

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Mercedes-Benz USA, LLC

BMW of North America, LLC,

Petitioners,

v.

Michigan Motor Technologies, LLC

Patent Owner.

IPR2023-01224

**DECLARATION OF GERALD J. MICKLOW, PH.D. IN SUPPORT
OF PETITION FOR *INTER PARTES* REVIEW OF**

U.S. PATENT NO. 6,557,540

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LIST OF EXHIBITS

Exhibit	Description
1001	U.S. Patent No. 6,557,540 to Mianzo et al (“the ’540 patent”)
1002	Prosecution File History of U.S. Patent No. 6,557,540 (“’540 file history”)
1003	Expert Declaration of Gerald J. Micklow, Ph.D., PE
1004	Curriculum Vitae of Gerald J. Micklow, Ph.D., PE
1005	US Pat. Pub. 2002/0029757 to Ogawa et al. (“Ogawa”)
1006	U.S. Patent No. 5,713,317 to Yoshioka (“Yoshioka”)
1007	“Torque Management of Engines with Variable Cam Timing,” M. Jankovic, F. Frischmuth, A. Stefanopoulou, and J. A. Cook, IEEE Control Systems, October 1998 (“Jankovic”)

I. INTRODUCTION

I, Gerald J. Micklow, Ph.D., P.E., declare as follows:

1. I have been retained on behalf of Mercedes-Benz USA, LLC (“MBUSA”) for the above-captioned *inter partes* review proceeding to provide my expert opinions and expert knowledge. I understand that this proceeding involves U.S. Patent No. 6,557,540 (“the ’540 patent”), titled “Method of calculating a valve timing command for an engine,” and that the ’540 patent is currently assigned to Michigan Motor Technologies LLC (“MMT”). I understand that the Petition submitted by MBUSA and BMW of North America, LLC (“BMW”) (collectively, “Petitioners”) challenges claims 1-2, 7, 10, 11, and 14 of the ’540 patent.

2. The ’540 patent describes a method for controlling engine valve timing. I am familiar with the technology described in the ’540 patent as of its earliest possible priority date, December 11, 2001.

3. I have been asked to provide my independent technical review, analysis, insights, and opinions regarding the ’540 patent and the references that form the basis for the grounds of unpatentability set forth in the Petition for *inter partes* review of the ’540 patent filed by Petitioners.

4. In preparing this Declaration, I have reviewed and am familiar with all the documents cited herein. I have reviewed and am familiar with the ’540 patent and its file history. I confirm that to the best of my knowledge the accompanying

exhibits are true and accurate copies of what they purport to be, and that an expert in the field would reasonably rely on them to formulate opinions such as those set forth in this Declaration.

5. I am being compensated at my customary rate of \$650 per hour for my work on this case. My compensation is not dependent upon my opinions, my testimony, or the outcome of this case.

II. SUMMARY OF GROUNDS

Ground	'540 Patent Claims	References	Basis
1	1-2, 7, 10-11, 14	Ogawa, Yoshioka	§103
2	1-2, 7, 10-11, 14	Yoshioka, Ogawa, Jankovic	§103

III. SUMMARY OF OPINIONS

6. In my opinion, the challenged claims of the '540 patent would have been obvious in view of the combinations of references that MBUSA asserts, as well as the state of the art in automotive engine control on or before the year 2001, known to a person of ordinary skill in the art.

7. Independent claim 1 of the '540 patent recites a method for calculating a valve timing command for an engine of a vehicle. Ex. 1001, 3:52-53. Specifically, the '540 patent broadly claims a method of calculating a valve timing command that

allegedly solves the problem of optimizing valve timing for a particular load on an engine. *Id.*, 1:30-33.

8. As discussed in this Declaration, the recited of claims 1-2, 7, 10-11, and 14 elements were basic, well-known techniques found in valve timing control systems as of December 11, 2001, which I understand is the earliest possible priority date for the '540 patent. And as discussed in this Declaration, the known problem of optimizing fuel efficiency and power output of an engine by varying valve timing for a particular load on an engine had been accomplished by the prior art in exactly the same way as recited in claims 1-16 of the '540 patent. Moreover, as further discussed in this Declaration, before the '540 patent's December 11, 2001 earliest possible priority date, a Person of Ordinary Skill in the Art (POSITA) would have been motivated to combine the asserted prior art references and, in so doing, they would have had a reasonable expectation of success.

9. Accordingly, it is my opinion that the challenged claims would have been obvious in view of the disclosures in the asserted prior art references, as described in detail below.

IV. QUALIFICATIONS

10. In forming the opinions in this declaration, I have considered and relied on my education, background, and experience. My experience and education are detailed in my curriculum vitae ("CV"). See Ex. 1004. My CV lists my

publications and identifies parties on behalf of whom I have provided expert testimony.

11. I am an expert in engine control systems. This expertise is directly applicable to the technological area of the '540 patent, which relates to methods for controlling engine valve control. See Ex. 1001, Abstract.

12. I have over forty-five years of experience in the design and analysis of automotive electromechanical systems, such as valve control systems. I am currently a full professor of Mechanical and Civil Engineering at Florida Institute of Technology, the head of Automotive Engineering, and the director of the Florida Center for Automotive Research (FCAR). I have been involved in throttle control fuel injection and combustion systems since 1988. For seven years, NASA Lewis Research Center funded my research in advanced gas turbine engine fuel injection and combustion systems. Since that time, I have also been involved in optimizing throttle and fuel injection and combustion systems for automotive and trucking applications along with racing applications. I have also dyno tested and track tested complex throttle and fuel injection systems.

13. I have a Bachelor of Science degree in Aerospace Engineering and a Master of Science degree in Aerospace Engineering, both from Pennsylvania State University. In 1989, I received my Ph.D. in Mechanical Engineering from Virginia Polytechnic Institute and State University.

14. From 1988-1996, I was an assistant professor in the Mechanical Engineering department at the University of Florida. At the University of Florida, I taught classes in power production systems for automotive applications, including internal combustion engines, fluid dynamics, combustion, jet and rocket propulsion, gas turbine engines, advanced fan and compressor design, compressible gas dynamics, turbomachinery, and others.

15. From 1996-2001, I was an associate professor in the Mechanical Engineering department at the University of Alabama. While at the University of Alabama, I helped start the Center for Advanced Vehicle Technology (CAVT), which researches complex vehicle components like throttle control systems and fuel injection systems.

16. From 2001-2005, I was an associate professor in the Mechanical Engineering and Engineering Science department at the University of North Carolina, Charlotte (UNCC). While at UNCC, I helped start the North Carolina Motorsports and Automotive Research Center (NCMARC) and was a key contributor to the start of the Motorsports Engineering program within the Mechanical Engineering department. With this program, I directly worked with four of the most competitive NASCAR teams in the country.

17. From 2005-2012, I was a full professor and program director of Mechanical Engineering in the newly established Engineering department at East

Carolina University in Greenville, North Carolina. While at East Carolina University, I chaired the Mechanical Engineering Concentration Development Committee and the Promotion and Tenure Committee for engineering.

18. In 2012, I joined the Florida Institute of Technology (“FIT”) as a full professor of Mechanical and Aerospace Engineering. During my tenure at FIT, I have acted as the Head of Automotive Engineering and the Director of the Florida Center for Automotive Research. At FIT, I have also taught classes in automotive engineering, internal combustion engines, Automotive Powertrains, Combustion, thermodynamics, fluid dynamics, advanced fan and compressor design, compressible gas dynamics, jet and rocket propulsion, turbomachinery, and others.

19. Also during the last 11 years, I have chaired forty-five technical sessions for the Society of Automotive Engineers (SAE) in throttle and intake systems, exhaust and particulate emission systems, direct injection spark and compression ignition engines, fuel injection and sprays, fuel economy, HCCI combustion, hybrid electric vehicle powertrains, high efficiency engine concepts, multidimensional engine modeling, on-board diagnostics, fuels and fuel additives, cold start characteristics, engine boosting systems, dual fuel combustion, and spark assisted compression ignition combustion. I am also an associate editor for the SAE International Journal of Fuels and Lubricants.

20. I have won numerous accolades throughout my professional career. To name a few, I was awarded the SAE Ralph Teetor Award for teaching excellence in 1995. In 2000, I was inducted into the U.S. Space Foundation Technology Hall of Fame for the Space Shuttle program. In 2002, I received the NASA Space Grant Act Award for work related to the Space Shuttle. In 2009, I received the SAE Faculty Advisor award. In 2016, I received the ASME Outstanding Professor of the Year award. And in 2017, I received the ASME Outstanding Research Professor of the Year award.

21. Based on my education and experience, I am an expert in the type of valve control systems at issue in this case, and I have been an expert in this area since before the '540 patent was filed with the United States Patent and Trademark Office. I am also intimately familiar with how a person of ordinary skill would have used and understood the terminology found in the '540 patent at the time of its filing.

V. SCOPE OF ASSIGNMENT

22. In forming my opinions regarding the validity of the '540 patent, I have considered the '540 patent's specification, including the Abstract and the figures. I have also considered the language of the patent's claims, as those terms would have been understood by a person having ordinary skill in the relevant field at least at the

time of the '540 patent's earliest possible priority date. I have also reviewed the prosecution (the "file history") of the '540 patent.

23. In forming my opinions, I have also considered the Exhibits that are listed in the Petition and any additional materials and information cited in this Declaration. I have also searched for and reviewed technical literature relevant to the field of the '540 patent.

24. I have relied on my personal knowledge, education, training, and professional experience to form my opinions concerning the '540 patent, including my experience in researching, studying, developing genetic expression systems.

25. This Declaration explains, based on facts and information currently available to me, the subject matter and opinions related to this Proceeding. As such, I am prepared to provide expert testimony regarding opinions formed resulting from my analysis of the issues and materials considered in this declaration, if asked to do so by the Board or by the parties' attorneys.

26. Additionally, I may discuss my own work, teachings, and knowledge of the state of the art in the relevant time period. I may rely on handbooks, textbooks, technical literature, and the like to demonstrate the state of the art in the relevant period and the evolution of relevant technologies.

27. Throughout this Declaration, I refer to specific pages of the '540 patent and other documents. These citations are intended to be exemplary and are not

intended to convey that the citations are the only source of evidence to support the propositions for which they are cited. I reserve my right to amend or alter my analysis and opinions in response to positions Patent Owner may take or upon the discovery of new information.

28. I am being compensated at my customary consulting rate of \$650 per hour for the time I spend on this matter. My compensation is in no way contingent on the nature of my opinions or the outcome of this or any other proceeding. I have no other interest in this proceeding. All of the opinions expressed in this Declaration are my own.

VI. LEGAL UNDERSTANDING

29. In this section, I describe my understanding of certain legal standards that I have relied upon in forming my opinions set forth in this Declaration. I have been informed of these legal standards by MBUSA's attorneys. I am not an attorney and I have not thoroughly researched the relevant patent law. I am relying only on instructions from MBUSA's attorneys for these legal standards.

A. Person of Ordinary Skill in the Art

30. I am informed that patent validity is determined from the perspective of a person of ordinary skill in the pertinent art at the time of the invention ("POSITA"). I understand that a POSITA is a hypothetical person who is

presumed to be aware of all pertinent art, thinks along conventional wisdom in the art, and is a person of ordinary creativity—not an automaton.

31. In forming my opinions, I have relied on my personal knowledge and professional experience in researching, studying and/or developing and applying, variable valve timing technology, and on the documents and information referenced in this Declaration.

32. In deciding the level of ordinary skill in the art, I am informed that the following factors may be considered:

- the levels of education and experience of persons working in the field;
- the types of problems encountered in the field; and
- the sophistication of the technology.

B. Claim Construction

33. I am informed that a patent may include two types of claims, independent claims and dependent claims. An independent claim stands alone and includes only the limitations it recites. A dependent claim can depend from an independent claim or another dependent claim. I am informed that a dependent claim includes all the limitations that it recites, in addition to the limitations recited in the claim from which it depends.

34. I understand that patent claim terms can be interpreted, or “construed.” I understand that, in construing a claim, the words of patent claims are given their plain meaning, as a POSITA would understand them at the time of the invention,

and the view of the patent and file history, unless their meaning is defined or disclaimed. I am informed that dictionaries, treatises, and other “extrinsic” sources of evidence may assist in determining the plain meaning of a term, but they cannot override a meaning that is otherwise unambiguous based on the intrinsic evidence.

35. I understand that in construing claims in an IPR proceeding, words in a claim are given their plain meaning, which is the meaning understood by a person of ordinary skill in the art in view of the patent and file history, unless specifically defined in the patent or prosecution history. I also understand that dictionaries or other extrinsic sources may assist in determining the plain and ordinary meaning but cannot override a meaning that is unambiguous from the intrinsic evidence.

36. I have been informed by MBUSA’s counsel that claim construction is a matter of law for the arbiter of law to decide. I am informed that, in an inter partes review, the Patent Trial and Appeal Board (“PTAB”) interprets claims in the same way as a district court would. Likewise, I understand that a POSITA interprets claims in the same way in both types of proceedings.

37. I reserve my right to amend or alter my analysis and opinions in view of any claim constructions adopted by the arbiter of law.

C. Obviousness

38. I am informed that a patent claim is unpatentable and invalid if the subject matter of the claim as a whole would have been obvious to a person of

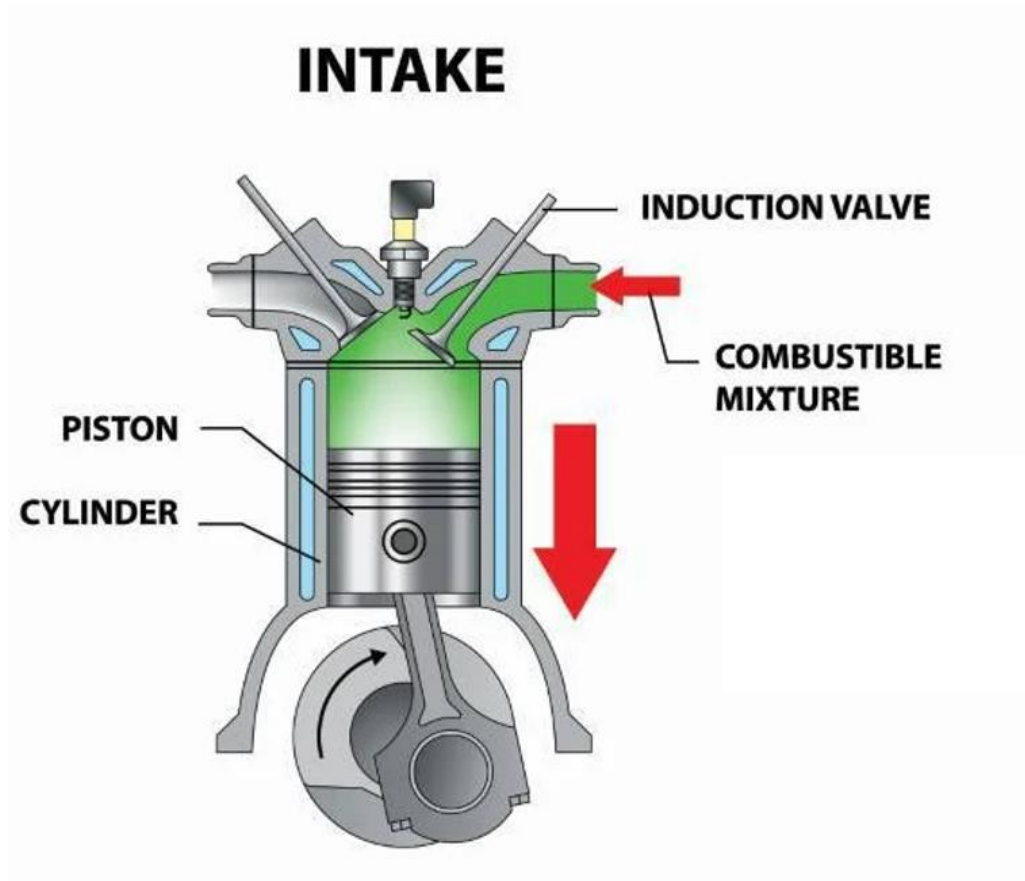
ordinary skill in the art of the claimed subject matter as of the time of the inventions at issue. I am informed that the following factors must be evaluated to determine whether the claimed subject matter is obvious: (1) the scope and content of the prior art; (2) the difference or differences, if any, between each claim of the patent and the prior art; and (3) the level of ordinary skill in the art at the time the patent was filed. Unlike anticipation, which allows consideration of only one item of prior art, I am informed that obviousness may be shown by considering more than one item of prior art. Moreover, I understand that objective indicia of non-obviousness, also known as “secondary considerations,” like the following also may be considered when assessing obviousness: (1) commercial success; (2) long-felt but unresolved needs; (3) copying of the invention by others in the field; (4) initial expressions of disbelief by experts in the field; (5) failure of others to solve the problem that the inventor solved; and (6) unexpected results. I also understand that evidence of objective indicia of non-obviousness must have a nexus with the claimed subject matter.

VII. THE '540 PATENT

A. Technology Background

39. Variable valve timing refers to a process of controlling the opening or closing timing of the intake or exhaust valves of an internal combustion engine's combustion chambers to improve aspects of engine performance, such as fuel economy or emissions.

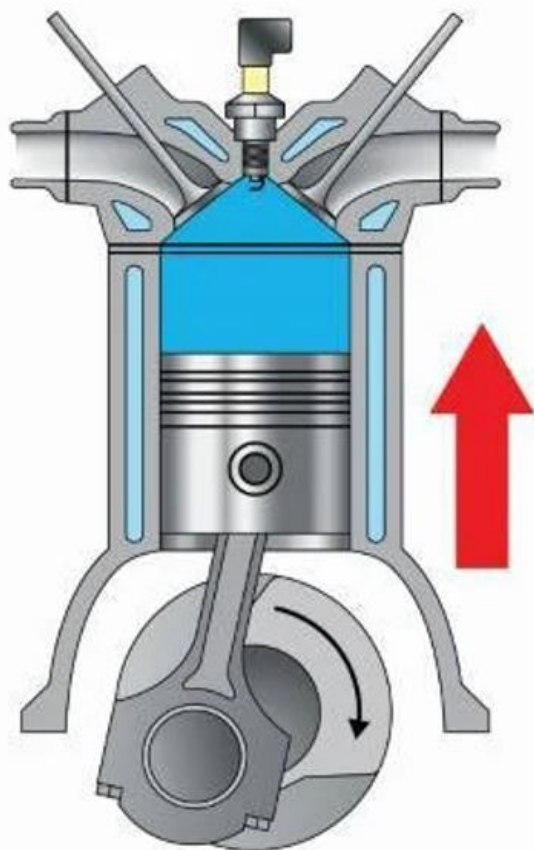
40. Internal combustion engines generate power through four unique stages. *Id.* at 1:13-14. In stage one, also called the intake stage, an intake valve opens, and a piston draws air and fuel into the cylinder through the opened intake port. *Id.* at 1:14-16.



Pure Diesel Power, *The Four-Stroke Cycle of An Automotive Engine* (Sept. 23, 2023), <https://puredieselpower.com/blog/four-stroke-cycle-automotive-engine>.

41. In stage two, the intake valve closes and the piston reverses direction, compressing the combustion chamber's air fuel mixture. Ex. 1001 at 1:16-18.

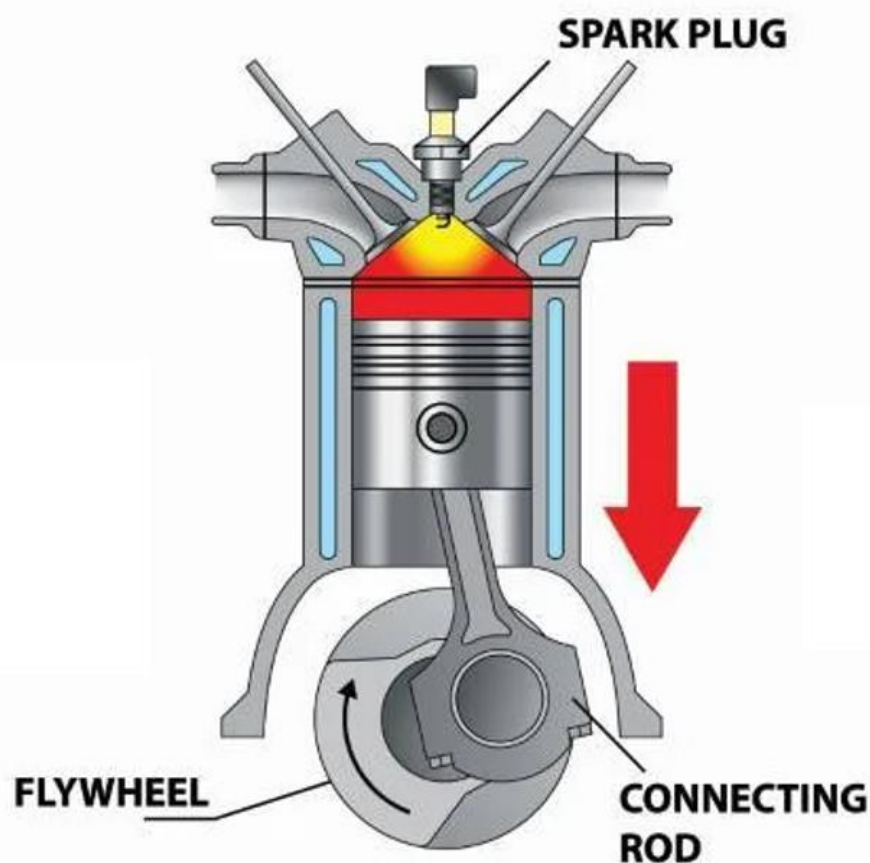
COMPRESSION



Pure Diesel Power, *The Four-Stroke Cycle of An Automotive Engine* (Sept. 23, 2023), <https://puredieselpower.com/blog/four-stroke-cycle-automotive-engine>.

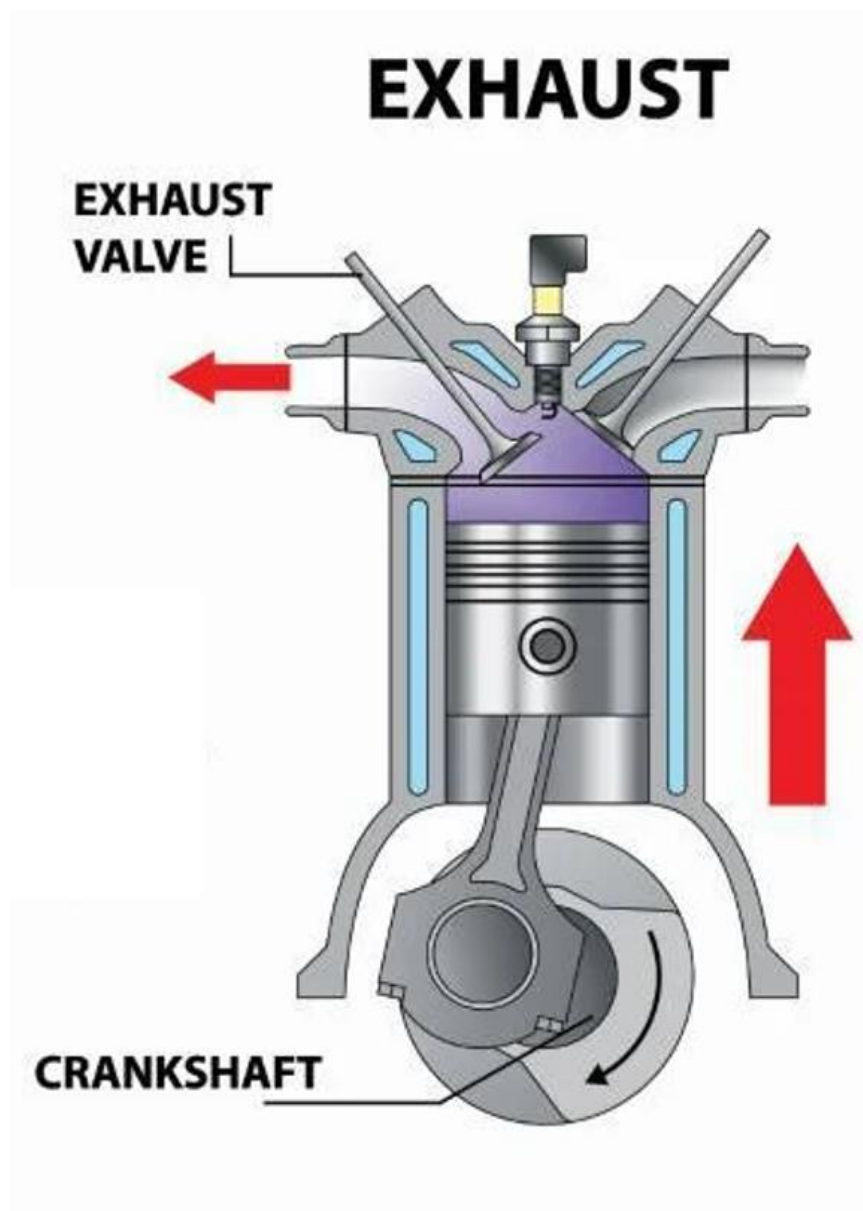
42. In stage three, also called the working or power stroke, the air fuel mixture is combusted using a spark resulting in a rapid combustion process which results in a large increase in pressure and temperature, driving the piston downward in the cylinder and powers the vehicle by driving the piston downward. Ex. 1001 at 1:18-20.

WORKING STROKE



Pure Diesel Power, *The Four-Stroke Cycle of An Automotive Engine* (Sept. 23, 2023), <https://puredieselpower.com/blog/four-stroke-cycle-automotive-engine>.

43. In stage four, the exhaust valve opens, the piston reverses direction, moving up in the cylinder and the combusted mixture is pushed out of the combustion chamber through the exhaust valve. Ex. 1001 at 1:20-23.



Pure Diesel Power, *The Four-Stroke Cycle of An Automotive Engine* (Sept. 23, 2023), <https://puredieselpower.com/blog/four-stroke-cycle-automotive-engine>.

44. The fuel efficiency and power output of the engine can be optimized by varying the point at which the intake and exhaust valves open and close during each stroke and how much time there is when both valves are open. Ex. 1001 at 1:30-33. For example, under light and medium engine load, fuel economy can be

optimized by opening the intake valve earlier and having a shorter overlap of time where the intake and exhaust valves are both open. C. Gray, *A Review of Variable Engine Valve Timing*, SAE Transactions , 1988, Vol. 97, Section 6: Journal of Engines (1988), 632. Similarly, opening the intake valve early during low engine speed can increase engine torque, while varying the intake valve timing to open it later increases engine torque at high engine speed. *Id.* at 632, FIG. 2.

45. Variable valve timing was well known in the art for more than ten years before the '540 patent's 2001 priority date. As early as 1988, "[i]t had long been known that improvements in gasoline engine performance would be obtainable if the valve timing were variable so that it could be optimised [sic] for any combination of engine speed and load throughout the whole operating range of the engine," and "[m]any devices" for performing variable valve timing had already been "described in the patent literature and . . . tested on engines." *Id.*, 631-34. Literature prior to 1988 had "decrib[ed] particular devices for varying the valve timing" of engines and "summar[ized] . . . the improvements in engine performance parameters resulting from optimising [sic] the valve timing." *Id.* For example, as shown in the figure below, literature in the art had already thoroughly described determining IVO (intake valve opening), IVC (intake valve closing), EVO (exhaust valve opening), and EVC (exhaust valve closing) commands, as claimed by the '540 patent:

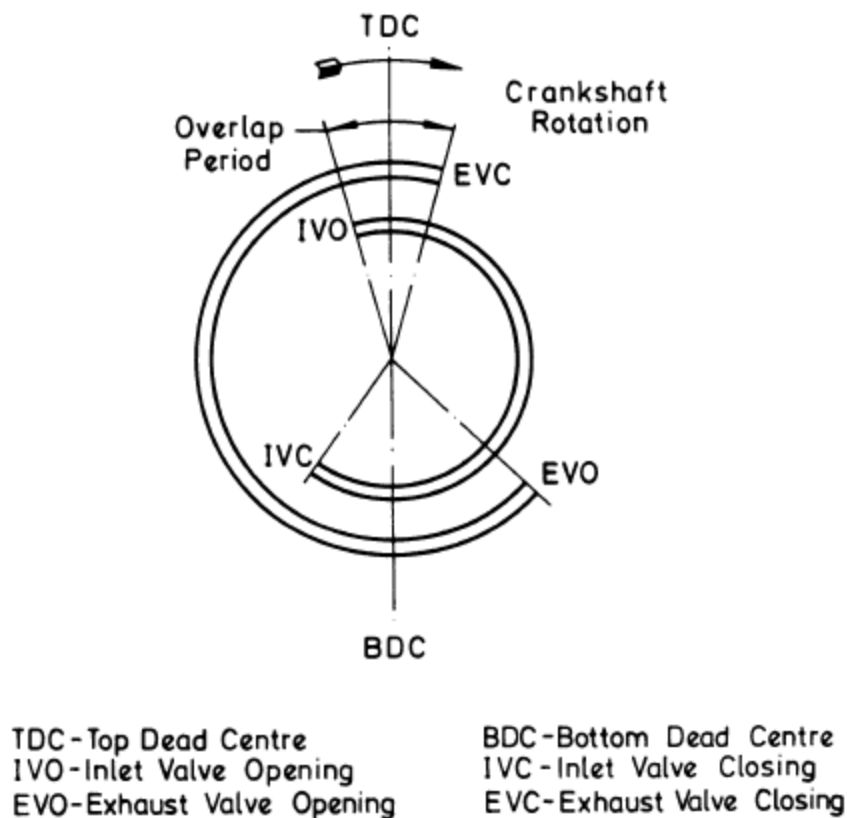


Figure 1 Valve Timing Diagram

Id. at FIG. 1.

46. Variable valve timing was not only well described in the literature prior to 2001 but had also been used in production vehicles for decades. The first use of variable valve timing in a production vehicle was in the 1903 Cadillac Runabout and Tonneau, almost *one hundred years* prior to the '540 patent's 2001 priority date. ELTA Automotive UK, *Milestone vehicles throughout the history of variable valve timing*, <https://eltaeurope.com/milestone-vehicles-throughout-the-history-of-variable-valve-timing/> (Nov. 27, 2022). Many car manufacturers, including

Porsche and Fiat, filed patents on aspects of variable valve timing in the 1950s and 1960s. *Id.* By the 1980s, still twenty years before the '540 patent's priority date, variable valve timing was commonly used in production cars. For example, from 1980 to 2000, Alfa Romeo, Nissan, Honda, Porsche, BMW, and Toyota all sold production vehicles with engines that made use of variable valve timing. *Id.*

B. Level of Ordinary Skill in the Art

47. In my opinion, a POSITA at the time of the alleged invention would have had a B.S. degree in Electrical Engineering or Mechanical Engineering (or equivalent), as well as at least 1-2 years of academic or industry experience in the design and analysis of internal combustion engines or, alternatively, at least an M.S. degree in Electrical Engineering or Mechanical Engineering.

48. I am well qualified to determine the level of ordinary skill in the art. First, I am very familiar with the technology of the '540 patent as of the 2001 timeframe. For example, during this 2001 timeframe, I was an associate professor in the Mechanical Engineering Department at the University of Alabama and had been a key member in starting the Center for Advanced Vehicle Technology (CAVT). CAVT was and is a University of Alabama Research Center dedicated to the advancement of vehicle technology. Based on unique interdisciplinary research and education programs, CAVT strives to provide the vehicular industry with novel ideas, scientific consultation, and new generations of engineers and

scientists formed in the latest technologies in this field. This includes the experimental and computational optimization of valve control systems for current, new, and advanced engine concepts. Further, I was advising the tenth Society of Automotive Engineers (SAE) Formula Collegiate Design Series Competition vehicle. Here, a formula style racecar is completely designed, fabricated, and built in-house every year from the computer design to the finished vehicle. A key and crucial concept is the design, fabrication, and testing of a custom intake manifold/fuel injection/throttle control system. This was all done in-house under my advisement. I also taught the design concepts of these systems at both the undergraduate and graduate level in a class I personally developed titled "Internal Combustion Engines." Further, from high performance applications on one end of the spectrum to fuel economy on the other end, I have direct experience designing and modifying the fuel injection/throttle body control system found in 1991-2001 GM LT-1 engines. These design modification and programming changes were verified on engine dynamometers and road and track testing to improve both fuel economy and performance. These engines were found in 1992-96 Chevrolet Corvettes, 1993-98 Chevrolet Camaro Z-28s, 1993-97 Pontiac Firebird Tran Ams, 1994-96 Buick Roadmasters, 1994-96 Chevrolet Caprices and Impala SSs, and 1994-96 Cadillac Fleetwoods.

49. As I explain in Section IV and further show in my CV, I had acquired extensive experience related to valve control systems by 2001.

C. Claims

50. The '540 patent contains 16 claims, 1 independent claim and 15 dependent claims. MBUSA's Petition challenges the 1 independent claim and 6 dependent claims. Claim 1 is representative and reproduced below:

A method for calculating a valve timing command for an engine of a vehicle, comprising:

obtaining an engine performance command;

receiving an environmental conditions signal;

determining a valve feedforward term based on the engine performance command and the environmental conditions signal;

receiving an engine performance feedback;

calculating a valve feedback term based on the engine performance command and the engine performance feedback; and

calculating a valve timing command based on the valve feedforward term and the valve feedback term.

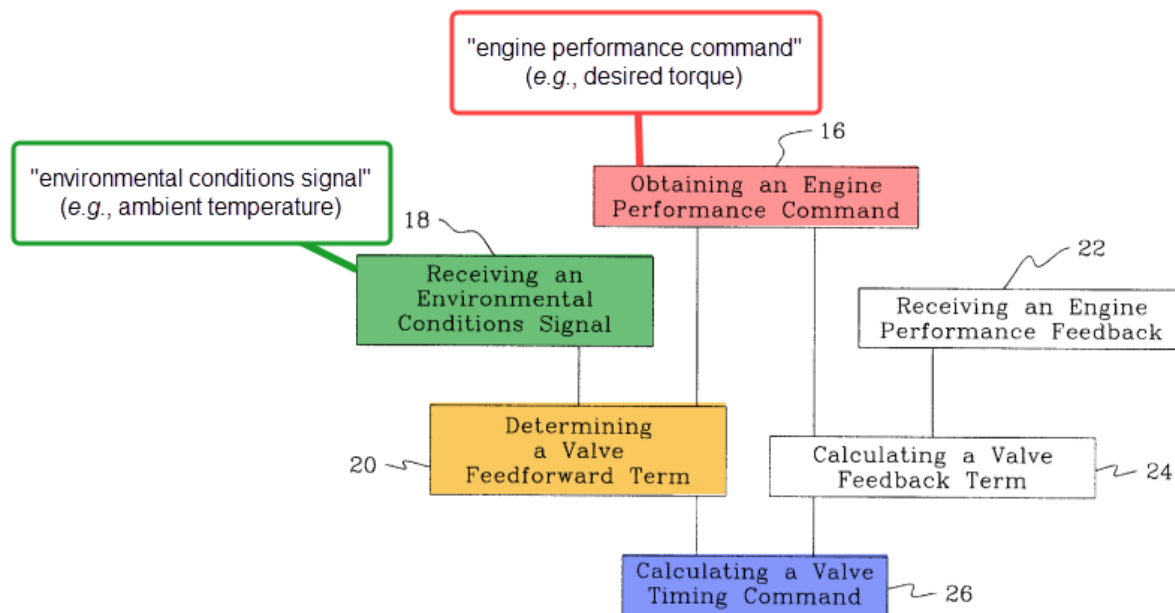
D. Specification

51. The '540 patent issued May 6, 2003, from U.S. Application No. 10/014,286 ("the '286 application"), which was filed on December 11, 2001. Ex. 1001.

52. The '540 patent claims methods for calculating commands to control the opening and closing timing of the intake and exhaust valves of an internal combustion engine's combustion cylinders. Ex. 1001 at Abstract.

53. The '540 patent claims only adjusting valve timing based on engine operating conditions and performance metrics. The '540 patent claims obtaining an "engine performance command" that indicates desired engine performance. The '540 patent teaches that desired engine torque is one example of the claimed "engine performance command." *Id.* at 2:16-19. The '540 patent teaches that its system also receives an "environmental conditions signal." *Id.* at 2:23-26. The '540 patent teaches that ambient temperature is one example of the claimed "environmental conditions signal." *Id.* at 2:23-33.

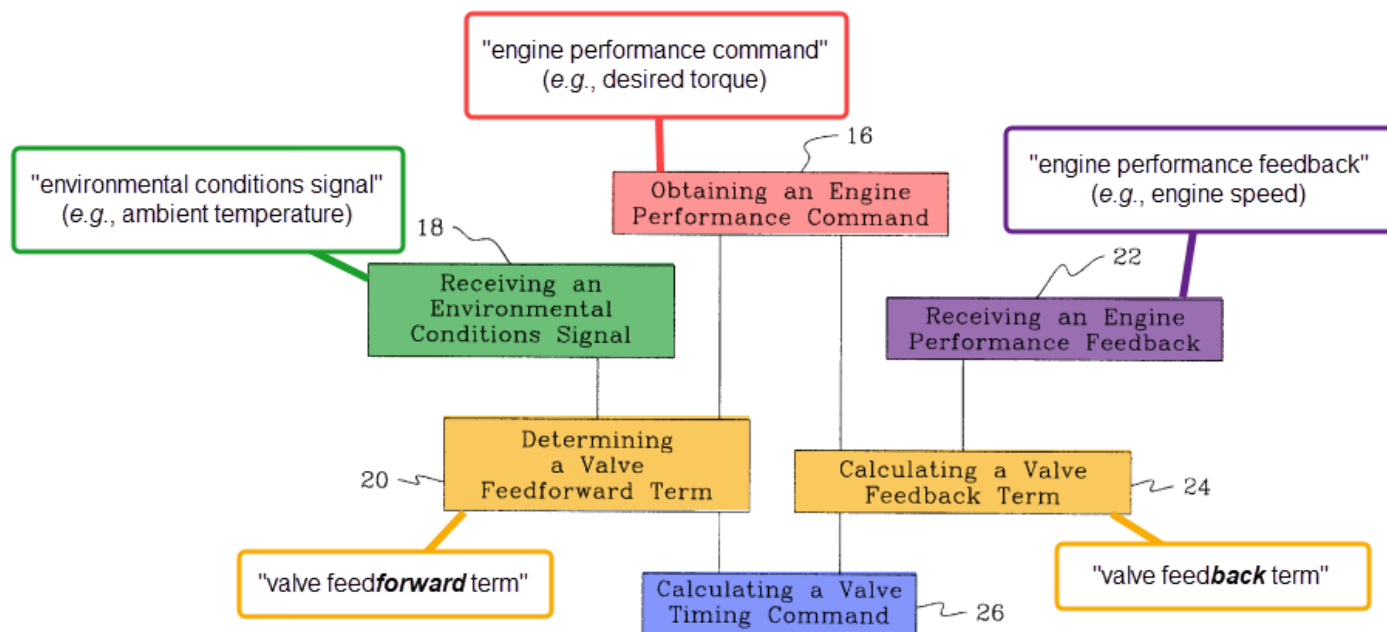
54. The '540 patent's claimed valve timing control method determines a "valve feedforward term" based on the "engine performance command" (*e.g.*, desired torque) and "environmental conditions signal" (*e.g.* ambient temperature). The '540 patent does not disclose any particular embodiment of the "valve feedforward term." The '540 patent teaches only that "valve feedforward term" is used in the computation of a "valve timing command":



Id. at FIG. 2 (annotated).

55. As shown in the '540 patent's Figure 2 above, determining the "valve feedforward term" is only half of the '540 patent's claimed method for determining a new "valve timing command."

56. The '540 patent's claimed method further calculates a "valve feedback term" based on the "engine performance command" (e.g., desired torque) and an "engine performance feedback." *Id.* at 2:66-3:7. The '540 patent teaches that an "engine performance feedback" includes data received from an engine sensor, for example, engine speed. As shown in annotated Figure 2 below, the '540 patent's claimed method calculates a "valve timing command" based on the "valve feedback term" and the "valve feedforward term":



Ex. 1001 at FIG. 2 (annotated).

57. The patent does not disclose any particular method for computing the “valve timing command” from the “valve feedforward” and “valve feedback” terms.

58. The ’540 patent discloses a number of different types of “valve timing commands” the claimed method may compute; for example, an EVO command to open the exhaust valve, an EVC command to close the exhaust valve, an IVO command to open the intake valve, or an IVC command to close the intake valve.

E. Prosecution History

59. From my review of the ’540 patent’s prosecution history, I note that the United States Patent and Trademark Office issued a Notice of Allowance for the application that became the ’540 patent without a single Office Action. See generally

Ex. 1002. It is my understanding that none of the references relied upon in MBUSA's Petition were before the examiner during prosecution of the '540 patent.

VIII. CHALLENGED CLAIMS

60. I have analyzed claims 1-2, 7, 10-11, and 14 of the '540 patent in connection with MBUSA's petition for *inter partes* review that accompanies this Declaration. I understand MBUSA is challenging the validity of these 6 claims ("Challenged Claims"). The Challenged Claims are reproduced below for reference.

Claim 1	
1[pre]	A method for calculating a valve timing command for an engine of a vehicle, comprising:
1[a]	obtaining an engine performance command;
1[b]	receiving an environmental conditions signal;
1[c]	determining a valve feedforward term based on the engine performance command and the environmental conditions signal;
1[d]	receiving an engine performance feedback;
1[e]	calculating a valve feedback term based on the engine performance command and the engine performance feedback; and
1[f]	calculating a valve timing command based on the valve feedforward term and the valve feedback term.

Claim 2	
2	The method of claim 1 wherein said obtaining an engine performance command includes receiving a vehicle performance command from a driver of the vehicle and deriving the engine performance command based on the vehicle performance command.

Claim 7	
7	The method of claim 1 wherein said receiving an engine performance

	feedback includes receiving engine speed data.
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Claim 10	
10	The method of claim 1 wherein said calculating a valve timing command includes calculating an EVO command, an EVC/IVO command, and an IVC command.

Claim 11	
11	The method of claim 1 further comprising receiving fuel conversion data.

Claim 14	
14	The method of claim 1 further comprising receiving engine emissions data.

IX. CLAIM CONSTRUCTION

61. It is my understanding that the challenged claims of the '540 patent are to be given their ordinary and customary meaning as understood by one of ordinary skill in the art at the time of the alleged invention in light of the specification and the prosecution history pertaining to the patent. In my opinion, for purposes of this proceeding, the Board should construe the following claim terms in the following manner.

A. Claims 1, 2, 6, and 8: “engine performance command”

62. Claims 1, 2, 6, and 8 recite an “engine performance command.” The '540 patent discloses that an engine performance command “is preferably a

desired engine torque,” but also “may alternatively be another suitable variable, such as a desired engine acceleration.” Ex. 1001 at 2:16-22.

63. In my opinion, a POSITA would understand “engine performance command” in view of the specification and claims to mean a “command that defines a desired engine torque, or other desired measure of engine performance, such as engine speed or engine acceleration.”

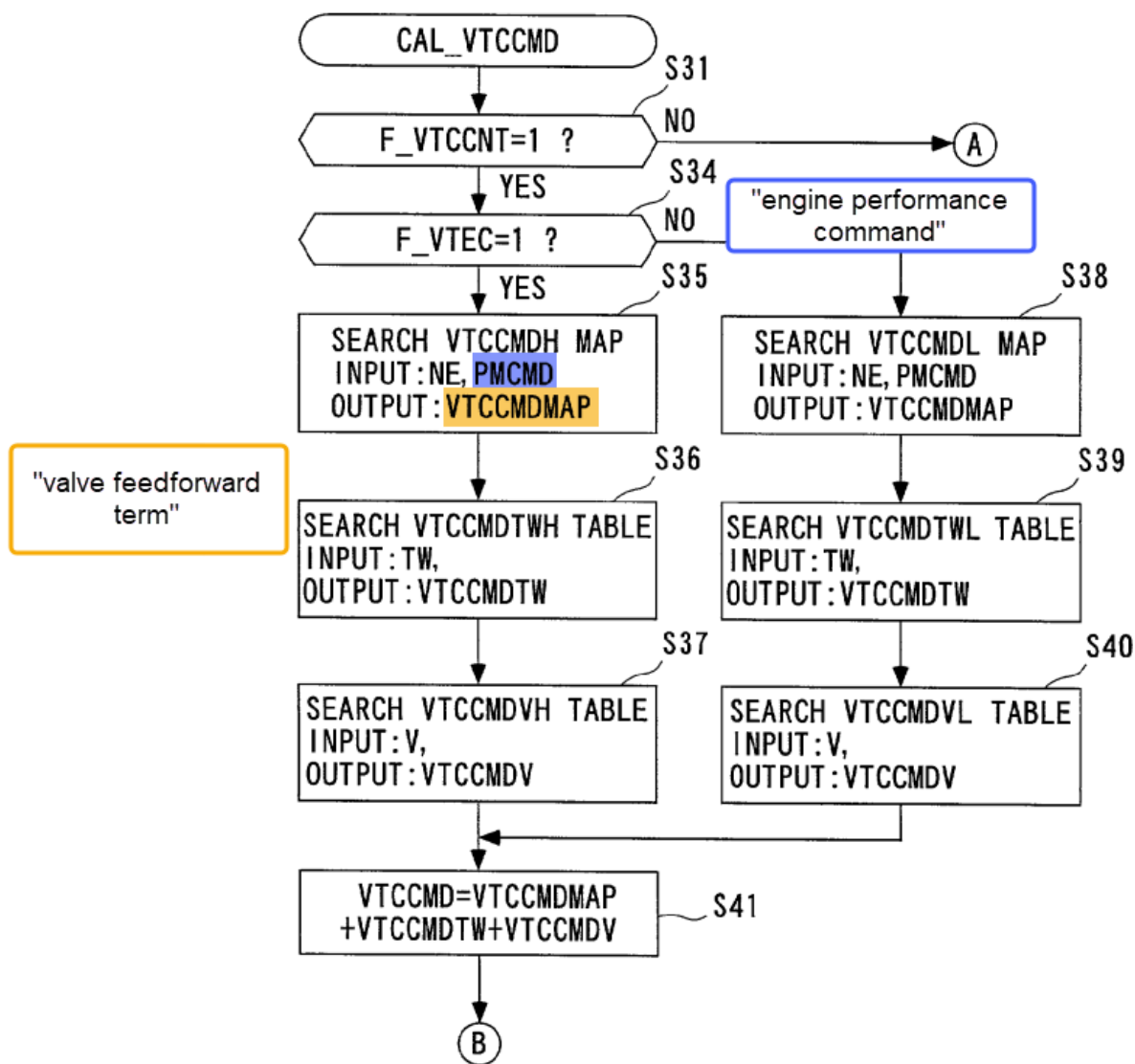
X. SUMMARY OF PRIOR ART

A. Ogawa

64. Ogawa, like the '540 patent, discloses a method for calculating valve timing based on engine performance and operating conditions. Ogawa teaches “a valve timing control method.” Ex. 1005 at ¶ 002. Ogawa further discloses receiving metrics corresponding to a desired engine performance, the current engine performance, and the environmental conditions the engine is operating. *Id.* at ¶¶ 0072 (“the CPU 2a determines . . . a required torque PMCMD”), 0070 (“the ECU 2 is further supplied with a signal indicative of a detected atmospheric pressure”), 0010 (“[t]he valve timing controller . . . compris[es] engine rotational speed detecting means for detecting a rotational speed of the internal combustion engine”).

65. Moreover, just like the '540 patent, Ogawa discloses determining both a valve feedforward and a valve feedback term. Ogawa discloses calculating the phase of a camshaft (“cam”) that controls the time at which either an intake or

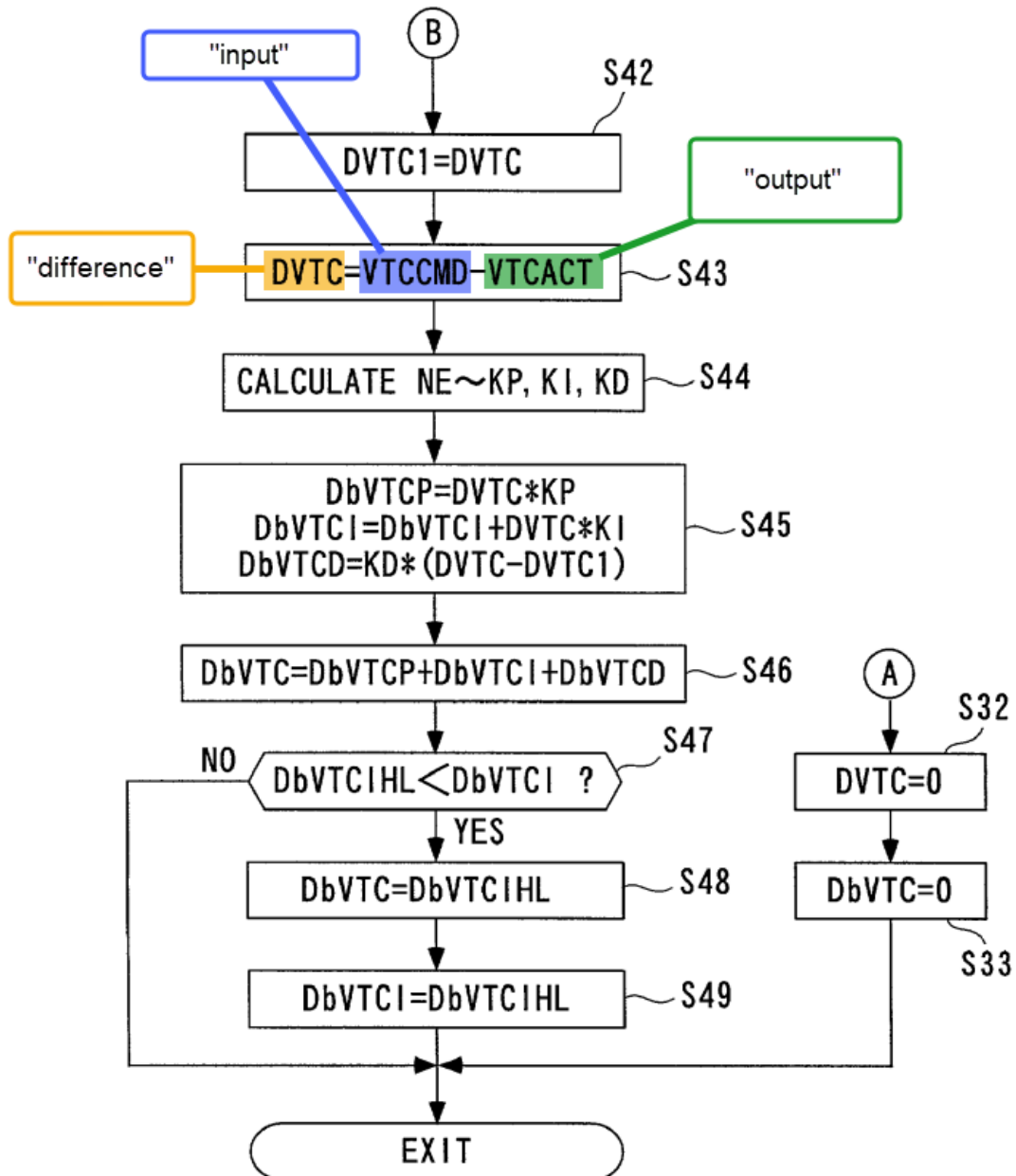
exhaust valve opens and closes based on the system's input metrics. *Id.* at ¶ 0002. As shown in annotated Figure 3 below, Ogawa teaches calculating a basic value target cam phase VTCCMDMAP, *i.e.*, a valve feedforward term, based on the desired engine torque PMCMD. *Id.* at ¶ 0084 (“in accordance with the . . . requested torque PMCMD” the engine control unit “find[s] a basic value VTCCMDMAP for a target cam phase.”)



Id. at FIG. 3 (annotated).

66. Also like the '540 patent, Ogawa teaches comparing an input value to an output value in to calculate a valve feedback term. As shown in annotated Figure 4 below, Ogawa discloses comparing an actual valve cam phase VTC ACT to an adjusted target valve cam phase VTCCMD to calculate a deviation amount DVTC,

i.e., a valve feedback term. *Id.* at ¶ 0090 (“the ECU 2 calculates a deviation between the [basic value] target cam phase VTCCMD . . . and a detected actual cam phase . . . VTCACT . . . as a current cam phase deviation DVTC”).



Id. at FIG. 4.

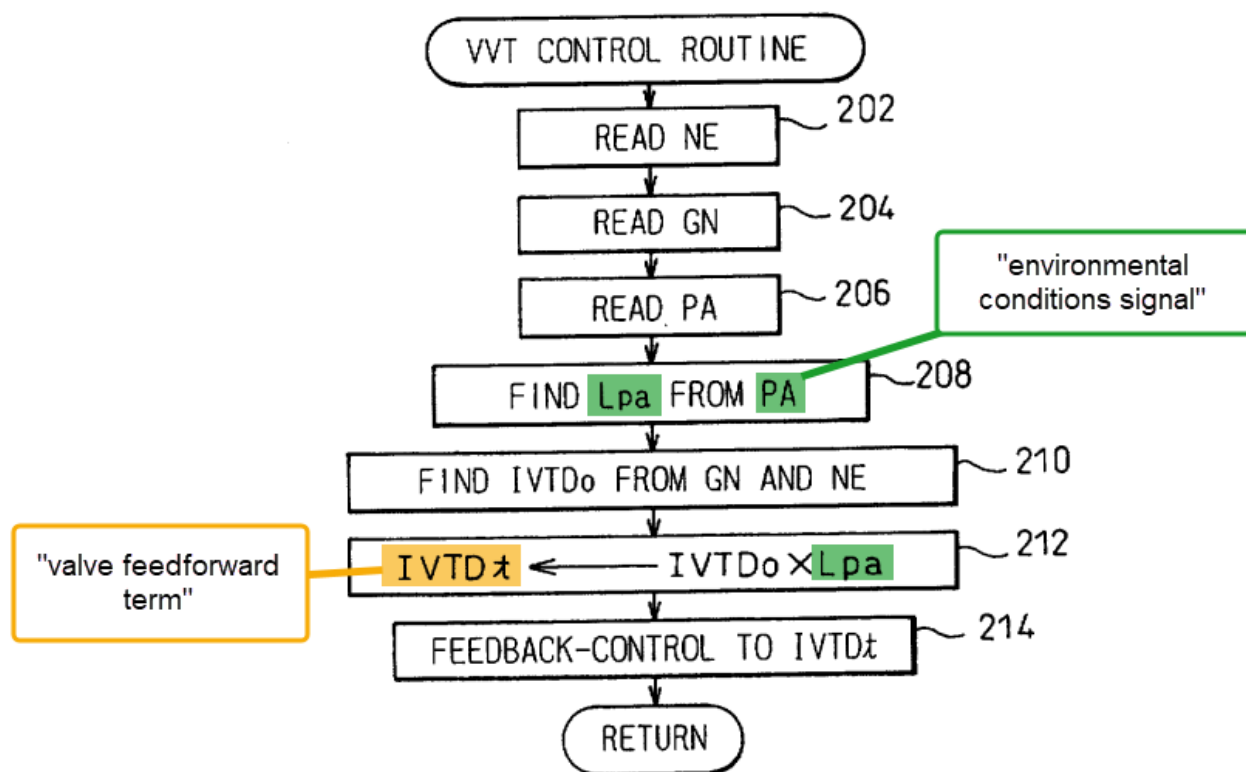
67. Finally, like the '540 patent, Ogawa teaches determining a valve timing command based on its valve feedback term DVTC and its valve feedforward term VTCCMDMAP. Ogawa discloses calculating DbVTC, which determines the duty ratio of a driving signal that controls the phase of the system's valve cam shaft, and therefore determines the timing of the opening and closing of the valve. *Id.* at ¶¶ 0059, 0060, 0082. Ogawa's system calculates its valve timing command DbVTC based on valve feedforward term VTCCMDMAP and valve feedback term DVTC: DbVTC is calculated based on the valve feedback term DVTC, which is itself calculated based on the valve feedforward term VTCCMDMAP. *Id.* at (1), ¶ 0091, FIG. 4.

B. Yoshioka

68. Like the '540 patent, Yoshioka teaches a process for calculating valve timing based on engine operating conditions and engine performance. Yoshioka discloses a method that "controls a continuously variable valve timing mechanisms of an internal combustion engine to continuously and variably control the timing of an intake valve." Ex. 1006 at Abstract. Yoshioka, like the '540 patent, also discloses receiving metrics regarding the current engine performance and the environmental conditions the engine is operating in. *Id.* at Ex. 1006 at 7:24-25 (Yoshioka's ECU receives "an atmospheric pressure PA detected by [an] atmospheric pressure sensor 46."), 4:42-5:46 ("crank angle sensor 51 generates a

position pulse for every 30 degrees of crank angle” from which “an engine revolution speed [is] detected.”).

69. Further, just like the '540 patent, Yoshioka discloses determining both a valve feedforward and a valve feedback term. As shown in annotated Figure 9 below, Yoshioka teaches determining a target timing displacement $IVTD_t$, i.e., a valve feedforward term, based on atmospheric pressure PA , engine load GN , and engine revolution speed NE . Ex. 1006 at 7:57-67.



Id. at FIG. 9 (annotated).

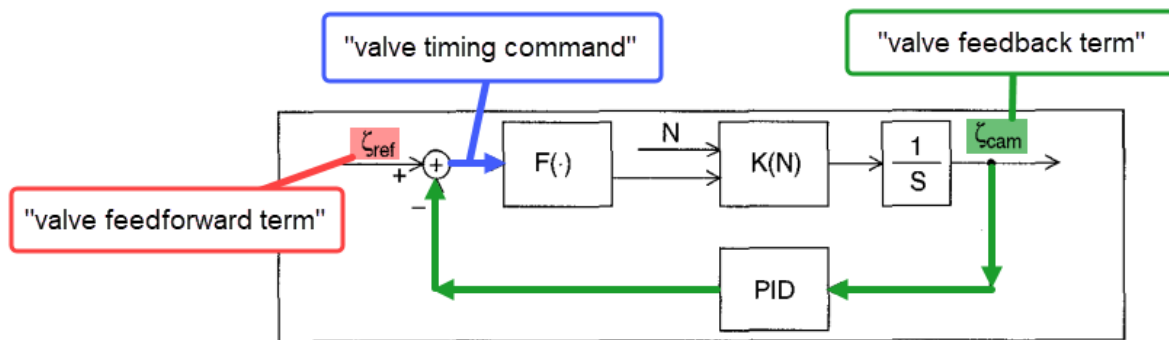
70. Also like the '540 patent, Yoshioka discloses comparing an input to an output to determine a valve feedback term. Yoshioka teaches determining target

valve displacement IVTDt, and then using “feedback-control,” *i.e.*, calculating a valve feedback term, “[t]o bring the displacement of the intake valve 23 to the target displacement IVTDt.” *Id.* at 8:5-7.

71. Yoshioka also discloses calculating a valve timing command based on it’s valve feedforward and valve feedback terms. Yoshioka discloses using it’s valve feedforward term IVTDt and feedback control, *i.e.*, a valve feedback term, to calculate control signals for a hydraulic control valve that bring the intake valve’s actual displacement to the target valve displacement. Ex. 1006 at 8:5-7.

C. Jankovic

72. Jankovic discloses using feedback and feedforward terms to determine a valve timing command, just like the ’540 patent. Jankovic teaches controlling valve timing via a “variable cam timing (VCT) system.” Ex. 1007 at 34. Jankovic discloses controlling a valve cam shaft phase via a calculated cam phasing command, *i.e.*, a valve timing command. Ex. 1007 at 36, 40, 41. As shown in annotated Figure 8 below, Jankovic’s system determines its valve timing command based on a valve feedback term cam position ζ_{cam} and a valve feedforward term, the previously calculated ζ_{ref} , using a “feedback loop.”



Id. at FIG. 8 (annotated).

XI. GROUND 1: THE COMBINATION OF OGAWA AND YOSHIOKA RENDERS OBVIOUS CLAIMS 1-2, 7, 10-11, AND 14.

73. In my opinion, a POSITA at the time of the alleged invention would have found claims 1-2, 7, 10-11, and 14 obvious over Ogawa in view of Yoshioka.

A. Motivation to Combine Ogawa with Yoshioka

74. In my opinion, a POSITA in possession of Ogawa's methods for determining valve timing commands would have been motivated to modify its method to calculate a valve feedforward term based on an environmental conditions signal; receive fuel conversion, ambient temperature, and engine emissions data; and calculate EVO, EVC, IVO, and IVC commands, based on the teachings of Yoshioka.

75. In my opinion, a POSITA would have recognized that modifying Ogawa's methods for calculating a valve timing command to account for atmospheric pressure when calculating a valve feedforward term, as taught by Yoshioka, would "improve the output of an engine at high altitude under high load." Ex. 1006 at 1:44-49. Yoshioka discloses calculating a valve feedforward term

IVTDt based on a correction coefficient L_{pa} , which is itself calculated based on atmospheric pressure signal PA , *i.e.*, an environmental conditions signal. Ex. 1006 at 6:16-36. Yoshioka further discloses calculating an EVO command, an EVC command, an IVO command, and an IVC command based on the valve feedforwrd term IVTDt. Ex. 1006 at 7:57-60.

76. Additionally, Yoshioka discloses that implementing its teachings regarding engines emissions and fuel conversion data “reduc[es] fuel consumption and improv[es] exhaust purifying performance at high altitudes under low/medium load.” Ex. 1006 at 1:44-49. Yoshioka teaches “an air-fuel ratio feedback correction according to a signal from [an] O_2 sensor 45” located at an engine’s exhaust pipe that “detect[s] the concentration of the oxygen in the exhaust gas,” *i.e.*, fuel conversion and emissions data. Ex. 1006 at 4:48-52, 5:24-30, 5:48-54.

77. Accordingly, in my opinion a POSITA would have been motivated to modify Ogawa’s would have been motivated modify its method, to calculate a valve feedforward term based on an environmental conditions signal; receive fuel conversion, ambient temperature, and engine emissions data; and calculate EVO, EVC, IVO, and IVC commands, based on the teachings of Yoshioka because such modifications would both improve engine output at high altitude under high load, and reduce fuel consumption and improve exhaust purifying at high altitudes under low/medium load. Ex. 1006 at 1:44-49.

78. Additionally, in my opinion a POSITA would be motivated to modify Ogawa based on the teachings of Yoshioka because they are both in the same field of endeavor as the '540 patent: controlling engine valve timing. Ex. 1001 at Abstract; Ex. 1005 at Abstract; Ex. 1006 at Abstract. In my opinion, Ogawa and Yoshioka both also use similar techniques to solve the same problem as the '540 patent. For example, as described herein, Ogawa discloses nearly all of the limitations of the '540 patent's claims 1, 2, and 7, and Yoshioka discloses calculating a valve feedforward term based on an environmental conditions signal as claimed in claim 1; receiving ambient temperature, fuel conversion, and engine emissions data as claimed in claims 3, 11 and 14; and calculating EVO, EVC, IVO, and IVC commands as claimed in claim 10.

79. Moreover, in my opinion a POSITA would have had a reasonable expectation of success modifying Ogawa's valve timing control methods based on the teachings of Yoshioka, because Ogawa teaches that its engine control unit ("ECU") already receives engine speed and atmospheric pressure signals, and that it sets its engine performance command PMCMD according to a particular engine load. In my opinion, a POSITA would easily be able to modify the software of Ogawa's ECU to calculate its valve feedforward term based on the atmospheric pressure, engine load, and engine speed data already received by Ogawa's ECU, as taught by Yoshioka. Ex. 1006 at ¶¶ 0070, 0116.

80. In my opinion, a POSITA also would have understood that Ogawa's ECU already receives input signals from a number of sensors and could easily be modified to receive a signal from an ambient temperature sensor and from an O₂ sensor located in the engine's exhaust pipe, as taught by Yoshioka. A POSITA also could easily modify the software that controls Ogawa's ECU to read temperature data from the ambient temperature sensor, and fuel conversion and exhaust data from an O₂ sensor.

81. Finally, in my opinion POSITA would have recognized that Ogawa's ECU already determines a target valve timing displacement VTCCMD, and would easily be able to modify the software running on Ogawa's ECU to calculate an EVO, EVC, IVO, and IVC command based on the target displacement, as taught by Yoshioka. Ex. 1006 at ¶¶ 0070, 0116.

B. Claim 1

1. 1[pre]: "A method for calculating a valve timing command for an engine of a vehicle, comprising:"

82. In my opinion, Ogawa discloses a method for calculating a valve timing command for an engine vehicle. Ogawa discloses "a valve timing control method" for a vehicle's "internal combustion engine." Ex. 1005 at ¶¶ 0002, 0037. Ogawa teaches methods that "determin[e] the [engine's] valve timing" by "control[ling] the duty ratio DbVTC of a driving signal outputted to the VTC electronic magnetic

control valve,” which itself controls the valve cam shaft phase (*i.e.*, a valve timing command). *Id.* at ¶¶ 0017, 0060, 0082.

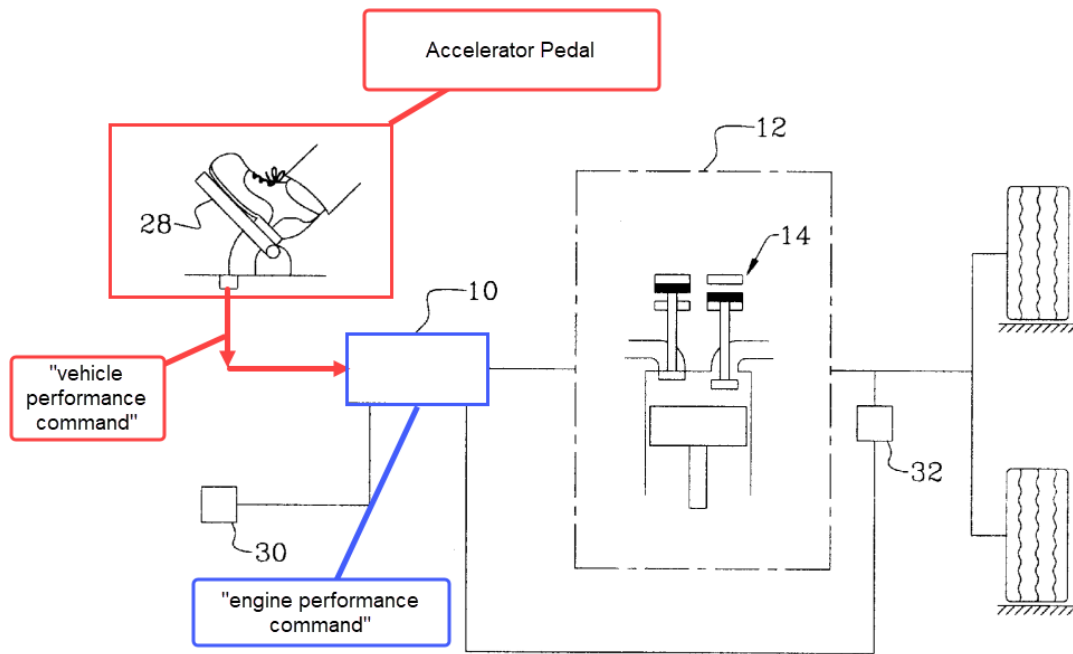
83. Accordingly, in my opinion Ogawa discloses the preamble of claim 1.

2. 1[a]: “obtaining an engine performance command;”

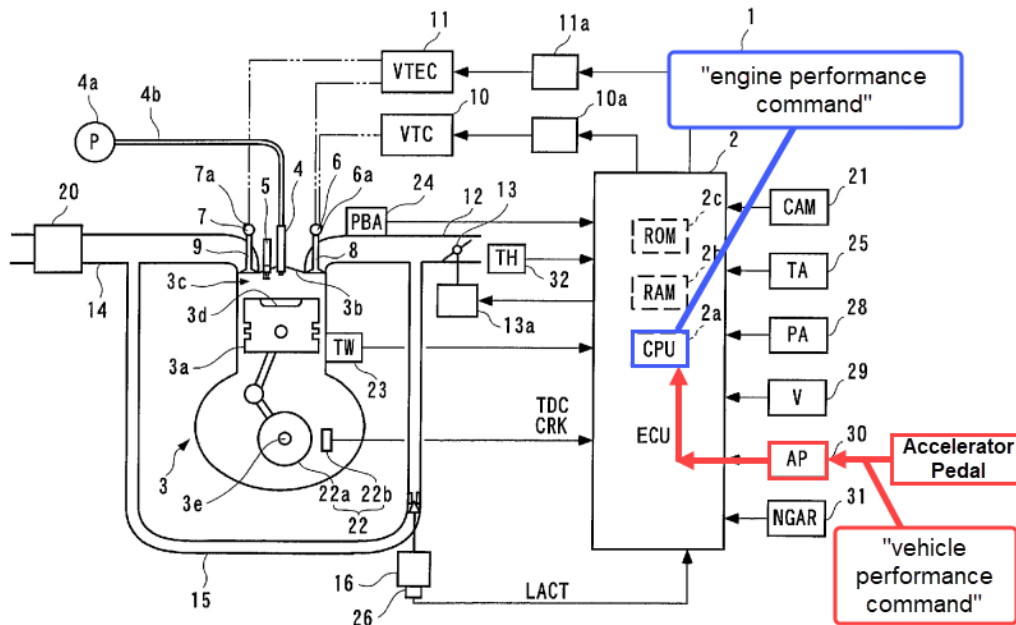
84. In my opinion, Ogawa discloses obtaining an engine performance command. Ogawa teaches “determin[ing] a required torque PMCMD [to be] output[] by the engine 3,” (*i.e.*, an engine performance command), based on “accelerator pedal opening AP,” “which is an operation amount of an accelerator pedal.” Ex. 1005 at ¶¶ 0070, 0072. Accordingly, Ogawa discloses a “command,” PMCMD, “that defines a desired engine torque.” Further, the ’540 patent teaches that desired torque is one example of an “engine performance command.” Ex. 1001 at 2:17-18 (“The engine performance command is preferably a desired engine torque”).

85. In fact, Ogawa’s derivation of an engine performance command that represents desired engine torque based on an accelerator pedal opening signal discloses the ’540 patent’s preferred embodiment of obtaining an engine performance command. The ’540 patent teaches that “[t]he action of obtaining an engine performance command . . . preferably includes deriving the engine performance command from the vehicle performance command,” where “the vehicle performance command is received from the foot of a driver with the use of a

conventional pedal.” Ex. 1001 at 2:4-22. Ogawa similarly discloses receiving the “accelerator pedal opening [signal] AP” from an accelerator pedal controlled by the driver that, with the “detected engine rotational speed,” is used to “determine a required [engine] torque PMCMD,” *i.e.*, the engine performance command. Ex. 1005 at ¶¶ 0011, 0070, 0072.



Ex. 1001 at FIG. 1 (annotated).



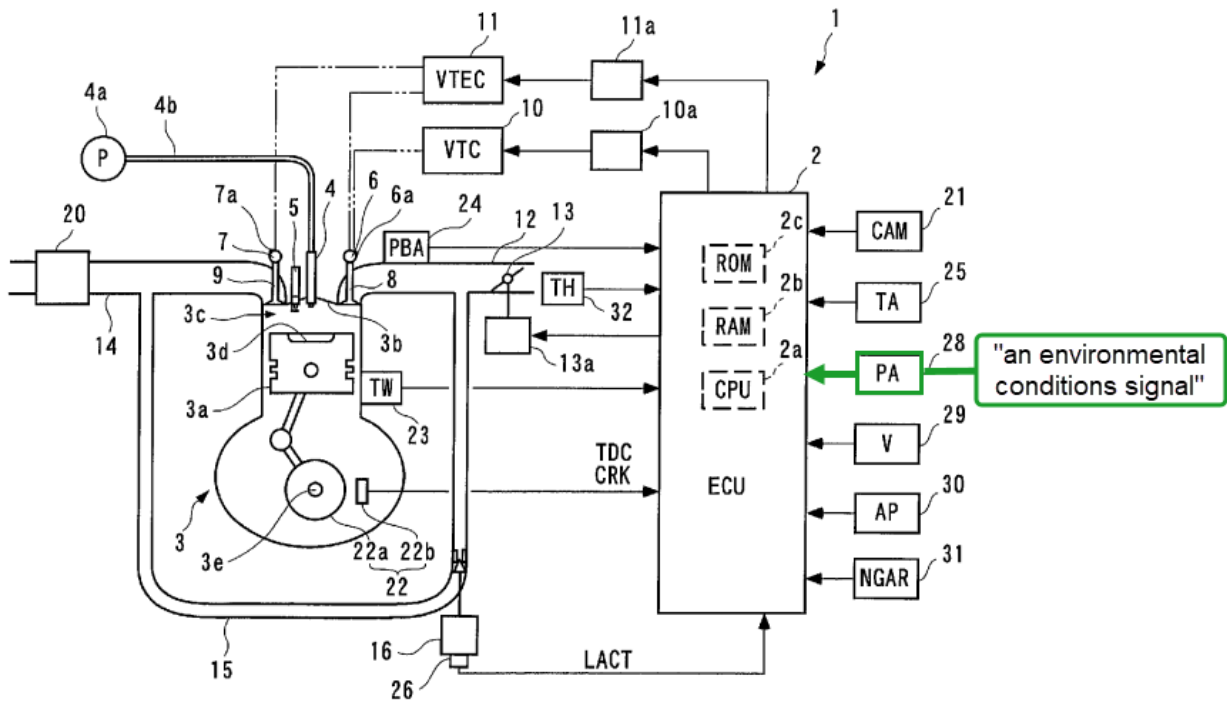
Ex. 1005 at FIG. 1 (annotated).

86. Accordingly, in my opinion Ogawa discloses claim limitation 1[a].

3. **1[b]: “receiving an environmental conditions signal;”**

87. In my opinion, Ogawa discloses receiving an environmental conditions signal.

88. As shown in annotated Figure 1 below, Ogawa teaches that its ECU receives “a signal indicative of a detected atmospheric pressure PA from an atmospheric pressure sensor 28” Ex. 1005 at ¶ 0070.



Id. at FIG. 1 (annotated).

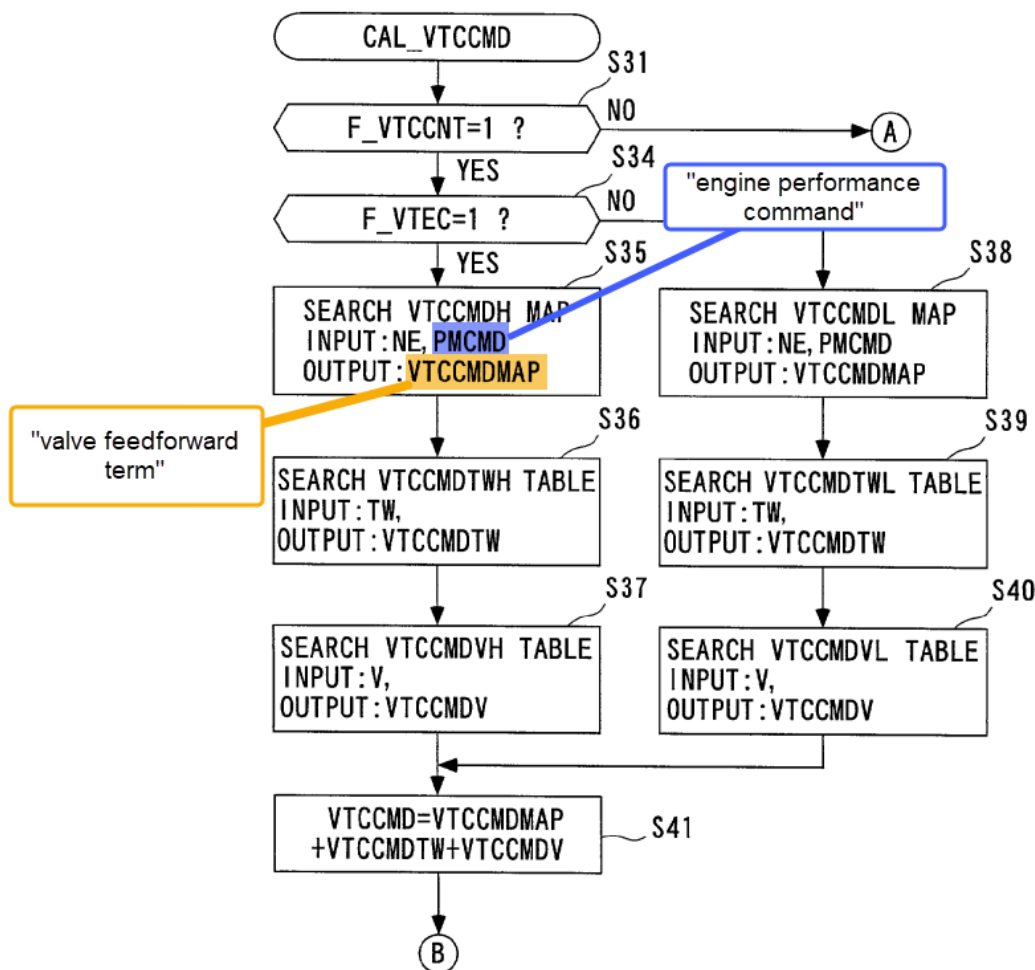
89. The '540 patent teaches that receiving an atmospheric or ambient pressure signal as taught by Ogawa discloses the '540 patent's preferred embodiment of an environmental conditions signal. Ex. 1001 at 2:23-35 ("The action of receiving an environmental conditions signal 18 preferably includes receiving an environmental conditions signal from an environmental sensor . . . such as ambient pressure.").

90. Accordingly, in my opinion Ogawa discloses limitation 1[b].

4. 1[c]: “determining a valve feedforward term based on the engine performance command and the environmental conditions signal;”

91. In my opinion, Ogawa in view of Yoshioka discloses determining a valve feedforward term based on the engine performance command and the environmental conditions signal.

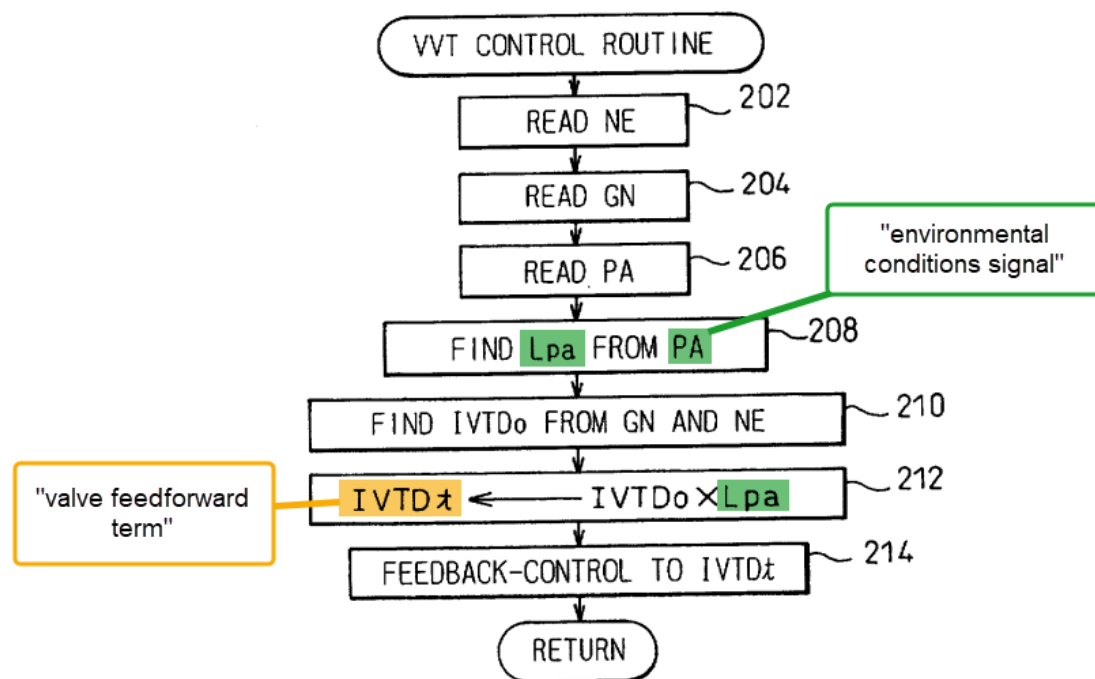
92. As explained in Sections XI.B.2 and 3 above, Ogawa teaches obtaining a desired engine torque PMCMD, which discloses an engine performance, and receiving an atmospheric pressure signal, which discloses an environmental conditions signal. Ogawa also discloses calculating a basic value target valve cam phase VTCCMDMAP, *i.e.*, a valve feedforward term. Ex. 1005 at ¶ 0082. As shown in annotated Figure 3 below, Ogawa teaches that VTCCMDMAP is calculated based on “the required torque PMCMD,” *i.e.*, the engine performance command, and engine speed NE. *Id.* at ¶¶ 0082, 0084, 0116.



Id. at FIG. 3 (annotated).

93. Additionally, Yoshioka disclose determining a target timing displacement IVTDt, *i.e.*, a valve feedforward term. Ex. 1006 at 7:41-45. Yoshioka calculates IVTDt based on correction coefficient Lpa, which is itself determined by atmospheric pressure signal PA, *i.e.*, an environmental conditions signal. Ex. 1006 at 7:57-60. Yoshioka discloses calculating an initial valve displacement IVTD0 based on engine speed NE and engine load GN. *Id.* at 7:63-

67. Finally, as shown in annotated Figure 9 below, Yoshioka uses inputs IVTD0 and Lpa to calculate valve feedforward term IVTDt. *Id.* at 8:1-5.



Id. at FIG. 9 (annotated).

94. In my opinion, a POSITA would have understood that modifying Ogawa’s system to calculate its valve feedforward term based on atmospheric pressure based on the teachings of Yoshioka would “improve the output of an engine at high altitude under high load, as well as reducing fuel consumption and improving exhaust purifying performance at high altitudes under low/medium load.” Ex. 1006 at 1:44-49.

95. Additionally, in my opinion a POSITA would have easily been able to modify Ogawa’s system based on the teachings of Yoshioka. A POSITA would

have understood that Ogawa's ECU receives an atmospheric pressure signal and an engine speed signal, and that the ECU determines engine performance command PMCMD based on a particular engine load. Ex. 1006 at ¶¶ 0070, 0116. A POSITA would have easily been able to modify the software running on Ogawa's ECU calculate a valve feedforward term calculation based on the atmospheric pressure, engine speed, and engine load data as taught by Yoshioka.

96. Accordingly, in my opinion Ogawa in view of Yoshioka renders obvious claim limitation 1[c].

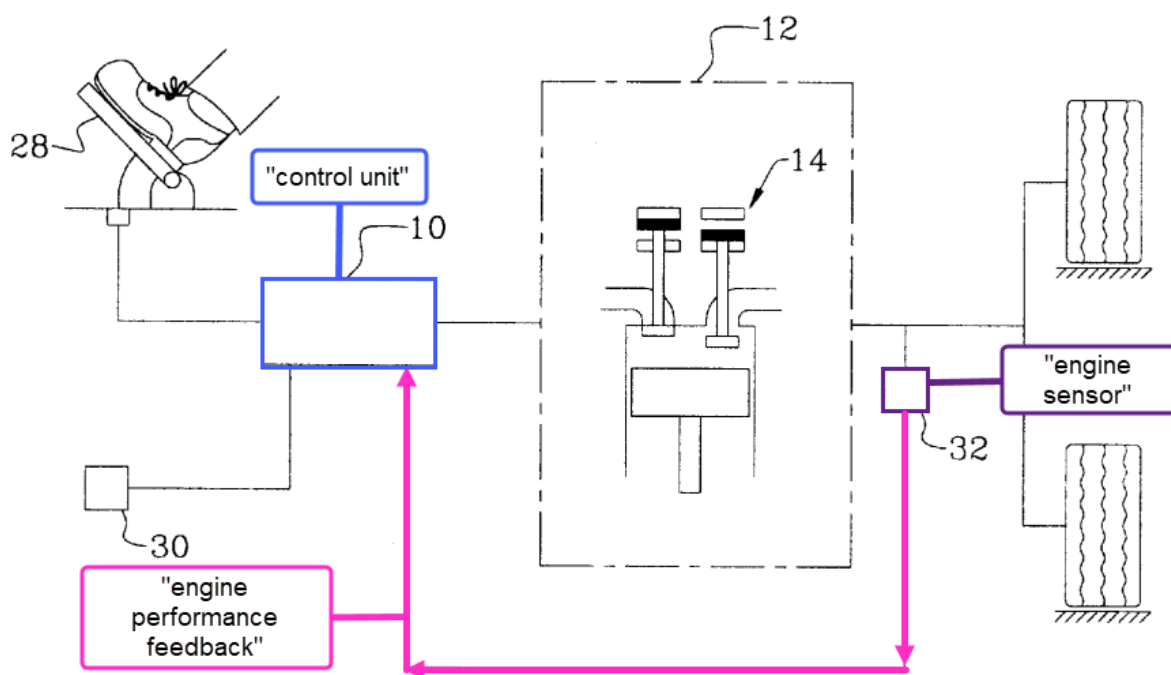
5. 1[d]: “receiving an engine performance feedback;”

97. In my opinion, Ogawa discloses receiving an engine performance feedback.

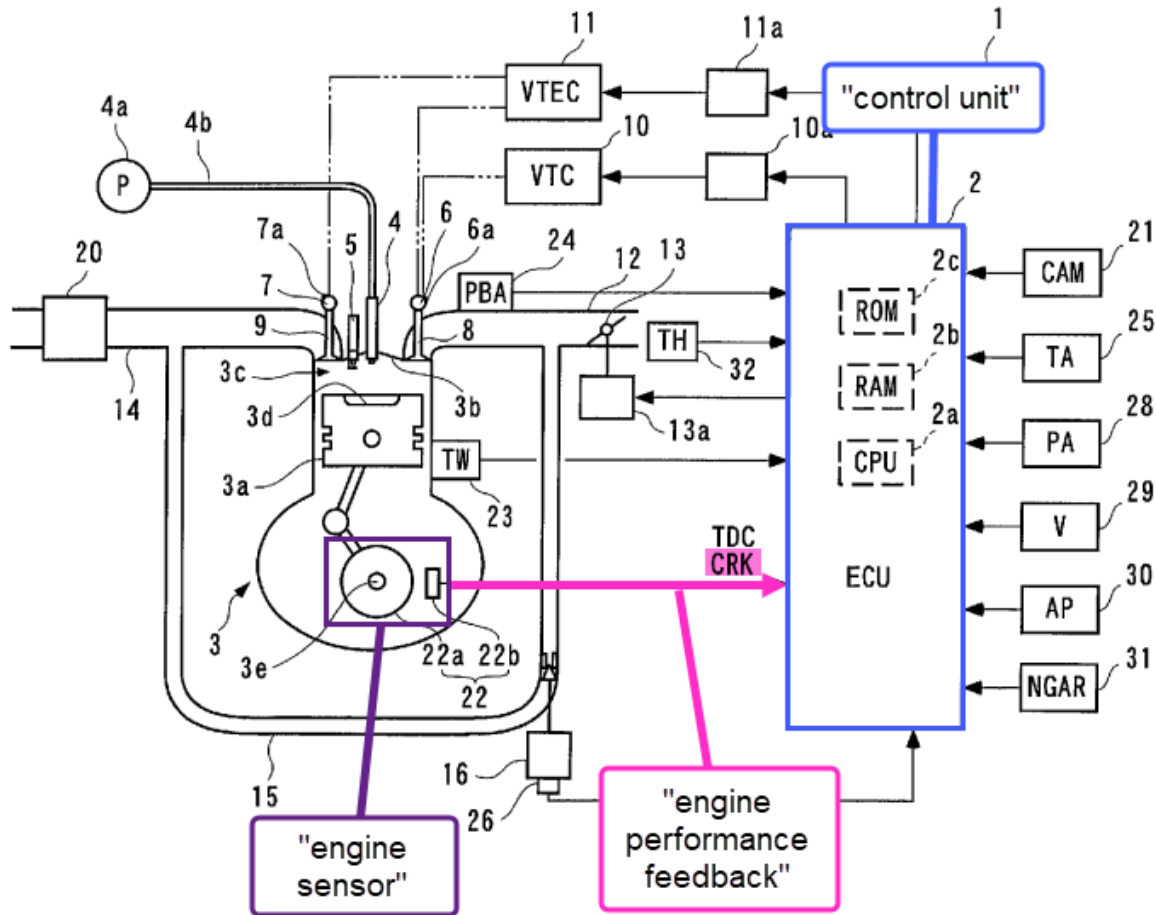
98. Ogawa teaches an “engine rotational speed detecting means” comprising “a crank angle sensor 22” that “outputs a CRK signal,” *i.e.*, an engine performance feedback, from which Ogawa's system “calculates the engine rotational speed.” Ex. 1005 at ¶¶ 0064, 0065. Ogawa teaches that the CRK signal is a “pulse signal” and “[o]ne pulse of the CRK signal is outputted every predetermined crank angle (for example, every 30°).” *Id.* at ¶ 0065. “The ECU 2 calculates the engine rotational speed NE of the engine 3 . . . based on the CRK signal.” *Id.*

99. As shown in annotated Figure 1 from the '540 patent and annotated Figure 1 from Ogawa below, Ogawa's CRK signal and crank angle sensor disclose

the '540 patent's preferred embodiment of an engine performance feedback. The '540 patent teaches that "receiving an engine performance feedback 22 preferably includes receiving the engine performance feedback from an engine sensor 32 in the vehicle" that "preferably senses the engine speed." Ex. 1001 at 2:36-42. Just like the '540 patent's preferred embodiment, Ogawa teaches a crank angle sensor in the vehicle, *i.e.*, an engine sensor, that outputs a CRK signal, *i.e.*, the engine performance feedback, that is used to determine engine rotational speed. Ex. 1005 at ¶¶ 0064, 0065.



Ex. 1001 at FIG. 1 (annotated).



Ex. 1005 at FIG. 1 (annotated).

100. Accordingly, in my opinion Ogawa discloses limitation 1[d].

6. 1[e]: “calculating a valve feedback term based on the engine performance command and the engine performance feedback; and”

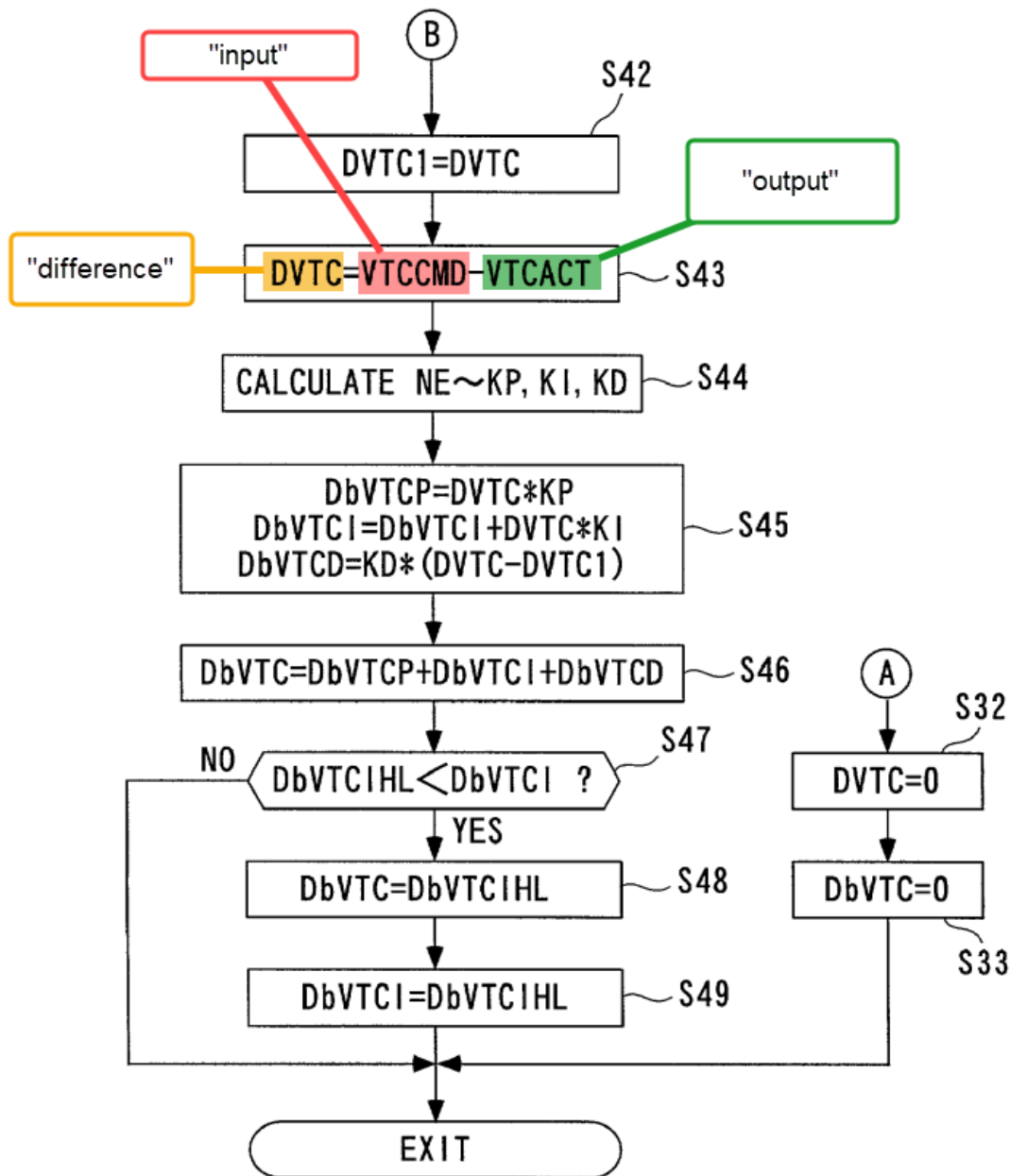
101. In my opinion, Ogawa discloses calculating a valve feedback term based on the engine performance command and the engine performance feedback.

102. The claims of the '540 patent do not place any restriction on the method for calculating the “valve feedback term.” The '540 patent teaches that one example of calculating the valve feedback term comprises “compar[ing] [an] input

with [an] output and [] calculat[ing] a correction term based on the difference.” Ex. 1001 at 2:66-3:4.

103. Ogawa discloses the ’540 patent’s exemplary method for calculating a “valve feedback term.” As shown in annotated Figure 4 below, Ogawa teaches “calculat[ing] a deviation between the basic value target cam phase VTCCMD,” *i.e.*, an input, and the “detected actual cam phase . . . VTCACT,” *i.e.*, an output, “as a current cam phase deviation DVTC,” *i.e.*, a difference.

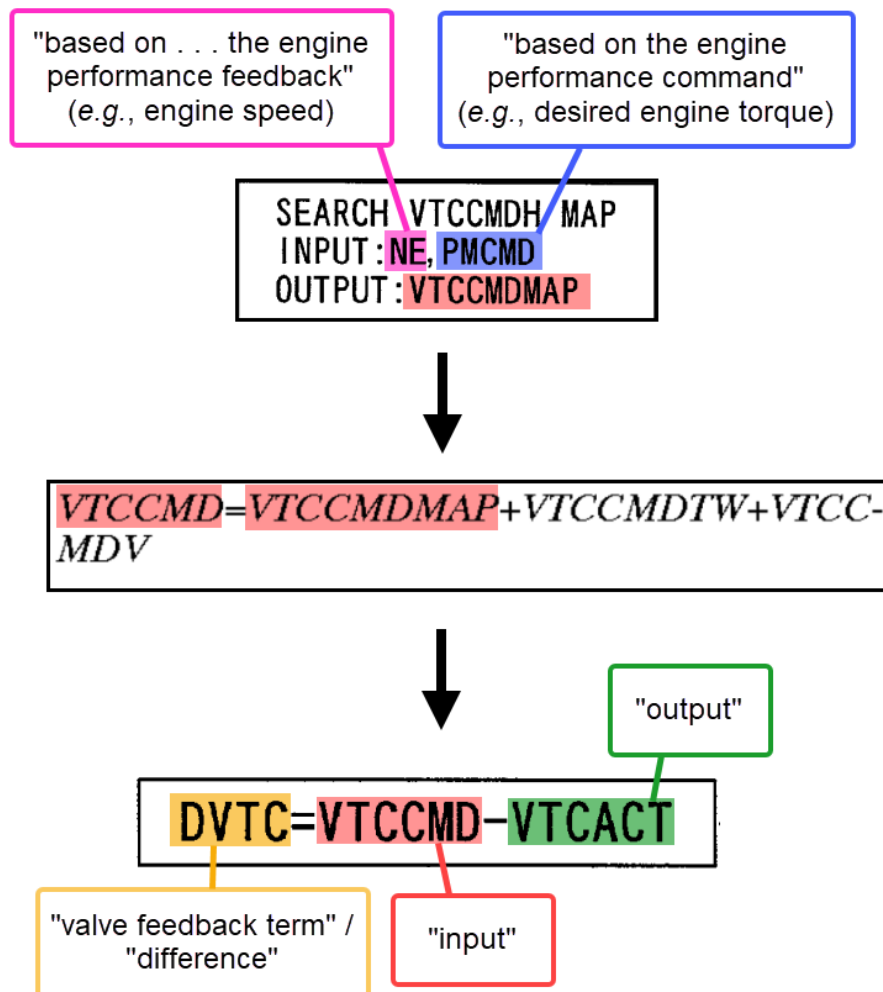
104. Accordingly, in my opinion Ogawa discloses calculating a valve feedback term DVTC.



Ex. 1005 at FIG. 4 (annotated.)

105. Ogawa also discloses calculating its valve feedback term DVTC based on Ogawa's engine performance command and engine performance feedback. As explained in Sections XI.B.2 and 4 above, Ogawa ECU obtains desired engine

torque PMCMD (an engine performance command), and signal CRK, (an engine performance feedback) that is used to calculate engine speed NE. Ex. 1005 at ¶¶ 0064, 0065, 0070, 0072. As shown in annotated Figure 2 and Expression 1 below, Ogawa's calculates its valve feedback term DVTC based on its engine performance command PMCMD and its engine performance feedback CRK.



Id. at FIG. 3, (1) (annotated).

106. Ogawa teaches calculating engine rotational speed NE based on engine performance command CRK. Ex. 1005 at ¶ 0065. Ogawa also teaches calculating a basic value target cam phase VTCCMDMAP based on engine rotational speed NE and engine performance command PMCMD. *Id.* at ¶ 0084. Ogawa teaches calculating VTCCMD based on VTCCMDMAP. *Id.* at (1). Finally, Ogawa discloses calculating valve feedback term DVTC based on VTCCMD. Accordingly, Ogawa's valve feedback term DVTC is calculated based on engine performance command PMCMD and engine performance feedback CRK.

107. Accordingly, in my opinion Ogawa discloses limitation 1[e].

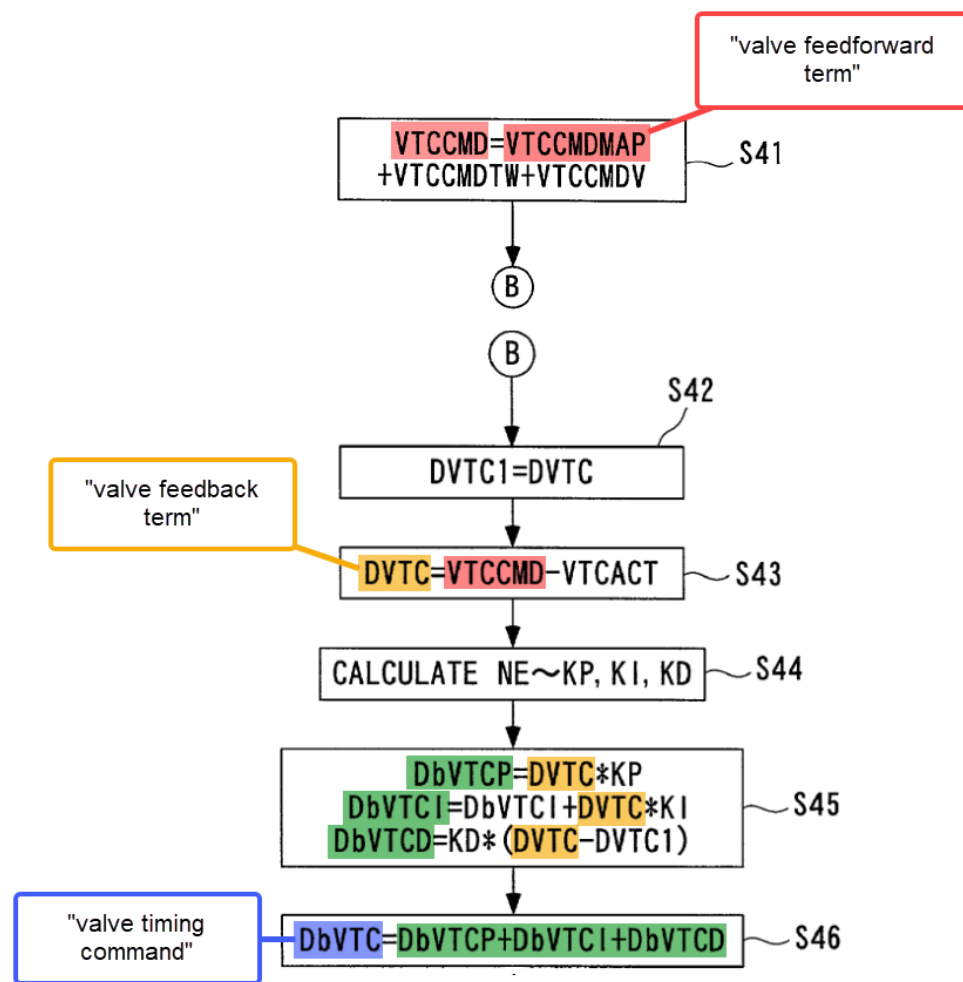
7. 1[f]: “calculating a valve timing command based on the valve feedforward term and the valve feedback term”

108. In my opinion, Ogawa discloses calculating a valve timing command based on the valve feedforward term and the valve feedback term.

109. The '540 patent does not restriction on how the “valve timing command” is calculated. Claim 1 only requires that the “valve timing command” is based on the “valve feedforward term” and “valve feedback term.” Ogawa discloses calculating a “valve timing command” based on its “valve feedforward term” and “valve feedback term.”

110. As shown in annotated Figures 3 and 4 below, Ogawa discloses calculating a “valve feedforward term” VTCCMDMAP, and calculating a “valve feedback term” DVTC based on the valve feedforward term. Ogawa teaches then

calculating a “valve timing command” DbVTC based on the “valve feedback term” DVTC. This valve timing command calculation method is demonstrated in annotated Figures 3 and 4 below.



Id. at FIGS. 3-4 (annotated).

111. At step 41, Ogawa teaches calculating target cam phase VTCCMD based on the feedforward term basic value target cam phase VTCCMDMAP. At step 43, Ogawa teaches calculating the feedback term DVTC based on the target cam phase VTCCMD, which was itself calculated from feedforward term basic value

target cam phase VTCCMDMAP. In step 45, Ogawa teaches generating three values--P-term DbVTCP, I-term DbVTCL, and D-term DbVTCD—based on feedback term DVTC, which was derived from feedforward term VTCCMDMAP. At step 46, Ogawa then teaches summing the P, I, and D-terms, which were derived from Ogawa’s “feedforward” and “feedback” terms, to calculate valve timing command DbVTC. Accordingly, Ogawa teaches calculating valve timing command DbVTC based on feedforward term VTCCMDMAP and feedback term DVTC.

112. Accordingly, in my opinion Ogawa discloses limitation 1[f].

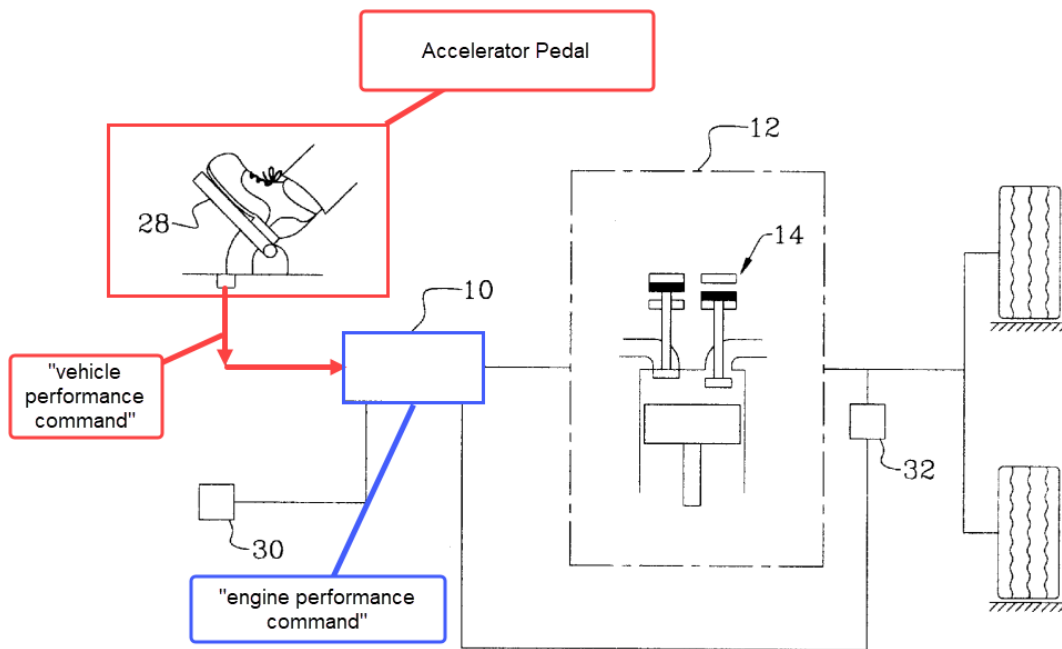
C. **Claim 2: “The method of claim 1 wherein said obtaining an engine performance command includes receiving a vehicle performance command from a driver of the vehicle and deriving the engine performance command based on the vehicle performance command.”**

113. In my opinion, Ogawa, in view of Yoshioka discloses the method of claim 1, wherein said obtaining an engine performance command includes receiving a vehicle performance command from a driver of the vehicle and deriving the engine performance command based on the vehicle performance command.

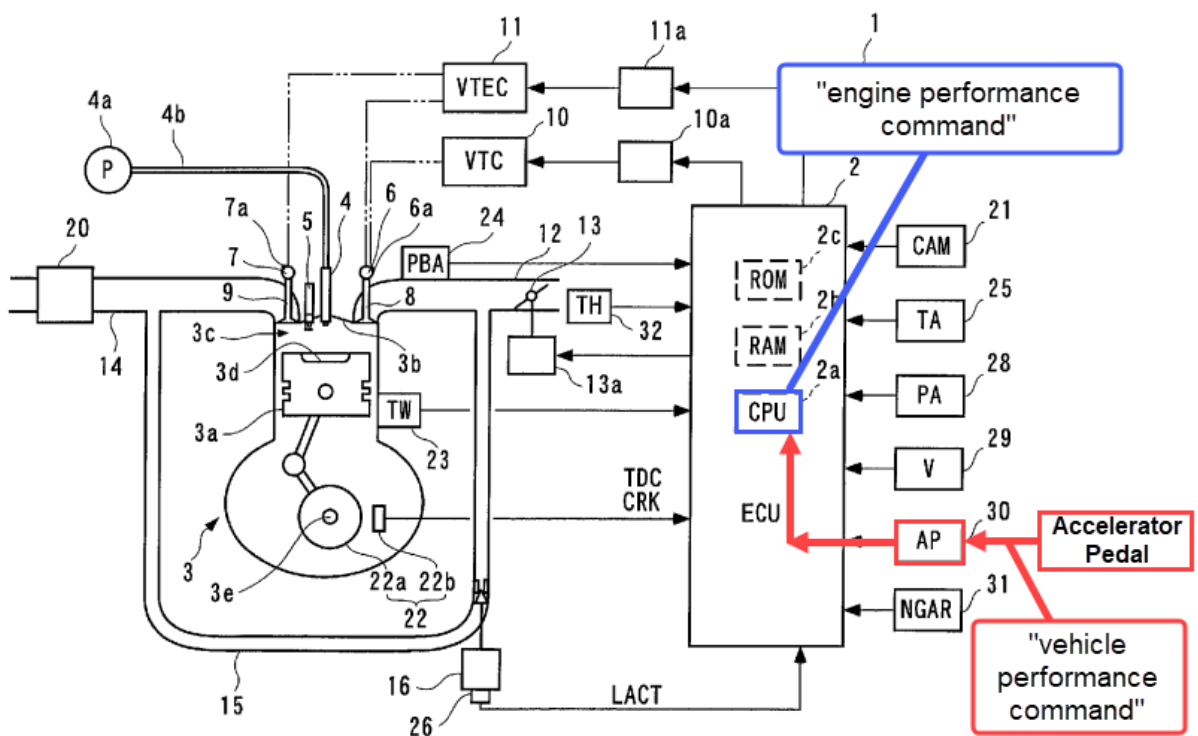
114. As explained in above, in my opinion, Ogawa in view of Yoshioka, discloses the method of claim 1. Ogawa further discloses “determin[ing] a required torque PMCMD,” *i.e.*, an engine performance command, from an “accelerator pedal opening [signal] AP,” “which is an operation amount of an accelerator pedal,” *i.e.*,

a vehicle performance command. Ex. 1005 at ¶¶ 0070, 0072. The '540 specification teaches that desired torque is one example of an “engine performance command,” and that a signal “received from the foot of a driver with the use of a conventional pedal” is one example of a “vehicle performance command.” Ex. 1001 at 2:4-18.

115. Ogawa’s derivation of an engine performance command that represents desired engine torque based on an accelerator pedal opening signal discloses the '540 patent’s preferred embodiment of obtaining an engine performance command. The '540 patent teaches that “[t]he action of obtaining an engine performance command . . . preferably includes deriving the engine performance command from the vehicle performance command,” where “the vehicle performance command is received from the foot of a driver with the use of a conventional pedal.” Ex. 1001 at 2:4-22. Ogawa similarly discloses receiving the “accelerator pedal opening [signal] AP” from an accelerator pedal controlled by the driver that is used to “determine a required torque PMCMD,” *i.e.*, the engine performance command. Ex. 1005 at ¶¶ 0070, 0072.



Ex. 1001 at FIG. 1 (annotated).



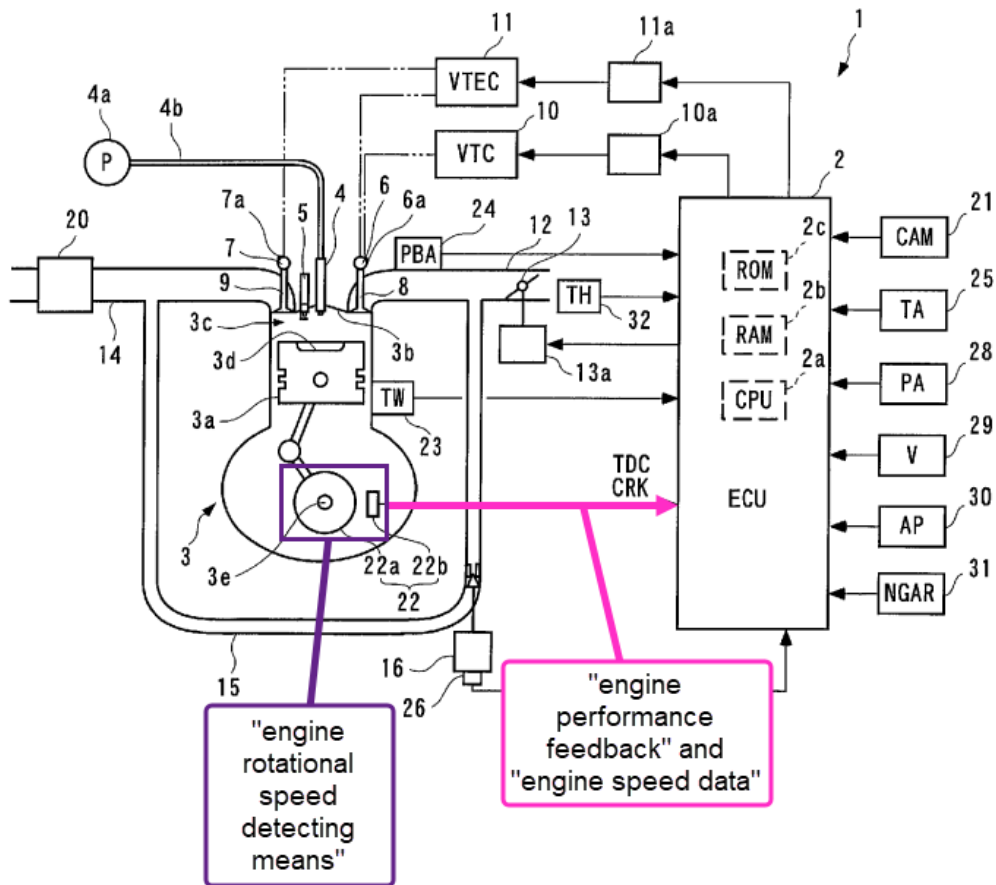
Ex. 1005 at FIG. 1 (annotated).

116. Accordingly, in my opinion Ogawa in view of Yoshioka renders obvious claim 2.

D. Claim 7: “The method of claim 1 wherein said receiving an engine performance feedback includes receiving engine speed data.”

117. In my opinion, Ogawa in view of Yoshioka discloses the method of claim 1 wherein said receiving an engine performance feedback includes receiving engine speed data.

118. As explained above, Ogawa in view of Yoshioka discloses the method of claim 1. As shown in annotated Figure 1 below, Ogawa further teaches an “engine rotational speed detecting means” comprising “a crank angle sensor 22” that “outputs a CRK signal,” *i.e.*, an engine performance feedback. Ex. 1005 at ¶¶ 0064, 0065. Ogawa also discloses calculating engine speed based on its engine performance command. Ogawa’s CRK signal is a “pulse signal” and “[o]ne pulse of the CRK signal is outputted every predetermined crank angle (for example, every 30°),” *i.e.*, engine speed data. *Id.* at ¶ 0065. “The ECU 2 calculates the engine rotational speed NE of the engine 3 . . . based on the CRK signal.” *Id.*



Id. at FIG. 1 (annotated).

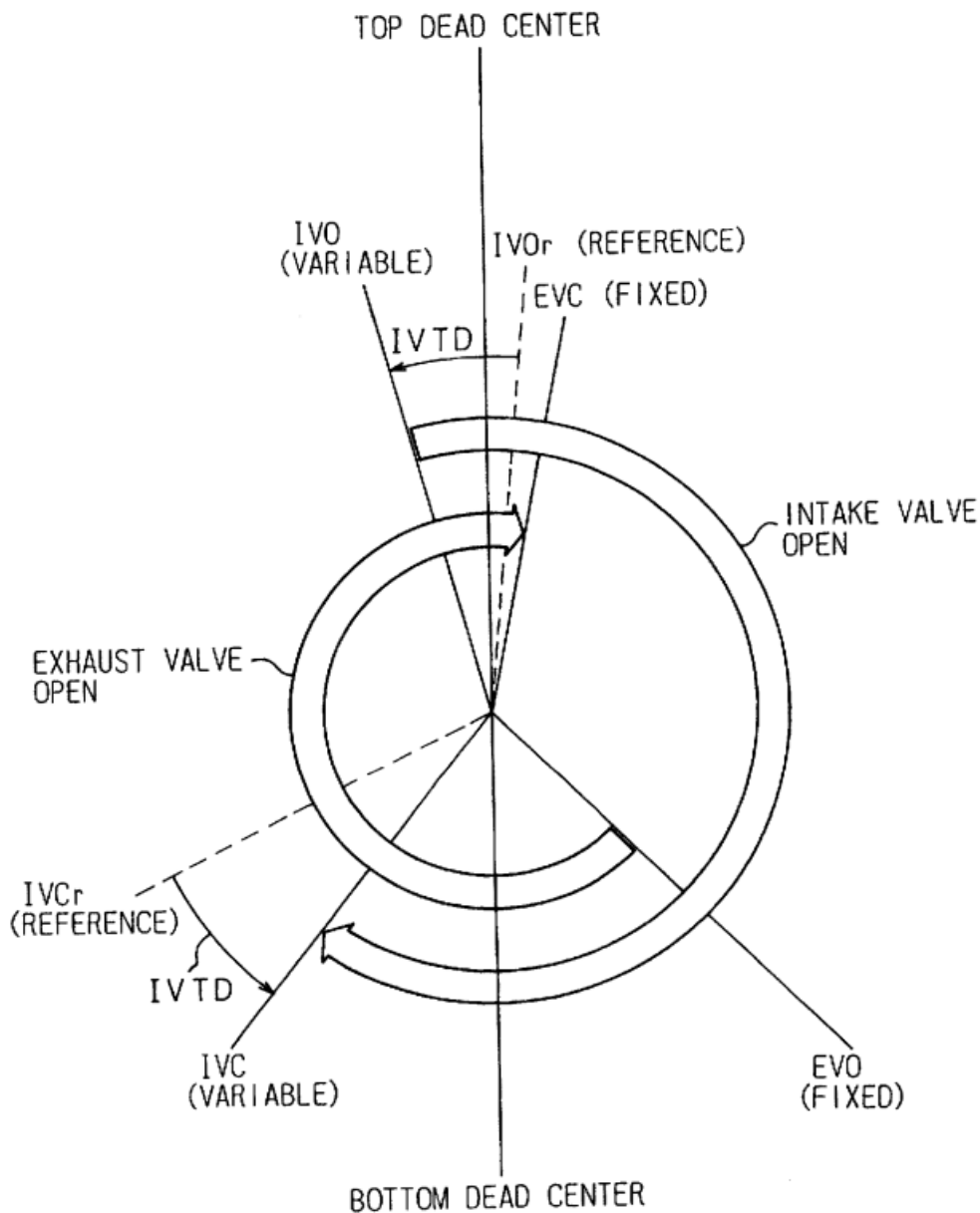
119. Accordingly, in my opinion Ogawa in view of Yoshioka discloses claim 7.

E. **Claim 10: “The method of claim 1 wherein said calculating a valve timing command includes calculating an EVO command, an EVC/IVO command, and an IVC command.”**

120. In my opinion, Ogawa in view of Yoshioka renders obvious the method of claim 1 wherein said calculating a valve timing command includes calculating an EVO command, an EVC/IVO command, and an IVC command.

121. As explained in above, Ogawa in view of Yoshioka discloses the method of claim 1. Yoshioka further teaches calculating an EVO command, an EVC command, an IVO command, and an IVC command. Yoshioka teaches calculating “crank angles corresponding to the open/close timing of the intake and exhaust valves.” Ex. 1006 at 6:16-18. Yoshioka discloses “a fixed value open timing EVO,” *i.e.*, an EVO command (*Id.* at 6:18-19), and a “fixed valve close timing EVC,” *i.e.*, an EVC command (*Id.* at 6:18-22). The values correspond to opening and closing timings for Yoshioka’s exhaust valve. *Id.* at 6:18-22.

122. Yoshioka also teaches calculating a “variable valve opening timing IVO and close timing IVC,” *i.e.*, IVO and IVC commands, for its input valve. *Id.* at 6:22-24. Yoshioka further discloses that calculating the valve opening and closing timings because such open and closing as part of calculating its valve timing displacement IVTD, *i.e.*, the valve timing command, because the opening and closings are dependent on the valve timing displacement IVTD. *Id.* at 6:25-36. Accordingly, Yoshioka discloses calculating a valve timing command, IVTD, which includes calculating an EVO command, an EVC command, an IVO command, and an IVC command. Yoshioka’s EVO, EVC, IVO, and IVC valve displacements shown in Figure 3 below.



Id. at FIG. 3.

123. In my opinion, a POSITA would have understood that modifying Ogawa's method to calculate EVO, EVC, IVO, and IVC commands to as part of calculating it valve timing command based on the teachings of Yoshioka would

“improve the output of an engine at high altitude under high load, as well as reducing fuel consumption and improving exhaust purifying performance at high altitudes under low/medium load.” Ex. 1006 at 1:44-49.

124. Additionally, in my opinion a POSITA would have easily been able to modify Ogawa to calculate an EVO, EVC, IVO, and IVC command based on the teachings of Yoshioka. A POSITA would have understood that Ogawa’s ECU calculates a target valve timing displacement VTCCMD. Ex. 1006 at ¶¶ 0070, 0116. Aa POSITA would easily be able to modify the software running on Ogawa’s ECU calculate an EVO, EVC, IVO, and IVC command based on the target displacement VTCCMD as taught by Yoshioka.

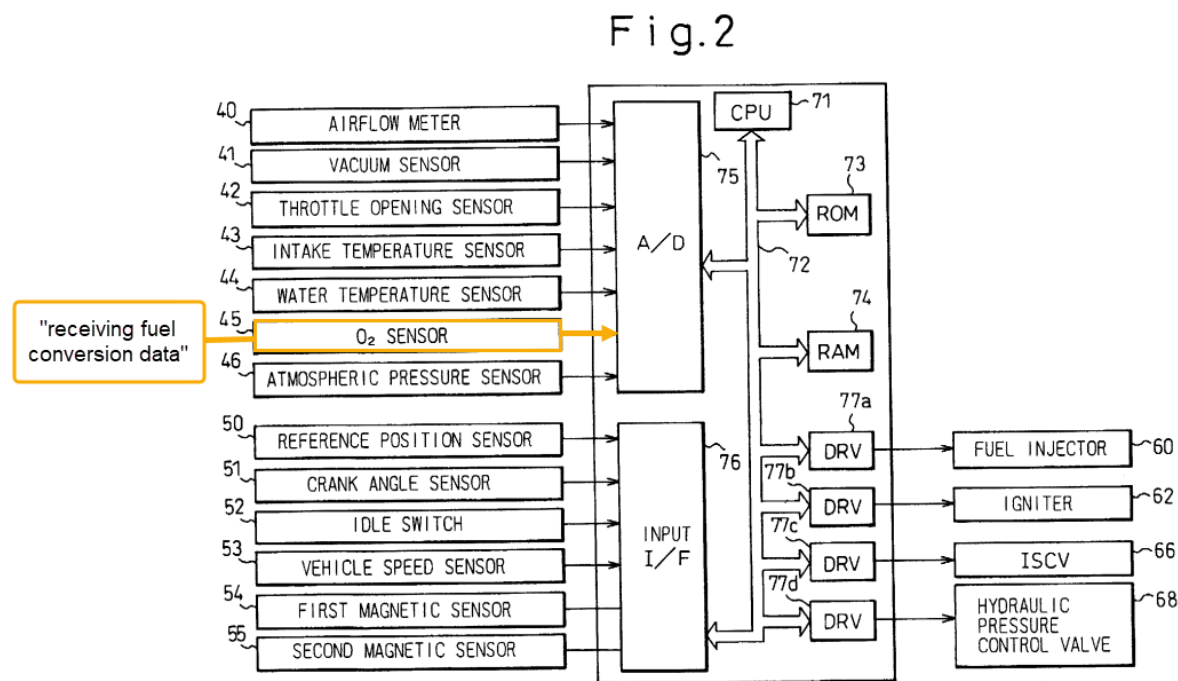
125. Accordingly, in my opinion Ogawa in view of Yoshioka discloses claim 10.

F. Claim 11: “The method of claim 1 further comprising receiving fuel conversion data.”

126. In my opinion, Ogawa in view of Yoshioka discloses the method of claim 1 further comprising receiving fuel conversion data.

127. As explained above, in my opinion Ogawa in view of Yoshioka discloses the method of claim 1. Yoshioka further teaches “an air-fuel ratio feedback correction according to a signal from [an] O₂ sensor 45” that “detect[s] the concentration of the oxygen in the exhaust gas,” i.e., fuel conversion data. Ex.

1006 at 4:48-52, 5:24-30, 5:48-54. As shown in annotated Figure 2 below, Yoshioka's ECU receives the fuel conversion data from the O₂ sensor:



Id. at FIG. 2 (annotated).

128. Yoshioka discloses the '540 patent's preferred embodiment of receiving fuel conversion data. The '540 patent teaches that the "action of receiving fuel conversion data . . . preferably include[s] receiving the fuel conversion data . . . from suitable emission sensors . . . in the . . . exhaust port of the engine." Ex. 1001 at 3:27-34. Yoshioka discloses an O₂ sensor located in the system's exhaust pipe from which the ECU receives a measured concentration of oxygen in the engine's exhaust gas. Ex. 1006 at 4:48-52, 5:24-30, 5:48-54.

129. Additionally, in my opinion a POSITA would have understood that modifying Ogawa's ECU to receive fuel conversion data from an O₂ sensor located in the engine's tail pipe based on the teachings of Yoshioka would "improve the output of an engine at high altitude under high load, as well as reducing fuel consumption and improving exhaust purifying performance at high altitudes under low/medium load." Ex. 1006 at 1:44-49.

130. In my opinion a POSITA also would have easily been able to modify Ogawa based on Yoshioka's teachings regarding an O₂ sensor. A POSITA would have recognized that Ogawa's ECU already receives numerous signals from sensors disposed throughout Ogawa's system, and that the ECU could be modified to receive a signal from an O₂ sensor placed in the system's exhaust pipe. A POSITA would easily be able to modify the software of Ogawa's ECU to read the data from the O₂ sensor based on the teachings of Yoshioka.

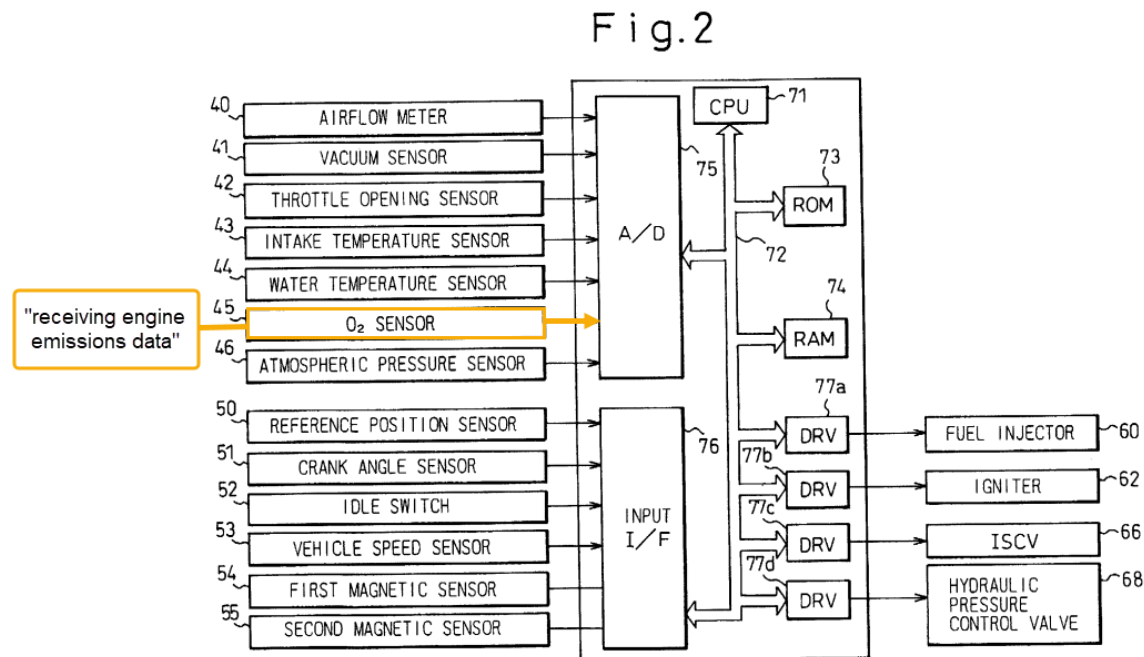
131. Accordingly, in my opinion Ogawa in view of Yoshioka renders obvious claim 11.

G. Claim 14: "The method of claim 1 further comprising receiving engine emissions data."

132. In my opinion, Ogawa in view of Yoshioka discloses the method of claim 1 further comprising receiving engine emissions data.

133. As explained above, in my opinion Ogawa in view of Yoshioka discloses the method of claim 1. Yoshioka further teaches "an air-fuel ratio

feedback correction according to a signal from [an] O₂ sensor 45” that “detect[s] the concentration of the oxygen in the exhaust gas,” *i.e.*, engine emissions data. Ex. 1006 at 4:48-52, 5:24-30, 5:48-54. As shown in annotated Figure 2 below, Yoshioka’s ECU receives the fuel conversion data from the O₂ sensor:



Id. at FIG. 2 (annotated).

134. Yoshioka discloses the '540 patent's preferred embodiment of receiving fuel conversion data. The '540 patent describes the “action of receiving . . . engine emissions data . . . preferably include[s] receiving the . . . engine emissions data from suitable emissions sensors . . . in the . . . exhaust port of the engine.” Ex. 1001 at 3:27-34. Yoshioka discloses an O₂ sensor located in the

system's exhaust pipe from which the ECU receives a measured concentration of oxygen in the engine's exhaust gas. Ex. 1006 at 4:48-52, 5:24-30, 5:48-54.

135. Additionally, in my opinion a POSITA would have understood that modifying Ogawa's ECU to receive engine emissions data from an O₂ sensor located in the engine's tail pipe based on the teachings of Yoshioka would "improve the output of an engine at high altitude under high load, as well as reducing fuel consumption and improving exhaust purifying performance at high altitudes under low/medium load." Ex. 1006 at 1:44-49.

136. In my opinion a POSITA also would have easily been able to modify Ogawa based on Yoshioka's teachings regarding an O₂ sensor. A POSITA would have recognized that Ogawa's ECU already receives numerous signals from sensors disposed throughout Ogawa's system, and that the ECU could be modified to receive a signal from an O₂ sensor placed in the system's exhaust pipe. A POSITA would easily be able to modify the software of Ogawa's ECU to read the data from the O₂ sensor based on the teachings of Yoshioka.

137. Accordingly, in my opinion Ogawa in view of Yoshioka renders obvious claim 14.

XII. GROUND 2: THE COMBINATION OF YOSHIOKA, OGAWA, AND JANKOVIC RENDERS OBVIOUS CLAIMS 1-2, 7, 10-11, AND 14.

In my opinion, a POSITA at the time of the alleged invention would have found claims 1-2, 7, 10-11, and 14 obvious over Yoshioka in view of Ogawa and

Jankovic.

A. Motivation to Combine Yoshioka with Ogawa

138. In my opinion, a POSITA in possession of Yoshioka's valve timing command calculating methods would have been motivated to obtain an engine performance command, determine a valve feedforward and valve feedback term based on that command, and receive a vehicle performance command based on the teachings of Ogawa.

139. A POSITA would have recognized that modifying Yoshioka's valve timing command calculation to calculate valve feedback and feedforward terms based on an engine performance command as taught by Ogawa would enable Yoshioka's system to "set[] a valve timing in accordance with an engine load even in the stratified combustion mode," and maintain fuel efficiency while "ensuring required engine power." Ex. 1005 at ¶¶ 0008, 0011. Additionally, Ogawa teaches that calculating valve feedforward and feedback terms based on an engine performance command ensures required engine power even when various engine operating conditions change, including throttle valve opening, intake pipe inner pressure, or the amount of intake air. Ex. 1005 at ¶¶ 0008, 0011. Ogawa teaches "determin[ing] a required torque PMCMD," *i.e.*, an engine performance command, based on and "accelerator pedal opening [signal] AP," "which is an operation amount of an accelerator pedal," *i.e.*, a vehicle performance command. Ex. 1005

at ¶¶ 0070, 0072. Ogawa teaches that its valve feedforward term VTCCMDMAP and valve feedback term DVTC are calculated based on the engine performance command PMCMD. Ex. 1005 at ¶¶ 0082, 0084, 0116.

140. Accordingly, in my opinion a POSITA would have been motivated to modify Yoshioka's valve timing command calculation methods based on the teachings of Ogawa to maintain fuel efficiency while setting valve timing in accordance with engine load, and to ensure required engine power during variable engine operating conditions. Ex. 1005 at ¶¶ 0008, 0011.

141. Further, a POSITA would be motivated to modify Yoshioka based on the teachings of Ogawa because they are both in the same field of endeavor as the '540 patent: controlling engine valve timing. Ex. 1001 at Abstract; Ex. 1005 at Abstract; Ex. 1006 at Abstract. Yoshioka and Ogawa both also use similar techniques to solve the same problem as the '540 patent. Yoshioka discloses nearly all of the limitations of claims 1-2, 7, 10, 11, and 14, and Ogawa discloses obtaining an engine performance command, determining a valve feedforward term based on the engine performance command, calculating a valve feedback term based on the engine performance command, and receiving a vehicle performance command from a driver of the vehicle and deriving the engine performance command based on the vehicle performance command as claimed in claims 1 and 2.

142. In my opinion, a POSITA also would have had a reasonable expectation of success of modifying Yoshioka's valve timing control methods based on Ogawa's teachings, including because Yoshioka's ECU already receives data from a "throttle sensor 42" that "detects the opening of the throttle valve 5," which a POSITA would understand is indicative of accelerator position, which Ogawa teaches can be used to calculate a desired engine torque engine performance command. Ex. 1006 at 4:20-21. A POSITA also would easily be able to modify the software running on Yoshioka's ECU to determine the desired engine torque engine performance command from the throttle opening data, which is indicative of accelerator position, and subsequently use the engine performance command to calculate a valve feedforward and valve feedback term.

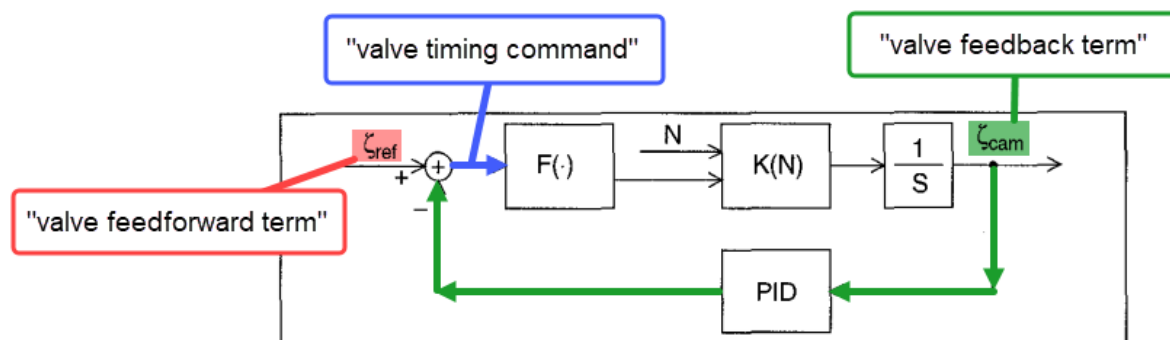
B. Motivation to Combine Yoshioka and Ogawa with Jankovic

143. In my opinion, a POSITA in possession of Yoshioka's methods for calculating valve timing commands, modified based on the teachings of Ogawa, would additionally have been motivated to modify the Yoshioka-Ogawa combination based on the teachings of Jankovic to calculate the valve timing command based on a valve feedforward term and a valve feedback

144. A POSITA would have recognized that Yoshioka teaches calculating a valve timing command from a valve feedback and valve feedforward term. As explained with respect to claim 1 below, Yoshioka teaches calculating IVTDt, a

valve feedforward term, using feedback control to bring the displacement of the intake valve to the target displacement, which would involve calculating a valve feedback term. Yoshioka further discloses that the valve feedforward term $IVTD_t$ and feedback control are used to generate control signals for a hydraulic control valve to bring the actual displacement of the intake valve to the target displacement. Ex. 1006 at 8:5-7. A POSITA would understand that Yoshioka's hydraulic control valve control signals disclose calculating a valve timing command.

145. Additionally, in my opinion a POSITA would have understood that, even if Yoshioka's system did not disclose a valve timing command, modifying Yoshioka's valve timing control method to use a feedback loop that calculates a valve timing command based on a feedforward and feedback term based on the teachings of Jankovic would provide various benefits, including reducing emissions and optimize valve timing during variable engine operating conditions. Ex. 1007 at 34. Jankovic discloses controlling a valve cam shaft phase via a calculated cam phasing command, *i.e.*, a valve timing command. Ex. 1007 at 36, 40, 41. As shown in annotated Figure 8 below, Jankovic's system determines its valve timing command based on a valve feedback term cam position ζ_{cam} and a valve feedforward term, the previously calculated ζ_{ref} , using a "feedback loop."



Id. at FIG. 8 (annotated).

146. Accordingly, a POSITA would have been motivated to modify Yoshioka's valve timing calculation method to use a feedback loop that includes based on a valve feedforward term and a valve feedback term to reduce the system's emissions and optimize valve timing during variable engine operating conditions. Ex. 1007 at 34.

147. A POSITA also would be motivated to modify Yoshioka based on the teachings of Jankovic because they are both in the same field of endeavor as the '540 patent: controlling engine valve timing. Ex. 1001 at Abstract; Ex. 1006 at Abstract; Ex. 1007 at 34-45. Yoshioka and Jankovic also both use similar techniques to solve the same problem as the '540 patent. Yoshioka discloses nearly all of the limitations of claims 1-2, 7, 10, 11, and 14, and Jankovic discloses calculating a valve timing command based on a valve feedforward and valve feedback term as claimed in claim 1.

148. In my opinion, a POSITA also would have had a reasonable expectation of success of modifying Yoshioka's valve timing control methods based on

Jankovic's teachings, including because Yoshioka already discloses calculating a valve feedforward and valve feedback term, and determining a valve timing command based on those terms. Ex. 1006 at 8:5-7. Even if Yoshioka did not disclose determining a valve timing command, a POSITA would have easily been able to modify the software running on Yoshioka's ECU to calculate a valve timing command based on the valve feedforward term and valve feedback term using a feedback loop based on the teachings of Jankovic.

C. Claim 1

1. 1[pre]: "A method for calculating a valve timing command for an engine of a vehicle, comprising:"

149. In my opinion, Yoshioka discloses a method for calculating a valve timing command for an engine vehicle. Yoshioka discloses a method for "control[ling] a continuously variable valve timing mechanisms of [a vehicle's] internal combustion engine to continuously and variably control the timing of an intake valve." Ex. 1006 at Abstract, 4:38-47. Yoshioka teaches calculating a target valve displacement IVTDt and a control signal to a hydraulic valve control that brings the displacement of the engine's intake valve to the target displacement, *i.e.*, a valve timing command. *Id.* at 8:5-7.

150. Accordingly, in my opinion Yoshioka discloses the preamble of claim 1.

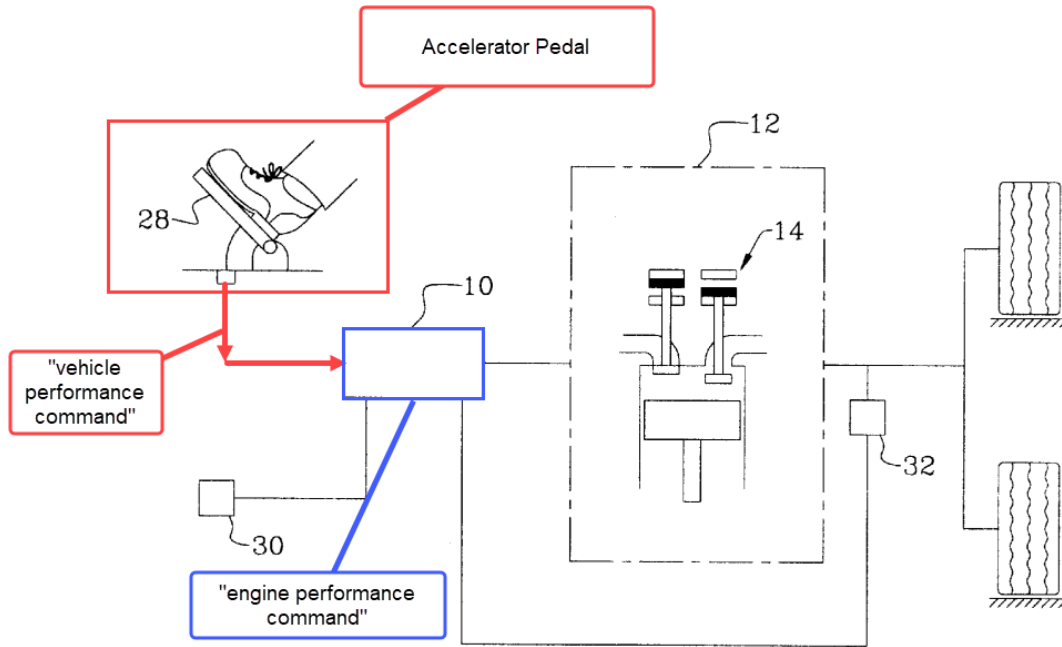
2. 1[a]: “obtaining an engine performance command;”

151. In my opinion, Yoshioka in view of Ogawa discloses obtaining an engine performance command.

152. In my opinion, Ogawa discloses obtaining an engine performance command. Ogawa teaches “determin[ing] a required torque PMCMD [to be] output[] by the engine 3,” (i.e., an engine performance command), based on “accelerator pedal opening AP,” “which is an operation amount of an accelerator pedal.” Ex. 1005 at ¶¶ 0070, 0072. Accordingly, Ogawa discloses a “command,” PMCMD, “that defines a desired engine torque.” Further, the ’540 patent teaches that desired torque is one example of an “engine performance command.” Ex. 1001 at 2:17-18 (“The engine performance command is preferably a desired engine torque”).

153. In fact, Ogawa’s derivation of an engine performance command that represents desired engine torque based on an accelerator pedal opening signal discloses the ’540 patent’s preferred embodiment of obtaining an engine performance command. The ’540 patent teaches that “[t]he action of obtaining an engine performance command . . . preferably includes deriving the engine performance command from the vehicle performance command,” where “the vehicle performance command is received from the foot of a driver with the use of a conventional pedal.” Ex. 1001 at 2:4-22. Ogawa similarly discloses receiving the

“accelerator pedal opening [signal] AP” from an accelerator pedal controlled by the driver that is used to “determine a required torque PMCMD,” *i.e.*, the engine performance command. Ex. 1005 at ¶¶ 0011, 0070, 0072.



Ex. 1001 at FIG. 1 (annotated).

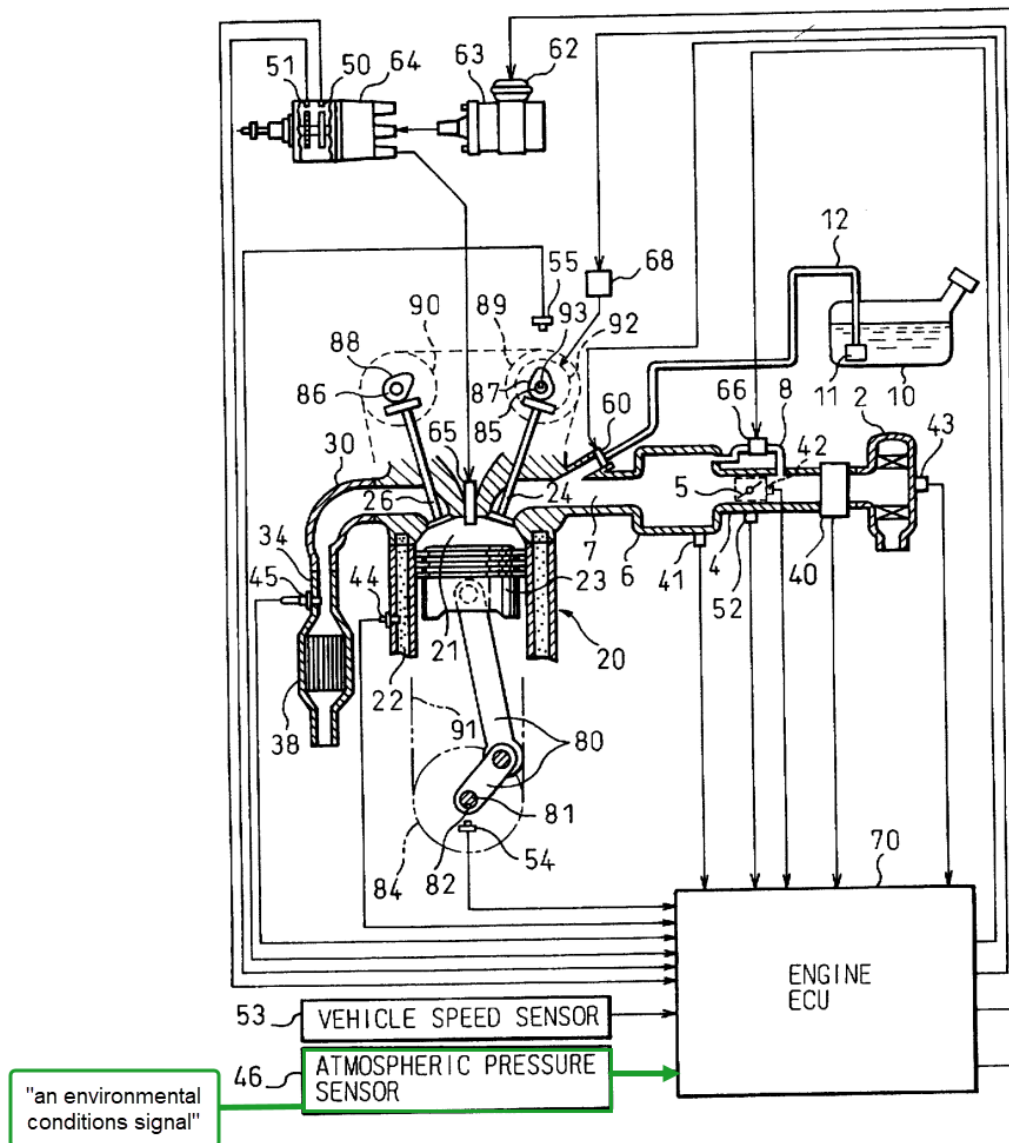
would understand Yoshioka's valve opening data is indicative of accelerator position, which Ogawa teaches can be used to calculate a desired engine torque engine performance command. A POSITA also would easily be able to modify the software running on Yoshioka's ECU to determine the desired engine torque engine performance command from the throttle opening data, which is indicative of accelerator position, and engine rotational speed, as taught by Ogawa, and subsequently use the engine performance command to calculate a valve feedforward and valve feedback term.

156. Accordingly, in my opinion Yoshioka in view of Ogawa renders obvious claim limitation 1[c].

3. 1[b]: “receiving an environmental conditions signal;”

157. In my opinion, Yoshioka discloses receiving an environmental conditions signal.

158. As shown in annotated Figure 1 below, Yoshioka teaches an ECU that receives “an atmospheric pressure [signal] PA detected by [an] atmospheric pressure sensor 46.” Ex. 1006 at 7:24-25.



Id. at FIG. 1 (annotated).

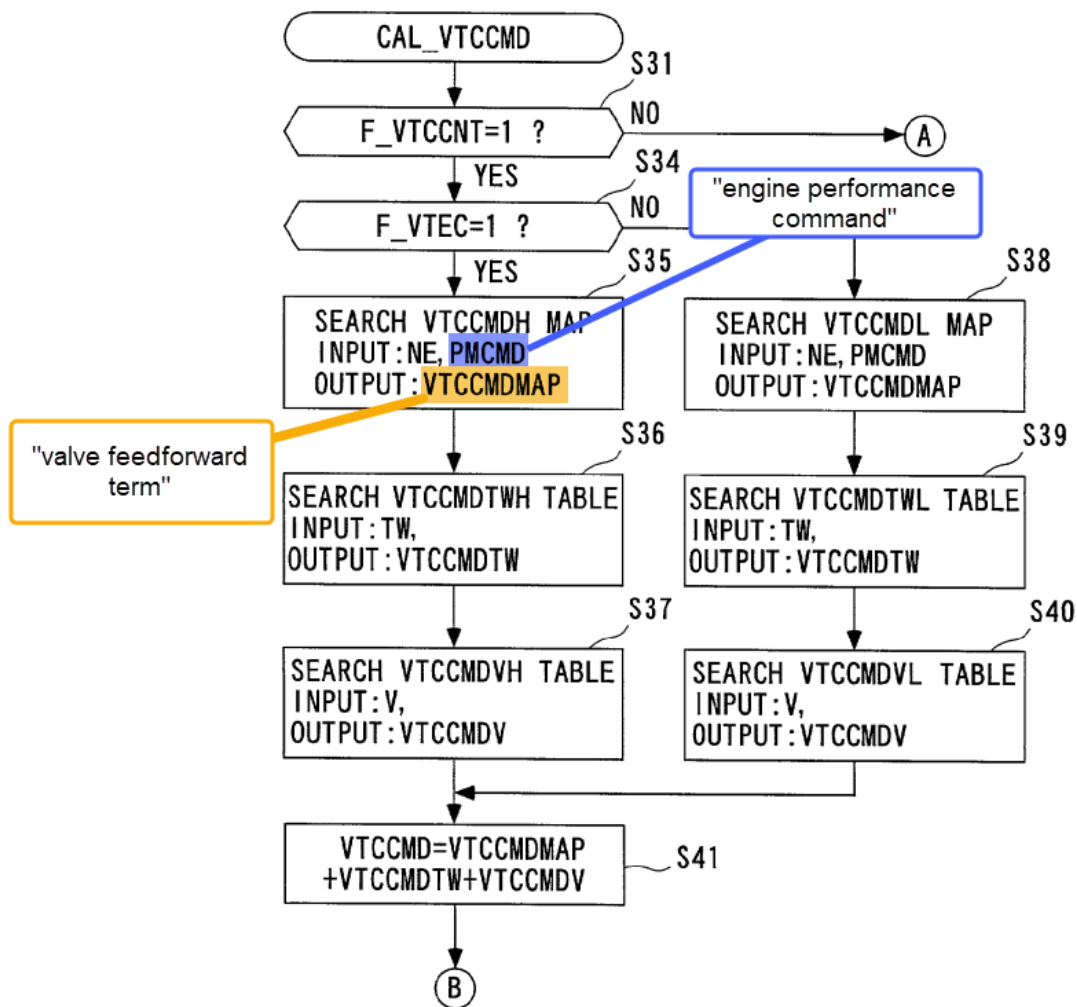
159. Yoshioka's atmospheric pressure sensor and signal disclose the '540 patent's preferred embodiment of an environmental conditions signal. Ex. 1001 at 2:23-35 ("The action of receiving an environmental conditions signal 18 preferably includes receiving an environmental conditions signal from an environmental sensor . . . such as ambient pressure.").

160. Accordingly, in my opinion Yoshioka discloses limitation 1[b].

4. 1[c]: “determining a valve feedforward term based on the engine performance command and the environmental conditions signal;”

161. In my opinion, Yoshioka in view of Ogawa discloses determining a valve feedforward term based on the engine performance command and the environmental conditions signal.

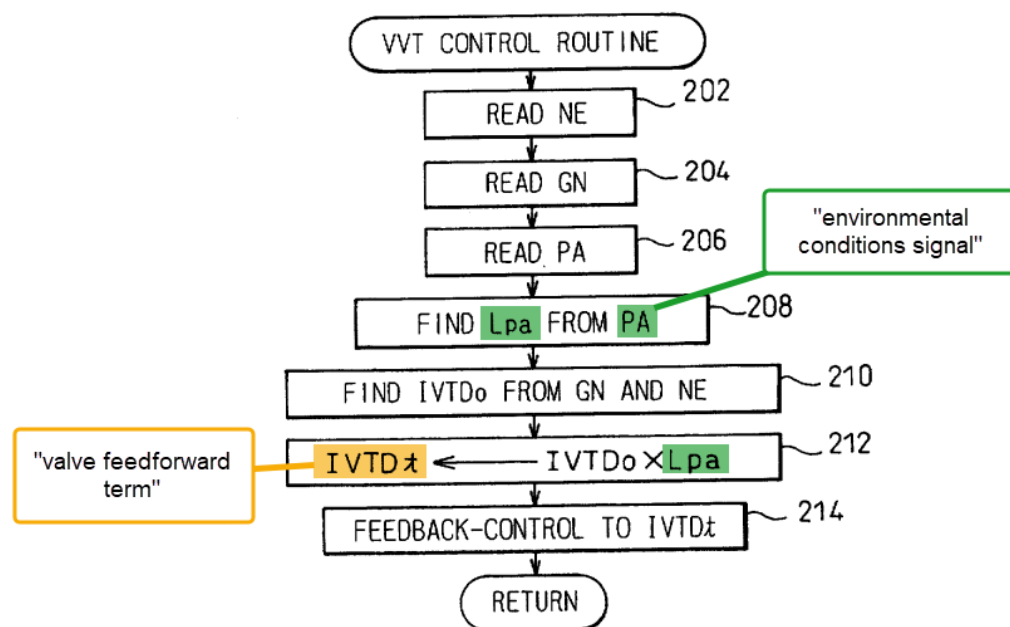
162. As explained in Sections XII.B.2 and 3 above, Ogawa teaches obtaining a desired engine torque PMCMD, which discloses an engine performance, and receiving an atmospheric pressure signal, which discloses an environmental conditions signal. Ogawa also discloses calculating a basic value target valve cam phase VTCCMDMAP, *i.e.*, a valve feedforward term. Ex. 1005 at ¶ 0082. As shown in annotated Figure 3 below, Ogawa teaches that VTCCMDMAP is calculated based on “the required torque PMCMD,” *i.e.*, the engine performance command, and engine speed NE. *Id.* at ¶¶ 0082, 0084, 0116.



Id. at FIG. 3 (annotated).

163. Additionally, Yoshioka discloses determining a target valve timing displacement IVTDt, *i.e.*, a valve feedforward term. Ex. 1006 at 7:41-45. Yoshioka calculates IVTDt based on correction coefficient Lpa, which is itself determined by atmospheric pressure signal PA, *i.e.*, an environmental conditions signal. Ex. 1006 at 7:57-60. Yoshioka discloses calculating an initial valve

displacement IVTD0 based on engine speed NE and engine load GN. *Id.* at 7:63-67. Finally, as shown in annotated Figure 9 below, Yoshioka uses inputs IVTD0 and Lpa to calculate valve feedforward term IVTDt. *Id.* at 8:1-5.



Id. at FIG. 9 (annotated).

164. A POSITA would have recognized that modifying Yoshioka's method based on the teachings of Ogawa to obtain an engine performance command and calculate a valve feedforward term based on that command would enable Yoshioka's method to "set[] a valve timing in accordance with the required torque, i.e., the load," and thus the valve timing would not be affected by "intake pipe inner pressure, amount of intake air, and so on." Ex. 1005 at ¶¶ 0008, 0011. By using a method as taught by Ogawa, Yoshioka's system can ensure required engine power. Ex. 1005 at ¶¶ 0008, 0011.

165. A POSITA also would have easily been able to modify Yoshioka's valve timing control method based on Ogawa's teachings. A POSITA would have recognized that Yoshioka discloses an ECU that receives information from a "throttle sensor 42" that "detects the opening of the throttle valve 5," which is indicative of accelerator position. Ex. 1006 at 4:20-21. This is the exact type of data Ogawa teaches deriving an engine performance command from. Further, a POSITA would have easily been able to modify software running on Yoshioka's ECU to first calculate a desired engine torque from the throttle opening data, which is indicative of accelerator position, and engine rotational speed, and to subsequently calculate a valve feedforward term on that desired engine torque as taught by Ogawa.

166. Accordingly, in my opinion Yoshioka in view of Ogawa renders obvious claim limitation 1[c].

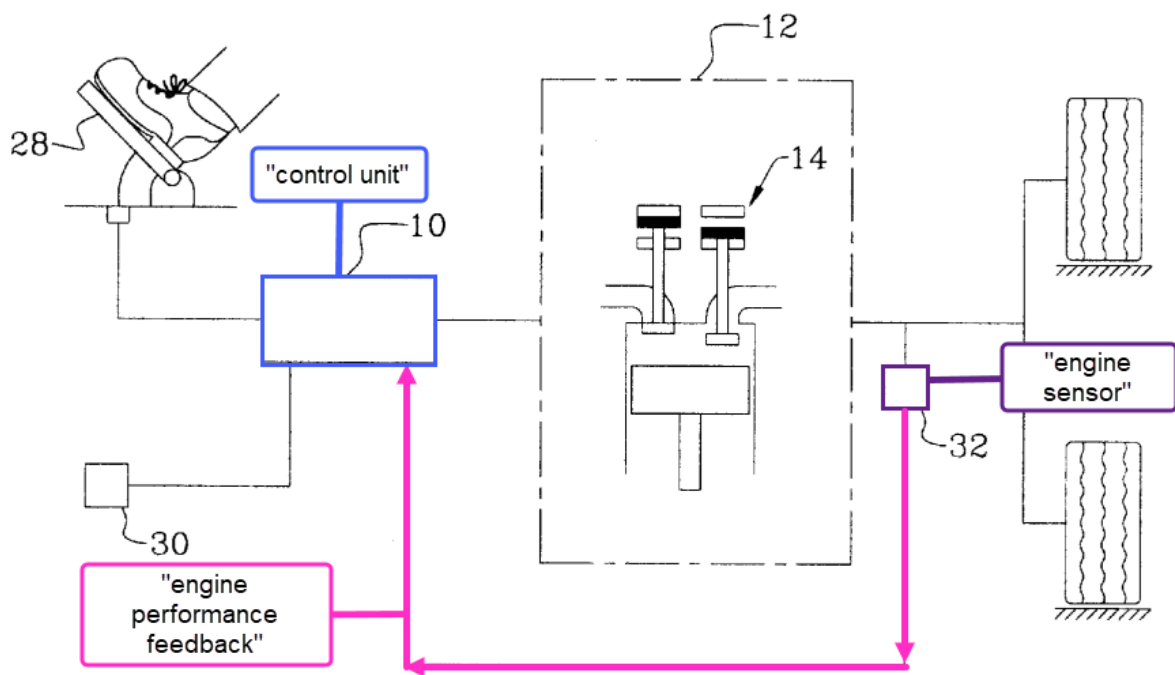
5. 1[d]: "receiving an engine performance feedback;"

167. In my opinion, Yoshioka discloses receiving an engine performance feedback.

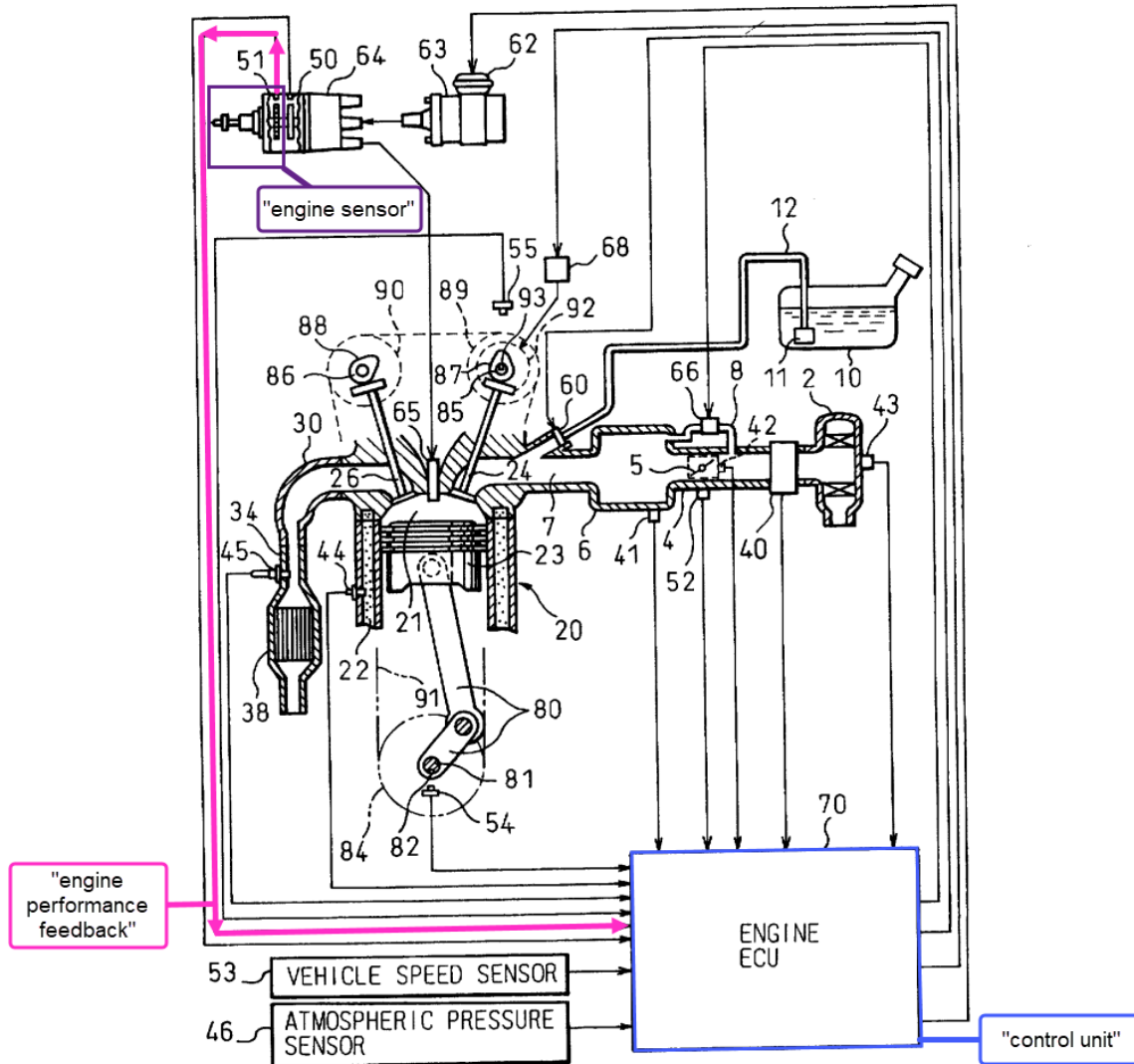
168. Yoshioka teaches detecting "an engine revolution speed" from a "crank angle sensor 51 [that] generates a position pulse," *i.e.*, an engine performance feedback. Ex. 1006 at 4:42-43, 5:43-46. Yoshioka discloses a crank angle sensor that "generates a position pulse for every 30 degrees of crank angle." *Id.* at 4:42-

43. Yoshioka's teaches using the crank angle sensor's position pulse to calculate engine speed. *Id.* at 5:43-46.

169. As shown in annotated Figure 1 from the '540 patent and annotated Figure 1 from Yoshioka below, Yoshioka's crank angle sensor and subsequent output signal disclose the '540 patent's preferred embodiment of an engine performance feedback. The '540 patent teaches that "receiving an engine performance feedback 22 preferably includes receiving the engine performance feedback from an engine sensor 32 in the vehicle" that "preferably senses the engine speed." Ex. 1001 at 2:36-42. Just like the '540 patent's preferred embodiment, Yoshioka teaches a crank angle sensor, *i.e.*, an engine sensor, that outputs a position pulse signal for every 30 degree change in the crank angle, *i.e.*, the engine performance feedback, from which Yoshioka's ECU calculates engine speed. Ex. 1006 at 4:42-43, 5:43-46.



Ex. 1001 at FIG. 1 (annotated).



Ex. 1006 at FIG. 1 (annotated).

170. Accordingly, Yoshioka discloses limitation 1[d].

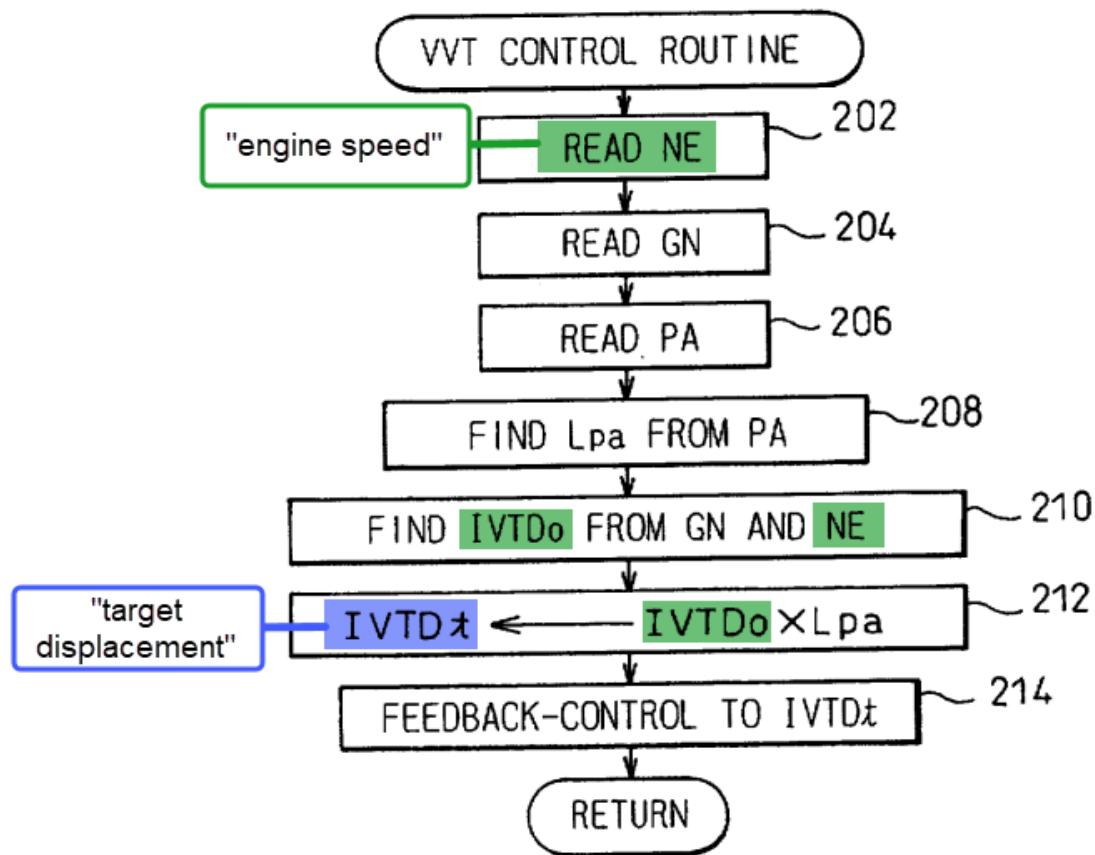
6. 1[e]: “calculating a valve feedback term based on the engine performance command and the engine performance feedback; and”

171. In my opinion, Yoshioka in view of Ogawa discloses calculating a valve feedback term based on the engine performance command and the engine performance feedback.

172. The claims of the '540 patent do not place any restriction on the method for calculating the “valve feedback term.” The '540 patent teaches that one example of calculating the valve feedback term comprises “compar[ing] [an] input with [an] output and [] calculat[ing] a correction term based on the difference.” Ex. 1001 at 2:66-3:4.

173. Yoshioka discloses the '540 patent's exemplary method for calculating a “valve feedback term.” As shown in annotated Figure 9 below, Yoshioka teaches that performing valve timing control via “feedback-control [of] the hydraulic pressure control valve 68.” Ex. 1006 at 6:6-15; 7:41-45. Yoshioka discloses calculating a target displacement IVTDt and subsequently using feedback-control—which involves calculating a valve feedback term—“[t]o bring the displacement of the intake valve 23 to the target displacement IVTDt.” *Id.* at 8:5-7.

174. Additionally, Yoshioka discloses using its engine performance feedback as an input to calculate its valve feedback term. Yoshioka's teaches calculating a valve feedback term based on target displacement IVTDt. *Id.* at 8:5-7. As shown in annotated Figure 9 below, engine speed NE is an input to calculating target displacement IVTDt.

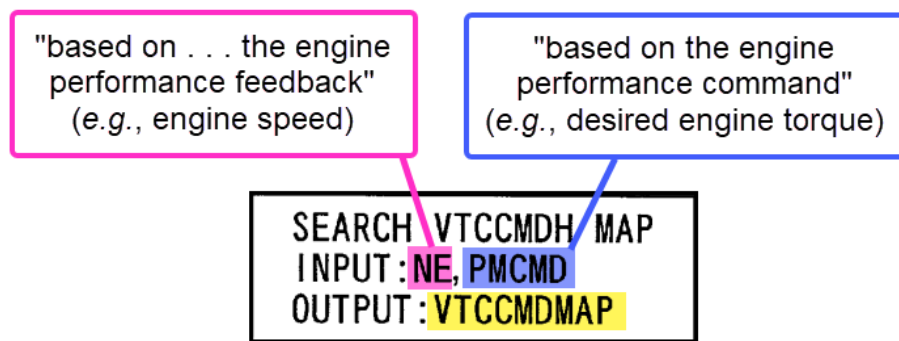


Id. at FIG. 9 (annotated).

175. Engine speed NE is itself calculated based on Yoshioka's engine performance feedback: the pulse signal output from Yoshioka's crank angle sensor. *Id.* at FIG. 9, 4:42-43, 5:43-46. Accordingly, Yoshioka discloses calculating a valve feedback term based on engine performance feedback.

176. Ogawa also teaches calculating its basic value target valve displacement VTCCMDMAP based on the engine performance command PMCMD. As explained above with regards to claim limitation 1[a], Ogawa teaches receiving a desired engine torque PMCMD, *i.e.*, an engine performance command. As

shown in annotated Figure 3 below, Ogawa teaches that its target cam phase VTCCMDMAP is calculated based on the engine performance command PMCMD. *Id.* at ¶ 0084.



Id. at FIG. 3 (annotated).

177. A POSITA would have recognized that modifying Yoshioka's method based on the teachings of Ogawa to calculate its target valve displacement based on an engine performance command would enable Yoshioka's system to maintain fuel efficiency while setting valve timing in accordance with engine load, and to ensure required engine power during variable engine operating conditions. Ex. 1005 at ¶¶ 0008, 0011.

178. A POSITA also would have easily been able to modify Yoshioka based on the teachings of Ogawa. Yoshioka discloses calculating a target displacement. Ex. 1006 at FIG. 9, 4:42-43, 5:43-46. Ogawa teaches that a target valve displacement can be calculated based on an engine performance command and engine rotational speed. Ex. 1005 at ¶ 84. A POSITA would have easily been

able to modify the software running on Yoshioka's ECU to calculate its target valve displacement based on the engine performance command and engine rotational speed as taught by Ogawa.

179. Accordingly, in my opinion Yoshioka in view of Ogawa renders obvious limitation 1[e].

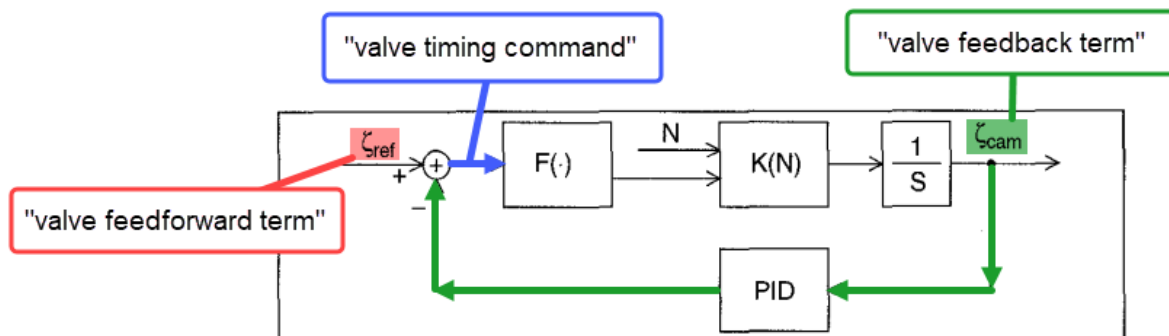
7. 1[f]: “calculating a valve timing command based on the valve feedforward term and the valve feedback term”

180. In my opinion, Yoshioka discloses calculating a valve timing command based on the valve feedforward term and the valve feedback term.

181. As explained with regards to claim limitations 1[c] and 1[e] above, Yoshioka teaches calculating a valve feedforward term IVTDt and a valve feedback term to adjust the intake valve displacement to the target displacement. Yoshioka also discloses calculating control signals for the hydraulic control valve 68 to bring the actual displacement of the intake valve to the target displacement, *i.e.*, a valve timing command, based on IVTDt, *i.e.*, the valve feedforward term, and the feedback control, *i.e.*, the valve feedback term. Ex. 1006 at 8:5-7.

182. Additionally, even if Yoshioka did not disclose calculating a valve timing command, Jankovic discloses controlling a valve cam shaft phase via a calculated cam phasing command, *i.e.*, a valve timing command. Ex. 1007 at 36, 40, 41. As shown in annotated Figure 8 below, Jankovic's system determines its

valve timing command based on a valve feedback term cam position ζ_{cam} and a valve feedforward term, the previously calculated ζ_{ref} , using a “feedback loop.”



Id. at FIG. 8 (annotated).

183. A POSITA would have recognized a POSITA would have understood that modifying Yoshioka’s valve timing control method to use a feedback loop that calculates a valve timing command based on a feedforward and feedback term based on the teachings of Jankovic would provide various benefits, including reducing emissions and optimize valve timing during variable engine operating conditions. Ex. 1007 at 34.

184. Moreover, a POSITA would have been able to easily modify the combination of Yoshioka based on Jankovic’s teachings. A POSITA would have understood that Yoshioka discloses calculating a valve feedforward term and a valve feedback term, and that, even if Yoshioka did not disclose calculating a valve timing command, the software running on Yoshioka’s ECU could easily be modified to implement a feedback loop to calculate a valve timing command based on the valve feedforward term and valve feedback term based on the teachings of Jankovic.

185. Accordingly, in my opinion Yoshioka in view of Jankovic renders obvious limitation 1[f].

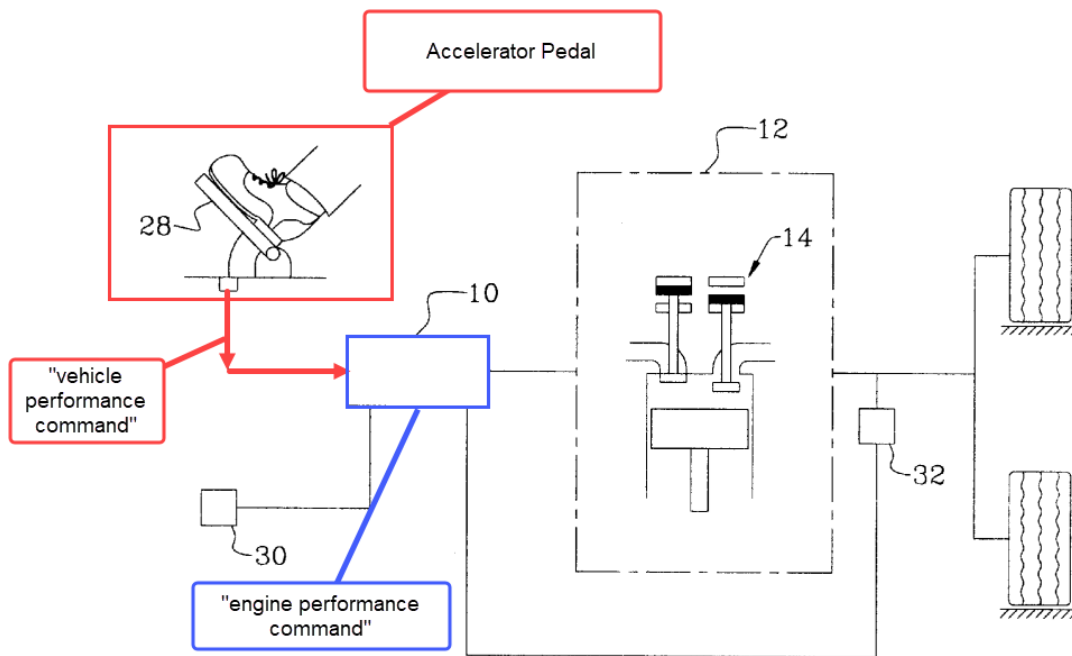
D. Claim 2: “The method of claim 1 wherein said obtaining an engine performance command includes receiving a vehicle performance command from a driver of the vehicle and deriving the engine performance command based on the vehicle performance command.”

186. In my opinion, Yoshioka in view of Ogawa and Jankovic discloses the method of claim 1 wherein said obtaining an engine performance command includes receiving a vehicle performance command from a driver of the vehicle and deriving the engine performance command based on the vehicle performance command.

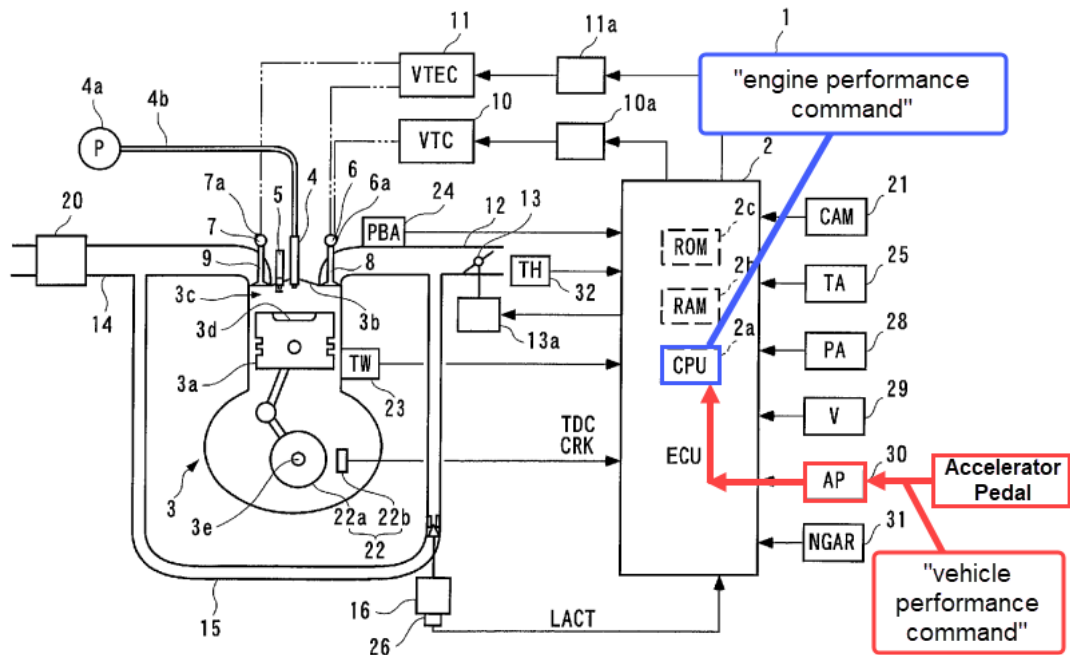
187. As explained above, in my opinion Yoshioka in view of Ogawa and Jankovic discloses the method of claim 1. Ogawa further discloses “determin[ing] a required torque PMCMD,” *i.e.*, an engine performance command, from an “accelerator pedal opening [signal] AP,” “which is an operation amount of an accelerator pedal,” *i.e.*, a vehicle performance command. Ex. 1005 at ¶¶ 0070, 0072. The ’540 specification teaches that desired torque is one example of an “engine performance command,” and that a signal “received from the foot of a driver with the use of a conventional pedal” is one example of a “vehicle performance command.” Ex. 1001 at 2:4-18.

188. Ogawa’s derivation of an engine performance command that represents desired engine torque based on an accelerator pedal opening signal discloses the ’540

patent's preferred embodiment of obtaining an engine performance command. The '540 patent teaches that "[t]he action of obtaining an engine performance command . . . preferably includes deriving the engine performance command from the vehicle performance command," where "the vehicle performance command is received from the foot of a driver with the use of a conventional pedal." Ex. 1001 at 2:4-22. Ogawa similarly discloses receiving the "accelerator pedal opening [signal] AP" from an accelerator pedal controlled by the driver that is used in conjunction with engine rotational speed to "determine a required [engine] torque PMCMD," *i.e.*, the engine performance command. Ex. 1005 at ¶¶ 0070, 0072.



Ex. 1001 at FIG. 1 (annotated).



Ex. 1005 at FIG. 1 (annotated).

189. A POSITA would have understood that modifying Yoshioka's method to obtain an engine performance command based on receiving a vehicle performance command from a driver of the vehicle as taught by Ogawa would enable Yoshioka's system to "set[] a valve timing in accordance with an engine load even in the stratified combustion mode," and maintain fuel efficiency while "ensuring required engine power." Ex. 1005 at ¶¶ 0008, 0011.

190. Additionally, a POSITA also would have easily been able to modify Yoshioka's valve timing control methods based on Ogawa's teachings, including because Yoshioka's ECU already receives data from a "throttle sensor 42" that "detects the opening of the throttle valve 5." Ex. 1006 at 4:20-21. A POSITA would understand that throttle position is indicative of accelerator position, which

Ogawa teaches can be used to calculate a desired engine torque engine performance command. A POSITA also would easily be able to modify the software running on Yoshioka's ECU to determine the desired engine torque engine performance command from the throttle opening data, which is indicative of accelerator position, and subsequently use the engine performance command to calculate a valve feedforward and valve feedback term.

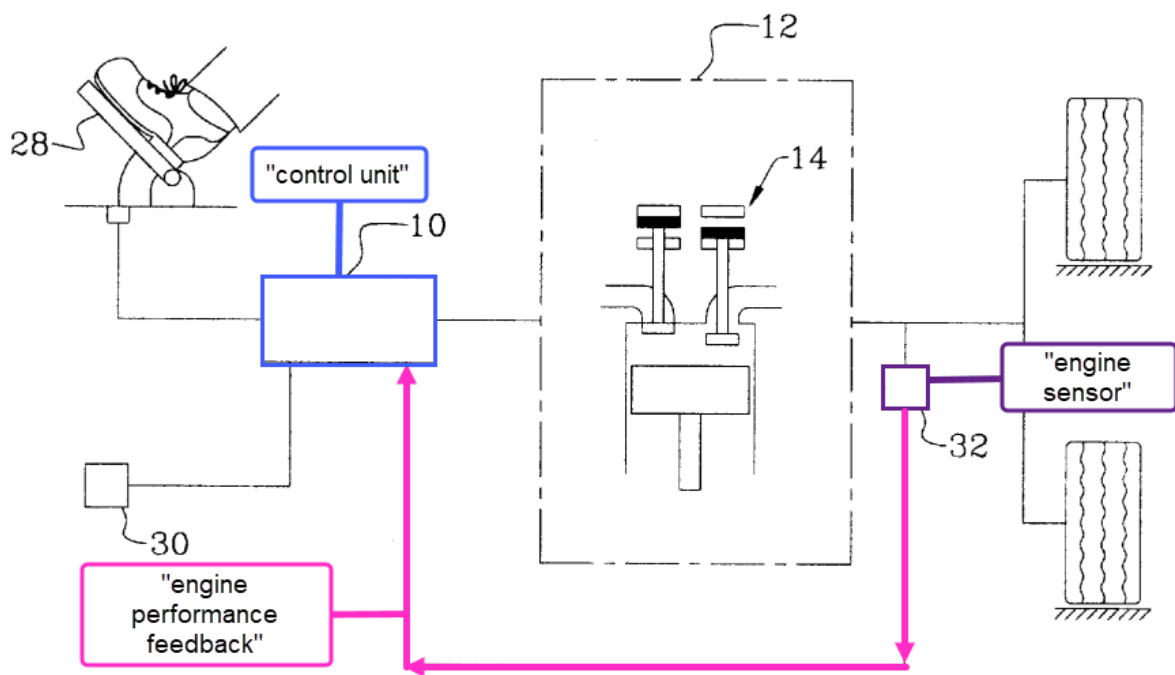
191. Accordingly, in my opinion Yoshioka in view of Ogawa and Jankovic renders obvious claim 2.

E. Claim 7: “The method of claim 1 wherein said receiving an engine performance feedback includes receiving engine speed data.”

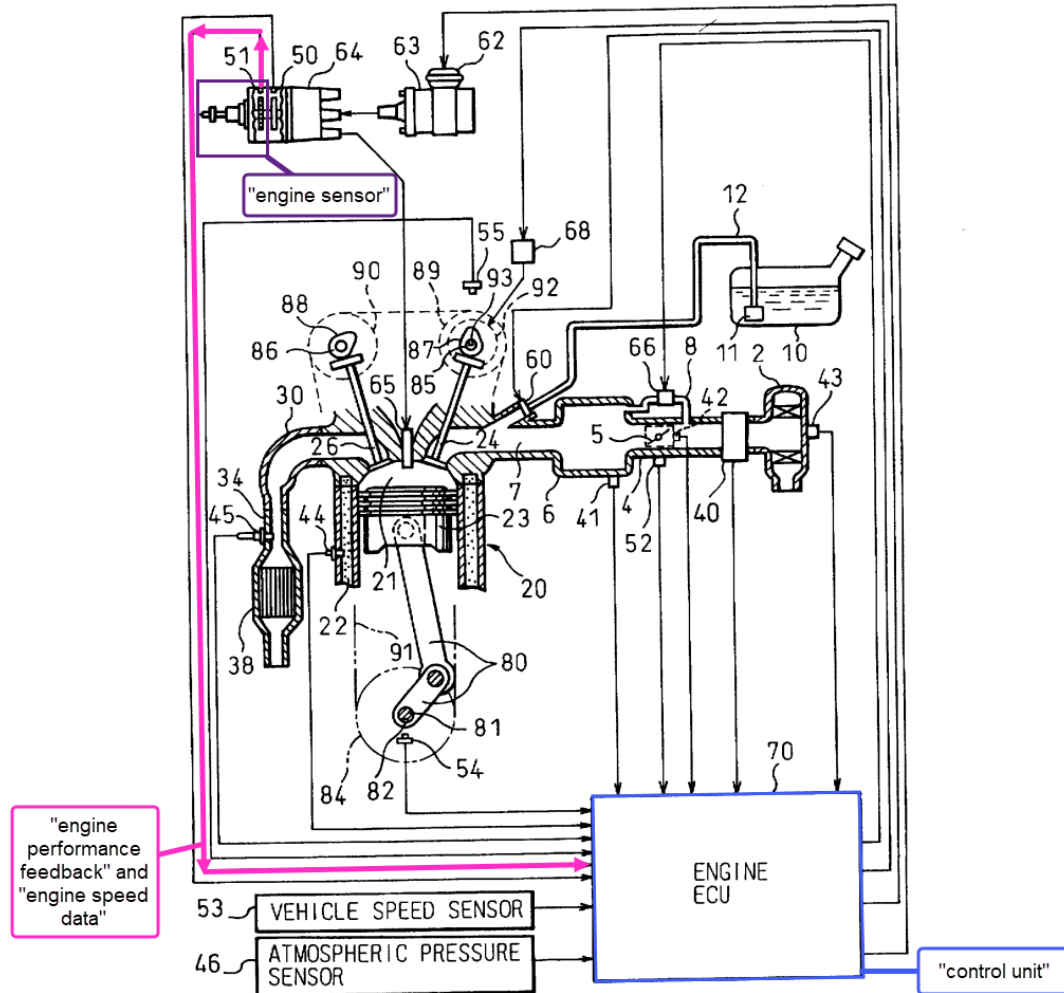
192. In my opinion, Yoshioka in view of Ogawa and Jankovic discloses the method of claim 1 wherein said receiving an engine performance feedback includes receiving engine speed data.

193. As explained above, in my opinion Yoshioka in view of Ogawa and Jankovic discloses the method of claim 1. Yoshioka additionally teaches detecting “an engine revolution speed” from a “crank angle sensor 51 [that] generates a position pulse,” *i.e.*, an engine performance feedback. Ex. 1006 at 4:42-43, 5:43-46. Yoshioka discloses a crank angle sensor that “generates a position pulse for every 30 degrees of crank angle.” *Id.* at 4:42-43. Yoshioka's teaches using the crank angle sensor's position pulse to calculate engine speed. *Id.* at 5:43-46.

194. As shown in annotated Figure 1 from the '540 patent and annotated Figure 1 from Yoshioka below, Yoshioka's crank angle sensor and subsequent output signal disclose the '540 patent's preferred embodiment of an engine performance feedback. The '540 patent teaches that "receiving an engine performance feedback 22 preferably includes receiving the engine performance feedback from an engine sensor 32 in the vehicle" that "preferably senses the engine speed." Ex. 1001 at 2:36-42. Just like the '540 patent's preferred embodiment, Yoshioka teaches a crank angle sensor, *i.e.*, an engine sensor, that outputs a position pulse signal for every 30 degree change in the crank angle, *i.e.*, the engine performance feedback, from which Yoshioka's ECU calculates engine speed. Ex. 1006 at 4:42-43, 5:43-46.



Ex. 1001 at FIG. 1 (annotated).



Id. at FIG. 1 (annotated).

195. Accordingly, in my opinion Yoshioka in view of Ogawa and Jankovic discloses claim 7.

F. **Claim 10: “The method of claim 1 wherein said calculating a valve timing command includes calculating an EVO command, an EVC/IVO command, and an IVC command.”**

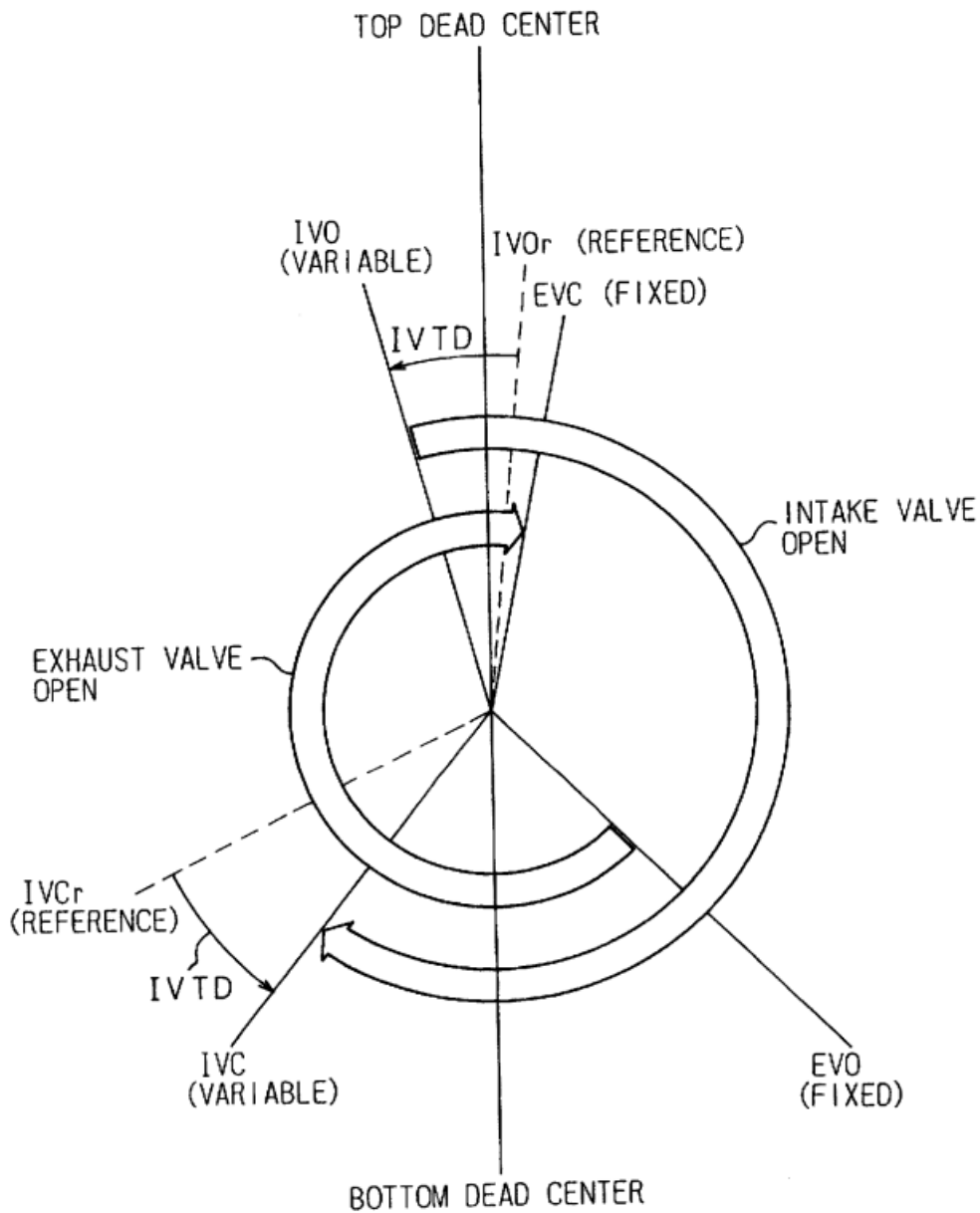
196. In my opinion, Yoshioka in view of Ogawa and Jankovic renders obvious the method of claim 1 wherein said calculating a valve timing command

includes calculating an EVO command, an EVC/IVO command, and an IVC command.

197. As explained above, in my opinion Yoshioka in view of Ogawa and Jankovic discloses the method of claim 1. Yoshioka further teaches calculating an EVO command, an EVC command, an IVO command, and an IVC command. Yoshioka teaches calculating “crank angles corresponding to the open/close timing of the intake and exhaust valves.” Ex. 1006 at 6:16-18. Yoshioka discloses “a fixed value open timing EVO,” *i.e.*, an EVO command (*Id.* at 6:18-19), and a “fixed valve close timing EVC,” *i.e.*, an EVC command (*Id.* at 6:18-22). The values correspond to opening and closing timings for Yoshioka’s exhaust valve. *Id.* at 6:18-22.

198. Yoshioka also teaches calculating a “variable valve opening timing IVO and close timing IVC,” *i.e.*, IVO and IVC commands, for its input valve. *Id.* at 6:22-24. Yoshioka further discloses that calculating the valve opening and closing timings because such open and closing as part of calculating its valve timing displacement IVTD, *i.e.*, the valve timing command, because the opening and closings are dependent on the valve timing displacement IVTD. *Id.* at 6:25-36. Accordingly, Yoshioka discloses calculating a valve timing command, IVTD, which includes calculating an EVO command, an EVC command, an IVO command, and

an IVC command. Yoshioka's EVO, EVC, IVO, and IVC valve displacements shown in Figure 3 below.



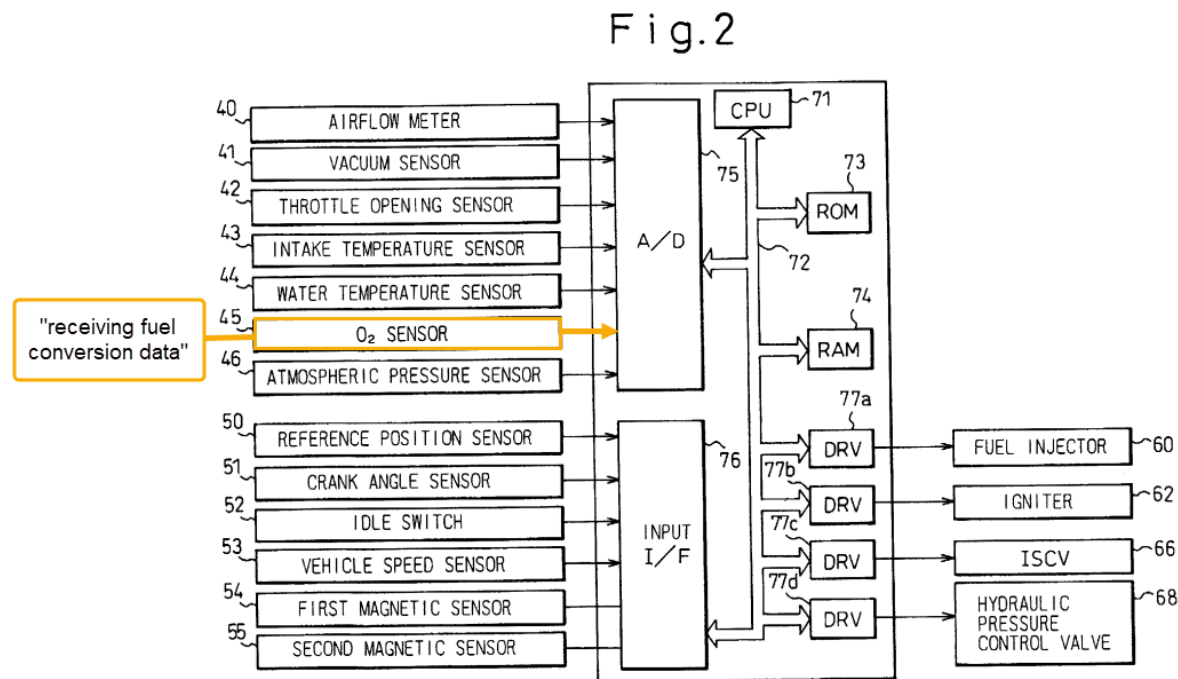
Id. at FIG. 3.

199. Accordingly, in my opinion Yoshioka in view of Ogawa and Jankovic discloses claim 10.

G. Claim 11: “The method of claim 1 further comprising receiving fuel conversion data.”

200. In my opinion, Yoshioka in view of Ogawa and Jankovic discloses the method of claim 1 further comprising receiving fuel conversion data.

201. As explained above, in my opinion Yoshioka in view of Ogawa and Jankovic discloses the method of claim 1. Yoshioka further teaches “an air-fuel ratio feedback correction according to a signal from [an] O₂ sensor 45” that “detect[s] the concentration of the oxygen in the exhaust gas,” *i.e.*, fuel conversion data. Ex. 1006 at 4:48-52, 5:24-30, 5:48-54. As shown in annotated Figure 2 below, Yoshioka’s ECU receives the fuel conversion data from the O₂ sensor:



Id. at FIG. 2 (annotated).

202. Yoshioka discloses the '540 patent's preferred embodiment of receiving fuel conversion data. The '540 patent teaches that the "action of receiving fuel conversion data . . . preferably include[s] receiving the fuel conversion data . . . from suitable emission sensors . . . in the . . . exhaust port of the engine." Ex. 1001 at 3:27-34. Yoshioka discloses an O₂ sensor located in the system's exhaust pipe from which the ECU receives a measured concentration of oxygen in the engine's exhaust gas. Ex. 1006 at 4:48-52, 5:24-30, 5:48-54.

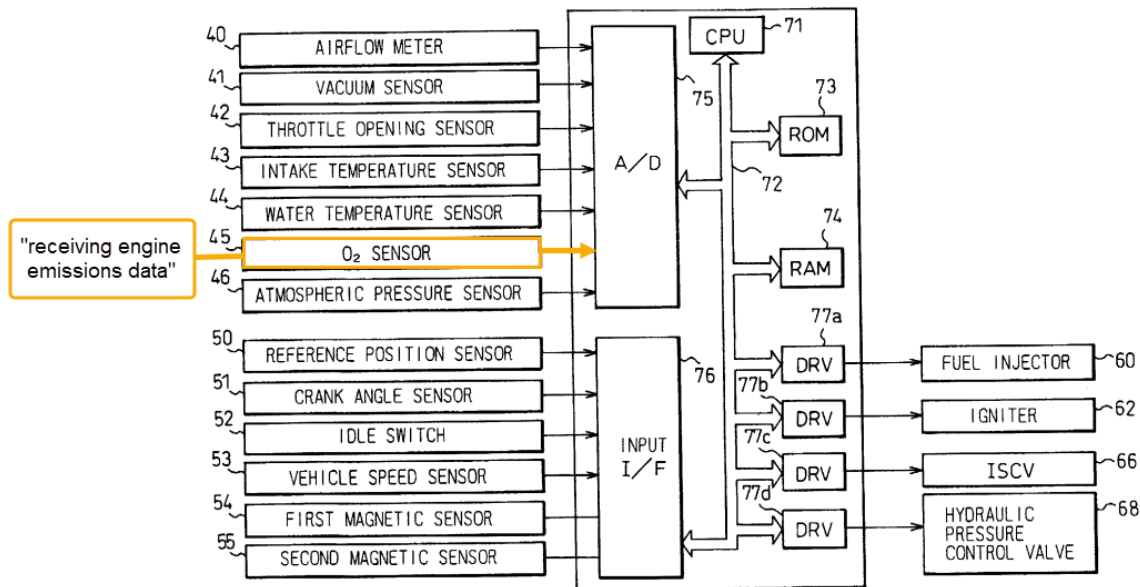
203. Accordingly, in my opinion Yoshioka in view of Ogawa and Jankovic renders obvious claim 11.

H. Claim 14: "The method of claim 1 further comprising receiving engine emissions data."

204. In my opinion, Yoshioka in view of Ogawa and Jankovic discloses the method of claim 1 further comprising receiving engine emissions data.

205. As explained above, Yoshioka in view of Ogawa and Jankovic discloses the method of claim 1. Yoshioka further teaches "an air-fuel ratio feedback correction according to a signal from [an] O₂ sensor 45" that "detect[s] the concentration of the oxygen in the exhaust gas," *i.e.*, engine emissions data. Ex. 1006 at 4:48-52, 5:24-30, 5:48-54. As shown in annotated Figure 2 below, Yoshioka's ECU receives the engine emissions data from the O₂ sensor:

Fig.2



Id. at FIG. 2 (annotated).

206. Yoshioka discloses the '540 patent's preferred embodiment of receiving fuel conversion data. The '540 patent describes the "action of receiving . . . engine emissions data . . . preferably include[s] receiving the . . . engine emissions data from suitable emissions sensors . . . in the . . . exhaust port of the engine." Ex. 1001 at 3:27-34. Yoshioka discloses an O₂ sensor located in the system's exhaust pipe from which the ECU receives a measured concentration of oxygen in the engine's exhaust gas. Ex. 1006 at 4:48-52, 5:24-30, 5:48-54.

207. Accordingly, in my opinion Yoshioka in view of Ogawa and Jankovic renders obvious claim 14.

XIII. SECONDARY CONSIDERATIONS

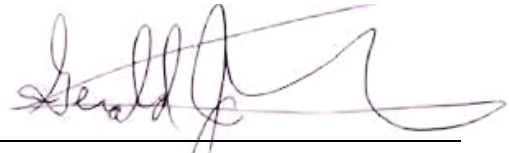
208. I understand that “secondary considerations” may be legally relevant to an obviousness analysis. If MMT presents such evidence, I will consider it; however, I do not believe that any commercial success of the claimed invention or other objective evidence would be attributable to the merits of the claimed invention given my analysis of the lack of novelty and the obviousness of the ’540 patent.

XIV. CONCLUSION

209. In signing this Declaration, I recognize that the Declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in the case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

210. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on the information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

July 18, 2023

A handwritten signature in purple ink, appearing to read "Gerald J. Micklow", written over a horizontal line.

Gerald J. Micklow, Ph.D., PE