

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

NISSAN MOTOR CO., LTD.,

Petitioner,

v.

LONGHORN AUTOMOTIVE GROUP LLC,

Patent Owner,

Patent No. 7,513,238B2 to Pfaff *et al.*

Issue Date: April 7, 2009

Title: DIRECTLY INJECTING INTERNAL COMBUSTION ENGINE

Inter Partes Review No.: IPR2025-01089

Petition for *Inter Partes* Review of U.S. Patent No. 7,513,238B2

Under 35 U.S.C. §§311-319 and 37 C.F.R. §42.100 *et seq.*

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TABLE OF EXHIBITS

Exhibit No.	Exhibit Name
1001	U.S. Patent No. 7,513,238B2 (the “’238 Patent”)
1002	Complaint filed in <i>Longhorn Automotive Group LLC v. Nissan Motor Co., Ltd.</i> , 2:24-cv-00397-JRG (E.D. Tex.) (May 31, 2024)
1003	Plaintiff’s “Appendix C: Claim Chart for U.S. Patent 7,513,238” served in <i>Longhorn Automotive Group LLC v. Nissan Motor Co., Ltd.</i> , 2:24-cv-00397-JRG (E.D. Tex.) (Nov. 22, 2024)
1004	Declaration of Dr. Glenn R. Bower Ph.D., PE
1005	Japanese Utility Model Application Publication No. S58-102720 to Ishida (“Ishida”) and Certified Translation Thereof
1006	Japanese Patent Application Publication No. 2697100 to Takatomo <i>et al.</i> (“Takatomo”) and Certified Translation Thereof
1007	U.S. Patent Application Publication No. 2002/0117146 to Gatellier <i>et al.</i> (“Gatellier”)
1008	U.S. Patent No. 6,314,933 to Iijima <i>et al.</i> (“Iijima”)
1009	Japanese Patent Application Publication No. S54-74012 to Oota (“Oota”) and Certified Translation Thereof
1010	Prosecution history of the ’238 Patent
1011	U.S. Patent No. 6,161,518 to Nakakita <i>et al.</i> (“Nakakita”)
1012	U.S. Patent Application Publication No. 2003/0217732 to Kataoka <i>et al.</i> (“Kataoka”)
1013	U.S. Patent Application Publication No. 2004/0123832 to Quigley <i>et al.</i> (“Quigley”)

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Exhibit No.	Exhibit Name
1014	“Visualization and Analysis of the Impingement Processes of a Narrow-Cone DI Gasoline Spray,” <i>SAE Technical Paper Series</i> , 2001-01-2023, Published May 7, 2001, by Park <i>et al.</i> (“Park”)
1015	“Internal Combustion Engine Fundamentals,” John B. Heywood, 1988 (“Heywood”)
1016	European Patent Application Publication No. 0697511 to Sekiguchi <i>et al.</i> (“Sekiguchi”)
1017	Excerpts from “Diesel-engine management”; 2 nd Ed., Bosch, 1999 (“Bosch”)

I. INTRODUCTION

Pursuant to 35 U.S.C. §§311-19 and 37 C.F.R. §42.100 *et seq.*, Petitioner, Nissan Motor Co., Ltd. (“Petitioner”), requests *Inter Partes* review of Claims 1-14 (the “Challenged Claims”) of U.S. Patent No. 7,513,238B2 (the “’238 Patent,” EX. 1001), which is assigned to Longhorn Automotive Group LLC (“LAG”). The Challenged Claims should be found unpatentable and canceled.

II. MANDATORY NOTICES

A. Real Party-In-Interest

Petitioner identifies Nissan Motor Co., Ltd. (Petitioner) as a real party-in-interest (“RPI”). Hyundai Motor Company, Kia Corporation, and Petitioner are defendants in a consolidated lawsuit with LAG. EX. 1002, 1 (the “Texas Action”). However, this Petition is not filed at any other party’s behest, and no other party is controlling, funding, or directing this proceeding. Thus, Hyundai and Kia are not RPIs. *See Uniloc 2017 LLC v. Facebook Inc.*, 989 F.3d 1018, 1028 (Fed. Cir. 2021) (“[T]he heart of the [real party in interest] inquiry [is] focused on ‘whether a petition has been filed at a [party’s] behest.’”) (quoting *Applications in Internet Time, LLC v. RPX Corp.*, 897 F.3d 1336, 1351 (Fed. Cir. 2018); *see also Wi-Fi One, LLC v. Broadcom Corp.*, 887 F.3d 1329, 1336 (Fed. Cir. 2018) (“To decide whether a party other than the petitioner is the real party in interest, the Board seeks to determine whether some party other than the petitioner is the ‘party or parties at whose behest

the petition has been filed.’” (quoting Trial Practice Guide, 77 Fed. Reg. 48,757, 48,759 (Aug. 14, 2012)); *see also* Patent Trial and Appeal Board Consolidated Trial Practice Guide 14 (Nov. 2019) (“[A]t a general level, the ‘real party-in-interest’ is the party that desires review of the patent. Thus, the ‘real party-in-interest’ may be the petitioner itself, and/or it may be the party or parties at whose behest the petition has been filed”).

B. Related Matters

The ’238 Patent is the subject of the following matters, which may be affected by a decision in this proceeding:

1. *Longhorn Automotive Group LLC v. Hyundai Motor Company and Kia Corporation*, 2:24-cv-00554-JRG (E.D. Tex.), filed July 19, 2024;
2. *Longhorn Automotive Group LLC v. Nissan Motor Co., Ltd.*, 2:24-cv-00397-JRG (E.D. Tex.), filed May 31, 2024;
3. *Longhorn Automotive Group LLC v. Volvo Car Corporation et al*, 2-24-cv-00603 (E.D. Tex.), filed July 30, 2024;
4. *Longhorn Automotive Group LLC v. Mitsubishi Motors Corporation*, 2-24-cv-00685 (E.D. Tex.), filed August 20, 2024;
5. *Longhorn Automotive Group LLC v. Mazda Motor Corporation*, 2-24-cv-00686 (E.D. Tex.), filed August 20, 2024; and
6. *Longhorn Automotive Group LLC v. Volkswagen AG*, 2-24-cv-00933

(E.D. Tex.), filed November 15, 2024.

Petitioner is not aware of any post-grant proceeding before the Office involving the '238 Patent. *See* 37 C.F.R. §§42.8(b)(3), 42.8(b)(4), 42.10(a), and 42.10(b).

C. Lead Counsel, Back-Up Counsel, and Service Information

Pursuant to 37 C.F.R. §§42.8(b)(3) and 42.10(a), Petitioner designates Pavan K. Agarwal (Reg. No. 40,888) as lead counsel and Roberto J. Fernandez (Reg. No. 73,761) as back-up counsel.

Pursuant to 37 C.F.R. §42.10(b), Petitioner filed a power of attorney for the above-designated counsel.

D. Service Information

Per 37 C.F.R. §42.8(b)(4), Petitioner provides the following service information for designated counsel:

Lead Counsel	Back-Up Counsel
Pavan K. Agarwal Reg. No. 40,888 FOLEY & LARDNER LLP 3000 K Street, NW, Suite 500 Washington Harbor 202-945-6162 pagarwal@foley.com	Roberto J. Fernandez Reg. No. 73,761 FOLEY & LARDNER LLP 321 North Clark St., Suite 3000 Chicago, Illinois 60654 312-832-4530 rfernandez@foley.com

Petitioner consents to service via email at the addresses listed above.

III. PAYMENT OF FEES

The required fee is paid by credit card, with authorization to charge any fee

deficiencies and credit overpayments to Deposit Acct. No. 19-0741 (Customer No. 22428).

IV. GROUNDS FOR STANDING

Pursuant to 37 C.F.R. §42.104(a), Petitioner certifies that the '238 Patent is available for *Inter Partes* review and that Petitioner is not barred or estopped from requesting *Inter Partes* review on the Grounds identified herein.

V. STIPULATION

Pursuant to the USPTO's March 26, 2025 Memorandum regarding "Interim Processes for PTAB Workload Management" and the "FAQs for Interim Processes for PTAB Workload Management"¹, Petitioner stipulates that if *Inter Partes* review is instituted, Petitioner will not pursue in district court any ground raised or that could have been reasonably raised against the Challenged Claims in this Petition. *Sotera Wireless, Inc. v. Masimo Corp.*, IPR2020-01019, Paper 12 (PTAB Dec. 1, 2020) (precedential as to §II.A).

VI. PRECISE RELIEF REQUESTED

A. Identification of Claims

Pursuant to 37 C.F.R. §§42.22(a)(1) and 42.104(b), the precise relief sought

¹ <https://www.uspto.gov/patents/ptab/faqs/interim-processes-workload-management>.

by Petitioner is that the Board review and cancel Claims 1-14 of the '238 Patent as being unpatentable under pre-AIA 35 U.S.C. §103(a), as set forth by this Petition and supported by the Declaration of Dr. Glenn R. Bower Ph.D., PE (EX. 1004), under the following Grounds:

Ground #	Challenged Claim(s)	Ground
1	1-3, 5, and 6	Anticipated by, or Minimally Obvious over, Japanese Utility Model Application Publication No. S58-102720 to Ishida (“Ishida”)
2	7 and 8	Obvious over Ishida and Japanese Patent Application Publication No. S54-74012 to Oota (“Oota”)
3	9-13	Obvious over Ishida and U.S. Patent Application Publication No. 2002/0117146 to Gatellier <i>et al.</i> (“Gatellier”)
4	4	Obvious over Ishida and U.S. Patent No. 6,314,933 to Iijima <i>et al.</i> (“Iijima”)
5	14	Obvious over Ishida, Gatellier, and Iijima
6	1-3, 5, and 6	Obvious over Ishida, as evidenced by Japanese Patent Application Publication No. 2697100 to Takatomo <i>et al.</i> (“Takatomo”)
7	7 and 8	Obvious over Ishida and Oota, as evidenced by Takatomo
8	9-13	Obvious over Ishida and Gatellier, as evidenced by Takatomo

Ground #	Challenged Claim(s)	Ground
9	4	Obvious over Ishida and Iijima, as evidenced by Takatomo
10	14	Obvious over Ishida, Gatellier, and Iijima, as evidenced by Takatomo
11	1-6	Obvious over Takatomo
12	9-12 and 14	Obvious over Takatomo and Gatellier

Petitioner establishes below that the Challenged Claims are unpatentable under the Grounds identified above, including by identifying where each claim element is found in the prior art, to demonstrate that Petitioner has at least a reasonable likelihood of prevailing on these Grounds.

B. Prior Art Patent Application Publications

1. Ishida

Ishida (EX. 1005) published July 13, 1983, and is prior art under at least pre-AIA 35 U.S.C. §102(b). Ishida was not referenced during prosecution of the '238 Patent. Ishida is not in English. A certified translation is provided before the translated text in the Exhibit, which is the text referenced below.

2. Takatomo

Takatomo (EX. 1006) published January 14, 1998, and is prior art under at least pre-AIA 35 U.S.C. §102(b). Takatomo was not referenced during prosecution of the '238 Patent. Takatomo is not in English. A certified translation is provided

before the translated text in the Exhibit, which is the text referenced below.

3. Gatellier

Gatellier (EX. 1007) published August 29, 2002, and is prior art under at least pre-AIA 35 U.S.C. §102(b). While cited by the applicant during prosecution of the '238 Patent, Gatellier was never discussed or applied by the Examiner, and never considered in combination with the other references relied upon in this Petition. *See* EX. 1010, 22.

4. Iijima

Iijima (EX. 1008) published November 13, 2001, and is prior art under at least pre-AIA 35 U.S.C. §102(b). Iijima was not referenced during prosecution of the '238 Patent.

5. Oota

Oota (EX. 1009) published June 13, 1979, and is prior art under at least pre-AIA 35 U.S.C. §102(b). Oota was not referenced during prosecution of the '238 Patent. Oota is not in English. A certified translation is provided before the translated text in the Exhibit, which is the text referenced below.

VII. THE '238 PATENT

A. Specification & Claims

The '238 Patent purports to describe a specific piston geometry for direct-injection internal combustion engines. EX. 1001, 1:12-15; EX. 1004, ¶62. The

alleged invention centers on a piston recess 10 designed to manage fuel distribution for early injection timings and late injection timings. EX. 1001, Abstract, 1:38-48.

The '238 Patent states, “[w]hen early homogenization is to be achieved within the combustion space of an operating internal combustion engine, in particular a diesel internal combustion engine, then injection time points of approximately 130 to 30° before the top dead center of the piston must be selected, since, at this time point, the combustion space pressure is still relatively low, so that the injected fuel can penetrate very deeply into the combustion space.” *Id.*, 1:25-32; EX. 1004, ¶62. The '238 Patent explains that, “[s]ince, however, it is not possible to operate the internal combustion engine with a homogeneous combustion process over its entire characteristic map, the piston recess must be designed both for homogeneous and for conventional mixture formation,” and that “[t]his is not easily possible in known solutions.” EX. 1001, 1:39-43; EX. 1004, ¶63.

According to the '238 Patent, the core of its design lies in a particular “surface” 13 within the piston recess. This surface 13 adjoins a central “elevation” 11 within the recess, and is claimed to be “substantially planar” with an “ascending gradient in the recess edge direction.” EX. 1001, 3:33-36; EX. 1004, ¶¶67-69.

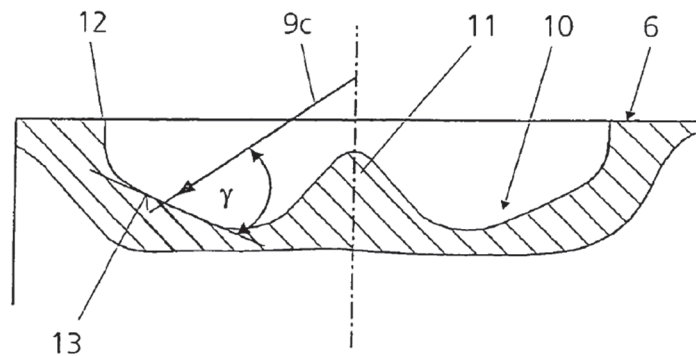


Fig. 4

EX. 1001, FIG. 4.

According to the '238 Patent, for *early* injections, this surface 13 distributes an early impinging injection jet 9a “both in a elevation direction and in the recess edge direction.” *Id.*, Claim 1, 3:8-16. For *late* injections, this same surface 13 purportedly likewise ensures that an injection jet 9b injected “as late as possible” is also distributed “both in the elevation direction and in the recess edge direction.” *Id.*, Claim 1, 3:66-4:2. These injection timings and their relative impingement points are depicted graphically in FIG. 1. *Id.*, 2:54-58; EX. 1004, ¶66.

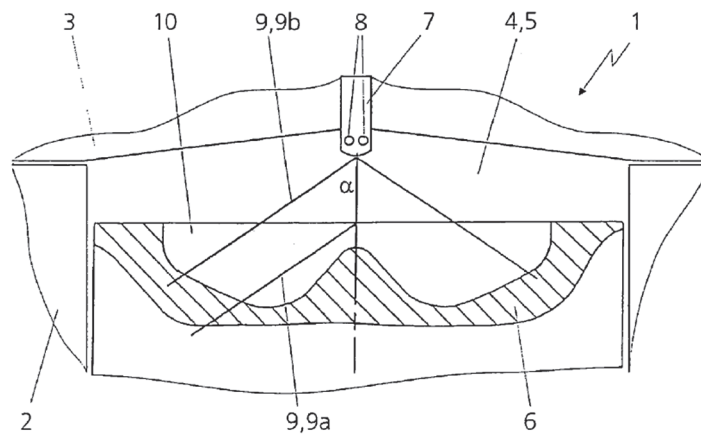


Fig. 1

EX. 1001, FIG. 1.

The '238 Patent purports to add further geometric features on the outer periphery of the piston recess, near its edge 12. These include an additional surface 23 adjoining the primary surface 13 and connected to the recess edge (Claim 2; FIG. 7), this additional surface 23 forming an acute angle with the piston top 25 (Claim 5; FIG. 8), and a radiused connection between this additional surface 23 and the primary surface 13 (Claim 6).

The purported object achieved by this specific piston surface geometry is to allow an internal combustion engine to be “operated by both a homogeneous and a conventional combustion process” effectively by optimizing fuel-air mixture formation irrespective of whether the injection occurs early or late in the engine cycle. *See id.*, 1:46-48, 2:6-8.

B. Prosecution History

The '238 Patent purports to be a National Stage under 35 U.S.C. §371 of International Patent Application No. PCT/EP2004/011637, filed October 15, 2004, and claims the benefit of German Patent Application No. 10350795.7, filed October 29, 2003. EX. 1010, 149, 151.

During prosecution of the '238 Patent, the applicant first canceled all pending claims and added new claims, provided a replacement Abstract, and made various amendments to the Specification. *Id.*, 84-89, 103-12. The Examiner mailed a non-

final Office Action rejecting claims 11, 12, 16-24, and 26-30 under pre-AIA 35 U.S.C. §102(b) as being anticipated by U.S. Patent No. 6,161,518 to Nakakita *et al.* (“Nakakita,” EX. 1011), rejecting claims 11-15, 18-25, and 27-30 under pre-AIA 35 U.S.C. §102(b) as being anticipated by U.S. Patent Application Publication No. 2003/0217732 to Kataoka *et al.* (“Kataoka,” EX. 1012), and rejecting claims 11, 12, 16-24, and 26-30 under pre-AIA 35 U.S.C. §102(b) as being anticipated by U.S. Patent Application Publication No. 2004/0123832 to Quigley *et al.* (“Quigley,” EX. 1013). EX. 1010, 40-43.

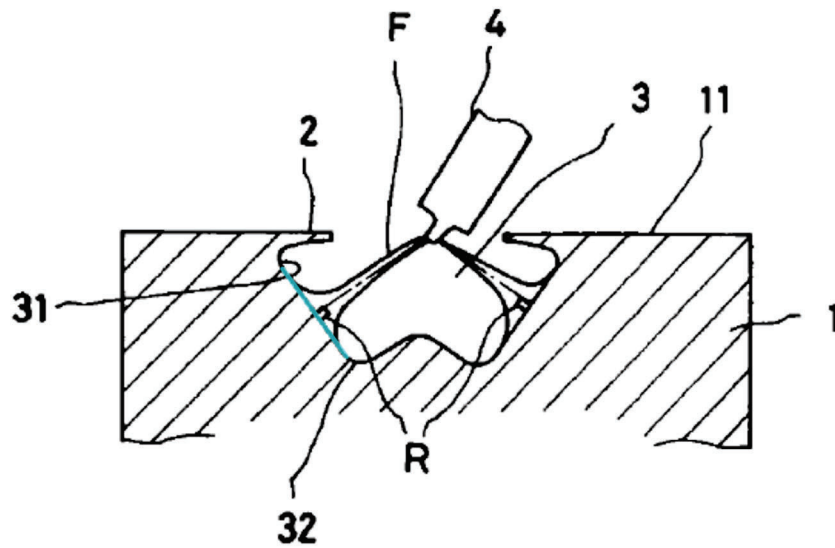
In response, the applicant amended claim 11 as follows:

Claim 11 (Currently Amended): A directly injecting internal combustion engine, comprising at least one cylinder which has a combustion space in which a piston executes an oscillating movement, and an injection nozzle for injection of fuel into the combustion space, wherein the piston ~~has~~ has a piston recess, which, in a central region thereof, has an elevation extending in a cylinder head direction, and a surface of the piston recess adjoining the elevation in a recess edge direction is connected to the elevation via a radius so that an injection jet impinging ~~in this region~~ the surface and injected as early as possible is distributed both in a elevation direction and in the recess edge direction, and the surface is substantially planar and has an extent ascending gradient in the recess edge direction such that an injection jet injected as late as possible impinges onto the surface, the last-mentioned injection jet being distributed both in the elevation direction and in the recess edge direction.

Id., 30. The applicant also canceled several claims.

In conjunction with these amendments, the applicant stated, “[t]he claimed geometry [of claim 11] allows the directly injecting engine to operate with both a homogenous operator and a conventional combustion operation by ensuring that the injection jet impinges at the piston recess for optimal intermixing of fuel and air independently of the injection time point as described at paragraph [0009] of the Specification” and, “[t]he three cited references do not show or suggest the claimed geometry in amended Claim 11.” *Id.*, 33. Specifically, the applicant alleged: “Nakakita et al’s piston does not have a surface with an ascending gradient. The Kataoka et al piston does not have a substantially planar surface anywhere in the recess. The Quigley et al piston does not have the claimed surface adjoining the elevation in terms of an ascending gradient. Nothing in the teachings of the cited documents would have led to the present invention.” *Id.* The Examiner then mailed a Notice of Allowance without comment. *Id.*, 15.

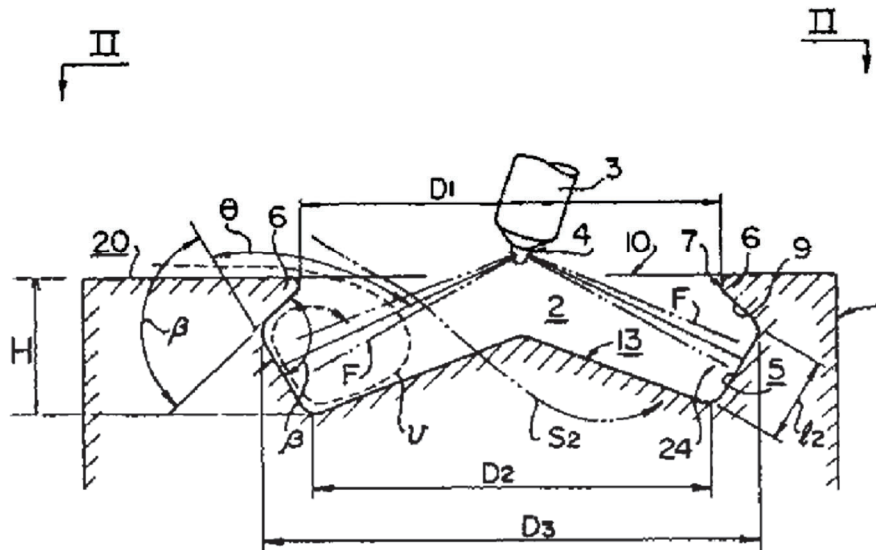
The purportedly novel geometry, and those features in particular, were known in the relevant field and fail to distinguish over the prior art identified herein. For example, Ishida explicitly discloses a side wall 31 (blue below) that is substantially planar with an ascending gradient. EX. 1005, FIG. 2; EX. 1004, ¶¶225-26.



EX. 1005, FIG. 2 (annotated).

Thus, the only allegedly distinguishing feature identified by the Examiner was disclosed by at least Ishida. Additionally, Takatomo discloses the exact same feature, as shown below. *See* EX. 1004, ¶329.

FIG. 1



EX. 1006, FIG. 1 (Takatomo).

VIII. LEVEL OF ORDINARY SKILL IN THE ART

A person of ordinary skill in the art (“POSITA”) as of the earliest claimed priority date of October 29, 2003² would have had at least a bachelor’s degree in mechanical engineering, and two or more years of experience in mechanical engineering and/or internal combustion engine system design. EX. 1004, ¶¶85-88. A person could also have qualified as a POSITA with some combination of more formal education (*e.g.*, Ph.D.) and less technical experience or less formal education and more technical or professional experience in the foregoing fields. *Id.* Superior education could compensate for a deficiency in work experience, and vice-versa. *Id.* To the extent necessary, the POSITA may have collaborated with other skilled artisans, such that the individual and/or team collectively would have had experience and/or knowledge of particular characteristics of an internal combustion engine system. *Id.*

IX. CLAIM CONSTRUCTION

A claim is construed in an IPR proceeding using the standard set forth in *Phillips v. AWH Corp.*, 415 F.3d 1303, 1316-1317 (Fed. Cir. 2005) (*en banc*). 37 C.F.R. §42.100(b). Petitioner submits that the Board need not specially construe any

² While not disputed for purposes of the asserted Grounds, Petitioner reserves the right to dispute the priority claim of the Challenged Claims in other proceedings.

terms of the Challenged Claims to institute IPR because they are shown to be anticipated and/or obvious regardless of construction. *Toyota Motor Corp. v. Cellport Sys., Inc.*, IPR2015-00633, Paper 11, 16 (PTAB Aug. 14, 2015). Petitioner does not concede that any claim of the '238 Patent meets statutory requirements, such as 35 U.S.C. §§101 and 112, and, therefore reserves all rights to contend that one or more of the Challenged Claims are invalid for reasons out of scope of IPR.

X. GROUNDS OF UNPATENTABILITY

As established below, all features of the Challenged Claims were well known in the prior art.

A. Ground 1: Claims 1-3, 5, and 6 Are Anticipated by, or Minimally Obvious over, Ishida.

Claims 1-3, 5, and 6 of the '238 Patent are unpatentable under 35 U.S.C. §102(b) as anticipated by Ishida or under §103(a) as minimally obvious over Ishida.

1. Ishida

Ishida discloses a combustion chamber for a direct-injection engine. EX. 1005, Title. Ishida addresses problems in conventional direct-injection diesel engines with spherical combustion chambers and lips (squish lips), where injected fuel can reach the bottom of the combustion chamber along the inner wall surface, leading to “significantly worse white smoke, odor, HC, etc.” *Id.*, p.3; *see also* EX. 1004, ¶91 (explaining that “HC” is the abbreviation for hydrocarbon). To overcome this, Ishida proposes a combustion chamber 3 in a piston 1 that includes: (1) a lip 2

formed at the peripheral edge of the combustion chamber inlet” (EX. 1005, p.3, FIG. 2); and (2) a side wall 31 sloped outwardly so that the injected fuel F from the fuel injection nozzle 4 impacts the side wall 31 at approximately a right angle R (*id.*, FIG. 2, p.4). These features are shown in FIG. 2 of Ishida below.

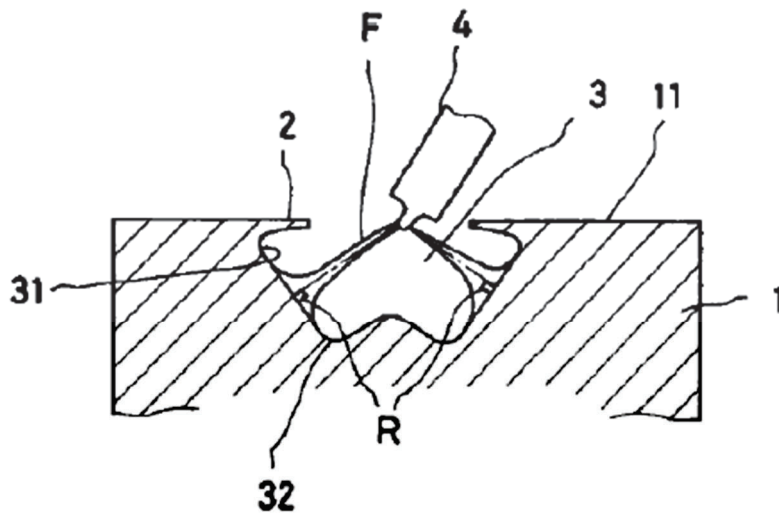


FIG. 2

Id., FIG. 2.

2. Claim 1

- i. **“A directly injecting internal combustion engine, comprising at least one cylinder which has a combustion space in which a piston executes an oscillating movement, and an injection nozzle for injection of fuel into the combustion space,”**

Ishida discloses these limitations of claim 1. Ishida is titled “Combustion Chamber for Direct-Injection Diesel Engine” and “relates to a combustion chamber for a direct injection-type diesel engine.” *Id.*, p.2. Ishida describes a piston 1 for such

an engine, a combustion chamber 3 formed in a piston top 11 of the piston 1, and a fuel injection nozzle 4 injecting fuel (F) into this combustion chamber. *Id.*, FIG. 2; p.4. A POSITA would have understood this describes a directly injecting internal combustion engine where the piston 1 executes an oscillating movement within a cylinder (understood to house piston 1), which has a combustion space. EX. 1004, ¶¶192-94.

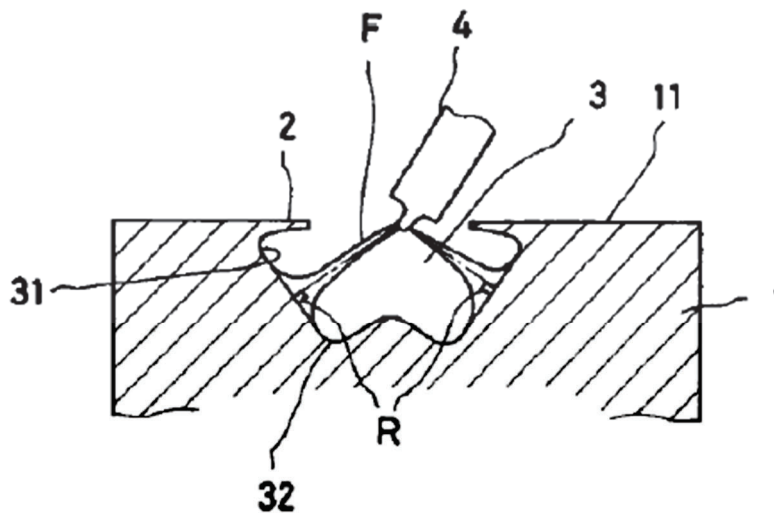


FIG. 2

EX. 1005, FIG. 2.

- ii. **“wherein the piston has a piston recess, which, in a central region thereof, has an elevation extending in a cylinder head direction, and”**

Ishida discloses these limitations of claim 1. The piston 1 in FIG. 2 has a combustion chamber 3 recessed in its top surface 11; this chamber 3 is the claimed

“piston recess.” *Id.*, ¶195. The “elevation” is disclosed by the protruding surface extending from the bottom surface 32 of Ishida’s chamber 3. *Id.*

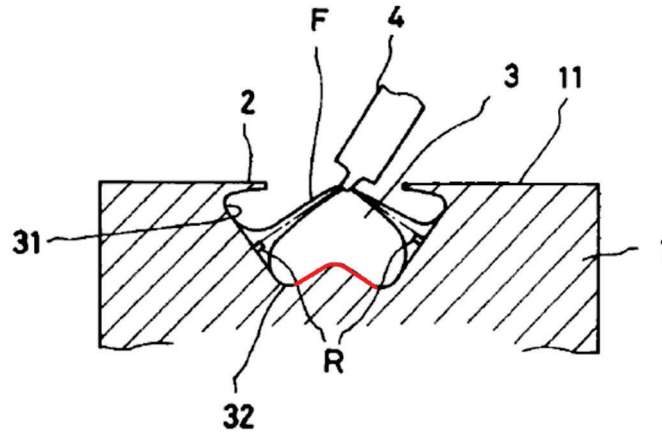
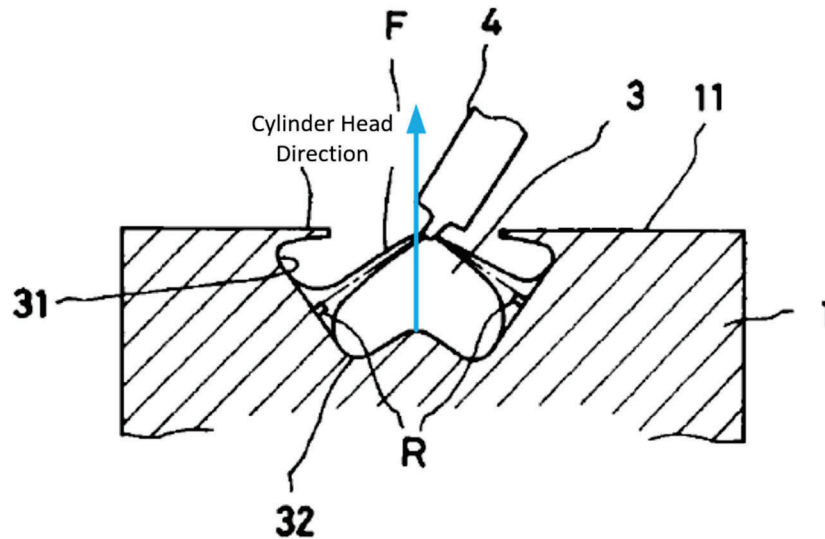


FIG. 2

EX. 1005, FIG. 2 (annotated).

Ishida’s FIG. 2 illustrates the bottom surface 32 including a central raised portion or “hump” that extends upwards, *i.e.*, in the cylinder head direction (the cylinder head would be above the piston). EX. 1004, ¶199; *see id.*, ¶¶197-98. While not explicitly labeled with a reference number for the elevation itself, the geometry of the combustion chamber 3 clearly shows a central peak. EX. 1005, FIG. 2; EX. 1004, ¶¶195-96. A POSITA would have understood this central peak as an “elevation.” EX. 1004, ¶¶195-96.



EX. 1005, FIG. 2 (annotated).

- iii. “[a] a surface of the piston recess adjoining the elevation in a recess edge direction is connected to the elevation via a radius [b] so that an injection jet impinging the surface and injected as early as possible is distributed both in a elevation direction and in the recess edge direction, and”

Ishida discloses these limitations of claim 1, which are addressed in turn.

- (a) “a surface of the piston recess adjoining the elevation...is connected to the elevation via a radius”

Ishida discloses this limitation. In Ishida’s FIG. 2, the side wall 31 of the combustion chamber 3 adjoins the central elevation (the central peak) and extends towards the peripheral edge where lip 2 is located (adjoins in the recess edge direction). EX. 1004, ¶¶202-05. The transition from the elevation (the central peak)

to the side wall 31 is depicted as a curved surface, which a POSITA would have understood as being connected via a radius. *Id.*

As discussed above, the “elevation” is Ishida’s central peak. The “surface” of the piston recess that adjoins this elevation and extends towards the recess edge (the junction between the lip 2 and the piston top 11) is Ishida’s side wall 31, as shown in Annotated FIG. 2 below. *Id.* This side wall 31 is “connected to the elevation via a radius.” *Id.*, ¶¶202-03. Annotated FIG. 2 of Ishida, reproduced below, identifies the exemplary surface (the side wall 31-blue) of the piston recess (chamber 3) adjoining the elevation via a radius (pink). *Id.*, ¶203.



EX. 1005, FIG. 2 (annotated).

- (b) “so that an injection jet impinging the surface and injected as early as possible is distributed both in a elevation direction and in the recess edge direction, and”

Ishida discloses this functional language of claim 1. The claims, specification, and prosecution history of the '238 Patent do not define what is meant by “injected

as early as possible.” Indeed, this language appears only in claim 1. *See* EX. 1004, ¶¶210-11. When describing the prior art, the ’238 Patent states, “[w]hen *early* homogenization is to be achieved within the combustion space of an operating internal combustion engine, in particular a diesel internal combustion engine, then injection time points of approximately 130 to 30° before the top dead center of the piston must be selected, since, at this time point, the combustion space pressure is still relatively low, so that the injected fuel can penetrate very deeply into the combustion space.” EX. 1001, 1:25-36 (emphasis added); EX. 1004, ¶212.

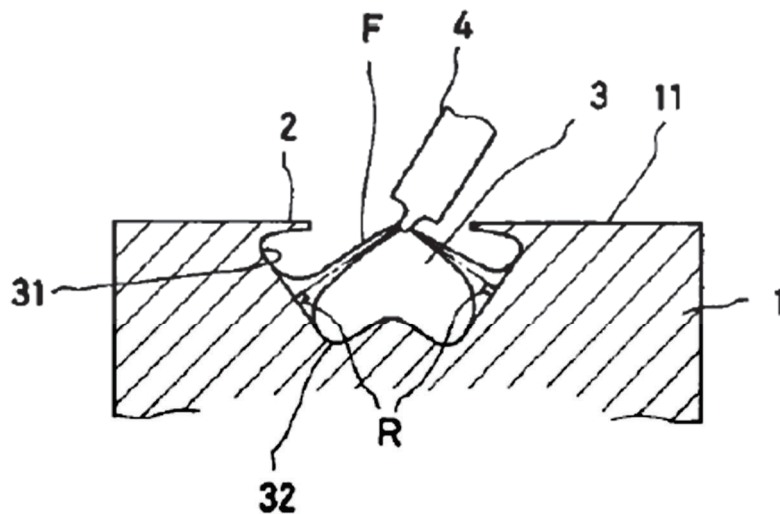


FIG. 2

EX. 1005, FIG. 2.

Regardless of its precise definition, Ishida satisfies the “early as possible” limitation of claim 1. EX. 1004, ¶213. While Ishida does not specify any particular

“early as possible” injection timing, its disclosed mechanism is applicable to injections occurring during the compression stroke, which would encompass timings a POSITA would consider “as early as possible” for a direct-injection diesel engine. *Id.*

Ishida’s invention is aimed at overcoming problems of “white smoke, odor, HC, etc.” that result when “injected fuel f from the fuel injection nozzle N reaches the bottom of the combustion chamber along the spherical inner wall surface N, resulting in significantly worse white smoke, odor, HC, etc.” EX. 1005, p.3 (referring to prior art FIG. 1). These issues are often pronounced with early injection timings where fuel has more opportunity to interact unfavorably with cooler surfaces or has insufficient time to mix and vaporize properly before ignition. EX. 1004, ¶214.

Ishida’s solution is a specific piston geometry—a lip 2 and an outwardly sloped side wall 31—designed to ensure “fuel from the fuel injection nozzle is set so as to impact the side wall of the combustion chamber at approximately a right angle.” EX. 1005, Claim; p.3. This geometric configuration is always present and will interact with the fuel spray *whenever* it is injected during the direct injection process. EX. 1004, ¶216.

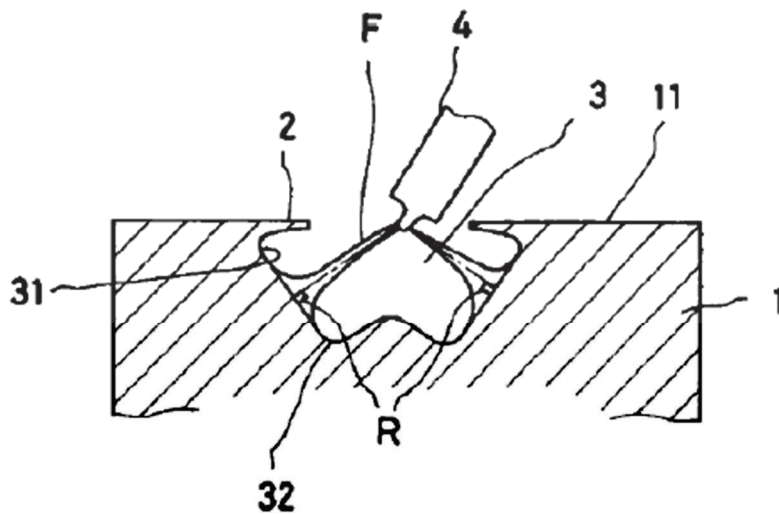
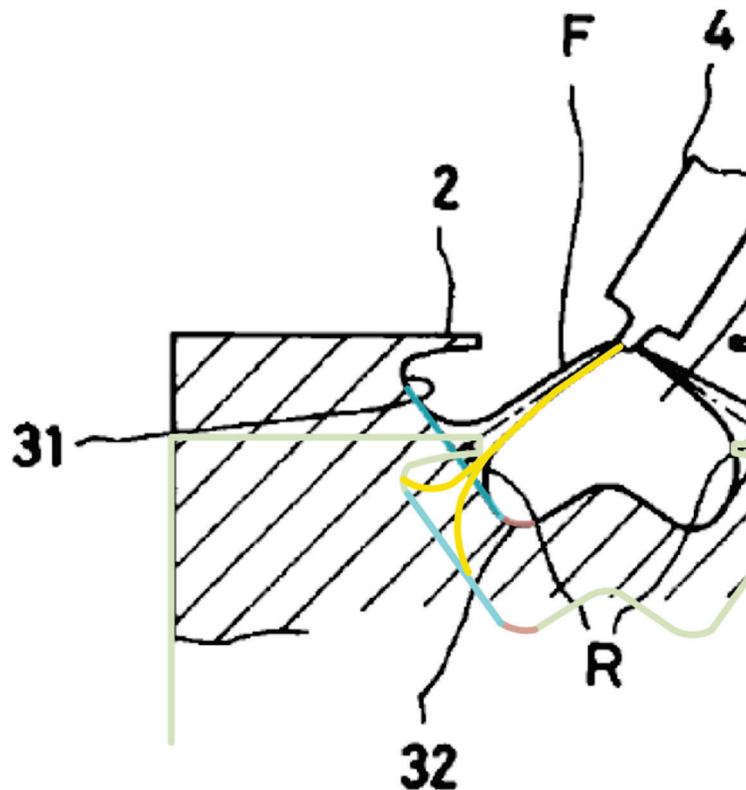


FIG. 2

EX. 1005, FIG. 2.

The claim requires that an “injection jet injected as early as possible impinges the surface.” In Ishida, the “surface” is its side wall 31. Ishida explicitly states that its design is configured so “that the injected fuel F from the fuel injection nozzle 4 *impacts the side wall* at approximately a right angle R” *Id.*, p.4 (emphasis added). This general statement of fuel impact on side wall 31 would necessarily apply to *any* direct injection event into the chamber, including those that occur “early as possible” in the compression stroke. EX. 1004, ¶216. There is no teaching in Ishida that its fuel impact strategy on side wall 31 is limited only to late injections. *Id.* In fact, to prevent the very problem of fuel reaching the bottom 32 prematurely (which is more likely with earlier, deeper-penetrating sprays into a lower-pressure environment),

the interaction with the side wall 31 is crucial. *Id.*, ¶217. As shown, a portion of the spray cone (gold) impinges the surface (blue) and is distributed both in an elevation direction (towards the central peak) and in the recess edge direction (towards an edge of the combustion chamber 3). *Id.*, ¶216.



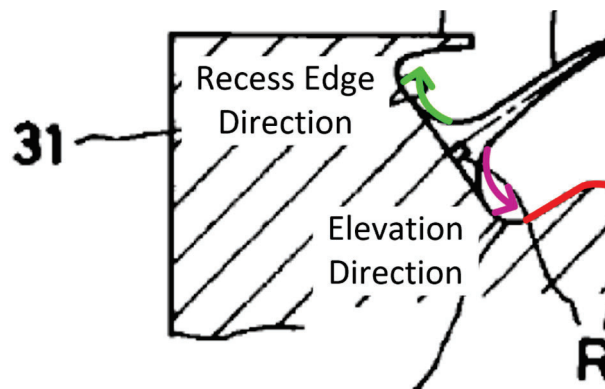
EX. 1005, FIG. 2 (annotated).

Upon this impingement of an “early as possible” injected fuel jet on Ishida’s side wall 31, the fuel is “distributed both in a elevation direction and in the recess edge direction” as claimed. Ishida explains the consequence of this impact: “the injected fuel F makes an impact that causes it to *rebound at the side wall 31* of the combustion chamber 3.” *Id.*, p.4. This “rebound” is the distributing mechanism:

- Elevation Direction: As shown in FIG. 2 below, when the fuel spray rebounds from the outwardly and upwardly sloped side wall 31, a significant component of the spray's momentum will be redirected generally inwards, towards the center of the bowl where the "elevation" is located. EX. 1005, FIG. 2. This satisfies the requirement for distribution in the "elevation direction." EX. 1004, ¶¶218-19.
- Recess Edge Direction: As shown in FIG. 2 below, the same rebound action, coupled with the diffusion inherent in spray impact, will also cause the fuel to spread along the surface of the side wall 31. EX. 1005, FIG. 2. Since the side wall 31 has an ascending gradient towards the lip 2 and the piston top surface 11 (which form the "recess edge"), this spreading constitutes distribution in the "recess edge direction." EX. 1004, ¶¶218-19.

This dual directional distribution is expressly shown in the annotation of FIG.

2. of Ishida, reproduced below.



EX. 1005, FIG. 2 (annotated).

The stated effect of this configuration is that it “significantly reduces the proportion of fuel in the combustion chamber reaching the bottom 32 along the side wall 31.” EX. 1005, p.4. This protective mechanism against fuel reaching the bottom prematurely is relevant for “early as possible” injections, which might otherwise over-penetrate. EX. 1004, ¶217. By forcing an impact and rebound on the side wall 31, Ishida actively manages and distributes fuel injected at these earlier timings. *Id.*, ¶219.

Therefore, Ishida’s explicit description of its design causing fuel to impact and rebound from the side wall 31, a mechanism that is continuously active and particularly beneficial for managing earlier injections to prevent them from reaching the bowl bottom uncombusted, satisfies the functional requirements of the “early as possible” limitation.

Any difference Patent Owner argues with regard to the functional language of this limitation and what is disclosed by Ishida is not patentable in view of Ishida. *See Rexnord Indus., LLC v. Kappos*, 705 F.3d 1347, 1355-56 (Fed. Cir. 2013) (claim dimension found to be an obvious design choice); *see also Airlite Plastics Co. v. Plastilite Corp.*, 526 F.2d 1078, 1082 (8th Cir. 1975) (claims obvious where difference over prior art limited to “form, proportions, or size”). For example, if Patent Owner contends that the specific early as possible injection timing impinging

side wall 31 is not expressly shown by Ishida, a POSITA would have found such timing an obvious design choice.

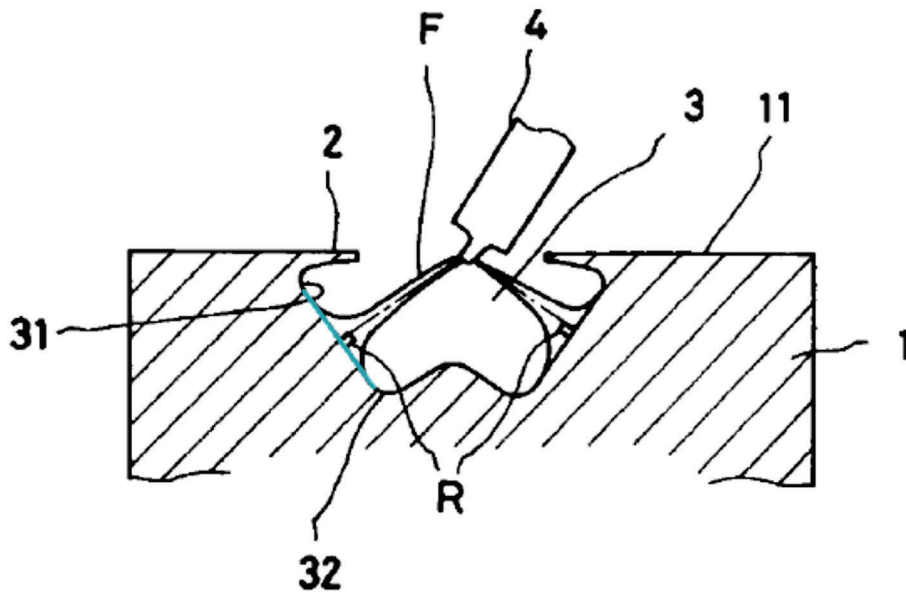
Ishida discloses that timing and directing fuel spray in order to directly impinge the planar surface and achieve dual directional distribution was known, and had known benefits in these types of piston designs, including reducing white smoke, odors, and HC. EX. 1004, ¶220. Selecting and optimizing any particular timing argued by Patent Owner to be “as early as possible” such that the fuel spray impinges the planar, ascending surface and achieves dual directional distribution would thus be obvious view of Ishida. *Id.*

- iv. **“the surface [a] is substantially planar and has an ascending gradient in the recess edge direction [b] such that an injection jet injected as late as possible impinges onto the surface, the last-mentioned injection jet being distributed both in the elevation direction and in the recess edge direction.”**

The “surface” of Ishida (side wall 31), meets these limitations of claim 1, which are addressed in turn.

- (a) **“is substantially planar, and has an ascending gradient in the recess edge direction”**

Ishida’s side wall 31 is depicted in the cross section of annotated FIG. 2, reproduced below, as a straight, inclined line (blue). A POSITA would have understood this to be “substantially planar.” EX. 1004, ¶¶225-26.



EX. 1005, FIG. 2 (annotated).

Further, as shown in Annotated FIG. 2, reproduced above, side wall 31 slopes upwards and outwards from its junction with elevation towards the lip 2 and the top surface of the piston 11, which constitutes the recess edge. EX. 1004, ¶226. This is clearly an “ascending gradient in the recess edge direction.” *Id.*

- (b) **“such that an injection jet injected as late as possible impinges onto the surface, the last-mentioned injection jet being distributed both in the elevation direction and in the recess edge direction.”**

Ishida discloses these functional limitations of claim 1. The claims, specification, and prosecution history of the '238 Patent do not define what is meant by “injected as late as possible.” Indeed, this language appears only in claim 1. In background, the '238 Patent states, “[s]ince, however, it is not possible to operate

the internal combustion engine with a homogeneous combustion process (which uses early injection) over its entire characteristic map, the piston recess must be designed both for homogeneous and for conventional mixture formation.” EX. 1001, 1:38-43. Homogenous mixture formulation is typically associated with early injection timing, implying that “late” injection is associated with “conventional mixture formation,” which in diesel engines typically means injection near top dead center. EX. 1004, ¶228.

The '238 Patent further states, “FIG. 1 depicts two different injection jets, to be precise an injection jet 9a, which is obtained when the piston 6 is at a top dead center, and an injection jet 9b, which is obtained in the case of fuel injection at the latest possible injection time point. The injection jets 9a and 9b are in each case illustrated merely as axes of an injection cone being distributed within the combustion space 5.” EX. 1001, 2:54-60. These injection jets, occurring at different timings, are superimposed on the piston of FIG. 1 below.

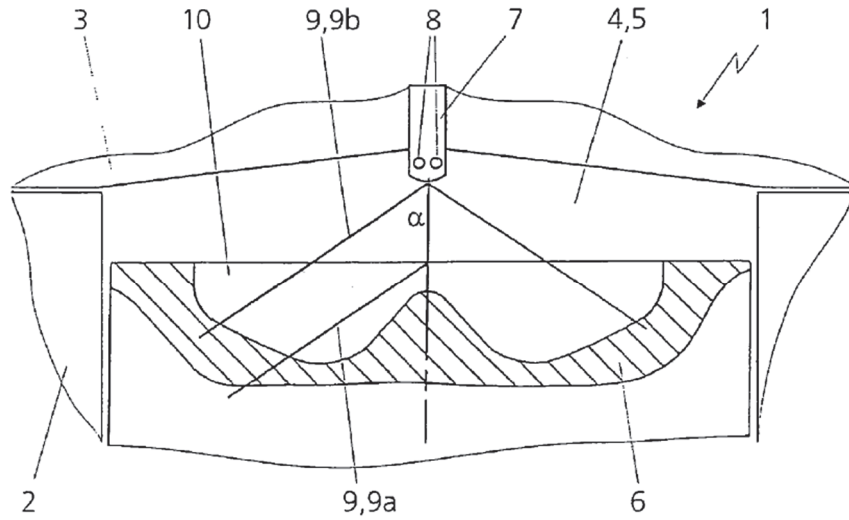


Fig. 1

Id., FIG. 1.

Because jet 9a is purportedly injected at TDC³ and jet 9b is purportedly distinct from jet 9a, the above explanation of FIG. 1 implies the “latest possible injection time point” would encompass injection timings slightly after TDC because jet 9b is purportedly *later* in time and shown when the piston is *below* TDC. EX. 1004, ¶230. While conventional diesel combustion is often initiated slightly before or at TDC, the main injection event can sometimes continue for a short period after TDC, especially at higher loads, in order to complete fuel delivery. *Id.*, ¶¶230, 234.

³ Petitioner acknowledges some ambiguity in FIG. 1 as jet 9a is also expressly stated as reflecting injection as “early as possible.” EX. 1005, 3:8-16.

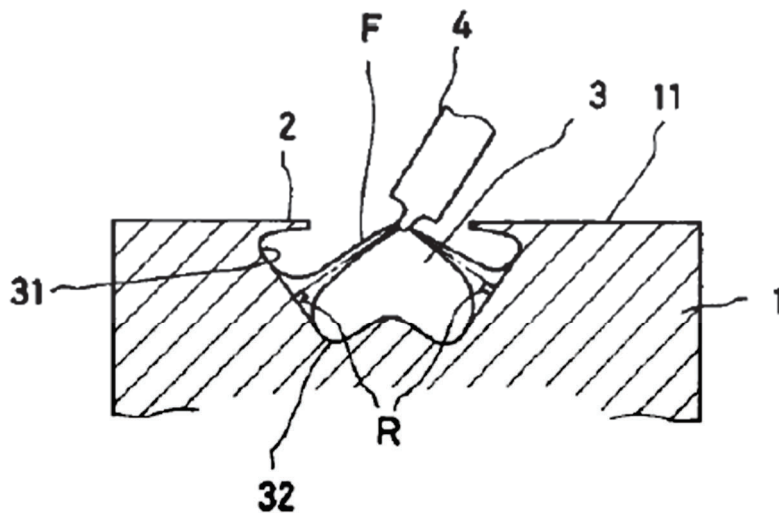


FIG. 2

EX. 1005, FIG. 2.

Regardless of its precise definition, Ishida satisfies the “late as possible” limitation of claim 1. EX. 1004, ¶232. Again, the fundamental operating principle of Ishida is that “fuel from the fuel injection nozzle is set so as to *impact the side wall of the combustion chamber.*” EX. 1005, Claim, p.3, 4 (emphasis added). This described interaction is not limited to an early phase of injection (discussed *supra*), but is the primary mechanism for *all* directly injected fuel within Ishida’s engine. EX. 1004, ¶233. Therefore, Ishida’s core inventive concept of side wall impingement must, and does, apply to “late as possible” injections just as it applies to “early as possible” injections. *Id.*, ¶235.

Ishida’s solution addresses problems such as incomplete combustion, smoke,

and HC emissions (EX. 1005, p.3), which are pertinent if the main fuel charge injected as “late as possible” is poorly managed (EX. 1004, ¶236). Ishida explicitly states, “[b]ecause the combustion chamber 3 in the present invention is configured as described above, the injected fuel F makes an impact that causes it to *rebound at the side wall 31* of the combustion chamber 3.” EX. 1005, p.4. This rebound mechanism is described generally for “the injected fuel F” and is therefore applicable when that fuel is injected as “late as possible.” EX. 1004, ¶233.

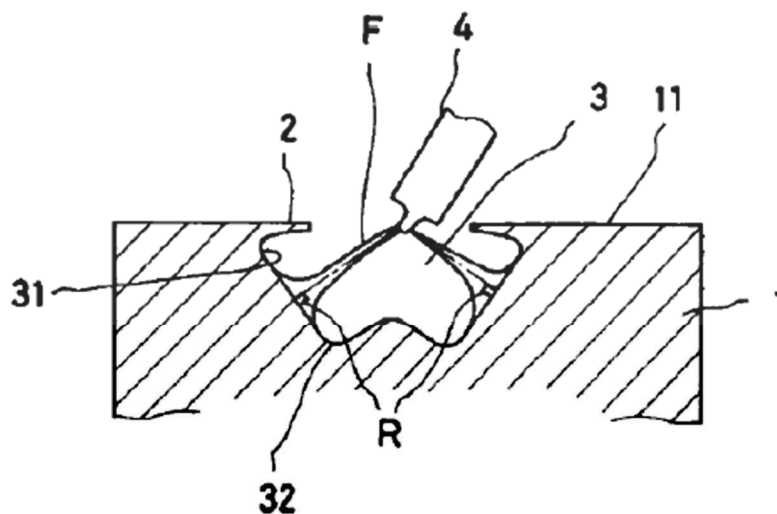


FIG. 2

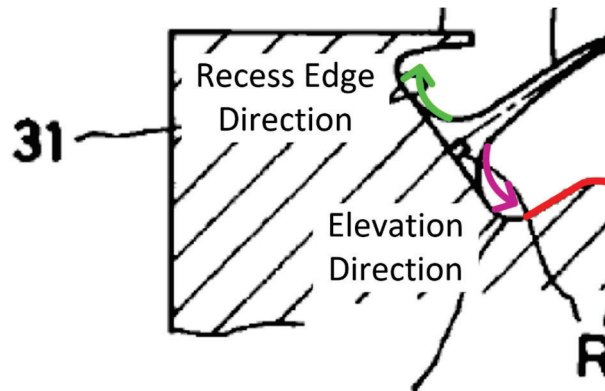
EX. 1005, FIG. 2.

Upon this impingement of a “late as possible” injected fuel jet on Ishida’s side wall 31, the fuel is “distributed both in a elevation direction and in the recess edge direction” as claimed. Ishida explains the consequence of this impact: “the injected

fuel F makes an impact that causes it to *rebound at the side wall 31* of the combustion chamber 3.” *Id.*, p.4 (emphasis added). This “rebound” is the distributing mechanism:

- Elevation Direction: As shown in FIG. 2 below, when the fuel spray rebounds from the outwardly and upwardly sloped side wall 31, a significant component of the spray’s momentum will be redirected generally inwards, towards the center of the bowl where the “elevation” is located. EX. 1005, FIG. 2. This satisfies the requirement for distribution in the “elevation direction.” EX. 1004, ¶¶238-39.
- Recess Edge Direction: As shown in FIG. 2 below, the same rebound action, coupled with the diffusion inherent in spray impact, will also cause the fuel to spread along the surface of the side wall 31. EX. 1005, FIG. 2. Since side wall 31 has an ascending gradient towards the lip 2 and the piston top surface 11 (which form the “recess edge”), this spreading constitutes distribution in the “recess edge direction.” EX. 1004, ¶¶238-39.

This dual directional distribution is expressly shown in the annotation of FIG. 2. of Ishida, reproduced below.



EX. 1005, FIG. 2 (annotated).

Ishida explains that this rebound “significantly reduces the proportion of fuel in the combustion chamber reaching the bottom 32 along the side wall 31.” EX. 1005, p.4. This effect, achieved by the impingement and subsequent rebound from side wall 31, is how Ishida manages the main fuel charge injected “late as possible” to ensure better combustion and reduce unwanted byproducts. EX. 1004, ¶233. The piston geometry is static, and its interaction with the spray is consistent for injections aimed at the side wall, including those occurring “as late as possible.” *Id.*, ¶237.

Any difference Patent Owner argues with regard to the functional language of this limitation and what is disclosed by Ishida is not patentable in view of Ishida. *See Rexnord*, 705 F.3d at 1355-56; *see also Airlite*, 526 F.2d at 1082. For example, if Patent Owner contends that the specific late as possible injection timing impinging side wall 31 is not expressly shown by Ishida, a POSITA would have found such timing an obvious design choice.

Ishida discloses that timing and directing fuel spray in order to directly

impinge the planar surface and achieve dual directional distribution was known, and had known benefits in these types of piston designs, including reducing white smoke, odors, and HC. Selecting and optimizing any particular timing argued by Patent Owner to be “as late as possible” such that the fuel spray impinges the planar, ascending surface and achieves dual directional distribution would thus be obvious over Ishida. *Id.*, ¶240.

3. Claim 2 – “The directly injecting internal combustion engine as claimed in claim 1, wherein a surface connected to the recess edge adjoins the surface of the piston recess.”

As shown in the annotation of Ishida below, a surface (purple) is connected to the recess edge (green) and adjoins the surface (blue) of the piston recess. *Id.*, ¶¶241-42.



Id., FIG. 2 (annotated). This interpretation of the surface adjoining the surface of the piston recess is consistent with the '238 Patent. *See* EX. 1001, 4:8-9 (“It is apparent from FIG. 7 that the surface 13 has adjoining it a surface 23 connected to the recess edge 12 via a radius 22.”); EX. 1004, ¶¶243-44. The '238 Patent discloses that the surface 23 adjoins the surface 13 despite the radius 22 being located therebetween.

4. Claim 3 – “The directly injecting internal combustion engine as claimed in claim 2, wherein the surface connected to the recess edge is connected via a radius to the surface of the piston recess.”

As shown in the annotation of Ishida below, the surface (purple) is connected to the recess edge (green) and that is connected via a radius (cream) to the surface (blue) of the piston recess. *Id.*, ¶245.

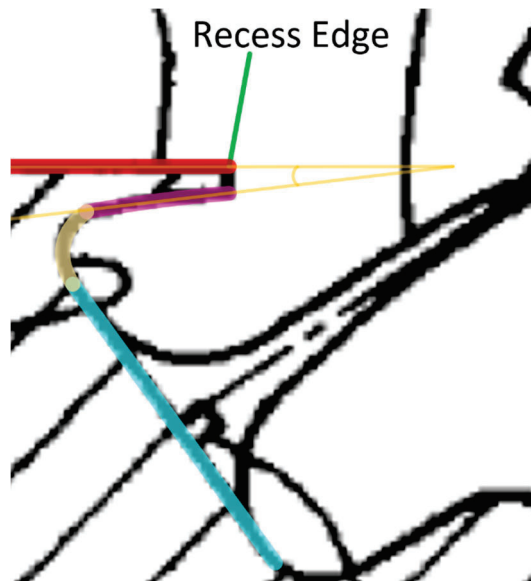


EX. 1005, FIG. 2 (annotated).

5. Claim 5 – “The directly injecting internal combustion engine as claimed in claim 2, wherein the surface connected to the recess edge forms an acute angle with an upper surface of the piston.”

As shown in the annotation of Ishida below, the surface (purple) connected to the recess edge (green) forms an acute angle with an upper surface (red) of the piston.

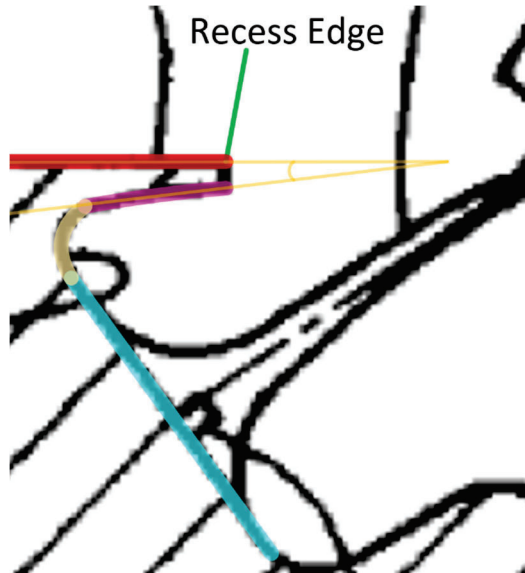
EX. 1004, ¶246.



EX. 1005, FIG. 2 (annotated).

6. Claim 6 – “The directly injecting internal combustion engine as claimed in claim 5, wherein the surface connected to the recess edge is connected via a radius to the surface of the piston recess.”

As shown in the annotation of Ishida below, the surface (purple) is connected to the recess edge (green) and that is connected via a radius (cream) to the surface (blue) of the piston recess. *Id.*, ¶250.



EX. 1005, FIG. 2 (annotated).

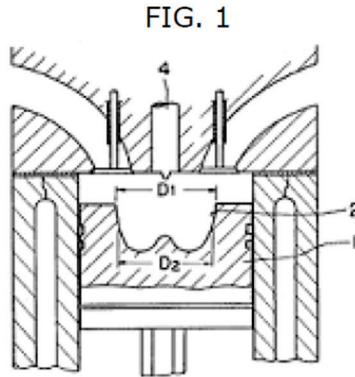
B. Ground 2: Claims 7 and 8 are Obvious Over Ishida and Oota.

Claims 7 and 8 of the '283 Patent are unpatentable under 35 U.S.C. §103(a) as obvious over Ishida and Oota.

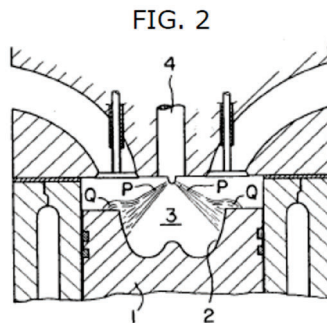
1. Oota

Oota is directed to a “combustion chamber of a direct injection diesel engine.”

EX. 1009, p. 1. Oota describes prior combustion chamber designs with reference to FIGS. 1 and 2, reproduced below. *Id.* Notably, FIG. 2 reflects a similar combustion chamber design as Ishida, but without the lip feature.



Id., FIG. 1.



Id., FIG. 2.

In the combustion chamber design of Figure 2, Oota observes that the “fuel (P) injected from the nozzle 4 into the combustion chamber 3 is partly blown upward toward the top of the piston 1 (as shown by Q in the figure)” and “[t]his fuel Q blown upward causes incomplete combustion, resulting in increased diesel black smoke and reduced combustion efficiency.” *Id.*, p. 1. Oota thus teaches injection directed primarily at the side wall, but also the consequences of having injection partially overspray onto the top surface. EX. 1004, ¶¶104, 167, 256.

2. The Predictable Combination of Ishida with Oota

As discussed in Ground 1, Ishida discloses a direct-injection diesel engine with a piston 1 having a combustion chamber 3. EX. 1005, FIG. 2, p. 4. Relevant to its combination with Oota, Ishida's combustion chamber includes a lip 2 at the recess edge. *Id.* As shown in FIG. 2 below, Oota describes a similar combustion chamber, but without the lip. EX. 1009, FIG. 2.

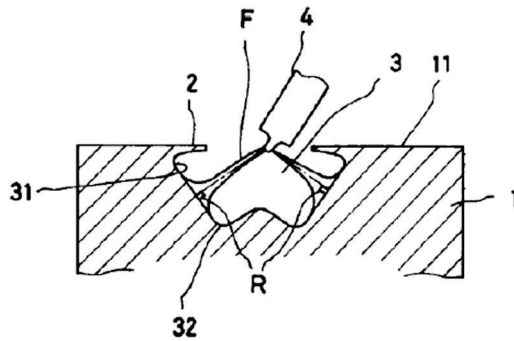
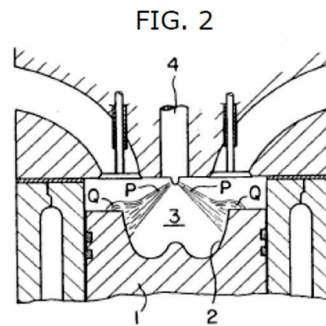


FIG. 2

EX. 1005, FIG. 2



EX. 1009, FIG. 2

A POSITA considering Ishida's lipped piston design would have found it obvious to modify Ishida by removing its lip 2, guided by the knowledge of simpler, known lipless piston designs reflected in FIG. 2 of Oota. EX. 1004, ¶¶102-05, 254-60. A POSITA is routinely faced with design choices involving complexity versus simplicity, and cost versus performance. *Id.*, ¶257. Lipless open-chamber pistons were a known and fundamental design configuration in the art. *Id.*, ¶¶102, 104. Thus, modifying Ishida to conform to this simpler, known lipless configuration would be a straightforward design permutation.

Oota explicitly presents its FIG. 2 as depicting a “known combustion chamber.” EX. 1009, p.1. This known prior art design in Oota’s FIG. 2 shows a simple open-chamber piston recess 3 in a piston 1 without any lip at its peripheral edge. In view of Ishida’s teachings as to the benefit of injection the fuel into the side wall, problems Oota identifies with respect its design are largely attributed to overspray onto the top surface of the piston, not to its lack of a lip. EX. 1004, ¶¶104, 256.

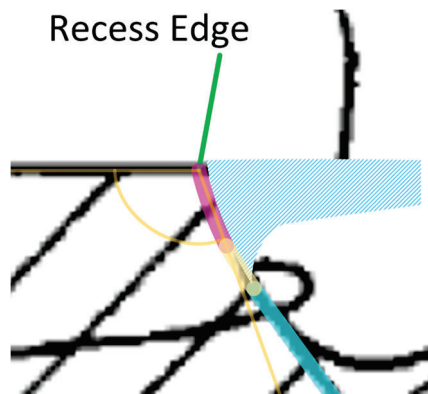
Moreover, a POSITA would have understood that the lipless configuration of Oota avoids drawbacks associated with Ishida’s lip. *Id.*, ¶104. Specifically, a POSITA would have understood that Ishida’s lip is prone to cracking during operation. *Id.*, ¶103. Relatively thin portions of a piston often crack during use of the piston due to the high temperatures and stresses experienced by these portions during operation. *Id.* Additionally, a POSITA would have understood that the lip 2 of Ishida would have required specialized machining to create, which would have been relatively expensive. *Id.* A POSITA would have understood that the lipless design of Oota would have been economically beneficial because these increased costs associated with the lip would be avoided. *Id.*, ¶104.

In view of the foregoing, A POSITA would have found it an obvious design choice to eliminate the lip of Ishida. *Id.* A POSITA would have had a reasonable expectation of success in making such a modification of Ishida because it would only

require application of known engineering approaches, and would have been well within the skill of a POSITA. *Id.*, ¶105.

3. Claim 7 – “The directly injecting internal combustion engine as claimed in claim 2, wherein the surface connected to the recess edge forms an obtuse angle with an upper surface of the piston.”

When Ishida’s lip 2 is removed, the piston recess (combustion chamber 3) terminates at the upper surface 11 of the piston 1. EX. 1004, ¶258. In this modified, lipless Ishida design: (i) the “recess edge” is the uppermost peripheral edge of the side wall 31 where it meets the flat top surface 11 of the piston; and (ii) the “surface connected to the recess edge” (as recited in claim 2 and referenced in claim 7) is this uppermost portion or termination of the side wall 31 at the piston’s top surface. Below is an annotation showing Ishida with the lip removed according to this obvious modification in view of Oota.



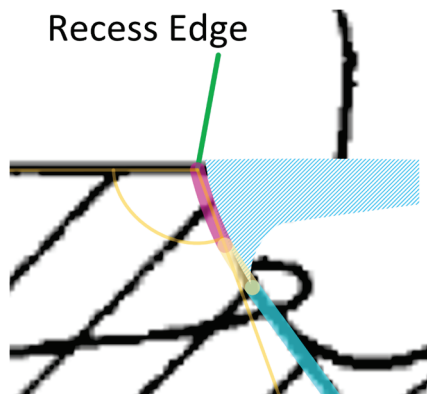
Id., ¶259.

Ishida’s side wall 31 is depicted as sloping outwards and upwards from the deeper part of the bowl towards the top of the piston. EX. 1005, FIG. 2. When this

outwardly and upwardly sloping side wall 31 meets the flat “upper surface of the piston” 11 in a lipless configuration (as depicted in Oota’s FIG. 2), the angle formed between the termination of this side wall (representing the “surface connected to the recess edge”) and the flat upper surface of the piston will be obtuse (greater than 90 degrees). EX. 1004, ¶260. This is a fundamental geometric consequence of an open bowl shape with an outwardly flared wall meeting a flat top surface. *Id.*

4. Claim 8 – “The directly injecting internal combustion engine as claimed in claim 7, wherein the surface connected to the recess edge is connected via a radius to the surface of the piston recess.”

In the modification of Ishida in view of Oota described above, the surface (purple) is connected to the recess edge (green) and is connected via a radius (cream) to the surface (the side wall - blue) of the piston recess. *Id.*, ¶261.



EX. 1005, FIG. 2 (annotated).

C. Ground 3: Claims 9-13 Are Obvious Over Ishida and Gatellier

1. Gatellier

Gatellier is directed to “an engine developing a combustion allowing very varied injection conditions.” EX. 1007, ¶[0014]. The stated problem Gatellier addresses is the limitation in selecting fuel injection times in conventional direct-injection engines, particularly when trying to avoid cylinder wall wetting while also enabling varied injection strategies like early pilot injections or late post-injections. *Id.*, ¶¶[0010]-[0012]. To overcome this, Gatellier proposes an engine and piston design that allows for a “great latitude for selection of the fuel injection times” (*id.*, ¶[0017]), and details early injection strategies such as “for low and average loads, in injecting the fuel...so as to obtain a long mixing time of the fuel with the air admitted before combustion” (*id.*, ¶¶[0043]-[0044]), and late injection strategies, “for high loads, in injecting the fuel through the same injection nozzle with the same nappe angle, so as to obtain stratified mixing of the fuel with the air and a progressive combustion.” *Id.*, ¶[0045]. Gatellier also allows for injection angles up to 120°, and preferably between 40° and 100°. *Id.*, ¶[0054].

2. The Predictable Combination of Ishida with Gatellier

Ishida discloses a direct-injection diesel engine with a piston 1 having a combustion chamber 3 with a side wall 31 designed for fuel F from an injection nozzle 4 to impinge upon. EX. 1005, FIG. 2, p. 4. While Ishida illustrates an injection

nozzle and fuel spray, it does not explicitly quantify the nappe angle of its injection nozzle. Gatellier explicitly teaches that an injection nappe angle “advantageously selected between 0° and 120°” and “preferably selected between 40° and 100°,” enhances the performance and flexibility of the engine. EX. 1007, ¶¶[0054], [0055], [0057]; EX. 1004, ¶263.

A POSITA seeking to enhance the performance and flexibility of an engine like Ishida’s, particularly in light of known issues with injection timing and wall wetting that Gatellier aims to solve, would have been motivated to apply Gatellier’s specific teachings regarding advantageous nappe angles. EX. 1004, ¶121. A POSITA would have reasonably expected that incorporating an injector with a nappe angle from Gatellier’s recommended range into an Ishida-type engine would successfully yield the desired improvements, such as greater injection timing flexibility, without compromising Ishida’s fundamental fuel-wall impingement mechanism. *Id.* This modification would be a standard engineering approach, well within the skill of a POSITA, to optimize injector characteristics for an existing piston bowl design. *Id.*, ¶122.

3. Claim 9 – “The directly injecting internal combustion engine as claimed in claim 1, wherein an injection angle of the injection nozzle is between 50° and 120°.”

As explained by Dr. Bower, Ishida’s injector utilizes an injection angle of approximately 120°. *Id.*, ¶¶120, 262. Moreover, injectors like that of Ishida

commonly used injection angles “between 50° and 120°.” *Id.* To the extent not expressly disclosed by Ishida, a POSITA would have found it obvious to use such an injection angle in view of Gatellier. *Id.*, ¶¶121-22, 262-66. The range of 50° to 120° recited in claim 9 falls squarely within Gatellier’s taught advantageous range. *Id.*, ¶266. *See In re Peterson*, 315 F.3d 1325, 1329 (Fed. Cir. 2003) (“A prima facie case of obviousness typically exists when the ranges of a claimed composition overlap the ranges disclosed in the prior art”). As explained above, selecting an injection angle between 50° and 120°, as taught by Gatellier, for use with an Ishida-type engine, would have been an obvious design choice. EX. 1004, ¶264.

4. Claim 10 – “The directly injecting internal combustion engine as claimed in claim 9, wherein a surface connected to the recess edge adjoins the surface of the piston recess.”

Claim 2 recites analogous limitations that are addressed above. *See* Section X.A.3; EX. 1004, ¶¶241-44, 267.

5. Claim 11 – “The directly injecting internal combustion engine as claimed in claim 10, wherein the surface connected to the recess edge is connected via a radius to the surface of the piston recess.”

Claims 3 and 6 recite analogous limitations that are addressed above. *See* Sections X.A.4 and X.A.6; EX. 1004, ¶¶245, 250, 268.

6. Claim 12 – “The directly injecting internal combustion engine as claimed in claim 10, wherein the surface connected to the recess edge forms an acute angle with an upper surface of the piston.”

Claim 5 recites analogous limitations that are addressed above. *See* Sections X.A.5; EX. 1004, ¶¶246-49, 269.

7. Claim 13 – “The directly injecting internal combustion engine as claimed in claim 10, wherein the surface connected to the recess edge forms an obtuse angle with an upper surface of the piston.”

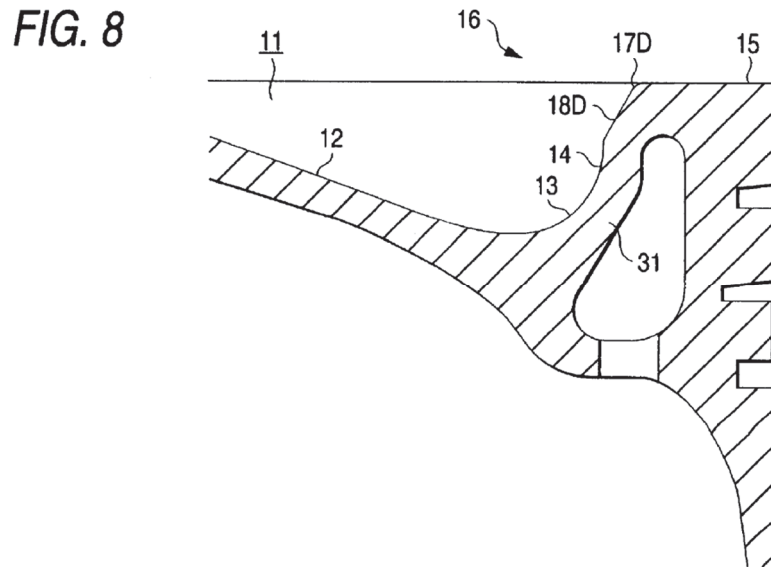
Claim 7 recites analogous limitations that are addressed above. *See* Section X.B.3; EX. 1004, ¶¶251-60, 270.

D. Ground 4: Claim 4 is Obvious Over Ishida and Iijima

1. Iijima

Iijima is directed to pistons for internal combustion engines, with a particular focus on improving durability by addressing heat points and stress concentrations, especially at the edge of the combustion chamber. EX. 1004, ¶123. Iijima describes various embodiments for shaping the “chamfered portion” 16, which is the “cross-sectionally angular portion defined by an upper edge portion...of an inner circumferential surface of the combustion chamber and a piston-top surface.” EX. 1008, 2:53-62; 7:45-49. Iijima’s FIG. 8 shows a chamfered portion that includes “a rounded portion 17D formed on the outer side of the conical surface portion [18D] and bent gradually outward in an arcuately curved manner toward the piston-top surface 15.” *Id.*, 8:39-44. Iijima explains that “providing rounded portions 17C, 17D

on the cross-sectionally angular portions of acuter anglels (sic) is effective in preventing heat points from occurring.” *Id.*, 8:45-49.



EX. 1008, FIG. 8.

2. The Predictable Combination of Ishida with Iijima

A POSITA seeking to improve the durability and reduce thermal stress on a piston like that shown in Ishida, would have been motivated to incorporate the teachings of Iijima regarding the rounding of the recess edge, and would have had a reasonable expectation of success. EX. 1004, ¶¶135-36. Ishida discloses a direct-injection diesel engine with a piston 1 having a combustion chamber 3. This chamber includes a lip 2 at its peripheral edge (the “recess edge”) which adjoins the side wall 31 of the recess. EX. 1005, FIG. 2. This lip 2 forms the “surface connected to the recess edge” and its top surface is essentially coplanar with, or forms part of, the “upper surface of the piston” 11. FIG. 2 of Ishida depicts a relatively sharp transition

where the outer radial extent of the lip 2 meets the general upper surface of the piston.

Iijima addresses the problem of “heat points” and stress occurring at the sharp “edge portion” of a combustion chamber. EX. 1008, 1:28-38, 2:30-36. A POSITA would have recognized that sharp edges, such as the outer periphery of Ishida’s lip 2 where it meets the piston top, can be susceptible to such issues. EX. 1004, ¶272. Iijima provides a clear solution: rounding this edge portion. *Id.*, ¶135. The embodiment of Iijima’s FIG. 8 with its rounded portion (17D) is expressly taught as “effective in preventing heat points from occurring.” *Id.*, ¶131.

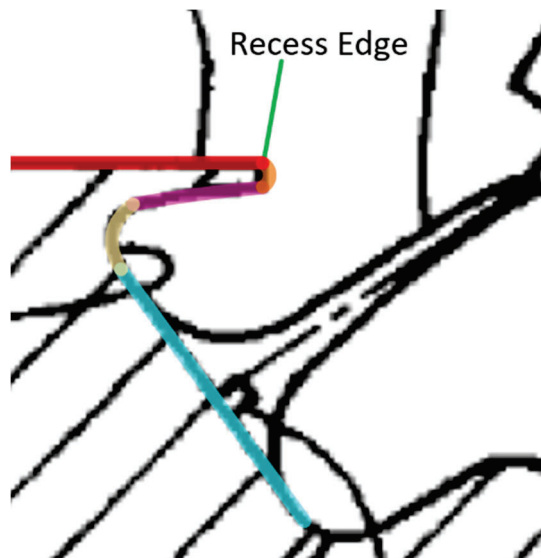
A POSITA, aware of potential thermal stress issues at the outer edge of Ishida’s lip 2, would be motivated to apply Iijima’s solution of providing a rounded transition (a radius) at this location. This would enhance the durability of Ishida’s piston by mitigating stress concentrations and the formation of heat points at the recess edge where it meets the piston’s upper surface. *Id.*, ¶135.

Rounding sharp corners to reduce stress concentrations and improve thermal durability is a fundamental and well-understood engineering principle. *Id.*, ¶135. Applying such a radius to the outer edge of Ishida’s lip 2 where it transitions to the piston top surface is a straightforward design modification. Iijima’s teaching of a rounded portion 17D merging the recess edge with the piston top surface 15 is directly applicable to the analogous region in Ishida (the outer periphery of lip 2

where it forms part of the upper piston surface 11). A POSITA would have reasonably expected that by incorporating a radiused transition at the outer edge of Ishida's lip 2, mirroring the concept of Iijima's rounded portion 17D, the benefits described by Iijima—namely, the prevention of heat points and improved durability—would be achieved. *Id.*, ¶272. This modification would not fundamentally alter the primary function of Ishida's piston bowl or lip concerning fuel impingement but would enhance its structural integrity at a critical location. *Id.*

3. Claim 4 – “The directly injecting internal combustion engine as claimed in claim 2, wherein the surface connected to the recess edge merges in a radius into an upper surface of the piston.”

The combination of Ishida and Iijima discloses the limitations of claim 4. *Id.*, ¶273. As shown in the annotation of Ishida below, upon combination with Iijima, the surface (purple) connected to the recess edge (green) merges in a radius (orange) into an upper surface (red) of the piston. *Id.*

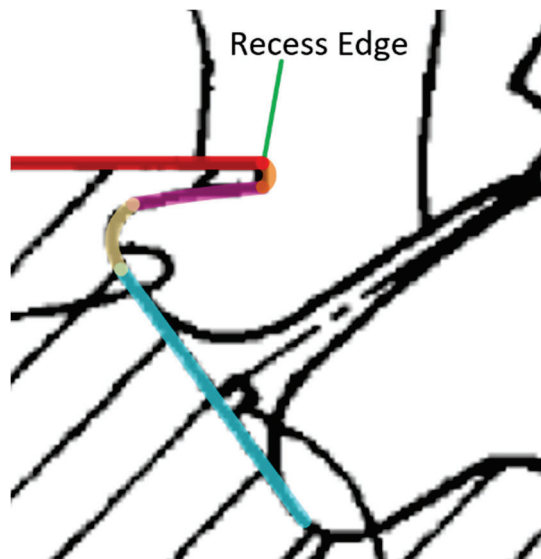


EX. 1005, FIG. 2 (annotated). This interpretation of the surface connected to the recess edge merging in a radius into an upper surface of the piston is consistent with corresponding discussion in the '238 Patent. *See* EX. 1001, 4:26-7; EX. 1004, ¶274.

E. Ground 5: Claim 14 is Obvious Over Ishida, Gatellier, and Iijima

1. Claim 14 – “The directly injecting internal combustion engine as claimed in claim 10, wherein the surface connected to the recess edge merges in a radius into an upper surface of the piston.”

The combination of Ishida, Gatellier, and Iijima discloses the limitations of claim 14. *Id.*, ¶275. The predictable combination of Ishida and Iijima is equally applicable to the Ishida piston utilizing the typical injection angles taught by Gatellier. As shown in the annotation of Ishida below, upon combination with Iijima, the surface (purple) connected to the recess edge (green) merges in a radius (orange) into an upper surface (red) of the piston. *See* EX. 1004, ¶¶137-41.



EX. 1005, FIG. 2 (annotated).

F. Ground 6: Claims 1-3 and 5-8 Are Obvious Over Ishida, As Evidenced By Takatomo

Claims 1-3 and 5-8 of the '283 Patent are unpatentable under 35 U.S.C. §103(a) as obvious over Ishida, as evidenced by Takatomo.

1. Takatomo

Takatomo is directed to a piston for direct-injection diesel engines, aiming to improve combustion and reduce hydrocarbon (HC) emissions. EX. 1006, 2:2-19. In its background, Takatomo explicitly acknowledges an earlier “proposal” by the same applicant (Isuzu Motors Ltd.), identified as Japanese Unexamined Utility Model Application Publication No. S 58-102720 (which is Ishida, EX. 1005).

Takatomo describes Ishida as featuring a piston cavity with an inwardly protruding lip, a side wall perpendicular to the fuel spray, and a central conical protrusion, consistent with the summary of Ishida provided above. *See* EX. 1006, 3:24-62. Takatomo acknowledges the stated goals of the Ishida design were to atomize fuel, spread it as a thin film on the side wall, and confine it within the cavity. *Id.*, ¶145.

Takatomo identifies two problems with Ishida,

(1) It is necessary to improve the mechanical strength of the lip against the fuel pressure of the engine with low compression ratio and high supercharging.

(2) At the maximum output point of the engine, the number of rotations is high, the fuel injection amount is also large, and the angular

velocity of injection pump is large, so the dynamic injection timing is significantly delayed. Therefore, if the maximum output point is set as the optimal timing, the dynamic injection timing is advanced in the case of low-speed rotation, and from a very early timing before the top dead center to a late timing after the top dead center, the fuel is injected and adheres to the top surface of piston (the upper surface of lip), so an excessively large amount of HC (blue-white smoke) is generated.

EX. 1006, 3:47-62.

Consistent with the discussion of Ground 1 (Ishida alone), this discussion of Ishida in Takatomo explains that a system using an Ishida-type piston, particularly when aiming for optimal timing at maximum output, would experience a wide range of actual injection timings across different operating conditions, encompassing both very early and late injections. EX. 1004, ¶148. While Ishida’s taught mechanism of side wall impingement is always active, according to Takatomo, overspray occurring at early and late injection timings was causing excessive HC. *Id.*, ¶146.

Three statements in Takatomo make this apparent:

First, Takatomo’s statement “if the maximum output point is set as the optimal timing, the dynamic injection timing is advanced in the case of low-speed rotation” indicates that optimizing for high-speed and/or high-load (maximum output) leads to an injection timing that becomes effectively *earlier* at low speeds. *Id.*, ¶152.

Second, Takatomo’s statement “...and from a very early timing before the top dead center to a late timing after the top dead center, the fuel is injected and adheres to the top surface of piston (the upper surface of lip), so an excessively large amount of

HC (blue-white smoke) is generated,” explicitly states that under these conditions (optimizing for max output and then running at varying speeds without active compensation), fuel injection occurs over a spectrum “from a very early timing before...TDC to a late timing after...TDC.” *Id.*

Third, Takatomo’s statement, “[f]or this reason, an auto-timer or the like for automatically adjusting the injection timing is required as an additional device.” This highlights that the Ishida design, when subjected to this wide range of actual injection timings due to varying engine conditions experienced problems (fuel on piston top, HC generation). The need for an auto-timer⁴ implies the base piston design itself was not optimally handling this full spectrum of injection timings. *Id.*

For its part, Takatomo achieves its stated objectives through a specific piston cavity 2 design. This cavity, recessed in the piston top surface 20, features a central “conical protruding portion” 13, formed in its bottom surface 11. Ex. 1006, 4:43-63, FIG. 1. The cavity also has an inclined “side wall” 5. *Id.*, 4:54-61, FIG. 1. Takatomo discloses a fuel injection nozzle 3 is disposed approximately on an axis of the cavity 2,” and explains “the fuel spray is injected radially outward and obliquely downward from each nozzle to an opposing side wall or corner.” *Id.*, 4:48-52.

⁴ An auto-timer is a device designed to optimize injection timing relative to piston position (*e.g.*, TDC) based on engine speed and/or load. EX. 1004, ¶148.

¶144. Takatomo highlights that optimizing such an engine for maximum output leads to the system experiencing a wide range of actual injection timings, “from a very early timing before the top dead center to a late timing after the top dead center.”

Considering operation at what a POSITA would have understood as “early as possible” injection (Takatomo’s “very early timing before top dead center”), Ishida’s design fundamentally relies on the fuel spray engaging the side wall. *Id.*, ¶146. However, Takatomo’s description of Ishida indicates that at these very early timings, while the side wall interaction was occurring, a portion of the fuel also “adheres to the top surface of piston (the upper surface of lip).” *Id.* Fuel spray, likely due to the piston’s lower position, was not exclusively interacting with the side wall in the intended manner; some was misdirected onto the lip’s upper surface, leading to “an excessively large amount of HC (blue-white smoke).” *Id.* Thus, even with the intended side wall impingement occurring, its efficacy was compromised by this concurrent misplacement of fuel, indicating a design limitation in handling very early injections cleanly. *Id.*

In the case of “as late as possible” injection, the fuel spray would most directly impact the side wall as Ishida envisioned, given the piston’s optimal position near top dead center. *Id.*, ¶147. The side wall impingement and subsequent rebound would be the dominant interaction. *Id.* However, Takatomo’s overall assessment, evidenced by the stated need for an auto-timer to manage injection timings, implies

that even if the fundamental side wall impingement was consistently achieved, the subsequent fuel distribution, air mixing, and overall combustion process across the entire spectrum of timings were not adequately optimized by Ishida's geometry alone. *Id.*, ¶¶148-49. The problems necessitating an auto-timer suggest that while the fuel-side wall interaction was a constant, its consequences in terms of efficient and clean combustion varied with timing. *Id.*, ¶149.

i. The Predictable Combination of Ishida with an Auto-Timer, as taught by Takatomo.

Takatomo explicitly discusses the prior proposal of Ishida. Takatomo identifies a specific problem with the Ishida design when used in engines where injection timing is optimized for maximum output, but not actively managed across the entire operating range. Takatomo states, "if the maximum output point is set as the optimal timing, the dynamic injection timing is advanced in the case of low-speed rotation, and from a very early timing before the top dead center to a late timing after the top dead center, the fuel is injected and adheres to the top surface of piston (the upper surface of lip), so an excessively large amount of HC (blue-white smoke) is generated." EX. 1006, 3:57-63.

Takatomo then provides an explicit solution to this identified problem: "For this reason, an auto-timer or the like for automatically adjusting the injection timing is required as an additional device." EX. 1006, 3:64-65. A POSITA, understanding

Ishida and Takatomo's analysis and suggestion, would have been motivated to combine Ishida's piston design with an auto-timer with a reasonable expectation of success. EX. 1004, ¶¶159-61.

Takatomo articulates a deficiency in the practical application of Ishida's piston when injection timing is not actively controlled: fuel misplacement and consequent high HC emissions, particularly at very early effective injection timings. *Id.*, ¶146. Takatomo then explicitly teaches the use of an auto-timer as the solution to precisely this problem. *Id.*, ¶148. The motivation for a POSITA would have been to utilize Ishida's piston effectively across a wider range of engine operating conditions. *Id.*, ¶159. This would ensure that the fuel spray is always directed optimally towards Ishida's intended impingement surface (side wall 31), rather than having portions undesirably striking the upper surface, by actively managing the injection timing. *Id.*, ¶160. This would allow Ishida's fundamental operating principle—fuel impingement on and rebound from side wall 31—to optimally function as designed across the engine's entire operational map. *Id.*

By implementing an auto-timer with Ishida's piston:

Addressing “Early As Possible” Injection: The auto-timer prevents the uncontrolled, excessively early injection that Takatomo identified as undesirably causing fuel to adhere on a top surface of the piston. *Id.*, ¶148. Instead, for any given engine condition that might necessitate an early injection (*e.g.*, for homogeneous

charge preparation), the auto-timer would adjust the timing to ensure that this “early as possible” *controlled* injection still allows the fuel spray from nozzle 4 to primarily and effectively impinge upon Ishida’s side wall 31. *Id.*, ¶160. The success expected would be that the fuel hits side wall 31 as per Ishida’s design, and then, as Ishida describes, rebounds and distributes. *Id.*

Addressing “Late As Possible” Injection: Similarly, for any engine condition requiring a later injection (*e.g.*, conventional diesel combustion closer to or after TDC), the auto-timer would ensure this “late as possible” *controlled* injection also results in the fuel spray impinging on Ishida’s side wall 31. *Id.* This is already a favorable condition for Ishida’s design, and the auto-timer would simply ensure this optimal timing is maintained when appropriate. *Id.*

Ishida’s design relies on fuel rebounding from the sloped side wall 31 to achieve distribution and reduce the proportion of fuel reaching the bottom 32 of the recess EX. 1005, p.4. A POSITA would have expected that because the auto-timer successfully ensures the fuel consistently impinges on this side wall 31 across the desired range of “early as possible” and “late as possible” controlled injection timings, then Ishida’s described fuel distribution mechanism (rebound leading to dispersal both inwards (towards the elevation) and outwards (towards the recess edge) functions as intended. *Id.*, ¶148. Controlling the impingement point via an

auto-timer would allow Ishida's specific geometry to achieve this distribution for both early and late controlled injections. *Id.*

3. Claim 1

- i. **“A directly injecting internal combustion engine, comprising at least one cylinder which has a combustion space in which a piston executes an oscillating movement, and an injection nozzle for injection of fuel into the combustion space,”**

Ishida, as evidenced by Takatomo, discloses these limitations of claim 1. *See* Section X.A.2.i.

- ii. **“wherein the piston has a piston recess, which, in a central region thereof, has an elevation extending in a cylinder head direction, and”**

Ishida, as evidenced by Takatomo, discloses these limitations of claim 1. *See* Section X.A.2.ii.

- iii. **“[a] a surface of the piston recess adjoining the elevation in a recess edge direction is connected to the elevation via a radius [b] so that an injection jet impinging the surface and injected as early as possible is distributed both in a elevation direction and in the recess edge direction, and”**

Ishida, as evidenced by Takatomo, discloses these limitations of claim 1. *See* Section X.A.2.iii.

Combining Ishida's piston with an auto-timer, as explicitly suggested by Takatomo to overcome a known deficiency, a POSITA would have arrived at an

engine configuration where fuel injected at controlled “early as possible” timings would impinge on Ishida’s side wall 31 and be distributed. EX. 1004, ¶281. This combination would thus render the “early as possible” injection and distribution limitations of claim 1 obvious. *Id.*, ¶¶278-82.

Any difference Patent Owner argues with regard to the functional language of this limitation and what is disclosed by Ishida is not patentable in view of Ishida. *See Rexnord*, 705 F.3d at 1355-56; *see also Airlite*, 526 F.2d at 1082. For example, if Patent Owner contends that the specific early as possible injection timing impinging side wall 31 is not expressly shown by Ishida, a POSITA would have found such timing an obvious design choice.

- iv. **“the surface [a] is substantially planar and has an ascending gradient in the recess edge direction [b] such that an injection jet injected as late as possible impinges onto the surface, the last-mentioned injection jet being distributed both in the elevation direction and in the recess edge direction.”**

Ishida discloses these limitations of claim 1. *See* Section X.A.2.iv.

Further, by combining Ishida’s piston with an auto-timer, as explicitly suggested by Takatomo to overcome a known deficiency, a POSITA would have arrived at an engine configuration where fuel injected at controlled “late as possible” timings would impinge on Ishida’s side wall 31 and be distributed. EX. 1004, ¶285. This combination would thus render the “late as possible” injection and distribution

limitations of claim 1 obvious. *Id.*, ¶¶283-86.

Any difference Patent Owner argues with regard to the functional language of this limitation and what is disclosed by Ishida is not patentable in view of Ishida. *See Rexnord*, 705 F.3d at 1355-56; *see also Airlite*, 526 F.2d at 1082. For example, if Patent Owner contends that the specific late as possible injection timing impinging side wall 31 is not expressly shown by Ishida, a POSITA would have found such timing an obvious design choice.

4. Claim 2 – “The directly injecting internal combustion engine as claimed in claim 1, wherein the surface connected to the recess edge is connected via a radius to the surface of the piston recess.”

Ishida, as evidenced by Takatomo, discloses the limitations of claim 2. *See* Section X.A.3; EX. 1004, ¶¶241-44, 287.

5. Claim 3 – “The directly injecting internal combustion engine as claimed in claim 2, wherein the surface connected to the recess edge is connected via a radius to the surface of the piston recess.”

Ishida, as evidenced by Takatomo, discloses the limitations of claim 3. *See* Section X.A.4; EX. 1004, ¶¶245, 288.

6. Claim 5 – “The directly injecting internal combustion engine as claimed in claim 2, wherein the surface connected to the recess edge forms an acute angle with an upper surface of the piston.”

Ishida, as evidenced by Takatomo, discloses the limitations of claim 5. *See* Section X.A.5; EX. 1004, ¶¶246-49, 289.

7. Claim 6 – “The directly injecting internal combustion engine as claimed in claim 5, wherein the surface connected to the recess edge is connected via a radius to the surface of the piston recess.”

Ishida, as evidenced by Takatomo, discloses the limitations of claim 6. *See* Section X.A.6; EX. 1004, ¶¶250, 290.

G. Ground 7: Claims 7 and 8 are Obvious Over Ishida and Oota, as Evidenced by Takatomo.

1. Claim 7 – “The directly injecting internal combustion engine as claimed in claim 2, wherein the surface connected to the recess edge forms an obtuse angle with an upper surface of the piston.”

Ishida and Oota, as evidenced by Takatomo, render obvious the limitations of claim 7. *See* Section X.B.3 (discussing combination of Ishida and Oota as to claim 7); EX. 1004, ¶¶251-60, 291.

2. Claim 8 – “The directly injecting internal combustion engine as claimed in claim 7, wherein the surface connected to the recess edge is connected via a radius to the surface of the piston recess.”

Ishida and Oota, as evidenced by Takatomo, render obvious the limitations of claim 8. *See* Section X.B.4 (discussing combination of Ishida and Oota as to claim 8); EX. 1004, ¶¶251-61, 292.

H. Ground 8: Claims 9-13 Are Obvious Over Ishida and Gatellier, as Evidenced by Takatomo

- 1. Claim 9 – “The directly injecting internal combustion engine as claimed in claim 1, wherein an injection angle of the injection nozzle is between 50° and 120°.”**

Ishida and Gatellier, as evidenced by Takatomo, render obvious the limitations of claim 9. *See* Section X.C.3 (discussing combination of Ishida and Gatellier as to claim 9); EX. 1004, ¶¶262-66, 293-97.

- 2. Claim 10 – “The directly injecting internal combustion engine as claimed in claim 9, wherein a surface connected to the recess edge adjoins the surface of the piston recess.”**

Claim 2 recites analogous limitations that are addressed above. *See* Sections X.A.3 and X.F.4; EX. 1004, ¶¶241-44, 287, 298.

- 3. Claim 11 – “The directly injecting internal combustion engine as claimed in claim 10, wherein the surface connected to the recess edge is connected via a radius to the surface of the piston recess.”**

Claims 3 and 6 recite analogous limitations that are addressed above. *See* Sections X.A.4, X.A.6, X.F.5, and X.F.7; EX. 1004, ¶¶245, 250, 288, 290.

- 4. Claim 12 – “The directly injecting internal combustion engine as claimed in claim 10, wherein the surface connected to the recess edge forms an acute angle with an upper surface of the piston.”**

Claim 5 recites analogous limitations that are addressed above. *See* Sections X.A.5 and X.F.6; EX. 1004, ¶¶246-49, 289, 300.

5. Claim 13 – “The directly injecting internal combustion engine as claimed in claim 10, wherein the surface connected to the recess edge forms an obtuse angle with an upper surface of the piston.”

Claim 7 recites analogous limitations that are addressed above. *See* Sections X.B.3 and X.G.1; EX. 1004, ¶¶251-60, 291, 301.

I. Ground 9: Claim 4 is Obvious Over Ishida and Iijima, as Evidenced by Takatomo

1. Claim 4 – “The directly injecting internal combustion engine as claimed in claim 2, wherein the surface connected to the recess edge merges in a radius into an upper surface of the piston.”

Ishida and Iijima, as evidenced by Takatomo, render obvious the limitations of claim 4. *See* Section X.D.3 (discussing combination of Ishida and Iijima as to claim 4); EX. 1004, ¶¶271-74, 302-05.

J. Ground 10: Claim 14 is Obvious Over Ishida, Gatellier, and Iijima, as Evidenced by Takatomo

1. Claim 14 – “The directly injecting internal combustion engine as claimed in claim 10, wherein the surface connected to the recess edge merges in a radius into an upper surface of the piston.”

Ishida, Gatellier, and Iijima as evidenced by Takatomo, render obvious the limitations of claim 14. *See* Section X.E.1 (discussing combination of Ishida, Gatellier, and Iijima as to claim 14); EX. 1004, ¶¶271-74, 302-05, 306.

K. Ground 11: Claims 1-6 Are Obvious Over Takatomo

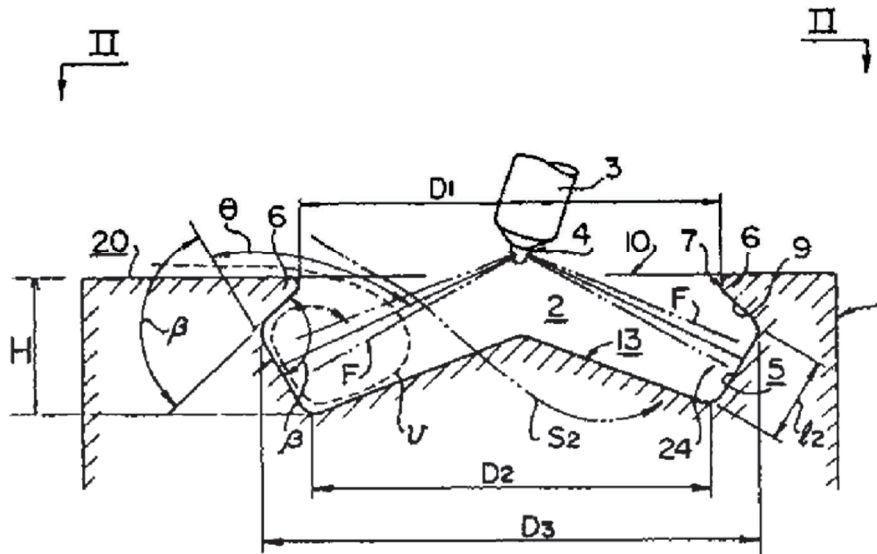
Claims 1-6 of the '238 Patent are unpatentable under 35 U.S.C. §103(a) as obvious over Takatomo.

1. Claim 1

- i. “A directly injecting internal combustion engine, comprising at least one cylinder which has a combustion space in which a piston executes an oscillating movement, and an injection nozzle for injection of fuel into the combustion space,”**

Takatomo discloses a “piston for an engine in which a cavity for direct supply of fuel spray is formed at the top of the piston.” EX. 1006, 2:1-3; EX. 1004, ¶230. This describes a directly injecting internal combustion engine. EX. 1004, ¶307. FIG. 1 of Takatomo further depicts a piston 1, a cavity 2 (which forms part of the combustion space within a cylinder), an injection nozzle 3 delivering fuel spray (F, F2) into the cavity, all within an engine cylinder where the piston 1 executes oscillating movement. EX. 1006, FIG. 1. A POSITA would have understood that the piston of Takatomo executes an oscillating movement in a combustion space of a cylinder because such an arrangement is conventional in internal combustion engines like that described in Takatomo. EX. 1004, ¶308.

FIG. 1



EX. 1006, FIG. 1.

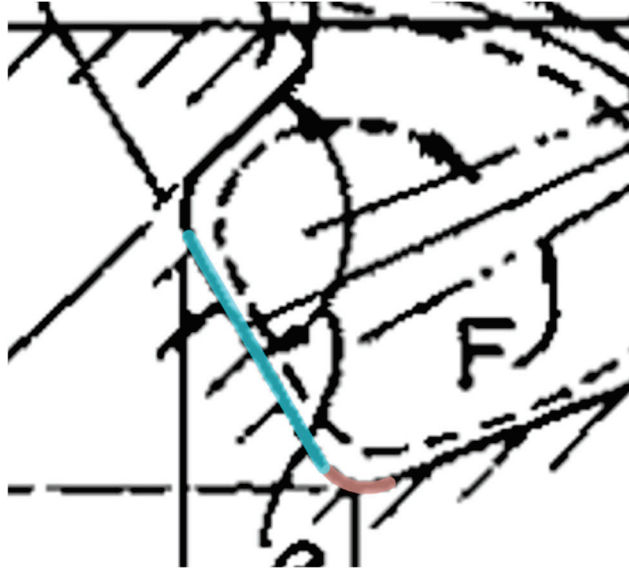
- ii. “wherein the piston has a piston recess, which, in a central region thereof, has an elevation extending in a cylinder head direction, and”

Takatomo discloses these limitations of claim 1. *Id.*, 4:40-43, 4:58-60; EX. 1004, ¶312. FIG. 1 of Takatomo depicts the piston 1 shown with a cavity 2 recessed in its top surface 20; this cavity 2 is the claimed piston recess. Centrally located within this cavity 2, Takatomo discloses a “conical protruding portion 13.” EX. 1006, 2:49-52; Claim 1; 1:13-14. This conical portion 13 constitutes the “elevation” as claimed, as it extends from the bottom surface 11 of the cavity 2 upwards, in the direction of the injection nozzle 3 and thus in the cylinder head direction.

iii. “[a] a surface of the piston recess adjoining the elevation in a recess edge direction is connected to the elevation via a radius [b] so that an injection jet impinging the surface and injected as early as possible is distributed both in a elevation direction and in the recess edge direction, and”

(a) “a surface of the piston recess adjoining the elevation...is connected to the elevation via a radius”

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EX. 1006, FIG. 1 (annotated).

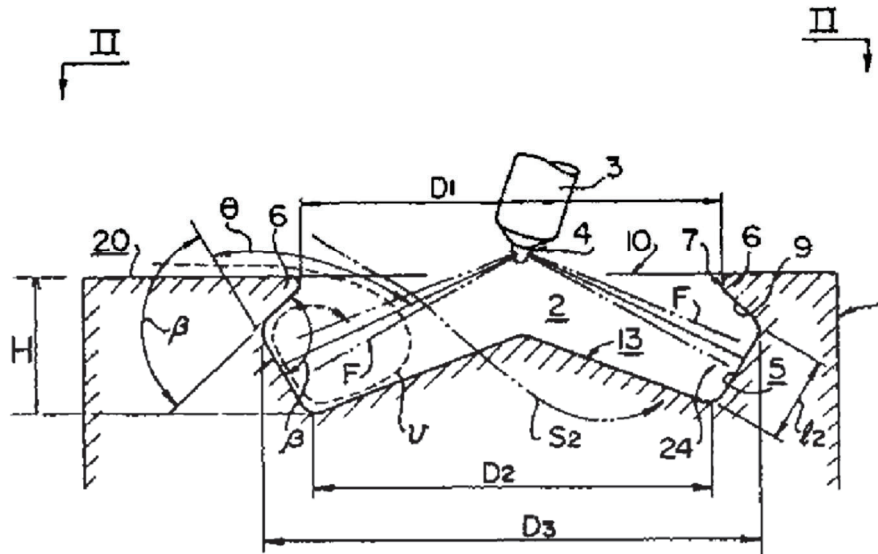
As shown in pink in annotated FIG. 1 above, the transition from the base of the central conical elevation 13 to the start of the inclined side wall 5 incorporates a radiused or smoothly curved connection. EX. 1004, ¶316. Thus, side wall 5 is “connected to the elevation via a radius.” *Id.*, ¶317.

- (b) **“so that an injection jet impinging the surface and injected as early as possible is distributed both in a elevation direction and in the recess edge direction, and”**

This functional language in claim 1 is disclosed by Takatomo. Takatomo states, “[w]ith the aforementioned configuration, the strength of the lip is ensured, and additionally the spray at the start of injection before top dead center and at the end of injection after top dead center collide with the protruding end and lower surface of the lip, smoothly guided to the straight portion of the side wall and flows

into the cavity while the fuel injection injected near the top dead center collides with the inclined surface of the side wall and is appropriately reversed and diffused.” EX. 1006, 4:20-27.

FIG. 1

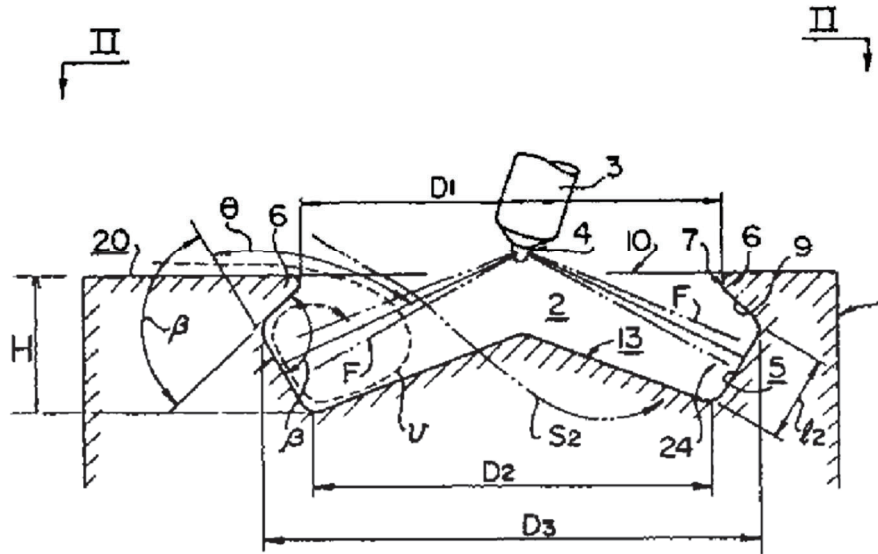


EX. 1006, FIG. 1.

While this passage describes a primary interaction of some early spray with the lip structure (6, 7, 9), a POSITA would have understood that a fuel spray is not a monolithic entity but rather a conical dispersion of fuel droplets with varying trajectories and energies. EX. 1004, ¶327. Considering the geometry shown in FIG. 1 of Takatomo, particularly the spray cone F originating from nozzle 3, and the fact that “early as possible” can encompass a range of timings where the piston is lower in the bore, portions of this dispersed early spray cone will bypass or have minimal

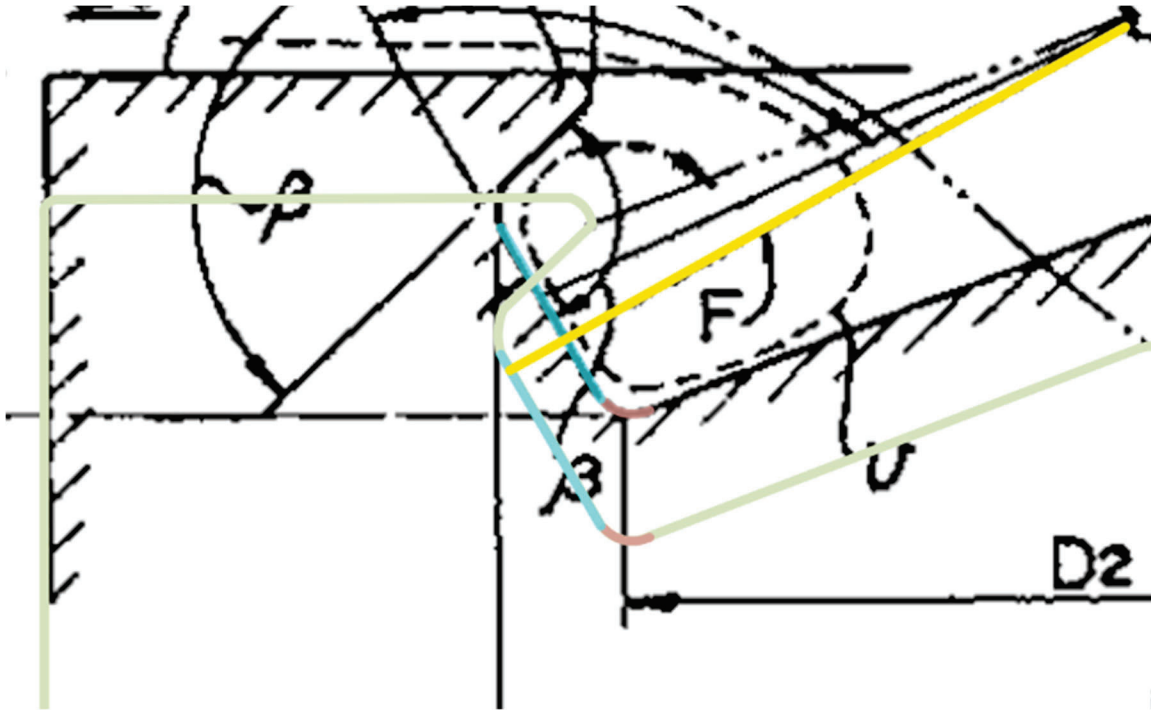
interaction with the relatively narrow lip 6 and instead directly impinge upon the more substantial side wall 5. *Id.*

FIG. 1



EX. 1006, FIG. 1.

FIG. 1 of Takatomo depicts the piston at a position that a POSITA would have understood is near top dead center, but when fuel spray is “injected as early as possible,” the piston will be positioned lower in the cylinder than what is exemplified by FIG. 1. EX. 1004, ¶320. Annotated FIG. 1 of Takatomo, reproduced below, schematically illustrates this scenario. *Id.*, ¶321. In this position, the lower and more axially directed portions of the early spray cone F would naturally target the side wall 5 directly. *Id.*



EX. 1006, FIG. 1 (annotated).

As shown, a portion of the spray cone (gold) impinges the surface (blue) and is distributed both in an elevation direction (towards the protrusion 13) and in the recess edge direction (towards an edge of the cavity 2). EX. 1004, ¶322.

Once a portion of the injected fuel directly impinges on the side wall 5, it will be “distributed both in a elevation direction and in the recess edge direction.” EX. 1004, ¶327. The upward and outward inclination of the side wall 5 directs fuel towards the “recess edge direction.” Simultaneously, turbulent breakup of the spray upon impacting the side wall 5, influenced by the guiding effect of the radius at the base of the elevation, will direct fuel radially inward, splashing or expanding towards

the central conical elevation 13, thus achieving distribution in the “elevation direction.” *Id.*

The description in Takatomo of spray being “smoothly guided to the straight portion of the side wall” (EX. 1006, 4:20-7) teaches that the side wall is a key guiding surface, and this guidance originates from direct impingement as well as from redirection by the lip. Therefore, even accounting for lip interaction, direct impingement and the claimed distribution on side wall 5 for early injection is disclosed.

To the extent that “injected as early as possible” is construed to require injection earlier than depicted above, it would have been obvious to perform such an injection in Takatomo and the injection jet still impinges the surface (blue) and is distributed both in an elevation direction and in the recess edge direction. *Id.*, ¶¶323, 328. A POSITA would have understood from Takatomo that the timing of injection is selectable and would select a timing that is tailored for a target application and where the jet impinges on the surface (blue), as taught by Takatomo.

Any difference with regard to the particular injection timing between what is required by claim 1 and what is disclosed by Takatomo is not patentable in view of Takatomo. *See Rexnord*, 705 F.3d at 1355-56; *see also Airlite*, 526 F.2d at 1082. Specifically, a POSITA would have found it an obvious design choice in view of Takatomo to select a particular injection timing so that an engine is tailored for a

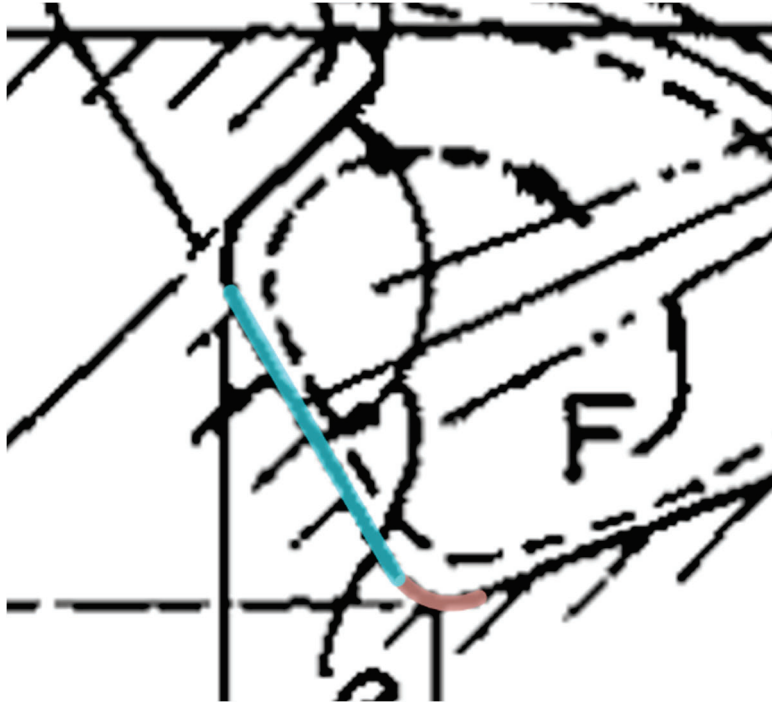
particular application. For example, Takatomo explains that there is a relationship between HC discharge and injection timing. EX. 1006, 7:10-3. A POSITA would have found it obvious to select an injection timing that provides a desired balance between load and HC discharge. EX. 1004, ¶328.

- iv. **“the surface [a] is substantially planar and has an ascending gradient in the recess edge direction [b] such that an injection jet injected as late as possible impinges onto the surface, the last-mentioned injection jet being distributed both in the elevation direction and in the recess edge direction.”**

The “surface” of Takatomo (side wall 5), meets these limitations of claim 1.

- (a) **“is substantially planar, and has an ascending gradient in the recess edge direction”**

Takatomo’s side wall 5 is described as an “inclined surface” and is depicted in FIG. 1 as a straight line. EX. 1006, Claim 1, 1:3, FIG. 1. A POSITA would have understood this to be “substantially planar.” EX. 1004, ¶329.

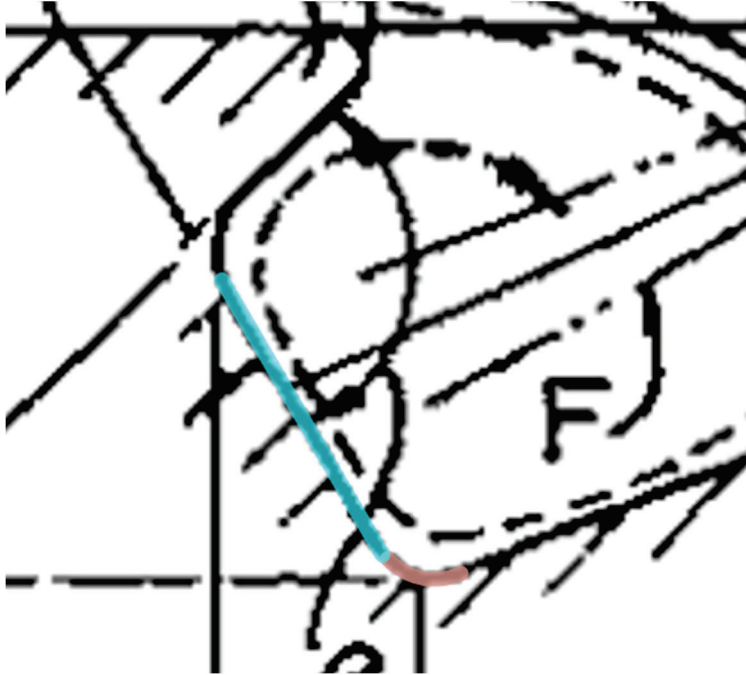


EX. 1006, FIG. 1 (annotated).

- (b) “such that an injection jet injected as late as possible impinges onto the surface, the last-mentioned injection jet being distributed both in the elevation direction and in the recess edge direction.”

This functional language in claim 1 is disclosed by Takatomo. Takatomo states that “fuel injection injected near the top dead center collides with the inclined surface of the side wall and is appropriately reversed and diffused.” EX. 1006, 4:19-26. FIG. 1 of Takatomo depicts the piston at a position that a POSITA would have understood is near top dead center. EX. 1004, ¶331. In FIG. 1, the injection jet impinges the surface (blue) and is distributed both in an elevation direction (a direction towards the protrusion 13) and in a recess edge direction (a direction

towards an edge of the cavity 2). A POSITA would have understood from Takatomo that the timing of injection is selectable and would select a timing that is tailored for a target application and where the jet impinges on the surface (blue), as taught by Takatomo.



Id.

Once a portion of injected fuel directly impinges on the side wall 5, it will be “distributed both in a elevation direction and in the recess edge direction.” The distribution of spray in the elevation and recess edge direction in Takatomo is akin to the distribution occurring in Ishida, which analysis is incorporated here by reference. *See* Section X.A.2.iv.b.

Any difference with regard to the particular injection timing between what is required by claim 1 and what is disclosed by Takatomo is not patentable in view of Takatomo. *See Rexnord*, 705 F.3d at 1355-56; *see also Airlite*, 526 F.2d at 1082. Specifically, a POSITA would have found it an obvious design choice in view of Takatomo to select a particular injection timing so that an engine is tailored for a particular application. For example, Takatomo explains that there is a relationship between HC discharge and injection timing. EX. 1006, 7:10-3. A POSITA would have found it obvious to select an injection timing that provides a desired balance between load and HC discharge.

2. Claim 2 – “The directly injecting internal combustion engine as claimed in claim 1, wherein a surface connected to the recess edge adjoins the surface of the piston recess.”

As shown in the annotation of Takatomo below, a surface (purple) is connected to the recess edge (green) and adjoins the surface (blue) of the piston recess. EX. 1004, ¶332.



EX. 1006, FIG. 2 (annotated). This interpretation of the surface adjoining the surface of the piston recess is consistent with the '238 Patent. *See* EX. 1001, 4:8-9 ("It is apparent from FIG. 7 that the surface 13 has adjoining it a surface 23 connected to the recess edge 12 via a radius 22."); EX. 1004, ¶333. The '238 Patent discloses that the surface 23 adjoins the surface 13 despite the radius 22 being located therebetween.

3. Claim 3 – "The directly injecting internal combustion engine as claimed in claim 2, wherein the surface connected to the recess edge is connected via a radius to the surface of the piston recess."

As shown in the annotation of Takatomo below, the surface (purple) is connected to the recess edge (green) and that is connected via a radius (cream) to the surface (blue) of the piston recess. EX. 1004, ¶334.



EX. 1006, FIG. 2 (annotated).

4. Claim 4 – “The directly injecting internal combustion engine as claimed in claim 2, wherein the surface connected to the recess edge merges in a radius into an upper surface of the piston.”

As shown in the annotation of Takatomo below, the surface (purple) connected to the recess edge (green) merges in a radius (orange) into an upper surface (red) of the piston. *Id.*, ¶335.



EX. 1006, FIG. 2 (annotated). This interpretation of the surface connected to the recess edge merging in a radius into an upper surface of the piston is consistent with corresponding discussion in the '238 Patent. *See* EX. 1001, 4:26-27; EX. 1004, ¶336.

5. Claim 5 – “The directly injecting internal combustion engine as claimed in claim 2, wherein the surface connected to the recess edge forms an acute angle with an upper surface of the piston.”

As shown in the annotation of Takatomo below, the surface (purple) connected to the recess edge (green) forms an acute angle with an upper surface (red) of the piston. EX. 1004, ¶337.



EX. 1006, FIG. 2 (annotated).

6. Claim 6 – “The directly injecting internal combustion engine as claimed in claim 5, wherein the surface connected to the recess edge is connected via a radius to the surface of the piston recess.”

As shown in the annotation of Takatomo below, the surface (purple) is connected to the recess edge (green) and that is connected via a radius (cream) to the surface (blue) of the piston recess. *Id.*, ¶338.



EX. 1006, FIG. 2 (annotated).

L. Ground 12: Claims 9-12 and 14 Are Obvious Over Takatomo and Gatellier

Claims 9-12 and 14 of the '283 Patent are unpatentable under 35 U.S.C. §103(a) as obvious over Takatomo and Gatellier. Takatomo would be predictably combined with Gatellier for the reasons provided in connection with analysis of Ishida, which is incorporated herein by reference. *See* Sections X.C.1 and X.C.2.

1. Claim 9 – “The directly injecting internal combustion engine as claimed in claim 1, wherein an injection angle of the injection nozzle is between 50° and 120°.”

A POSITA seeking to enhance the performance and flexibility of an engine like Takatomo’s, particularly in light of known issues with injection timing and wall wetting that Gatellier aims to solve, would have been motivated to apply Gatellier’s specific teachings regarding advantageous nappe angles. *Id.*, ¶¶339-43. The range of 50° to 120° recited in claim 9 falls squarely within Gatellier’s taught advantageous range. *Id.*, ¶343. Selecting an injection angle between 50° and 120°, as taught by Gatellier, for use with a Takatomo-type engine, would have been an obvious design choice.

2. Claim 10 – “The directly injecting internal combustion engine as claimed in claim 9, wherein a surface connected to the recess edge adjoins the surface of the piston recess.”

Claim 2 recites analogous limitations that are addressed above. *See* Section X.K.2; EX. 1004, ¶¶332-33, 344.

3. Claim 11 – “The directly injecting internal combustion engine as claimed in claim 10, wherein the surface connected to the recess edge is connected via a radius to the surface of the piston recess.”

Claims 3 and 6 recite analogous limitations that are addressed above. *See* Sections X.K.3 and X.K.6; EX. 1004, ¶¶334, 345.

- 4. Claim 12 – “The directly injecting internal combustion engine as claimed in claim 10, wherein the surface connected to the recess edge forms an acute angle with an upper surface of the piston.”**

Claim 5 recites analogous limitations that are addressed above. *See* Section X.K.5; EX. 1004, ¶¶337, 346.

- 5. Claim 14 – “The directly injecting internal combustion engine as claimed in claim 10, wherein the surface connected to the recess edge merges in a radius into an upper surface of the piston.”**

Claim 4 recites analogous limitations that are addressed above. *See* Section X.K.4; EX. 1004, ¶¶335-36, 347.

XI. CONCLUSION

Petitioner respectfully requests that *Inter Partes* review be instituted and that Claims 1-14 of the '238 Patent be canceled.

Respectfully submitted,

Dated: June 3, 2025

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Certificate Under 37 C.F.R. §42.24(d)

The undersigned certifies that the foregoing Petition for *Inter Partes* Review, excluding any table of contents, mandatory notices under 37 C.F.R. §42.8, certificates of service or word count, or appendix of exhibits, contains 13,637 words according to the word-processing program used to prepare this document (Microsoft Word), which is less than the 14,000 allowed under 37 C.F.R. §42.24(a)(1)(i).

By: / Pavan K. Agarwal /

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CERTIFICATE OF SERVICE

The undersigned hereby certifies that a copy of the foregoing Petition for *Inter Partes* Review together with all exhibits and other papers filed therewith was served on June 3, 2025 to counsel of record by mail to:

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Petition for *Inter Partes* Review
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