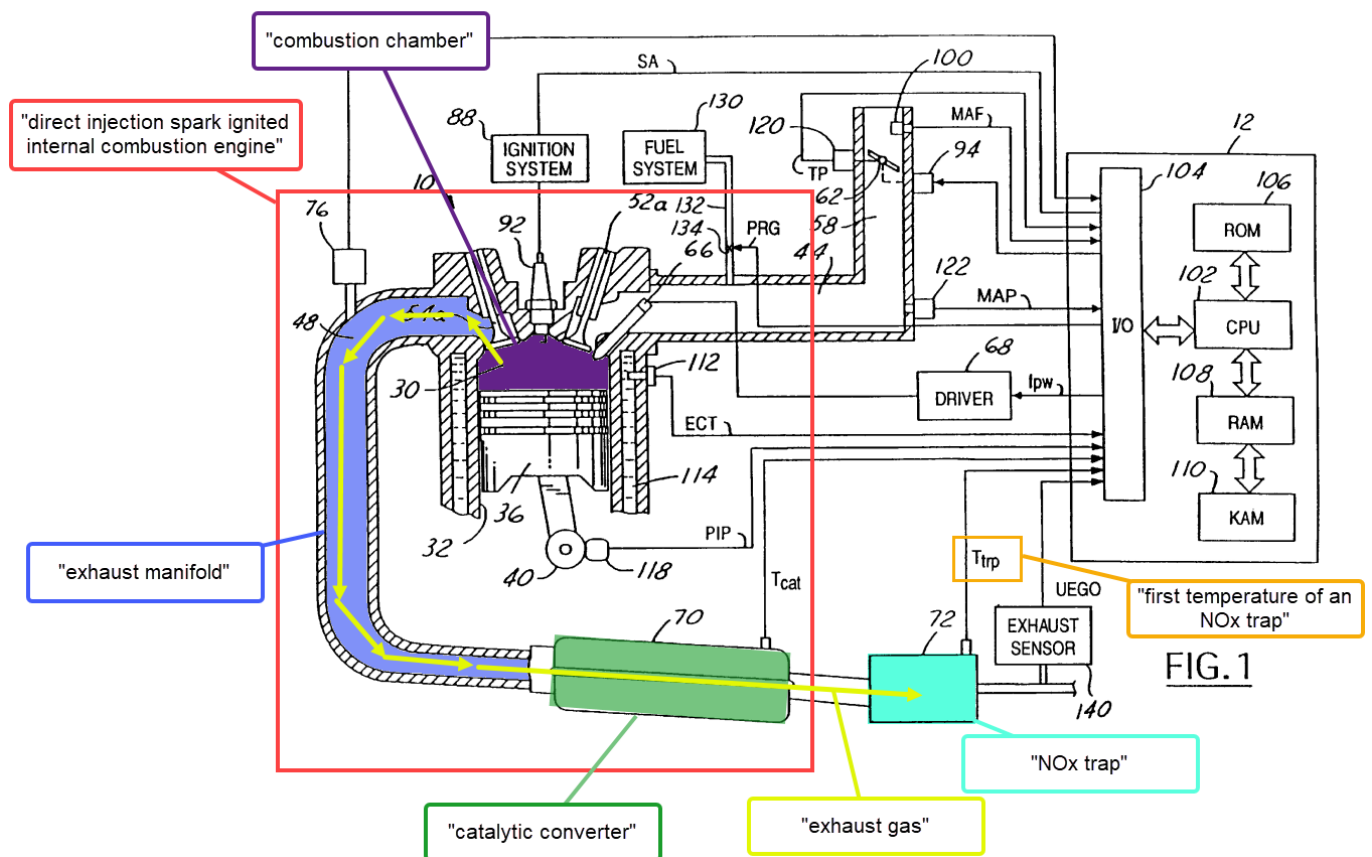
Moreover, Kerns discloses that its invention includes an “engine control method.” *Id.* at 1:1-2.

Thus, Kerns discloses the preamble of claim 1. Ex. 1003 at ¶¶ 151-154.

- b. 1[a] “measuring a first temperature of an NOx trap that is in contact with an exhaust gas exhausted from a combustion chamber while the engine is operating in the stratified mode;”

Kerns discloses measuring a first temperature of an NOx trap that is in contact with an exhaust gas exhausted from a combustion chamber while the engine is

operating in the stratified mode.¹¹ Ex. 1003 at ¶¶ 155-158. As shown below in Figure 1, Kerns teaches an NO_x trap 72 that is downstream from an “exhaust manifold 48” that is connected to “[c]ombustion chamber 30” such that exhaust gas from the combustion chamber is directed through the exhaust manifold to the NO_x trap. Ex. 1006 at 2:59-3:66; Ex. 1003 at ¶¶ 155-158.

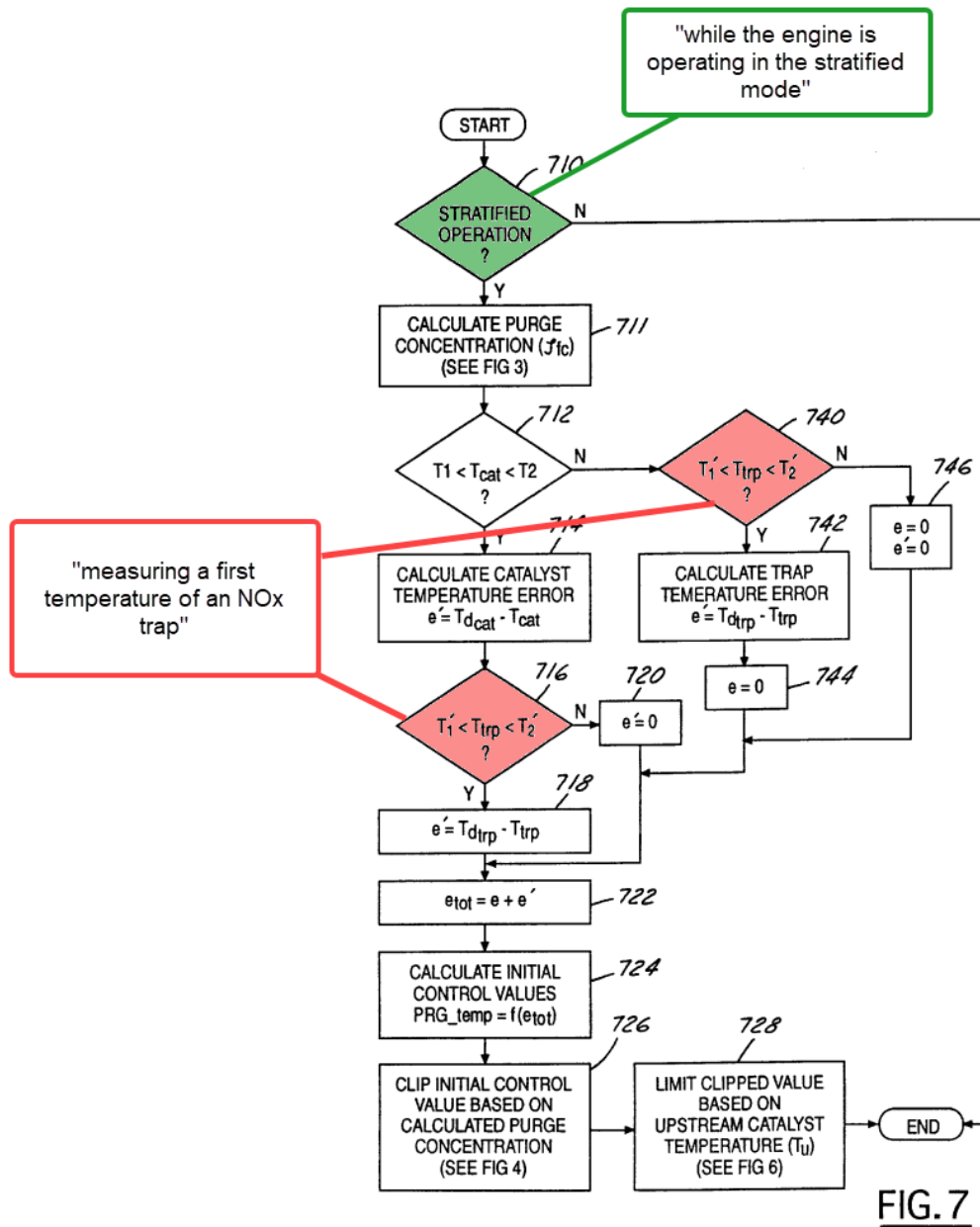


Ex. 1006 at FIG. 1 (annotations added).

Moreover, as shown below in Figure 7, “[f]irst, in step 710 a determination is

¹¹ The PTAB previously found it was reasonably likely that Kerns invalidates this claim limitation. *Volkswagen Group of America, Inc. v. Michigan Motor Technologies LLC*, IPR2020-00452, Paper 12 at 34-35 (PTAB Sept. 9, 2020).

made as to whether engine 10 is operating in a stratified mode where fuel is injected directly into cylinder 30 during a compression stroke,” *i.e.*, while the engine is operating in the stratified mode. *Id.* at 10:51-53. Then in step 716, “a determination is made as to whether temperature T_{trp} of NOx trap 72 is between threshold values $T1'$ and $T2'$.” *Id.* at 11:1-3. By disclosing that temperature T_{trp} of NOx trap 72 is compared to other values, Kerns necessarily discloses that temperature T_{trp} of NOx trap 72 is measured, *i.e.*, measuring a first temperature of an NOx trap. *Id.*; Ex. 1003 at ¶¶ 155-158. Moreover, Kerns teaches that T_{trp} may be provided by a “temperature sensor 126,” *i.e.*, measuring a first temperature of an NOx trap. Ex. 1006 at 4:18-24.



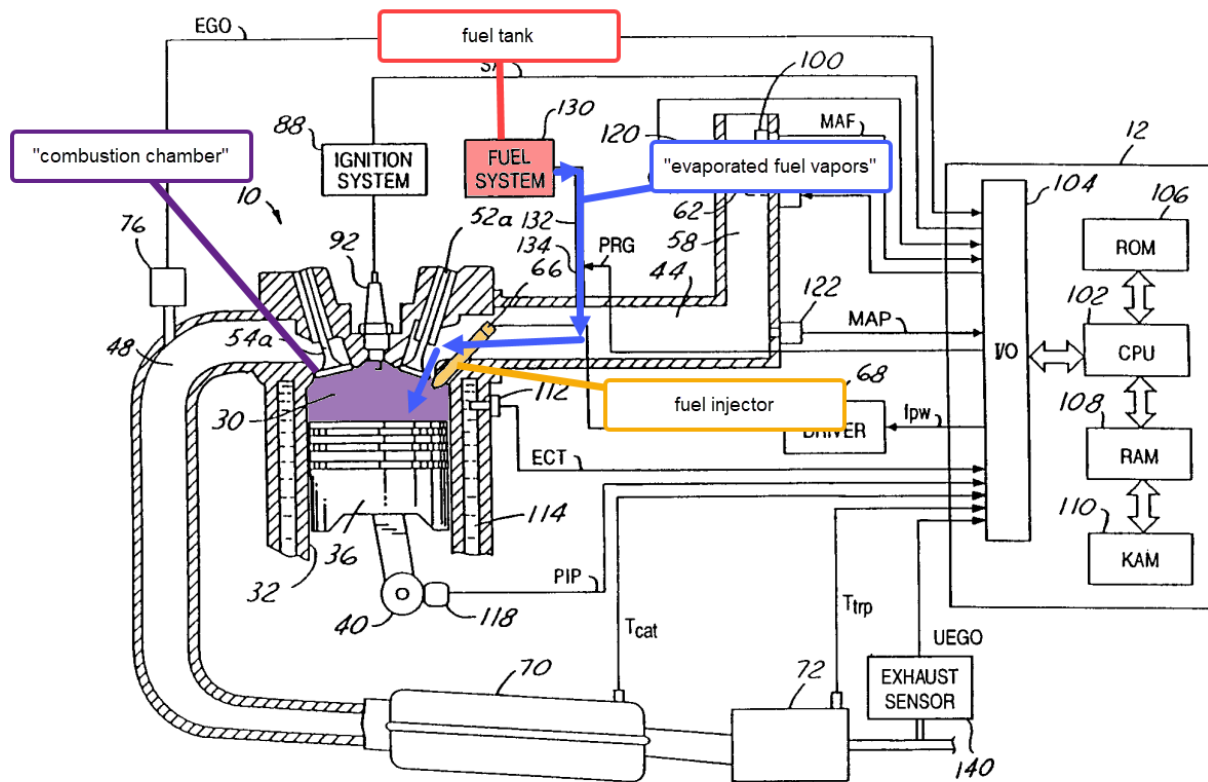
Id. at FIG. 7 (annotations added);

Thus, Kerns discloses the claim limitation 1[a]. Ex. 1003 at ¶¶ 155-158.

- c. 1[b]: “enabling evaporated fuel vapors to enter the combustion chamber at a flow rate while the engine is operating in the stratified mode;”

Kerns discloses enabling evaporated fuel vapors to enter the combustion

chamber at a flow rate while the engine is operating in the stratified mode.¹² Ex. 1003 at ¶¶ 159-162. Kerns teaches “purging fuel vapors into the combustion chamber,” and particularly “purging fuel vapors during stratified operation.” Ex. 1006 at 2:6-23.



Id. at FIG. 1 (annotations added).

Kerns further teaches a “purge flow rate” $\dot{m}_p$, *i.e.*, a flow rate at which the evaporated fuel vapors enter the combustion chamber. *Id.* at 9:10-48.

¹² The PTAB previously found it was reasonably likely that Kerns invalidates this claim limitation. *Volkswagen Group of America, Inc. v. Michigan Motor Technologies LLC*, IPR2020-00452, Paper 12 at 35-36 (PTAB Sept. 9, 2020).

Thus, Kerns discloses claim limitation 1[b]. Ex. 1003 at ¶¶ 159-162.

- d. *1[c]: “measuring a second temperature of the NOx trap while the engine is operating in the stratified mode; and”*

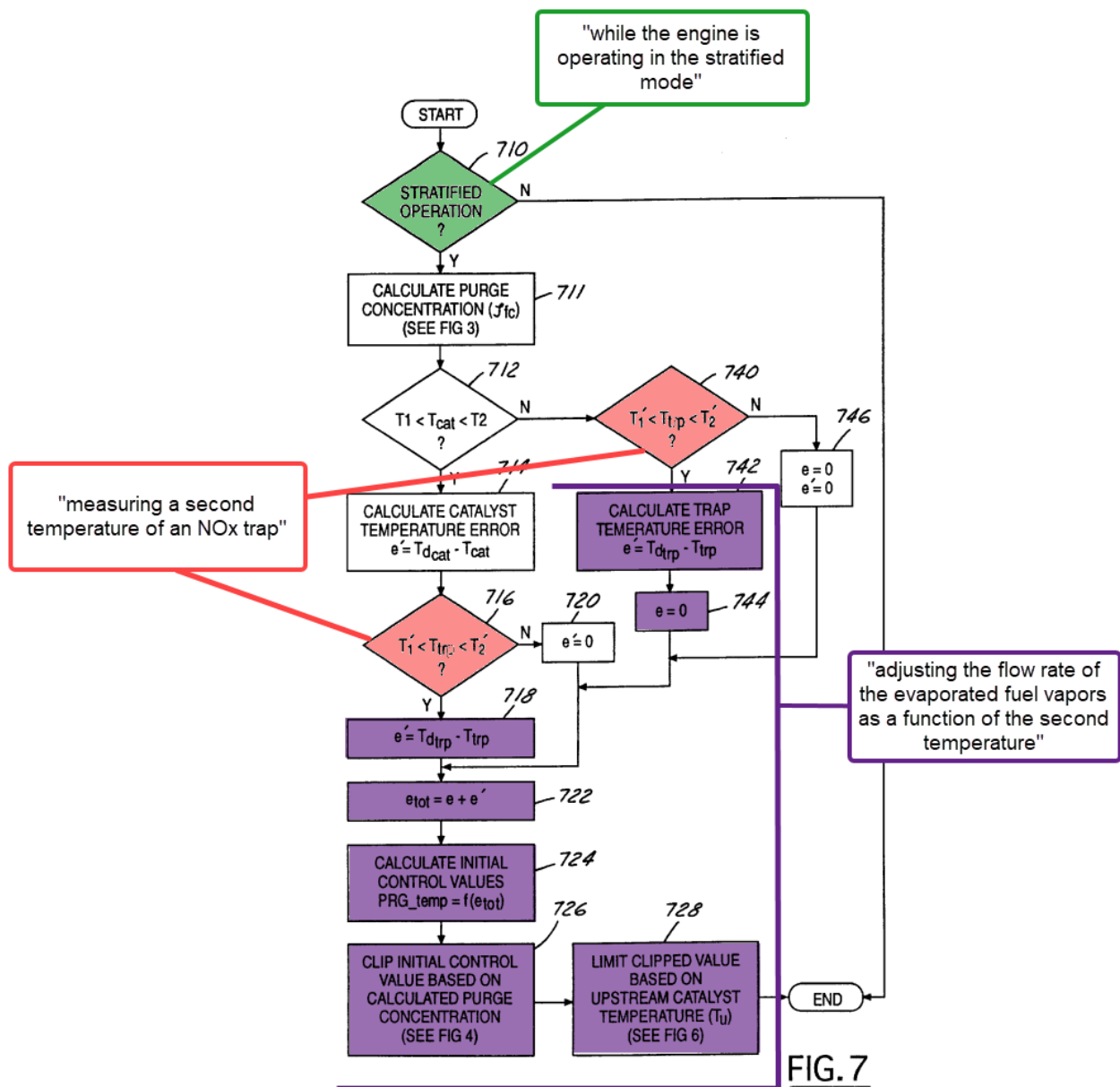
Kerns in view of Takahashi discloses measuring a second temperature of the NOx trap while the engine is operating in the stratified mode.¹³ Ex. 1003 at ¶¶ 163-169.

As shown below in Figure 7, Kerns’ teaches “[f]irst, in step 710 a determination is made as to whether engine 10 is operating in a stratified mode where fuel is injected directly into cylinder 30 during a compression stroke,” *i.e.*, while the engine is operating in the stratified mode. *Id.* at 10:51-53. Then in step 716, “a determination is made as to whether temperature T_{trp} of NOx trap 72 is between threshold values T1’ and T2’.” *Id.* at 11:1-3. By disclosing that temperature T_{trp} of NOx trap 72 is compared to other values, Kerns necessarily discloses that temperature T_{trp} of NOx trap 72 is measured, *i.e.*, measuring a first temperature of an NOx trap. *Id.*; Ex. 1003 at ¶¶ 163-169. Moreover, Kerns teaches that T_{trp} may be provided by a “temperature sensor,” *i.e.*, measuring a first temperature of an NOx trap. Ex. 1006 at 4:18-24.

A POSITA would also understand that Kerns’ methods, including the one

¹³ The PTAB previously found it was reasonably likely that Kerns alone invalidates this claim limitation. *Volkswagen Group of America, Inc. v. Michigan Motor Technologies LLC*, IPR2020-00452, Paper 12 at 36-37 (PTAB Sept. 9, 2020).

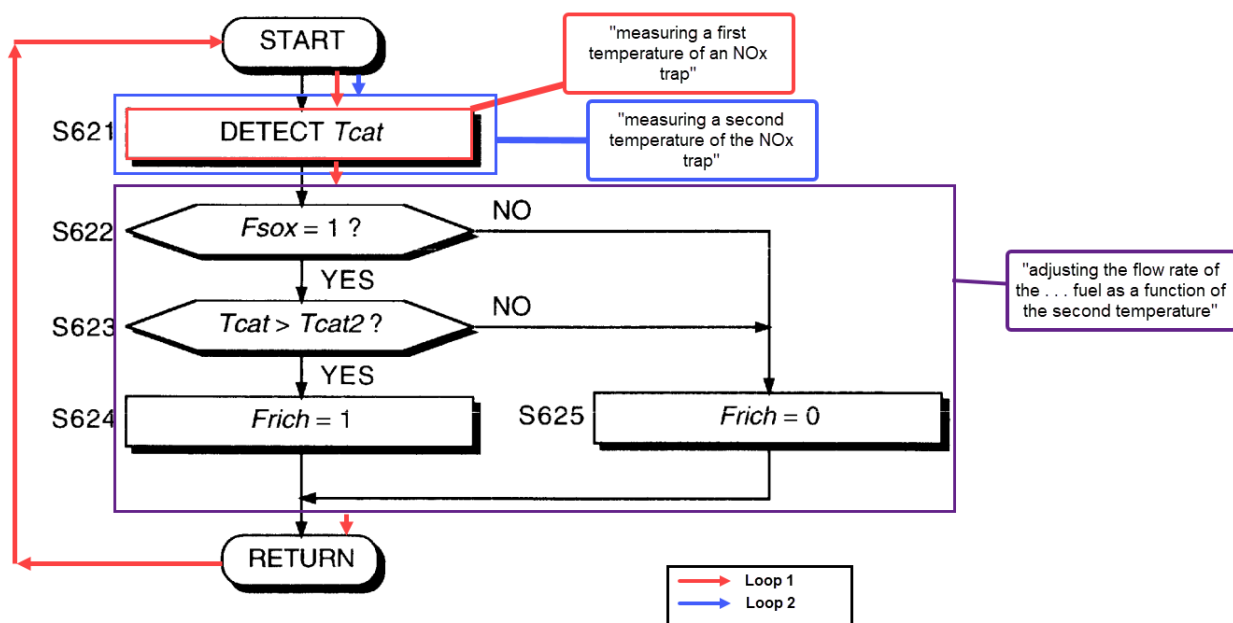
disclosed in Figure 7, run in a continuous loop such that on the second loop of the method a second temperature of the NOx trap would be measured. Ex. 1003 at ¶¶ 163-169. Kerns teaches that its methods “purg[e] fuel vapors into the combustion chamber when said downstream emission control device temperature,” *i.e.*, NOx trap temperature, “is below a predetermined threshold.” Ex. 1006 at 2:6-8. A POSITA would understand that in order to determine “when said downstream emission control device temperature is below a predetermined threshold” Kerns’ methods would repeatedly measure the NOx trap temperature. Ex. 1003 at ¶¶ 163-169.



Id. at FIG. 7 (annotations added).

Likewise, Takahashi discloses measuring a second temperature of an NOx trap. Ex. 1003 at ¶¶ 163-169. Takahashi discloses “a catalyst . . . disposed in an exhaust passage . . . of an internal combustion engine . . . for trapping nitrogen oxides [(“NOx”)] in the exhaust” and “a catalyst temperature control method for such an internal combustion engine.” Ex. 1008 at Abstract, 2:54-64. Takahashi teaches

an “air-fuel ratio rich condition determining routine . . . performed every 10 milliseconds,” *i.e.*, repeated in a continuous loop. *Id.* at 10:30-32. As shown below in Figure 6, Takahashi’s routine measures catalyst temperature T_{cat} , determines whether T_{cat} exceeds a certain temperature threshold T_{cat2} , and then, based on whether T_{cat} exceeds the threshold, sets the flag F_{rich} either to 0 or 1 to indicate whether the air/fuel ratio will be enriched. *Id.* at 10:30-57.



Id. at FIG. 6 (annotations added).

A POSITA viewing Kerns’ fuel injection methods would have been motivated to modify Kerns’ method to operate a continuous loop that measures a first and second temperature of an NOx trap based on the teachings of Takahashi. Ex. 1003 at ¶¶ 163-169.

A POSITA would have been motivated to modify Kerns to repeatedly monitor NOx trap temperature based on the teachings of Takahashi because, as explicitly taught by Takahashi, continuous monitoring of the temperature of devices used for catalytic treatment, such as a catalytic converter or NOx trap, and adjusting fuel injection based on such temperatures enables the catalyst to discharge sulfur oxides without impairing the durability of the catalyst. Ex. 1008 at 1:49-54; Ex. 1003 at ¶¶ 163-169.

A POSITA would understand that the code in Kerns' electronic engine controller, which is a conventional microcomputer, could be modified to repeatedly measure the NOx trap temperature and adjust fueling based on the temperature as taught by Takahashi by repeating the methods already disclosed by Kerns. Ex. 1003 at ¶¶ 163-169.

Thus, Kerns in view of Takahashi renders obvious claim limitation 1[c]. Ex. 1003 at ¶¶ 163-169.

- e. *1[d]: "adjusting the flow rate of the evaporated fuel vapors as a function of the second temperature when the second temperature is within a lower temperature threshold and an upper temperature threshold."*

Kerns in view of Takahashi renders obvious adjusting the flow rate of the evaporated fuel vapors as a function of the second temperature when the second temperature is within a lower temperature threshold and an upper temperature

threshold.¹⁴ Ex. 1003 at ¶¶ 170-178.

Kerns teaches that the flow of fuel vapors, $\dot{m}_p$, is “controlled via purge valve 134” based on “control signal PRG.” Ex. 1006 at 4:26-29.

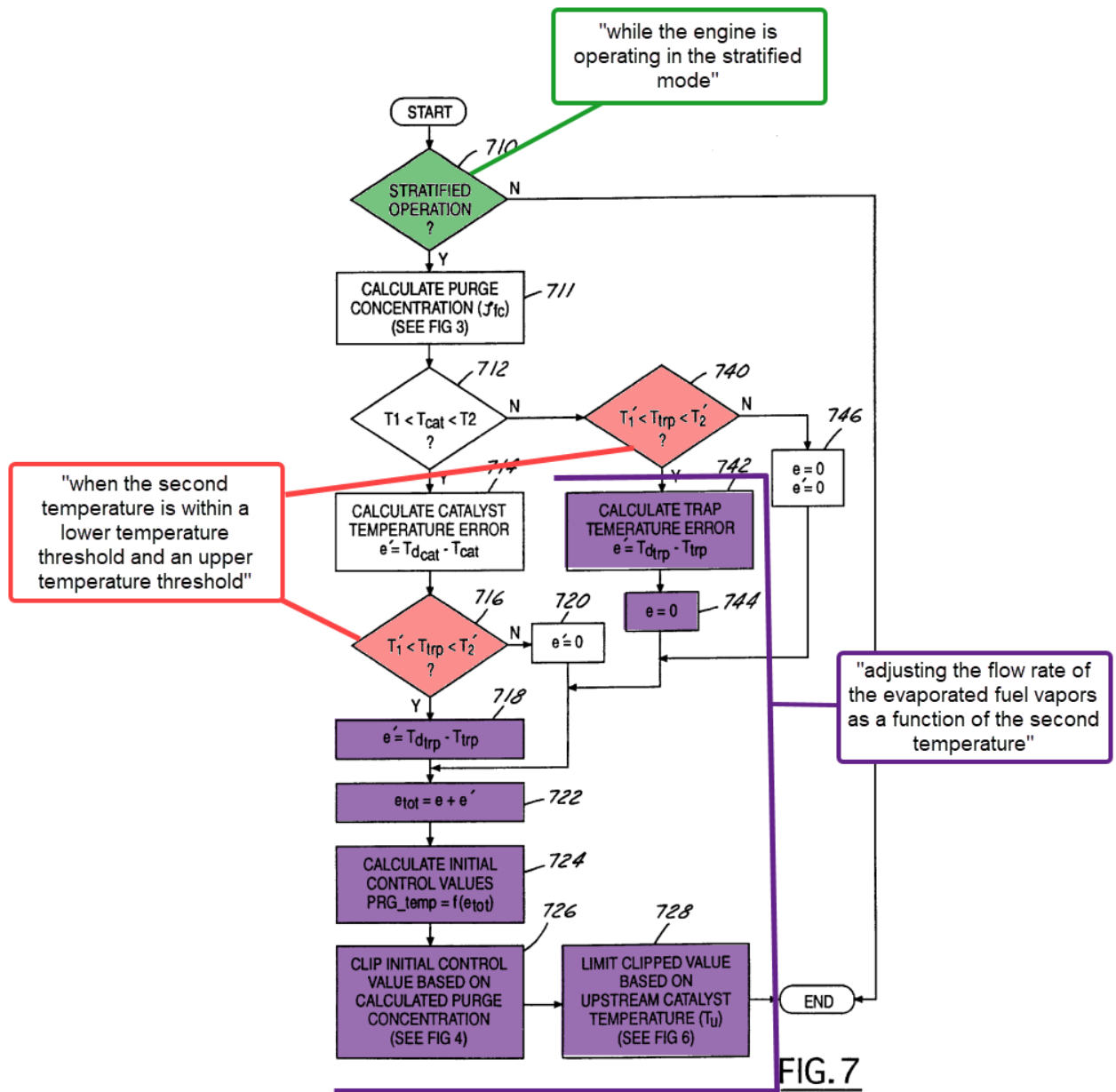
$$\dot{m}_p = g(PRG)$$

Id. at 9:10-15 (showing fuel vapor flow rate $\dot{m}_p$ is calculated as a function of control signal PRG).

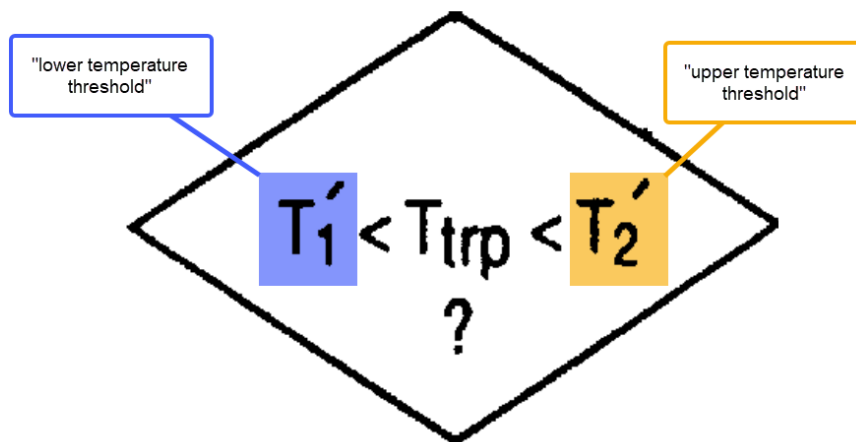
Control signal PRG is calculated based on a NOx trap temperature error e' . *Id.* at 11:8-11. NOx trap temperature error e' is the difference between desired NOx trap temperature T_{dtrp} and actual NOx trap temperature T_{trp} , *i.e.*, it is a function of the NOx trap temperature. As shown below in Figure 7, e' —and subsequently control signal PRG and evaporated fuel vapor flow rate $\dot{m}_p$ —are recalculated when (1) the engine is operating in stratified mode and (2) NOx trap temperature T_{trp} is within lower threshold value $T1'$ and upper threshold value $T2'$. *Id.* at 11:1-38. As explained in § XIII.2.c, *supra*, Kerns’ methods, including the one disclosed in Figure 7, run in a continuous loop such that on the second loop of the method a second temperature of the NOx trap would be measured. Ex. 1003 at

¹⁴ The PTAB previously found it was reasonably likely that Kerns invalidates this claim limitation. *Volkswagen Group of America, Inc. v. Michigan Motor Technologies LLC*, IPR2020-00452, Paper 12 at 37-39 (PTAB Sept. 9, 2020).

¶¶ 170-178.



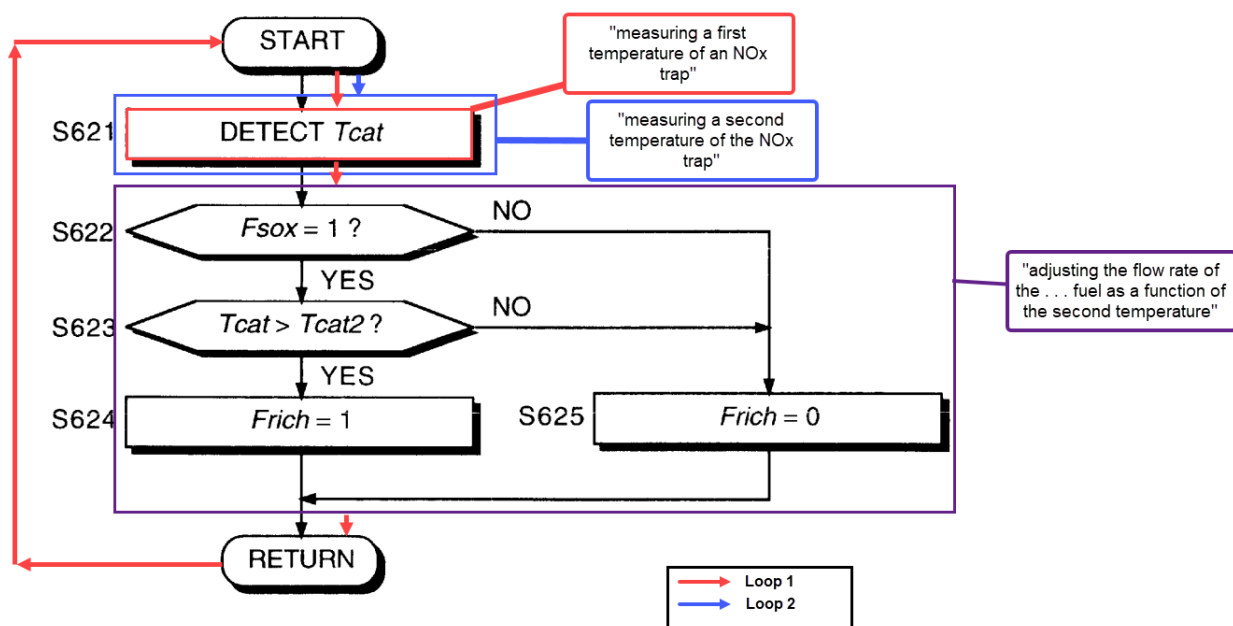
Id. at FIG. 7 (annotations added).



Id.

Thus, Kerns discloses adjusting the flow rate of the evaporated fuel vapors as a function of the second temperature when the second temperature is within a lower temperature threshold and an upper temperature threshold.

Likewise, as explained in §§ XIII.1 and 2.d, *supra*, Takahashi discloses measuring a second temperature of an NO_x trap. Ex. 1003 at ¶¶ 170-178. Takahashi teaches an “air-fuel ratio rich condition determining routine . . . performed every 10 milliseconds.” *Id.* at 10:30-32. As shown below in Figure 6, Takahashi’s routine measures catalyst temperature T_{cat} , determines whether T_{cat} exceeds a certain temperature threshold T_{cat2} , and then, based on whether T_{cat} exceeds the threshold, sets the flag F_{rich} either to 0 or 1 to indicate whether the air/fuel ratio will be enriched. *Id.* at 10:30-57.



Id. at FIG. 6 (annotations added).

A POSITA would have been motivated to combine a method of repeatedly monitoring catalyst temperature and adjusting air/fuel ratio based on the temperature as disclosed by Takahashi because, as Takahashi teaches, repeatedly monitoring the temperature of devices used for catalytic treatment, such as a catalytic converter or NOx trap, and adjusting fuel injection based on such temperatures enables the catalyst to discharge sulfur oxides without impairing the durability of the catalyst. Ex. 1008 at 1:49-54; Ex. 1003 at ¶¶ 170-178. Moreover, A POSITA would have been able to easily apply continuous catalyst temperature monitoring based on the teachings of Takahashi to Kerns' engine control system, including at least because Kerns already teaches methods for adjusting fuel flow based on the temperature of

an NOx trap. Ex. 1006 at FIG. 7. Ex. 1003 at ¶¶ 170-178. A POSITA would understand that the code in Kerns' electronic engine controller, which is a conventional microcomputer, could be modified to implement Takahashi's method of repeatedly measuring the NOx trap temperature and adjusting fueling based on the temperature. Ex. 1003 at ¶¶ 170-178.

A POSITA viewing Kerns' fuel delivery methods would have been motivated to modify Kerns' method to operate a continuous loop that measures a first and second temperature of an NOx trap based on the teachings of Takahashi. Ex. 1003 at ¶¶ 170-178.

A POSITA would have been motivated to modify Kerns to repeatedly monitor NOx trap temperature based on the teachings of Takahashi because, as explicitly taught by Takahashi, continuous monitoring of the temperature of devices used for catalytic treatment, such as a catalytic converter or NOx trap, and adjusting fuel injection based on such temperatures enables the catalyst to discharge sulfur oxides without impairing the durability of the catalyst. Ex. 1008 at 1:49-54; Ex. 1003 at ¶¶ 170-178.

A POSITA would understand that the code in Kerns' electronic engine controller, which is a conventional microcomputer, could be modified to repeatedly measure the NOx trap temperature and adjust fueling based on the temperature as taught by Takahashi by repeating the methods already disclosed by Kerns. Ex. 1003 at ¶¶ 170-178.

Thus, Kerns in view of Takahashi renders obvious claim limitation 1[d]. Ex. 1003 at ¶¶ 170-178.

3. Claim 2:

- a. *“The method of claim 1, further comprising: switching the engine to the homogeneous mode when the second temperature is below the lower temperature threshold.”*

Kerns in view of Takahashi discloses the method of claim 1, further comprising switching the engine to the homogeneous mode when the second temperature is below the lower threshold.¹⁵ Ex. 1003 at ¶¶ 179-182. As explained in § XIII.2, *supra*, Kerns in view of Takahashi discloses the method of claim 1. Likewise, Kerns teaches that “when the stratified mode no longer provides a fuel savings because of the additional fuel vapor injected to maintain temperature of the emission control device, the engine air/fuel operating mode is switched to the homogeneous mode thereby maximizing fuel economy.” Ex. 1006, 7:62-8:5. Kerns discloses that an NOx trap is an emission control device, and that the lower temperature threshold “T1” represents a lower level below which NOx trap 72 cannot support an exothermic reaction. *Id.* at 4:47-49; 11:3-8. Kerns teaches that “[t]he engine switches to . . . a purely homogenous mode” when “fuel vapor purge is burned in the cylinder and does not create an exothermic reaction,” *i.e.*, when the

¹⁵ The PTAB previously found it was reasonably likely that Kerns alone invalidates this claim limitation. *Volkswagen Group of America, Inc. v. Michigan Motor Technologies LLC*, IPR2020-00452, Paper 12 at 40 (PTAB Sept. 9, 2020).

temperature of the NOx trap is below temperature required for exothermic reactions—the lower temperature threshold. *Id.* at 6:52-61.

Thus, Kerns in view of Takahashi and Hepburn renders claim 2 obvious. Ex. 1003 at ¶¶ 179-182.

4. Claim 3:

- a. *“The method of claim 2, further comprising: measuring a fuel level of the evaporated fuel vapors after the switching the engine to the homogeneous mode.”*

Kerns in view of Takahashi discloses the method of claim 2, further comprising measuring a fuel level of the evaporated fuel vapors after switching the engine to the homogeneous mode.¹⁶ Ex. 1003 at ¶¶ 183-187. As explained in § XIII.3, *supra*, Kerns in view of Takahashi discloses the method of claim 2. Kerns teaches that “[a]s the engine switches to the homogeneous mode, the new fuel flow rate from the fuel injectors . . . is found as:

$$\dot{m}_{f_h} = \dot{m}_{f_{stoich}} - \rho_f \dot{m}_p$$

when fuel vapor purge is continued in the homogeneous mode.” Ex. 1006 at 8:15-22.

As shown in the above formula taught by Kerns, to calculate the new fuel flow

¹⁶ The PTAB previously found it was reasonably likely that Kerns alone invalidates this claim limitation. *Volkswagen Group of America, Inc. v. Michigan Motor Technologies LLC*, IPR2020-00452, Paper 12 at 36-37 (PTAB Sept. 9, 2020).

rate $\dot{m}_{fh}$ Kerns teaches first calculating the input ρ_f , the “fuel vapor concentration.” *Id.* at 5:5-8, 8:15-22. Kerns teaches that the fuel vapor concentration ρ_f is calculated based on the following formula:

$$\rho_f = \frac{\dot{m}_p + \dot{m}_a - \lambda S \dot{m}_f}{\dot{m}_p(1 + \lambda S)}$$

Id. at 5:10-14. Kerns teaches that in the above formula used to calculate fuel vapor concentration when the engine switches to homogeneous mode, λ “is measured relative air/fuel ratio in the exhaust,” *i.e.*, a measured fuel level of the evaporated fuel vapors. Thus, Kerns discloses that after switching the engine to the homogeneous mode, measuring relative air/fuel ratio λ , *i.e.*, a measured fuel level, to calculate fuel vapor concentration and the new flow rate. Ex. 1003 at ¶¶ 183-187.

Thus, Kerns in view of Takahashi renders claim 3 obvious. Ex. 1003 at ¶¶ 183-187.

5. Claim 4:

- a. *“The method of claim 3, wherein the measuring the fuel level comprises measuring the fuel level via an exhaust gas oxygen sensor.”*

Kerns in view of Takahashi discloses the method of claim 3, wherein the measuring the fuel level comprises measuring the fuel level via an exhaust gas

oxygen sensor.¹⁷ Ex. 1003 at ¶¶ 188-191. As explained in § XIII.4, *supra*, Kerns in view of Takahashi discloses the method of claim 3. Kerns further teaches an “[e]xhaust gas oxygen sensor 76” “coupled to exhaust manifold 48” that measures “a relative air fuel ratio λ ,” *i.e.*, the fuel level. Ex. 1006 at 3:22-28.

Thus, Kerns in view of Takahashi renders claim 4 obvious. Ex. 1003 at ¶¶ 188-191.

6. Claim 5:

- a. “The method of claim 4, wherein the measuring the fuel level comprises measuring the fuel level with an universal exhaust gas oxygen sensor.”

Kerns in view of Takahashi discloses the method of claim 4, wherein the measuring the fuel level comprises measuring the fuel level with a universal exhaust gas oxygen sensor.¹⁸ Ex. 1003 at ¶¶ 192-195. As explained in § XIII.5, *supra*, Kerns in view of Takahashi discloses the method of claim 4. Kerns discloses that its exhaust gas oxygen sensor 76 provides “signal UEGO,” *i.e.*, it is a universal exhaust gas oxygen sensor. Ex. 1006 at 3:22-28; Ex. 1003 at ¶¶ 192-195. As explained with respect to claim 4, Kerns teaches using its universal gas oxygen

¹⁷ The PTAB previously found it was reasonably likely that Kerns alone invalidates this claim limitation. *Volkswagen Group of America, Inc. v. Michigan Motor Technologies LLC*, IPR2020-00452, Paper 12 at 36-37 (PTAB Sept. 9, 2020).

¹⁸ The PTAB previously found it was reasonably likely that Kerns alone invalidates this claim limitation. *Volkswagen Group of America, Inc. v. Michigan Motor Technologies LLC*, IPR2020-00452, Paper 12 at 36-37 (PTAB Sept. 9, 2020).

sensor to measure a relative air fuel ratio λ , *i.e.*, the fuel level. *Id.* at 3:22-28.

Thus, Kerns in view of Takahashi renders claim 5 obvious. Ex. 1003 at ¶¶ 192-195.

XIV. SECONDARY CONSIDERATIONS DO NOT SUPPORT A FINDING OF NON-OBVIOUSNESS

At this stage of these proceedings, Petitioners have no burden to identify and rebut secondary considerations. Rather, Patent Owner must first present a *prima facie* case for such consideration, which Petitioners should then have the chance to rebut. *Sega of Am., Inc. v. Uniloc USA, Inc.*, IPR2015-01453, at *10 (Mar. 10, 2015). For that reason, the Board typically rejects arguments against institution based on objective indicia, so that the Petitioners can have a fair opportunity to address any secondary indicia evidence on reply. *Petroleum Geo-Services Inc. v. WesternGeco LLC*, IPR2015-01478, at *22 (Mar. 17, 2015); Ex. 1003, ¶ 119.

XV. MANDATORY DISCLOSURES

A. Real Parties-in-Interest under 37 C.F.R. 42.8(b)(1)

The only real parties-in-interest are Petitioner Mercedes-Benz USA; Mercedes-Benz Intellectual Property GmbH & Co. KG; Mercedes-Benz AG; and Mercedes-Benz Group AG.

B. Related Matters under 37 C.F.R. 42.8(b)(2)

U.S. Patent 6,561,166 (the “’166 patent,” Ex. 1001) is the subject of one pending district court case: *Michigan Motor Technologies, LLC v. Mercedes-Benz USA, LLC*, Case 1:22-cv-03957 (N.D. Ill.)

C. Lead and Back-Up Counsel under 37 C.F.R. 42.8(b)(3)

Petitioner provides the following counsel and service information. Pursuant to 37 C.F.R. § 42.10(b), a Power of Attorney accompanies this Petition. Petitioner agrees to accept electronic service at the email addresses below.

LEAD COUNSEL	BACK-UP COUNSEL
James M. Glass (Reg. No. 46729) jimglass@quinnemanuel.com <u>Postal and Hand Delivery Address:</u> QUINN EMANUEL URQUHART & SULLIVAN, LLP 51 Madison Ave, 22nd Floor New York, New York 10010 Tel: (212) 849-7000 Fax: (212) 849-7100	Jeff S. Gerchick (<i>pro hac vice</i> application forthcoming) jeffgerchick@quinnemanuel.com <u>Postal and Hand Delivery Address:</u> QUINN EMANUEL URQUHART & SULLIVAN, LLP 1300 I St NW #900, Washington, DC 20005 Tel: (202) 538-8000 Fax: (202) 538-8100

D. Service Information under 37 C.F.R. 42.8(b)(4)

A copy of this entire Petition, including all Exhibits and a power of attorney, is being served by FEDERAL EXPRESS, costs prepaid, to the address of the attorney or agent of record for Michigan Motor Technologies, LLC (“MMT” or “Patent Owner”) at the USPTO:

Timothy Devlin (Registration No. 41,706)
1526 Gilpin Ave.
Wilmington, DE 19806

Petitioners consent to service by electronic mail at: qe-mmt-

mbusa@quinnemanuel.com. A Power of Attorney is filed concurrently herewith under 37 C.F.R. 42.10(b).

A. Payment of Fees under 37 C.F.R. § 42.15(a)

The undersigned authorizes the Office to charge the fee required for this Petition for Inter Partes Review to Deposit Account No. 50-5708. Any additional fees that might be due are also authorized.

XVI. CONCLUSION

Petitioners respectfully request that *inter partes* review of the '166 patent be instituted and that the challenged claims be cancelled as unpatentable pursuant to 35 U.S.C. §318(b).

Respectfully Submitted,

June 21, 2023

/s/ Jim Glass

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CERTIFICATE OF SERVICE

In accordance with 37 C.F.R. §§ 42.6(e) and 42.105, the undersigned certifies that on June 21, 2023, a complete and entire copy of the **PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 6,561,166 UNDER 35 U.S.C. §§ 311-319 AND 37 C.F.R. §§ 42.100 *ET SEQ.*** (“Petition”) including exhibits and testimony relied upon were served on the Patent Owner at the correspondence address of record for the subject patent and counsel for Patent Owner in the District Court Litigation, as included below:

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CERTIFICATION UNDER 37 C.F.R. § 42.24(d)

Pursuant to 37 C.F.R. § 42.24(d), the undersigned hereby certifies that the word count under § 42.24(a)(1) for the foregoing Petition for *Inter Partes* Review totals 13,999 words, within the 14,000 word limit allowed under § 42.24(a)(1)(i).

Date: June 21, 2023

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