

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

FORD MOTOR CO.,
Petitioner,

v.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY,
Patent Owner.

IPR2021-00341
Patent 9,708,965 B2

Before, LYNNE H. BROWNE, BARRY L. GROSSMAN, and
JAMES J. MAYBERRY, *Administrative Patent Judges*.

MAYBERRY, *Administrative Patent Judge*.

JUDGMENT
Final Written Decision
Determining All Challenged Claims Unpatentable
35 U.S.C. § 318(a)

ORDER
Dismissing Patent Owner's Motion to Exclude Evidence
37 C.F.R. § 42.64(c)

I. INTRODUCTION

Petitioner, Ford Motor Company, filed a Petition (“Pet.”) requesting *inter partes* review of claims 1, 3–5, 11–17, 19, and 21 (the “Challenged Claims”) of U.S. Patent No. 9,708,965 B2 (Ex. 1001, the “’965 patent”). Paper 2. The ’965 patent is owned by Massachusetts Institute of Technology (“Patent Owner”). Paper 9, 2. Ethanol Boosting Systems, LLC is the exclusive licensee of the ’965 patent. *Id.*

For the reasons provided below, we conclude that Petitioner has proven, by a preponderance of the evidence, that claims 1, 3–5, 11–17, 19, and 21 of the ’965 patent are unpatentable. We also dismiss Patent Owner’s Motion to Exclude Evidence as moot.

A. *Procedural History*

In response to the Petition, Patent Owner, filed a Preliminary Response to the Petition. Paper 6. With our authorization, Petitioner filed a Preliminary Reply (Paper 7) and Patent Owner filed a Preliminary Sur-reply (Paper 8). Considering the information in the Petition, the Preliminary Response, Preliminary Reply, and Preliminary Sur-reply, we denied institution in an initial decision. Paper 10 (“Inst. Dec.”). Petitioner timely filed a Request for Rehearing of that decision, and also requested a Precedential Opinion Panel (“POP”) review our Institution Decision. Paper 11 (“Pet. Req. Reh’g” or “Petitioner Rehearing Request”); Ex. 3002. POP review was denied. Paper 13.

Central to our decision denying institution, and Petitioner’s Rehearing Request, is a claim construction of the “fuel terms,” a construction originating in the parallel district court litigation and appealed to the U.S. Court of Appeals for the Federal Circuit. *See* Inst. Dec. 17–28; Pet. Req. Reh’g 1–2; *see also* Ex. 2016 (providing Notice of Appeal). In our initial

Institution Decision, we adopted the claim construction that was adopted by the district court in *Ford II*¹, at least with respect to requiring two different fuels, and that was consistent with a previous construction affirmed by the Federal Circuit for a set of related patents, which was the subject of prior litigation, in *Ford I*². *See* Inst. Dec. 17–28. The construction adopted in the Institution Decision was consistent with the construction asserted by Petitioner in the district court, and inconsistent with the construction asserted by Patent Owner in the district court and Petitioner in the Petition. *See id.*

The Federal Circuit vacated the district court’s claim construction in *Ford II*, and remanded that case to the district court, agreeing with Patent Owner that the claim construction of the fuel terms did not require two different fuels. Paper 16; *Ethanol Boosting Sys., LLC v. Ford Motor Co.*, No. 2021-1949, 2022 WL 2798395 (Fed. Cir. July 18, 2022) (hereinafter referred to as “Ex. 1042”). In light of the Federal Circuit determining the construction of the fuel terms did not require two different fuels, we granted Petitioner’s Rehearing Request and instituted trial on all challenges in the Petition, applying the construction asserted by Petitioner in the Petition. Paper 17, 34.

Patent Owner filed a request for rehearing (Paper 19), and a POP request (*see* Paper 22). Both requests were denied. Papers 29, 32.

Patent Owner filed a Patent Owner Response to the Petition. Paper 33 (“PO Resp.”). Petitioner filed a Reply to the Patent Owner

¹ *Ethanol Boosting Systems, LLC v. Ford Motor Company, LLC*, No. 1:20-cv-00706-CFC (Del.) (“Ford II”). *See* § I.C.1, *infra*.

² *Ethanol Boosting Systems, LLC v. Ford Motor Company, LLC*, No. 1:19-cv-00196-CFC (D. Del.) (“Ford I”). *See* § I.C.2, *infra*.

Response. Paper 37 (“Pet. Reply”). Patent Owner filed a Sur-reply to Petitioner’s Reply. Paper 41 (“PO Sur-reply”).

Patent Owner filed a Motion to Exclude Evidence. Paper 42 (“Motion”). Petitioner filed an Opposition to the Motion and Patent Owner filed a Reply to the Opposition. Papers 44, 46.

An oral hearing for this proceeding was held on September 6, 2023, and the transcript for that hearing is entered in the record. Paper 50 (“Tr.”).

B. Real Parties-in-Interest

Petitioner identifies itself as the sole real party-in-interest. Pet. 73. Patent Owner identifies itself and Ethanol Boosting Systems, LLC, the exclusive licensee of the ’965 patent, as real parties-in-interest. Paper 9, 2.

C. Related Matters

1. The Bromberg Patents

Petitioner and Patent Owner indicate that the ’965 patent is the subject of litigation in the U.S. District Court for the District of Delaware in *Ford II*. Pet. 73; Paper 3, 2. Petitioner also filed, concurrent with the filing of the Petition, petitions for *inter partes* review of two related patents, in cases numbered IPR2021-00339 (challenging US 10,619,580) and IPR2021-00340 (challenging US 10,781,760). Pet. 73; Paper 3, 3.

Following claim construction in *Ford II*, the parties stipulated to non-infringement, and Patent Owner appealed the claim construction to the Federal Circuit. Prelim. Resp. 3–4; *see also* Ex. 2001 (providing the district court’s claim construction order in *Ford II*); Ex. 2013 (providing stipulation); Ex. 2016 (providing Notice of Appeal). The Federal Circuit vacated the district court’s claim construction and remanded *Ford II* back to the district court. Ex. 1042.

2. *The Cohn Patents*

The '965 patent and other Bromberg Patents are related to a family of four patents through a continuation-in-part application of an original application (U.S. Patent App. No. 10/991,774 (the "'774 application"))—U.S. Patent Nos. 8,069,839; 9,255,519; 9,810,166; and 10,138,826 (the "Cohn Patents"). *Compare* Ex. 1001, 1:5–16 (tracing the family for the '965 patent to the '774 application), *with* Ex. 3001, 1:5–27 (tracing the family for US 9,255,519 (the "'519 patent") to the '774 application, this exhibit filed as Ex. 1001 in IPR2019-01401). The Cohn Patents were the subject of litigation in the U.S. District Court for the District of Delaware in *Ford I*. Following claim construction in *Ford I*, the parties stipulated to non-infringement, and Patent Owner appealed the claim construction to the Federal Circuit. Prelim. Resp. 5; *see also* Ex. 1035 (providing the district court's claim construction order); Ex. 2004 (providing final judgment). The Federal Circuit affirmed the district court's claim construction. Ex. 1041 (providing the Federal Circuit's Rule 36 affirmance).

Petitioner filed eight petitions for *inter partes* review challenging the Cohn Patents, in cases numbered IPR2019-01399, IPR2019-01400, IPR2019-01401, and IPR2019-01402 (the "first set" of Cohn petitions), and in cases numbered IPR2020-00010, IPR2020-00011, IPR2020-00012, and IPR2020-00013 (the "second set" of Cohn petitions). Of these eight proceedings, trial was instituted in three of the proceedings—IPR2019-01399, IPR2019-01401, and IPR2019-01402. *See* Exs. 2005–2007 (providing the Final Written Decisions in IPR2019-01399, IPR2019-01401, and IPR2019-01402, respectively); Exs. 2008–2012 (providing decisions denying institution in IPR2020-00010, IPR2020-00011, IPR2020-00012, IPR2020-00013, and IPR2019-01400, respectively).

D. '965 Patent

The '965 patent, titled “Optimized Fuel Management System for Direct Injection Ethanol Enhancement of Gasoline Engines,” issued July 18, 2017, from an application filed July 23, 2015, and ultimately claims priority to an application filed November 18, 2004. Ex. 1001, codes (54), (45), (22), (63). The '965 patent is directed “to an optimized fuel management system for use with spark ignition gasoline engines in which an anti-knock agent which is a fuel is directly injected into a cylinder of the engine.” *Id.* at 1:20–23. We reproduce Figure 3 from the '965 patent below.

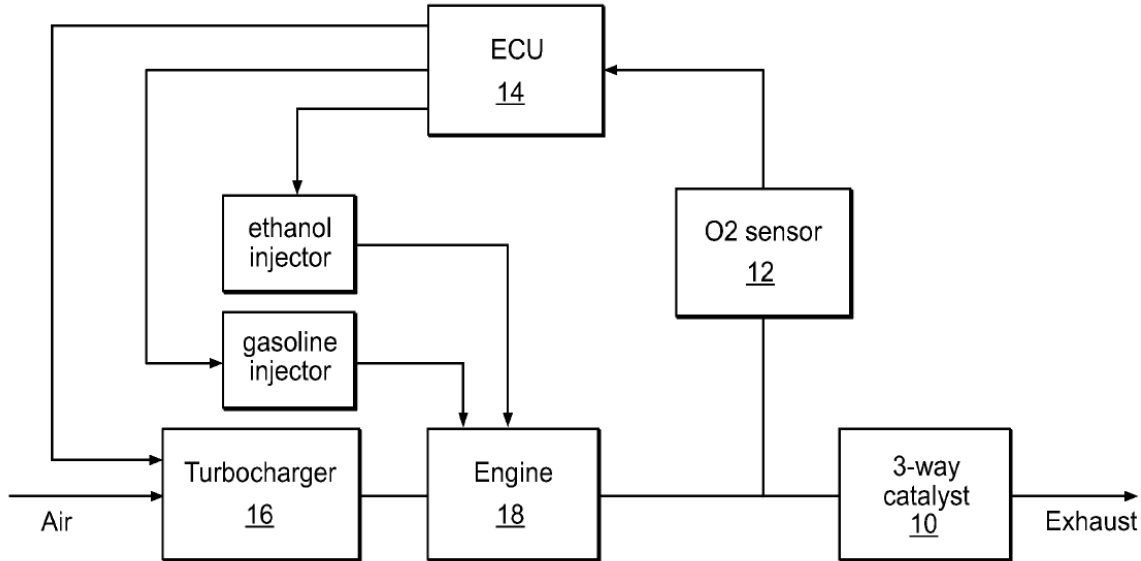


FIG. 3

Figure 3 depicts “schematic diagram of an embodiment of the fuel management system disclosed [in the '965 patent] for maintaining stoichiometric conditions with metering/control of ethanol, gasoline, and air flows into an engine.” Ex. 1001, 2:38–41. The fuel management system manages a system including gasoline engine 18 and a source of an anti-knock agent. *Id.* at 1:45–47. The anti-knock agent increases engine

efficiency and serves as a substitution for gasoline as a fuel. *Id.* at 1:47–50. An injector, controlled by electronic control unit (ECU) 14, directly injects the anti-knock agent into a cylinder of engine 18 to control knock. *Id.* at 1:50–54. That is, the anti-knock agent is introduced directly into the engine cylinder, not mixed with air outside the cylinder then introduced through a port in the engine. *Cf. id.* at 1:66–67, 3:9–16 (discussing port injection), 16:64–17:2 (claiming a first fuel system that directly injects fuel into a cylinder and a second fuel system that injects fuel in a region outside the cylinder). The ECU may initiate this injection in response to information from a knock sensor, or when the engine torque is above a selected value. *Id.* at 1:54–59. Preferably, the anti-knock agent has a heat of vaporization that is at least twice that of gasoline or a heat of vaporization per unit of combustion energy that is at least three times that of gasoline, such as ethanol. *Id.* at 1:60–64.

Gasoline is port injected into engine 18, that is, injected and mixed with air outside of the cylinder of engine 18. Ex. 1001, 1:66–67, 3:9–16. The gasoline-air mixture is then introduced into the cylinder through a port in the engine.

The '965 patent states that engine 18 should operate with a stoichiometric air-to-fuel ratio so that engine exhaust can be treated with 3-way exhaust catalyst 10, minimizing emissions. Ex. 1001, 8:62–65. The fuel management system employs ECU 14 and oxygen sensor 12 to control the amount of air into turbocharger 16, and the amount of gasoline and of ethanol used to insure stoichiometric operation. *Id.* at 8:65–9:3. That is, when the fuel management system employs ethanol octane enhancement, the management system adjusts the amounts of air, gasoline, and ethanol such that the fuel-air ratio is substantially equal to 1. *Id.* at 9:3–6.

ECU 14 may operate in an open loop mode, “that is, the control is determined by comparison to an engine map lookup table rather than by feedback from a sensed parameter,” such as from a knock sensor. Ex. 1001, 9:24–27. In a closed loop mode, ECU 14 controls engine 18 based on input from a knock sensor, so as to determine the amount of ethanol to be injected, with input from oxygen sensor 12 used to determine the total amount of fuel needed. *Id.* at 9:61–64, 16:41–46. Alternatively, ECU 14 may use open loop control to determine the amount of ethanol to gasoline ratio, and closed loop to determine the total amount of fuel. *Id.* at 9:64–67.

The fuel management system causes engine 18 to operate, under partial engine load conditions, with closed loop and gasoline only. Ex. 1001, 9:56–58. With increasing engine load, the fuel management system may then change to open loop operation, using a lookup table to control engine fueling. *Id.* at 9:58–60. The engine may use 100 percent ethanol at the highest values of torque. *Id.* at 10:17–20.

E. Challenged Claims

Of the Challenged Claims, claims 1, 14, 17, and 19 are independent claims. Claim 1, reproduced below, is representative.

1. A fuel management system for a spark ignition engine [A³] where the fuel management system controls fueling from a first fueling system that directly injects fuel into at least one cylinder as a liquid and increases knock suppression by evaporative cooling and from a second fueling system that injects fuel into a region outside of the cylinder; and
[B] where there is a range of torque where both fueling systems are used at the same value of manifold pressure; and
[C] where a fraction of fuel in the cylinder that is introduced by the first fueling system increases with increasing

³ We use the Petitioner’s notation for limitations for claim 1, and other independent claims. *See, e.g.*, Pet. 76–81 (providing claim appendix).

manifold pressure so as to prevent knock by providing increased knock resistance; and

[D] where the fuel management system controls the change in the fraction of fuel introduced by the first fueling system using closed loop control that utilizes a sensor that detects knock and where open loop control is also used; and

[E] where the open loop control uses an engine map lookup table; and

[F] where open loop control is used during transients in engine load.

Ex. 1001, 16:64–17:19. Independent claim 14 is similar to claim 1, and includes a limitation directed to fuel management during start up. *Id.* at 17:58–18:17. Independent claim is similar to claim 1, and includes a limitation directed to non-uniform distribution of fuel in the cylinder. *Id.* at 18:24–45. Independent claim 19 is similar to claim 1, and includes a limitation directed to minimizing wall wetting. *Id.* at 18:48–67.

F. Prior Art and Asserted Grounds

Petitioner asserts that the Challenged Claims are unpatentable on the following grounds:

Claims Challenged	35 U.S.C. §	References/Basis
1, 3, 4, and 11–13	103(a)	Schray, ⁴ Miura ⁵
5, 14–17, 19, 21	103(a)	Schray, Miura, Zhao ⁶

⁴ Schray et al., US 6,505,603 B1, issued Jan. 14, 2003 (Ex. 1005, “Schray”).

⁵ Hajime Miura, JP Unexamined Pat. App. Pub. 2003-13785, published Jan. 15, 2003 (Ex. 1008). Ex. 1008 includes a Japanese version of the reference, an English translation of the reference, and a certification of the translation.

⁶ Zhao et al., *Automotive Gasoline Direct-Injection Engines* (Soc. of Auto. Eng. 2002) (Ex. 1010, “Zhao”). Ex. 1010 includes excerpts from the publication.

Claims Challenged	35 U.S.C. §	References/Basis
1, 3–5, 11–17, 19, 21	103(a)	Rubbert, ⁷ Yuushiro, ⁸ Bosch ⁹
1, 3, 4, 11–17	103(a)	Ohtani ¹⁰
5, 19, 21	103(a)	Ohtani, Zhao

The following subsections provide a brief description of the asserted prior art references.

1. *Schray*

Schray, titled “Fuel Injection Method for an Internal Combustion Engine,” issued on January 14, 2003. Ex. 1005, codes (54), (45). Schray is directed to a method that employs double fuel injections and ignition angle intervention to control engine knock. *See id.* at 1:42–63. We reproduce Schray’s Figure 1, below.

⁷ DE 198 53 799 A1, published May 25, 2000 (Ex. 1007, “Rubbert”). Ex. 1007 includes a German version of the reference, an English translation of the reference, and a certification of the translation.

⁸ JP Unexamined Pat. App. Pub. H10-252512, published Sept. 22, 1998 (Ex. 1006, “Yuushiro”). Ex. 1006 includes a Japanese version of the reference, an English translation of the reference, and a certification of the translation.

⁹ *Automotive Handbook* (3d ed. 1993) (Ex. 1011, “Bosch”). Ex. 1011 includes excerpts from the handbook.

¹⁰ US Pat. Pub. 2005/0098156 A1, published May 12, 2005 (Ex. 1009, “Ohtani”).

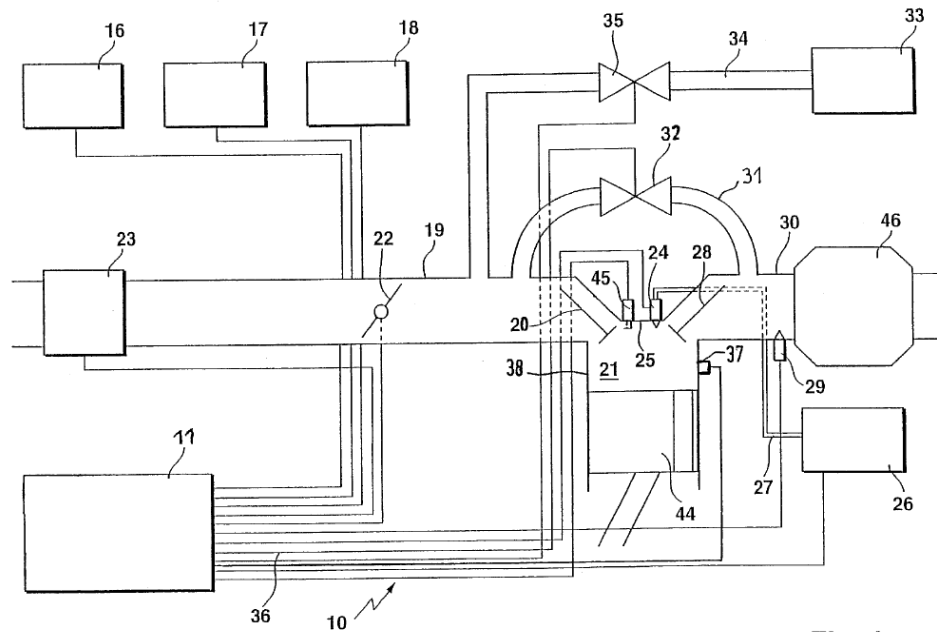


Fig. 1

Figure 1 depicts a schematic of an internal combustion engine with a control system that employs Schray's method. Ex. 1005, 2:1–2. Engine 10 includes injection valve 24, spark plug 45, cylinder 38 (with combustion chamber 21), intake manifold 19, knock sensor 37, lambda probe 29, and catalytic converter 46. *Id.* at 2:9–41. Control apparatus 11 controls engine 10. *Id.* at 2:55–56.

In Schray's method:

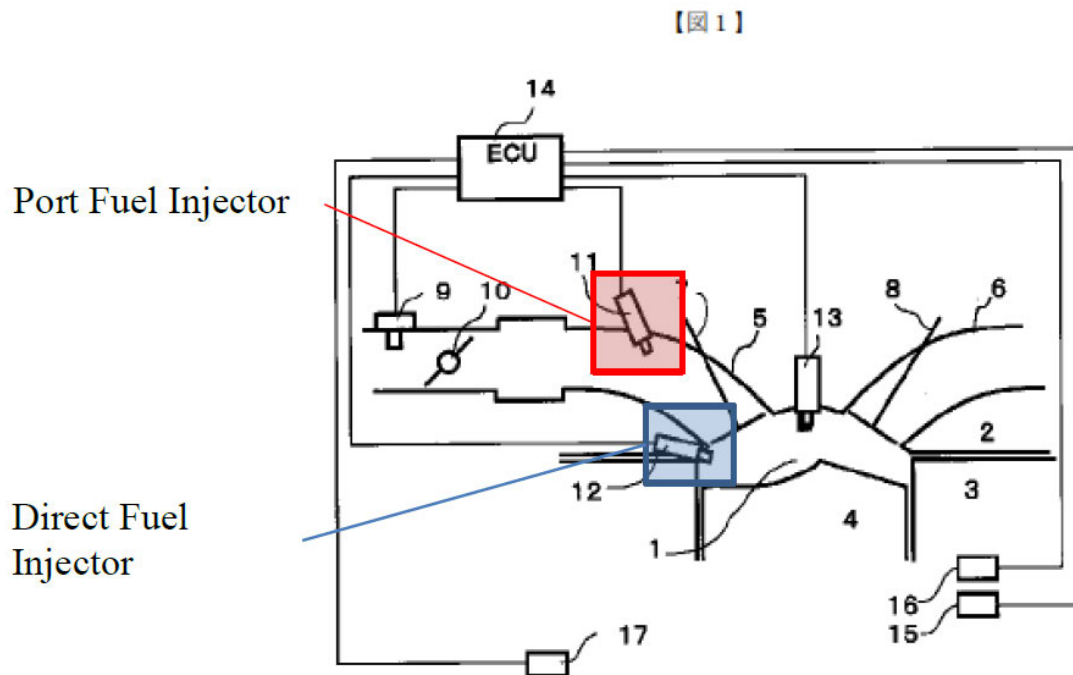
A tendency-to-knock signal is determined . . . [and] compared to a threshold value and double injections are initiated when this threshold value is exceeded.

In this context, double injection means that the first injection takes place in the induction stroke and the second injection takes place in the compression stroke. The second injection causes the air/fuel mixture present in the combustion chamber 21 because of the first injection to be cooled whereby the danger of an uncontrolled ignition of the air/fuel mixture is reduced.

Ex. 1005, 3:46–60.

2. *Miura*

Miura, titled “Control Device for Direct Injection Spark Ignition Internal Combustion Engine,” published on January 15, 2003. Ex. 1008, codes (54), (43). Miura is directed to controlling knock by sub-stratifying the air-fuel mixture. *See id.* at code (57). We reproduce Miura’s Figure 1, as annotated by Petitioner, below.



Pet. 14. Figure 1 depicts a diagram of Miura’s system. Ex. 1008 ¶ 14. The system includes combustion chamber 1, spark plug 13, intake path 5, intake unit (port) fuel injection valve 11 (annotated in red), and direct injection fuel valve 12 (annotated in blue). *Id.* ¶¶ 14–16.

Engine control unit (ECU) 14 controls operation of the engine. Ex. 1008 ¶ 16. “[I]n the high load range where knocking may occur, the required fuel is injected after dividing, and the air-fuel mixture in the combustion chamber 1 is sub-stratified to perform knocking improvement control to suppress the occurrence of knocking.” *Id.* ¶ 21. “[S]ub-stratified

combustion can be performed by injecting a portion of the required fuel during the exhaust stroke via the intake unit fuel injection valve 11, and injecting the remaining fuel during the compression stroke via the in-cylinder direct injection fuel injection valve 12.” *Id.* ¶ 17; *see also id.* at Fig. 2 (providing flowchart of knock suppression method).

Miura describes that its “invention may be applied to an engine of a type for performing the intake stroke injection and compression stroke injection using only the in-cylinder direct injection fuel injection valve 12.” Ex. 1008 ¶ 36.

3. *Zhao*

Zhao, titled “Automotive Gasoline Direct-Injection Engines,” includes a copyright of 2002. Ex. 1010, 1, 6. “Zhao is a well-known text on which a [person having ordinary skill in the art] would have relied.” Pet. 8 (referencing Ex. 1003 ¶¶ 11, 183 (Clark declaration)); *see also* Ex. 1010, 7–11 (providing the table of contents).

4. *Rubbert*

Rubbert, titled “Method for Mixture Formation in a Mixture-Compressing External-Ignition Internal Combustion Engine with Fuel Injection,” published on May 25, 2000. Ex. 1007, codes (54), (43). Rubbert discloses a combination of induction pipe injection (that is, port injection) and direct injection of fuel. *Id.* at code (57). Rubbert describes that

in the idling and partial load ranges, the greater portion of fuel in the mixture is injected by induction pipe injection than by direct injection. The directly injected fuel in this load range results in an ignitable mixture near the spark plug and allows reliable ignition of the lean mixture in the entire combustion chamber.

In contrast, the fuel portion in the mixture can be mostly or completely injected by direct injection in the full-load range of the internal combustion engine, which means that the

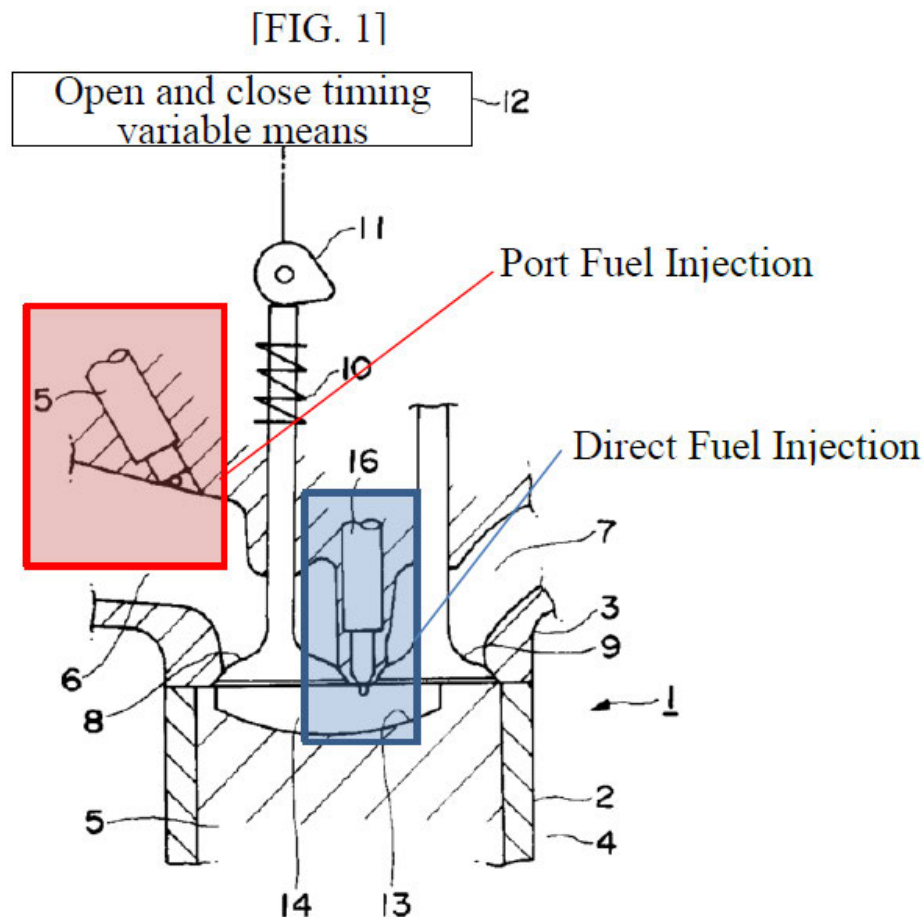
advantages of direct injection with respect to cylinder filling and knock limit can be fully utilized.

Id. at 2, col. 1–col. 2.

5. *Yuushiro*

Yuushiro, titled “Compression Ignition Type Internal Combustion Engine,” published September 22, 1998. Ex. 1006, codes (54), (43).

Yuushiro “relates to a compression ignition type internal combustion engine that compresses premixed gas at high pressure, and causes compression ignition.” *Id.* ¶ 1. We reproduce Petitioner’s annotated version of Yuushiro’s Figure 1, below.



Pet. 38. Annotated Figure 1 depicts “a cross-section view . . . of [Yuushiro’s] compression ignition internal combustion engine,” and

includes Petitioner's labels "Port Fuel Injection"¹¹ (in red) and "Direct Fuel Injection" (in blue). Ex. 1006, 10 ("Brief Description of the Drawings"); Pet. 38. Engine 1 includes cylinder 4 with cylinder head 3, intake port 6, combustion chamber 14, port injection valve 15, and in-cylinder injection valve 16. Ex. 1006 ¶¶ 21, 22, 25.

We reproduce Yuushiro's Figure 3 below.

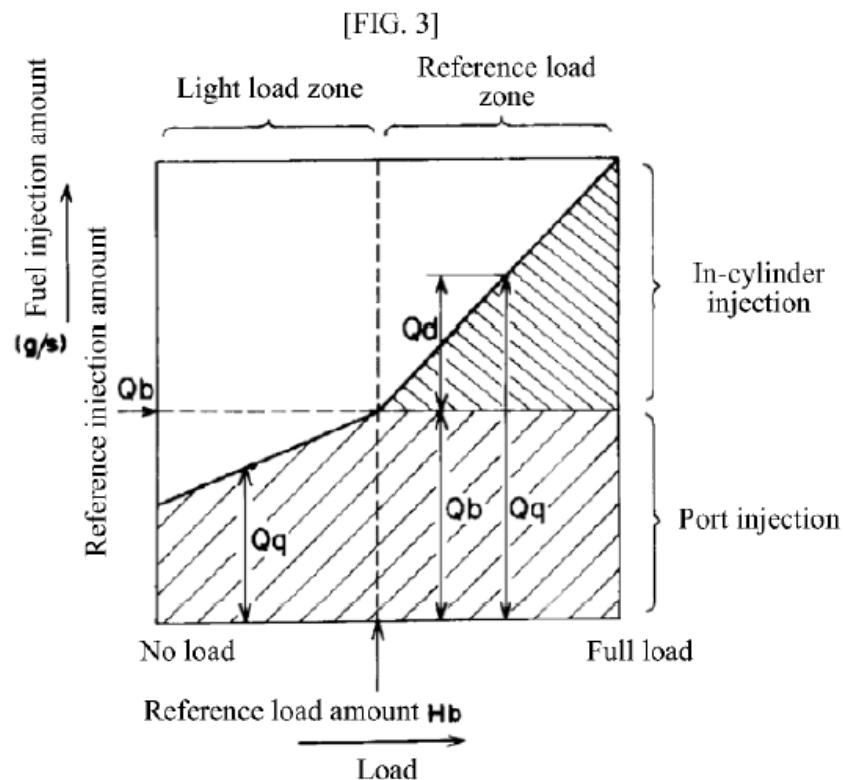


Figure 3 provides an exemplary fuel injection map. Ex. 1006, 10 ("Brief Description of the Drawings"). Yuushiro discloses that its system identifies a reference load amount (H_b), corresponding to a reference injection amount (Q_b), the maximum amount of fuel injected through port injection for which knocking does not occur. *Id.* ¶¶ 16, 38, 39. Loads that

¹¹ Yuushiro's Figure 1 includes a reference number "5" for the port injection valve and for the piston. The port injection valve should be reference numeral "15." See Ex. 1006 ¶¶ 21, 25.

are equal to or less than H_b correspond to a light load zone and loads greater than H_b correspond to a high load zone. *Id.* ¶ 39. For loads in the light load zone, only port injection through valve 15 is used. *Id.* For loads in the high load zone, both port injection and direct injection are used. *Id.* As seen in Figure 3, in the high load zone, the amount of fuel directly injected into the cylinder through valve 16, Q_d , increases with increasing load, as the port injection amount, Q_b , remains the same, that is, at the maximum value for which knocking does not occur. *Id.* ¶ 39, Fig. 3; *see also id.* ¶¶ 41–50 (describing operations in the light load zone), ¶¶ 51–58 (describing operations in the high load zone).

6. *Bosch*

Bosch, which Petitioner contends was published in 1993, is titled “Automotive Handbook.” Ex. 1011, 1–3¹²; Pet. 7. As seen in its table of contents, the Handbook covers a wide array of subjects directed to automotive engineering. *See* Ex. 1011, 4–5. Exhibit 1011 includes excerpts from the handbook, covering sensors (pp. 6–12), mathematics (pp. 13–16), quality (pp. 17–19), engineering statistics (pp. 20–23), reliability (pg. 24), data processing in motor vehicles (pp. 25–26), control engineering (pp. 27–28), internal-combustion engines (pp. 29–58), engine cooling (pp. 59–60), air filters (pg. 61), charging systems (pp. 62–64), exhaust systems (pp. 65–66), engine management (pp. 67–91), and exhaust emissions (pp. 92–97).

7. *Ohtani*

Ohtani, titled “Knocking Determination Apparatus for Internal Combustion Engine,” published on May 12, 2005, from an application filed

¹² We refer to the pagination supplied by Petitioner for the exhibit.

November 8, 2004. Ex. 1009, codes (54), (43), (22). Ohtani “relates to a knocking determination apparatus for an internal combustion engine having an intake injector for injecting fuel into an intake system and an in-cylinder injector for injecting fuel into a combustion chamber.” *Id.* ¶ 2. We reproduce Ohtani’s Figure 1, below.

Fig. 1

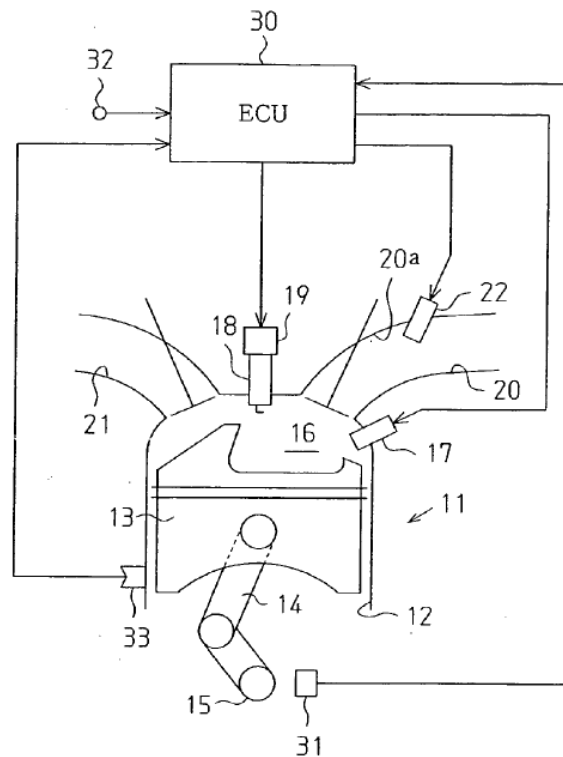


Figure 1 depicts “a schematic view of an internal combustion engine provided with a knocking determination apparatus.” Ex. 1009 ¶ 14. Engine 11 includes cylinder 12, piston 13, injector 17, an in-cylinder injector, and injector 22, an intake, or port, injector. *Id.* ¶¶ 29, 30, 32. Engine 11 also includes spark plug 11, air intake port 20, ECU 30, and knock sensor 33. *Id.* ¶¶ 31, 34, 35.

II. ANALYSIS OF PETITIONER'S CHALLENGES

A. *Applicable Law*

In *inter partes* reviews, a petitioner bears the burden of proving unpatentability of the challenged claims, and the burden of persuasion never shifts to the patent owner. *Dynamic Drinkware, LLC v. Nat'l Graphics, Inc.*, 800 F.3d 1375, 1378 (Fed. Cir. 2015). To prevail in this proceeding, Petitioner must support its challenge by a preponderance of the evidence. 35 U.S.C. § 316(e) (2018); 37 C.F.R. § 42.1(d) (2023). Accordingly, all of our findings and conclusions are based on a preponderance of the evidence standard.

Petitioner's five asserted grounds of unpatentability are each based on obviousness under 35 U.S.C. § 103(a).

Section 103(a) [of 35 U.S.C.] forbids issuance of a patent when “the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains.”

KSR Int'l Co. v. Teleflex Inc., 550 U.S. 398, 406 (2007). The question of obviousness is resolved on the basis of underlying factual determinations, including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of ordinary skill in the art; and (4) when available, objective evidence, such as commercial success, long felt but unsolved needs, and failure of others.¹³ *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966); *see KSR Int'l Co.*, 550 U.S. at 407 (“While the sequence of these questions might be reordered

¹³ Neither party directs us to any objective evidence in the record for our consideration.

in any particular case, the [*Graham*] factors continue to define the inquiry that controls.”). The Court in *Graham* explained that these factual inquiries promote “uniformity and definiteness,” for “[w]hat is obvious is not a question upon which there is likely to be uniformity of thought in every given factual context.” *Graham*, 383 U.S. at 18.

The Supreme Court made clear that we apply “an expansive and flexible approach” to the question of obviousness. *KSR Int’l Co.*, 550 U.S. at 415. Whether a patent claiming the combination of prior art elements would have been obvious is determined by “whether the improvement is more than the predictable use of prior art elements according to their established functions.” *Id.* at 417. To support this conclusion, however, it is not enough to show merely “that the prior art includes separate references covering each separate limitation” in a challenged claim. *Unigene Labs., Inc. v. Apotex, Inc.*, 655 F.3d 1352, 1360 (Fed. Cir. 2011). Rather, obviousness additionally requires that a person of ordinary skill at the time of the invention “would have selected and combined those prior art elements in the normal course of research and development to yield the claimed invention.” *Id.*

“Additionally, ‘universal’ motivations known in a particular field to improve technology provide ‘a motivation to combine prior art references even absent any hint of suggestion in the references themselves.’” *Intel Corp. v. PACTXPP Schweiz AG*, 61 F.4th 1373, 1380 (Fed. Cir. 2023) (emphasis omitted). “And if there’s a known technique to address a known problem using ‘prior art elements according to their established functions,’ then there is a motivation to combine.” *Id.*

“[O]bviousness must be determined in light of *all the facts*, and . . . a given course of action often has simultaneous advantages and disadvantages,

and this does not necessarily obviate motivation to combine” teachings from multiple references. *Medichem, S.A. v. Rolabo, S.L.*, 437 F.3d 1157, 1165 (Fed. Cir. 2006) (emphasis added); *see also PAR Pharm., Inc. v. TWI Pharms., Inc.*, 773 F.3d 1186, 1196 (Fed. Cir. 2014) (“The presence or absence of a motivation to combine references in an obviousness determination is a pure question of fact.”). As a factfinder, we also must be aware “of the distortion caused by hindsight bias and must be cautious of arguments reliant upon *ex post* reasoning.” *KSR Int’l Co.*, 550 U.S. at 421.

B. Level of Ordinary Skill in the Art

The level of skill in the art is “a prism or lens” through which we view the prior art and the claimed invention. *Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001). The person of ordinary skill in the art is a hypothetical person who is presumed to have known the relevant art at the time of the invention. *In re GPAC Inc.*, 57 F.3d 1573, 1579 (Fed. Cir. 1995). Factors that may be considered in determining the level of ordinary skill in the art include, but are not limited to, the types of problems encountered in the art, the sophistication of the technology, and educational level of active workers in the field. *Id.* In a given case, one or more factors may predominate. *Id.*

Petitioner contends that a person having ordinary skill in the art at the time of the invention “would have . . . at least a bachelor’s degree in engineering and at least five years of experience in the field of internal combustion engine design and controls.” Pet. 8 (referencing Ex. 1003 ¶ 10 (providing Dr. Clark’s testimony regarding the level of ordinary skill in the art)). Petitioner contends that additional experience could compensate for a different type of education. *Id.*

Patent Owner does not expressly address the level of ordinary skill in the art in its Patent Owner Response. Dr. Shaver opines that the level of ordinary skill is “bachelor’s degree in mechanical engineering, or a related field, and at least five years of experience in the field of internal combustion engine design and controls.” Ex. 2020 ¶ 42. Dr. Shaver adds that “[i]ndividuals with different experience and education could still be of ordinary skill in the art if that additional experience or education compensates for a deficit in their education and experience stated above.” *Id.* Dr. Shaver’s opinion varies slightly from Petitioner’s proposed level of ordinary skill in the art—Dr. Shaver specifies a bachelor’s degree in “mechanical engineering, or a related field,” and Petitioner specifies “engineering.”

On the complete trial record, we adopt Petitioner’s characterization of the level of ordinary skill, which we find is essentially the same as Patent Owner’s declarant’s characterization. Petitioner’s proposed level of ordinary skill in the art is consistent with the level reflected in the ’965 patent and prior art references. *See, e.g.*, Exs. 1001, 1005, 1006, 1007, 1008, 1009 (describing mechanical aspects of internal combustion engines and systems for controlling those engines).

C. Claim Construction

In *inter partes* reviews, we interpret a claim “using the same claim construction standard that would be used to construe the claim in a civil action under 35 U.S.C. 282(b).” 37 C.F.R. § 42.100(b). Under this standard, we construe the claim “in accordance with the ordinary and customary meaning of such claim as understood by one of ordinary skill in the art and the prosecution history pertaining to the patent.” *Id.*

Petitioner proposes constructions for four terms: 1) “spark ignition engine,” 2) the direct injection (“DI”) terms,¹⁴ 3) “range of torque,” and 4) fuel terms¹⁵. Pet. 3–6. We determine that we need discuss only the fuel terms. *See Realtime Data, LLC v. Iancu*, 912 F.3d 1368, 1375 (Fed. Cir. 2019) (“The Board is required to construe ‘only those terms . . . that are in controversy, and only to the extent necessary to resolve the controversy.’”) (quoting *Vivid Techs., Inc. v. Am. Sci. & Eng’g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999)).

In our Rehearing Decision resulting from Petitioner’s Rehearing Request, we construed the fuel terms consistent with the Federal Circuit’s construction of the terms—“the fuel terms to encompass a configuration where the first fueling system and the second fueling system use the same fuel.” Paper 17, 8, 24. In response, Patent Owner argues that the directly injected fuel cannot be gasoline only. PO Resp. 16.

Patent Owner argues that, in the District Court, Petitioner prevailed in obtaining a construction for the fuel terms, and more precisely, the directly

¹⁴ For example, independent claim 1 recites “where a fraction of fuel in the cylinder that is introduced by the first fueling system increases with increasing manifold pressure so as to prevent knock by providing increased knock resistance.” Ex. 1001, 17:6–9. Independent claims 14, 17, and 19 recite similar subject matter. *See id.* at 18:1–6, 18:34–40, 18:55–59; *see also* Pet. 3 (“Claims 1, 12, 14, 17, and 19 recite the use of direct injection (‘DI’) ‘to prevent knock,’ albeit in different ways.”).

¹⁵ For example, independent claim 1 recites “where the fuel management system controls fueling from a first fueling system that directly injects fuel into at least one cylinder” and “where the fuel management system controls fueling from . . . a second fueling system that injects fuel into a region outside of the cylinder.” Ex. 1001, 16:65–17:2. Independent claims 14, 17, and 19 recite similar subject matter. *See id.* at 17:59–64, 18:25–30, 18:49–53.

injected/first fuel system fuel to be a fuel that contains an anti-knock agent that is not gasoline and that is different from the fuel used in for port injection. PO Resp. 16 (referencing Ex. 1035, 1–2). Patent Owner then argues that the Federal Circuit reversed the portion of the construction requiring the port and direct injection fuels to be different, but kept intact the portion of the construction that the directly injected fuel contain a knock agent other than gasoline. *Id.* at 16–17.

We do not read the Federal Circuit’s decision to be so limiting. Instead, as Patent Owner argues, the appeal was directed to the two fuels issue only. We conclude that the decision is directed to that portion of the construction only. *See* Ex. 1042, 4.

Also, in the Petition, Petitioner applies the construction that Patent Owner advocated at the District Court. Pet. 6. Specifically, Petitioner proposes that the

“Second fueling system that injects fuel into a region outside of the cylinder” (or port injection) should be construed to mean “injection of fuel through a manifold,” and “first fueling system that directly injects fuel” (or direct injection) should be construed to mean “injection of fuel into the cylinder,” consistent with their respective ordinary and customary meanings.

Id. at 5 (referencing Ex. 1003 ¶ 109); *see also* Ex. 1039, 11–17 (providing Patent Owner’s proposed construction), Tr. 42:19–21 (“So this anti-knock agent that is not gasoline, my question is did that -- was that part of Patent Owner’s construction at the District Court level? MR. COGSWELL: No, it was not.”). We adopt this construction for the fuel terms, a construction not inconsistent with the Federal Circuit’s ruling in *Ford II*. Thus, we construe the fuel terms to mean that the first fueling system is not limited to using

fuels different than the fuel in the second fueling system, nor limited to an anti-knock agent that is not gasoline.

To the extent that the scope of any particular claim term requires discussion, however, we provide it in our assessment of the challenges, which we turn to next.

D. Ground 1: Claims 1, 3, 4, and 11–13 as unpatentable over Schray and Miura

Petitioner contends that claims 1, 3, 4, and 11–13 are unpatentable over the combination of Schray and Miura. Pet. 1, 9–22. Below, we discuss the scope and content of the prior art and any differences between the prior art and claimed subject matter, on a limitation-by-limitation basis. First, we address Petitioner’s reasons for combining the teachings of Schray and Miura.

1. Reasons to combine Schray and Miura

a) Petitioner’s contentions

First, Petitioner contends that “[b]oth Schray and Miura are directed to a spark ignition engine that relies on direct fuel injection to suppress knock.” Pet. 10 (referencing Ex. 1005, 3:1–19, 3:55–60; Ex. 1008 ¶¶ 16, 26; Ex. 1003 ¶ 120). Petitioner contends that, “[t]o reduce knock, Schray discloses the use of a single direct injector for two injections.” *Id.* (referencing Ex. 1005, 3:53–55; Ex. 1003 ¶ 121). Petitioner reasons that a person having ordinary skill in the art “would have modified Schray to include a port fuel injector as well as its disclosed direct fuel injector, as is taught by Miura, to provide the engine of Schray with additional benefits relating to mixing and stable combustion at low loads.” *Id.* at 10–11 (referencing Ex. 1003 ¶ 121). Petitioner, relying on Dr. Clark’s testimony, adds that the benefits of port fuel injection were well known to a person

having ordinary skill in the art. *Id.* at 11 (referencing Ex. 1003 ¶ 121; Ex. 1010, 4). Dr. Clark supports his opinion that the benefits of port fuel injection were well known with reference to Bosch. *See* Ex. 1003 ¶ 121 (quoting Ex. 1011, 29, 67).

Petitioner contends that a person having ordinary skill in the art would have had a reasonable expectation of success in making the proposed modification, because Miura teaches an engine that uses both direct and port injection, and because both Schray's and Miura's engines operate similarly. Pet. 11 (referencing Ex. 1008 ¶¶ 17, 20, 36; Ex. 1005, 3:16–18; Ex. 1003 ¶ 122). Petitioner contends that a person having ordinary skill in the art would have understood that adding an intake portion fuel injection valve would have been a simple substitution. *Id.* (referencing Ex. 1003 ¶¶ 112–123).

Next, Petitioner contends that a person having ordinary skill in the art “would have . . . incorporated open loop control into Schray based on the teachings of Miura.” Pet. 11 (referencing Ex. 1003 ¶¶ 124–129). Petitioner contends that an artisan of ordinary skill “would have understood that when Miura's open loop control strategy is added to the control strategy of Schray, the resulting fuel management strategy would advantageously vary [direct injection] as a result of both load and speed.” *Id.* at 11–12 (referencing Ex. 1003 ¶ 128). Petitioner explains that “[s]uch a combined system would also retain the benefits espoused by Schray, namely the ability to obtain a high torque and a low development of toxic substances while avoiding knock and the ability to vary the proportion of the first and second (or late) injections between 30 and 70” percent. *Id.* at 12 (referencing Ex. 1003 ¶ 128; Ex. 1005, 4:5–10). Petitioner adds that a person having ordinary skill in the art “would have understood that the combination of open and closed

loop control would also provide for additional control over engine variables[, including] . . . allow[ing] both for the anticipation of knock and the mitigation of knock when knock is detected.” *Id.* (referencing Ex. 1003 ¶ 128).

Petitioner contends that a person having ordinary skill in the art would have had a reasonable expectation of success in incorporated open loop knock control into Schray, because it was well known at the time of the invention to use both open and closed loop control for an engine. Pet. 12 (referencing Ex. 1003 ¶ 129).

b) Patent Owner’s response

Patent Owner responds that a person having ordinary skill in the art would not have been motivated to combine the teachings of Schray and Miura to arrive at the claimed invention. PO Resp. 21. Specifically, Patent Owner argues that Miura disables knock control at high engine revolutions per minute (rpms) and Schray prevents knock throughout the full range of rpms. *Id.* Patent Owner argues that using Miura’s open loop control strategy would “eviscerate the purpose of Schray.” *Id.* at 21–22 (referencing Ex. 1005, 1:15–20; Ex. 2020 ¶ 89).

Patent Owner also argues that incorporating Miura’s teaching of port injection would add complexity with no offsetting benefit. PO Resp. 22. Patent Owner argues that Petitioner does not demonstrate the Schray would benefit from the benefits of mixing and stable combustion at low loads provided by port injection. *Id.* Patent Owner argues that Schray teaches stratified combustion at low loads. *Id.* at 22–23.

Next, Patent Owner argues that a person having ordinary skill in the art “would not have look to Schray to supplement the knock mitigation routine of Miura for the additional reason that Schray and Miura describe

different approaches to knock mitigation.” PO Resp. 23 (referencing Ex. 2020 ¶ 91). Patent Owner argues that Schray always uses direct injection and vaporization cooling for knock control. *Id.*

c) Petitioner’s reply and Patent Owner’s sur-reply

Petitioner replies that the proposed combination does not rely on Miura’s knock control at high speeds. Pet. Reply 10. Petitioner also argues that Miura does not disable knock control, but instead uses spark retard. *Id.* Petitioner argues that Dr. Clark opined that the proposed combination would use Schray’s late direct injection in the knock endangered region, “allowing high torque and low development of toxic substances.” *Id.* at 11 (referencing Ex. 1003 ¶¶ 111, 120–129, 143–148, and characterizing this testimony as “unrebutted”).

Petitioner replies that the proposed combination does not rely on Schray’s stratified mode embodiment. Pet. Reply 11 (referencing Pet. 10; Ex. 1003 ¶ 121). Petitioner argues that Dr. Clark testifies that the fuel management system of the combined teachings would benefit from port injection, with its known benefits of better mixing and stable combustion at low loads. *Id.* (referencing Ex. 1003 ¶¶ 111, 121–123, 135, 136, 140, 146, 147, 157; Ex. 1011, 353, 428; Ex. 1001, 2:64–66; Ex. 1046, 113:25–114:17, 135:3–23; Ex. 2020 ¶ 30). Petitioner adds that Patent Owner’s argument ignores Schray’s teachings of homogenous operation throughout the operating range. *Id.* (referencing Ex. 1005, 3:16–19; Ex. 1046, 373:21–374:6, 366:23–373:20; 1003 ¶ 122; Pet. 11).

Petitioner also replies that Patent Owner “ignores that Miura’s second injection provides vaporization cooling, like Schray.” Pet. Reply 12 (referencing Ex. 1003 ¶¶ 120, 124–125). Petitioner argues that “Miura’s late-[direct injection] mixes with the [port injection] in the combination to

become stoichiometric.” *Id.* (referencing Ex. 1008 ¶ 20; Ex. 1046, 203:16–23 (admitting overall stoichiometric mixtures with lean portions within the cylinder); 180:4–181:24; Ex. 1001, 11:20–28).

Patent Owner replies that Petitioner’s argument that it is not relying on Miura’s high speed knock control is “belated[.]” PO Sur-reply 9–10. Patent Owner argues that the Petition neglects the “stratified mode” in Schray, which is “essential.” *Id.* at 10 (referencing Ex. 1005, 2:65–67).

d) Analysis and conclusions – reasons to combine Schray and Miura

We have reviewed the complete trial record and find that Petitioner has provided, by the preponderance of the evidence, sufficient reasons, with rational underpinnings, that a person having ordinary skill in the art would have been motivated to modify Schray with Miura’s teachings to arrive at the claimed invention and would have had a reasonable expectation of success in doing so. *See KSR Int’l Co.*, 550 U.S. at 418 (stating that, to facilitate the analysis of an obviousness position, the proponent should provide “some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness”); *see also id.* at 417 (“[W]hen a patent ‘simply arranges old elements with each performing the same function it had been known to perform’ and yields no more than one would expect from such an arrangement, the combination is obvious.”).

We credit Dr. Clark’s testimony, for at least the reason that it is supported by, and consistent with, evidence in the record¹⁶. With respect to

¹⁶ Dr. Clark states that his “opinions are based on [his] experience and knowledge and the information [he has] reviewed as of the date of [his] Declaration.” Ex. 1003 ¶ 11.

modifying Schray with Miura's teaching of port injection, Dr. Clark testifies that a

person of skill in the art would have understood that modifying Schray to include a port fuel injector as well as its disclosed direct fuel injector, as is taught by Miura, would have provided the engine of Schray with additional benefits relating to mixing and stable combustion at low loads while still relying on a homogeneous air-fuel mixture over the entire operating range.

Ex. 1003 ¶ 121. Dr. Clark adds that these benefits were well known. *Id.* (citing Ex. 1011, 353, 428). Dr. Clark also testifies that a person having ordinary skill in the art would have had a reasonable expectation of success, given both references disclose homogeneous operations, and Miura discloses an engine with both port and direct injection. *Id.* ¶¶ 122 (citing Ex. 1005, 3:16–18; Ex. 1008 ¶ 20), 123 (citing Ex. 1008 ¶ 36).

We also credit Dr. Clark's testimony with respect to modifying Schray to include Miura's teaching of open loop control. Dr. Clark testifies that a

person of ordinary skill in the art would have understood that when Miura's open loop control strategy is added to the control strategy of Schray, the resulting fuel management strategy would advantageously vary direct injection as a result of engine operating conditions to include both load and speed. Such a combined system would have the benefits espoused by Schray, namely the ability to obtain a high torque and a low development of toxic substances while avoiding knock. . . . [T]he combined system would allow both for the anticipation of knock (e.g., based on open loop control from Miura) and the mitigation of knock when knock is detected (e.g., based on closed loop control from Schray).

Ex. 1003 ¶ 128; *see also id.* ¶¶ 124–127 (supporting the opinion in paragraph 128, including providing evidentiary support for the bases of the opinion), 129 (“[A] person of ordinary skill in the art would have had a

reasonable expectation of success in the combination as it was well-known to operate engines with both open loop and closed loop control,” including as taught in Schray).

We have reviewed Patent Owner’s arguments and find that they do not demonstrate a deficiency in Petitioner’s contentions with respect to motivation to combine Schray and Miura. We understand Petitioner to contend that Schray’s engine would benefit from Miura’s general teachings of using open loop control, such that how Miura operates its knock control at high loads would not have dissuaded a person having ordinary skill in the art from using both open and closed loop control. Also, as Petitioner argues, the proposed combination employs Schray’s knock suppression at high loads. *See* Pet. Reply 11; Ex. 1003 ¶¶ 111, 120–129, 143–148.

We also do not agree with Patent Owner that Schray would not benefit from port injection, because operating in a stratified mode is “essential” to Schray’s engine. As Petitioner argues, Schray identifies a homogenous operating mode, which is identified as “essential.” *See* Pet. Reply 11; Ex. 1005, 2:65–3:18; *see also id.* at 2:61–63 (“[E]ngine 10 can be operated in different operating modes which differ essentially by the injection time point, the ignition time point, and the cylinder charge.”).

With respect to Patent Owner’s argument that a person having ordinary skill in the art would not have looked to Miura for knock suppression, as its technique differs from Schray, which always uses direct injection and vaporization cooling for knock control, we find that Patent Owner has not sufficiently overcome Petitioner’s evidence in support of the modification. To the extent Patent Owner argues that Schray teaches away from Miura’s technique, Patent Owner does not adequately explain why Schray’s approach would discredit Miura’s approach. We also agree with

Petitioner that Miura discloses vaporization cooling to suppress knock. *See* Pet. Reply 12; Ex. 1003 ¶¶ 120, 124–125; Ex. 1008 ¶¶ 27–30.

To the extent necessary, we address any additional arguments directed to motivation associated with a specific limitation in our limitation-by-limitation analysis, below.

2. *Independent claim 1*

a) *Preamble*

The preamble of claim 1 recites “[a] fuel management system for a spark ignition engine.” Ex. 1001, 16:64¹⁷. Petitioner contends that both “Miura and Schray disclose an engine having a spark plug using a timed spark to initiate ignition.” Pet. 13 (referencing Ex. 1005, 2:20–21; Ex. 1008 ¶ 16; Ex. 1003 ¶¶ 130–132).

Upon review of the information in the Petition and corresponding evidence, we find that Petitioner has demonstrated, by a preponderance of the evidence, that both Miura and Schray disclose spark ignition engines. *See* Ex. 1005, 2:20–21; Ex. 1008 ¶ 16; Ex. 1003 ¶¶ 130–132. In view of this determination, we need not resolve whether the preamble is limiting. Patent Owner does not dispute Petitioner’s contentions with respect to the preamble and this ground. *See* PO Resp. 22–27.

b) *Limitation 1[A]: Fueling systems limitation*

Claim 1 also recites “where the fuel management system controls fueling from a first fueling system that directly injects fuel into at least one cylinder as a liquid and increases knock suppression by evaporative cooling and from a second fueling system that injects fuel into a region outside of

¹⁷ Claim 1 does not include a transitional phrase, which typically separates the preamble of a claim with the body of a claim. We follow Petitioner’s designation of the preamble. *See* Pet. 13.

the cylinder.” Ex. 1001, 16:65–17:2 (limitation 1[A], the “fueling systems” limitation of claim 1). Petitioner contends that Schray discloses direct injection from a first fueling system, using injection valve 24, with this injection providing evaporative cooling. Pet. 13–14 (referencing Ex. 1005, 2:16–17, 2:55–56, 3:55–60; Ex. 1003 ¶¶ 133, 134).

Petitioner recognizes that Schray does not disclose a second fueling system using port injection. Pet. 14. Petitioner contends that Miura discloses a fuel management system that employs both direct injection and port injection, and that a person having ordinary skill in the art would have looked to Miura to modify Schray. *Id.* (referencing Ex. 1008 ¶¶ 15–16, 27; Ex. 1003 ¶¶ 135, 136); *see also id.* (providing an annotated version of Miura’s Figure 1, identifying the port fuel injector and direct fuel injector).

Petitioner contends that both Schray and Miura disclose knock suppression by evaporative cooling. Pet. 15 (referencing Ex. 1005, 3:55–60; Ex. 1008 ¶ 27; Ex. 1003 ¶¶ 133–136).

Upon review of the information in the Petition and corresponding evidence, and in light of our analysis of Petitioner’s reasons to combine the teachings of Schray and Miura, discussed above, we find Petitioner has demonstrated, by a preponderance of the evidence, that the combination of Schray and Miura teaches or suggests the subject matter of the “fueling systems” limitation of claim 1. *See* Ex. 1005, 2:16–17, 2:55–56, 3:55–60; Ex. 1008 ¶¶ 15–16, 27, Fig. 1; Ex. 1003 ¶¶ 133–136. Patent Owner does not dispute Petitioner’s contentions with respect to the subject matter of this limitation. *See* PO Resp. 22–27.

c) Limitation 1[B]: Range of torque limitation

Claim 1 also recites “where there is a range of torque where both fueling systems are used at the same value of manifold pressure.” Ex. 1001,

17:3–5 (limitation 1[B], the “range of torque” limitation of claim 1).

Petitioner contends that both Schray’s and Miura’s fueling systems have a torque or load range where engine knock needs to be suppressed (Schray’s “knock endangered operating regions” and Miura’s high load range).

Pet. 15–16 (referencing Ex. 1005, 3:61–64; Ex. 1008 ¶¶ 20–21; Ex. 1003 ¶¶ 138–139). Petitioner contends, for example, that “[i]n the high load range and thus across multiple manifold pressures, Miura discloses that the required fuel is injected after dividing it between the intake stroke (port fuel injection) and the compression stroke (direct injection).” *Id.* at 16 (referencing Ex. 1008 ¶ 21; Ex. 1003 ¶ 141).

Upon review of the information in the Petition and corresponding evidence, and in light of our analysis of Petitioner’s reasons to combine the teachings of Schray and Miura, discussed above, we find Petitioner has demonstrated, by a preponderance of the evidence, that the combination of Schray and Miura teaches or suggests the subject matter of the “range of torque” limitation of claim 1. *See* Ex. 1005, 3:61–64; Ex. 1008 ¶¶ 20–21; Ex. 1003 ¶¶ 138–141. Patent Owner does not dispute Petitioner’s contentions with respect to this limitation. *See* PO Resp. 22–27.

d) Limitation 1[C]: Fraction of fuel limitation

Claim 1 also recites “where a fraction of fuel in the cylinder that is introduced by the first fueling system increases with increasing manifold pressure so as to prevent knock by providing increased knock resistance.” Ex. 1001, 17:6–9 (limitation 1[C], the “fraction of fuel” limitation of

claim 1¹⁸). Petitioner contends that both Schray's and Miura's fuel systems disclose the subject matter of this limitation. Pet. 16–18.

Petitioner contends that “Schray discloses that the proportion of the fuel mass to be injected by each injection is determined based on the extent of the tendency-to-knock signal and/or from an engine parameter specific characteristic field stored in the control apparatus 11,” and “that the proportion of the first and second (or late) injections varies between 30 and 70” percent. Pet. 17 (referencing Ex. 1005, 3:46–48, 4:1–10; Ex. 1003 ¶ 144). Petitioner contends that a person having ordinary skill in the art “would have recognized that an engine operating at higher loads would operate at higher temperatures and pressures, and therefore demand a higher ratio of fuel from the second injection to provide cooling to prevent knock.” *Id.* (referencing Ex. 1003 ¶ 145). Petitioner also contends that “Miura discloses varying the portion of directly injected fuel based on engine operating conditions (*e.g.*, engine rpm)” and “employs . . . an accelerator position sensor and air intake volume, both of which are predictors of load.” *Id.* (referencing Ex. 1008 ¶¶ 19, 30; Ex. 1003 ¶¶ 146–147) (footnote omitted).

Petitioner concludes that a person having ordinary skill in the art “would have understood that the combined system would change [direct

¹⁸ Petitioner argues that this limitation “is functional and should not be afforded patentable weight.” Pet. 16 (footnote omitted); *see also id.* at 4 (“[T]he DI Terms are not entitled to patentable weight because they are statements of a desired result, rather than an apparatus or specific structure to accomplish the desired result,” citing *Hewlett-Packard Co. v. Bausch & Lomb Inc.*, 909 F.2d 1464, 1468 (Fed. Cir. 1990); *In re Schreiber*, 128 F.3d at 1478–1479 (Fed. Cir. 1997)). Because we find that the combination of Schray and Miura teach or suggest the subject matter of this limitation, we do not reach this issue.

injection] fueling based on load and, thus, the fraction of fuel from the [direct injection] system would increase with an increase in load or manifold pressure.” Pet. 18 (referencing Ex. 1003 ¶¶ 143–147).

Patent Owner argues that Petitioner’s contentions are based on inherency. PO Resp. 24–26. Patent Owner argues that Petitioner’s contention “about [no direct injection at] ‘low and medium load ranges,’ even if correct, says *nothing* about whether the [direct injection] fraction ‘increases with increasing manifold pressure *so as to prevent knock by providing increased knock resistance.*’” *Id.* at 24 (referencing Ex. 2020 ¶ 120). Patent Owner additionally argues that Petitioner’s contention about actions in the low and medium ranges is incorrect, as Miura teaches stratified combustion in the low and medium range, which would be achieved by direct injection. *Id.*

Additionally, Patent Owner argues that Petitioner’s alternative argument that Schray satisfies this limitation is incorrect, as Schray uses 100 percent direct injection. PO Resp. 24 (referencing Ex. 2020 ¶ 121). Patent Owner adds that “Schray does not necessarily disclose that the fraction of fuel supplied by the first and the second [direct injection] pulses increases with increasing manifold pressure[, as n]othing in Schray requires the fraction of fuel in either [direct injection] pulse to change in any particular manner with increasing manifold pressure.” *Id.* at 25 (referencing Ex. 2020 ¶¶ 122, 123).

Additionally, Patent Owner argues that “[e]ven if Petitioner argued that the combination of references taught the invention, rather than relying on the separate inherent disclosures of each reference, there would have been no motivation to combine the references to arrive at the recited limitation. PO Resp. 26 (referencing Ex. 2020 ¶ 125).

Petitioner replies that Patent Owner ignores the combined teachings of the references. Pet. Reply 12. Petitioner argues that a person having ordinary skill in the art “would have understood that the proportion of the second or late injection increases as torque increases from, for example, 30%-70%.” *Id.* at 13 (quoting Ex. 1003 ¶ 144). Petitioner adds that “[i]t is undisputed that knock is more likely at higher torques,” and Schray’s teaching to vary the proportion of fuel between 30 percent and 70 percent demonstrates the limitation is disclosed. *Id.* at 14 (referencing Ex. 1046, 140:12–141:14, 184:18–185:18, 282:7–21, 388:14–390:13, 486:17–21; Ex. 2022, 39:23–42:7, Ex. 1003 ¶¶ 144–148, 174).

In reply, Patent Owner argues that in Schray, there is no disclosure of the connection between manifold pressure and torque and “the connection between increasing torque and increasing manifold pressure in an engine can in general change with changes in the air/fuel ratio,” and “the Petition fails to show any *necessary* disclosure of a connection of increasing fraction of DI with increasing *manifold pressure*.” PO Sur-reply 11.

We have reviewed Patent Owner’s arguments and find that they do not demonstrate a deficiency in Petitioner’s contentions with respect to the subject matter of this limitation. We agree with Petitioner that Patent Owner’s arguments ignore the combined teachings of Schray and Miura upon which Petitioner relies. *See, e.g.*, Pet. 17 (“Even if Limitation [1.C] is interpreted to require an increase in the fraction of [direct injection] fuel for each increase in manifold pressure, this is also taught by the combination.”), 18 (“[A person having ordinary skill in the art] would have understood that the combined system would change [direct injection] fueling based on load and, thus, the fraction of fuel from the [direct injection] system would increase with an increase in load or manifold pressure” (footnote omitted)).

We also do not understand Petitioner to base its contentions on inherency. We credit Dr. Clark's testimony that a "person of ordinary skill in the art would have understood that manifold pressure scales with torque and horsepower at a given engine size." Ex. 1003 ¶ 140; *see, e.g.*, Ex. 1034, 2–3 (contending that engine load corresponds to manifold pressure); Ex. 1028, 220 (presenting page 827 of *Internal Combustion Engine Fundamentals*, which states "Load, of course, varies by varying inlet manifold pressure."); *cf.* Ex. 1001, 7:66–8:3 (stating that torque and horsepower scale with manifold pressure in a given engine size). That is, Petitioner contends that the combined teachings disclose the subject matter of the limitation, albeit using different language.

We also credit Dr. Clark's testimony that the combined teachings of Schray and Miura indicate that additional direct injection is used at higher engine loads, which at least suggests the subject matter of this limitation. *See* Ex. 1003 ¶¶ 143–147. We credit this testimony, in part, because it is consistent with our understanding of Schray and Miura. Miura discloses that at low and medium loads, homogenous lean combustion or homogenous stoichiometric combustion methods can be used, with homogenous combustion associated with port injection. *See* Ex. 1008 ¶¶ 17, 20. Miura and Schray disclose direct injection at higher loads, and that direct injection provides evaporative cooling for knock suppression. *See* Ex. 1005, 3:46–60, 4:1–10; Ex. 1008 ¶¶ 3, 21, 27.

We do not credit Dr. Shaver's testimony with respect to Miura teaching stratified combustion at low and medium ranges. *See* Ex. 2020 ¶ 120. Although Miura does teach stratified combustion, it also teaches homogeneous combustion at low and medium ranges, which would be from port injection. *See* Ex. 1008 ¶ 20.

With respect to both Patent Owner’s argument (PO Resp. 26) and Dr. Shaver’s testimony (Ex. 2020 ¶ 125) directed to no motivation to combine the teachings of Schray and Miura, we address that argument above, in the subsection analyzing Petitioner’s contentions directed to motivation to combine.

Upon review of the information in the Petition and corresponding evidence, and Patent Owner’s counter arguments and evidence, and in light of our analysis of Petitioner’s reasons to combine the teachings of Schray and Miura, discussed above, we find Petitioner has demonstrated, by a preponderance of the evidence, that the combination of Schray and Miura teaches or suggests the subject matter of the “fraction of fuel” limitation of claim 1.

e) Limitation 1[D]: Knock detection limitation

Claim 1 also recites “where the fuel management system controls the change in the fraction of fuel introduced by the first fueling system using closed loop control that utilizes a sensor that detects knock and where open loop control is also used.” Ex. 1001, 17:10–15 (limitation 1[D], the “knock detection” limitation of claim 1). Petitioner contends that Schray discloses a closed loop control system using a knock sensor. Pet. 18 (referencing Ex. 1005, 2:25–29, 4:18–20; Ex. 1003 ¶ 149). Petitioner contends that Miura discloses employing an open loop system using a preset map, and that a person having ordinary skill in the art would have looked to Miura for this teaching for the reasons outlined for modifying Schray’s system with Miura’s port injection system, which we discuss in connection with our analysis of the “fueling systems” limitation of claim 1. *Id.* at 19 (referencing Ex. 1008 ¶ 29; Ex. 1003 ¶ 155).

Patent Owner argues that Petitioner does not demonstrate that Schray's knock sensor is inherently part of a closed loop system. PO Resp. 26–27. Petitioner replies that “Patent Owner admits Schray teaches ‘use of a knock sensor and subsequent use of double injections.’” Pet. Reply 15 (referencing PO Resp. 26–27; Ex. 1046, 454:2–9). Petitioner argues that Dr. Clark's unrebutted testimony explains that the double injection is initiated in response to the knock sensor to mitigate knock. *Id.* (referencing Ex. 1003 ¶¶ 139–140). Patent Owner replies that Petitioner has not met the standard for inherency.

We have reviewed Patent Owner's arguments and find that they do not demonstrate a deficiency in Petitioner's contentions with respect to the subject matter of this limitation. We do not agree with Patent Owner that Petitioner's position is grounded in inherency. Petitioner and Dr. Clark direct us to disclosure in Schray that teaches or suggests that Schray's fuel management system operates with closed loop control, with the system performing mitigative measures, such as double injection, in response to signals from the knock sensor. *See, e.g.*, Ex. 1005, 1:35–37 (“The control apparatus evaluates the knock signal and initiates suitable countermeasures when a knocking combustion is detected.”), 2:30–33 (“[A] conclusion as to a knocking combustion can be drawn by evaluating the signal of the knock sensor and/or of the ion flow sensor 37.”), 4:17–19 (“When detecting a ‘knocking’ combustion, double injections are carried out in addition to the knock control by shifting the ignition angle in a direction of retard.”).

Upon review of the information in the Petition and corresponding evidence, and Patent Owner's counter arguments and evidence, and in light of our analysis of Petitioner's reasons to combine the teachings of Schray and Miura, discussed above, we find Petitioner has demonstrated, by a

preponderance of the evidence, that the combination of Schray and Miura teaches or suggests the subject matter of the “knock detection” limitation of claim 1.

f) Limitation 1[E]: Engine map lookup table limitation

Claim 1 also recites “where the open loop control uses an engine map lookup table.” Ex. 1001, 17:16–17 (limitation 1[E], the “engine map lookup table” limitation of claim 1). As discussed above in connection with our analysis of the “knock detection” limitation of claim 1, Petitioner contends that Miura teaches using an engine map lookup table. *See* Pet. 19 (referencing Ex. 1008 ¶ 29; Ex. 1003 ¶ 155); *see also id.* (including Petitioner’s contentions with respect to the “knock detection” limitation of claim 1).

Upon review of the information in the Petition and corresponding evidence, and in light of our analysis of Petitioner’s reasons to combine the teachings of Schray and Miura, discussed above, we find Petitioner has demonstrated, by a preponderance of the evidence, that the combination of Schray and Miura teaches or suggests the subject matter of the “engine map lookup table” limitation of claim 1. Patent Owner does not dispute Petitioner’s contentions with respect to this limitation.

g) Limitation 1[F]: Open loop limitation

Finally, claim 1 recites “where open loop control is used during transients in engine load.” Ex. 1001, 17:18–19 (limitation 1[F], the “open loop” limitation of claim 1). Petitioner contends that Miura discloses that its preset map “is operational throughout the drive cycle as it is used in the high load range as well as the low and medium load ranges.” Pet. 19 (referencing Ex. 1008 ¶¶ 20–21). Petitioner contends that a person having ordinary skill

in the art “would have understood that Miura open loop control strategy is used during transients (e.g., changes in engine load).” *Id.* at 19–20 (referencing Ex. 1002, 131; Ex. 1003 ¶ 157).

Upon review of the information in the Petition and corresponding evidence, and in light of our analysis of Petitioner’s reasons to combine the teachings of Schray and Miura, discussed above, we find Petitioner has demonstrated, by a preponderance of the evidence, that the combination of Schray and Miura teaches or suggests the subject matter of the “open loop” limitation of claim 1. Patent Owner does not dispute Petitioner’s contentions with respect to this limitation.

h) Conclusion as to Ground 1, Independent Claim 1

For the reasons discussed above, we conclude, on the complete trial record, that Petitioner demonstrates, by a preponderance of the evidence, that claim 1 is unpatentable under 35 U.S.C. § 103(a) over Schray and Miura.

3. Claims 3, 4, and 11–13

a) Claim 3

Claim 3 depends from claim 1 and further recites “where use of the second fueling system in addition to the first fueling system is employed to obtain combustion stability.” Ex. 1001, 17:24–26. Petitioner contends that both Miura and Schray disclose homogenous operations, which provide combustion stability, and that the combination of Schray and Miura employ both port injection and direct injection. Pet. 20 (referencing Ex. 1005, 3:16–18; Ex. 1008 ¶ 32; Ex. 1034, 7–11; Ex. 1001, 3:10–12; Ex. 1003 ¶¶ 150–161).

Upon review of the information in the Petition and corresponding evidence, and in light of our analysis of Petitioner’s reasons to combine the

teachings of Schray and Miura, discussed above, we find Petitioner has demonstrated, by a preponderance of the evidence, that the combination of Schray and Miura teaches or suggests the subject matter of claim 3. Patent Owner does not dispute Petitioner's contentions with respect to this claim.

b) Claim 4

Claim 4 depends from claim 1 and further recites “where fuel from the first fueling system is introduced when the engine torque is above a selected value.” Ex. 1001, 17:27–29. Petitioner contends that “[a]s is presented in Limitation [1.B], Miura discloses that the required fuel is injected after dividing it between the intake stroke and the compression stroke.” Pet. 21 (referencing Ex. 1008, ¶ 21; Pet. 15–16 (providing contentions for Limitation [1.B]); Ex. 1003 ¶¶ 163–165).

Patent Owner responds that Petitioner makes an inherency argument and the disclosure in Miura upon which Petitioner relies does not necessarily disclose in any way that direct injection fuel is “introduced when the engine torque is above a selected value” because “Petitioner identifies no connection between dividing the required fuel and torque being ‘above a selected value.’” PO Resp. 27.

Petitioner replies that Patent Owner ignores the reference to limitation 1[B] in the Petitioner's contentions with respect to claim 4, which identifies Miura's teachings of divided injections in the high load range, and Dr. Clark's testimony “that ‘Miura discloses that the high load range is activated above a certain value (e.g., load).’” Pet. Reply 16 (referencing Ex. 1003 ¶¶ 164–165, which cites Ex. 1008 ¶¶ 20–21, Fig. 8).

Patent Owner replies that Petitioner has clearly made an inherency argument over Miura. PO Sur-reply 13.

We have reviewed Patent Owner’s argument and find that it does not demonstrate a deficiency in Petitioner’s contentions with respect to the subject matter of claim 4. We do not agree with Patent Owner that Petitioner’s position is based on inherency. Instead, Petitioner contends that Miura discloses that fuel is injected in the high load region, the recited “selected value.” We credit Dr. Clark’s testimony that “Miura discloses that the fuel is injected in the compression stroke, such as by an in-cylinder direct injection fuel injection valve 12 (e.g., direct fuel injection valve), only when the engine is above a selected value (e.g., high load),” as it is consistent with Miura’s teachings. *See* Ex. 1003 ¶¶ 164–165; Ex. 1008 ¶¶ 20–21.

Upon review of the information in the Petition and corresponding evidence, including Patent Owner’s counter argument and evidence, and in light of our analysis of Petitioner’s reasons to combine the teachings of Schray and Miura, discussed above, we find Petitioner has demonstrated, by a preponderance of the evidence, that the combination of Schray and Miura teaches or suggests the subject matter of claim 4.

c) Claim 11

Claim 11 depends from claim 1 and further recites “where there is a range of torque in which only the second fueling system is used.” Ex. 1001, 17:49–51. As discussed above in our analysis of claim 1, Petitioner modifies Schray’s teachings with Miura’s teachings of port fuel injection. *See* Pet. 14. For claim 11, Petitioner contends that Miura discloses “when the engine is not in the high load range, normal control is performed (e.g., fueled by the second fueling system or the port fueling system).” Pet. 21 (referencing Ex. 1008 ¶¶ 4, 25; Ex. 1003 ¶ 168).

Upon review of the information in the Petition and corresponding evidence, and in light of our analysis of Petitioner’s reasons to combine the teachings of Schray and Miura, discussed above, we find Petitioner has demonstrated, by a preponderance of the evidence, that the combination of Schray and Miura teaches or suggests the subject matter of claim 11. Patent Owner does not dispute Petitioner’s contentions with respect to this claim.

d) Claim 12

Claim 12 depends from claim 11 and further recites “where as torque increases there is a selected value of torque at which the first fueling system is also employed and prevents knock that would otherwise occur.”

Ex. 1001, 17:52–55. Petitioner cross references its analysis for “Claim 9.” Pet. 21–22. It appears that Petitioner actually means independent claim 1, based on the analysis by Dr. Clark (and the fact that claim 9 is not challenged). *See* Ex. 1003 ¶¶ 170–176 (referencing the analysis for limitation 1[C]); *cf.* Pet. 44–45 (addressing claim 12 for Ground 3 and referencing limitation 1[C]).

Patent Owner disputes one aspect of Petitioner’s analysis for claim 12—the “select value of torque,” for the reasons argued for claim 4. PO Resp. 29. Petitioner replies to the arguments for claim 4 and 12 together. *See* Pet. Reply 16. For the reasons discussed above in our analysis of claim 4, we find that Petitioner sufficiently demonstrates that Miura discloses a select value of torque where direct injection is used to prevent knock, such that the combination of Schray and Miura teaches or suggests the subject matter of claim 12.

Upon review of the information in the Petition and corresponding evidence, including Patent Owner’s counter argument and evidence, and in light of our analysis of Petitioner’s reasons to combine the teachings of

Schray and Miura, discussed above, we find Petitioner has demonstrated, by a preponderance of the evidence, that the combination of Schray and Miura teaches or suggests the subject matter of claim 12.

e) Claim 13

Claim 13 depends from claim 1 and further recites “where the second fueling system uses port fuel injection.” Ex. 1001, 17:56–57. Petitioner contends, as it did for claim 1, that Miura teaches port injection. Pet. 22 (referencing Ex. 1008 ¶ 4; Ex. 1003 ¶ 179).

Upon review of the information in the Petition and corresponding evidence, and in light of our analysis of Petitioner’s reasons to combine the teachings of Schray and Miura, discussed above, we find Petitioner has demonstrated, by a preponderance of the evidence, that the combination of Schray and Miura teaches or suggests the subject matter of claim 13. Patent Owner does not dispute Petitioner’s contentions with respect to this claim.

f) Conclusions as to Claims 3, 4, and 11–13

For the reasons discussed above, we conclude, on the complete trial record, that Petitioner demonstrates, by a preponderance of the evidence, that claims 3, 4, and 11–13 are unpatentable under 35 U.S.C. § 103(a) over Schray and Miura.

E. Ground 2: Claims 5, 14–17, 19, and 21 as Unpatentable over Schray, Miura, and Zhao

Petitioner contends that claims 5, 14–17, 19, and 21 are unpatentable over the combination of Schray, Miura, and Zhao. Pet. 1, 22–32. Below, we discuss the scope and content of the prior art and any differences between the prior art and claimed subject matter, on a limitation-by-limitation basis. First, we address Petitioner’s reasons for combining the teachings of Schray, Miura, and Zhao.

1. *Reasons to combine Schray, Miura, and Zhao*

Petitioner contends that, although Schray and Miura describe direct injection to prevent knock, they “do not explicitly describe well-known benefits allowed by the use of direct injection, such as the ability to use variable valve timing (‘VVT’), incorporate a turbocharger, rely on non-uniform distribution, and/or minimize wall wetting.” Pet. 23 (referencing Ex. 1003 ¶ 187). Petitioner contends that a person having ordinary skill in the art would have understand these concepts and known they are benefits to using direct injection. *Id.* Petitioner contends that a person having ordinary skill in the art would have turned to Zhao, a reference book, “to provide the necessary details so as to further improve knock suppression and improve efficiency.” *Id.* (referencing Ex. 1003 ¶ 188).

Petitioner specifically contends that a person having ordinary skill in the art

would have turned to Zhao to implement VTT to decrease the temperature in the cylinder so as to yield higher torque and fuel economy[, . . . to implement a stratified-charge mixture or non-uniform mixture in the cylinder so as to reduce catalyst light off time[, and] . . . to implement a system that minimizes wall wetting so as to reduce degradations in oil quantity and cylinder bore wear.

Id. at 23–24 (referencing Ex. 1003 ¶¶ 189–191). Petitioner adds that Zhao includes implementation details and experiments, a person having ordinary skill in the art would have had a reasonable likelihood of success in combining Zhao’s teachings with Schray and Miura. *Id.* at 24 (referencing Ex. 1003 ¶ 192).

Patent Owner responds that Zhao does not remedy the reasons why a person having ordinary skill in the art would not have combined Schray and Miura, as argued for Ground 1.

For the reasons discussed above in connection with our analysis of Ground 1, we find that Petitioner has provided, by the preponderance of the evidence, sufficient reasons, with rational underpinnings, that a person having ordinary skill in the art would have been motivated to modify Schray with Miura's teachings to arrive at the claimed invention and would have had a reasonable expectation of success in doing so. *See KSR Int'l Co.*, 550 U.S. at 418. We also find that Petitioner has provided, by the preponderance of the evidence, sufficient reasons, with rational underpinnings, that a person having ordinary skill in the art would have been motivated to further modify the combination of Schray and Miura as proposed in Ground 1 with Zhao. *See, e.g., id.* at 417 (“[W]hen a patent ‘simply arranges old elements with each performing the same function it had been known to perform’ and yields no more than one would expect from such an arrangement, the combination is obvious.”). Patent Owner does not directly address Petitioner's reasons for combining Zhao's teachings with Schray and Miura.

2. *Claim 5*

Claim 5 depends from claim 1 and further recites “where variable valve timing is used to decrease the octane requirement of the engine.” Ex. 1001, 17:30–32. Petitioner contends that “Zhao discloses a [direct injection] engine with VVT that yields a higher output torque over the entire speed range and improved fuel economy while still relying on standard octane fuel.” Pet. 24 (referencing Ex. 1010, 299; Ex. 1003 ¶¶ 194–195). Petitioner contends that a person having ordinary skill in the art “would have understood that because the Zhao engine that was able to operate using

regular fuel, the VVT system enabled a reduction in knock (*e.g.*, a reduction in the octane requirement).” *Id.* (referencing Ex. 1003 ¶¶ 194–195).

Patent Owner argues that Zhao does not remedy the deficiencies in Petitioner’s contentions with respect to claim 1, from which claim 5 depends. PO Resp. 30. We address Patent Owner’s arguments against Petitioner’s positions with respect to claim 1 above, in connection with our analysis of Ground 1, and find that they did not identify a deficiency in Petitioner’s positions.

Additionally, we have reviewed the information in the Petition and corresponding evidence directed to claim 5, and in light of our analysis of Petitioner’s reasons to combine the teachings of Schray, Miura, and Zhao discussed above, and our analysis of Ground 1, we find Petitioner has demonstrated, by a preponderance of the evidence, that the combination of Schray, Miura, Zhao teaches or suggests the subject matter of claim 5.

3. *Independent claim 14*

Petitioner relies on its arguments for independent claim 1 and dependent claim 11 for its contentions with respect to the limitations of independent claim 14. *See* Pet. 24–27; *see also* Ex. 1003 ¶¶ 196–225 (providing Dr. Clark’s testimony directed to claim 14).

Patent Owner argues against limitations 14[C] and 14[D], incorporating its arguments against limitations 1[C] and 1[D] for Ground 1, and saying that Petitioner does not rely on any teachings from Zhao for these limitations. PO Resp. 30–31.

We address Patent Owner’s arguments against Petitioner’s positions with respect to claim 1 above, in connection with our analysis of Ground 1, and find that they did not identify a deficiency in Petitioner’s positions.

Additionally, we have reviewed the information in the Petition and corresponding evidence directed to claim 14, and in light of our analysis of Petitioner's reasons to combine the teachings of Schray, Miura, and Zhao discussed above, and our analysis of claims 1 and 11 under Ground 1, we find Petitioner has demonstrated, by a preponderance of the evidence, that the combination of Schray, Miura, Zhao teaches or suggests the subject matter of claim 14.

4. *Claim 15*

Claim 15 depends from claim 14 and further recites "where during the first 30 seconds of engine operation a higher fraction of fuel is provided by the second fueling system than would ordinarily be used." Ex. 1001, 18:18–21. Petitioner contends that "[e]ngine startup is associated with low load operation, which is conducted with use of only the second fueling system." Pet. 27 (referencing Ex. 1003 ¶ 229; Pet. 21 (analyzing claim 11, Ground 1)). Petitioner adds that a person having ordinary skill in the art would have understood that "the predominance of low load operation in the first 30 seconds would demand greater use of the second fueling system than would be demanded during an ordinary driving cycle." Pet. 27 (referencing Ex. 1003 ¶ 229).

Upon review of the information in the Petition and corresponding evidence, and in light of our analysis of Petitioner's reasons to combine the teachings of Schray, Miura, and Zhao discussed above, we find Petitioner has demonstrated, by a preponderance of the evidence, that the combination of Schray, Miura, and Zhao teaches or suggests the subject matter of claim 15. Patent Owner does not dispute Petitioner's contentions with respect to this claim.

5. *Claim 16*

Claim 16 depends from claim 14 and further recites “where the second fueling system uses port fuel injection.” Ex. 1001, 18:22–23. Petitioner references its analysis for claims 11 and 13 under Ground 1. Pet. 27.

Upon review of the information in the Petition and corresponding evidence, and in light of our analysis of Petitioner’s reasons to combine the teachings of Schray, Miura, and Zhao discussed above, we find Petitioner has demonstrated, by a preponderance of the evidence, that the combination of Schray, Miura, and Zhao teaches or suggests the subject matter of claim 16. Patent Owner does not dispute Petitioner’s contentions with respect to this claim.

6. *Independent claim 17*

Petitioner relies on its arguments for independent claims 1 and 14 for most of its contentions with respect to the limitations of independent claim 17. *See* Pet. 28–29; *see also* Ex. 1003 ¶¶ 236–266 (providing Dr. Clark’s testimony directed to claim 17). The one exception is for limitation 17[B], which recites “where the fuel from the first fueling system is injected so as to provide a non-uniform distribution of fuel in the cylinder.” Ex. 1001, 18:30–32 (limitation 17[B], the “non-uniform distribution” limitation of claim 17).

Petitioner contends that “Zhao discloses that injection of fuel relatively late in the cycle, such as is disclosed by Schray and Miura (see claims 20 and 21 *infra*), is invoked to obtain a stratified-charge mixture in the cylinder.” Pet. 28 (referencing Ex. 1010, 166; Ex. 1003 ¶ 246). That is, Zhao informs a person having ordinary skill in the art how Schray’s and Miura’s injection of fuel late in the cycle affects the charge in the cylinder.

Petitioner adds that, “[b]y relying on a stratified-charge mixture, [a person having ordinary skill in the art] would have understood that there was a non-uniform distribution of fuel in the cylinder.” *Id.* (referencing Ex. 1003 ¶¶ 246–248). Dr. Clark testifies that “Zhao presents stoichiometric stratified control as an option,” which would have been “beneficial.” Ex. 1003 ¶ 246 (citing Ex. 1010, 166, F. 6.2-2).

Patent Owner references back to its arguments for limitations 1[C] and 1[D] made under Ground 1 in arguing against Petitioner’s contentions for claim 17. PO Resp. 31–32. Patent Owner does not expressly address limitation 17[B].

We address Patent Owner’s arguments against Petitioner’s positions with respect to claim 1 above, in connection with our analysis of Ground 1, and find that they did not identify a deficiency in Petitioner’s positions.

Additionally, we have reviewed of the information in the Petition and corresponding evidence directed to claim 17, and in light of our analysis of Petitioner’s reasons to combine the teachings of Schray, Miura, and Zhao discussed above, and our analysis of claims 1 and 14 under Ground 1, we find Petitioner has demonstrated, by a preponderance of the evidence, that the combination of Schray, Miura, Zhao teaches or suggests the subject matter of claim 17.

7. Independent claim 19

Petitioner relies on its arguments for independent claim 1 for most of its contentions with respect to the limitations of independent claim 19. *See* Pet. 30–31; *see also* Ex. 1003 ¶¶ 268–300 (providing Dr. Clark’s testimony directed to claim 19). The one exception is for limitation 19[G], which recites “where the direct injection of fuel by the first fueling system is

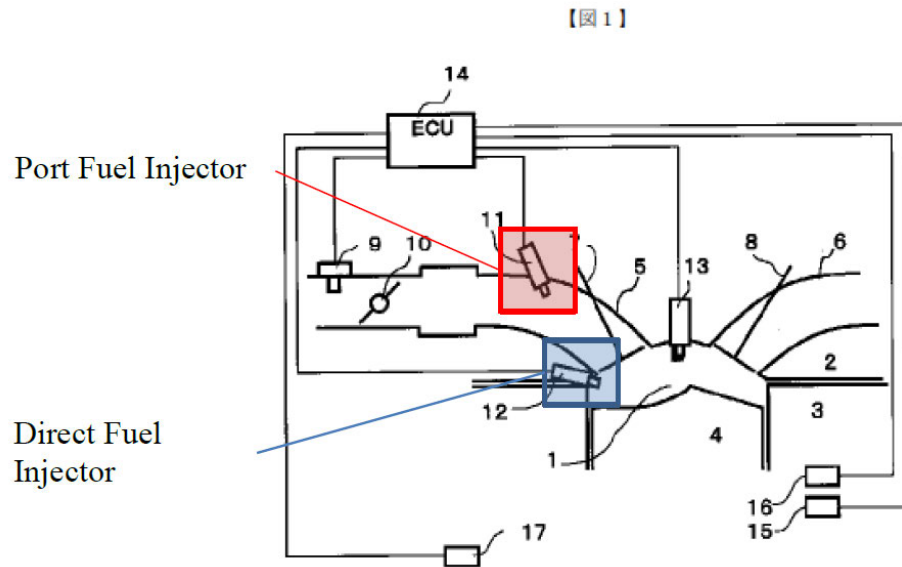
carried out so as to minimize wall wetting.” Ex. 1001, 18:65–67 (limitation 19[G], the “wall wetting” limitation of claim 19).

Petitioner contends that the combination of Schray and Miura discloses the subject matter of the wall wetting limitation. Petitioner contends that “Miura illustrates an injector that aims the fuel towards a sculpted piston that would deflect the injection jet away from the wall.” Pet. 31 (referencing Ex. 1008 ¶ 17, Fig. 1; Ex. 1003 ¶¶ 297–300). Petitioner adds that “Patent Owner confirms that spray geometry demonstrates minimizing wall wetting.” *Id.* (referencing Ex. 1034, 67¹⁹).

Miura discloses that “when fuel is injected by the in-cylinder direct injection fuel injection valve 12 during a compression stroke, a concentrated air-fuel mixture is formed in the vicinity of the spark plug 13.” Ex. 1008 ¶ 17. Dr. Clark testifies that “[i]n this way the fuel is guided to a location where it does not wet the cylinder wall.” Ex. 1003 ¶ 297. Dr. Clark testifies that injecting fuel during the compression stroke, as taught in Miura, causes the fuel to encounter hot gases, which also contributes to minimizing wall wetting. *Id.* ¶ 298.

¹⁹ Exhibit 1034 is Patent Owner’s infringement contentions. For limitation 19[G], Patent Owner states that “[f]uel is likely sprayed in a manner that mixes quickly with gas in order to provide rapid vaporization, and the engines would be configured such that vaporization will occur before the fuel reaches the wall. Such factors that demonstrate that wall wetting would be minimized would include the use of spray holes; geometry of the spray; numbers of spray holes; pressure; and timing of the applicable injections.” Ex. 1034, 67.

We reproduce Miura's Figure 1, below, as annotated by Petitioner.



Pet. 14. Figure 1 depicts a diagram of Miura's system. Ex. 1008 ¶ 14. The system includes combustion chamber 1, spark plug 13, intake path 5, intake unit (port) fuel injection valve 11 (annotated in red), and direct injection fuel valve 12 (annotated in blue). *Id.* ¶¶ 14–16. As seen from Figure 1, direct injection fuel valve 12 is directed to the sculpted portion of piston 4. *See also* Ex. 1003 ¶ 297 (“Miura illustrates a side-mounted in-cylinder injector that aims the fuel towards a sculpted piston that would deflect the injection jet.”).

Patent Owner argues that Petitioner relies on inherency to demonstrate that Miura's teachings disclose this limitation. PO Resp. 33. Patent Owner argues that “Petitioner fails to make any argument for why Miura's ‘sculpted piston’ would necessarily minimize wall wetting.” *Id.* (emphasis omitted). Patent Owner adds that its statement in its infringement contentions does not support why Miura's teachings necessarily discloses minimizing wall wetting. *Id.*

We have reviewed Patent Owner’s argument and find that it does not demonstrate a deficiency in Petitioner’s contentions with respect to the subject matter of limitation 19[G]. Petitioner and Dr. Clark explain that an injection geometry that directs fuel into the sculpted portion of the piston, near the spark plug, and during the compression stroke minimizes wall wetting. Pet. 31; Ex. 1003 ¶¶ 297–298; *cf.* Ex. 1001, 6:55–62 (“Because of the large heat of vaporization, there could be enough charge cooling with early injection so that the rate of vaporization of ethanol is substantially decreased. By instead injecting into the hot gases, which is the case with injection after the inlet valve has closed, the temperature at the end of full vaporization of the ethanol is substantially increased with respect to early injection, increasing the evaporation rate and minimizing wall wetting.”). We credit Dr. Clark’s testimony as it is consistent with the evidence of record, including how Patent Owner understands the ordinary meaning of the claim limitation as evidenced by its infringement contentions, and how the Specification describes how this function is accomplished. As such, the combined teachings of Schray and Miura disclose “the direct injection of fuel by the first fueling system is carried out so as to minimize wall wetting” as required by the claim. *See* Ex. 1001, 18:65–67.

Additionally, Patent Owner directs us to its arguments against limitations 1[C] and 1[D] under Ground 1 for limitations 19[C] and 19[D]. PO Resp. 32–33. We address Patent Owner’s arguments against Petitioner’s positions with respect to claim 1 above, in connection with our analysis of Ground 1, and find that they did not identify a deficiency in Petitioner’s positions.

Upon review of the information in the Petition and corresponding evidence, including Patent Owner’s counter argument and evidence, and in

light of our analysis of Petitioner’s reasons to combine the teachings of Schray, Miura, and Zhao discussed above, we find Petitioner has demonstrated, by a preponderance of the evidence, that the combination of Schray, Miura, Zhao teaches or suggests the subject matter of claim 19.

8. *Claim 21*

Claim 21 depends from claim 18²⁰ and further recites “where the directly injected fuel is introduced in the cylinder after the inlet valve has closed.” Ex. 1001, 19:4–6. Petitioner directs us to its analysis for claims 11 and 13 under Ground 1. Pet. 32. Petitioner adds that “both Schray and Miura disclose a late injection during the compression stroke.” *Id.* (referencing Ex. 1003 ¶¶ 301–302). Petitioner contends that a person having ordinary skill in the art “would have understood that the intake valve is closed substantially before 80 degrees BTDC (Schray) or 260 degrees ATDC (100 degree BTDC) (Miura)[, and] . . . the injection proceeds for many degrees of crank angle and the values given above address only the start of injection” *Id.* (referencing Ex. 1005, 4:9–10; Ex. 1008 ¶¶ 32–34; Ex. 1003 ¶ 303).

Upon review of the information in the Petition and corresponding evidence, and in light of our analysis of Petitioner’s reasons to combine the teachings of Schray, Miura, and Zhao discussed above, we find Petitioner has demonstrated, by a preponderance of the evidence, that the combination of Schray, Miura, and Zhao teaches or suggests the subject matter of

²⁰ Claim 18 depends from claim 16 and recites “[t]he fuel management system of claim 16 where second fuel system uses port fuel injection.” Ex. 1001, 18:46–47. Claim 16 recites “[t]he fuel management system of claim 14 where the second fueling system uses port fuel injection.” *Id.* at 18:22–23. As can be seen, claim 18 does not add any limitation. As such, we treat claim 21 as depending from claim 16.

claim 21. Patent Owner does not dispute Petitioner's contentions with respect to this claim.

9. *Conclusions – Ground 2*

We conclude, based on the complete record, that Petitioner has demonstrated, by a preponderance of the evidence, that claims 5, 14–17, 19, and 21 are unpatentable under 35 U.S.C. § 103 over Schray, Miura, and Zhao.

F. *Grounds 3–5*

Because we determine that all Challenged Claims are unpatentable under Grounds 1 and 2, we need not reach Grounds 3, 4, and 5. *See SAS Inst. Inc. v. Iancu*, 138 S. Ct. 1348, 1359 (2018) (holding that a petitioner “is entitled to a final written decision addressing all of the *claims* it has challenged” (emphasis added)); *see also* 35 U.S.C. § 318(a) (“[T]he Patent Trial and Appeal Board shall issue a final written decision with respect to the patentability of any patent claim challenged by the petitioner.”); *Boston Sci. Scimed, Inc. v. Cook Grp. Inc.*, 809 F. App'x 984, 990 (Fed. Cir. 2020) (nonprecedential) (stating that the “Board need not address issues that are not necessary to the resolution of the proceeding,” such as “alternative arguments with respect to claims [the Board] found unpatentable on other grounds”).

III. MOTION TO EXCLUDE EVIDENCE

Patent Owner moves to exclude certain of Petitioner's evidence. Paper 42. Petitioner opposes and Patent Owner replies to the opposition. Papers 44, 46. Specifically, Patent Owner moves to exclude Exhibits 1050 through 1056. Because we do not rely on these exhibits or the arguments for

which the Exhibits were entered in this Final Written Decision, we dismiss Patent Owner's motion as moot.

IV. CONCLUSION

After considering all the evidence and arguments presently before us, we determine Petitioner has proven, by a preponderance of the evidence, that all of the Challenged Claims are unpatentable.²¹

²¹ Should Patent Owner wish to pursue amendment of the Challenged Claims in a reissue or reexamination proceeding subsequent to the issuance of this decision, we draw Patent Owner's attention to the April 2019 Notice Regarding Options for Amendments by Patent Owner Through Reissue or Reexamination During a Pending AIA Trial Proceeding, 84 Fed. Reg. 16,654 (Apr. 22, 2019). If Patent Owner chooses to file a reissue application or a request for reexamination of the challenged patent, we remind Patent Owner of its continuing obligation to notify the Board of any such related matters in updated mandatory notices. *See* 37 C.F.R. §§ 42.8(a)(3), (b)(2).

In summary:

Claims	35 U.S.C. §	Reference(s)/ Basis	Claims Shown Unpatentable	Claims Not Shown Unpatentable
1, 3, 4, 11–13	103(a)	Schray, Miura	1, 3, 4, 11–13	
5, 14–17, 19, 21	103(a)	Schray, Miura, Zhao	5, 14–17, 19, 21	
1, 3–5, 11–17, 19, 21	103(a)	Rubbert, Yuushiro, Bosch ²²		
1, 3–4, 11–17	103(a)	Ohtani ²³		
5, 19, 21	103(a)	Ohtani, Zhao ²⁴		
Overall Outcome			1, 3–5, 11–17, 19, 21	

²² We do not reach Ground 3, which alleges that claims 1, 3–5, 11–17, 19, and 21 are unpatentable under 35 U.S.C. § 103(a) over Rubbert, Yuushiro, and Bosch.

²³ We do not reach Ground 4, which alleges that claims 1, 3, 4, and 11–17 are unpatentable under U.S.C. § 103(a) over Ohtani.

²⁴ We do not reach Ground 5, which alleges that claims 5, 19, and 21 are unpatentable under 35 U.S.C. § 103(a) over Ohtani and Zhao.

V. ORDER

In consideration of the foregoing, it is hereby:

ORDERED that claims 1, 3–5, 11–17, 19, and 21 of U.S. Patent No. 9,708,965 B2 are determined to be unpatentable;

FURTHER ORDERED that, because this is a Final Written Decision, parties to the proceeding seeking judicial review of the decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

IPR2021-00341
Patent 9,708,965 B2

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