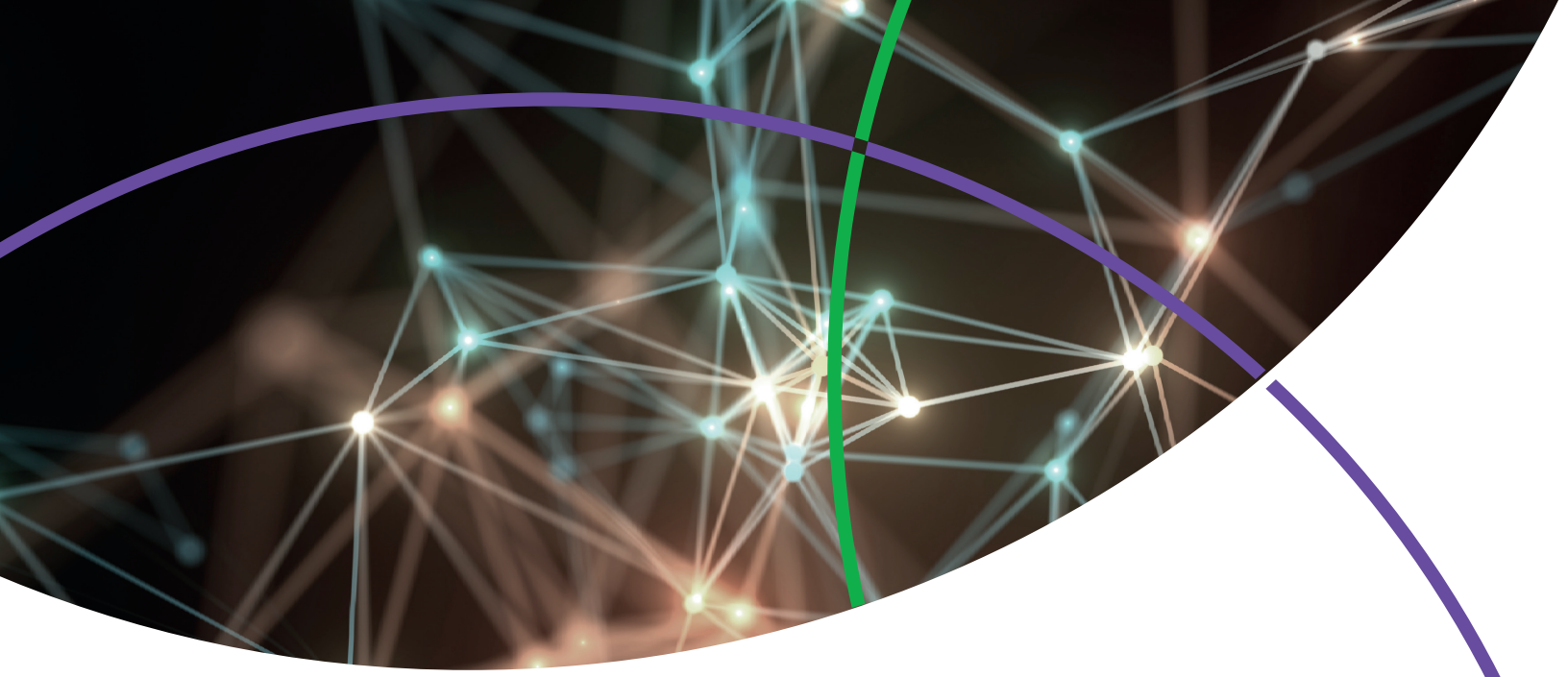


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PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

FILE HISTORY

US 6,557,540

PATENT:	6,557,540
INVENTORS:	MIANZO LAWRENCE A COLLINS BRETT D HASKARA IBRAHIM
TITLE:	Method of calculating a valve timing command for an engine
APPLICATION NO:	US200114286A
FILED:	11 DEC 2001
ISSUED:	06 MAY 2003
COMPILED:	19 SEP 2022

MAY 06 2003

PATENT NUMBER and ISSUE DATE

6557540

U.S. UTILITY Patent Application

APPL NUM	FILING DATE	CLASS	SUBCLASS	GAU	EXAMINER
10014286	12/11/2001	123	679 68	3747	SOLIS 6557540

**APPLICANTS: Mianzo Lawrence; Collins Brett; Haskara Ibrahim;

BEST COPY

**CONTINUING DATA VERIFIED:

** FOREIGN APPLICATIONS VERIFIED:

PG-PUB DO NOT PUBLISH ☐ RESCIND ☐

Foreign priority claimed ☐ yes ☒ no
35 USC 119 conditions met ☐ yes ☒ no
Verified and Acknowledged Examiners's initials:

ATTORNEY DOCKET NO
10541-070

TITLE : Method of calculating a valve timing command for an engine

U.S.DEPT. OF COMM /PAT & TM-PTO-436L(Rev 12-94)

3-28-03 Formal Drawings (3 sht(s) set 1 12-11-01

NOTICE OF ALLOWANCE MAILED		CLAIMS ALLOWED	
12/11/02	Assistant Examiner	Total Claims 16	Print Claim for O.G 1
ISSUE FEE		DRAWING	
Amount Due # 1280.00 / Date Paid 3-17-03	ERICK SOLIS PRIMARY EXAMINER Primary Examiner	Sheets Drwg. 3 / Figs.Drwg. 3 4 / Print Fig. 2	
☐ TERMINAL DISCLAIMER	PREPARED FOR ISSUE	Application Examiner	

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J1050 U.S. PTO 10/014286 12/11/01

JC1137

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

6,557,540

Method of calculating a valve timing command for an engine

Transaction History

Date	Transaction Description
12-11-2001	Workflow - Drawings Finished
12-11-2001	Workflow - Drawings Matched with File at Contractor
12-11-2001	Information Disclosure Statement (IDS) Filed
12-11-2001	Information Disclosure Statement (IDS) Filed
12-11-2001	Initial Exam Team nn
01-25-2002	Application Is Now Complete
02-01-2002	Application Dispatched from OIPE
03-07-2002	Case Docketed to Examiner in GAU
12-11-2002	Mail Notice of Allowance
12-11-2002	Notice of Allowance Data Verification Completed
12-12-2002	Dispatch to Publications
12-13-2002	Workflow - File Sent to Contractor
12-13-2002	Receipt into Pubs
01-23-2003	Receipt into Pubs
03-17-2003	Issue Fee Payment Verified
03-17-2003	Issue Fee Payment Received
03-28-2003	Application Is Considered Ready for Issue
04-01-2003	Receipt into Pubs
04-17-2003	Issue Notification Mailed
05-06-2003	Recordation of Patent Grant Mailed
05-06-2003	Patent Issue Date Used in PTA Calculation
06-12-2003	Information Disclosure Statement (IDS) Filed
06-12-2003	Information Disclosure Statement (IDS) Filed
07-08-2003	Mail Miscellaneous Communication to Applicant
07-08-2003	Miscellaneous Communication to Applicant - No Action Count
07-29-2003	Correspondence Address Change
09-06-2017	File Marked Found
10-04-2017	File Marked Found
05-14-2018	Petition Requesting Trial
10-02-2018	Termination or Final Written Decision
11-25-2019	Petition Requesting Trial
01-22-2020	Correspondence Address Change
01-23-2020	Email Notification
01-23-2020	Change in Power of Attorney (May Include Associate POA)
06-05-2020	Request for Trial Denied

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10014286

J1050 U.S. PTO
10/014286
12/11/01

INITIALS 1-15-02

CONTENTS

		Date Received (incl. C. of M.) or Date Mailed			Date Received (incl. C. of M.) or Date Mailed
1.	Application papers. + PTO		31.		
2.	IDS	12-11-01	32.		
3.	NOA	12/11/02	33.		
4.	Prior Art	6-12-03	34.		
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ISSUE SLIP STAPLE AREA (for additional cross-references)

ISSUING CLASSIFICATION

ORIGINAL		CROSS REFERENCE(S)	
CLASS	SUBCLASS	CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)
123	878	123	90.15
INTERNATIONAL CLASSIFICATION		701	103
F01L	1134		
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INDEX OF CLAIMS

✓ ..... Rejected - (Through numeral) ... Canceled N ..... Non-elected A ..... Appeal
= ..... Allowed + ... Restricted I ..... Interference O ..... Objected

Claim Final	Claim Original	Date
1	1	12-15-02
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If more than 150 claims or 9 actions staple additional sheet here

09/2502 01

SEARCH

Class	Sub.	Date	Exmr.
123	678	12/9/02	ES
	90.15	↓	↓
	90.19		
701	103	12/9/02	ES

INTERFERENCE SEARCHED

Class	Sub.	Date	Exmr.
123	678	12/9/02	ES
	90.15		↓
	90.19	12/9/02	ES

SEARCH NOTES

(List databases searched. Attach search strategy inside.)

	Date	Exmr.
None	12/9/02	ES

US006557540B1

(12) **United States Patent**
Mianzo et al.

(10) **Patent No.: US 6,557,540 B1**
(45) **Date of Patent: May 6, 2003**

(54) **METHOD OF CALCULATING A VALVE TIMING COMMAND FOR AN ENGINE**

(75) Inventors: **Lawrence A. Mianzo**, Plymouth, MI (US); **Brett D. Collins**, Ypsilanti, MI (US); **Ibrahim Haskara**, Brownstown, MI (US)

(73) Assignee: **Visteon Global Technologies, Inc.**, Dearborn, MI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/014,286**

(22) Filed: **Dec. 11, 2001**

(51) **Int. Cl.**[7] **F01L 1/34**
(52) **U.S. Cl.** **123/678**; 123/90.15; 701/103
(58) **Field of Search** 123/678, 90.15, 123/90.19; 701/103

(56) **References Cited**

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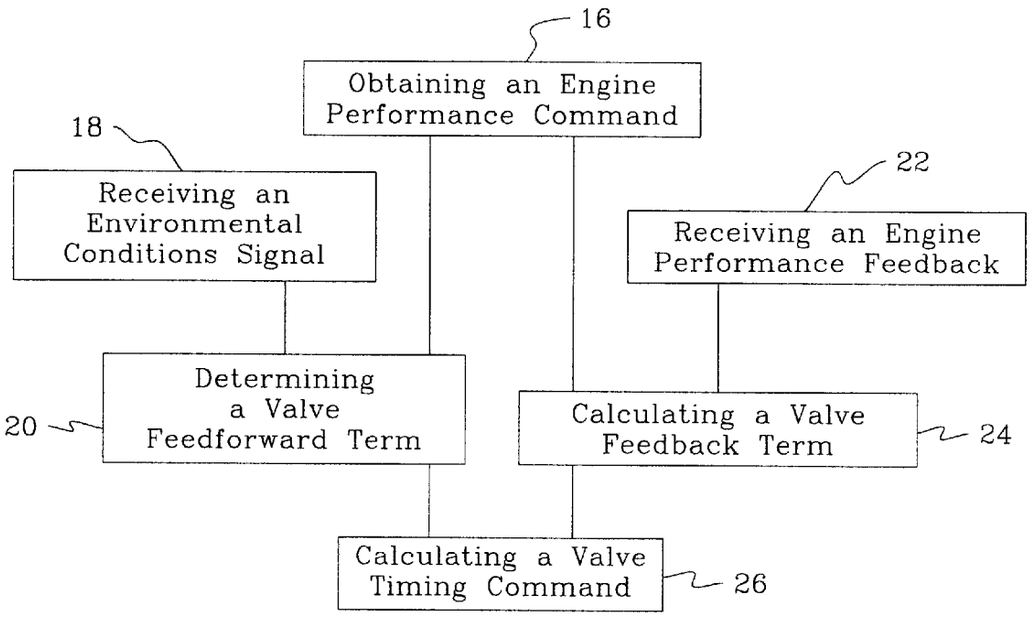
* cited by examiner

Primary Examiner—Erick Solis
(74) *Attorney, Agent, or Firm*—Brinks Hofer Gilson & Lione

(57) **ABSTRACT**

A method to calculate valve timing commands for an engine with variable valve timing is hereby disclosed. The method includes determining a valve feedforward term based on an engine performance command and an environmental conditions signal, calculating a valve feedback term based on the engine performance command and an engine performance feedback, and calculating a valve timing command based on the valve feedforward term and the valve feedback term.

16 Claims, 3 Drawing Sheets



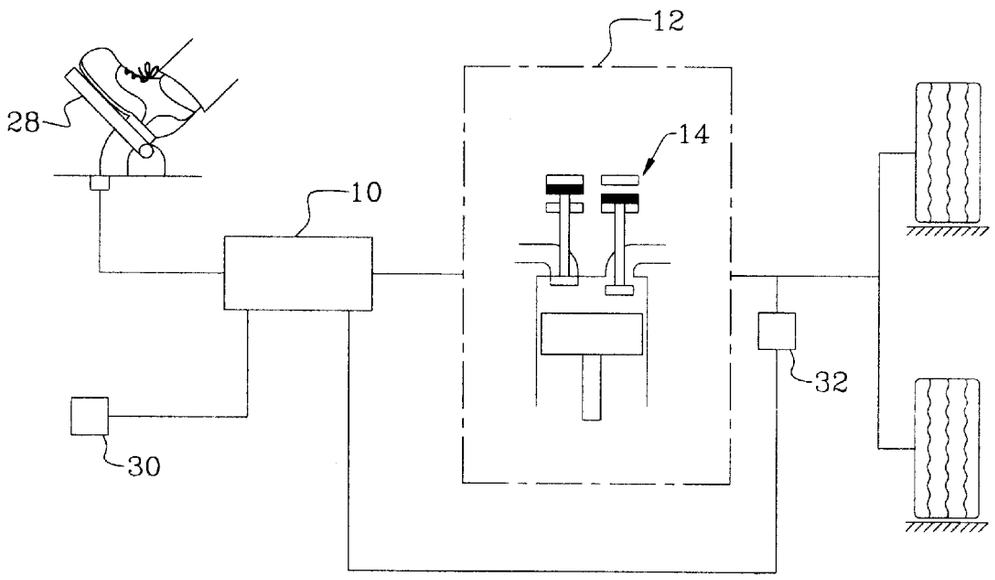


FIGURE 1

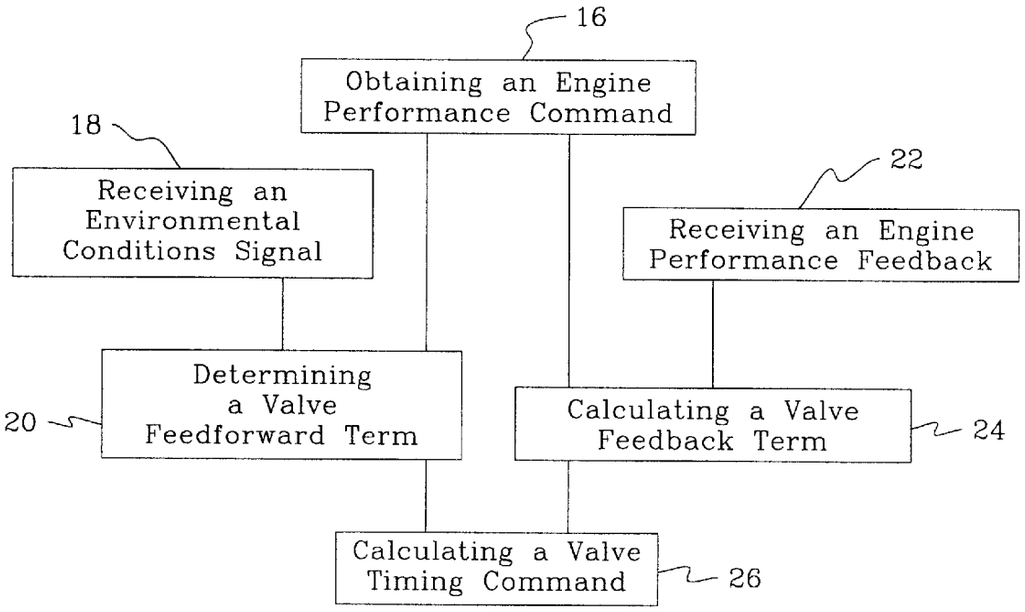

16
Obtaining an Engine Performance Command
18
Receiving an Environmental Conditions Signal
22
Receiving an Engine Performance Feedback
20
Determining a Valve Feedforward Term
Calculating a Valve Feedback Term
24
Calculating a Valve Timing Command
26

FIGURE 2

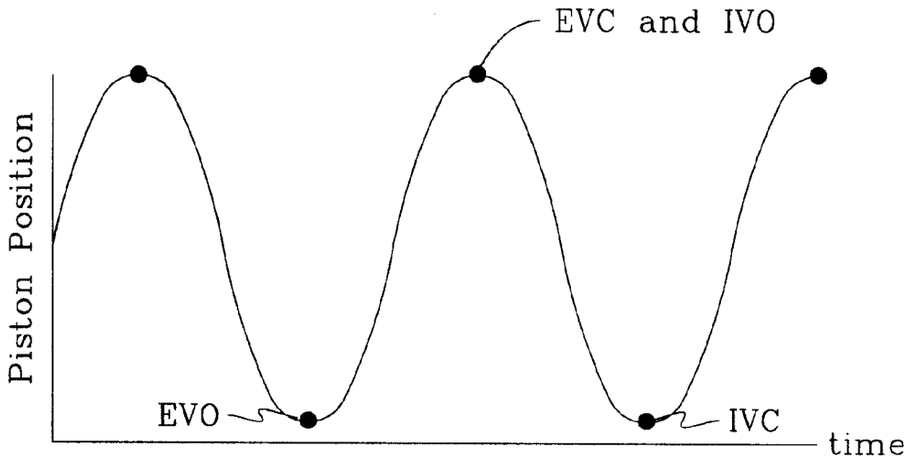


FIGURE 3A

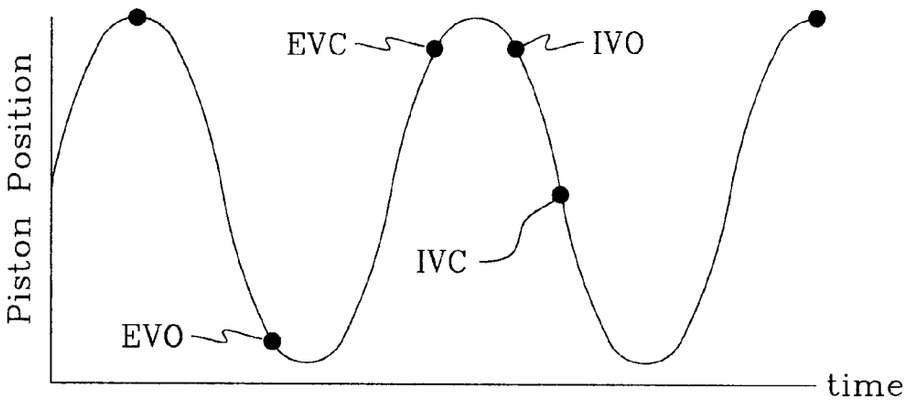


FIGURE 3B

METHOD OF CALCULATING A VALVE TIMING COMMAND FOR AN ENGINE

TECHNICAL FIELD

This invention relates generally to calculating commands for an engine and, more specifically, to calculating a valve timing command for an engine with variable timing valve actuators.

BACKGROUND

In gasoline engines of most vehicles, each cylinder of the engine cycles through four unique stages. In the first stage, an inlet valve opens and a piston draws air and fuel through the inlet valve and into the cylinder. The inlet valve closes and the piston reverses direction in the second stage to compress the air and fuel mixture. In the third stage, a spark combusts the mixture, which drives the piston (and powers the vehicle). An exhaust valve opens and the piston once again reverses direction, in the fourth stage, to push the combusted mixture through the exhaust valve and out of the cylinder.

The controlling of the inlet valve and the exhaust valve of each cylinder is a difficult task. The engine speed, which can exceed 6,000 rpm in most vehicles, dictates that the opening and closing of the inlet valve and the exhaust valve must be able to occur up to 50 times per second. In conventional engines, cams driven by the engine actuate the inlet valve and the exhaust valve. Modern research, however, has shown that fuel efficiency and power output of the engine may be optimized with an adjustment of the valve timing for a particular load on the engine. Some variable valve timing engines have been proposed, but the theoretical fuel efficiency and output power of these engines have not yet been reached.

BRIEF DESCRIPTION OF THE FIGURES

FIG. **1** is schematic of a vehicle having an engine controlled with the method of the preferred embodiment;

FIG. **2** is a flowchart of the method of the preferred embodiment; and

FIG. **3** is two timing charts of the valves of an engine.

DESCRIPTION OF THE PREFERRED METHODS

The following description of the two preferred method of the invention is not intended to limit the invention to these preferred methods, but rather to enable any person skilled in the art of variable valve timing control to make and use this invention.

As shown in FIG. **1**, the preferred method of the invention has been specifically created to be performed by a control unit **10** to calculate valve timing commands for an engine **12** with electromagnetic valve actuators **14**. The method, however, may be performed by any suitable device to calculate valve timing commands for any suitable engine with any suitable variable timing valves.

As shown in FIG. **2**, the preferred method of the invention has six principle actions: obtaining an engine performance command **16**; receiving an environmental conditions signal **18**; determining a valve feedforward term **20**; receiving an engine performance feedback **22**; calculating a valve feedback term **24**; and calculating a valve timing command **26** based on the valve feedforward term and the valve feedback term. The method performed by the control unit may, of course, include other suitable actions before, during, or after these principle actions.

The action of obtaining an engine performance command **16** preferably includes receiving a vehicle performance command from a driver. Preferably, the vehicle performance command is received from the foot of a driver with the use of a conventional pedal **28**, as shown in FIG. **1**. Alternatively, the vehicle performance command could be received from the driver with the use of any suitable device. The action of obtaining an engine performance command also preferably includes deriving the engine performance command from the vehicle performance command. The engine performance command is preferably based on the vehicle performance command, but may alternatively be based on additional suitable factors, such as a traction control signal or a cruise control signal. The engine performance command is preferably a desired engine torque and, for this reason, the engine performance command may be thought of as an engine torque command. The engine performance command, however, may alternatively be another suitable variable, such as a desired engine acceleration.

The action of receiving an environmental conditions signal **18** preferably includes receiving an environmental conditions signal from an environmental sensor **30** in the vehicle. The environmental sensor **30** preferably senses the ambient temperature outside the vehicle and communicates this data to the control unit **10**, which uses the data to determine the valve feedforward term. Other information, such as the ambient pressure, may be useful in the determination of the valve feedforward term. For this reason, the environmental sensor **30** may alternatively sense other suitable information. The environmental sensor **30** is preferably a conventional environmental sensor, but may alternatively be any suitable device.

Similarly, the action of receiving an engine performance feedback **22** preferably includes receiving the engine performance feedback from an engine sensor **32** in the vehicle. The engine sensor **32** preferably senses the engine speed and communicates this data to the control unit **10**, which uses the data to determine the valve feedforward term and the valve feedback term. Other engine measurables, such as engine torque data, may be useful in the determination of the terms. For this reason, the engine sensor **32** may alternatively sense other suitable information. The engine sensor **32** is preferably a conventional engine sensor, but may alternatively be any suitable sensor.

The action of determining a valve feedforward term **20** preferably includes determining the valve feedforward term based on the engine torque command, the ambient temperature data, and the engine speed data. The determination, however, may be based on other suitable factors, such as engine torque data, air-fuel ratio data, engine combustion stability data, or ambient pressure data. The control unit **10** preferably includes a look-up table, which has been optimized for fuel efficiency, power output, and engine emissions based on various engine torque commands, various ambient temperature data, and various engine speed data (or engine torque data). The control unit **10** may alternatively be programmed to perform a real-time optimization of the fuel efficiency, power output, and engine emission (or any other suitable measurement) based on the engine torque command, the ambient temperature data, and the engine speed data (or any other suitable commands and measurables).

The action of calculating the valve feedback term **24** preferably includes comparing the engine performance com-

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US PATENT NO. 6,557,540

mand and the engine performance feedback. By the definition of the term, the valve feedback term functions to compare the input with the output and to calculate a correction term based on the difference, if any. The comparison and the calculation are preferably accomplished by the control unit **10**, but may alternatively be accomplished by a suitable separate device.

As shown in FIG. **3**A, the position of the piston in the cylinder can be traced as a sinusoidal wave over a time period. The events of the opening of the exhaust valve ("EVO"), the closing of the exhaust valve ("EVC"), the opening of the inlet valve ("IVO"), and the closing of the inlet valve ("IVC") can be placed on this sinusoidal wave. As shown in FIG. **3**B, the events of the EVO, the EVC, the IVO, and the IVC may be shifted within the time period (note that the shift in the EVC and the IVO preferably mirror each another, but may alternatively be separately controlled). The adjustment of the timing of the EVO, the EVC/IVO, and the IVC when used partially, separately, or together may provide the desired fuel efficiency, power output, and emissions from the engine **12** of the vehicle. The action of calculating a valve timing command **26** preferably includes calculating an EVO command, an EVC/IVO command, and an IVC command. The control unit **10**, of course, may alternatively include other suitable parameters for the control of the variable timing valves.

The second preferred method of the invention includes the principle actions of the first preferred method and the additional principle action of receiving fuel conversion data and engine emissions data. These preferably include receiving the fuel conversion data and engine emissions data from suitable emission sensors (not shown) in the cylinder or the exhaust port of the engine **12**. The emission sensors preferably sense the amount of NO_x in the exhaust and communicates this data to the control unit **10**. The control unit **10** preferably uses this information to modify the output value from the look-up table, but may alternatively use this information to continually adjust the values in the look-up table. The control unit **10** may alternatively use this information as another factor in the determination of the valve feedback term. The emission sensors are preferably conventional emission sensors, but may alternatively be any suitable sensor.

As any person skilled in the art of variable valve engine control will recognize from the previous detailed description and from the figures and claims, modifications and changes can be made to the preferred methods without departing from the scope of this invention defined in the following claims.

We claim:

1. 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.

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.

3. The method of claim **1** wherein said receiving an environmental conditions signal includes receiving ambient temperature data.

4. The method of claim **3** wherein said determining a valve feedforward term includes determining the valve feedforward term based on the ambient temperature data.

5. The method of claim **4** wherein said determining a valve feedforward term includes determining the valve feedforward term based on the engine performance feedback.

6. The method of claim **5** wherein said determining a valve feedforward term includes referencing a look-up table with the engine performance command, the ambient temperature, and the engine performance feedback.

7. The method of claim **1** wherein said receiving an engine performance feedback includes receiving engine speed data.

8. The method of claim **1** wherein said obtaining an engine performance command includes obtaining an engine torque command; and wherein receiving an engine performance feedback includes receiving engine torque data.

9. The method of claim **8** wherein calculating a valve feedback term includes calculating a valve feedback term based on the engine torque command and the engine torque data.

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.

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

12. The method of claim **11** wherein said determining a valve feedforward term includes determining a valve feedforward term based on the fuel conversion data.

13. The method of claim **11** wherein said calculating a valve feedback term includes calculating a valve feedback term based on the fuel conversion data.

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

15. The method of claim **14** wherein said determining a valve feedforward term includes determining a valve feedforward term based on the engine emissions data.

16. The method of claim **11** wherein said calculating a valve feedback term includes calculating a valve feedback term based on the engine emissions data.

* * * * *

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Bib Data Sheet

CONFIRMATION NO. 3146

SERIAL NUMBER	FILING DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
10/014,286	12/11/2001 RULE	123	3747	10541-070

APPLICANTS

Lawrence A. Mianzo, Plymouth, MI;
Brett D. Collins, Ypsilanti, MI;
Ibrahim Haskara, Brownstown, MI;

** CONTINUING DATA ********** None ES

** FOREIGN APPLICATIONS ********** None ES

IF REQUIRED, FOREIGN FILING LICENSE GRANTED
** 01/24/2002

		STATE OR COUNTRY	SHEETS DRAWING	TOTAL CLAIMS	INDEPENDENT CLAIMS
Foreign Priority claimed	☐ yes ☑ no	MI	3	16	1
35 USC 119 (a-d) conditions met	☐ yes ☑ no ☐ Met after Allowance				
Verified and Acknowledged	Examiner's Signature E Solis Initials				

ADDRESS
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TITLE
Method of calculating a valve timing command for an engine

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U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE
FEE RECORD SHEET

12/18/2001 MAHMED1 00000001 061500 10014286
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(5/87)

*U.S GPO: 2000-468-987/39595

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PTO/SB/05 (11-00)
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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.	10541-070
First Inventor	Mianzo et al.
Title	Method of Calculating a Valve Timing Command for an Engine
Express Mail Label No.	ET718954276US

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO: Assistant Commissioner for Patents, Box Patent Application, Washington, D.C. 20231

1. [✓] Fee Transmittal Form (e.g., PTO/SB/17) *(Submit an original, and a duplicate for fee processing)*
2. [ ] Applicant claims small entity status. See 37 CFR 1.27.
3. [✓] Specification *[Total Pages 10]* *(preferred arrangement set forth below)*
   - Descriptive title of the invention
   - Cross Reference to Related Applications
   - Statement Regarding Fed sponsored R & D
   - Reference to sequence listing, a table, or a computer program listing appendix
   - Background of the Invention
   - Brief Summary of the Invention
   - Brief Description of the Drawings *(if filed)*
   - Detailed Description
   - Claim(s)
   - Abstract of the Disclosure
4. [✓] Drawing(s) *(35 U.S.C. 113)* *[Total Sheets 3]*
5. Oath or Declaration *[Total Pages 3]*
   - a. [✓] Newly executed (original or copy)
   - b. [ ] Copy from a prior application (37 CFR 1.63(d)) *(for continuation/divisional with Box 18 completed)*
     - i. [ ] DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).
6. [ ] Application Data Sheet. See 37 CFR 1.76
7. [ ] CD-ROM or CD-R in duplicate, large table or Computer Program *(Appendix)*
8. Nucleotide and/or Amino Acid Sequence Submission *(if applicable, all necessary)*
   - a. [ ] Computer Readable Form (CRF)
   - b. Specification Sequence Listing on:
     - i. [ ] CD-ROM or CD-R (2 copies); or
     - ii. [ ] paper
   - c. [ ] Statements verifying identity of above copies

J1050 U.S. PTO 10/014286

ACCOMPANYING APPLICATION PARTS

9. [✓] Assignment Papers (cover sheet & document(s))
10. [ ] 37 CFR 3.73(b) Statement *(when there is an assignee)* [✓] Power of Attorney
11. [ ] English Translation Document *(if applicable)*
12. [✓] Information Disclosure Statement (IDS)/PTO-1449 [✓] Copies of IDS Citations
13. [ ] Preliminary Amendment
14. [✓] Return Receipt Postcard (MPEP 503) *(Should be specifically itemized)*
15. [ ] Certified Copy of Priority Document(s) *(if foreign priority is claimed)*
16. [ ] Request and Certification under 35 U.S.C. 122 (b)(2)(B)(i). Applicant must attach form PTO/SB/35 or its equivalent.
17. [✓] Other: Express Mailing Certificate, Additional Return Receipt Postcard

18. If a CONTINUING APPLICATION, *check appropriate box, and supply the requisite information below and in a preliminary amendment, or in an Application Data Sheet under 37 CFR 1.76:*

[ ] Continuation [ ] Divisional [ ] Continuation-in-part (CIP) of prior application No.: ____ / ____

Prior application information: Examiner ____ Group / Art Unit ____

For CONTINUATION OR DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 5b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

19. CORRESPONDENCE ADDRESS

[☑] *Customer Number or Bar Code Label* (Insert Customer No. or Attach bar code label here) 23494 or [ ] *Correspondence address below*

PATENT & TRADEMARK OFFICE

Name				
Address				
City	State		Zip Code	
Country	Telephone		Fax	

Name (Print/Type) Jeffrey M. Cox		Registration No. (Attorney/Agent)	42,445
Signature		Date	11 December 2001

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US PATENT NO. 6,557,540

PTO/SB/17 (XX-XX)
Approved for use through 10/31/2002. OMB 0651-0032
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE
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FEE TRANSMITTAL for FY 2002

Patent fees are subject to annual revision.

TOTAL AMOUNT OF PAYMENT	$780.00

Complete if Known	
Application Number	
Filing Date	
First Named Inventor	Mianzo
Examiner Name	
Group Art Unit	
Attorney Docket No.	10541-070

METHOD OF PAYMENT

1. ☒ The Commissioner is hereby authorized to charge indicated fees and credit any overpayments to:

Deposit Account Number: 06-1500

Deposit Account Name:

☒ Charge Any Additional Fee Required Under 37 CFR §§ 1.16 and 1.17

☐ Applicant claims small entity status. See 37 CFR § 1.27

2. ☐ Payment Enclosed:

☐ Check ☐ Credit card ☐ Money Order ☐ Other

FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
101	740	201	370	Utility filing fee	740.00
106	330	206	165	Design filing fee	
107	510	207	255	Plant filing fee	
108	740	208	370	Reissue filing fee	
114	160	214	80	Provisional filing fee	
				SUBTOTAL (1)	$740.00

2. EXTRA CLAIM FEES

	Extra Claims		Fee from below	Fee Paid
Total Claims	16 -20** =	0	X =	0.00
Independent Claims	1 - 3** =	0	X =	0.00
Multiple Dependent			=	

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
103	18	203	9	Claims in excess of 20
102	84	202	42	Independent claims in excess of 3
104	280	204	140	Multiple dependent claim, if not paid
109	84	209	42	** Reissue independent claims over original patent
110	18	210	9	** Reissue claims in excess of 20 and over original patent
				SUBTOTAL (2) $0.00

***or number previously paid, if greater; For Reissues, see above*

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
105	130	205	65	Surcharge - late filing fee or oath	
127	50	227	25	Surcharge - late provisional filing fee or cover sheet	
139	130	139	130	Non - English specification	
147	2,520	147	2,520	For filing a request for *ex parte* reexamination	
112	920*	112	920*	Requesting publication of SIR prior to Examiner action	
113	1,840*	113	1,840*	Requesting publication of SIR after Examiner action	
115	110	215	55	Extension for reply within first month	
116	400	216	200	Extension for reply within second month	
117	920	217	460	Extension for reply within third month	
118	1,440	218	720	Extension for reply within fourth month	
128	1,960	228	980	Extension for reply within fifth month	
119	320	219	160	Notice of Appeal	
120	320	220	160	Filing a brief in support of an appeal	
121	280	221	140	Request for oral hearing	
138	1,510	138	1,510	Petition to institute a public use proceeding	
140	110	240	55	Petition to revive - unavoidable	
141	1,280	241	640	Petition to revive - unintentional	
142	1,280	242	640	Utility issue fee (or reissue)	
143	460	243	230	Design issue fee	
144	620	244	310	Plant issue fee	
122	130	122	130	Petitions to the Commissioner	
123	50	123	50	Processing fee under 37 CFR § 1.17(q)	
126	180	126	180	Submission of Information Disclosure Statement	
581	40	581	40	Recording each patent assignment per property (times number of properties)	40.00
146	740	246	370	Filing a submission after final rejection (37 CFR § 1.129(a))	
149	740	249	370	For each additional invention to be examined (37 CFR § 1.129(b))	
179	740	279	370	Request for Continued Examination (RCE)	
169	900	169	900	Request for expedited examination of a design application	
Other fee (specify)					

*Reduced by Basic Filing Fee Paid SUBTOTAL (3) $40.00

SUBMITTED BY

Complete *(if applicable)*

Name (Print/Type)	Jeffrey M. Cox	Registration No. (Attorney/Agent)	42,445	Telephone	(734) 302-6000
Signature				Date	11 December 2001

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METHOD OF CALCULATING A VALVE TIMING COMMAND FOR AN ENGINE

TECHNICAL FIELD

[0001] This invention relates generally to calculating commands for an engine and, more specifically, to calculating a valve timing command for an engine with variable timing valve actuators.

BACKGROUND

[0002] In gasoline engines of most vehicles, each cylinder of the engine cycles through four unique stages. In the first stage, an inlet valve opens and a piston draws air and fuel through the inlet valve and into the cylinder. The inlet valve closes and the piston reverses direction in the second stage to compress the air and fuel mixture. In the third stage, a spark combusts the mixture, which drives the piston (and powers the vehicle). An exhaust valve opens and the piston once again reverses direction, in the fourth stage, to push the combusted mixture through the exhaust valve and out of the cylinder.

[0003] The controlling of the inlet valve and the exhaust valve of each cylinder is a difficult task. The engine speed, which can exceed 6,000 rpm in most vehicles, dictates that the opening and closing of the inlet valve and the exhaust valve must be able to occur up to 50 times per second. In conventional engines, cams driven by the engine actuate the inlet valve and the exhaust valve. Modern research, however, has shown that fuel efficiency and power output of the engine may be optimized with an adjustment of the valve timing for a particular load on the

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engine. Some variable valve timing engines have been proposed, but the theoretical fuel efficiency and output power of these engines have not yet been reached.

BRIEF DESCRIPTION OF THE FIGURES

[0004] FIGURE 1 is schematic of a vehicle having an engine controlled with the method of the preferred embodiment;

[0005] FIGURE 2 is a flowchart of the method of the preferred embodiment; and

[0006] FIGURE 3 is two timing charts of the valves of an engine.

DESCRIPTION OF THE PREFERRED METHODS

[0007] The following description of the two preferred method of the invention is not intended to limit the invention to these preferred methods, but rather to enable any person skilled in the art of variable valve timing control to make and use this invention.

[0008] As shown in FIGURE 1, the preferred method of the invention has been specifically created to be performed by a control unit 10 to calculate valve timing commands for an engine 12 with electromagnetic valve actuators 14. The method, however, may be performed by any suitable device to calculate valve timing commands for any suitable engine with any suitable variable timing valves.

[0009] As shown in FIGURE 2, the preferred method of the invention has six principle actions: obtaining an engine performance command 16; receiving an environmental conditions signal 18; determining a valve feedforward term 20; receiving an engine performance feedback 22; calculating a valve feedback term

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24; and calculating a valve timing command 26 based on the valve feedforward term and the valve feedback term. The method performed by the control unit may, of course, include other suitable actions before, during, or after these principle actions.

[00010] The action of obtaining an engine performance command 16 preferably includes receiving a vehicle performance command from a driver. Preferably, the vehicle performance command is received from the foot of a driver with the use of a conventional pedal 28, as shown in FIGURE 1. Alternatively, the vehicle performance command could be received from the driver with the use of any suitable device. The action of obtaining an engine performance command also preferably includes deriving the engine performance command from the vehicle performance command. The engine performance command is preferably based on the vehicle performance command, but may alternatively be based on additional suitable factors, such as a traction control signal or a cruise control signal. The engine performance command is preferably a desired engine torque and, for this reason, the engine performance command may be thought of as an engine torque command. The engine performance command, however, may alternatively be another suitable variable, such as a desired engine acceleration.

[00011] The action of receiving an environmental conditions signal 18 preferably includes receiving an environmental conditions signal from an environmental sensor 30 in the vehicle. The environmental sensor 30 preferably senses the ambient temperature outside the vehicle and communicates this data to the control unit 10, which uses the data to determine the valve feedforward term. Other information, such as the ambient pressure, may be useful in the determination

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of the valve feedforward term. For this reason, the environmental sensor 30 may alternatively sense other suitable information. The environmental sensor 30 is preferably a conventional environmental sensor, but may alternatively be any suitable device.

[00012] Similarly, the action of receiving an engine performance feedback 22 preferably includes receiving the engine performance feedback from an engine sensor 32 in the vehicle. The engine sensor 32 preferably senses the engine speed and communicates this data to the control unit 10, which uses the data to determine the valve feedforward term and the valve feedback term. Other engine measurables, such as engine torque data, may be useful in the determination of the terms. For this reason, the engine sensor 32 may alternatively sense other suitable information. The engine sensor 32 is preferably a conventional engine sensor, but may alternatively be any suitable sensor.

[00013] The action of determining a valve feedforward term 20 preferably includes determining the valve feedforward term based on the engine torque command, the ambient temperature data, and the engine speed data. The determination, however, may be based on other suitable factors, such as engine torque data, air-fuel ratio data, engine combustion stability data, or ambient pressure data. The control unit 10 preferably includes a look-up table, which has been optimized for fuel efficiency, power output, and engine emissions based on various engine torque commands, various ambient temperature data, and various engine speed data (or engine torque data). The control unit 10 may alternatively be programmed to perform a real-time optimization of the fuel efficiency, power output, and engine emission (or any other suitable measurement) based on the engine

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torque command, the ambient temperature data, and the engine speed data (or any other suitable commands and measurables).

[00014] The action of calculating the valve feedback term 24 preferably includes comparing the engine performance command and the engine performance feedback. By the definition of the term, the valve feedback term functions to compare the input with the output and to calculate a correction term based on the difference, if any. The comparison and the calculation are preferably accomplished by the control unit 10, but may alternatively be accomplished by a suitable separate device.

[00015] As shown in FIGURE 3A, the position of the piston in the cylinder can be traced as a sinusoidal wave over a time period. The events of the opening of the exhaust valve ("EVO"), the closing of the exhaust valve ("EVC"), the opening of the inlet valve ("IVO"), and the closing of the inlet valve ("IVC") can be placed on this sinusoidal wave. As shown in FIGURE 3B, the events of the EVO, the EVC, the IVO, and the IVC may be shifted within the time period (note that the shift in the EVC and the IVO preferably mirror each another, but may alternatively be separately controlled). The adjustment of the timing of the EVO, the EVC/IVO, and the IVC when used partially, separately, or together may provide the desired fuel efficiency, power output, and emissions from the engine 12 of the vehicle. The action of calculating a valve timing command 26 preferably includes calculating an EVO command, an EVC/IVO command, and an IVC command. The control unit 10, of course, may alternatively include other suitable parameters for the control of the variable timing valves.

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[00016] The second preferred method of the invention includes the principle actions of the first preferred method and the additional principle action of receiving fuel conversion data and engine emissions data. These preferably include receiving the fuel conversion data and engine emissions data from suitable emission sensors (not shown) in the cylinder or the exhaust port of the engine 12. The emission sensors preferably sense the amount of NO_x in the exhaust and communicates this data to the control unit 10. The control unit 10 preferably uses this information to modify the output value from the look-up table, but may alternatively use this information to continually adjust the values in the look-up table. The control unit 10 may alternatively use this information as another factor in the determination of the valve feedback term. The emission sensors are preferably conventional emission sensors, but may alternatively be any suitable sensor.

[00017] As any person skilled in the art of variable valve engine control will recognize from the previous detailed description and from the figures and claims, modifications and changes can be made to the preferred methods without departing from the scope of this invention defined in the following claims.

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CLAIMS

We Claim:

1. 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.

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.

3. The method of Claim 1 wherein said receiving an environmental conditions signal includes receiving ambient temperature data.

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4. The method of Claim 3 wherein said determining a valve feedforward term includes determining the valve feedforward term based on the ambient temperature data.

5. The method of Claim 4 wherein said determining a valve feedforward term includes determining the valve feedforward term based on the engine performance feedback.

6. The method of Claim 5 wherein said determining a valve feedforward term includes referencing a look-up table with the engine performance command, the ambient temperature, and the engine performance feedback.

7. The method of Claim 1 wherein said receiving an engine performance feedback includes receiving engine speed data.

8. The method of Claim 1 wherein said obtaining an engine performance command includes obtaining an engine torque command; and wherein receiving an engine performance feedback includes receiving engine torque data.

9. The method of Claim 8 wherein calculating a valve feedback term includes calculating a valve feedback term based on the engine torque command and the engine torque data.

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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.

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

12. The method of Claim 11 wherein said determining a valve feedforward term includes determining a valve feedforward term based on the fuel conversion data.

13. The method of Claim 11 wherein said calculating a valve feedback term includes calculating a valve feedback term based on the fuel conversion data.

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

15. The method of Claim 14 wherein said determining a valve feedforward term includes determining a valve feedforward term based on the engine emissions data.

16. The method of Claim 11 wherein said calculating a valve feedback term includes calculating a valve feedback term based on the engine emissions data.

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ABSTRACT

[00018] A method to calculate valve timing commands for an engine with variable valve timing is hereby disclosed. The method includes determining a valve feedforward term based on an engine performance command and an environmental conditions signal, calculating a valve feedback term based on the engine performance command and an engine performance feedback, and calculating a valve timing command based on the valve feedforward term and the valve feedback term.

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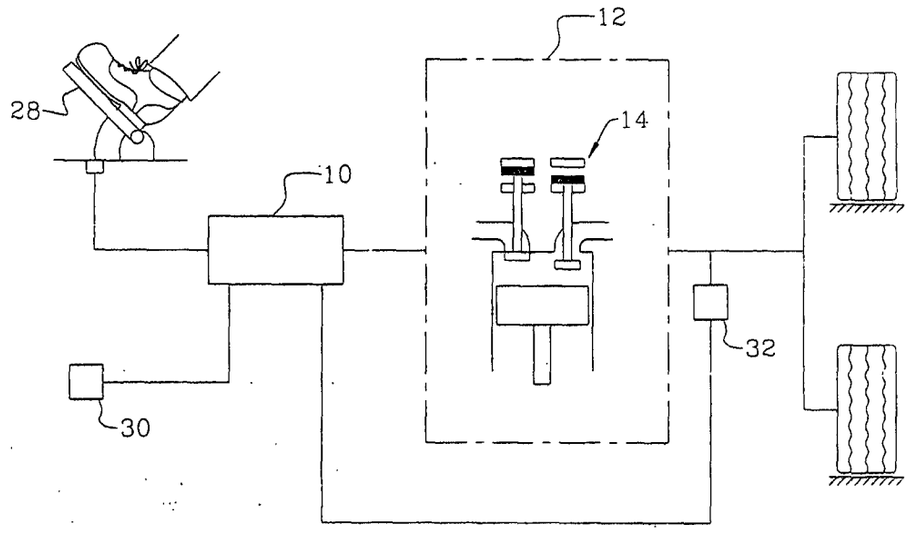


FIGURE 1

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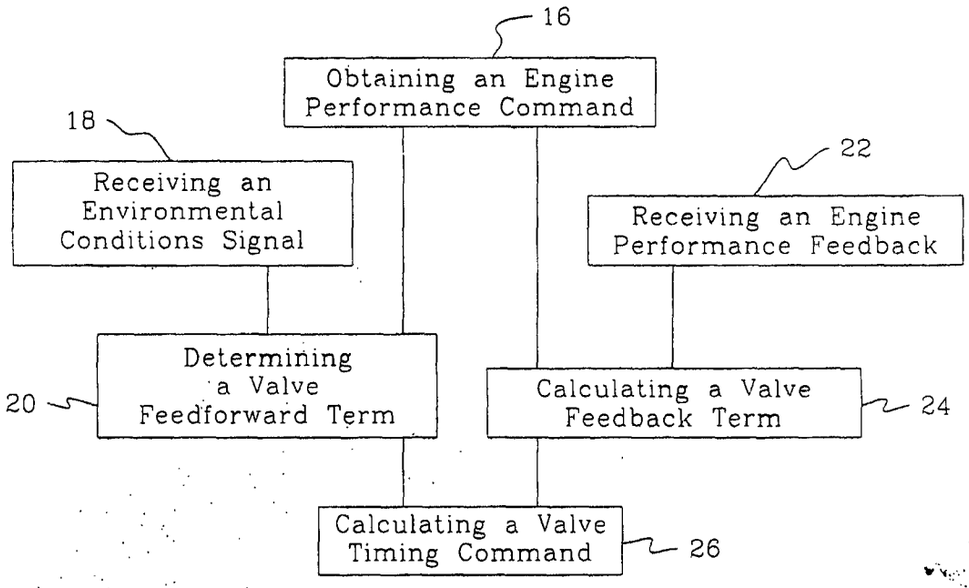

16
Obtaining an Engine Performance Command
18
Receiving an Environmental Conditions Signal
22
Receiving an Engine Performance Feedback
Determining a Valve Feedforward Term
20
Calculating a Valve Feedback Term
24
Calculating a Valve Timing Command
26

FIGURE 2

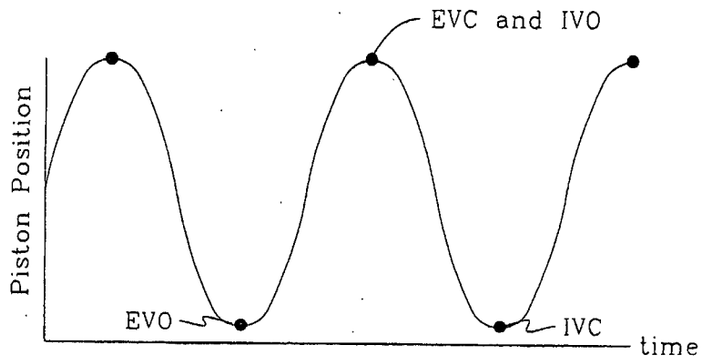


FIGURE 3A

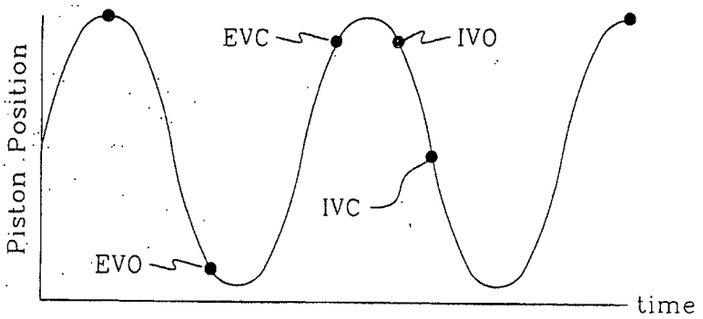


FIGURE 3B

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

6557540

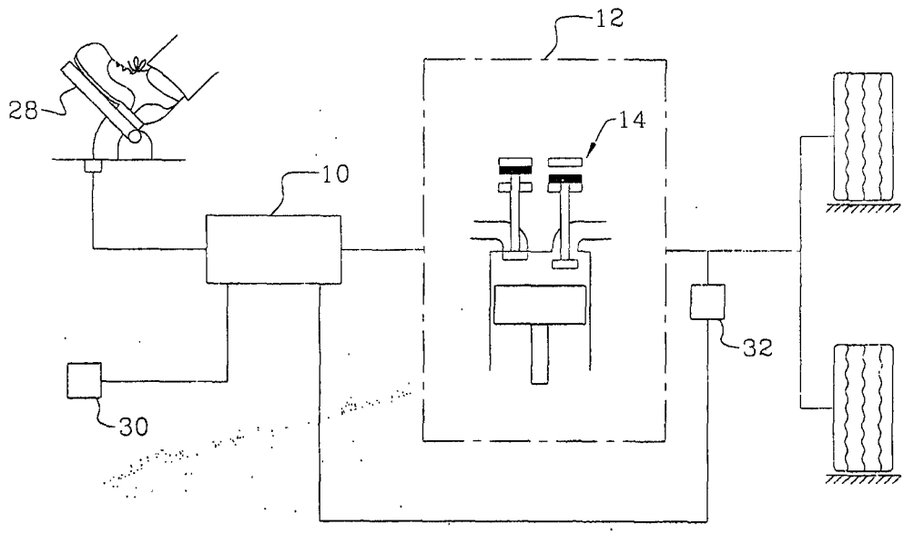


FIGURE 1

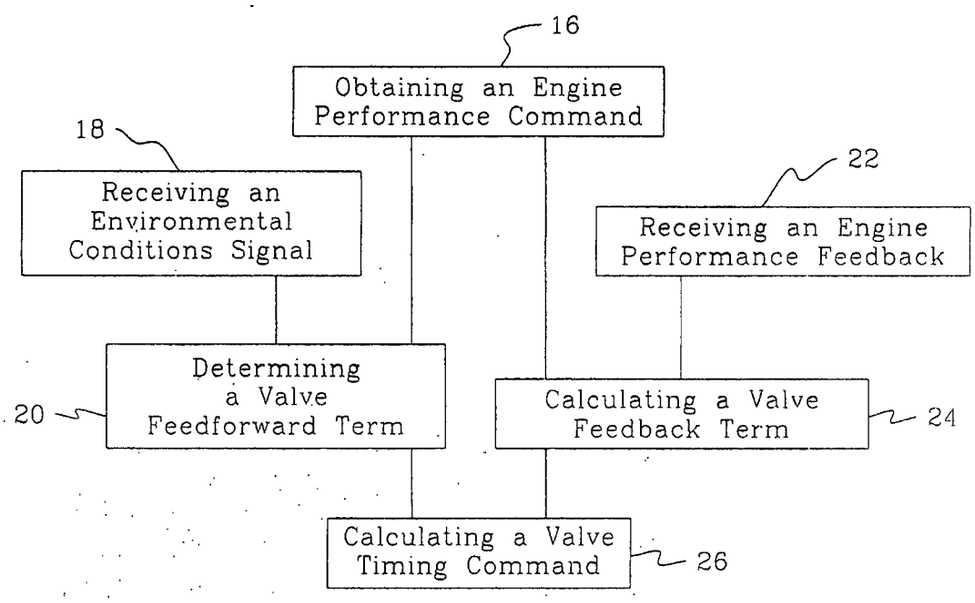


FIGURE 2

Express Mail Label No. EL 977 141 525 US

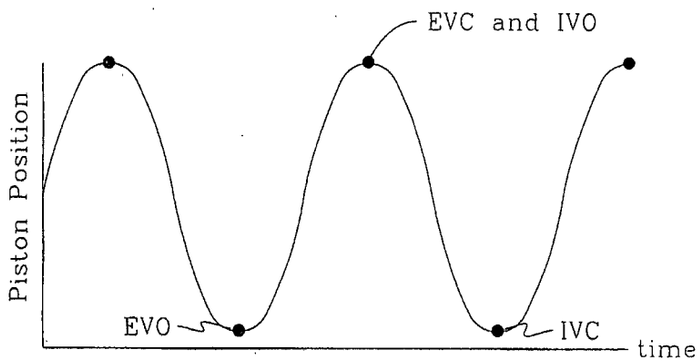


FIGURE 3A

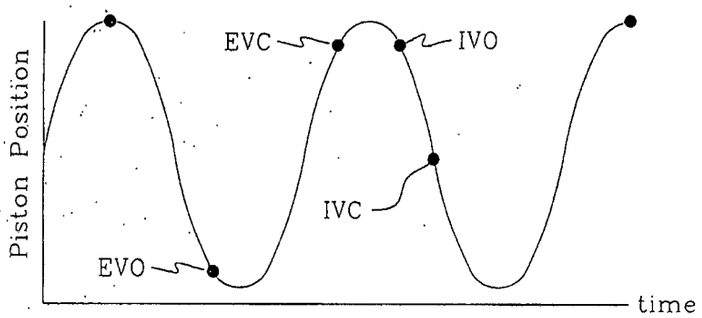


FIGURE 3B

Attorney Docket No.: 10541-070
Visteon Case No.: V200-0655

DECLARATION AND POWER OF ATTORNEY ORIGINAL APPLICATION

As a below named inventor, I hereby declare:

My residence, post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor or an original, first and joint inventor of the subject matter that is claimed and for which a patent is sought on the invention entitled:

METHOD OF CALCULATING A VALVE TIMING COMMAND FOR AN ENGINE

the specification of which is attached hereto.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge my duty to disclose to the United States Patent and Trademark Office all information that I know to be material to the patentability of this application as defined in Title 37 C.F.R. § 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s):			Priority Not Claimed
_____ (Number)	_____ (Country)	_____ (Filing Date)	☐
_____ (Number)	_____ (Country)	_____ (Filing Date)	☐
_____ (Number)	_____ (Country)	_____ (Filing Date)	☐

I hereby claim the benefit under 35 U.S. C. Section 119(e) of any United States provisional application(s) listed below:

_____ (Application Serial No.)	_____ (Filing Date)
_____ (Application Serial No.)	_____ (Filing Date)
_____ (Application Serial No.)	_____ (Filing Date)

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

I hereby claim the benefit un)5 U.S.C. Section 120 of any United St applications(s), or Section 365(c) of any PCT International Application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, C.F.R., Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

(Application Serial No.)	(Filing Date)	(Status: patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(Status: patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(Status: patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on 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 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorneys, agents, and each shareholder, attorney of counsel, associate, and employee of Brinks Hofer Gilson & Lione, who is a registered Patent Attorney or registered Patent Agent, my attorney with full power of substitution and revocation to prosecute this application and transact all business in the United States Patent and Trademark Office connected therewith and to act on my behalf before the competent International Authorities in connection with any and all international applications filed by me.

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James E. Stephenson, Reg. No. 17,191
David D. Murray, Reg. No. 28,647
Eric J. Sosenko, Reg. No. 34,440
Jeffrey M. Cox, Reg. No. 42,445
Raymond J. Vivacqua, Reg. No. 45,369
J. Matthew Buchanan, Reg. No. 47,459
Sujatha Subramaniam, Reg. No. P48,739
Larry I. Shelton, Reg. No. 45,100
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29074
PATENT & TRADEMARK OFFICE

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PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

Full name of second inventor, if any	Brett D. Collins
Second inventor's signature	Date 11/01/01
Residence	2298 Woodview Rd., #862, Ypsilanti, Michigan 48198
Citizenship	US
Post Office Address	SAME AS RESIDENCE ADDRESS

Full name of third inventor, if any	Ibrahim Haskara
Third inventor's signature	Date 11/02/01
Residence	23771 Brownstown Square Drive, 202, Brownstown, Michigan 48174
Citizenship	TR
Post Office Address	SAME AS RESIDENCE ADDRESS

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

Application Assignment Record

According to the application transmittal letter, an assignment recording ownership was filed with this application; however, a copy of this record was not located in the original file history record obtained from the United States Patent and Trademark Office. Upon your request, we will attempt to obtain the assignment documents from the Assignment Recordation Branch of of the United States Patent and Trademark Office or from a related application case (if applicable). Please note that additional charges will apply for this service.

This page is not part of the official USPTO record. It has been determined that content identified on this document is missing from the original file history record.

PATENT
Attorney Docket No.: 10541-070

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

#2

J1050 U.S. PTO
10/014286
12/11/01

Group Art Unit:	Unknown
Examiner:	Unknown
Inventors:	PENG, et al.
Serial No:	Unknown
Filed:	Concurrent Herewith
For:	METHOD OF CALCULATING A VALVE TIMING COMMAND FOR AN ENGINE

INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
Washington, DC 20231

Sir:

Under the duties of disclosure, candor, and good faith of 37 CFR §1.56, the Applicant hereby submits the references listed on the attached PTO-1449 form for consideration by the Examiner. In the opinion of the Applicant, the pending claims are patentably distinct from the listed references.

Under 37 CFR §1.97(b)(1), no fee should be required. If a fee is required, however, please charge any such fee pursuant to 37 CFR §1.16 or §1.17 to deposit account no. 06-1500.

Respectfully submitted,

Date: 11 December 2001

Jeffrey M. Cox
Reg. No. 42,445
Attorney for Applicant

BRINKS HOFER GILSON & LIONE
P.O. Box 10395
Chicago, IL 60610
(734) 302-6000

INFORMATION DISCLOSURE CITATION *(Use several sheets if necessary)*	Docket Number (Optional) 10541-070	Application Number Unknown
	Applicant(s) Peng et al.	
	Filing Date Concurrent Herewith	Group Art Unit ~~Unknown~~ 3747

U.S. PATENT DOCUMENTS

*EXAMINER INITIAL	REF	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
ES		4,700,684	10/20/87	Pischinger et al.			
ES		5,743,221	04/28/98	Schmitz			
ES		5,752,491	05/19/98	Schmitz et al.			

U1050 U.S. PTO 10/014286 12/11/01

FOREIGN PATENT DOCUMENTS

	REF	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS *(Including Author, Title, Date, Pertinent, Pages, Etc)*

EXAMINER	DATE CONSIDERED
Erik R Solé	12/9/2002

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP Section 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

BRINKS
HOFER
GILSON
&LIONE

A PROFESSIONAL CORPORATION
INTELLECTUAL PROPERTY ATTORNEYS

524 SOUTH MAIN STREET
SUITE 200
ANN ARBOR, MICHIGAN 48104-2921
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TELEPHONE 734-302-6000

CHICAGO, IL
SAN JOSE, CA
INDIANAPOLIS, IN
ARLINGTON, VA

11 December 2001

Commissioner of Patents
Box Patent Application
Washington, D.C. 20231

Sir:

EXPRESS MAILING CERTIFICATE

Applicant(s):	Mianzo et al
Title:	Method of Calculating a Valve Timing Command for an Engine
Attorney Docket:	10541-070
Attorney:	Jeffrey M. Cox

"Express Mail" Mailing Label No. ET718954276US

Date of Deposit .....11 December 2001

I hereby certify and verify that the accompanying **Utility Patent Application Transmittal, Fee Transmittal, Specification on ten (10) pages, Formal Drawings on three (3) sheets, Declaration and Power of Attorney, Recordation Cover Sheet, Assignment, Information Disclosure Statement, PTO Form 1449 with references, and two (2) Return Postcards** are being deposited with the United States Postal Service Express Mail Post Office To Addressee service under 37 C.F.R. 1.10 on the date indicated above and are addressed to Commissioner for Patents, Box Patent Application, Washington, D.C. 20231.

Ashley L. Rhoades

Signature of Person Mailing Document(s)

Transaction History Date 2002-12-11
Date information retrieved from USPTO Patent Application Information Retrieval (PAIR) system records at www.uspto.gov

Notice of Allowability	Application No.	Applicant(s)	
	10/014,286	MIANZO ET AL.	
	Examiner	Art Unit	
	Erick R Solis	3747	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *the filing of 11 December 2001*.
2. ☒ The allowed claim(s) is/are *1-16*.
3. ☒ The drawings filed on *11 December 2001* are accepted by the Examiner.
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
      1. ☐ Certified copies of the priority documents have been received.
      2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
      3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.
5. ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).
   (a) ☐ The translation of the foreign language provisional application has been received.
6. ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application. **THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.**

7. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

8. ☐ CORRECTED DRAWINGS must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No. ____.
   (b) ☐ including changes required by the proposed drawing correction filed _____, which has been approved by the Examiner.
   (c) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No. _____

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the top margin (not the back) of each sheet. The drawings should be filed as a separate paper with a transmittal letter addressed to the Official Draftsperson.

9. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1☒ Notice of References Cited (PTO-892)
2☐ Notice of Informal Patent Application (PTO-152)
3☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
4☐ Interview Summary (PTO-413), Paper No.____ .
5☒ Information Disclosure Statements (PTO-1449), Paper No. 2.
6☐ Examiner's Amendment/Comment
7☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
8☐ Examiner's Statement of Reasons for Allowance
9☐ Other

Erick R. Solis
Primary Examiner
Art Unit: 3747

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

Notice of References Cited	Application/Control No. 10/014,286	Applicant(s)/Patent Under Reexamination MIANZO ET AL.	
	Examiner Erick R Solis	Art Unit 3747	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
X	A	US-6,196,174	03-2001	Wada et al.	123/90.15
X	B	US-6,053,137	04-2000	Trzmiel et al.	123/90.17
X	C	US-2002/0092488	07-2002	Aoyama et al.	123/90.16
X	D	US-2001/0013324	08-2001	Yoshizawa et al.	123/90.16
X	E	US-2001/0004884	06-2001	Tachibana et al.	123/90.15
X	F	US-6,330,869	12-2001	Yoshiki et al.	123/90.15
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

29074 7590 12/11/2002

BRINKS HOFER GILSON & LIONE
P.O. BOX 10395
CHICAGO, IL 60611

EXAMINER
SOLIS, ERICK R

ART UNIT	CLASS-SUBCLASS
3747	123-679000

DATE MAILED: 12/11/2002

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/014,286	12/11/2001	Lawrence A. Mianzo	10541-070	3146

TITLE OF INVENTION: METHOD OF CALCULATING A VALVE TIMING COMMAND FOR AN ENGINE

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1280	$300	$1580	03/11/2003

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE REFLECTS A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE APPLIED IN THIS APPLICATION. THE PTOL-85B (OR AN EQUIVALENT) MUST BE RETURNED WITHIN THIS PERIOD EVEN IF NO FEE IS DUE OR THE APPLICATION WILL BE REGARDED AS ABANDONED.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:
A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status is changed, pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above and notify the United States Patent and Trademark Office of the change in status, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check the box below and enclose the PUBLICATION FEE and 1/2 the ISSUE FEE shown above.

☐ Applicant claims SMALL ENTITY status. See 37 CFR 1.27.

II. PART B - FEE(S) TRANSMITTAL should be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). Even if the fee(s) have already been paid, Part B - Fee(s) Transmittal should be completed and returned. If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Box ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PTOL-85 (REV. 04-02) Approved for use through 01/31/2004.

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Box ISSUE FEE**
Commissioner for Patents
Washington, D.C. 20231
Fax (703)746-4000

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 4 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Legibly mark-up with any corrections or use Block 1)

29074 7590 12/11/2002

BRINKS HOFER GILSON & LIONE
P.O. BOX 10395
CHICAGO, IL 60611

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Box Issue Fee address above, or being facsimile transmitted to the USPTO, on the date indicated below.

(Depositor's name)

(Signature)

(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/014,286	12/11/2001	Lawrence A. Mianzo	10541-070	3146

TITLE OF INVENTION: METHOD OF CALCULATING A VALVE TIMING COMMAND FOR AN ENGINE

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1280	$300	$1580	03/11/2003

EXAMINER	ART UNIT	CLASS-SUBCLASS
SOLIS, ERICK R	3747	123-679000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. Use of a Customer Number is required.

2. For printing on the patent front page, list (1) the names of up to 3 registered patent attorneys or agents OR; alternatively, (2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 _____
2 _____
3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. Inclusion of assignee data is only appropriate when an assignment has been previously submitted to the USPTO or is being submitted under separate cover. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) ☐ individual ☐ corporation or other private group entity ☐ government

4a. The following fee(s) are enclosed:

☐ Issue Fee
☐ Publication Fee
☐ Advance Order - # of Copies _____

4b. Payment of Fee(s):

☐ A check in the amount of the fee(s) is enclosed.
☐ Payment by credit card. Form PTO-2038 is attached.
☐ The Commissioner is hereby authorized by charge the required fee(s), or credit any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

Commissioner for Patents is requested to apply the Issue Fee and Publication Fee (if any) or to re-apply any previously paid issue fee to the application identified above.

(Authorized Signature) (Date)

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, Washington, D.C. 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, Washington, DC 20231.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

TRANSMIT THIS FORM WITH FEE(S)

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/014,286	12/11/2001	Lawrence A. Mianzo	10541-070	3146

29074 7590 12/11/2002

BRINKS HOFER GILSON & LIONE
P.O. BOX 10395
CHICAGO, IL 60611

EXAMINER	
SOLIS, ERICK R	
ART UNIT	**PAPER NUMBER**
3747	

DATE MAILED: 12/11/2002

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The patent term adjustment to date is 0 days. If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the term adjustment will be 0 days.

If a continued prosecution application (CPA) was filed in the above-identified application, the filing date that determines patent term adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) system. (http://pair.uspto.gov)

Any questions regarding the patent term extension or adjustment determination should be directed to the Office of Patent Legal Administration at (703)305-1383.

PTOL-85 (REV. 04-02) Approved for use through 01/31/2004.

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/014,286	12/11/2001	Lawrence A. Mianzo	10541-070	3146

29074 7590 12/11/2002

BRINKS HOFER GILSON & LIONE
P.O. BOX 10395
CHICAGO, IL 60611
UNITED STATES

EXAMINER	
SOLIS, ERICK R	
ART UNIT	**PAPER NUMBER**
3747	

DATE MAILED: 12/11/2002

Notice of Fee Increase on January 1, 2003

If a reply to a "Notice of Allowance and Fee(s) Due" is filed in the Office on or after January 1, 2003, then the amount due will be higher than that set forth in the "Notice of Allowance and Fee(s) Due" since there will be an increase in fees effective on January 1, 2003. See Revision of Patent and Trademark Fees for Fiscal Year 2003; Final Rule, 67 Fed. Reg. 70847, 70849 (November 27, 2002).

The current fee schedule is accessible from: http://www.uspto.gov/main/howtofees.htm.

If the issue fee paid is the amount shown on the "Notice of Allowance and Fee(s) Due," but not the correct amount in view of the fee increase, a "Notice to Pay Balance of Issue Fee" will be mailed to applicant. In order to avoid processing delays associated with mailing of a "Notice to Pay Balance of Issue Fee," if the response to the Notice of Allowance and Fee(s) due form is to be filed on or after January 1, 2003 (or mailed with a certificate of mailing on or after January 1, 2003), the issue fee paid should be the fee that is required at the time the fee is paid. If the issue fee was previously paid, and the response to the "Notice of Allowance and Fee(s) Due" includes a request to apply a previously-paid issue fee to the issue fee now due, then the difference between the issue fee amount at the time the response is filed and the previously paid issue fee should be paid. See Manual of Patent Examining Procedure, Section 1308.01 (Eighth Edition, August 2001).

Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at (703) 305-8283.

PTOL-85 (REV. 04-02) Approved for use through 01/31/2004.

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

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Transaction History Date 2003-03-17
Date information retrieved from USPTO Patent Application Information Retrieval (PAIR) system records at www.uspto.gov

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Box ISSUE FEE**
Commissioner for Patents
Washington, D.C. 20231
Fax **(703)746-4000**

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 4 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Legibly mark-up with any corrections or use Block 1)

29074 7590 12/11/2002

BRINKS HOFER GILSON & LIONE
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CHICAGO, IL 60611

OIPE JC140 MAR 17 2003 PATENT & TRADEMARK OFFICE

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Box Issue Fee address above, or being facsimile transmitted to the USPTO, on the date indicated below.

Jeffrey M. Cox	(Depositor's name)
	(Signature)
10 March 2003	(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/014,286	12/11/2001	Lawrence A. Mianzo	10541-070	3146

TITLE OF INVENTION: METHOD OF CALCULATING A VALVE TIMING COMMAND FOR AN ENGINE

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	~~$1280~~ $1300	$300	~~$1580~~ $1600	03/11/2003

EXAMINER	ART UNIT	CLASS-SUBCLASS
SOLIS, ERICK R	3747	123-679000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. Use of a Customer Number is required.

2. For printing on the patent front page, list (1) the names of up to 3 registered patent attorneys or agents OR, alternatively, (2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Brinks Hofer Gilson & Lione
2
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. Inclusion of assignee data is only appropriate when an assignment has been previously submitted to the USPTO or is being submitted under separate cover. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: Visteon Global Technologies, Inc.

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Dearborn, Michigan

Please check the appropriate assignee category or categories (will not be printed on the patent) ☐ individual ☒ corporation or other private group entity ☐ government

4a. The following fee(s) are enclosed:

☒ Issue Fee
☒ Publication Fee
☐ Advance Order - # of Copies _____

4b. Payment of Fee(s):

☐ A check in the amount of the fee(s) is enclosed.
☐ Payment by credit card. Form PTO-2038 is attached.
☒ The Commissioner is hereby authorized by charge the required fee(s), or credit any overpayment, to Deposit Account Number 06-1500 (enclose an extra copy of this form).

Commissioner for Patents is requested to apply the Issue Fee and Publication Fee (if any) or to re-apply any previously paid issue fee to the application identified above.

(Authorized Signature) Jeffrey M. Cox
Reg. No. 42,445

(Date) 3/10/2003

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

10/014,286

03/20/2003 STEUMEL2 00000072 061500 10014286

01 FC:1501 1300.00 CH
02 FC:1504 300.00 CH

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, Washington, D.C. 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, Washington, DC 20231.

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TRANSMIT THIS FORM WITH FEE(S)

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

File History Content Report

The following content is missing from the original file history record obtained from the United States Patent and Trademark Office. No additional information is available.

Document Date - 2003-05-06

Document Title - USPTO Grant

This page is not part of the official USPTO record. It has been determined that content identified on this document is missing from the original file history record.

O I P E JC66
JUN 12 2003
PATENT & TRADEMARK OFFICE

3747

Attorney Docket No.: 10541-070

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:
Mianzo et al.

Serial No.: 10/014,286

Filed: December 11, 2001

For: METHOD OF CALCULATING A VALVE TIMING COMMAND FOR AN ENGINE

Examiner: Erick R. Solis

Group Art Unit: 3747

TRANSMITTAL

Commissioner for Patents
U.S. Patent and Trademark Office
P. O. Box 1450
Alexandria, VA 22313-1450

RECEIVED
JUN 16 2003
TECHNOLOGY CENTER R3700

Sir:

Attached is/are:

- ☒ Information Disclosure Statement
- ☒ Form PTO - 1449 with copy of references
- ☐
- ☒ Return Receipt Postcard

Fee calculation and payment:

- ☐ No additional fee is required.
- ☐ An extension fee in an amount of $_____ for a _____-month extension of time under 37 C.F.R. § 1.136(a).
- ☒ A petition or processing fee in an amount of $180.00 under 37 C.F.R. § 1.17(p).
- ☐ An additional filing fee has been calculated as shown below:

	Claims Remaining After Amendment		Highest No. Previously Paid For	Present Extra
Total		Minus		
Indep.		Minus		
First Presentation of Multiple Dep. Claim				

Small Entity		or	Other Than Small Entity	
Rate	Add'l Fee		Rate	Add'l Fee
x $9=			x $18=	
x 42=			x $84=	
+$140=			+ $280=	
Total	$		Total	$

- ☐ A check in the amount of $_____ to cover the above-identified fee(s) is enclosed.
- ☒ Please charge Deposit Account No. 06-1500 (VISTEON GLOBAL TECHNOLOGIES, INC.) in the amount of $180.00. A copy of this Transmittal is enclosed for this purpose.
- ☒ The Commissioner is hereby authorized to charge payment of any additional filing fees required under 37 CFR § 1.16 and any patent application processing fees under 37 CFR § 1.17 associated with this paper (including any extension fee required to ensure that this paper is timely filed), or to credit any overpayment, to Deposit Account No. 06-1500. A copy of this Transmittal is enclosed for this purpose.

Respectfully submitted,

June 9, 2003
Date

Eric J. Sosenko (Reg. No. 34,440)
☒ Attorney/Agent Of Record
☐ 37 C.F.R. 1.34(a)

CERTIFICATE OF MAILING UNDER 37 C.F.R. §1.8

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail, with sufficient postage, in an envelope addressed to: Commissioner for Patents, U.S. Patent and Trademark Office, P. O. Box 1450, Alexandria, VA 22313-1450, on the below date:

Date: June 9, 2003 Name: Ashley L. Rhoades Signature: Ashley L. Rhoades

BRINKS HOFER GILSON & LIONE
P.O. Box 10395
Chicago, IL 60610

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

PE JC66 JUN 12 2003 PATENT & TRADEMARK OFFICE

Attorney Docket No.: 10541-070

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:
Mianzo et al.

Serial No.: 10/014,286

Filed: December 11, 2001

For: METHOD OF CALCULATING A VALVE TIMING COMMAND FOR AN ENGINE

Examiner: Erick R. Solis

Group Art Unit: 3747

INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
U.S. Patent and Trademark Office
P. O. Box 1450
Alexandria, VA 22313-1450

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JUN 16 2003
TECHNOLOGY CENTER R3700

Sir:

In accordance with the duty of disclosure under 37 C.F.R. §1.56, and more particularly in accordance with 37 C.F.R. §1.97(d), Applicant cites the following references (each listed for the Examiner's convenience on the enclosed Form PTO-1449):

DOCUMENT NUMBER	DATE	NAME
5,123,397	06/23/1992	Richeson
5,967,115	10/19/1999	Konopka et al.

A copy of each listed reference for which a copy is required under 37 C.F.R. §1.98(a)(2) is also enclosed. Applicant respectfully solicits the Examiner's consideration of the listed references and entry thereof into the record of this application.

06/13/2003 SSESHE1 00000060 061500 10014286
01 FC:1806 180.00 CH

BRINKS HOFER GILSON & LIONE
P.O. Box 10395
Chicago, IL 60610

By submitting this Statement, Applicant is attempting to fully comply with the duty of candor and good faith mandated by 37 C.F.R. §1.56. As such, this Statement is not intended to constitute an admission that any of the enclosed references, or other information referred to therein, constitutes "prior art" or is otherwise "material to patentability," as that phrase is defined in 37 C.F.R. §1.56(a).

Applicant hereby certifies that each item of information in this Statement was first cited in a communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of this Statement.

Applicant has also calculated a processing fee in the amount of $180.00 to be due under 37 C.F.R. §1.17(p) in connection with the filing of this Statement. Applicant has enclosed a check covering this fee, or authorized charging the fee to a deposit account, as indicated in the Transmittal accompanying this Statement.

Respectfully submitted,

June 9, 2003
Date

Eric J. Sosenko (Reg. No. 34,440)

Enclosures: Form PTO-1449 (one sheet)
Copies of listed references

BRINKS HOFER GILSON & LIONE
P.O. Box 10395
Chicago, IL 60610

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

INFORMATION DISCLOSURE CITATION *(Use several sheets if necessary)*	Docket Number (Optional) 10541-070	Application Number 10/014,286
	Applicant(s) Mianzo et al.	
	December 11, 2001	Group Art Unit 3747

OIPE JUN 12 2003 PATENT & TRADEMARK OFFICE

6/25/03

U.S. PATENT DOCUMENTS

*EXAMINER INITIAL	REF	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
		5,123,397	06/23/1992	Richeson			
		5,967,115	10/19/1999	Konopka et al.			

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JUN 16 2003
TECHNOLOGY CENTER R3700

FOREIGN PATENT DOCUMENTS

	REF	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS *(Including Author, Title, Date, Pertinent. Pages, Etc)*

EXAMINER	DATE CONSIDERED

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP Section 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

FORM PTO-A820
COMMERCE
(also form PTO-1449)

P09A/REV04

Patent and Trademark Office*U.S. DEPARTMENT OF

SHEET 1 OF 1

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/014,286	12/11/2001	Lawrence A. Mianzo	10541-070	3146

29074 7590 07/08/2003

BRINKS HOFER GILSON & LIONE
P.O. BOX 10395
CHICAGO, IL 60611

EXAMINER	
SOLIS, ERICK R	
ART UNIT	**PAPER NUMBER**
3747	5

DATE MAILED: 07/08/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

PTO-90C (Rev. 07-01)

UNITED STATES DEPARTMENT OF COMMERCE
U.S. Patent and Tra nark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450

APPLICATION NO./ CONTROL NO.	FILING DATE	FIRST NAMED INVENTOR / PATENT IN REEXAMINATION	ATTORNEY DOCKET NO.

EXAMINER

ART UNIT	PAPER
	5

DATE MAILED:

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner for Patents

Aknowledgement of Receipt of Information Disclosure Statement

The Information Disclosure Statement received on 12 June 2003 has been received and entered into the file of this application. This Information Disclosure Statement does not comply with MPEP 609 as it has been received after the payment of the issue fee and as a matter of fact after the publication of the patent. Therefore, the cited references have not been considered.

Erick R Solis
Primary Examiner
Art Unit: 3747
(703) 308-2651

PTO-90C (Rev.04-03)

File History Content Report

The following content is missing from the original file history record obtained from the United States Patent and Trademark Office. No additional information is available.

Document Date - 2003-07-29

Document Title - USPTO Communication Re: Change of Address

This page is not part of the official USPTO record. It has been determined that content identified on this document is missing from the original file history record.

504528526 08/31/2017

PATENT ASSIGNMENT COVER SHEET

Electronic Version v1.1
Stylesheet Version v1.2

EPAS ID: PAT4575232

SUBMISSION TYPE:	NEW ASSIGNMENT
NATURE OF CONVEYANCE:	ASSIGNMENT

CONVEYING PARTY DATA

Name	Execution Date
GODO KAISHA IP BRIDGE	09/02/2016

RECEIVING PARTY DATA

Name:	MOBILE AUTOMOTIVE TECHNOLOGIES, LLC
Street Address:	951 GOVERNMENT STREET, SUITE B
City:	MOBILE
State/Country:	ALABAMA
Postal Code:	36604

PROPERTY NUMBERS Total: 42

Property Type	Number
Patent Number:	6345604
Patent Number:	6347680
Patent Number:	6379281
Patent Number:	6443128
Patent Number:	6510839
Patent Number:	6557540
Patent Number:	6561166
Patent Number:	6571157
Patent Number:	6581565
Patent Number:	6581574
Patent Number:	6588260
Patent Number:	6598581
Patent Number:	6607302
Patent Number:	6609497
Patent Number:	6612287
Patent Number:	6619106
Patent Number:	6644115
Patent Number:	6736122
Patent Number:	6741441
Patent Number:	6752741

Property Type	Number
Patent Number:	6757149
Patent Number:	6758885
Patent Number:	6763804
Patent Number:	6766788
Patent Number:	6817592
Patent Number:	6847882
Patent Number:	6856209
Patent Number:	6874362
Patent Number:	6976477
Patent Number:	6988031
Patent Number:	7089894
Patent Number:	7116081
Patent Number:	7124963
Patent Number:	7137577
Patent Number:	7143501
Patent Number:	7168637
Patent Number:	7191755
Patent Number:	7198207
Patent Number:	7293554
Patent Number:	7487761
Patent Number:	7712451
Patent Number:	7982358

CORRESPONDENCE DATA

Fax Number: (302)449-9010

Correspondence will be sent to the e-mail address first; if that is unsuccessful, it will be sent using a fax number, if provided; if that is unsuccessful, it will be sent via US Mail.

Phone: 3024499010
Email: mmcclain@devlinlawfirm.com
Correspondent Name: TIMOTHY DEVLIN
Address Line 1: 1306 N. BROOM STREET
Address Line 2: 1ST FLOOR
Address Line 4: WILMINGTON, DELAWARE 19806

NAME OF SUBMITTER:	TIMOTHY DEVLIN
SIGNATURE:	/TIMOTHY DEVLIN/
DATE SIGNED:	08/31/2017
	This document serves as an Oath/Declaration (37 CFR 1.63).

Total Attachments: 3
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EXHIBIT B

U.S. PATENT ASSIGNMENT

WHEREAS, Godo Kaisha IP Bridge 1 ("Assignor"), is the owner of (i) United States Patent and Patent Applications listed in Schedule A and the following (ii) through (iv) to the extent Assignor owns, controls or has the right to license or enforce them at any time: (ii) any patents or patent applications that claim priority directly or indirectly from any of the foregoing patent(s) in subsection (i), or from which priority is directly or indirectly claimed by any such patent(s) in subsection (i), or that have common priority with any such patent(s) in subsection (i); (iii) any foreign counterparts, foreign related patents, continuations, divisionals, continuations-in-part, extensions, substitutions, reissues, renewals and all results of oppositions, reexaminations, supplemental examinations, requests for continued examination and other review procedures of any of the foregoing in subsections (i) and (ii); and (iv) all patents issuing on patent applications covered by any of the foregoing subsections (i) through (iii) (together the "Assigned Patents").

WHEREAS, Mobile Automotive Technologies, LLC, an Alabama limited liability company ("Assignee") is desirous of acquiring title in and to the Assigned Patents.

WHEREAS, Assignor is the owner of any and all right, title, and interest in and to the Assigned Patents.

WHEREAS, Assignor desires to sell, assign, and transfer all its right, title, and interest in the Assigned Patents to Assignee, and Assignee desires to obtain all such right, title, and interest in the Assigned Patents from Assignor.

NOW, THEREFORE, in consideration of good and valuable consideration, the receipt and adequacy of which is hereby acknowledged, Assignor hereby sells, assigns, transfers and conveys unto Assignee, its permitted successors and assigns, all of Assignor's right, title, and interest in and to the Assigned Patents, together with all claims, demands, or causes of action that Assignor has or might have by reason of any infringement of the Assigned Patents prior to the effective date of this assignment, including the right to sue and collect damages for all past, present and future infringement and all lost profits resulting therefrom.

IN WITNESS WHEREOF, this Agreement has been executed by duly authorized representatives of the Parties on the dates below.

Signature

Hideyuki Ogata
Name

Date: Sept. 2, 2016

Signature

KEVIN C. BRADY
Name

Date: AUG 27, 2016

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

SCHEDULE A

Patents:

US6345604
US6347680
US6379281
US6443128
US6510839
US6557540
US6561166
US6571157
US6581565
US6581574
US6588260
US6598581
US6607302
US6609497
US6612287
US6619106
US6644115
US6736122
US6741441
US6752741
US6757149
US6758885
US6763804
US6766788
US6817592
US6847882
US6856209
US6874362
US6976477
US6988031
US7089894
US7116081
US7124963
US7137577
US7143501
US7168637
US7191755
US7198207

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

US7293554
US7487761
US7712451
US7982358

DE103 44 494.7-34
GB2385013
GB2422688
JP4235485

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

504528590 08/31/2017

PATENT ASSIGNMENT COVER SHEET

Electronic Version v1.1
Stylesheet Version v1.2

EPAS ID: PAT4575296

SUBMISSION TYPE:	NEW ASSIGNMENT
NATURE OF CONVEYANCE:	ASSIGNMENT

CONVEYING PARTY DATA

Name	Execution Date
GODO KAISHA IP BRIDGE	11/02/2016

RECEIVING PARTY DATA

Name:	MOBILE AUTOMOTIVE TECHNOLOGIES, LLC
Street Address:	951 GOVERNMENT STREET, SUITE B
City:	MOBILE
State/Country:	ALABAMA
Postal Code:	36604

PROPERTY NUMBERS Total: 42

Property Type	Number
Patent Number:	6345604
Patent Number:	6347680
Patent Number:	6379281
Patent Number:	6443128
Patent Number:	6510839
Patent Number:	6557540
Patent Number:	6561166
Patent Number:	6571157
Patent Number:	6581565
Patent Number:	6581574
Patent Number:	6588260
Patent Number:	6598581
Patent Number:	6607302
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Patent Number:	6612287
Patent Number:	6619106
Patent Number:	6644115
Patent Number:	6736122
Patent Number:	6741441
Patent Number:	6752741

Property Type	Number
Patent Number:	6757149
Patent Number:	6758885
Patent Number:	6763804
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Patent Number:	6847882
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Patent Number:	7124963
Patent Number:	7137577
Patent Number:	7143501
Patent Number:	7168637
Patent Number:	7191755
Patent Number:	7198207
Patent Number:	7293554
Patent Number:	7487761
Patent Number:	7712451
Patent Number:	7982358

CORRESPONDENCE DATA

Fax Number: (302)449-9010

Correspondence will be sent to the e-mail address first; if that is unsuccessful, it will be sent using a fax number, if provided; if that is unsuccessful, it will be sent via US Mail.

Phone: 3024499010
Email: mmcclain@devlinlawfirm.com
Correspondent Name: TIMOTHY DEVLIN
Address Line 1: 1306 N. BROOM STREET
Address Line 2: 1ST FLOOR
Address Line 4: WILMINGTON, DELAWARE 19806

NAME OF SUBMITTER:	TIMOTHY DEVLIN
SIGNATURE:	/TIMOTHY DEVLIN/
DATE SIGNED:	08/31/2017
	This document serves as an Oath/Declaration (37 CFR 1.63).

Total Attachments: 3
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504528678 08/31/2017

PATENT ASSIGNMENT COVER SHEET

Electronic Version v1.1
Stylesheet Version v1.2

EPAS ID: PAT4575384

SUBMISSION TYPE:	NEW ASSIGNMENT
NATURE OF CONVEYANCE:	ASSIGNMENT

CONVEYING PARTY DATA

Name	Execution Date
MOBILE AUTOMOTIVE TECHNOLOGIES, LLC	08/28/2017

RECEIVING PARTY DATA

Name:	MICHIGAN MOTOR TECHNOLOGIES LLC
Street Address:	2360 ORCHARD LAKE ROAD SUITE 100
City:	SYLVAN LAKE
State/Country:	MICHIGAN
Postal Code:	48320

PROPERTY NUMBERS Total: 42

Property Type	Number
Patent Number:	6345604
Patent Number:	6347680
Patent Number:	6379281
Patent Number:	6443128
Patent Number:	6510839
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SIGNATURE:	/TIMOTHY DEVLIN/
DATE SIGNED:	08/31/2017
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Total Attachments: 2
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EXHIBIT B

U.S. PATENT ASSIGNMENT

WHEREAS, Mobile Automotive Technologies, LLC, an Alabama limited liability company ("Assignor"), is the owner of (i) United States Patent and Patent Applications listed in Schedule A and the following (ii) through (iv) to the extent Assignor owns, controls or has the right to license or enforce them at any time: (ii) any patents or patent applications that claim priority directly or indirectly from any of the foregoing patent(s) in subsection (i), or from which priority is directly or indirectly claimed by any such patent(s) in subsection (i), or that have common priority with any such patent(s) in subsection (i); (iii) any foreign counterparts, foreign related patents, continuations, divisionals, continuations-in-part, extensions, substitutions, reissues, renewals and all results of oppositions, reexaminations, supplemental examinations, requests for continued examination and other review procedures of any of the foregoing in subsections (i) and (ii); and (iv) all patents issuing on patent applications covered by any of the foregoing subsections (i) through (iii) (together the "Assigned Patents").

WHEREAS, Michigan Motor Technologies LLC ("Assignee") is desirous of acquiring title in and to the Assigned Patents.

WHEREAS, Assignor is the owner of any and all right, title, and interest in and to the Assigned Patents.

WHEREAS, Assignor desires to sell, assign, and transfer all its right, title, and interest in the Assigned Patents to Assignee, and Assignee desires to obtain all such right, title, and interest in the Assigned Patents from Assignor.

NOW, THEREFORE, in consideration of good and valuable consideration, the receipt and adequacy of which is hereby acknowledged, Assignor hereby sells, assigns, transfers and conveys unto Assignee, its permitted successors and assigns, all of Assignor's right, title, and interest in and to the Assigned Patents, together with all claims, demands, or causes of action that Assignor has or might have by reason of any infringement of the Assigned Patents prior to the effective date of this assignment, including the right to sue and collect damages for all past, present and future infringement and all lost profits resulting therefrom.

IN WITNESS WHEREOF, this Agreement has been executed by duly authorized representatives of the Parties on the dates below.

Signature

Name John Mobile Automotive Technologies LLC

Date: 8/25/17

Signature

Name KEVIN C BRADY MICHIGAN MOTOR TECHNOLOGIES LLC

Date: 8/28/17

SCHEDULE A

Patents:

US6345604
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US6379281
US6443128
US6510839
US6557540
US6561166
US6571157
US6581565
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US7137577
US7143501
US7168637
US7191755
US7198207
US7293554
US7487761
US7712451
US7982358
DE103 44 494.7-34
GB2385013
GB2422688
JP4235485
DE103 22 529.3

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

504584165 10/06/2017

PATENT ASSIGNMENT COVER SHEET

Electronic Version v1.1
Stylesheet Version v1.2

EPAS ID: PAT4630877

SUBMISSION TYPE:	RESUBMISSION
NATURE OF CONVEYANCE:	ASSIGNMENT
RESUBMIT DOCUMENT ID:	504528590

CONVEYING PARTY DATA

Name	Execution Date
GODO KAISHA IP BRIDGE	11/02/2016

RECEIVING PARTY DATA

Name:	MOBILE AUTOMOTIVE TECHNOLOGIES, LLC
Street Address:	951 GOVERNMENT STREET, SUITE B
City:	MOBILE
State/Country:	ALABAMA
Postal Code:	36604

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Patent Number:	6736122
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Patent Number:	6856209
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Patent Number:	7487761
Patent Number:	7712451
Patent Number:	7982358

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NAME OF SUBMITTER:	TIMOTHY DEVLIN
SIGNATURE:	/Timothy Devlin/
DATE SIGNED:	10/06/2017
	This document serves as an Oath/Declaration (37 CFR 1.63).

Total Attachments: 6

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source=MobileAutoSignedPAA#page3.tif

AMENDMENT NO. 1 TO THE PATENT ASSIGNMENT AGREEMENT

This Amendment No. 1 (the "**Amendment**"), dated as of the latest execution date below, is entered into by Mobile Automotive Technologies, LLC, an Alabama limited liability company and Godo Kaisha IP Bridge 1, with its principal offices at c/o Sakura Sogo Jimusho, 1-11 Kanda Jimbocho, Chiyoda-ku, Tokyo 102-0083, Japan, and amends the Patent Assignment Agreement entered into by the parties, executed on September 2, 2016 (the "**PTA**"). Capitalized terms not defined herein are defined in the PTA.

The parties agree to retroactively amend the PTA as follows:

1. Exhibit A to the PTA is hereby retroactively amended and restated in its entirety in the form of Exhibit A attached hereto.

2. The parties intend and agree that this Amendment shall be effective as of the Effective Date of the PTA with the same force and effect as if executed on that date. Except as expressly amended by this Amendment, all other terms, conditions and provisions of the PTA shall apply.

IN WITNESS WHEREOF, the parties have executed this Amendment through their duly authorized representatives.

Mobile Automotive Technologies, LLC

By: _____

Name: Kevin C. Brady

Title: Managing Member

Date: 10-21-2016

Godo Kaisha IP Bridge 1

By: _____

Name: Hideyuki Ogata

Title: Executive Manager

Date: 11-2-2016

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

EXHIBIT A

Patents:

1 US6345604
2 US6347680
3 US6379281
4 US6443128
5 US6510839
6 US6557540
7 US6561166
8 US6571157
9 US6581565
10 US6581574
11 US6588260
12 US6598581
13 US6607302
14 US6609497
15 US6612287
16 US6619106
17 US6644115
18 US6736122
19 US6741441
20 US6752741
21 US6757149
22 US6758885
23 US6763804
24 US6766788
25 US6817592
26 US6847882
27 US6856209
28 US6874362
29 US6976477
30 US6988031
31 US7089894
32 US7116081
33 US7124963
34 US7137577
35 US7143501
36 US7168637

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

37 US7191755
38 US7198207
39 US7293554
40 US7487761
41 US7712451
42 US7982358
43 DE103 44 494.7-34
44 GB2385013
45 GB2422688
46 JP4235485
47 DE103 22 529.3

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

EXHIBIT B

U.S. PATENT ASSIGNMENT

WHEREAS, Godo Kaisha IP Bridge 1 ("Assignor"), is the owner of (i) United States Patent and Patent Applications listed in Schedule A and the following (ii) through (iv) to the extent Assignor owns, controls or has the right to license or enforce them at any time: (ii) any patents or patent applications that claim priority directly or indirectly from any of the foregoing patent(s) in subsection (i), or from which priority is directly or indirectly claimed by any such patent(s) in subsection (i), or that have common priority with any such patent(s) in subsection (i); (iii) any foreign counterparts, foreign related patents, continuations, divisionals, continuations-in-part, extensions, substitutions, reissues, renewals and all results of oppositions, reexaminations, supplemental examinations, requests for continued examination and other review procedures of any of the foregoing in subsections (i) and (ii); and (iv) all patents issuing on patent applications covered by any of the foregoing subsections (i) through (iii) (together the "Assigned Patents").

WHEREAS, Mobile Automotive Technologies, LLC, an Alabama limited liability company ("Assignee") is desirous of acquiring title in and to the Assigned Patents.

WHEREAS, Assignor is the owner of any and all right, title, and interest in and to the Assigned Patents.

WHEREAS, Assignor desires to sell, assign, and transfer all its right, title, and interest in the Assigned Patents to Assignee, and Assignee desires to obtain all such right, title, and interest in the Assigned Patents from Assignor.

NOW, THEREFORE, in consideration of good and valuable consideration, the receipt and adequacy of which is hereby acknowledged, Assignor hereby sells, assigns, transfers and conveys unto Assignee, its permitted successors and assigns, all of Assignor's right, title, and interest in and to the Assigned Patents, together with all claims, demands, or causes of action that Assignor has or might have by reason of any infringement of the Assigned Patents prior to the effective date of this assignment, including the right to sue and collect damages for all past, present and future infringement and all lost profits resulting therefrom.

IN WITNESS WHEREOF, this Agreement has been executed by duly authorized representatives of the Parties on the dates below.

Signature

Hideyuki Ogata
Name

Date: Sept. 2, 2016

Signature

KEVIN C. BRADY
Name

Date: AUG 27, 2016

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

SCHEDULE A

Patents:

US6345604
US6347680
US6379281
US6443128
US6510839
US6557540
US6561166
US6571157
US6581565
US6581574
US6588260
US6598581
US6607302
US6609497
US6612287
US6619106
US6644115
US6736122
US6741441
US6752741
US6757149
US6758885
US6763804
US6766788
US6817592
US6847882
US6856209
US6874362
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US6988031
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US7116081
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US7137577
US7143501
US7168637
US7191755
US7198207

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

US7293554
US7487761
US7712451
US7982358

DE103 44 494.7-34
GB2385013
GB2422688
JP4235485

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

Transaction History Date 2018-05-14
Date information retrieved from USPTO Patent Application Information Retrieval (PAIR) system records at www.uspto.gov

Paper No._____

UNITED STATES PATENT AND TRADEMARK OFFICE

_____

BEFORE THE PATENT TRIAL AND APPEAL BOARD

_____

HYUNDAI MOTOR COMPANY,

Petitioner

v.

MICHIGAN MOTOR TECHNOLOGIES LLC,

Patent Owner

Patent No. 6,557,540

Issue Date: May 6, 2003

Title: METHOD OF CALCULATING A VALVE TIMING COMMAND FOR AN ENGINE

Inter Partes Review No.: IPR2018-01061

PETITIONER'S POWER OF ATTORNEY

PETITIONER'S POWER OF ATTORNEY

Petitioner, Hyundai Motor Company ("HMC"), hereby appoints the following as its attorneys to transact all business in the United States Patent and Trademark Office associated with the above-captioned *Inter Partes* review:

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The individual signing below has the authority to act on behalf of HMC and execute this document.

Date: May 14, 2018 By: _____

Name: Hoe-il Kim

Title: General Manager, IP Legal Team

Company: Hyundai Motor Company

CERTIFICATE OF SERVICE

I hereby certify that on May 14, 2018, I caused a true and correct copy of the foregoing materials:

- Petition for *Inter Partes* Review of U.S. Patent No. 6,557,540 under 35 U.S.C. § 311-319 and 37 C.F.R. § 42.100 *Et Seq.*
- Exhibits 1001 – 1034
- Power of Attorney

to be served via:

Via FedEx Mail

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Dated: May 14, 2018

By: */Brian C. McCormack/*
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Paper No._____

UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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HYUNDAI MOTOR COMPANY,

Petitioner

v.

MICHIGAN MOTOR TECHNOLOGIES LLC,

Patent Owner

Patent No. 6,557,540

Issue Date: May 6, 2003

Title: METHOD OF CALCULATING A VALVE TIMING COMMAND FOR AN ENGINE

Inter Partes Review No. IPR2018-01061

PETITION FOR *INTER PARTES* REVIEW OF CLAIMS 1-3, 7, 10-11, AND 14 OF U.S. PATENT NO. 6,557,540 UNDER 35 U.S.C. §§ 311-319 AND 37 C.F.R. § 42.100 *ET. SEQ.*

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VIII. CLAIM-BY-CLAIM EXPLANATION OF GROUNDS FOR UNPATENTABILITY 26

A. Ground 1: Claims 1-3, 7, 10-11, and 14 are unpatentable under pre-AIA 35 U.S.C. § 103(a) as obvious based on Yoshioka in view of Jankovic. 29

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1. **Claim 1** 33
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EXHIBIT LIST

EXHIBIT NUMBER	DESCRIPTION
1001	U.S. Patent No. 6,557,540 to Mianzo et al ("the '540 patent")
1002	Declaration of Scott Andrews
1003	File History for the '540 patent
1004	U.S. Patent No. 5,713,317 to Yoshioka ("Yoshioka")
1005	"Torque Management of Engines with Variable Cam Timing," M. Jankovic, F. Frischmuth, A. Stefanopoulou, and J. A. Cook, IEEE Control Systems, October 1998 ("Jankovic")
1006	"Bosch Fuel Injection Systems," F. Aird, Berkeley Publishing Group, 2001, ISBN 1-55788-365-3 ("Aird")
1007	"Bosch Fuel Injection & Engine Management," C. O. Probst, Robert Bentley, Inc., 1992, ISBN-978-0-8376-0300-1 ("Probst")
1008	"Modeling and Control of Advanced Technology Engines," A. Stefanopoulou, U. Mich., 1996 ("Stefanopoulou")
1009	"Automotive Encyclopedia," W. Toboldt & L. Johnson, Goodheart-Wilcox Co. Inc., 1979, ISBN 0-87006-268-9 ("Toboldt")
1010	"Bosch Automotive Handbook," Robert Bosch GmbH, 2000, ISBN 0-7680-0669-4 ("Bosch")
1011	CV of Scott Andrews
1012	"Automotive Electronics Handbook," R. Jurgen, McGraw-Hill, Inc., ISBN0-07-033189-8, 1994 ("Jurgen")
1013	McGraw-Hill Electronics Dictionary, 6th ed. By Neil Sclater and John Markus © 1997 Mcgraw-Hill Inc., ISBN 0-07-057837-0.

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

1014	"The New Shorter Oxford English Dictionary," Oxford University Press, vol. 1, 0-19-861271-0ISBN, 1993 ("Oxford Dictionary")
1015	Declaration of Sylvia D. Hall-Ellis, Ph.D.
1016	CV of Sylvia D. Hall-Ellis, Ph.D.
1017	Jurgen MARC Record from the Library of Congress
1018	Jurgen MARC Record from the OCLC Connexion database
1019	Probst MARC Record from the Library of Congress
1020	Probst MARC Record from the OCLC Connexion database
1021	Aird MARC Record from the Library of Congress
1022	Aird MARC Record from the OCLC Connexion database
1023	Toboldt MARC Record from the Library of Congress
1024	Toboldt MARC Record from the OCLC Connexion database
1025	Bosch MARC Record from the San Francisco Public Library
1026	Bosch MARC Record from the OCLC Connexion database
1027	Sclater MARC Record from the Library of Congress
1028	Sclater MARC Record from the OCLC Connexion database
1029	Oxford Dictionary MARC Record from the Library of Congress
1030	Oxford Dictionary MARC Record from the OCLC Connexion database
1031	Stefanopoulou MARC Record from the University of Michigan Library
1032	Stefanopoulou MARC Record from the OCLC Connexion database
1033	Jankovic MARC Record from the Library of Congress

PETITIONER'S EXHIBIT 1002
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1034	Jankovic MARC Record from the OCLC Connexion database

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

I. INTRODUCTION

Petitioner, Hyundai Motor Company ("Hyundai" or "Petitioner"), hereby petitions for *inter partes* review and cancellation of claims 1-3, 7, 10-11, and 14 of U.S. Patent No. 6,557,540 ("the '540 patent") (Ex. 1001). The challenged claims generally relate to methods and devices for determining a valve timing command. As detailed in this Petition, the claimed configurations were well-known in the relevant art prior to the '540 patent.

II. MANDATORY NOTICES

Pursuant to 37 C.F.R. § 42.8(a)(1), Petitioner provides the following mandatory disclosures.

A. Real Party-In-Interest

Hyundai Motor Company and Hyundai America Technical Center, Inc. are the real parties-in-interest.

B. Related Matters

Michigan Motor Technologies LLC ("MMT" or "Patent Owner") sued Hyundai Motor Company and Hyundai America Technical Center, Inc. in Michigan Motor Technologies LLC v. Hyundai Motor Company et al, No. 2:17-cv-12901 (E.D. Mich), alleging infringement of the '540 patent. Hyundai is not aware of any other pending judicial or administrative matter that would affect, or be affected by, a decision in this proceeding.

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

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

LEAD COUNSEL	BACK-UP COUNSEL
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D. Service Information Under 37 C.F.R. § 42.8(b)(4)

Petitioner consents to electronic service by email at: HMC-MMT-IPR@BakerMcKenzie.com.

III. PAYMENT OF FEES UNDER 37 C.F.R. § 41.103

Petitioner authorizes the United States Patent and Trademark Office (USPTO) to charge the fees set forth in 37 C.F.R. § 42.15(a) for this Petition, and any additional fees that might be due, to Deposit Account No. 13-0480 (Attorney Docket No. 10035108-50391355). This Petition meets the fee requirements of 35 U.S.C. § 312(a)(1).

PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

IV. REQUIREMENTS FOR INTER PARTES REVIEW UNDER 37 C.F.R. § 42.104

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

Petitioner certifies that the '540 patent is available for *inter partes* review and that Petitioner is not barred or estopped from requesting an *inter partes* review challenging claims 1-3, 7, 10, 11, and 14 of the '540 patent on the grounds identified in this Petition.

B. Identification of Challenge Under 37 C.F.R. § 42.104(b) and Statement of Precise Relief Requested

Petitioner respectfully requests the Board initiate *inter partes* review of claims 1-3, 7, 10-11, and 14 of the '540 patent based on the following grounds:

No.	Claims	Ground	Reference(s)
1	1-3, 7, 10-11, 14	103(a)[1]	Yoshioka and Jankovic

Section VIII below demonstrates, for each of the statutory grounds, that there is a reasonable likelihood that Petitioner will prevail. *See* 35 U.S.C. § 314(a).

V. TECHNICAL OVERVIEW

A. Background

1. Technological Background

Several competing objectives are present in internal combustion engines,

[1]The Leahy-Smith America Invents Act ("AIA"), Pub. L. No. 112- 29, 125 Stat. 284, 296–07 (2011), took effect on September 16, 2012. Because the '540 patent was filed before that date, Petitioner has applied the pre-AIA versions of 35 U.S.C. §§ 102 and 103.

including developing maximum power output, while attaining efficient fuel consumption and minimizing exhaust byproducts. Ex. 1002 ¶ 36. To achieve these objectives, internal combustion engine electrical controls focus on managing the ratio of fuel and air. *Id*. To power an automobile, an engine takes in air, mixes it with fuel, and combust the air-fuel mixture. *Id*. at ¶ 33. The combustion process produces power to power the automobile. *Id*. The intake of air is controlled by the throttle valve. *Id*. ¶ 34. The throttle valve is linked to the accelerator pedal, whereby "[d]epressing the pedal opens the throttle valve, permitting an increased amount of air-fuel mixture to reach the manifold." Ex. 1009 p. 11, Automotive Encyclopedia p. 239[2]; Ex. 1002 ¶ 34. To minimize exhaust byproducts, a POSITA would have long appreciated exhaust gas recirculation (EGR) methods for controlling emissions. Ex. 1002 ¶¶ 39-40; Ex. 1007 p. 24, Probst ch. 2 p. 17; Ex. 1007 pp. 47-48, Probst ch. 2 pp. 21-22.[3] A POSITA further would have appreciated that variable cam timing (VCT) methods were used to control EGR. Ex. 1002 ¶ 42; Ex. 1008 pp. 18-19, Modeling and Control of Advanced Technology Engines pp. 6-7.[4] A POSITA would have further known that both feedforward and feedback controls had been used in electronic engine management

[2]Ex. 1009 has a copyright date of 1979, and was published and accessible to the public no later than December 20, 1978. Ex. 1015 ¶¶ 60-65.

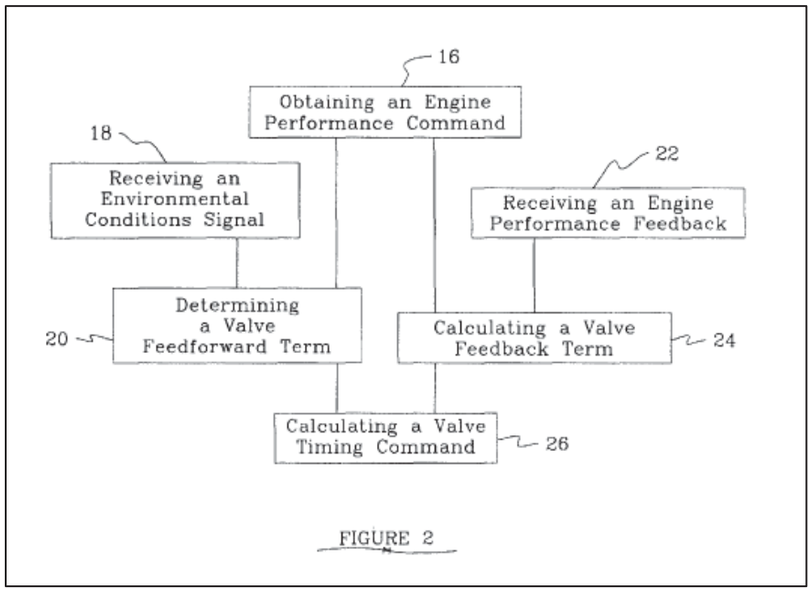
[3]Ex. 1007 has a copyright date of 1989, and was published and accessible to the public no later than May 26, 1989. Ex. 1015 ¶¶ 48-53.

[4]Ex. 1008 has a copyright date of 1996, and was published and accessible to the public no later than June 27, 1996. Ex. 1015 ¶¶ 54-59.

to address and account for a variety of variables, including, for example, engine speed, load, and air-fuel ratio. Ex. 1002 ¶ 46-47; Ex. 1007 p. 57, Probst ch. 3 p. 31; Ex. 1013 p. 13, McGraw-Hill Electronics Dictionary p. 168.[5]

2. The '540 Patent

The '540 patent relates to a "method of calculating a valve timing command for an engine." Ex. 1001 at Title. The '540 patent describes and claims the method quite generically, and Figure 2 illustrates the claimed method.

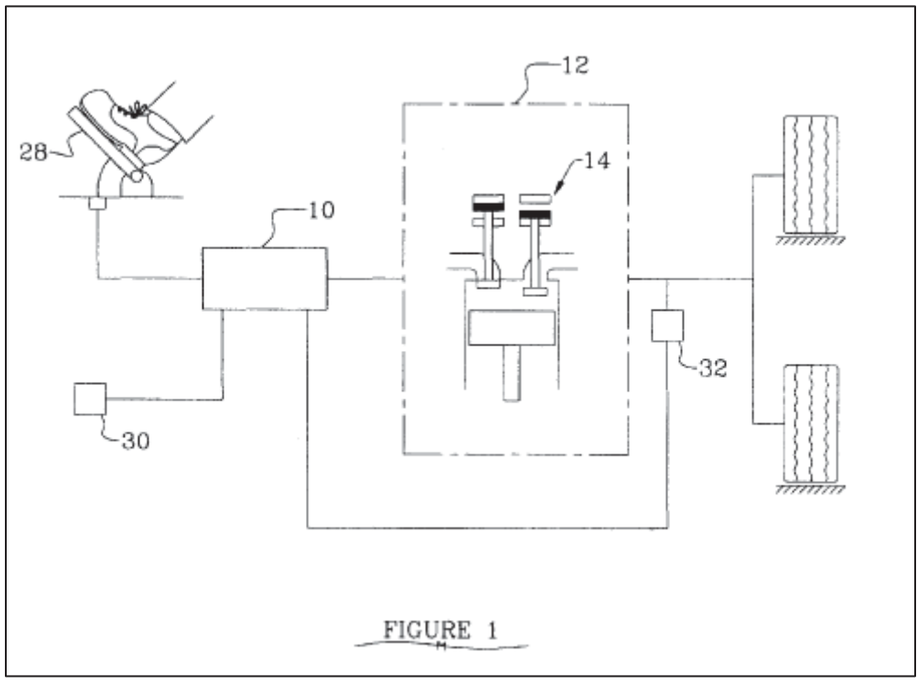


Ex. 1001 Fig. 2

The '540 patent describes that that an engine performance command is received at 16, which preferably includes receiving a vehicle performance command from a driver. Ex. 1001 2:4-6. For example, the vehicle performance

[5]Ex. 1013 has a copyright date of 1997, and was published and accessible to the public no later than April 14, 1997. Ex. 1015 ¶¶ 78-83.

command includes a driver pressing down on a conventional pedal 28, as shown in Figure 1 (below). *Id*. at 7-9. Referring back to Figure 2, an environmental conditions signal is received at action 18, which includes a signal from an environmental sensor 30 (sensor 30 is shown below in Figure 1).



Ex. 1001 Fig. 1

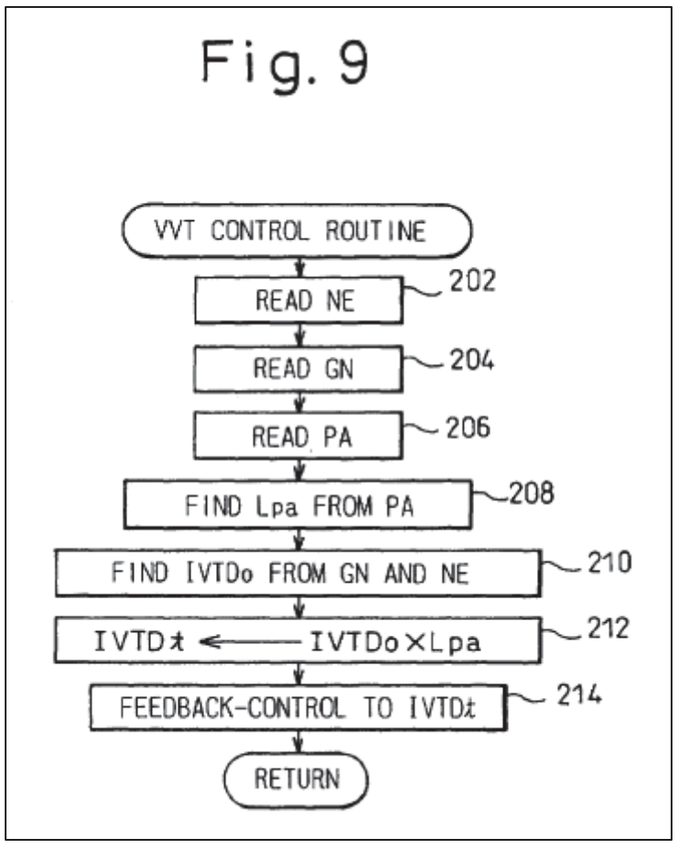
The ’540 patent further discloses that engine performance feedback is received at action 22, which may include engine speed, engine torque data, or “other suitable information.” *Id*. at 2:36-47. A valve feedforward term (target valve timing displacement $IVTD_t$) is determined at action 20, preferably based on an engine torque command, the ambient temperature data, and the engine speed data, but can also be based on “other suitable factors, such as engine torque data,

air-fuel ratio data, engine combustion stability data, or ambient pressure data." *Id*. at 2:48-54. However, the claims only recite that the feedforward term is based on the environmental conditions signal and the engine performance command. *Id*. at cl. 1. The feedforward term is preferably based on using a look-up table with optimized variables and values. *Id*. at 2:54-59. The '540 patent further discloses that a valve feedback term is calculated by comparing the engine performance command with the engine performance feedback. *Id*. 2:66-3:1. The feedback term "compare[s] the input with the output and . . . calculate[s] a correction term based on the difference." *Id*. at 3:1-4. The valve timing command is then calculated based on the feedforward term and the feedback term. *Id*. 1:65-2:1.

3. Yoshioka

U.S. Patent No. 5,713,317 to Yoshioka (Ex. 1004) was filed on Jul. 15, 1996, and was patented on Feb. 3, 1998, and thus qualifies as prior art under pre-AIA 35 U.S.C. §) and 102(b). Yoshioka relates to a "method of and apparatus for continuously and variably controlling valve timing of internal combustion engine." Ex. 1004 at Title. Yoshioka's Figure 9 is an illustration of one aspect of the disclosed methods.

PETITIONER'S EXHIBIT 1002
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Ex. 1004 Fig. 9

Yoshioka discloses that various engine performance commands are received, including, for example, a signal from the throttle opening sensor 42, which measures the opening of the throttle valve (which, as discussed further below, relates directly to the performance desired by the driver as interpreted from the accelerator pedal position[6]). Ex. 1004 at 4:20-25. As is well-known by a person of ordinary skill in the art, the throttle valve and the opening of the throttle is controlled by the accelerator pedal—or by a human driver pushing on the

[6]Ex. 1005 at 2, Jankovic p. 35; Ex. 1002 ¶¶ 125-126.

accelerator pedal. *See e.g.* Ex. 1002 ¶¶ 34-35; Ex. 1009 at 11, Tobold at 239; Ex. 1007 at 79, Probst at 5:11. As shown in Figure 9, Yoshioka further discloses that an environmental conditions signal is received at action 206, whereby the atmospheric pressure is read and detected by an atmospheric pressure sensor. Ex. 1004 7:24-25, 7:55-56. Yoshioka further discloses that engine performance feedback is received, including readings from magnetic sensors 54, 55 at the camshaft and crankshaft of the engine. *Id*. at 6:6-15. A valve feedforward term in the form of a target valve timing displacement ($IVTD_t$) is determined at action 212, based on the environmental conditions signal PA and the engine performance command (the load GN, which directly relates to the engine performance command). *Id*. at 8:1-2, Fig. 9 at 204-212. The feedforward term is based on a look-up table with optimized variables and values, as shown in Figure 4. *Id*. at 7:36-40 ("Step 112 refers to the map of FIG. 4 according to the engine load GNpa and engine revolution speed NE, to find a displacement IVTDpa to be imposed on the open/close timing of the intake valve 24."); 8:1-4. Yoshioka further discloses that a valve feedback term is calculated by comparing the engine performance command with the engine performance feedback. *Id*. at 8:5-8. Specifically, to set the open/close timing of the intake valve, the hydraulic pressure control valve 68 is feedback-controlled according to signals from the first and second magnetic sensors 54 and 55 so that the camshaft of the intake valve maintains a required

PETITIONER'S EXHIBIT 1002
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rotational phase with respect to the crankshaft. *Id*. at 6:6-15 And the valve timing control or command is adjusted by "bring[ing] the actual displacement of the intake valve 24 to the target displacement IVTDt," as a result of the feedback control. *Id*.

4. Jankovic

"Torque Management of Engines with Variable Cam Timing," by Mrdjan Jankovic *et al*, Ex. 1005 ("Jankovic"), was published in October 1998 in *IEEE Control Systems*, and thus qualifies as prior art under pre-AIA 35 U.S.C. § and 102(b). Ex. 1015 ¶¶ 37-41 (establishing authenticity and accessibility to the public no later than October 31, 1998, for Ex. 1005); *see also Ericsson Inc. v. Intellectual Ventures I LLC*, IPR2014-00527 Paper No. 41, Final Written Decision (admitting an IEEE article as prior art by accepting the publication information on the IEEE copyright line); Ex. 1005 p. 34 (showing "©1998IEEE" on the copyright line). Jankovic also provides a variable cam timing (VCT) system, to address both "drivability and emissions performance by utilizing an electro-hydraulic mechanism to rotate the camshaft relative to the crankshaft in order to retard the cam timing with respect to the intake and exhaust strokes in the engine." Ex. 1005 at 1, Jankovic at 34. Both the intake and exhaust valve timings are part of the overall engine management scheme in Jankovic.

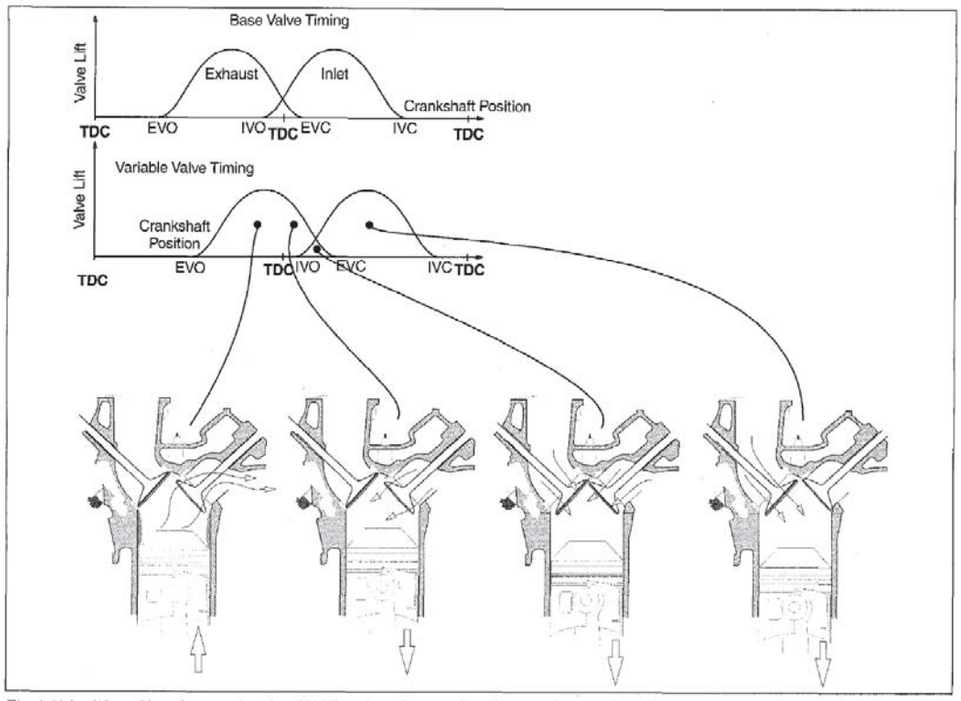


Fig. 1. Valve lift profiles of conventional and VCT engines. By retarding the cam phasing, the exhaust valve stays open during the intake event for a longer time period, retaining otherwise unburned HC and reducing the combustion temperature due to the dilution of the inert gas.

Ex. 1005 at 2, Jankovic p. 36

Jankovic's VCT system incorporates both feedforward compensation and a feedback loop, similar to Yoshioka. Ex. 1005 pp. 1, 7-8, Jankovic pp. 36, 40-41. With respect to the feedback loop, Jankovic discloses that the actual measured cam offset ζ_{CAM} (engine performance feedback) is fed into a PID control calculation, and the output of the PID (feedback term) is then compared to the target camshaft offset ζ_{REF} (feedforward term). Ex. 1005 p. 8, Jankovic p. 41; Ex. 1002 ¶ 108. The difference is used as a correction to control the VCT system (valve timing command). Ex. 1005 p. 8, Jankovic p. 41; Ex. 1002 ¶ 108. Jankovic describes that its goal is to improve "drivability and emissions performance" by using a variable

valve timing controller to rotate the camshaft relative to the crankshaft. Ex. 1005 pp. 1-2, Jankovic pp. 34-35. Jankovic provides a detailed mathematical model of a feedback controller in this context. Ex. 1002 ¶ 178; Ex. 1005 p. 7, Jankovic p. 41, Fig. 8.

B. The Claimed Invention

The challenged claims of the '540 patent are generally directed to methods for calculating valve timing commands for a vehicle engine. Independent claim 1 is reproduced below as an exemplary claim:

> 1. 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.

Ex. 1001 cl. 1. The dependent claims further recite method limitations, such as, receiving a vehicle performance command from a driver of the vehicle (claim 2);

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receiving ambient temperature (claim 3); and receiving fuel conversion data (claim 11); among others.

C. The Prosecution History of the ’540 Patent

During prosecution of the ’540 patent, the application received a first office action allowance without any claim rejections. Ex. 1003 at 33. The examiner did not provide any reasons for allowability. However, Petitioner notes that Yoshioka, and Jankovic were not before the examiner during prosecution of the ’540 patent.

VI. LEVEL OF ORDINARY SKILL IN THE ART

The following factors are pertinent to a determination of the level of ordinary skill in the art: (1) educational level of the inventor; (2) type of problems encountered in the art; (3) prior art solutions to those problems; (4) rapidity with which innovations are made; (5) sophistication of the technology; and (6) educational level of workers active in the field. *Denso Corp. v. Collision Avoidance Techs. Inc.*, IPR2017-01715, Decision Instituting *Inter Partes* Review, Paper No. 7 (Jan. 23, 2018) (citing *Environmental Designs, Ltd. v. Union Oil Co.*, 713 F.2d 693, 696-697 (Fed. Cir. 1983) (internal citations omitted)). “Not all factors may be present in every case, and one or more of these or other factors may predominate in a particular case.” *Id*. Moreover, the prior art may reflect an appropriate skill level. *Id*. citing *Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001).

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The prior art of record in the current proceeding is primarily directed to methods and systems for continuous and variable control of valve timing for an engine. *See, e.g.*, Ex. 1004 at Abstract ("A method or apparatus controls a continuously variable valve timing mechanism of an internal combustion engine to continuously and variably control the timing of an intake valve according to atmospheric pressure."); Ex. 1005 p. 1, Jankovic p. 34 ("The variable cam timing (VCT) system with which this paper is concerned addresses both drivability and emissions performance by utilizing an electro-hydraulic mechanism to rotate the camshaft relative to the crankshaft in order to retard the cam timing with respect to the intake and exhaust strokes of the engine."). The types of problems and solutions encountered in the prior art include, for example, exhaust emissions standards and vehicle performance deterioration (Ex. 1005 at 1, Jankovic p. 34), and providing high-performing engines at various altitudes and atmospheric pressures, improving exhaust purifying performance, and reducing fuel consumption (Ex. 1004 at 1:39-47). Workers in the field of automotive electronics design would typically have a bachelor's or master's degree in electrical engineering degree and at least several years of experience. Ex. 1002 ¶ 17.

Accordingly, Petitioner submits that a person of ordinary skill in the art would have had a bachelor's degree in electrical engineering and at least 4-5 years of work experience in automotive electrical or electronics systems design, or

would have had a masters degree in electrical engineering and at least 2 years of work experience in automotive electrical or electronics systems design. Ex. 1002 ¶ 17.

VII. CONSTRUCTION OF THE CLAIMS

In *inter partes* review proceedings, claims in unexpired patents should be interpreted using the broadest reasonable interpretation in light of the claim language and specification of the patent. 37 C.F.R. § 42.100(b); *Cuozzo Speed Techs., LLC v. Lee*, 136 S. Ct. 2131, 2144-46 (2016). The Federal Circuit recently provided guidance on the proper application of the "broadest reasonable interpretation" standard. *In re Smith Int'l, Inc.*, No. 16-2303, 871 F.3d 1375, 1382 (Fed. Cir. Sept. 26, 2017). As articulated in *Smith*, the "broadest reasonable interpretation" is one that "corresponds with what and how the inventor describes his invention in the specification, i.e., an interpretation that is 'consistent with the specification.'" I*d*. at 1382-1383. Accordingly, the correct interpretation under the broadest reasonable interpretation should be an interpretation that is consistent with the specification. *Id*. at 1383.

Other than the terms specifically discussed below, Petitioner does not at this time contend that any other term requires explicit construction by the Board. Instead, Petitioner proposes, for purposes of this proceeding only, that the claim terms of the '540 patent take on their broadest reasonable construction. This claim

construction analysis is not, and should not be viewed as, a concession by Petitioner as to the proper scope of any claim term in any litigation. In addition, these assumptions are not a waiver of any argument in any litigation that claim terms in the '540 patent are indefinite or otherwise invalid.

A. Construction of "engine performance"

The term "engine performance" should be construed to mean "engine measurable or engine response." The term "engine performance" appears in claims 1, 2, and 5-8.[7] This interpretation is based on the broadest reasonable interpretation of these terms in the context of the claims and in view of the specification of the '540 patent. The specification of the '540 patent does not define "engine performance." In the claims, the term "engine performance" arises in two contexts—"engine performance command," and "engine performance feedback." For example, independent claim 1 recites, in part, "obtaining an engine performance command," and "receiving an engine performance feedback." Dependent claim 2 recites, in part, "wherein said obtaining an engine performance command includes receiving a vehicle performance command from a driver of the vehicle." And dependent claim 7 recites, in part, "wherein said receiving an engine performance feedback includes receiving engine speed data."

[7]This section focuses on claims 1, 2, and 7, because those claims are included in the grounds for institution of *inter partes* review herein.

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The specification describes the "engine performance" in terms of engine performance command in general and broad terms:

> The action of obtaining an engine performance command also preferably includes deriving the engine performance command from the vehicle performance command. The engine performance command is preferably based on the vehicle performance command, but may alternatively be based on additional suitable factors, such as a traction control signal or a cruise control signal. ***The engine performance command is preferably a desired engine torque and, for this reason, the engine performance command may be thought of as an engine torque command. The engine performance command, however, may alternatively be another suitable variable, such as a desired engine acceleration***.

Ex. 1001 2:10-22 (emphasis added). Accordingly, the specification gives several examples of engine performance commands, and also states that the engine performance command could "be another suitable variable." *Id*. The specification thus discusses "engine performance" in terms of its connection with a desired engine response or action (e.g., desired engine torque or desired engine acceleration).

Similarly, the specification describes the "engine performance" in terms of the engine performance feedback in very general and broad terms:

> Similarly, the action of receiving an engine performance feedback **22** preferably includes receiving the engine performance

> feedback from an engine sensor **32** in the vehicle. The engine sensor **32** preferably senses the engine speed and communicates this data to the control unit **10**, which uses the data to determine the valve feedforward term and the valve feedback term. Other engine measurables, such as engine torque data, may be useful in the determination of the terms. For this reason, the engine sensor **32** may alternatively sense other suitable information. The engine sensor **32** is preferably a conventional engine sensor, but may alternatively be any suitable sensor.

Ex. 1001 2:36-47. Accordingly, the specification gives several examples of engine performance feedback, such as engine speed and engine torque data, but also states that the engine performance feedback could be an "other engine measurable" or "other suitable information." *Id*.

Accordingly, Petitioner submits that a person of ordinary skill in the art would understand the term "engine performance" in view of the context of the claims and the specification, to mean "engine measurable or engine response." Ex. 1002 ¶¶ 68-75; *see, e.g., In re Morris*, 127 F.3d at 1054.

B. Construction of "environmental conditions signal"

The term "environmental conditions signal" should be construed to mean "signal representing a parameter of the environment." The term "environmental conditions signal" appears in claims 1 and 3. This interpretation is based on the broadest reasonable interpretation of these terms in the context of the claims and in

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view of the specification of the ’540 patent. The specification of the ’540 patent does not define “environmental conditions signal.” Independent claim 1 recites, in part, “receiving an environmental conditions signal” and “determining a valve feedforward term based on the engine performance command and the environmental conditions signal.” Dependent claim 3 recites, in part, “wherein said receiving an environmental conditions signal includes receiving ambient temperature data.”

The specification describes the environmental conditions signal in very general and broad terms:

> The action of receiving an environmental conditions signal **18** preferably includes receiving an environmental conditions signal from an environmental sensor **30** in the vehicle. The environmental sensor **30** preferably senses the ambient temperature outside the vehicle and communicates this data to the control unit **10**, which uses the data to determine the valve feedforward term. Other information, such as the ambient pressure, may be useful in the determination of the valve feedforward term. For this reason, the environmental sensor **30** may alternatively sense other suitable information. The environmental sensor **30** is preferably a conventional environmental sensor, but may alternatively be any suitable device.

Ex. 1001 2:23-35. Accordingly, the specification gives several examples of an environmental conditions signal, such as ambient temperature and ambient

pressure, but also states that the environmental conditions signal could be "other suitable information." *Id*.

The '540 patent does not define "environmental conditions signal," but does describe the signal as preferably being received from an "environmental sensor 30." *Id*.; Ex. 1002 ¶ 77. A person of ordinary skill in the art, in view of the context of the '540 patent, would understand that such a sensor would be outputting an electrical signal providing a kind of parameter about the environment. Ex. 1002 ¶ 77.

Accordingly, Petitioner submits that a person of ordinary skill in the art would understand the term "environmental conditions signal" in view of the context of the claims and the specification, to mean "signal representing a parameter of the environment." Ex. 1002 ¶¶ 76-78; *see, e.g., In re Morris*, 127 F.3d at 1054.

C. Construction of "vehicle performance command"

The term "vehicle performance command" should be construed to mean "signal derived from a driver action to initiate a vehicle performance parameter." The term "vehicle performance command" appears in claim 2. This interpretation is based on the broadest reasonable interpretation of these terms in the context of the claims and in view of the specification of the '540 patent. The specification of the '540 patent does not define "vehicle performance command." Dependent

claim 2 recites, in part, "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."

The specification describes the vehicle performance command in very general and broad terms:

> Preferably, the vehicle performance command is received from the foot of a driver with the use of a conventional pedal **28**, as shown in FIG. **1**. Alternatively, the vehicle performance command could be received from the driver with the use of any suitable device. The action of obtaining an engine performance command also preferably includes deriving the engine performance command from the vehicle performance command. The engine performance command is preferably based on the vehicle performance command, but may alternatively be based on additional suitable factors, such as a traction control signal or a cruise control signal. The engine performance command is preferably a desired engine torque and, for this reason, the engine performance command may be thought of as an engine torque command. The engine performance command, however, may alternatively be another suitable variable, such as a desired engine acceleration.

Ex. 1001 2:4-22. Accordingly, the specification provides that the vehicle performance command could be received from the foot of a driver with the use of a

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conventional pedal, but that it could also be received from the driver with the use of any suitable device. *Id*. The '540 patent does not define "command," but a person of ordinary skill in the art at the time of the invention, and in the context of the '540 patent, would understand "command" to mean an electrical signal or input, or a representation of an electrical signal or input, associated with initiating a response. The New Shorter Oxford English Dictionary, Oxford University Press 1993, defines command as a "symbolic expression which defines an operation in a computer; a signal initiating the performance of such an operation." Ex. 1014 at 4, Oxford Dictionary p. 449.[8]

Accordingly, Petitioner submits that a person of ordinary skill in the art would understand the term "environmental conditions signal" in view of the context of the claims and the specification, to mean "signal derived from a driver action to initiate a vehicle performance parameter." Ex. 1002 ¶¶ 79-81; *see, e.g., In re Morris*, 127 F.3d at 1054.

D. Construction of "fuel conversion data"

The term "fuel conversion data" should be construed to mean "data representing a direct or indirect measure of the volume of fuel burned in the combustion process." The term "fuel conversion data" appears in claims 11, 12,

[8]Ex. 1014 has a copyright date of 1993, and was published and accessible to the public no later than November 17, 1993. Ex. 1015 ¶¶ 84-89.

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and 13.[9] This interpretation is based on the broadest reasonable interpretation of these terms in the context of the claims and in view of the specification of the '540 patent. The specification of the '540 patent does not define "fuel conversion data." Dependent claim 11 recites, in part, "receiving fuel conversion data."

The specification describes the fuel conversion data in very general and broad terms:

> The second preferred method of the invention includes the principle actions of the first preferred method and the additional principle action of receiving fuel conversion data and engine emissions data. These preferably include receiving the fuel conversion data and engine emissions data from suitable emission sensors (not shown) in the cylinder or the exhaust port of the engine **12**. The emission sensors preferably sense the amount of NO_x in the exhaust and communicates this data to the control unit **10**. The control unit **10** preferably uses this information to modify the output value from the look-up table, but may alternatively use this information to continually adjust the values in the look-up table. The control unit **10** may alternatively use this information as another factor in the determination of the valve feedback term. The emission sensors are preferably conventional emission sensors, but may alternatively be any suitable sensor.

Ex. 1001 3:27-43. Accordingly, the specification provides that the fuel conversion data is preferably received from "suitable emission sensors (not shown) in the

[9]This section focuses on claim 11 because it is included in the grounds for institution of *inter partes* review herein.

cylinder or the exhaust port of the engine 12." *Id*. The '540 patent goes on to explain that the emission sensors preferably sense the amount of NO_x in the exhaust, and that the sensors are preferably conventional emission sensors but may be "any suitable sensor." *Id*.

Based on this disclosure, a person of ordinary skill in the art would understand that "'fuel conversion' refers to the conversion of fuel into exhaust gas components and heat, and that a suitable measure of fuel conversion would be a direct or indirect measurement of how much of the fuel provided to the engine had been converted or burned in the combustion process." Ex. 1002 ¶ 83.

Accordingly, Petitioner submits that a person of ordinary skill in the art would understand the term "fuel conversion data" in view of the context of the claims and the specification, to mean "data representing a direct or indirect measure of the volume of fuel burned in the combustion process." Ex. 1002 ¶¶ 82-84; *see, e.g., In re Morris*, 127 F.3d at 1054.

E. Construction of "engine emissions data"

The term "engine emissions data" should be construed to mean "data representing a direct or indirect measure of the concentration of emissions gases in the engine exhaust." The term "engine emissions data" appears in claims 14, 15,

and 16.[10] This interpretation is based on the broadest reasonable interpretation of these terms in the context of the claims and in view of the specification of the '540 patent. The specification of the '540 patent does not define "engine emissions data." Dependent claim 14 recites, in part, "receiving engine emissions data."

The specification describes the engine emissions data in very general and broad terms:

> The second preferred method of the invention includes the principle actions of the first preferred method and the additional principle action of receiving fuel conversion data and engine emissions data. These preferably include receiving the fuel conversion data and engine emissions data from suitable emission sensors (not shown) in the cylinder or the exhaust port of the engine **12**. The emission sensors preferably sense the amount of NO_x in the exhaust and communicates this data to the control unit **10**. The control unit **10** preferably uses this information to modify the output value from the look-up table, but may alternatively use this information to continually adjust the values in the look-up table. The control unit **10** may alternatively use this information as another factor in the determination of the valve feedback term. The emission sensors are preferably conventional emission sensors, but may alternatively be any suitable sensor.

Ex. 1001 3:27-43. Accordingly, the specification provides that the engine emissions data is preferably received from "suitable emission sensors (not shown)

[10]This section focuses on claim 14 because it is included in the grounds for institution of *inter partes* review herein.

in the cylinder or the exhaust port of the engine 12." *Id*. The '540 patent goes on to explain that the emission sensors preferably sense the amount of NO_x in the exhaust, and that the sensors are preferably conventional emission sensors but may be "any suitable sensor." *Id*.

Moreover, a person of ordinary skill in the art would understand that emissions sensors may sense emissions directly or indirectly, depending on the kind of emissions sensor, and often rely on the known combustion processes and chemistry to allow an estimate of emissions based on the measurement of indirect parameters. Ex. 1002 ¶ 86. A person of ordinary skill in the art would also appreciate that the "primary emissions from the combustion process are oxides of nitrogen (typically designated NOx), carbon monoxide (CO), and unburned hydrocarbons (HC)" and that the quantity of these emissions varies as the air-fuel ratio varies. *Id*. Accordingly, Petitioner submits that a person of ordinary skill in the art would understand the term "engine emissions data" would mean "data representing a direct or indirect measure of the concentration of emissions gases in the engine exhaust." Ex. 1002 ¶¶ 85-87; *see, e.g.*, *In re Morris*, 127 F.3d at 1054.

VIII. CLAIM-BY-CLAIM EXPLANATION OF GROUNDS FOR UNPATENTABILITY

Pre-AIA Section 103(a) of the United States patent laws provides that a "patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 , if the differences between the subject matter

sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains." 35 U.S.C. § 103(a). The Supreme Court's decision in *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398 (2007) (hereinafter "*KSR*") sets forth the standard for determining obviousness under 35 U.S.C. § 103. The obviousness inquiry is resolved based on an analysis of several factual inquiries, as set forth in *Graham v. John Deere Co. of Kansas City*, 383 U.S. 1, 17 (1966): (1) the scope and content of the prior art; (2) differences between the prior art and the claims at issue; (3) the level of ordinary skill in the pertinent art; and (4) evaluation of any relevant secondary considerations. Instead, the Court found that a rigid application of the "teaching, suggestion, and motivation" test was "incompatible with [Supreme Court] precedents." *KSR*, 550 U.S. at 405.

The Court emphasized that an "expansive and flexible approach" should be used when determining obviousness. *Id*. at 415. The Court set forth several rationales and principles, including the following: (1) if a work is available in one field of endeavor, and design incentives and other market forces can prompt variations of it (either in the same field or a different one), and a person of ordinary skill can implement a predictable variation, the variation is obvious; (2) if a technique has been used to improve one device, and a person of ordinary skill in

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the art would recognize that it would improve similar devices in the same way, using the technique is obvious unless its application is beyond his or her skill; (3) the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results; (4) if the improvement is nothing more than the predictable use of prior art elements according to their established functions, it is likely obvious, among others. *Id*. at 416-17.

The Court in *KSR* also recognized that "[o]ften, it will be necessary for a court to look to interrelated teachings of multiple patents; the effects of demands known to the design community or present in the marketplace; and the background knowledge possessed by a person having ordinary skill in the art, all in order to determine whether there was an apparent reason to combine the known elements in the fashion claimed by the patent at issue." *Id*. at 418. And the Court cautioned that "the analysis need not seek out precise teachings directed to the specific subject matter of the challenged claim, for a court can take account of the inferences and creative steps that a person of ordinary skill in the art would employ." *Id*. The Court also recognized that "[c]ommon sense teaches . . . that familiar items may have obvious uses beyond their primary purposes, and in many cases a person of ordinary skill will be able to fit the teachings of multiple patents together like pieces of a puzzle." *Id*. at 420. And the Court further recognized that

"[a] person of ordinary skill is also a person of ordinary creativity, not an automaton." *Id*. at 421.

A. Ground 1: Claims 1-3, 7, 10-11, and 14 are unpatentable under pre-AIA 35 U.S.C. § 103(a) as obvious based on Yoshioka in view of Jankovic.

Claims 1-3, 7, 10-11, and 14 are unpatentable under pre-AIA 35 U.S.C. § 103(a) as obvious based on Yoshioka in view of Jankovic.

Yoshioka provides a method and apparatus for continuously and variably controlling valve timing of an internal combustion engine. Ex. 1004 at Title. Yoshioka specifically addresses adjusting valve timing in an internal combustion engine according to atmospheric pressure. *See, e.g.*, Ex. 1004 at Abstract. Yoshioka's disclosure includes "a method . . . for optimizing valve timing according to atmospheric pressure for a continuously variable valve timing mechanism . . . " and "improve[s] the output of an engine at high altitudes under high load, as well as reducing fuel consumption and improving exhaust purifying performance at high altitudes under low/medium load." *Id*. at 1:39-48; *see also id*. 2:30-34; Ex. 1002 ¶ 174.

Yoshioka discloses a method for receiving a signal from the throttle valve sensor 42, which detects the opening of the throttle valve 5 (an engine performance command). Ex. 1004 4:20-21. Yoshioka's method further includes reading an atmospheric pressure PA detected from an atmospheric pressure sensor 46

(receiving an environmental conditions signal). Ex. 1004 7:24-25, Fig. 2 at 46. Yoshioka further discloses calculating a target valve timing displacement or offset, $IVTD_t$. (determining a valve feedforward term). Ex. 1004 Fig. 9 at 212. The target valve offset is based on engine load GN, which is calculated according to mass flow rate of intake air detected by an airflow meter. Ex. 1004 Fig. 9 at 204-212, 7:20-24. The mass flow rate of intake air is directly related to the opening of the throttle valve. Ex. 1004 7:20-24. Accordingly, the target valve timing offset is based on the opening of the throttle valve (the engine performance command). *Id*. The target valve timing offset is also calculated based on the atmospheric pressure detected by sensor 46 (the environmental conditions signal). Ex. 1004 Fig. 9 at 206-212.

Yoshioka further discloses receiving signals from first and second magnetic sensors 54, 55, which are arranged closely to the crankshaft 81 and camshaft 85, respectively. Ex. 1004 5:4-9, Fig. 2 at 54, 55. First and second magnetic sensors 54, 55 provide reference pulses, and the position of the camshaft relative to the crankshaft (engine performance feedback) is thus received. *Id*. Yoshioka further discloses that the signals received from the first and second magnetic sensors 54, 55, are utilized to feedback control the hydraulic pressure control valve, so that the camshaft of the intake valve maintains a required rotational phase with respect to the crankshaft (calculating a valve feedback term). *Id*. 6:6-15. The feedback

control serves to bring an actual displacement of the cam and crank angles to the target valve timing displacement $IVTD_t$ (calculating the valve timing command). *Id*. 7:41-45.

Jankovic also provides a variable cam timing (VCT) system, to address both "drivability and emissions performance by utilizing an electro-hydraulic mechanism to rotate the camshaft relative to the crankshaft in order to retard the cam timing with respect to the intake and exhaust strokes in the engine." Ex. 1005 at 1, Jankovic p. 34. Both the intake and exhaust valve timings are part of the overall engine management scheme in Jankovic.

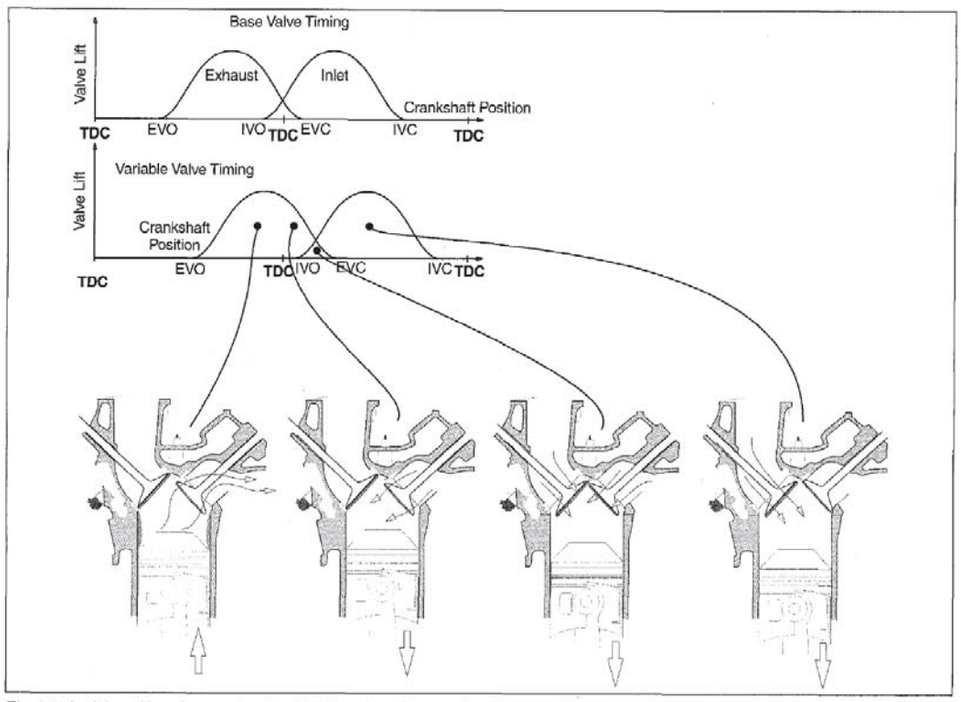


Fig. 1. Valve lift profiles of conventional and VCT engines. By retarding the cam phasing, the exhaust valve stays open during the intake event for a longer time period, retaining otherwise unburned HC and reducing the combustion temperature due to the dilution of the inert gas.

Ex. 1005 p. 2, Jankovic p. 35

Jankovic's VCT system incorporates both feedforward compensation and a feedback loop, similar to Yoshioka. Ex. 1005 at 3, 7-8, Jankovic pp. 36, 40-41. With respect to the feedback loop, Jankovic discloses that the actual measured cam offset ζ_{CAM} (engine performance feedback) is fed into a PID control calculation, and the output of the PID (feedback term) is then compared to the target camshaft offset ζ_{REF} (feedforward term). Ex. 1005 Fig. 8 at 8, Jankovic p. 41; Ex. 1002 ¶¶ 101-108. The difference is used as a correction to control the VCT system (valve timing command). *Id*.

Both Yoshioka and Jankovic address the same issue of internal combustion engine management using variable valve timing. Ex. 1004 1:8-13; Ex. 1005 at 1-2, Jankovic pp. 34-35; Ex. 1002 ¶¶ 173-175. Yoshioka specifically relates to controlling the valve timing using a hydraulic pressure control valve, which is feedback-controlled to change the phase of the camshaft relative to the crankshaft to reduce fuel consumption and improve exhaust purifying performance at various altitudes and loads. Ex. 1004 1:39-47, 6:6-15. Jankovic meanwhile describes that its goal is to improve "drivability and emissions performance" by using a variable valve timing controller to rotate the camshaft relative to the crankshaft. Ex. 1005 at 1-2, Jankovic p. 34-35. Both references describe using feedback controllers to accomplish the valve timing control. Ex. 1002 ¶ 176; Ex. 1004 8:6-7, 41-45, Fig. 9; Ex. 1005 at 8, Jankovic p. 41, Fig. 8. Jankovic provides a detailed mathematical

model of a feedback controller in this context. Ex. 1002 ¶¶ 177-178; Ex. 1005 at 8, Jankovic p. 41, Fig. 8.

A person of ordinary skill in the art would have considered both Yoshioka and Jankovic in solving problems relating to variable valve timing control for internal combustion engines, given that both references are in the same field of endeavor and both seek to solve similar problems. Ex. 1002 ¶¶ 172-178. Combining the teachings of Yoshioka and Jankovic would have been nothing more than a combination of known elements in the same field of endeavor to a person of ordinary skill in the art, and would have had a reasonable expectation that a valve timing command would be achieved by the system, as discussed in Yoshioka and Jankovic. *KSR*, 550 U.S. at 416-417; Ex. 1002 ¶¶ 172-178.

For the reasons discussed above, and for the reasons provided below with respect to each claim, the combination of Yoshioka and Jankovic meets all of the limitations of claims 1-3, 7, 10-11, and 14 of the '540 patent, either expressly or inherently, as further discussed below with respect to each claim.

1. Claim 1

Claim 1[a] (preamble)	A method for calculating a valve timing command for an engine of a vehicle, comprising:

Yoshioka describes a method for calculating a valve timing command for an engine of a vehicle. *See, e.g.*, Ex. 1004 at Title ("Method of and Apparatus for

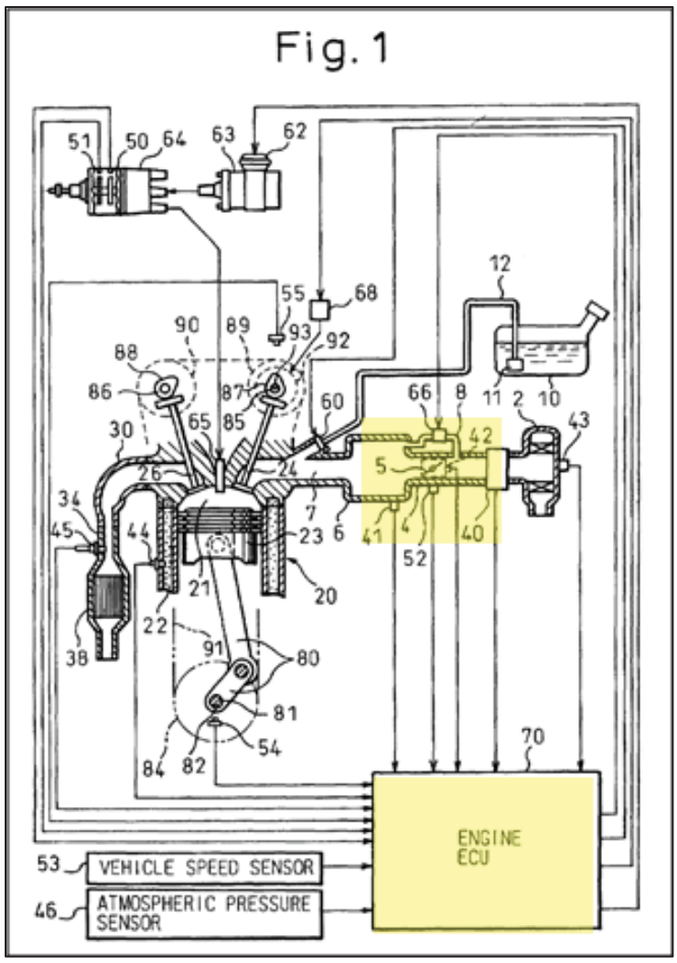
Continuously and Variably Controlling Valve Timing of Internal Combustion Engine"). Yoshioka specifically addresses adjusting valve timing in an internal combustion engine according to atmospheric pressure. *See, e.g.*, Ex. 1004 at Abstract; Ex. 1002 ¶ 112. Yoshioka's disclosure includes "a method . . . for optimizing valve timing according to atmospheric pressure for a continuously variable valve timing mechanism . . . " and aims to "improve the output of an engine at high altitudes under high load, as well as reducing fuel consumption and improving exhaust purifying performance at high altitudes under low/medium load." *Id*. at 1:39-48; *see also id*. 2:30-34; Ex. 1002 ¶ 112; *see also* Ex. 1004 at cl. 1 ("A method of controlling a continuously variable valve timing mechanism of an internal combustion engine").

Claim 1[b]	obtaining an engine performance command;

Yoshioka further describes obtaining an engine performance command. Ex. 1004, 4:13-15; Ex. 1002 ¶¶ 117-126. The '540 patent does not specify what is meant by the term engine performance command. Instead, the '540 patent explains this concept broadly, including discussing that obtaining an "engine performance command 16 ***preferably*** includes receiving a vehicle performance command from a driver," including "from the foot of a driver with the use of a conventional pedal." Ex. 1001 at 2:4-8 (emphasis added). Further, the '540 patent describes

that the engine performance command is "***preferably***" derived "from the vehicle performance command." Ex. 1001, 2:11-13 (emphasis added). The engine performance command may also be based on "additional suitable factors, such as traction control signal or a cruise control signal." *Id*. at 2:14-16. Yoshioka further discusses that the engine performance command is "***preferably*** a desired engine torque and, for this reason, the engine performance command may be thought of as an engine torque command." *Id*. at 2:16-19 (emphasis added).. But the engine performance command "may alternatively be ***another suitable variable***, such as desired engine acceleration." *Id*. at 2:19-22 (emphasis added).

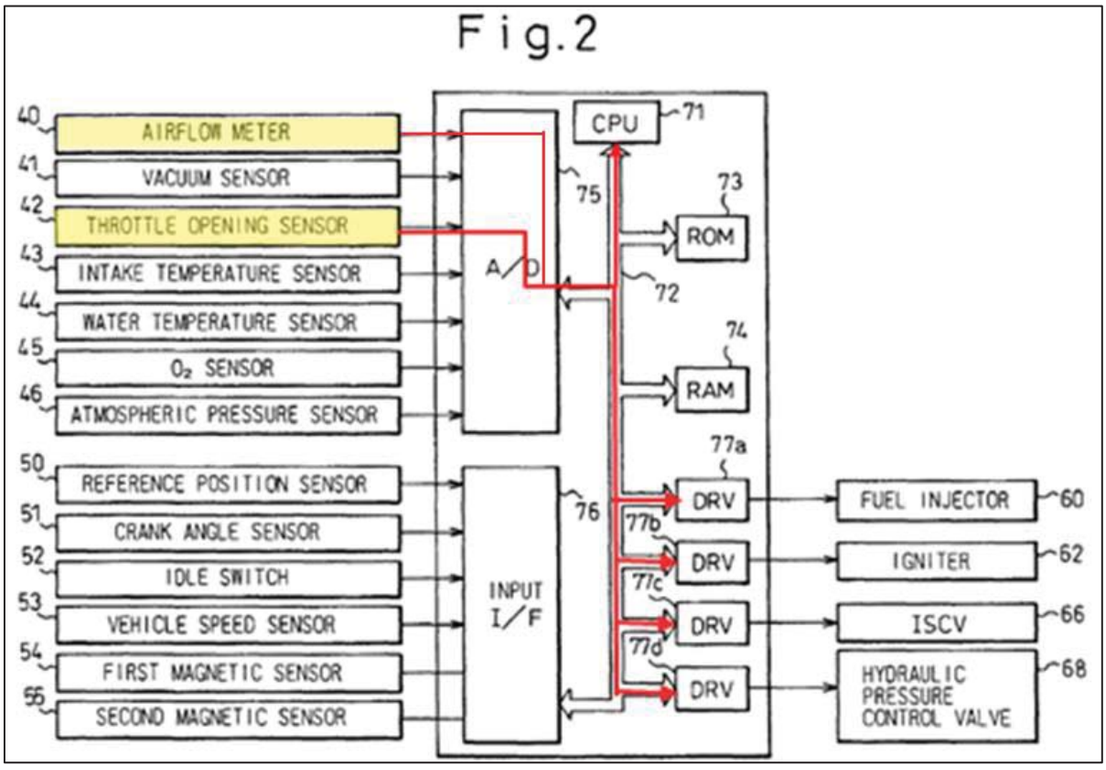
Yoshioka describes an electronically controlled internal combustion engine equipped with a throttle and throttle sensor. Ex. 1004, 3:18-22. Figure 1 is a general view of the engine, including a "throttle valve 5 arranged in the throttle body 4," which "adjusts the quantity of intake air." *Id*. 4:13-14. "An airflow meter 40 measures the mass flow rate of intake air." *Id*. 4:13-15. And a "throttle sensor 42 detects the opening of the throttle valve 5." *Id*. 4:20-21. Figure 1 is reproduced below.



Ex. 1004 Fig. 1 (annotated).

As shown in Figure 1, the engine includes an electronic engine control unit (ECU) 70, which is a "microcomputer to control fuel injection, ignition timing, idling speed, and in addition, the open/close timing of a valve[.]" *Id*. at 5:22-24. Figure 2 is a block diagram of the ECU 70. *Id*. at 5:24-25. As is shown in annotated Figure 2 (reproduced below), the CPU 71 of the ECU receives signals or inputs from the throttle opening sensor 42 and airflow meter 40, and then processes

the signals (together with signals received from the other signals and switches), and provides actuator control signals through drive control circuits 77a through 77d. *Id*. at 5:25-31; Ex. 1002 ¶ 118.



Ex. 1004 Fig. 2 (annotated).

A person of ordinary skill in the art would appreciate and well understand that the opening of the throttle valve 5, as taught by Yoshioka, relates directly to a vehicle performance command received by a driver because the throttle valve opens when a driver depresses the pedal in a vehicle. *See supra* § XIII.A.2; Ex. 1002 ¶ 119; *see also* Ex. 1007 at 14, Probst ch. 2 p. 7 ("Fuel delivery requirements

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depend more than anything else on how much work you are asking the engine to do—on how much of a 'load' you are placing on it. To accelerate, you step down harder on the accelerator. This opens the throttle valve . . . ."). Accordingly, the opening of the throttle valve 5, as measured by the throttle sensor 42 (which sends its signal to the CPU of the ECU), is the same as obtaining an engine performance command, because the throttle valve opening is derived from or based on pressing the accelerator pedal. Ex. 1004 at 4:13-15, 4:20-21, Fig. 2; *see also* Ex. 1001 at 2:4-8 (describing that an engine performance command can include receiving a vehicle performance command from a driver, like the foot of a driver with the use of a conventional pedal), *id*. 2:11-13 (describing that an engine performance command can be derived from the vehicle performance command).

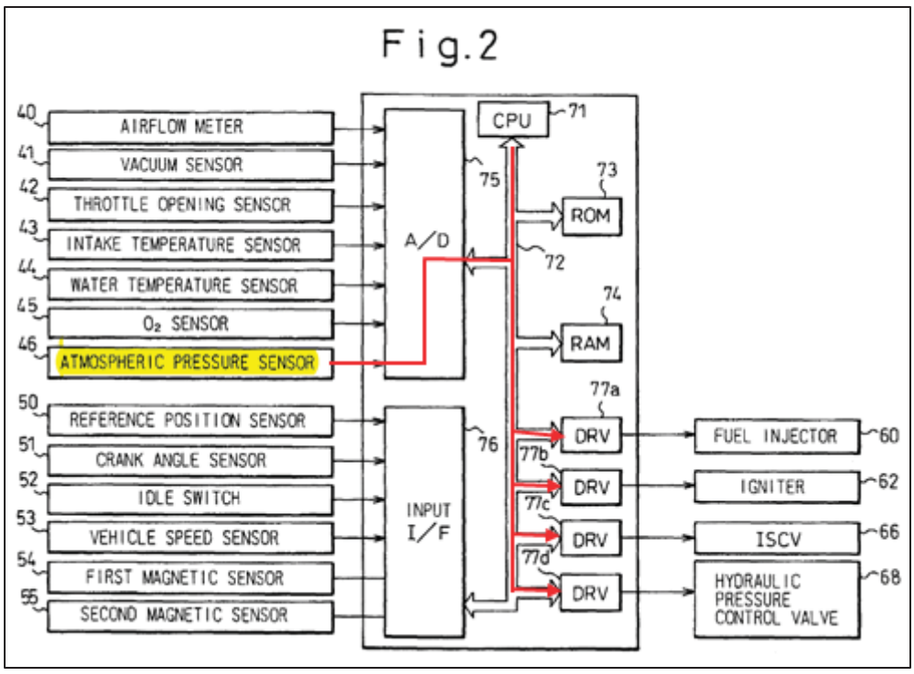
Accordingly, Yoshioka teaches obtaining an engine performance command because it teaches a throttle sensor 42 detecting the opening of the throttle valve 5 and sending a signal to the CPU of the ECU. Ex. 1004 4:13-14, 4:20-21; Ex. 1002 ¶¶ 117-126; *supra* § XIII.A.2; Ex. 1007 at 14, Probst ch. 2 p. 7; Ex. 1001 at 2:4-8, 2:11-13.

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Claim 1[c]	receiving an environmental conditions signal;

Yoshioka further describes receiving an environmental conditions signal. Ex. 1004, 4:13-15; Ex. 1002 ¶¶ 127-131. The '540 patent broadly describes the environmental conditions signal as a signal indicating the ambient temperature, ambient pressure, or "other suitable information." Ex. 1001 2:23-33. The '540 patent further describes that the environmental conditions signal is received at the "environmental sensor 30." *Id*. 2:23-26.

Yoshioka describes a method including reading an atmospheric pressure PA detected by the atmospheric pressure sensor 46 in the internal combustion engine. Ex. 1004 7:24-25, Fig. 2 at 46. As is shown in annotated Figure 2 (reproduced below), the CPU 71 of the ECU receives a signal from the atmospheric pressure sensor 46, and then processes the signals (together with signals received from the other signals and switches), and provides actuator control signals through drive control circuits 77a through 77d. *Id*. at 5:25-31, 7:24-25; Ex. 1002 ¶ 128; *see also* Ex. 1001 Figs. 7, 9, 12, and 15 (showing steps for reading atmospheric pressure PA at 106, 206, 306, and 406, respectively). Accordingly, Yoshioka teaches obtaining an environmental conditions signal.



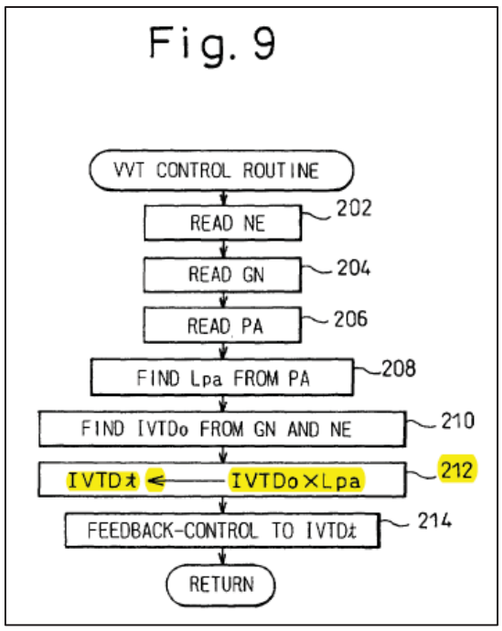
Ex. 1004 Fig. 2 (annotated).

Claim 1[d]	determining a valve feedforward term based on the engine performance command and the environmental conditions signal;

Yoshioka further describes determining a valve feedforward term based on the engine performance command and the environmental conditions signal. Ex. 1004, 7:46-52 (referring to the target displacement); Ex. 1002 ¶¶ 132-137. The '540 patent describes a control unit 10, which uses data to determine a valve feedforward term. Ex. 1001 2:28-29. The control unit 10 may use ambient temperature or "other information, such as ambient pressure," in the determination of the valve feedforward term. *Id*. at 2:26-31. The determination may also be

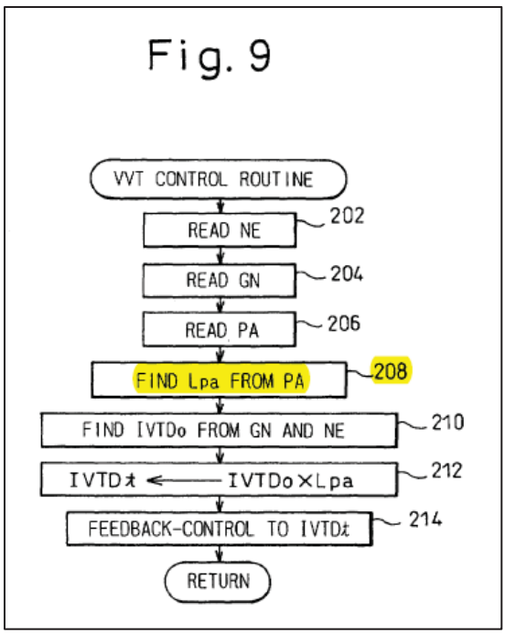
based on "other suitable factors," including, for example, "engine torque data, air-fuel ratio data, engine combustion stability data, or ambient pressure data." *Id*. at 2:51-54. The '540 further discusses that the "control unit 10 preferably includes a look-up table, which has been optimized for" various factors, commands, or measurables. *Id*. at 2:54-65.

Yoshioka describes "set[ting] a ***target displacement*** to be imposed on the open/close timing of the intake valve 24 according to a detected engine load and decreas[ing] the target displacement as an atmospheric pressure becomes lower, to maintain the output of the engine at high altitudes under high load . . . ." Ex. 1004 7:46-52 (emphasis added). Yoshioka discloses that the target displacement, $IVTD_t$, is determined from and based on several contributing elements: (1) L_{pa} (correction coefficient); and (2) $IVTD_o$ (an initial valve displacement). *Id*. at Fig. 9 at 212, 8:1-5. This is illustrated in Fig. 9, below, as box 212.



Ex. 1004 Fig. 9 (annotated).

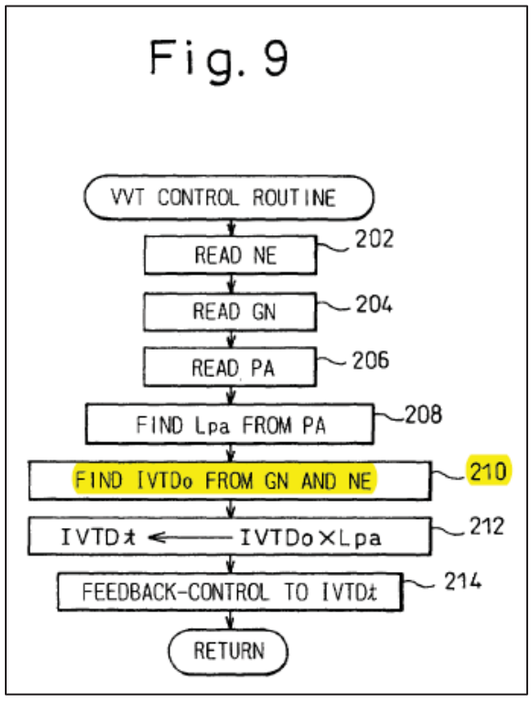
With respect to (1), the correction coefficient L_{pa} is determined based on atmospheric pressure PA. *Id*. at 7:57-60. This aspect of Yoshioka includes box 208 in Fig. 9, which is provided below. *Id*. The correction coefficient is determined according to a map stored in the ROM 73 of the ECU. *Id*. at 7:63-64, Fig. 2 at 73. Accordingly, Yoshioka's target displacement $IVTD_t$ is determined from and based on an environmental conditions signal (atmospheric pressure PA). *Id*.; Ex. 1002 ¶¶ 132-134.



Ex. 1004 Fig. 9 (annotated).

With respect to (2), the initial valve displacement $IVTD_o$ is determined based on engine load GN and engine speed NE. Ex. 1004 7:63-67. Load GN is defined as "the mass of intake air per engine revolution," and thus is based directly on the Yoshioka's engine performance command (opening of the throttle valve 5). Ex. 1004 7:20-24, 7:55-56, 6:37-42, 5:43-46 ("The mass of intake air per engine revolution is calculated according to the mass flow rate of intake air measured by the airflow meter 40 . . . ."), 4:13-15 ("A throttle valve 5 arranged in the throttle body 4 adjusts the quantity of intake air. An airflow meter 40 measures the mass flow rate of intake air."); *see also supra* § VIII.A.1 at 1[b]; Ex. 1002 ¶ 117; *see also* Ex. 1007 at 14, Probst p. 2-7. This aspect of Yoshioka includes box 210 in

Fig. 9, provided below. Accordingly, Yoshioka's target displacement $IVTD_t$ is determined from and based on an engine performance command (opening of the throttle valve). Ex. 1002 ¶¶ 132-134.



Ex. 1004 Fig. 9 (annotated).

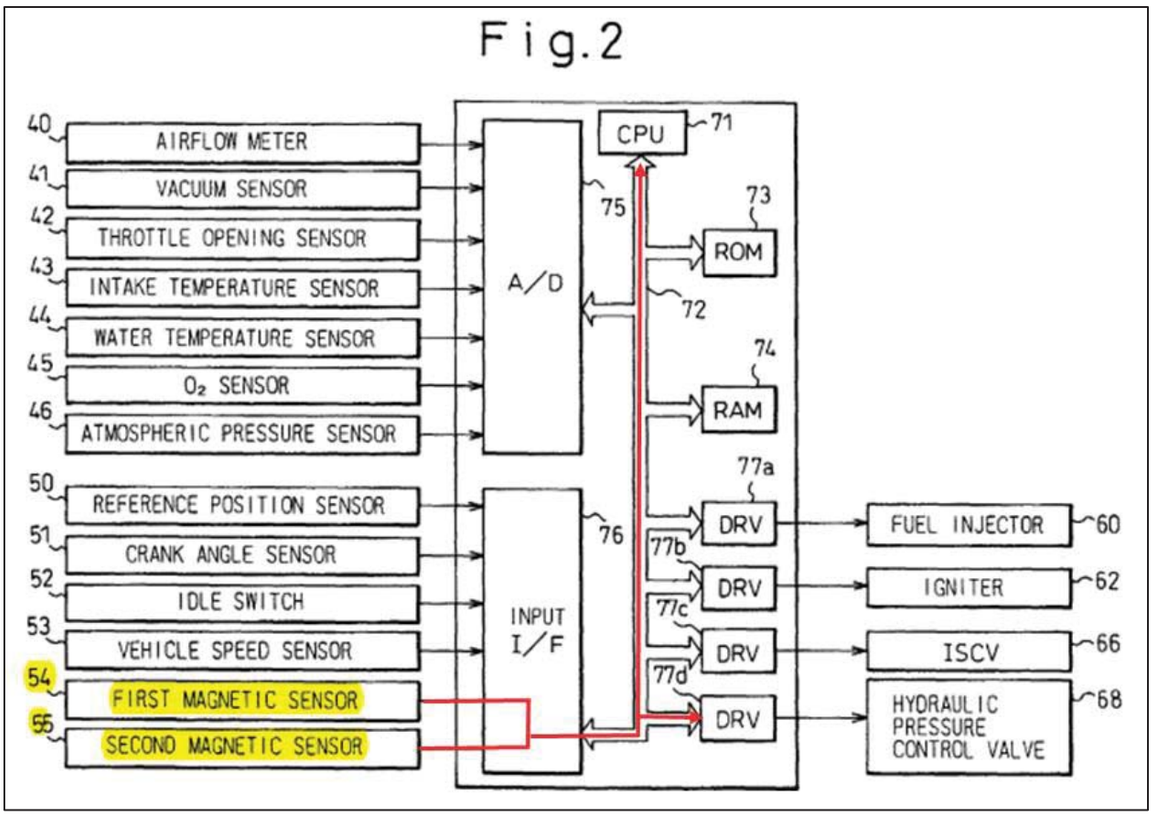
Claim 1[e]	receiving an engine performance feedback;

Yoshioka further discloses receiving an engine performance feedback. Ex. 1004, 5:4-10, Fig. 2 at 54, 55; Ex. 1002 ¶¶ 138-39. The '540 patent describes engine performance feedback as "preferably includ[ing] receiving the engine performance feedback from an engine sensor 32 in the vehicle." Ex. 1001 2:36-38. The engine sensor may sense engine speed, or "other engine measurables, such as

engine torque data" or "other suitable information." *Id*. at 2:39-45. The engine sensor may be "any suitable sensor." *Id*. at 2:45-47.

Yoshioka discloses using magnetic sensors 54 and 55 arranged close to the crankshaft and camshaft of the engine, respectively. Ex. 1004 5:4-9. The magnetic sensors 54 and 55 generate reference pulses or signals provided to the CPU 71 of the engine electronic control unit ("ECU"). *Id*. at Fig. 1 (ref. nos. 54, 55, 70), Fig. 2 (ref. nos. 54, 55), 5:4-9, 3:23-24; Ex. 1002 ¶¶ 138-139. These signals are used by the ECU to feedback control the hydraulic pressure control valve so that the camshaft maintains a certain rotational phase with respect to the crankshaft. Ex. 1004 6:6-15. As is shown in annotated Figure 2 (reproduced below), the CPU 71 of the ECU receives signals from magnetic sensors 54, 55, and then processes the signals (together with signals received from the other signals and switches), and provides actuator control signals through drive control circuits 77a through 77d. *Id*. at 5:25-31, 6:6-15; Ex. 1002 ¶¶ 138-139. Accordingly, the signals or reference pulses generated by the magnetic sensors in the engine constitute "engine performance feedback" as recited in claim 1 of the '540 patent. Ex. 1004 5:4-9; Ex. 1002 ¶¶ 138-139.[11]

[11]Yoshioka also discloses receiving an engine speed (NE) detected by the crank angle sensor 51. *See* Ex. 1004 5:38-46; *see also* Ex. 1004 Figs. 1-2 at 51, Figs. 7, 9, 12, 15 at 102, 202, 302, 402, respectively ("Read NE").



Ex. 1004 Fig. 2 (annotated).

Jankovic also discloses receiving several kinds of engine performance feedback, including, but not limited to, engine speed (N) and camshaft offset (ζ_{CAM}). Ex. 1005 at 2, Jankovic p. 35 ("The disturbance (cam phasing) is measured."), *id*. at 36 (listing the notation for "*N*" (engine speed) and for "ζ_{CAM}" (cam phasing)); *id*. at 36 Fig. 2 (illustrating that engine speed N and cam phasing ζ_{CAM} are each received by the engine model with VCT in the disclosed system), *id*. at 41 Fig. 8 (same); Ex. 1002 ¶¶ 140-41. Annotated Figure 8 of Jankovic is reproduced below for illustrative purposes. *See also* Ex. 1002 ¶¶ 140-41.

Accordingly, engine speed N and camshaft offset ζ_{CAM} both constitute "engine performance feedback" as recited in claim 1 of the '540 patent. Ex. 1005 at 2-3, Jankovic pp. 35-36, 41; Ex. 1002 ¶¶ 140-41.

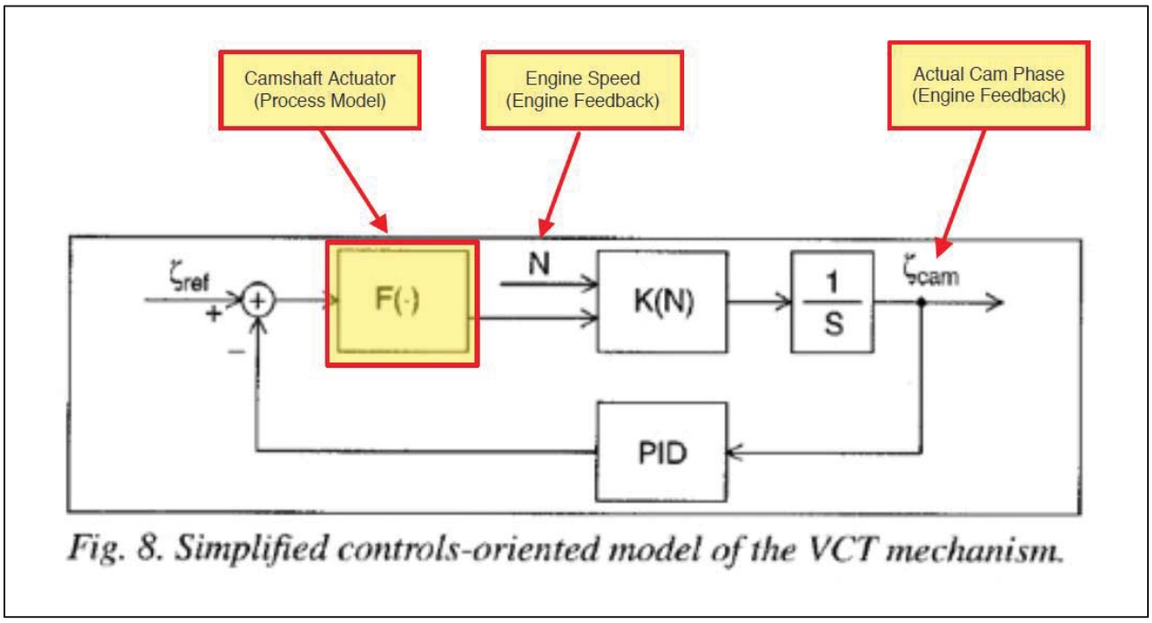


Fig. 8. Simplified controls-oriented model of the VCT mechanism.

Ex. 1005 Fig. 8 at 8, Jankovic p. 41 (annotated)

Like Yoshioka, Jankovic also addresses variable valve timing for intake/exhaust valves in engines. Ex. 1004 at 1:39-43; Ex. 1005 at 1, Jankovic p. 34 (E.g., "The variable cam timing (VCT) system with which this paper is concerned addresses both drivability and emissions performance by utilizing an electro-hydraulic mechanism to rotate the camshaft relative to the crankshaft in order to retard the cam timing with respect to the intake and exhaust strokes of the engine."); *id.* at 2, Jankovic p. 35 (E.g., "Of the remaining three, dual equal VCT,

where the intake valve timing and exhaust valve timing are advanced or retarded equally, gives the best overall performance in terms of emissions and fuel economy."); Ex. 1002 ¶¶ 173-175. Each reference also discloses using feedback control to optimize valve timing control. Ex. 1004 8:6-8, 8:41-45; Ex. 1005 at 7, Jankovic p. 40; Ex. 1002 ¶ 176. Accordingly, a person of ordinary skill in the art would consider both Jankovic and Yoshioka, and combinations thereof, when solving problems relating to variable valve timing in intake/exhaust valves in engines. Ex. 1002 ¶¶ 172-178. Further, a person of ordinary skill in the art would have combined Jankovic and Yoshioka as a combination of known elements, "to produce a predictable result of ensuring that the commanded valve timing was in fact achieved by the system, a goal described by both Yoshioka and Jankovic." *Id*. ¶ 178; *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 415-417 (2007). Thus, a person of ordinary skill in the art would have had a reason to combine Yoshioka and Jankovic, and would have had a reasonable expectation of success in doing so, rendering claim 1 obvious. *Id*. Additional discussion on the obviousness of the Yoshioka and Jankovic combination is provided above in Section XVI.A.1.

Claim 1[f]	calculating a valve feedback term based on the engine performance command and the engine performance feedback; and

Yoshioka further discloses calculating a valve feedback term based on the engine performance command and the engine performance feedback. Ex. 1004, 7:20-45, 8:5-7; Ex. 1002 ¶¶ 142-150. The '540 patent describes calculating the valve feedback term as comparing an input with an output and calculating a correction term based on the difference, if any. Ex. 1001 2:66-3:4. The comparison may be accomplished by the engine control unit 10, but may alternatively be accomplished by a suitable separate device. *Id*. at 3:5-6.

Yoshioka discloses that the ECU "feedback-control[s]" the hydraulic pressure control valve so that the camshaft maintains a certain rotational phase with respect to the crankshaft. Ex. 1004 6:6-15; Ex. 1002 ¶ 145. To effect this, Yoshioka teaches that the actual displacement of the intake valve (the feedback term—as measured by magnetic sensors 84, 85) is adjusted toward the target displacement $IVTD_t$ (the feedforward term, which is based on the engine performance command). Ex. 1004 Fig. 9 at 212, 214, 7:20-45, 8:5-7; *see also supra* § VIII.A.1.at 1[d] (explaining that the engine feedforward term is based on the engine performance command); Ex. 1002 ¶ 145.

A POSITA would understand that "feedback control," as disclosed in Yoshioka, means that an actual output is compared to a target or goal output, and

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the difference is used to drive the actual output to match the goal or target output. Ex. 1002 ¶¶ 47, 146. Ex. 1013 pp. 12-13, McGraw-Hill Electronics Dictionary pp. 162, 168 (defining feedback controller as "A circuit or element in a closed loop system that controls the motor or other actuator in a closed loop system to correct an error signal" and defining error signal as "A voltage or current proportional to the difference between the desired and actual response in a closed loop system").

Accordingly, by disclosing that the system is "feedback-controlled," Yoshioka also discloses that the actual displacement is compared with the target displacement. Ex. 1002 ¶¶ 145-146. Stated another way, in order for the ECU adjust the actual displacement of the intake valve to the target displacement $IVTD_t$, a POSITA would understand that the ECU first compares the actual displacement with the target displacement to determine the offset. *Id*.; Ex. 1002 ¶¶ 47, 146; Ex. 1013 pp. 12-13. Accordingly, the actual valve offset (engine performance feedback) comparison with the target displacement (feedforward term, which is based on the engine performance command) constitutes "calculating a valve feedback term" as cited in claim 1, because it is a comparison of an input with an output and determining a correction based on the difference. Ex. 1004 Fig. 9 at 214, 7:20-45, 8:5-7; Ex. 1002 ¶¶ 142-147; Ex. 1001 2:66-3:4. Accordingly, Yoshioka's ECU calculates a valve feedback term based on the "engine performance feedback" and "engine performance command."

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Alternatively and additionally, Jankovic discloses calculating a valve feedback term based on the engine performance command and the engine performance feedback. As mentioned above, Jankovic's system uses several kinds of engine performance feedback, including, but not limited to, engine speed (N) and camshaft offset (ζ_{CAM}). Ex. 1005 at 2, Jankovic p. 35 ("The disturbance (cam phasing) is measured"), *id*. at 3, Jankovic p. 36 (listing the notation for "*N*" (engine speed) and for "ζ_{CAM}" (cam phasing)); *id*. at Fig. 2 at 2, Jankovic p. 36 (illustrating that engine speed and cam phasing are each received by the engine model with VCT in the disclosed system), *id*. at 8, Jankovic p. 41 Fig. 8; Ex. 1002 ¶¶ 148-150. The Jankovic system also receives a reference camshaft phasing ζ_{REF}, which is based on throttle angle due to the driver's request or demand (Jankovic denotes throttle angle as Θ_0). *Id*. at 3, Jankovic p. 36, Fig. 2 (showing Θ_0 as an input to the CAM Schedule block which generates ζ_{REF}); *id*. at 8, Jankovic p. 41, Fig. 8 (showing ζ_{REF} fed into Jankovic's VCT mechanism).

Jankovic discloses that the reference camshaft phasing ζ_{REF} (which is based on throttle angle or engine performance command), engine speed N, and actual camshaft phase ζ_{CAM} are all inputs—either directly or indirectly—into the proportional-integral-derivative ("PID") calculation. Ex. 1005 p. 8, Jankovic p. 41, Fig. 8; Ex. 1002 ¶¶ 148-150. The output of the PID calculation is the calculated valve feedback term. Ex. 1005 Fig. 8; Ex. 1002 ¶¶ 148-150.

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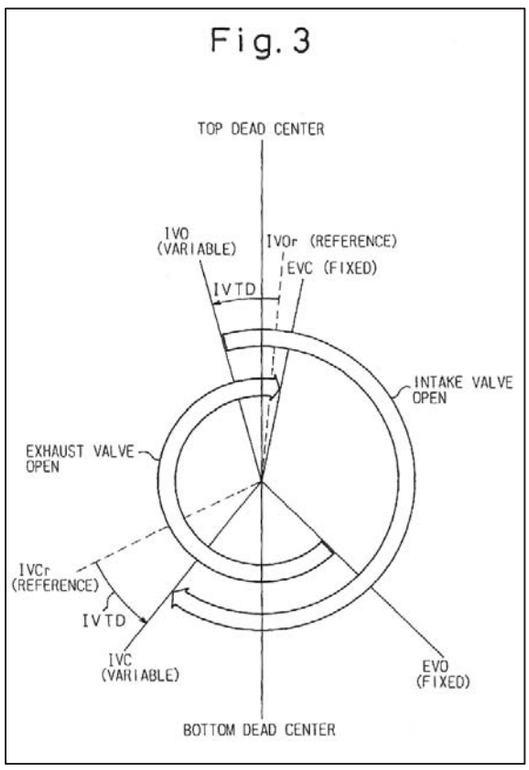
For the reasons discussed above, a person of ordinary skill in the art would have had a reason to combine Yoshioka and Jankovic, and would have had a reasonable expectation of success in doing so, rendering claim 1 obvious. *See supra* § VIII.A.1. at 1[e].

Claim 1[g]	calculating a valve timing command based on the valve feedforward term and the valve feedback term.

Yoshioka further discloses calculating a valve timing command based on the valve feedforward term and the valve feedback term. Ex. 1004, 7:20-45, 8:5-7, Fig. 9 at 214; Ex. 1002 ¶¶ 151-153. The '540 patent describes calculating the valve timing command as "preferably includ[ing] calculating an EVO command, an EVC/IVO command, and an IVC command," but that "other suitable parameters" may be used "for the control of the variable timing valves." Ex. 1001 3:21-26.

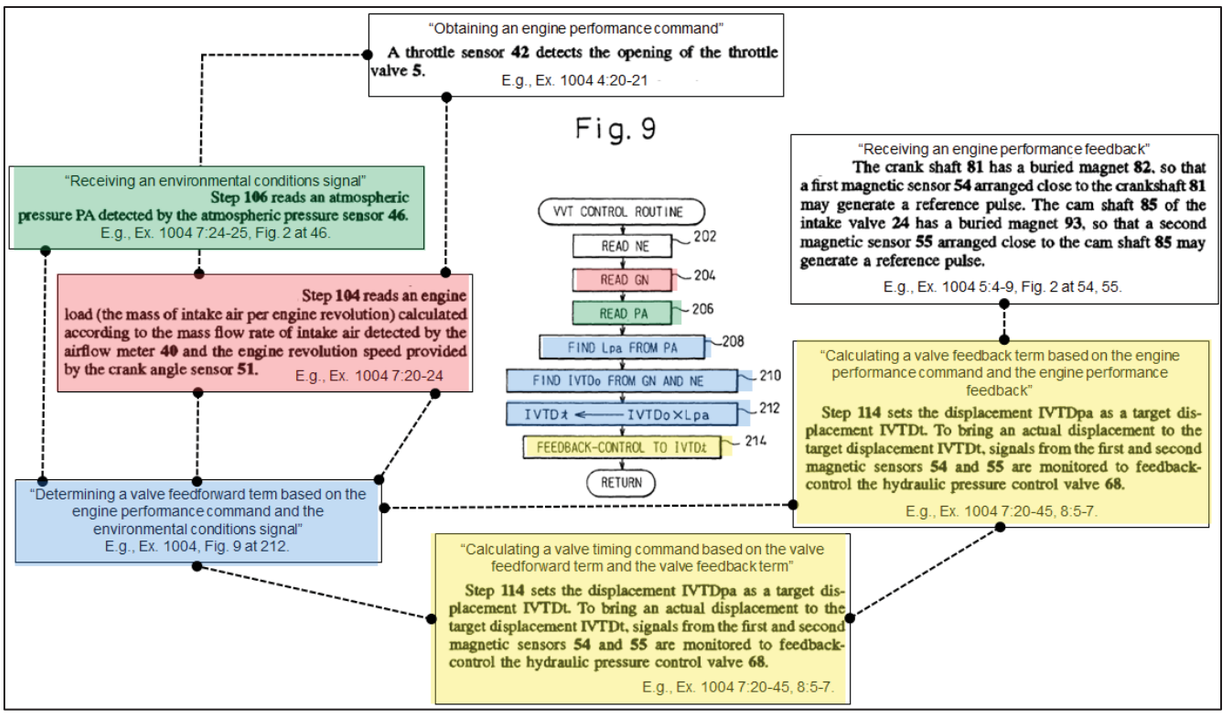
As discussed above, Yoshioka discloses that the ECU feedback-controls the hydraulic pressure control valve so that the camshaft maintains a certain rotational phase with respect to the crankshaft. Ex. 1004 6:6-15; Ex. 1002 ¶ 151. To effect this, Yoshioka teaches that the actual displacement of the intake valve (the feedback term—as measured by magnetic sensors 84, 85) is adjusted toward the target displacement $IVTD_t$ (the feedforward term, which is based on the engine

performance command). Ex. 1004 7:20-45, 8:5-7; *see also supra* § VIII.A.1 at 1[d] (explaining that the engine feedforward term is based on the engine performance command); Ex. 1002 ¶¶ 132-134. Yoshioka also describes that the relative phase of the crankshaft and camshaft positions determines the valve offset. Ex. 1004 6:16-19; Ex. 1002 ¶ 142. Yoshioka discloses a "timing chart showing crank angles corresponding to the open/close timing of the intake and exhaust valves . . . ." Ex. 1004 6:16-19. The valve timing displacement, and its relationship to the crank angles, is also disclosed in Yoshioka. *Id*. at 6:26-37; Ex. 1002 ¶ 142. Figure 3 is reproduced below.



Yoshioka further discloses that the CPU of the ECU provides actuator control signals through drive control circuits, including the hydraulic pressure control valve. *See* Ex. 1004 Fig. 2 at 68, 5:22-34, 6:6-15.

In summary, Yoshioka discloses a method in which the CPU of the ECU receives the target valve offset, IVTDt (valve feedforward term), receives the result of the comparison of the actual valve offset with the target valve offset (valve feedback term), and then generates actuator control signals for the hydraulic pressure control valve. Ex. 1004 Fig. 9 at 214, 7:20-45, 8:5-7, Fig. 2 at 68, 6:6-15; Ex. 1002 ¶¶ 151-52. Accordingly, Yoshioka teaches calculating a valve timing command based on the valve feedforward term and the valve feedback term. Ex. 1002 ¶¶ 151-52; Ex. 1004 6:6-13 (". . .the hydraulic pressure control valve 68 is feedback-controlled according to signals from the first and second magnetic sensors 54 and 55 so that the camshaft 85 of the intake valve 24 maintains a required rotational phase with respect to the crankshaft 81."). A schematic is provided below illustrating the method of claim 1 mapped to the teachings of Yoshioka.



Alternatively, and additionally, Jankovic discloses calculating a valve timing command based on the valve feedforward term and the valve feedback term. Ex. 1005, Fig. 8; Ex. 1002 ¶ 153. As established above, Jankovic discloses the valve feedforward term (reference camshaft phasing ζ_{REF}) and the valve feedback term (output of the PID calculation). The VCT engine model of Jankovic receives the reference camshaft phasing ζ_{REF} and the output of the PID calculation and uses these inputs to calculate the valve timing command. Ex. 1002 ¶ 153; Ex. 1005 Fig. 8. Annotated figure 8 from Jankovic illustrates the calculated valve timing command (see below). Ex. 1005 at 41; Ex. 1002 ¶ 153.

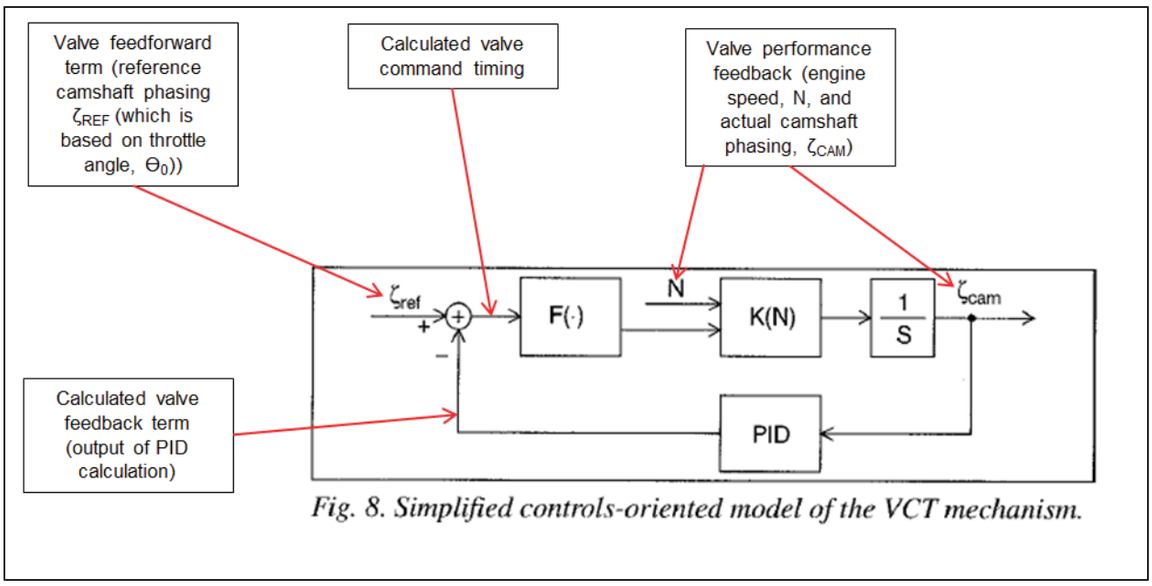


Fig. 8. Simplified controls-oriented model of the VCT mechanism.

For the reasons discussed above, a person of ordinary skill in the art would have had a reason to combine Yoshioka and Jankovic, and would have had a reasonable expectation of success in doing so, rendering claim 1 obvious. *See supra* § VIII.A.1 at 1[e].

2. Claim 2

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.

Yoshioka further discloses 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. Ex. 1004, 4:20-25; Ex. 1002 ¶¶ 154-156. The '540 patent describes the vehicle performance command from the driver as preferably being received from "the foot of a driver with the use of a conventional pedal." Ex. 1001 2:4-8, Fig. 1 at 28. The '540 patent further discusses that the "vehicle performance command could be received from the driver with the use of any suitable device." *Id*. at 8-10.

As discussed above, Yoshioka teaches detecting the opening of the throttle valve 5. *See supra* § VIII.A.1 at 1[b]. As further discussed above, a person of ordinary skill in the art would appreciate and well understand that the opening of the throttle valve 5 relates directly to a vehicle performance command received by a driver because the throttle valve opens when a driver depresses the pedal in a vehicle. *See supra* § VIII.A.1 at 1[b]; Ex. 1002 ¶ 119; *see also* Ex. 1007 p. 14, Bosch Fuel Injection & Engine Management ch. 2 p. 7 ("Fuel delivery requirements depend more than anything else on how much work you are asking the engine to do—on how much of a 'load' you are placing on it. To accelerate, you step down harder on the accelerator. This opens the throttle valve . . . ."). Accordingly, the opening of the throttle valve 5 is the same as obtaining an engine performance command, because the throttle valve opening is derived from or based on pressing the accelerator pedal. Ex. 1004 at 4:13-21; *see also* Ex. 1001 at 2:4-8 (describing that an engine performance command can include receiving a vehicle

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performance command from a driver, like the foot of a driver with the use of a conventional pedal), 2:11-13 (describing that an engine performance command can be derived from the vehicle performance command). Accordingly, Yoshioka teaches receiving a vehicle performance command from a driver of the vehicle and deriving the engine performance command based on the vehicle performance command. *Id*. 4:13-14, 4:20-21; Ex. 1002 ¶ 119, 154; *supra* § VIII.A.1 at 1[b]; Ex. 1007 p. 14, Bosch Fuel Injection & Engine Management ch. 2 p. 7; Ex. 1001 at 2:4-8, 2:11-13.

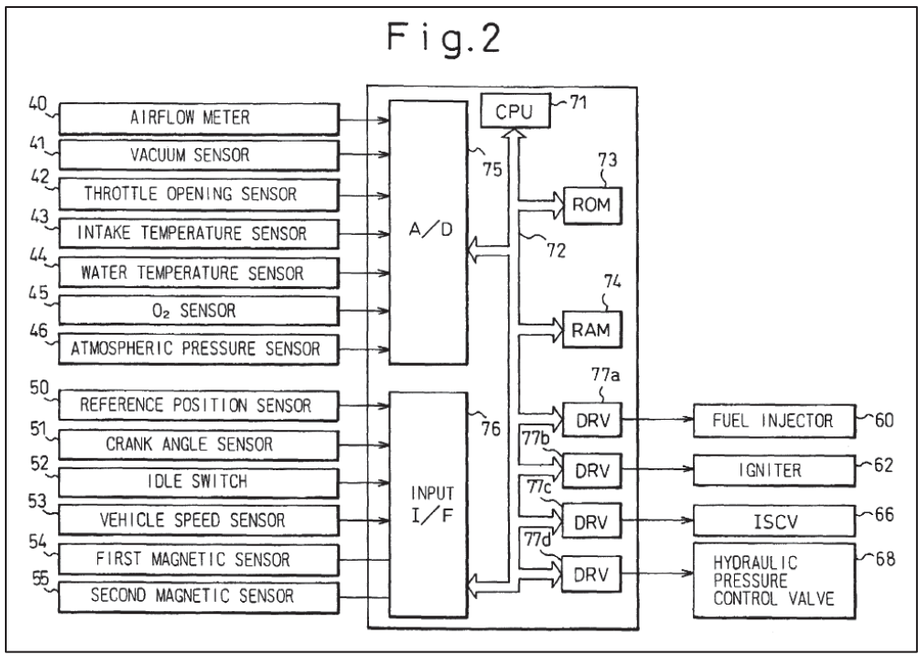
Alternatively and additionally, Jankovic discloses that the throttle opening (throttle angle Θ_0) is derived from the performance desired by the driver as interpreted from the accelerator pedal position. Ex. 1005 at 35; Ex. 1002 ¶ 155-156. A person of ordinary skill in the art would have had a reason to combine the teachings of Jankovic and Yoshioka for the reasons discussed above, and would have had a reasonable expectation of success in doing so—particularly in view of the common understanding and knowledge by persons of ordinary skill in the art with respect to the relationship between the accelerator pedal (driver command) and the throttle angle. *See supra* § VIII.A.1; *see also* Ex. 1002 ¶¶ 172-178; Ex. 1007 p. 14, Bosch Fuel Injection & Engine Management ch. 2 p. 7.

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3. Claim 3

Claim 3	The method of claim 1 wherein said receiving an environmental conditions signal includes receiving ambient temperature data.

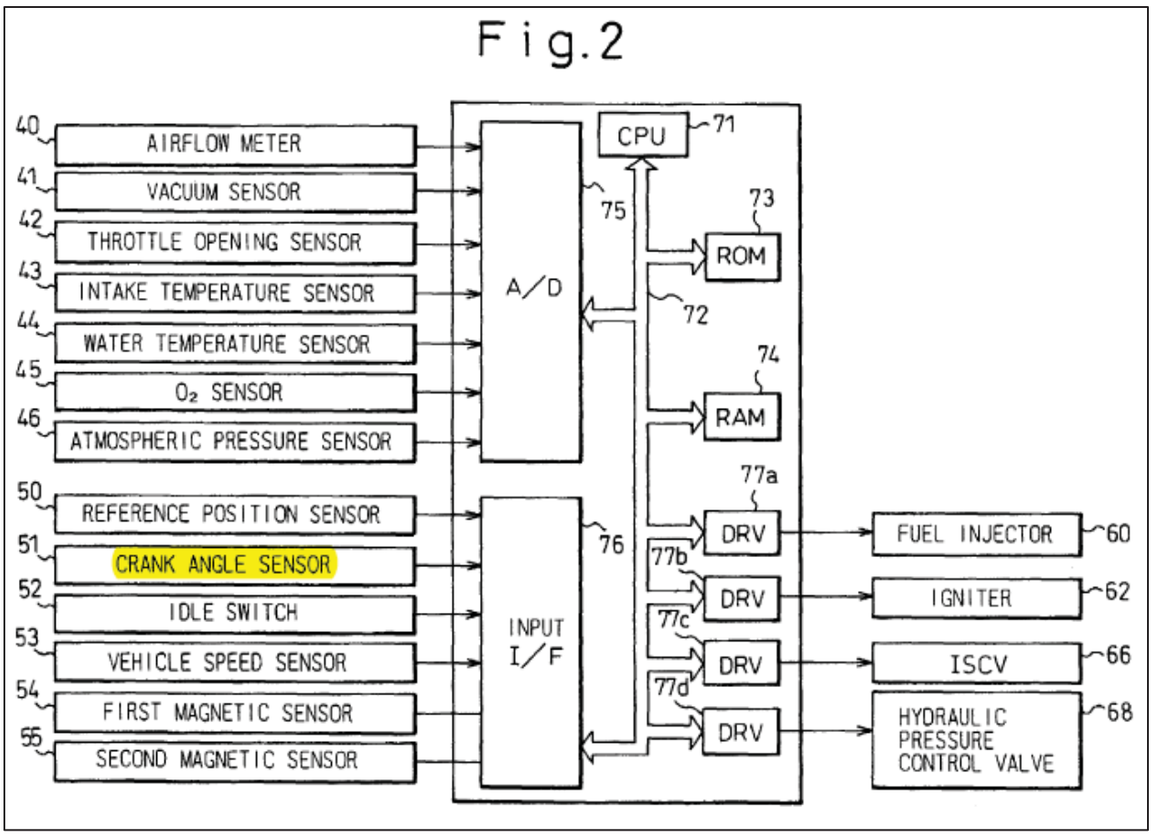
Yoshioka further discloses wherein said receiving an environmental conditions signal includes receiving ambient temperature data. Ex. 1004, 4:15-16; Ex. 1002 ¶ 157. Yoshioka discloses that a "temperature sensor 43 detects the temperature of intake air." Ex. 1004 4:15-16, Fig. 2 at 43. Yoshioka further discloses that a CPU 71 of the ECU "receives signals from the sensors and switches through an A/D converter 75 and an interface 76, processes the signals, and provides actuator control signals through drive control circuits 77a to 77d." *Id*. at 5:26-31. Accordingly, the signal received by the CPU 71 of the ECU includes ambient temperature data detected by sensor 43. *Id*. 4:15-16, 5:26-31; Ex. 1002 ¶ 157.



4. Claim 7

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

Yoshioka further discloses wherein receiving an engine performance feedback includes receiving engine speed data. Ex. 1004, 7:16-24; Ex. 1002 ¶ 158. Yoshioka specifically teaches that the output of the crank angle sensor 51 is used to calculate engine revolution speed NE. Ex. 1004 7:16-24; Ex. 1002 ¶ 158. The CPU of the ECU receives the signals from all of the sensors and switches providing input to the ECU, including the crank angle sensor 51. Ex. 1004 5:22-30, Fig. 2 at 51; Ex. 1002 ¶ 158. Figure 2 of Yoshioka is reproduced below showing the crank angle sensor 51.



Ex. 1004 Fig. 2 (annotated).

Accordingly, Yoshioka's discloses wherein said receiving an engine performance feedback includes receiving engine speed data. Ex. 1004 5:22-30, Fig. 2 at 51; Ex. 1002 ¶ 158.

Alternatively and additionally, Jankovic also discloses wherein said receiving an engine performance feedback includes receiving engine speed data. *See* Ex. 1005 Fig. 8; Ex. 1002 ¶ 159. As discussed above, actual cam phasing ζ_{CAM}, constitutes engine performance feedback. *See supra* § VIII.A.1. at 1[e]. The

cam phasing ζ_{CAM} is based on engine speed N, as depicted below in Figure 8. Ex. 1005 Fig. 8 (annotated); Ex. 1002 ¶ 159.

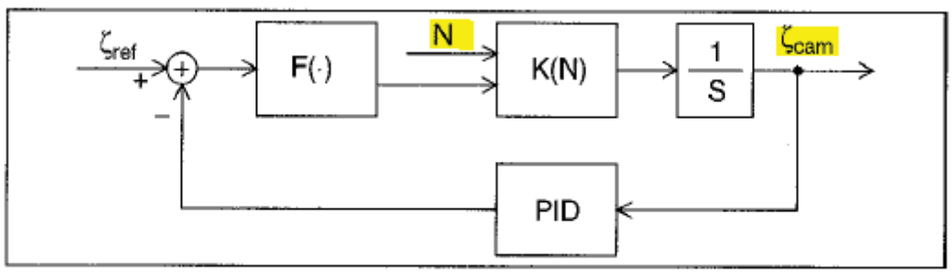


Fig. 8. Simplified controls-oriented model of the VCT mechanism.

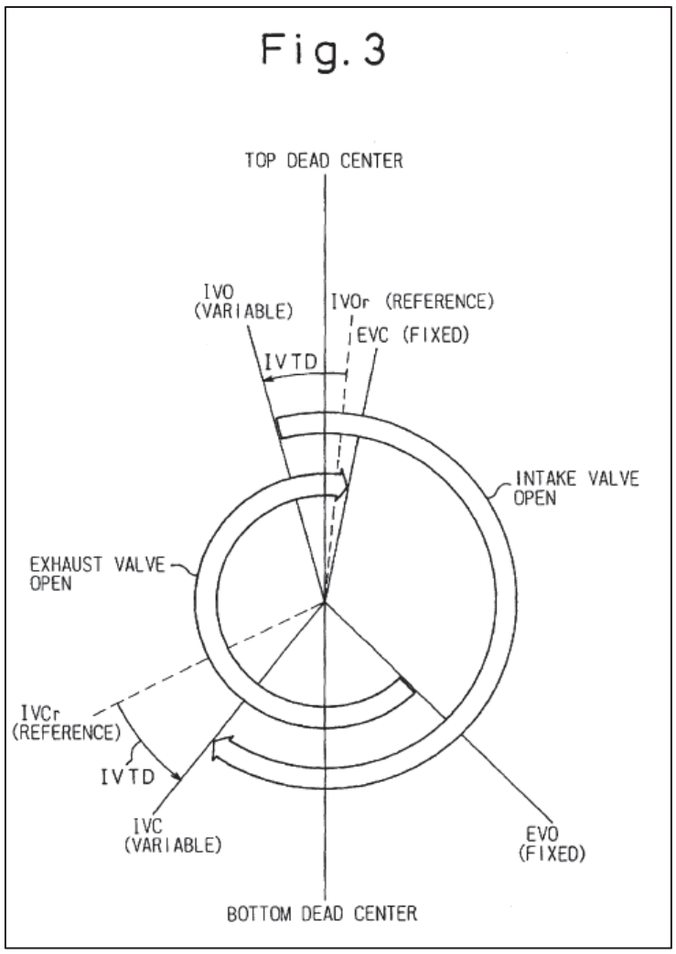
A person of ordinary skill in the art would have had a reason to combine the teachings of Jankovic and Yoshioka for the reasons discussed above, and would have had a reasonable expectation of success in doing so. *See supra* § VIII.A.1; Ex. 1002 ¶¶ 172-178. Accordingly, the combination of Yoshioka and Jankovic also discloses wherein said receiving an engine performance feedback includes receiving engine speed data.

5. Claim 10

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.

Yoshioka further discloses wherein said calculating a valve timing command includes calculating an EVO command, an EVC/IVO command, and an IVC command. Ex. 1004, 6:16-18, 9:35-37, cl. 1; Ex. 1002 ¶ 160. The '540 patent

notes that the "the events of the EVO, the EVC, the IVO, and the IVC may be shifted within the time period," and that the "adjustment of the timing of the EVO, the EVC/IVO, and the IVC . . . may provide the desired fuel efficiency . . . ." Ex. 1001 3:14-21. The '540 patent does not describe what is meant by an "EVO command," an "EVC/IVO command," or an "IVC command," and instead just generally states that calculating the "valve timing command 26 preferably includes calculating an EVO command, an EVC/IVO command, and an IVC command." *Id*. at 3:21-24. Yoshioka discloses a timing chart showing the crank angles corresponding to the open and close timing of the intake and exhaust valves. Ex. 1004 6:16-18. Figure 3 is reproduced below:



With respect to Figure 3, Yoshioka discloses that the "exhaust valve 26 is opened at fixed valve open timing EVO," and "is closed at fixed valve close timing EVC." Ex. 1004 6:18-21. Yoshioka further discloses that "the intake valve 24 involves a fixed open period and a variable valve opening timing IVO and valve close timing IVC." *Id*. at 6:22-24. The valve timing command IVTD serves as the control target quantity. *Id*. at 6:27-28. Moreover, Yoshioka explicitly teaches that, "although the embodiments variably control the open/close timing of the intake

valve 24, the present invention is naturally applicable to control the exhaust valve 26 too." *Id*. at 9:34-37. Accordingly, Yoshioka teaches calculating EVO, EVC, IVO, and IVC commands in reference to IVTD, and thus discloses wherein said calculating a valve timing command includes calculating an EVO command, an EVC/IVO command, and an IVC command. *Id*.; Ex. 1002 ¶ 160.

Alternatively and additionally, Jankovic also discloses wherein said calculating a valve timing command includes calculating an EVO command, an EVC/IVO command, and an IVC command. *See* Ex. 1005 Fig. 1; Ex. 1002 ¶¶ 161-162. Specifically, Jankovic discloses varying the valve opening and closing intervals for the intake and exhaust valves of the engine, as shown in Figure 1, reproduced below.

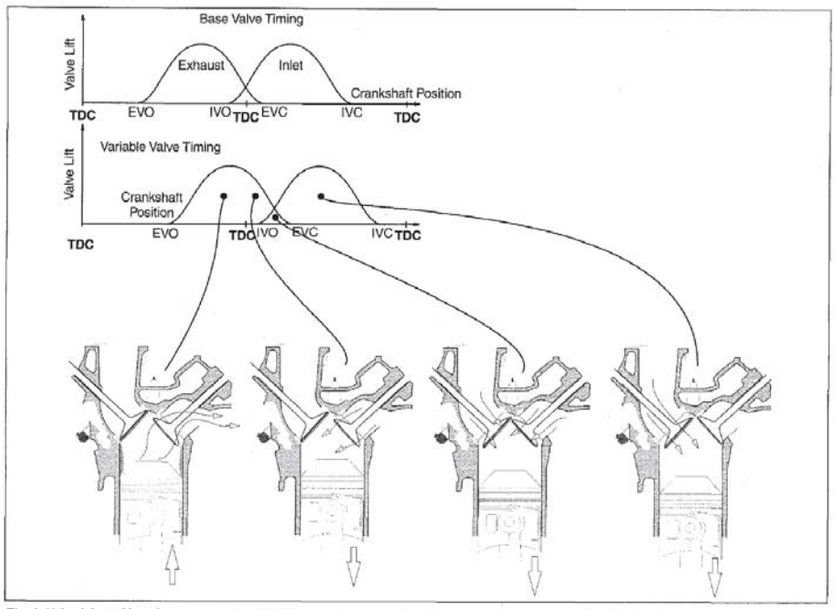


Fig. 1. Valve lift profiles of conventional and VCT engines. By retarding the cam phasing, the exhaust valve stays open during the intake event for a longer time period, retaining otherwise unburned HC and reducing the combustion temperature due to the dilution of the inert gas.

Ex. 1005 p. 2, Jankovic p. 35 at Fig. 1.

A person of ordinary skill in the art would have had a reason to combine the teachings of Jankovic and Yoshioka for the reasons discussed above, and would have had a reasonable expectation of success in doing so. *See supra* § VIII.A.1; Ex. 1002 ¶¶ 172-178. Accordingly, the combination of Yoshioka and Jankovic also discloses wherein said calculating a valve timing command includes calculating an EVO command, an EVC/IVO command, and an IVC command.

6. Claim 11

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

Yoshioka further discloses receiving fuel conversion data. Ex. 1004, 5:48-54; Ex. 1002 ¶¶ 163-164. The '540 patent discusses that the fuel conversion data is received from "suitable emissions sensors (not shown) in the cylinder or the exhaust port of the engine 12." Ex. 1001 3:30-33.

Specifically, Yoshioka teaches receiving "an air-fuel ratio feedback correction according to a signal from the O_2 sensor 45 . . . ." Ex. 1004 at 5:48-54. Yoshioka further discloses that the CPU 71 of the ECU receives data from the O_2 sensor 45. *Id*. Fig. 2 at 45, 5:24-30. Yoshioka further discloses that an "exhaust valve 26 discharges an exhaust gas of the combusted air-fuel mixture into an exhaust manifold 30 connected to an exhaust pipe 34." *Id*. at 4:48-52. Yoshioka

then teaches that the O_2 sensor 45 "detect[s] the concentration of the oxygen in the exhaust gas." *Id*. 4:49-52. Yoshioka further teaches that the O_2 sensor 45 is located at the exhaust pipe 34. *Id*. 4:49-52. Accordingly, Yoshioka teaches that fuel conversion data (e.g., the concentration of oxygen in the exhaust gas) is received from an emissions sensor (the O_2 sensor 45). Ex. 1002 ¶¶ 163-164. Accordingly, Yoshioka teaches receiving fuel conversion data. Ex. 1002 ¶¶ 163-164.

Alternatively and additionally, Jankovic also teaches receiving fuel conversion data. *See* Ex. 1005 Fig. 2; Ex. 1002 ¶ 165. Specifically, Jankovic discloses that the "generation of torque depends on the cylinder air charge m_{cyl}, air-fuel ratio A/F, spark retard from MBT σ, and engine speed." Ex. 1005 p. 3, Jankovic p. 36. The air-fuel ratio is typically derived from the quantity of oxygen present in the exhaust gas, as measured for example by the O_2 sensor of Yoshioka. Ex. 1002 ¶¶ 165-166. A person of ordinary skill in the art would have had a reason to combine the teachings of Jankovic and Yoshioka for the reasons discussed above, and would have had a reasonable expectation of success in doing so. *See supra* § VIII.A.1; Ex. 1002 ¶¶ 172-178. Accordingly, the combination of Yoshioka and Jankovic also teaches receiving fuel conversion data.

7. Claim 14

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

Yoshioka further discloses receiving fuel conversion data. Ex. 1004, 5:48-54; Ex. 1002 ¶¶ 167-168. The '540 patent discusses that engine emissions data is received from "suitable emissions sensors (not shown) in the cylinder or the exhaust port of the engine 12." Ex. 1001 3:30-33.

As discussed above, Yoshioka teaches receiving "an air-fuel ratio feedback correction according to a signal from the O_2 sensor 45, and an air-fuel ratio learning correction to equalize a central feedback correction value to a theoretical air-fuel ratio." Ex. 1004 at 5:48-54. Yoshioka further discloses that the CPU 71 of the ECU receives data from the O_2 sensor 45. *Id*. Fig. 2 at 45, 5:24-30; Ex. 1002 ¶ 168. Yoshioka further discloses that an "exhaust valve 26 discharges an exhaust gas of the combusted air-fuel mixture into an exhaust manifold 30 connected to an exhaust pipe 34." *Id*. at 4:48-52. Yoshioka then teaches that the O_2 sensor 45 "detect[s] the concentration of the oxygen in the exhaust gas." *Id*. 4:49-52. Yoshioka further teaches that the O_2 sensor 45 is located at the exhaust pipe 34. *Id*. 4:49-51. The quantity of oxygen present in the exhaust gas, as measured for example by the O_2 sensor of Yoshioka, represents the level of emissions in the exhaust gas. Ex. 1002 ¶¶ 167-168. Accordingly, Yoshioka teaches that emissions

data (e.g., the concentration of oxygen in the exhaust gas) is received from an emissions sensor (the O_2 sensor 45) at the CPU of the ECU. Ex. 1002 ¶¶ 167-168. Accordingly, Yoshioka teaches receiving engine emissions data. Ex. 1002 ¶¶ 167-168.

Alternatively and additionally, Jankovic also teaches receiving engine emissions data. *See* Ex. 1005 Fig. 2; Ex. 1002 ¶¶ 169-171. Specifically, as mentioned above, Jankovic discloses that the "generation of torque depends on the cylinder air charge m_{cyl}, air-fuel ratio A/F, spark retard from MBT σ, and engine speed." Ex. 1005 p. 3, Jankovic p. 36. The measurement of the air-fuel ratio as described by Jankovic, represents the level of emissions in the exhaust gas. Ex. 1002 ¶¶ 169-171. A person of ordinary skill in the art would have had a reason to combine the teachings of Jankovic and Yoshioka for the reasons discussed above, and would have had a reasonable expectation of success in doing so. *See supra* § VIII.A.1; Ex. 1002 ¶¶ 172-178. Accordingly, the combination of Yoshioka and Jankovic also teaches receiving engine emissions data.

IX. CONCLUSION

For the foregoing reasons, Petitioner asks that *inter partes* review of the '540 patent be instituted and claims 1-3, 7, 10-11, and 14 be cancelled.

Petition for *Inter Partes Review* of U.S. Patent No. 6,557,540

Respectfully submitted,

Dated: May 14, 2018

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CERTIFICATE OF COMPLIANCE

I hereby certify that this brief complies with the type-volume limitations of 37 C.F.R. § 42.24, because it contains 12,633 words (as determined by the Microsoft Word word-processing system used to prepare the brief), excluding the parts of the brief exempted by 37 C.F.R. § 42.24.

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CERTIFICATE OF SERVICE

I hereby certify that on May 14, 2018, I caused a true and correct copy of the foregoing materials:

- Petition for *Inter Partes* Review of U.S. Patent No. 6,557,540 under 35 U.S.C. § 311-319 and 37 C.F.R. § 42.100 *Et Seq.*
- Exhibits 1001 – 1034
- Power of Attorney

to be served via:

Via FedEx Mail

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US006557540B1

(12) **United States Patent**
Mianzo et al.

(10) **Patent No.: US 6,557,540 B1**
(45) **Date of Patent: May 6, 2003**

(54) **METHOD OF CALCULATING A VALVE TIMING COMMAND FOR AN ENGINE**

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(73) Assignee: **Visteon Global Technologies, Inc.**, Dearborn, MI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/014,286**

(22) Filed: **Dec. 11, 2001**

(51) **Int. Cl.**[7] **F01L 1/34**
(52) **U.S. Cl.** **123/678**; 123/90.15; 701/103
(58) **Field of Search** 123/678, 90.15, 123/90.19; 701/103

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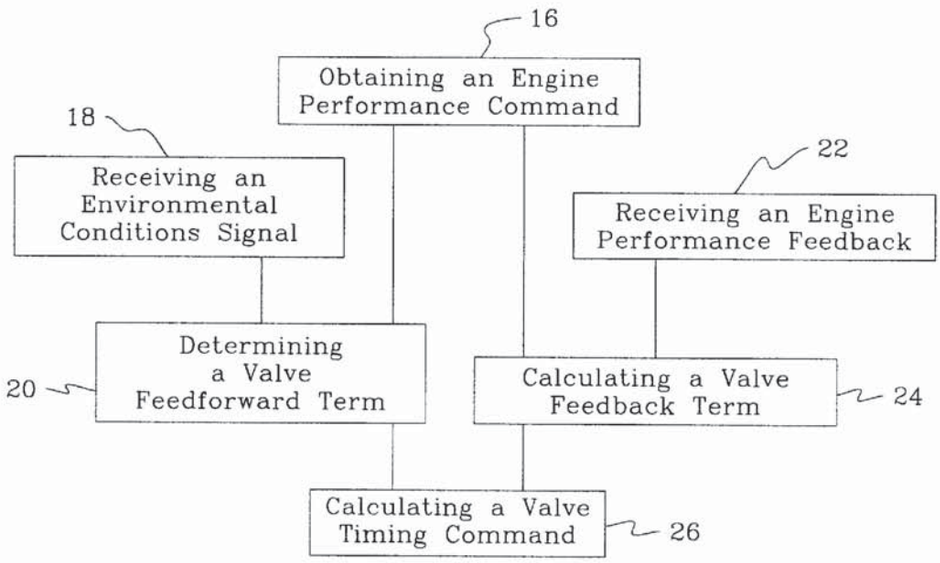
* cited by examiner

Primary Examiner—Erick Solis
(74) *Attorney, Agent, or Firm*—Brinks Hofer Gilson & Lione

(57) **ABSTRACT**

A method to calculate valve timing commands for an engine with variable valve timing is hereby disclosed. The method includes determining a valve feedforward term based on an engine performance command and an environmental conditions signal, calculating a valve feedback term based on the engine performance command and an engine performance feedback, and calculating a valve timing command based on the valve feedforward term and the valve feedback term.

16 Claims, 3 Drawing Sheets



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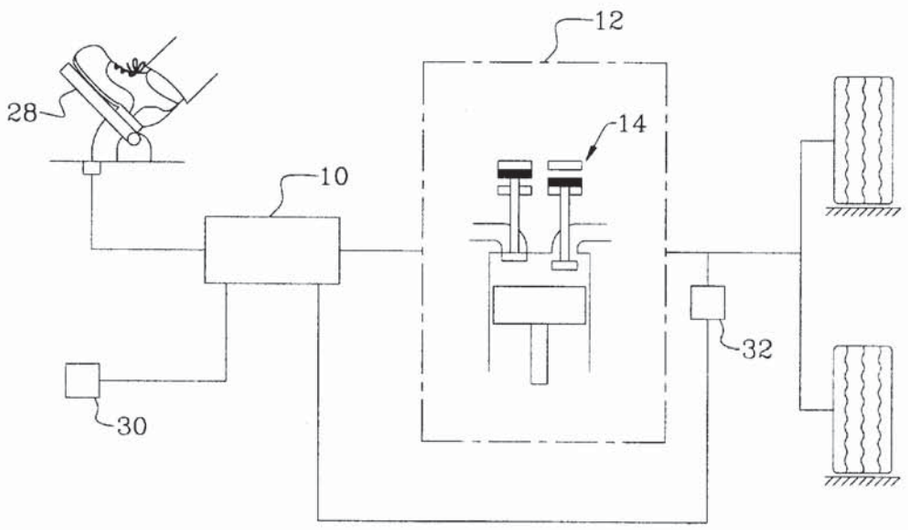


FIGURE 1

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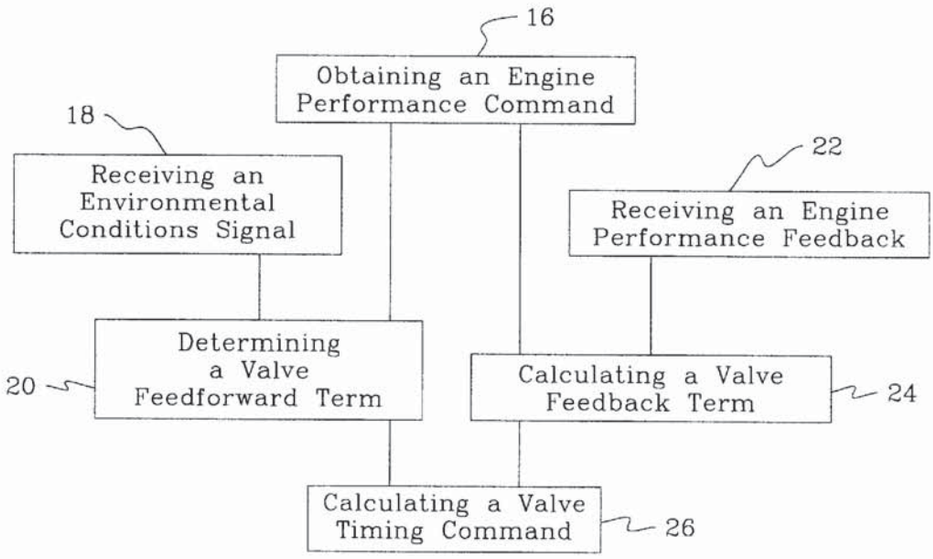


FIGURE 2

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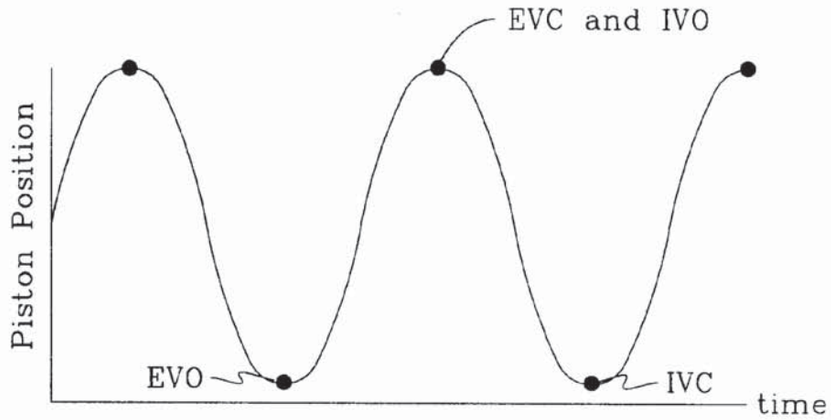


FIGURE 3A

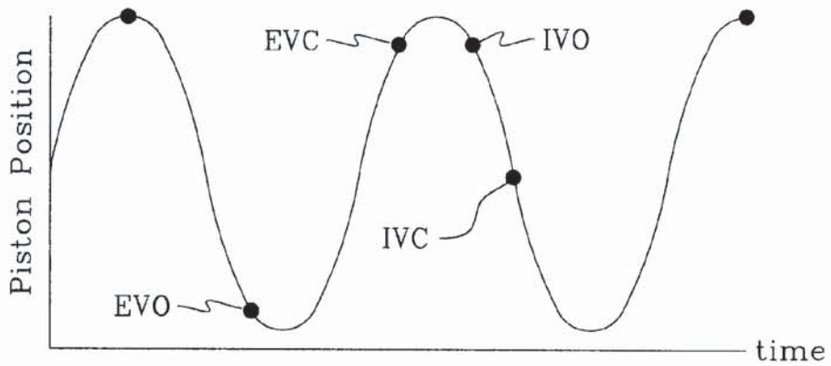


FIGURE 3B

PETITIONER'S EXHIBIT 1002
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METHOD OF CALCULATING A VALVE TIMING COMMAND FOR AN ENGINE

TECHNICAL FIELD

This invention relates generally to calculating commands for an engine and, more specifically, to calculating a valve timing command for an engine with variable timing valve actuators.

BACKGROUND

In gasoline engines of most vehicles, each cylinder of the engine cycles through four unique stages. In the first stage, an inlet valve opens and a piston draws air and fuel through the inlet valve and into the cylinder. The inlet valve closes and the piston reverses direction in the second stage to compress the air and fuel mixture. In the third stage, a spark combusts the mixture, which drives the piston (and powers the vehicle). An exhaust valve opens and the piston once again reverses direction, in the fourth stage, to push the combusted mixture through the exhaust valve and out of the cylinder.

The controlling of the inlet valve and the exhaust valve of each cylinder is a difficult task. The engine speed, which can exceed 6,000 rpm in most vehicles, dictates that the opening and closing of the inlet valve and the exhaust valve must be able to occur up to 50 times per second. In conventional engines, cams driven by the engine actuate the inlet valve and the exhaust valve. Modern research, however, has shown that fuel efficiency and power output of the engine may be optimized with an adjustment of the valve timing for a particular load on the engine. Some variable valve timing engines have been proposed, but the theoretical fuel efficiency and output power of these engines have not yet been reached.

BRIEF DESCRIPTION OF THE FIGURES

FIG. **1** is schematic of a vehicle having an engine controlled with the method of the preferred embodiment;

FIG. **2** is a flowchart of the method of the preferred embodiment; and

FIG. **3** is two timing charts of the valves of an engine.

DESCRIPTION OF THE PREFERRED METHODS

The following description of the two preferred method of the invention is not intended to limit the invention to these preferred methods, but rather to enable any person skilled in the art of variable valve timing control to make and use this invention.

As shown in FIG. **1**, the preferred method of the invention has been specifically created to be performed by a control unit **10** to calculate valve timing commands for an engine **12** with electromagnetic valve actuators **14**. The method, however, may be performed by any suitable device to calculate valve timing commands for any suitable engine with any suitable variable timing valves.

As shown in FIG. **2**, the preferred method of the invention has six principle actions: obtaining an engine performance command **16**; receiving an environmental conditions signal **18**; determining a valve feedforward term **20**; receiving an engine performance feedback **22**; calculating a valve feedback term **24**; and calculating a valve timing command **26** based on the valve feedforward term and the valve feedback term. The method performed by the control unit may, of course, include other suitable actions before, during, or after these principle actions.

The action of obtaining an engine performance command **16** preferably includes receiving a vehicle performance command from a driver. Preferably, the vehicle performance command is received from the foot of a driver with the use of a conventional pedal **28**, as shown in FIG. **1**. Alternatively, the vehicle performance command could be received from the driver with the use of any suitable device. The action of obtaining an engine performance command also preferably includes deriving the engine performance command from the vehicle performance command. The engine performance command is preferably based on the vehicle performance command, but may alternatively be based on additional suitable factors, such as a traction control signal or a cruise control signal. The engine performance command is preferably a desired engine torque and, for this reason, the engine performance command may be thought of as an engine torque command. The engine performance command, however, may alternatively be another suitable variable, such as a desired engine acceleration.

The action of receiving an environmental conditions signal **18** preferably includes receiving an environmental conditions signal from an environmental sensor **30** in the vehicle. The environmental sensor **30** preferably senses the ambient temperature outside the vehicle and communicates this data to the control unit **10**, which uses the data to determine the valve feedforward term. Other information, such as the ambient pressure, may be useful in the determination of the valve feedforward term. For this reason, the environmental sensor **30** may alternatively sense other suitable information. The environmental sensor **30** is preferably a conventional environmental sensor, but may alternatively be any suitable device.

Similarly, the action of receiving an engine performance feedback **22** preferably includes receiving the engine performance feedback from an engine sensor **32** in the vehicle. The engine sensor **32** preferably senses the engine speed and communicates this data to the control unit **10**, which uses the data to determine the valve feedforward term and the valve feedback term. Other engine measurables, such as engine torque data, may be useful in the determination of the terms. For this reason, the engine sensor **32** may alternatively sense other suitable information. The engine sensor **32** is preferably a conventional engine sensor, but may alternatively be any suitable sensor.

The action of determining a valve feedforward term **20** preferably includes determining the valve feedforward term based on the engine torque command, the ambient temperature data, and the engine speed data. The determination, however, may be based on other suitable factors, such as engine torque data, air-fuel ratio data, engine combustion stability data, or ambient pressure data. The control unit **10** preferably includes a look-up table, which has been optimized for fuel efficiency, power output, and engine emissions based on various engine torque commands, various ambient temperature data, and various engine speed data (or engine torque data). The control unit **10** may alternatively be programmed to perform a real-time optimization of the fuel efficiency, power output, and engine emission (or any other suitable measurement) based on the engine torque command, the ambient temperature data, and the engine speed data (or any other suitable commands and measurables).

The action of calculating the valve feedback term **24** preferably includes comparing the engine performance com-

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mand and the engine performance feedback. By the definition of the term, the valve feedback term functions to compare the input with the output and to calculate a correction term based on the difference, if any. The comparison and the calculation are preferably accomplished by the control unit **10**, but may alternatively be accomplished by a suitable separate device.

As shown in FIG. **3**A, the position of the piston in the cylinder can be traced as a sinusoidal wave over a time period. The events of the opening of the exhaust valve ("EVO"), the closing of the exhaust valve ("EVC"), the opening of the inlet valve ("IVO"), and the closing of the inlet valve ("IVC") can be placed on this sinusoidal wave. As shown in FIG. **3**B, the events of the EVO, the EVC, the IVO, and the IVC may be shifted within the time period (note that the shift in the EVC and the IVO preferably mirror each another, but may alternatively be separately controlled). The adjustment of the timing of the EVO, the EVC/IVO, and the IVC when used partially, separately, or together may provide the desired fuel efficiency, power output, and emissions from the engine **12** of the vehicle. The action of calculating a valve timing command **26** preferably includes calculating an EVO command, an EVC/IVO command, and an IVC command. The control unit **10**, of course, may alternatively include other suitable parameters for the control of the variable timing valves.

The second preferred method of the invention includes the principle actions of the first preferred method and the additional principle action of receiving fuel conversion data and engine emissions data. These preferably include receiving the fuel conversion data and engine emissions data from suitable emission sensors (not shown) in the cylinder or the exhaust port of the engine **12**. The emission sensors preferably sense the amount of NO_x in the exhaust and communicates this data to the control unit **10**. The control unit **10** preferably uses this information to modify the output value from the look-up table, but may alternatively use this information to continually adjust the values in the look-up table. The control unit **10** may alternatively use this information as another factor in the determination of the valve feedback term. The emission sensors are preferably conventional emission sensors, but may alternatively be any suitable sensor.

As any person skilled in the art of variable valve engine control will recognize from the previous detailed description and from the figures and claims, modifications and changes can be made to the preferred methods without departing from the scope of this invention defined in the following claims.

We claim:

1. 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.

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.

3. The method of claim **1** wherein said receiving an environmental conditions signal includes receiving ambient temperature data.

4. The method of claim **3** wherein said determining a valve feedforward term includes determining the valve feedforward term based on the ambient temperature data.

5. The method of claim **4** wherein said determining a valve feedforward term includes determining the valve feedforward term based on the engine performance feedback.

6. The method of claim **5** wherein said determining a valve feedforward term includes referencing a look-up table with the engine performance command, the ambient temperature, and the engine performance feedback.

7. The method of claim **1** wherein said receiving an engine performance feedback includes receiving engine speed data.

8. The method of claim **1** wherein said obtaining an engine performance command includes obtaining an engine torque command; and wherein receiving an engine performance feedback includes receiving engine torque data.

9. The method of claim **8** wherein calculating a valve feedback term includes calculating a valve feedback term based on the engine torque command and the engine torque data.

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.

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

12. The method of claim **11** wherein said determining a valve feedforward term includes determining a valve feedforward term based on the fuel conversion data.

13. The method of claim **11** wherein said calculating a valve feedback term includes calculating a valve feedback term based on the fuel conversion data.

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

15. The method of claim **14** wherein said determining a valve feedforward term includes determining a valve feedforward term based on the engine emissions data.

16. The method of claim **11** wherein said calculating a valve feedback term includes calculating a valve feedback term based on the engine emissions data.

* * * * *

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US PATENT NO. 6,557,540

IPR2018-01061
US Patent No. 6,557,540

Exhibit No. 1002

UNITED STATES PATENT AND TRADEMARK OFFICE

_____

BEFORE THE PATENT TRIAL AND APPEAL BOARD

_____

Hyundai Motor Company,

Petitioner

v.

Michigan Motor Technologies LLC,

Patent Owner

Patent No. 6,557,540

Issue Date: May 6, 2003

Title: METHOD OF CALCULATING A
VALVE TIMING COMMAND FOR AN ENGINE

Inter Partes Review No. IPR2018-01061

DECLARATION OF SCOTT ANDREWS

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I. INTRODUCTION

1. I have been retained by counsel for Hyundai Motor Company ("HMC" or "Petitioner"), and asked to review and provide my opinion on the invalidity of claims 1-3, 7, 10-11, and 14 of U.S. Patent No. 6,557,540. (Ex. 1001, "'540 patent"). This declaration accompanies the petition for *inter partes* review no. IPR2018-01061 ("Petition").

2. I am being compensated at an hourly consulting rate for time actually spent reviewing materials and performing my analysis of the technical issues relevant to this matter. My compensation is not contingent on the outcome of this proceeding or the content of my opinions.

II. BACKGROUND

3. I have over 30 years of professional experience in the field of automotive technologies and systems, including vehicle information systems and vehicle safety and control systems. Further, I have authored numerous published technical papers and am a named inventor on 11 U.S. and foreign patents.

4. I received a Bachelor of Science degree in Electrical Engineering from University of California, Irvine in 1977 and a Master of Science degree in Electronic Engineering from Stanford University in 1982.

5. From 1977 to 1979, I worked at Ford Aerospace where I designed, tested and delivered microwave radar receiver systems.

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6. From 1979 to 1983, I worked at Teledyne Microwave, where I developed high reliability microwave components and developed CAD tools.

7. From 1983 to 1996, I worked at TRW, Inc., having held various positions. From 1983 to 1985, I was a Member of the technical staff and a Department Manager in the Space Electronics sector. Between 1985 and 1990 I was a project manager working on various communications systems projects including the US DoD Advanced Research Projects Administration (ARPA) MIMIC Program. Between 1990 and 1993 I was the Manager of MMIC (monolithic-microwave-integrated-circuit) Products Organization. In this role, I developed business strategy and managed customer and R&D programs. During this time, I also developed the first single chip 94 GHz Radar, used for automotive cruise control and anti-collision systems. In 1993 I transferred to the TRW Automotive Electronics Group, and managed about 30 engineers in the Systems Engineering and Advanced Product Development organization. In this role, I managed advanced development programs such as advanced automotive electronics sensors and control systems, adaptive cruise control using millimeter wave radar, occupant sensing, automatic crash notification systems, in-vehicle information systems, and other emerging transportation products.

8. My work I at TRW included the development of various types of sensors for vehicle systems, as well as control systems based on those sensors. For example, I

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worked on an electronic power steering system that required the real-time feedback controlled variation of the electrical drive signals to produce a motor drive signal to provide steering boost while still providing a realistic steering wheel feel to the driver. I also worked on various electronic systems that used feed-forward techniques in order to improve transient response characteristics.

9. In addition, my work in the auto industry in general has provided me with the opportunity to develop and test a variety of vehicle control systems, including sensing and responding to various gaseous mixtures, air fuel ratio controls based on environmental sensors and exhaust sensors, and numerous other closed loop control systems.

10. I was employed as a Project General Manager in the Electronics Division of Toyota Motor Corporation at Toyota headquarters in Toyota City, Japan from April 1996 to around April 2000. In this position, I was responsible for leading the development of vehicle telematics systems, infotainment systems, including on-board and off-board navigation systems, traffic information systems, vehicle communications systems, safety applications, and automated vehicle control systems.

11. I am currently a consultant for Cogenia Partners, LLC, focusing on systems engineering, business development and technical strategy supporting automotive and information technology. I have been in this position since 2001. In one of my

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active engagements, I serve as the technical lead on a project funded by the National Highway Traffic Safety Administration (NHTSA) to develop requirements for connected vehicle safety systems in preparation for NHTSA regulations governing such systems. I also serve as a technical consultant on multiple projects sponsored by the Federal Highway Administration (FHWA) related to connected vehicle technology research.

12. In the various positions mentioned above, I was responsible for research and development projects relating to numerous vehicle information systems, user interface systems, sensory systems, control systems and safety systems, and also had the opportunity to collaborate with numerous researchers and suppliers to the auto industry. I therefore believe that I have a detailed understanding of the state of the art during the relevant period, as well as a sound basis for opining how persons of skill in the art at that time would understand the technical issues in this case.

13. A more complete summary of my experience, expertise, and publications is set forth in my curriculum vitae (Ex. 1011).

III. SUMMARY OF MY OPINIONS

14. In my opinion, claims 1-3, 7, 10-11, and 14 (the "challenged claims") of the '540 patent are invalid as obvious. My opinions are based on my expertise in the technology of the '540 patent at the time the application was filed, as well as my review of the '540 patent, its file history, and the prior art discussed in the Petition.

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If the patent owner is allowed to submit additional evidence pertaining to the validity of the '540 patent, I intend to review that as well and update my analysis and conclusions as appropriate and allowed under the rules of this proceeding.

15. I reviewed and contributed to the Petition's explanation as to why the challenged claims are unpatentable as obvious. The Petition's explanation as to why the challenged claims are unpatentable reflects my understanding, and I incorporate it herein by reference.

IV. LEGAL PRINCIPLES

16. I am not an attorney. I have been informed that it is a basic principle of patent law that assessing the validity of a patent claim involves a two-step analysis. In the first step, the claim language must be properly construed to determine its scope and meaning. In the second step, the claim as properly construed, must be compared to the alleged prior art to determine whether the claim is valid. I use the principles below, however, as a guide in formulating my opinions.

A. Person of Skill in the Art

17. I have been informed "A person of ordinary skill in the art" ("POSITA") is a hypothetical person who is presumed to have known the relevant art at the time of the invention. Such a hypothetical person would have the capability of understanding the scientific and engineering principles applicable to the pertinent art of the claimed invention. Factors that may be considered in determining the

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level of ordinary skill in the art include: (A) the type of problems encountered in the art; (B) prior art solutions to those problems; (C) rapidity with which innovations are made; (D) sophistication of the technology; and (E) educational level of active workers in the field. Here, workers in the field of automotive electronics would typically have a bachelor's or master's degree in electrical engineering and several years of experience. Accordingly, it is my opinion that a person of ordinary skill in the art here would have had a bachelor's degree in electrical engineering and at least 4-5 years of work experience in automotive electrical or electronics systems design, or would have had a masters degree in electrical engineering and at least 2 years of work experience in automotive electrical or electronics systems design.

B. Claim Interpretation

18. I have been informed that in an *inter partes review,* the words of a patent must be given their broadest reasonable construction in light of the specification as it would be interpreted by one of ordinary skill in the art. This meaning must be ascertained from a reading of the patent documents, paying special attention to the language of the claims, the written specifications, and the prosecution history. I understand that an inventor may also attribute special meanings to some terms by defining those terms or by otherwise incorporating such meanings in these documents.

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19. My methodology for determining the meaning of claim phrases was first to carefully study the patent. In particular, I studied the claims themselves, followed by a study of the background, detailed specification, figures, and other patent content. Next, I reviewed the file histories looking for any clarifications or limitations that might be attached to claim terms. In some circumstances, I looked at other documents, such as references applied by the patent office.

C. Priority Date

20. I understand that the '540 patent application (Application No. 10/014,286) was filed on December 11, 2001. Accordingly, my opinions reference December 11, 2001, as the relevant date for the claimed invention, although the main prior art references I have relied upon pre-date December 11, 2001 by several years.

D. Prior Art

21. I have been informed that only information which satisfies one of the categories of prior art set forth in 35 U.S.C. § 102 may be used in any invalidity analysis under §§ 102 or 103. Therefore, if information is not properly classified as prior art under one of the subsections of § 102 of the Patent Code, then it may not be considered in an anticipation or obviousness determination. It is also my understanding that, for *inter partes review*, applicable prior art is limited to patents and printed publications.

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E. Anticipation

22. I have been informed that to anticipate a patent claim under 35 U.S.C. § 102, a single asserted prior art reference must disclose each and every element of the claimed invention, either explicitly or inherently, to a person of ordinary skill in the art. I understand that a disclosure of an asserted prior art reference can be "inherent" only if the missing element is necessarily present or is the inevitable outcome of the process and/or thing that is explicitly described in the asserted prior art reference.

F. Obviousness

23. I have been informed that to find a patent claim invalid under 35 U.S.C. § 103 the petitioner must show that the differences between the claimed invention and the prior art would have been obvious, at the time the invention was made, to "a person having ordinary skill in the art" to which the claimed invention pertains.

24. I have been informed that obviousness may be shown by demonstrating that it would have been obvious to modify what is taught in a single piece of prior art to create the patented invention. Obviousness may also be shown by showing that it would have been obvious to combine the teachings of more than one prior art reference.

25. I understand that in the Graham v. John Deere decision, the Supreme Court outlined three issues that must be resolved in the obviousness determination: (1)

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the level of ordinary skill in the pertinent art, (2) the scope and content of the prior art, (3) differences between the prior art and the claims at issue. "Objective" considerations, such as commercial success and praise of the alleged invention, may also be considered in the obviousness analysis.

i. Motivation to Combine

26. I have been informed that in the KSR v. Teleflex decision, the Supreme Court outlined a variety of factors to consider in determining whether a claimed combination of components is obvious. These factors are set forth below for reference.

KSR Factor No.	KSR Factor Description
1	The identified prior art includes an express or inherent suggestion to modify or combine the reference in a way that renders the claimed invention obvious.
2	The combination of familiar elements of the asserted claims is obvious because it does no more than yield predictable results.
3	The asserted patents simply arrange old elements with each performing the same function it had been known to perform and yields no more than one would expect from such an arrangement, the combination is obvious.
4	Because the subject matter of the asserted patents is available in one field of endeavor, design incentives and other market forces can prompt variations of it, either in the same field or a different one, rendering the combination obvious.
5	Because the technique of the patents-in-suit has been used to

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	improve one device, a person of ordinary skill in the art would recognize that it would improve similar devices in the same way, and thus using the technique is obvious unless its actual application is beyond his or her skill.
6	I may consider the interrelated teachings of multiple patents; the effects of demands known to the design community or present in the marketplace; and the background knowledge possessed by a person having ordinary skill in the art, all in order to determine whether there was an apparent reason to combine the known elements in the fashion claimed by the patents at issue.
7	Market demand has driven design trends to render the claimed invention of the patents-in-suit obvious.
8	The subject matter of the asserted patents extends to what is obvious, and is therefore invalid.
9	The claimed subject matter of the patents-in-suit is an obvious solution to a problem that was known at the time of invention.
10	The familiar items of the claims of the patents-in-suit have obvious uses beyond their primary purposes, and a person of ordinary skill will be able to fit the teachings of prior art references together like pieces of a puzzle to demonstrate that the asserted claims are obvious.
11	The need and problem known in the field at the time of invention of the patent-in-suit, and addressed by the patent-in-suit, provides a reason for combining known prior art elements in the manner claimed in the patents-in-suit.
12	There was a design need and/or market pressure to solve the problem addressed by the patents-in-suit. Because there was a finite number of identified, predictable solutions to the problem addressed in the patents-in-suit, a person of ordinary skill would have had good reason to pursue the known options within his or her technical grasp. Such a pursuit would have led to the anticipated success, making it likely that the product was not of

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	innovation but of ordinary skill and common sense. In that instance the fact that a combination was obvious to try might show that it was obvious.

27. I also have been informed that it is improper to rely on hindsight, that is, to rely on the teachings of the patent claims, in order to merely show that the elements of the claims can be found in various otherwise unrelated prior art references. Instead, obviousness is found by considering whether a POSITA would have had a reason to combine the prior art to achieve the claimed invention.

28. I also understand that, for example, this reason may come from sources such as explicit statements in the prior art, or from the knowledge of a person having ordinary skill in the art. Alternatively, any need or problem known in the field at the time and addressed by the patent may provide a reason for combining elements of the prior art. I also understand that when there is a design need or market pressure, and there are a finite number of predictable solutions, a person of ordinary skill may be motivated to apply both his skill and common sense in trying to combine the known options in order to solve the problem.

29. Moreover, I understand that the obviousness inquiry requires a flexible approach. I understand that the obviousness inquiry recognizes that a POSITA is also a person of ordinary creativity (not an automaton), that familiar items may have obvious uses beyond their primary purposes, and that, in many cases, a

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POSITA will be able to fit the teachings of multiple patents together like pieces of a puzzle.

ii. Secondary Considerations

30. I understand that certain objective factors, sometimes known as "secondary considerations," may also be taken into account in determining whether a claimed invention would have been obvious or not. These considerations include:

(a) commercial success of a product due to the merits of the claimed invention;

(b) a long-felt, but unsatisfied need for the invention;

(c) failure of others to find the solution provided by the claimed invention;

(d) deliberate copying of the invention by others;

(e) unexpected results achieved by the invention;

(f) praise of the invention by others skilled in the art;

(g) lack of independent simultaneous invention within a comparatively short space of time;

(h) teaching away from the invention in the prior art.

31. I also understand that these objective indications are only relevant to obviousness if there is a connection, or nexus, between them and the invention covered by the patent claims.

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V. DOCUMENTS RELIED UPON

32. In this declaration, I rely on the following documents, which are hereby incorporated by reference.

Exhibit Number	Document
Ex. 1001	U.S. Patent No. 6,557,540
Ex. 1003	U.S. Patent No. 6,557,540 File History
Ex. 1004	U.S. Patent No. 5,713,317 ("Yoshioka")
Ex. 1005	Torque Management of Engines with Variable Valve Timing, By Jankovic, Firschmuth, Stefanopoulou, and Cook ("Jankovic"), IEEE Control Systems in October, 1998
Ex. 1006	Bosch Fuel Injection Systems, by Forbes Aird, ©2001 Forbes Aird, published by the Berkeley Publishing Group, ISBN 1-55788-365-3
Ex. 1007	Bosch Fuel Injection & Engine Management, by Charles O. Probst, ©1992, Robert Bentley, Inc. ISBN-978-0-8376-0300-1

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Ex. 1008	Modeling and Control of Advanced Technology Engines by Anna Stefanopoulou, A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy (Electrical Engineering: Systems) in The University of Michigan 1996
Ex. 1009	Automotive Encyclopedia, by William Toboldt and Larry Johnson, © 1979 Goodheart-Wilcox Co. Inc. ISBN 0-87006-268-9
Ex. 1010	Bosch Automotive Handbook, © 2000 Robert Bosch GmbH, ISBN 0-7680-0669-4
Ex. 1011	CV of Scott Andrews
Ex. 1012	Automotive Electronics Handbook, by Ronald Jurgen, © 1994, McGraw-Hill, Inc. ISBN0-07-033189-8
Ex. 1013	McGraw-Hill Electronics Dictionary, 6th ed. By Neil Sclater and John Markus © 1997 Mcgraw-Hill Inc. ISBN 0-07-057837-0
Ex. 1014	"The New Shorter Oxford English Dictionary," Oxford University Press, vol.

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	1, 0-19-861271-0ISBN, 1993 ("Oxford Dictionary")

VI. OVERVIEW OF THE TECHNOLOGY

A. Background of the Technology

33. Internal combustion engines operate by mixing a combustible fuel such as gasoline or diesel oil with air, compressing this mixture and then either igniting it with an electrical spark (gasoline engines), or relying on the heat of compression to ignite the mixture (diesel engines). The resulting exothermic expansion causes the engine components (typically pistons) to move, thereby producing rotational power for whatever use the engine is intended. A 4-stroke engine is essentially a pump that draws air in, mixes it with fuel, and combusts the air-fuel mixture. That combustion produces power that turns the engine, causing it to expel the burned fuel and air (exhaust), and draw in air again, and the cycle continues. In the process, depending on the engine, substantially more power is generated than is required to maintain the intake / compression / ignition / exhaust cycle, and that power is then used for other purposes, for example, powering an automobile.

34. To control the engine speed (and thus output power), the intake of air has long been controlled by a throttle valve. For example, in 1992, Probst described the role of the throttle valve as follows:

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> The throttle valve regulates air flow into the engine. The more it is open, the greater the air flow into the engine. The throttle valves is located downstream from the mixture control unit, usually mounted on the intake manifold, and is controlled by the accelerator cable.
> (Ex. 1007 p. 79; Probst ch. 5 p. 11)

And, in 1979, Toboldt and Johnson described the throttle valve as follows:

> One of the most important controls on a carburetor is the throttle valve, or valves. The throttle valve is a device for varying the amount of air –fuel mixture that enters the intake manifold. This control is necessary so that the speed of the vehicle can be changed. The throttle valve, figure 21-5, is simply a round disk mounted on a shaft, so that it can be tilted at various angles in the carburetor throttle valve body. It is connected by means of a suitable linkage to the accelerator pedal in the driving compartment of the vehicle. Depressing the pedal opens the throttle valve, permitting an increased amount of air-fuel mixture to reach the manifold.
> (Ex. 1009 p. 11; Automotive Encyclopedia p. 239)

35. An example throttle valve is illustrated in the figure below:

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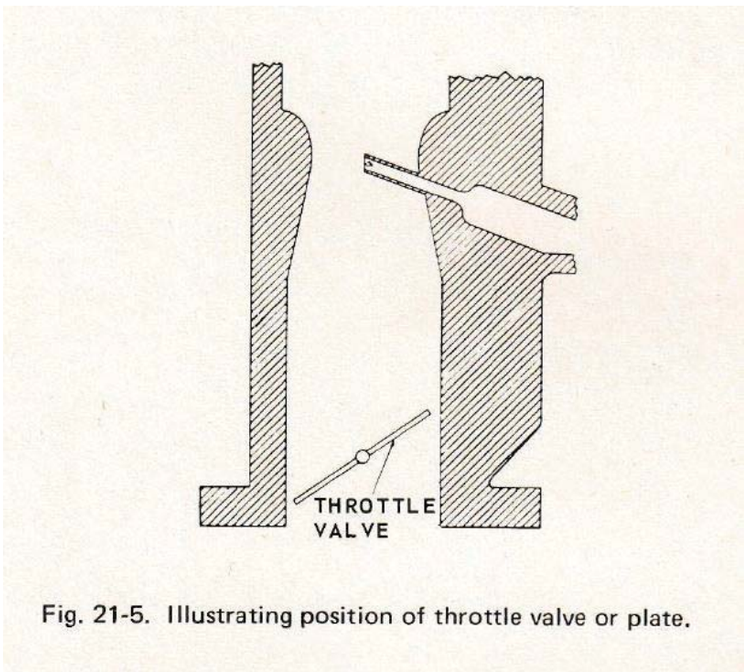


Fig. 21-5. Illustrating position of throttle valve or plate.

(Ex. 1009 p. 11, Automotive Encyclopedia p. 239)

36. There are three competing objectives with internal combustion engines: The development of maximum power output with minimum fuel consumption, and minimum exhaust byproducts (e.g. emissions). Key to meeting these goals is the management of the ratio of fuel and air. Too much fuel (what is known as a "rich" mixture) and the resulting exhaust will contain substantial unburned fuel, excessive hydrocarbon emissions (HC), and poor fuel economy. Too little fuel, and the "lean" mixture will cause the engine to run hot, misfire and generate substantial levels of CO and NOx in the exhaust. Accordingly, a POSITA would have appreciated that the efficiency of the combustion of the air fuel mixture in the cylinder(s) depends heavily on the ratio of air and fuel. The so-called stoichiometric air-fuel ratio is the

ratio wherein all of the fuel in the mixture is combusted with all of the oxygen in the cylinder. The stoichiometric ratio is typically considered to be 14.7:1 air to fuel. To simplify computations this term is normalized using variable called “lambda” (λ). Thus a lambda of 1.0 corresponds to an air fuel ratio of 14.7:1. This is also indicated in the figure below (from Probst, 1992) which illustrates the relationship between air fuel ratio, power and fuel consumption:

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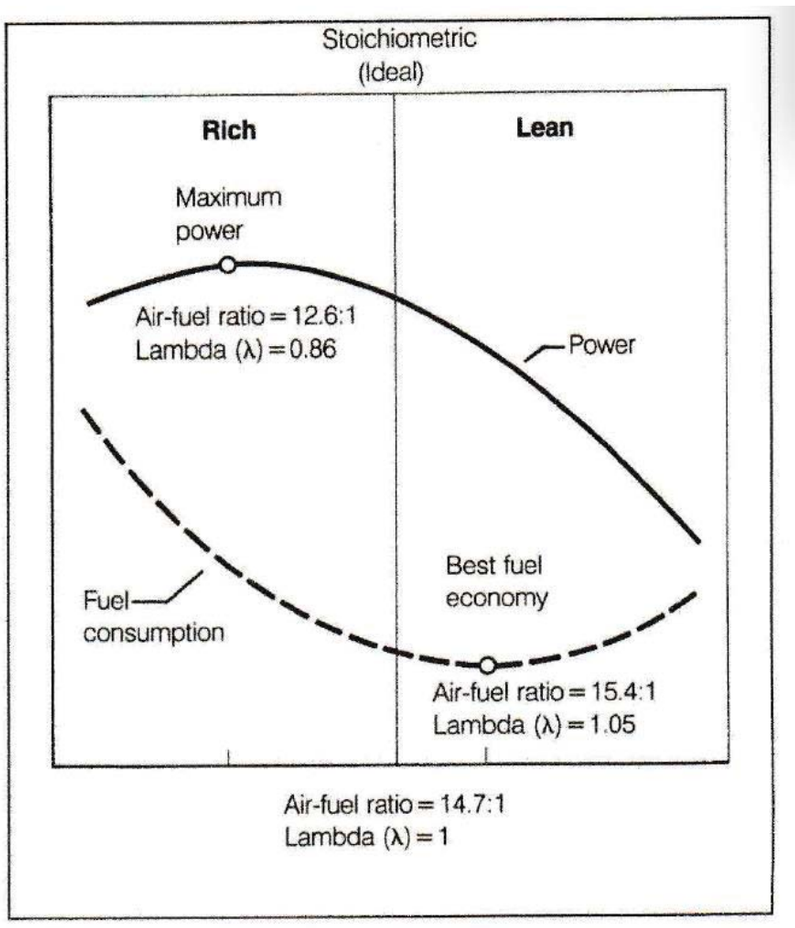


Fig. 2-7. The air-fuel ratio which delivers maximum power is slightly richer than stoichiometric; the one which delivers minimum fuel consumption is slightly more lean than stoichiometric. The stoichiometric ratio is a compromise which sacrifices very little of either.

(Ex. 1007 p. 12, Probst ch. 2 p. 5)

37. Of course, since the combustion is not ideal, as a POSITA would have appreciated, there are a variety of byproducts, and these are known collectively as ”emissions”.

38. For example, the primary emissions from the combustion process are oxides of nitrogen (typically designated NOx), carbon monoxide (CO), and unburned

hydrocarbons (HC). As can be seen in the figure below, from 1992, the quantity of these emissions varies as the air fuel ratio varies.

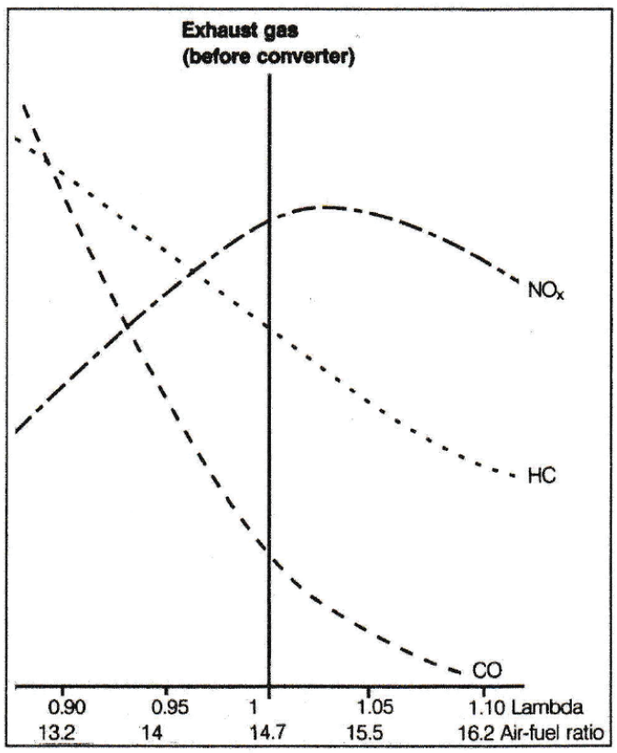


Fig. 4-3. Pollutant levels in engine exhaust change drastically as air-fuel ratio changes. Notice the trade-off between control of HC and CO, and control of NO_x.

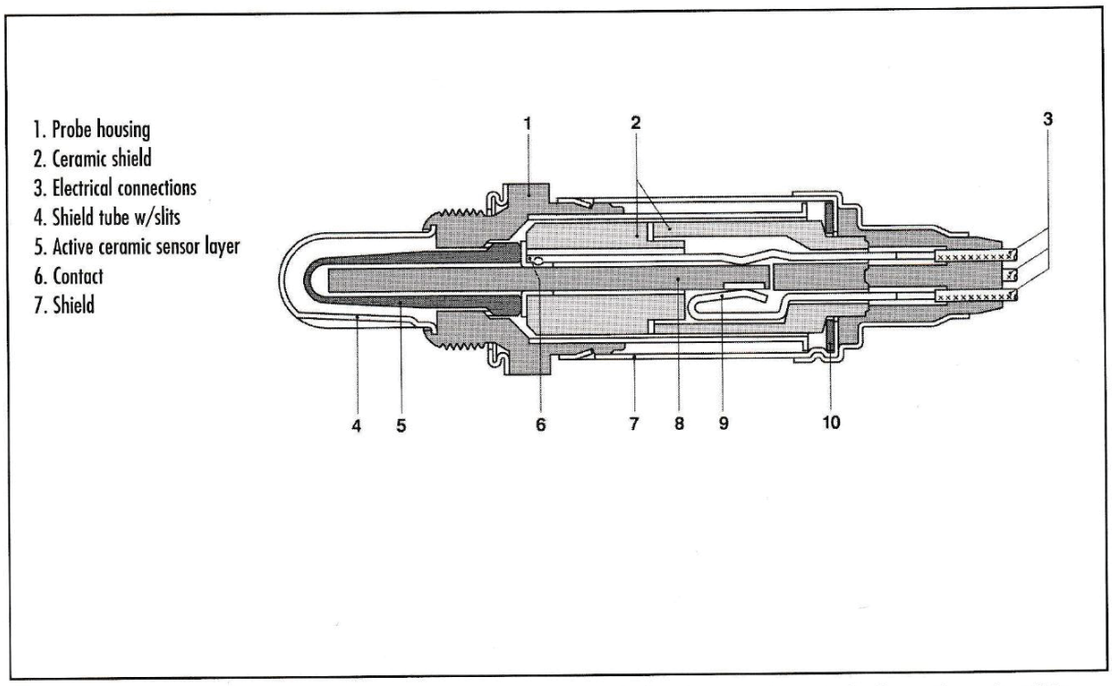
(Ex. 1007 p. 23, Probst ch. 2 p. 16)

39. The oxygen sensor, sometimes referred to as a "lambda sensor", was developed in order to measure the amount of oxygen in the exhaust, and therefore how closely to a stoichiometric air fuel ratio the engine is operating. For example, according to Aird, the lambda sensor is described as follows:

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In construction, the lambda sensor consists of a hollow ceramic bulb, with both inner and outer surfaces covered with a microthin layer of platinum. For protection, the outer surface is surrounded by a shield. This bulb is inserted into the exhaust system so that its exterior surface is washed by the exhaust gas stream, while its hollow interior is exposed to the atmosphere. In operation, the lambda sensor acts like an oxygen-powered battery: A difference in the oxygen level of the gasses surrounding the two surfaces of the sensor causes it to generate a small voltage.



Lambda sensors have a voltage output that rises from near zero in the absence of oxygen in the engine exhaust to a bit less than one volt when small traces of it are present. This characteristic enables an electronic fuel injection system to control fuel delivery on the basis of the sensor's reading of the exhaust gas. The sensor only works when hot, however. To reduce the time between engine start-up from cold and the sensor reaching its operating temperature, some versions are electrically heated. (Robert Bosch Corporation).

(Ex. 1006 p. 22, Bosch Fuel Injection Systems p. 35)

40. Similarly, Probst in 1989 explained a lambda sensor:

> The lambda sensor is essentially a small battery that generates a voltage signal based on the differential between the oxygen content of the exhaust gas, and the oxygen content of the ambient air.
>
> A cutaway view of the lambda sensor is shown in Fig. 2-46. The tip of the sensor that protrudes into the exhaust gas is hollow, so that the interior of the tip can be exposed to the ambient air. Both sides of the ceramic tip of the sensor are covered with metal electrodes that react to create a voltage only if the ambient air has a higher oxygen content than the exhaust and the ceramic material is hotter than 575°F (300°C)[.]
>
> When these conditions are met, voltage is generated between the two sides of the tip. The voltage is usually about 1 volt. But if the engine is running lean, the exhaust gas has about the same amount of oxygen as the ambient air, so the lambda sensor will generate little or no voltage; if the engine is running rich, the oxygen content of the exhaust will be much lower than the ambient air and the sensor voltage will be larger.
>
> (Ex. 1007 at 47-48, Probst at ch. 3 pp. 21-22.)

Thus, a POSITA would have understood that the oxygen sensor output represents the fuel conversion (e.g., rich vs. lean) of the engine.

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41. One method long known and used to control emissions is known as exhaust gas recirculation (EGR) wherein a small amount of the exhaust gas is re-introduced into the intake. For example, from Probst in 1992:

> Exhaust Gas Recirculation (EGR) is a technique for reducing the formation of oxides of nitrogen (NO_X). A small amount of exhaust gas is rerouted back into the combustion chambers, diluting the combustible mixture and lowering combustion temperature. You'll remember that excessive combustion temperature is the cause of NO_X formation.
> (Ex. 1007 p. 24 Probst ch. 2 p. 17)

42. A POSITA would also appreciate that one way to implement EGR is to physically sample the exhaust gas and introduce it back into the intake using a pressure controlled valve. One drawback of this approach is that the exhaust gasses are very hot, and corrosive, and the EGR valves were consequently somewhat unreliable. An alternative solution is to control the valve timing so that the exhaust valve remains open briefly during the intake stroke. This causes a small amount of the exhaust gas in the exhaust manifold (just pumped out of the cylinder by the piston) to be drawn back into the cylinder. For example, from Stefanopoulou in 1996:

> Exhaust gas recirculation (EGR) was introduced in the early 1970s to suppress the formation of oxides of nitrogen (NOx). The inert exhaust gases dilute the inducted air-fuel charge and

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lower the combustion temperature which reduces NOx feedgas emissions.

Conventionally, exhaust gas recirculation is accomplished by controlling the exhaust gas that is supplied from the exhaust manifold to the intake manifold through a vacuum actuated valve The EGR control algorithm is a simple PI or PID loop that adjusts the amount of exhaust gas to the scheduled steady-state point which is a function of engine speed, coolant temperature and engine load (or another load related variable). EGR alters the breathing process dynamics and consequently the torque response. Careful steady-state and transient control design is necessary to maintain good engine torque response, and for this reason, EGR is typically turned o in transient engine operations, engine warm-up, and idling.

An innovative mechanical design approach to controlling EGR is the development of the variable cam timing (VCT) mechanism. By retarding the cam timing, combustion products which would otherwise be expelled during the exhaust stroke are retained in the cylinder during the subsequent intake stroke. This is a method of phasing the camshaft to control residual dilution and achieve the same results with the conventional external EGR system, thus providing an innovative solution to an old problem.

(Ex. 1008 pp. 18-19, Modeling and Control of Advanced Technology Engines pp. 6-7)

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43. Atmospheric pressure and temperature play a significant role in the operation of the engine. This is because the density of air depends on these two factors. Specifically, since the volume of the cylinder is fixed by the engine itself (i.e., the bore and stroke of the cylinder(s)), the number of air molecules that are present in the cylinder will vary as the density of the air changes, and the air density is directly related to temperature and pressure by the ideal gas law:

$$pv=nRT$$

Where p is the pressure, v is the volume, n is the number of moles of gas molecule, T is the temperature, and R is a constant.[1]

44. In the above relation, if the volume is constant (i.e., the fixed cylinder volume), then as the pressure increases at a constant temperature, the number n of molecules will increase. Similarly, if the volume and pressure are constant then if the temperature increases, the number of molecules n will decrease.

45. Thus, a POSITA would have appreciated that a key element of engine control is to determine the number of molecules of air are present in the cylinder, and to then meter the proper amount of fuel to achieve a stoichiometric air fuel ratio. To achieve this, various sensors are used. For example, a pressure sensor and temperature sensor can be used together with the known volume of the

[1] See Ex.1010, Bosch Automotive Handbook, © 2000 Robert Bosch GmbH , page 59

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cylinder to estimate the number of air molecules are present. Alternatively, the air flow can be measured directly, and then the number of molecules can be estimated based on the temperature. For example, in 1994, Jurgen[2] described that barometric pressure sensors are useful to compensate for altitude changes. And in 1992, Probst described using an air temperature sensor to adjust for density air changes. For example:

> With the air cleaner removed, you can see the Air Temperature Sensor in the air-flow sensor, as shown in figure 2-34. Known as he NTC1, this sensor also has a negative temperature coefficient. Remember, the control unit sends a signal which is changed by the air temperature sensor. Cold air, weighing more, needs more fuel, so a cold air signal also adds fuel to the basic pulse time. The air fuel ratio relates weight of air to weight of fuel. The combination input signals of volume (from the air flow sensor), corrected for temperature are the same as inputs of weight or mass of air passing into the engine.
> (Ex. 1007 pp. 42-43, Probst ch. 3 pp. 16-17)

46. A POSITA would have further known that many electronic engine management systems use data tables representing the relationships between multiple variables. These are also often called "maps" since they often represent a surface-like or topographic map. Such relationships (whether calculated via

[2] *See* Ex. 1012, Automotive Electronics Handbook, by Ronald Jurgen, page 2.7

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algorithm or stored in look-up tables or maps) would have been well-known to a POSITA as a type of feedforward control. For example, from Probst in 1992:

> The main map in the control unit is a set of lambda memory points used to determine the desired air-fuel ratio for the fuel injection pulses. The lambda memory map, shown in Fig. 4-8 is derived from lab and road tests, and modified for the requirements of the vehicle and the country where it will operate:

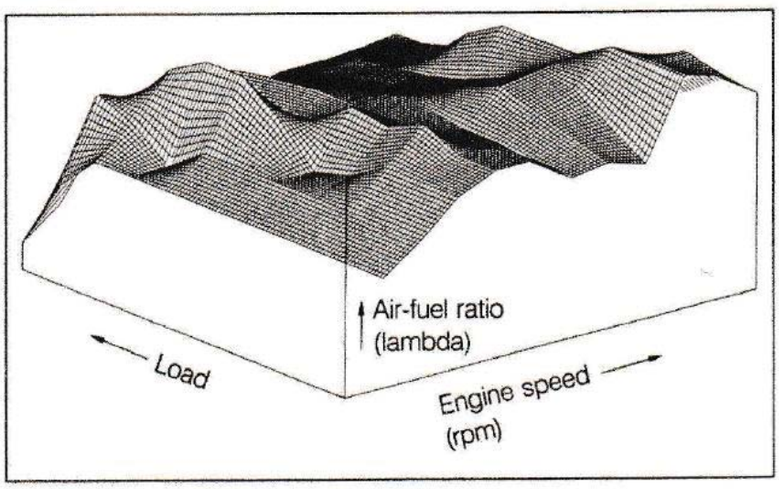


Fig. 4-8. Lambda "map" establishes lambda, or air-fuel ratio for each load/speed point.

(Ex. 1007 p. 57, Probst ch. 3 p. 31)

47. Feedback control has also long been a well-known approach wherein an actual output is compared to a target or goal output, and the difference is used to drive the actual output to match the goal or target output. For example, as of 1997, the McGraw-Hill Electronics Dictionary described a feedback controller as: "A

circuit or element in a closed loop system that controls the motor or other actuator in a closed loop system to correct an error signal."[3] This dictionary also described an error signal as: "A voltage or current proportional to the difference between the desired and actual response in a closed loop system."[4]

VII. SCOPE OF THE PRIOR ART

48. I have been informed by counsel that when determining whether a patent is obvious, the general scope and content of the prior art at the time is relevant. That is, a finding of obviousness is more likely if there is a wide variety of prior art that discloses functionalities and system architectures identical or similar to those of the challenged patent. Conversely, a finding of obviousness is less likely if there is a scarcity of prior art that discloses similar functionalities and architectures.

49. Here, as illustrated below, the body of prior art disclosing the major functionalities and structures of the '540 patent was broad and rich. While I have focused only on a few key prior art references in this declaration, I am confident that numerous other prior art references had also disclosed all of the major functionalities claimed by the '540 patent well before its priority date. While my analysis below is focused on the specific items of prior art discussed in the Petition,

[3]Ex. 1013 at 13, McGraw-Hill Electronics Dictionary, p. 168.

[4]Ex. 1013 at 12, McGraw-Hill Electronics Dictionary, p. 162.

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my knowledge of the broader prior art available to a POSITA as of the priority date of the ‘540 patent informs my judgments concerning obviousness.

VIII. CLAIM CONSTRUCTION

50. It is my understanding that, in an inter-partes review, all claim terms should be given their broadest reasonable interpretation.

51. In the sections below, I set forth my interpretations of those claim terms that I feel require construction beyond the plain and ordinary meaning of the terms as they would be understood by a person of skill in the art under the broadest reasonable interpretation.

IX. SUMMARY OF THE ‘540 PATENT

52. The ‘540 patent is directed toward a “method of calculating a valve timing command for an engine” (‘540 patent at Title). The patent is relatively brief, and provides no detailed information on specific implementations for this method. The control strategy is summarized in Figure 2 of the patent, reproduced below.

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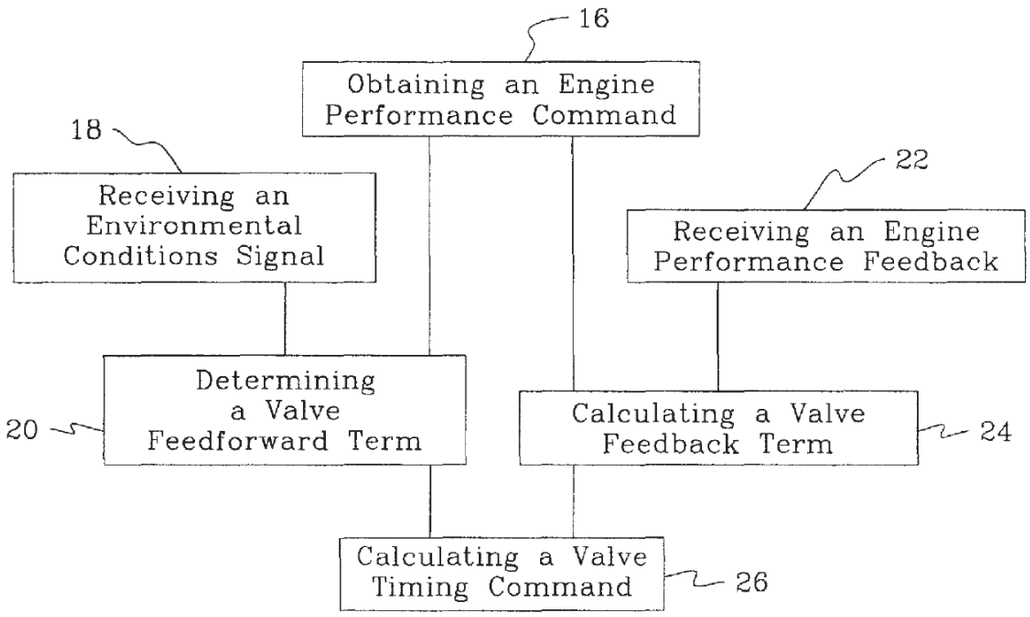


FIGURE 2

(Ex. 1001, '540 patent, Fig. 2)

53. The method begins by obtaining an "engine command". The engine command is described as being derived either from a vehicle command provided by the driver (e.g., pressing on the accelerator pedal), or from other commands generated by vehicle systems such as cruise control or traction control. For example:

> The action of obtaining an engine performance command 16 preferably includes receiving a vehicle performance command from a driver. Preferably, the vehicle performance command is

> received from the foot of a driver with the use of a conventional pedal 28, as shown in FIG. 1.
>
> (Ex. 1001, '540 patent, col. 2, lines 4-8)
>
> The action of obtaining an engine performance command also preferably includes deriving the engine performance command from the vehicle performance command.
>
> (Ex. 1001, '540 patent, col. 2, lines 11-13)
>
> The engine performance command is preferably based on the vehicle performance command, but may alternatively be based on additional suitable factors, such as a traction control signal or a cruise control signal.
>
> (Ex. 1001, '540 patent, col. 2, lines 13-16)
>
> The engine performance command is preferably a desired engine torque and, for this reason, the engine performance command may be thought of as an engine torque command. The engine performance command, however, may alternatively be another suitable variable, such as a desired engine acceleration.
>
> (Ex. 1001, '540 patent, col. 2, lines 16-22)

54. This engine performance command is used with other factors to determine a valve feed-forward term, and a valve feed-back term.

55. I note that, while Figure 2 above does not indicate any engine performance data inputs (i.e. "engine performance feedback") to the valve feed forward term determination process, the patent specification does. For example:

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> The engine sensor 32 preferably senses the engine speed and communicates this data to the control unit 10, which uses the data to determine the valve feedforward term and the valve feedback term.
> (Ex. 1001, '540 patent, col. 2, lines 38-42)

56. The valve feed forward term is also based on the output from an environmental sensor (i.e., receiving and environmental conditions signal (from an environmental sensor). For example:

> The environmental sensor 30 preferably senses the ambient temperature outside the vehicle and communicates this data to the control unit 10, which uses the data to determine the valve feedforward term. Other information, such as the ambient pressure, may be useful in the determination of the valve feedforward term.
> (Ex. 1001, '540 patent, col. 2, lines 26-31)

57. The valve feed-forward term is described as being preferably determined using a look-up table. The patent specification describes that the valve feed-forward term is determined (e.g., from a table) using the engine performance command, the environmental information and engine operating parameters such as engine speed, engine torque (presumably produced torque), air-fuel ratio, or "combustion stability data" (I note, there is no further discussion of how parameters such as "combustion stability" might be measured, for example using knock sensors or misfire sensors).

> The action of determining a valve feedforward term preferably includes determining the valve feedforward term based on the engine torque command, the ambient temperature data, and the engine speed data. The determination, however, may be based on other suitable factors, such as engine torque data, air-fuel ratio data, engine combustion stability data, or ambient pressure data.
>
> (Ex. 1001, '540 patent, col. 2, lines 48-54)

58. The valve feed-back term is described as being determined based on the engine performance command and "engine performance feedback". Engine performance feedback is described as including parameters such as engine speed and/or "other engine measurables" such as engine torque.

> Similarly, the action of receiving an engine performance feedback 22 preferably includes receiving the engine performance feedback from an engine sensor 32 in the vehicle. The engine sensor 32 preferably senses the engine speed and communicates this data to the control unit 10, which uses the data to determine the valve feedforward term and the valve feedback term. Other engine measurables, such as engine torque data, may be useful in the determination of the terms. For this reason, the engine sensor 32 may alternatively sense other suitable information.
>
> (Ex. 1001, '540 patent, col. 2, lines 36-45)

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59. I note that other parameters that a POSITA would consider "engine measurables", such as air-fuel ratio and "combustion stability" are not described as inputs to the valve feedback term, but rather are described as inputs to the valve feedforward term.

60. The actual computation of the valve feedback term is described as a comparison process to determine a difference between the engine performance command and the engine performance feedback data. For example:

> The action of calculating the valve feedback term 24 preferably includes comparing the engine performance command and the engine performance feedback. By the definition of the term, the valve feedback term functions to compare the input with the output and to calculate a correction term based on the difference, if any.
>
> (Ex. 1001,'540 patent, col. 2, line 66 to col. 3, line 4)

61. The patent describes that the valves of the engine may be operated in a sequence illustrated by Figures 3A and 3B, reproduced below.

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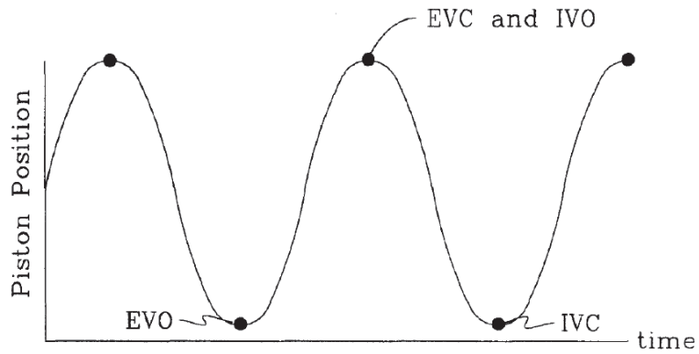


FIGURE 3A

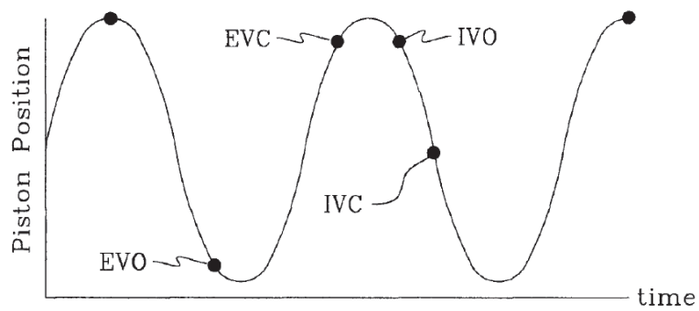


FIGURE 3B

(Ex. 1001, '540 patent, Figs. 3A-3B)

62. Figure 3A shows the valve timing under typical circumstances, while Figure 3B shows the valve commands shifted to different times. For example:

> As shown in FIG. 3A, the position of the piston in the cylinder can be traced as a sinusoidal wave over a time period. The events of the opening of the exhaust valve ("EVO"), the closing of the exhaust valve ("EVC"), the opening of the inlet valve ("IVO"), and the closing of the inlet valve ("IVC") can be placed on this sinusoidal wave. As shown in FIG. 3B, the events of the EVO, the EVC, the IVO, and the IVC may be shifted within the time period (note that the shift in the EVC

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> and the IVO preferably mirror each another, but may alternatively be separately controlled).
> (Ex. 1001, '540 patent, col. 3, lines 8-18)

63. The patent then describes that the valve timing command is calculated based on the valve feed-forward term, and the valve feed-back term. The valve timing command is described as an exhaust valve opening (EVO) time (or time shift), an exhaust valve close (EVC) time (or time shift), an intake valve open (IVO0 time (or time shift), and an intake valve close (IVC) time (or time shift). For example:

> The action of calculating a valve timing command 26 preferably includes calculating an EVO command, an EVC/IVO command, and an IVC command.
> (Ex. 1001, '540 patent, col. 3, lines 21- 24)

64. The patent also admits that other factors may be used to determine valve timing commands. For example:

> The control unit 10, of course, may alternatively include other suitable parameters for the control of the variable timing valves.
> (Ex. 1001, '540 patent, col. 3, lines 24- 26)

65. The patent also describes a second embodiment wherein the valve timing command is further based on fuel conversion data such as data from emissions sensors located in the engine exhaust port. For example:

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> The second preferred method of the invention includes the principle actions of the first preferred method and the additional principle action of receiving fuel conversion data and engine emissions data. These preferably include receiving the fuel conversion data and engine emissions data from suitable emission sensors (not shown) in the cylinder or the exhaust port of the engine 12. The emission sensors preferably sense the amount of NOx in the exhaust and communicates this data to the control unit 10.
>
> (Ex. 1001, '540 patent, col. 3, lines 27- 35)

66. The patent suggests that these additional terms be used to modify the data in the look-up table, but also admits that it could be used in the determination of the valve feedback term. For example:

> The control unit 10 preferably uses this information to modify the output value from the look-up table, but may alternatively use this information to continually adjust the values in the look-up table. The control unit 10 may alternatively use this information as another factor in the determination of the valve feedback term.
>
> (Ex. 1001, '540 patent, col. 3, lines 35-41)

67. I note that the patent offers no description of any algorithms, computational devices or data transformations that might be used to determine the valve feed-forward or valve feed-back terms, nor does it describe how these terms would be used to calculate a valve timing command.

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X. OPINIONS ON CLAIM CONSTRUCTION

A. "engine performance"

68. This term appears in challenged claims 1-2, and 7. The term "engine performance" is used in two contexts in the claims: (1) engine performance command; and (2) engine performance feedback.

69. The '540 patent describes the "engine performance" in the context of the engine performance command as:

> The action of obtaining an engine performance command also preferably includes deriving the engine performance command from the vehicle performance command. The engine performance command is preferably based on the vehicle performance command, but may alternatively be based on additional suitable factors, such as a traction control signal or a cruise control signal. ***The engine performance command is preferably a desired engine torque and, for this reason, the engine performance command may be thought of as an engine torque command. The engine performance command, however, may alternatively be another suitable variable, such as a desired engine acceleration***.
>
> (Ex. 1001,'540 patent, col. 2, lines 10-22, *emphasis added*)

70. Thus the '540 patent provides examples of an engine performance command, i.e., "an engine torque command" or "a desired engine acceleration," and it also

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describes that the engine performance command could be "another suitable variable."

71. The '540 patent also describes that the engine performance command is derived from either a vehicle performance command (i.e., from the driver), or a signal from some other vehicle system such as traction control or cruise control. It is noteworthy that each of these represents an input associated with a request for an engine response, but beyond that, the type of response is not defined explicitly.

72. The '540 patent describes the "engine performance" in the context of the engine performance feedback as:

> Similarly, the action of receiving an engine performance feedback 22 preferably includes receiving the engine performance feedback from an engine sensor 32 in the vehicle. ***Other engine measurables***, such as engine torque data, may be useful in the determination of the terms. For this reason, the engine sensor 32 may alternatively sense ***other suitable information.*** The engine sensor 32 is preferably a conventional engine sensor, but may alternatively ***be any suitable sensor***.
> (Ex. 1001, '540 patent, col. 2, lines 36-47)

73. Thus the '540 patent provides examples of the term engine performance feedback, i.e., "engine torque data," but it also describes that the engine performance feedback could be "other suitable information."

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74. The ‘540 patent also describes that the engine performance feedback is preferably derived from a sensor, and is characterized as an “engine measurable.”

75. Thus, in my opinion, a POSITA would understand the term “engine performance” would encompass engine responses or “measurable”, as the patent describes in the contexts discussed above. Accordingly, in my opinion, the term “engine performance,” under the broadest reasonable interpretation and in the context of the specification and claims of the ‘540 patent, should be construed as “engine measurable or engine response.”

B. “environmental conditions signal”

76. This term appears in challenged claims 1 and 3, The ‘540 patent describes the environmental conditions signal as:

> The action of receiving an environmental conditions signal 18 preferably includes receiving an environmental conditions signal from an environmental sensor 30 in the vehicle. The environmental sensor 30 preferably ***senses the ambient temperature*** outside the vehicle and communicates this data to the control unit 10, which uses the data to determine the valve feedforward term. Other information, such as the ***ambient pressure,*** may be useful in the determination of the valve feedforward term. For this reason, the environmental sensor 30 may alternatively sense ***other suitable information***. The environmental sensor 30 is preferably a conventional

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> environmental sensor, but may alternatively be any suitable device.
>
> (Ex. 1001, '540 patent, col. 2, lines 23-35)

77. Thus the '540 patent provides examples of the term environmental conditions signal, i.e., "ambient temperature or "ambient pressure", but it also describes that the environmental conditions signal could be "other suitable information". The '540 patent does describe that the environmental conditions signal is derived from environmental sensor 30. I note that a POSITA would understand that a sensor is a device for measuring a parameter, and, in the context of electronic engine control, a signal is an electrical current associated with a voltage (i.e. an electric signal as opposed to a sound or visual signal). Thus environmental sensor 30 would output an electrical signal representing the measurement of an environmental parameter. Lastly in my opinion, a POSITA would understand the term "environment" to represent the ambient conditions within which the vehicle/engine must operate, that is conditions that the vehicle does not itself change in any appreciable way.

78. Thus, in my opinion, under the broadest reasonable interpretation and in the context of the specification and claims of the '540 patent, the term "environmental conditions signal" should be construed to mean "signal representing a parameter of the environment."

C. "vehicle performance command"

79. This term appears in challenged claim 2. The '540 patent describes the vehicle performance command as:

> The action of obtaining an engine performance command 16 preferably includes ***receiving a vehicle performance command from a driver.*** Preferably, ***the vehicle performance command is received from the foot of a driver with the use of a conventional pedal*** 28, as shown in FIG. 1. Alternatively, the vehicle performance command could be received from the driver with the use of any suitable device.
> (Ex. 1001, '540 patent, col. 2, lines 4-10)

80. The '540 patent thus makes it clear that the vehicle performance command is an input from the driver, and it is associated with a performance aspect of the vehicle such as accelerating or slowing down. The New Shorter Oxford English Dictionary defines command as a "symbolic expression which defines an operation in a computer; a signal initiating the performance of such an operation." Ex. 1014 at 4, Oxford Dictionary p. 449. Accordingly, a POSITA would understand a command to be an initiation of some action. And it is well-known in vehicle systems that the accelerator pedal may be connected to the engine through mechanical (e.g., a cable or linkage) or electrically (e.g., an electric throttle control), thus the command could take the form of an electrical or mechanical signal.

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81. Thus, in my opinion, under the broadest reasonable interpretation and in the context of the specification and claims of the '540 patent, the term "vehicle performance command" should be construed to mean "signal derived from a driver action to initiate a vehicle performance parameter"

D. "fuel conversion data"

82. This term appears in challenged claim 11. The '540 patent describes fuel conversion data as:

> The second preferred method of the invention includes the principle actions of the first preferred method and the additional principle ***action*** of ***receiving fuel conversion data*** and engine emissions data. ***These preferably include receiving the fuel conversion data and engine emissions data from suitable emission sensors*** (not shown) in the cylinder or the exhaust port of the engine 12.
> (Ex. 1001, '540 patent, col. 3, lines 27-33)

83. The '540 patent does not provide any examples of fuel conversion data or "suitable emissions sensors". A POSITA would understand, for example as described in the background section of this declaration, that "fuel conversion" refers to the conversion of fuel into exhaust gas components and heat, and that a suitable measure of fuel conversion would be a direct or indirect measurement of

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how much of the fuel provided to the engine had been converted or burned in the combustion process.

84. Thus, in my opinion, under the broadest reasonable interpretation and in the context of the specification and claims of the '540 patent, the term "fuel conversion data" should be construed to mean "data representing a direct or indirect measure of the volume of fuel burned in the combustion process".

E. "engine emissions data"

85. This term appears in challenged claim 14. The '540 patent describes engine emissions data as:

> The second preferred method of the invention includes the principle actions of the first preferred method and the additional principle action of receiving fuel conversion data and ***engine emissions data. These preferably include receiving the fuel conversion data and engine emissions data from suitable emission sensors (not shown) in the cylinder or the exhaust port of the engine 12.*** The emission sensors preferably sense the amount of NOx in the exhaust and communicates this data to the control unit 10. …. ***The emission sensors are preferably conventional emission sensors, but may alternatively be any suitable sensor***.
>
> (Ex. 1001'540 patent, col. 3, lines 27-43, *excerpted and emphasis added*)

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86. The ‘540 patent does not provide any examples of “suitable emissions sensors”. Emissions sensors range in complexity from very simple to very sophisticated. In general emissions sensors in a vehicle are as simple as possible. For example, most engine management systems do not include complex and expensive gas analyzers. A POSITA would understand, for example, as described in the background section of this declaration, that emissions sensors may be either direct or indirect, and may rely on the known combustion processes and chemistry to allow an estimate of emissions based on the measurement of other indirect parameters. It is well-known that the primary emissions from the combustion process are oxides of nitrogen (typically designated NOx), carbon monoxide (CO), and unburned hydrocarbons (HC). As can be seen in the figure below, the quantity of these emissions varies as the air fuel ratio varies. Thus, it is possible to estimate the volume or concentration of emissions products by measuring the air fuel ratio or any variable that is associated with the air fuel ratio (e.g. the oxygen in the exhaust).

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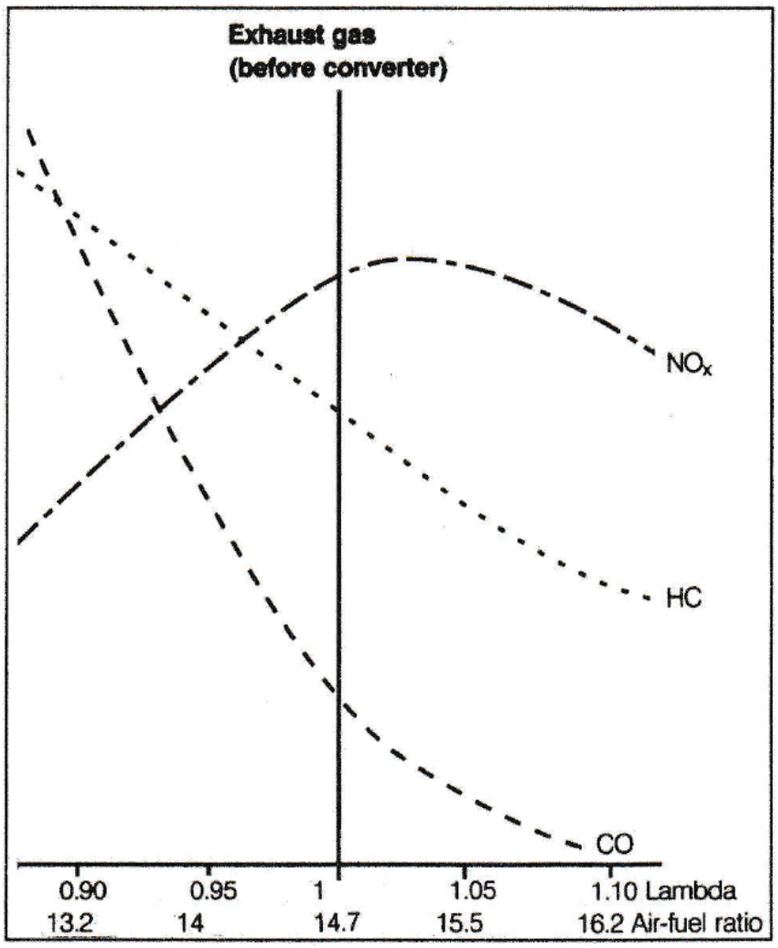


Fig. 4-3. Pollutant levels in engine exhaust change drastically as air-fuel ratio changes. Notice the trade-off between control of HC and CO, and control of NO_x.

(Ex. 1007 p. 23, Probst p. 2:16)

87. Thus, in my opinion, under the broadest reasonable interpretation and in the context of the specification and claims of the '540 patent, the term "engine emissions data" should be construed to mean "data representing a direct or indirect measure of the concentration of emissions gases in the engine exhaust".

XI. OVERVIEW OF THE PRIOR ART

A. U.S. Patent No. 5,713,317 ("Yoshioka")

88. U.S. Patent No. 5,713,317 issued on February 3, 1998 from an application filed on July 15, 1996. The patent also claims priority to Japanese patent application 7-190524, filed July 26, 1995. Yoshioka qualifies as prior art under at least 35 U.S.C. §§ 102(a) and (b).

89. Yoshioka describes a "method and apparatus for continuously and variably controlling valve timing for an internal combustion engine" (Ex. 1004, '317 patent, at Title).

90. Specifically, Yoshioka describes adjusting the valve timing according to the atmospheric pressure to provide improved performance over a wide range of altitudes. For example:

> When driving at high altitudes, an engine receives a smaller quantity of intake air due to the low concentration of air. The first and second aspects of the present invention are capable of optimizing valve timing to maintain the output of the engine at high altitudes.
> (Ex. 1004, '317 patent, col. 2, lines 30-34)

91. To accomplish this, Yoshioka uses a hydraulic actuator that causes the cam shaft drive gear to rotate either forward or backward to control the phase of the camshaft relative to the crankshaft. For example:

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> A continuously variable mechanism 92 having a known structure to determine the open/close timing of the intake valve 24 is arranged between the cam shaft 85 and the timing pulley 89. The mechanism 92 turns the cam shaft 85 and timing pulley 89 relative to each other. More precisely, the mechanism 92 uses the cam shaft 85 and timing pulley 89 as external gears and connects them to each other through an intermediate helical gear. The helical gear is axially moved by hydraulic pressure, to drive the cam shaft 85 and timing pulley 89 relative to each other. The hydraulic pressure is controlled by a control valve 68.
> (Ex. 1004, '317 patent, col. 5, lines 10-20)

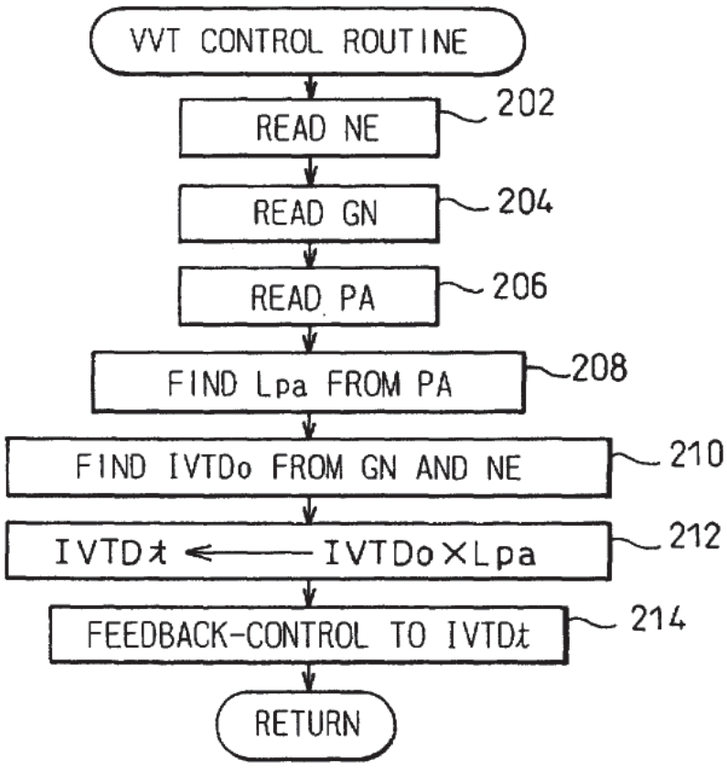
92. Yoshioka describes that the actuator is controlled using an algorithm that determines the valve displacement according to a map or table, and then adjusts the target valve displacement according to the atmospheric pressure, as described below in connection with Figure 9, reproduced below.

> The second embodiment ***sets a target displacement to be imposed on the open/close timing of the intake valve 24 according to a detected engine load and decreases the target displacement as an atmospheric pressure becomes lower***, to maintain the output of the engine at high altitudes under high load, similar to the first embodiment. FIG. 9 is a flowchart showing a variable valve timing (WT) control routine according to the second embodiment.
> (Ex. 1004, '317 patent, col. 7, lines 47-55, *emphasis added*)

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Fig. 9



(Ex. 1004, '317 patent, Fig. 9)

93. Yoshioka also describes that the engine load is determined by measuring the mass air flow and the engine speed. For example:

> Step 104 reads an engine load (the mass of intake air per engine revolution) calculated according to the mass flow rate of intake air detected by the airflow meter 40 and the engine revolution speed provided by the crank angle sensor 51.
> (Ex. 1004, '317 patent, col. 7, lines 20-24)

94. I note that Yoshioka also describes steps 202 through 206 of Figure 9 as being the same as steps 10

> Steps 202 to 206 are the same as steps 102 to 106 of the first embodiment of FIG. 7.
> (Ex. 1004, '317 patent col. 7, lines 55-56)

95. Yoshioka also describes that the mass air flow is related to the throttle opening. For example:

> A throttle valve 5 arranged in the throttle body 4 adjusts the quantity of intake air. An airflow meter 40 measures the mass flow rate of intake air.
> (Ex. 1004, '317 patent, col. 4, lines 13-15)

96. Thus, measuring the engine load includes measuring the torque demand as represented by the throttle opening.

97. Yoshioka describes that the initial valve offset IVTD0 is read from a map (i.e. a table), and that this value is subsequently corrected using the atmospheric pressure measurement, to arrive at a target valve offset. For example:

> Step 210 refers to the map of FIG. 4 according to the engine load GN and engine revolution speed NE and finds a displacement IVTD0 to be imposed on the open/close timing of the intake valve 24.
> Step 212 corrects the displacement IVTD0 and provides a target displacement IVTDt as follows:

IVTDt ←IVTD0×Lpa

(Ex. 1004, '317 patent, col. 7, line 64 to col. 8, line 4)

98. Yoshioka then describes that the actual valve timing is adjusted to achieve this offset using a feedback scheme. For example:

> To bring the actual displacement of the intake valve 24 to the target displacement IVTDt, the hydraulic control valve 68 is feedback-controlled.
> (Ex. 1004, '317 patent, col. 8, lines 5 -7)

B. Torque Management of Engines with Variable Valve Timing, By Jankovic, Stefanopoulou, and Cook

99. Torque Management of Engines with Variable Valve Timing, By Jankovic, Firschmuth, Stefanopoulou, and Cook ("Jankovic") was published in IEEE Control Systems in October, 1998. Jankovic qualifies as prior art under at least 35 U.S.C. §§ 102(a) and (b).

100. Jankovic describes an engine model and control system for a variable valve timing engine aimed at reducing emissions and improving drivability (i.e., performance, fuel economy, etc.).

For example;

> In addition to the reduction of NOx and HC emissions, variable cam timing permits the engine designer to optimize cam timing over a wide range of engine operating conditions, providing

> both good idle quality (minimal overlap between the intake and exhaust events) and improved wide-open throttle performance (maximum inducted charge). In this article, we will assume that the camshaft position is continuously variable to achieve the full benefits in emissions and torque.
> (Ex. 1005 pp. 1-2, Jankovic pp. 34-35)

101. Jankovic describes varying both the intake and exhaust valve timing as part of the overall engine management scheme. For example, as illustrated in Figure 1, reproduced below. For example:

> Four versions of VCT are available for double overhead camshaft (DOHC) engines: phasing only the intake cam (intake only), phasing only the exhaust cam (exhaust only), phasing the intake and exhaust cams equally (dual equal), and phasing the two camshafts independently (dual independent). The dual independent VCT provides the best performance, but it is the most complex and expensive to implement.
> (Ex. 1005 p. 2, Jankovic p. 35)

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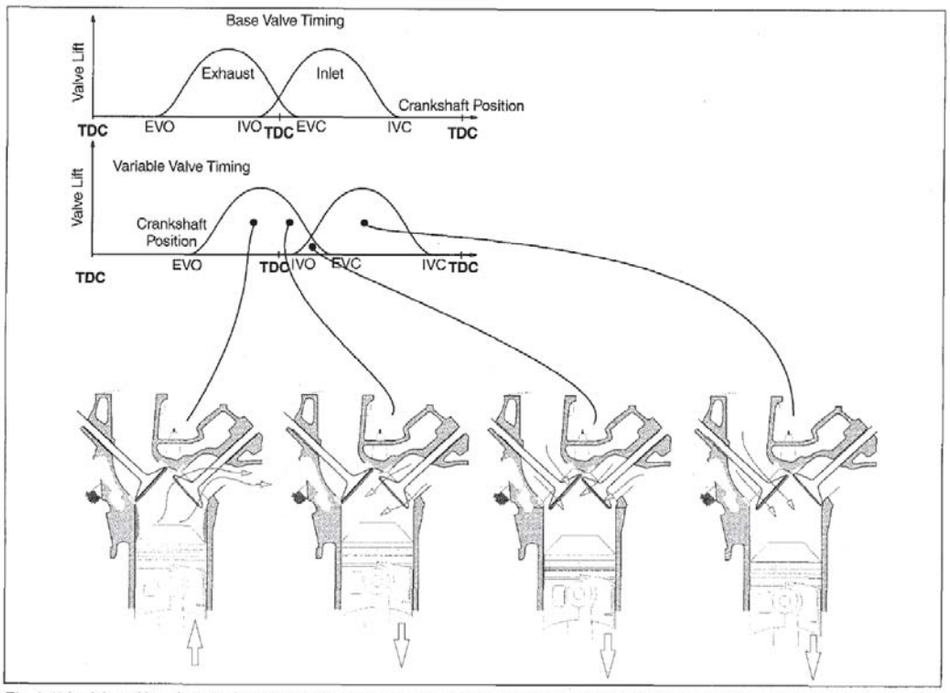


Fig. 1. Valve lift profiles of conventional and VCT engines. By retarding the cam phasing, the exhaust valve stays open during the intake event for a longer time period, retaining otherwise unburned HC and reducing the combustion temperature due to the dilution of the inert gas.

(Ex. 1005 p. 2, Jankovic p. 35)

102. Jankovic presents an overall model of the engine management system as shown in Figure 2, reproduced below.

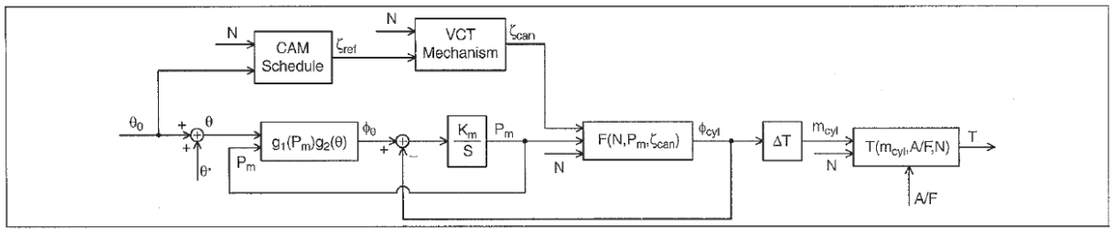


Fig. 2. Engine model with VCT and electronic throttle.

(Ex. 1005 p. 3, Jankovic p. 36)

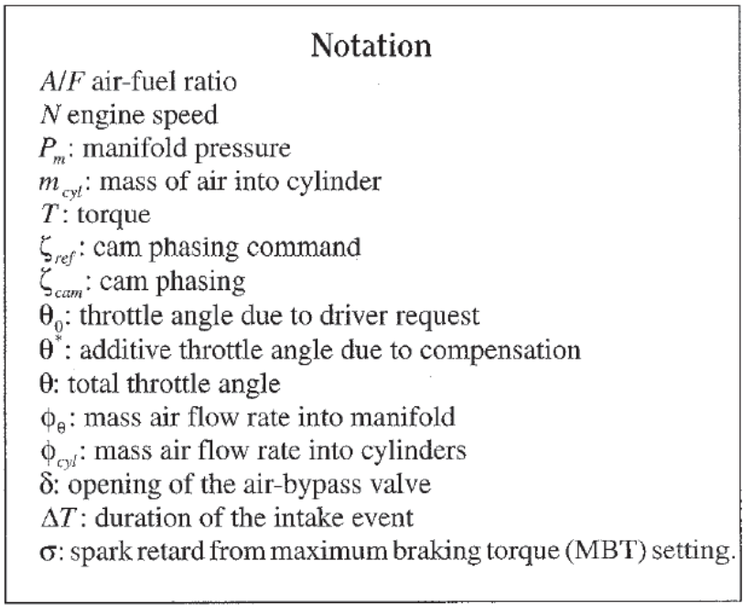
103. Jankovic describes this model as follows:

> From the controller design point of view, several prominent characteristics of this problem will dictate our approach:
>
> - The model of the plant is low order, nonlinear, with known nonlinearities available from the dynamometer mapping data.
> - The disturbance (cam phasing) is measured. The output (cylinder mass air flow, or cylinder air charge, or torque) is not measured.
> - Transient response is much more important than steady state accuracy.
>
> The first three items above suggest that a feedforward compensation may be the most appropriate, so this is the approach we adopt. Our compensator design is based on a low order nonlinear model of a VCT engine derived in [12] Starting from the nonlinear model we develop a nonlinear control algorithm that rejects the air-charge (torque) disturbance and recovers the drivability of the conventional engine.
>
> (Ex. 1005 pp. 2-3, Jankovic, pp. 35-36)

104. To support their mathematical analysis Jankovic provides a summary of the variables and symbols as provided below.

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Notation

A/F air-fuel ratio
N engine speed
P_m: manifold pressure
m_{cyl}: mass of air into cylinder
T: torque
ζ_{ref}: cam phasing command
ζ_{cam}: cam phasing
θ_0: throttle angle due to driver request
θ^*: additive throttle angle due to compensation
θ: total throttle angle
ϕ_θ: mass air flow rate into manifold
ϕ_{cyl}: mass air flow rate into cylinders
δ: opening of the air-bypass valve
ΔT: duration of the intake event
σ: spark retard from maximum braking torque (MBT) setting.

(Ex. 1005 p. 3, Jankovic p. 36)

105. As can be appreciated, from Figure 2 above, the driver throttle input Θ_0 is supplemented by a feedback loop that corrects the driver's throttle input in order to assure conformance to the control algorithm.

106. Jankovic describes that, based on the driver's throttle input Θ_0, and the engine speed N, the system selects a reference camshaft offset ζREF using a cam schedule, that is a table or engine map relating the cam offset to engine speed and throttle angle. For example:

> A block diagram in Fig. 2 shows the cam timing reference ζ_{REF}, scheduled on engine speed and driver demanded throttle Θ_0
> (Ex. 1005 p. 3, Jankovic p. 36)

107. Jankovic also describes that once the target camshaft offset ζ_{REF} is selected, the system uses a VCT (Variable Cam Timing) feedback control system to assure that the actual cam offset ζ_{CAM} matches the target ζ_{REF}. For example:

> The VCT actuator system consists of a control valve and the actuator itself. This control oriented model captures the dominant behavior of the VCT actuator system. These dominant dynamics can be reduced to a single integrator. Adding higher frequency components does not add much to the accuracy of this model. The static control valve behavior is captured in the function F(·). It is purely a function of the control input. The gain of the VCT actuator depends heavily on the engine speed N and is described by the static function K(N). A block diagram of the VCT mechanism model is shown in Fig. 8.
>
> (Ex. 1005 p. 7, Jankovic p. 40)

108. This feedback system is illustrated in Figure 8, reproduced below, wherein the actual measured camshaft offset $\zeta_{CAM,}$ is processed through a proportional-integral-derivative (PID) control computation, and this is then compared to the target camshaft offset ζ_{REF}. The difference is then used as a supplemental or corrective input to the VCT actuator.

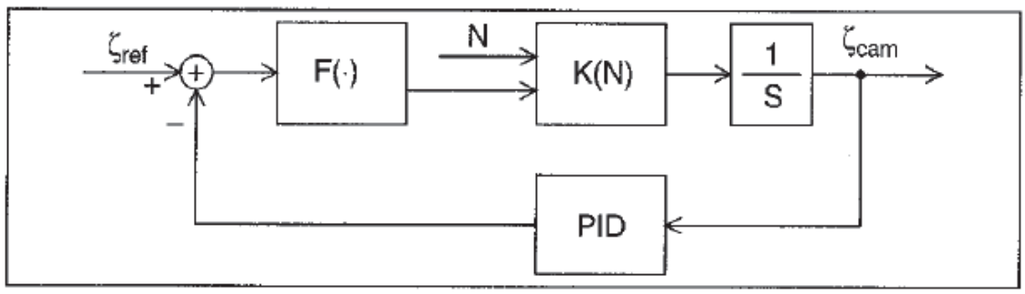


Fig. 8. Simplified controls-oriented model of the VCT mechanism.

(Ex. 1005 p. 8, Jankovic p. 41)

XII. CLAIMS 1-3, 7, 10-11, AND 14 OF THE '540 PATENT ARE INVALID AS OBVIOUS

109. It is my opinion that claims 1-3, 7, 10-11, and 14 of the '540 Patent are invalid because they would have been obvious to a skilled artisan at the time the application that became the '540 Patent was filed. The Petition sets forth the arguments for invalidity based on the prior art. Below I elaborate on certain points raised in the discussion of the Petition from the perspective of a skilled artisan at the time the '540 Patent was filed.

A. Ground 1: Claims 1-3, 7, 10-11, and 14 are Rendered Obvious Under the Combination of Yoshioka and Jankovic

i. Summary

110. In my opinion, claims 1-3, 7, 10-11, and 14 of the '540 patent are rendered obvious by U.S. Patent No. 5,713,317 ("Yoshioka") in combination with the paper titled "Torque Management of Engines with Variable Valve Timing" ("Jankovic").

111. I set forth a detailed analysis of these references relative to the claim elements below.

ii. Claim Element Analysis

a. Claim 1

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

112. Yoshioka describes "a method of, and apparatus for continuously and variably controlling valve timing of (an) internal combustion engine". (Ex. 1004, '317 patent, at Title). Specifically, Yoshioka describes a method for adjusting the timing of valves based on the atmospheric pressure so that the overall performance of the engine is improved over a wide range of operating conditions.

For example:

> …valve timing mechanism of an internal combustion engine to continuously and variably control the timing of an intake valve according to atmospheric pressure.
> (Ex. 1004, '317 patent at Abstract)

> An object of the present invention is to provide a method of and an apparatus for optimizing valve timing according to atmospheric pressure for a continuously variable valve timing mechanism of an internal combustion engine.
> (Ex. 1004, '317 patent, col. 1 lines 39-43)

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113. Yoshioka further indicates that the subject engine is an engine in a vehicle. For example, Figure 1, reproduced below, identifies a "vehicle speed sensor" input, and Yoshioka also refers to automobiles and driving in numerous places in the patent. For example:

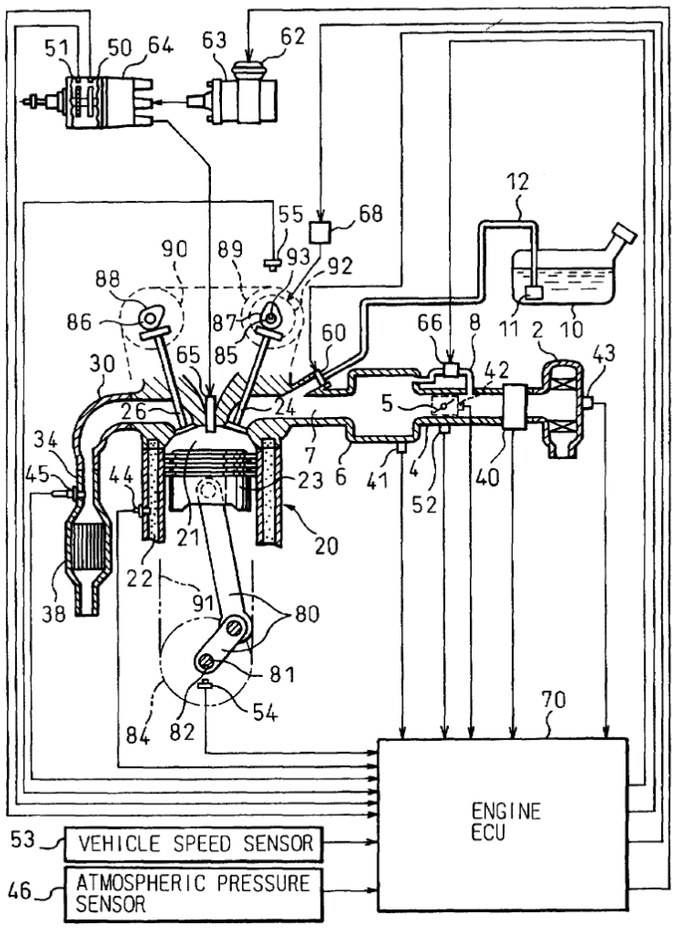
> There are many variable mechanisms that optimize the reduced open/close timing of a valve of an automobile engine according to driving conditions.
> (Ex. 1004, '317 patent, col. 1, lines 15-17)

> When driving at high altitudes, an engine receives a smaller quantity of intake air due to the low concentration of air. The first and second aspects of the present invention are capable of optimizing valve timing to maintain the output of the engine at high altitudes.
> (Ex. 1004, '317 patent, col. 2, lines 30-34)

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Fig. 1



(Ex. 1004, '317 patent, Fig. 1)

114. Jankovic describes a model and algorithm for the management of torque in variable cam timing (i.e., variable valve timing) engines (Jankovic, at title).

115. Jankovic describes varying both the intake and exhaust valve timing as part of the overall engine management scheme. For example, as illustrated in Figure 1, reproduced below. For example:

> Four versions of VCT are available for double overhead camshaft (DOHC) engines: phasing only the intake cam (intake only), phasing only the exhaust cam (exhaust only), phasing the intake and exhaust cams equally (dual equal), and phasing the two camshafts independently (dual independent). The dual independent VCT provides the best performance, but it is the most complex and expensive to implement.
>
> (Ex. 1005 p. 2, Jankovic p. 35)

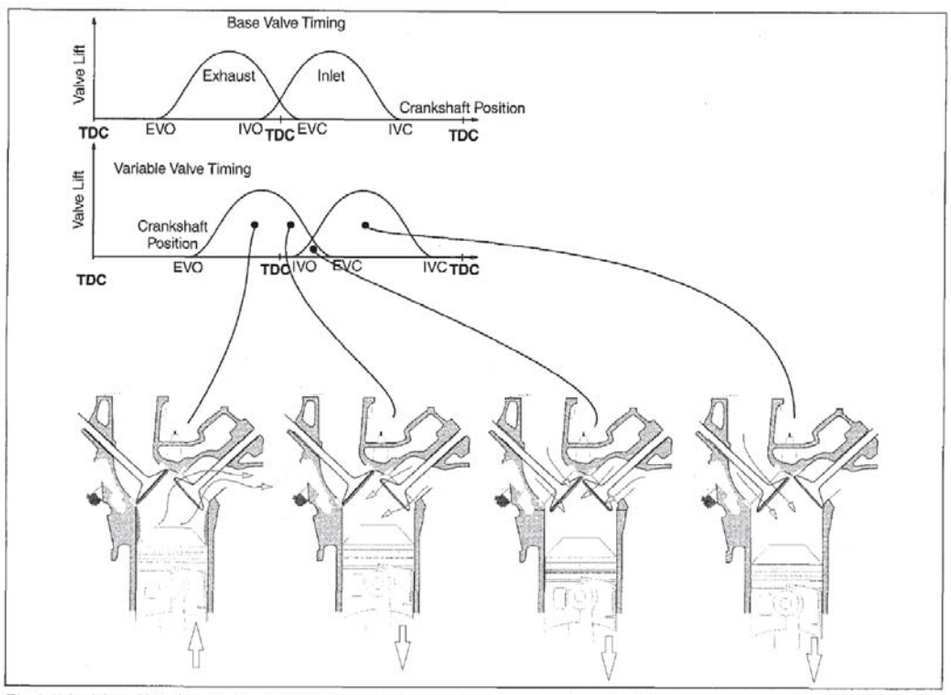
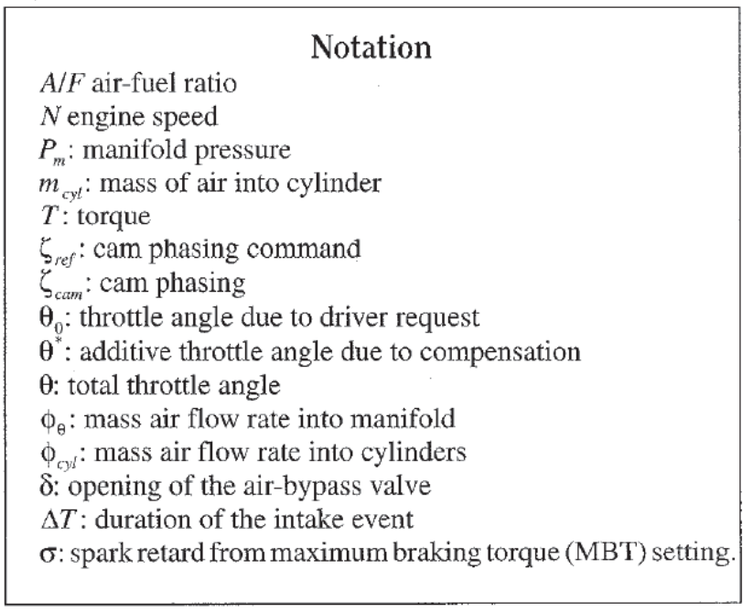


Fig. 1. Valve lift profiles of conventional and VCT engines. By retarding the cam phasing, the exhaust valve stays open during the intake event for a longer time period, retaining otherwise unburned HC and reducing the combustion temperature due to the dilution of the inert gas.

(Ex. 1005 p. 2, Jankovic p. 35)

116. Jankovic provides listing of variables referenced in the paper, these are reproduced in the figure below. Included in this list are the cam phasing command,

the cam phase (i.e. the actual phase of the camshaft), the throttle angle due to the driver request, the total throttle angle and numerous other parameters.



Notation

A/F air-fuel ratio
N engine speed
P_m: manifold pressure
m_{cyl}: mass of air into cylinder
T: torque
ζ_{ref}: cam phasing command
ζ_{cam}: cam phasing
θ_0: throttle angle due to driver request
θ^*: additive throttle angle due to compensation
θ: total throttle angle
ϕ_θ: mass air flow rate into manifold
ϕ_{cyl}: mass air flow rate into cylinders
δ: opening of the air-bypass valve
ΔT: duration of the intake event
σ: spark retard from maximum braking torque (MBT) setting.

(Ex. 1005 p. 3, Jankovic p. 36)

obtaining an engine performance command;

117. Yoshioka describes that the engine is equipped with a throttle and a throttle opening sensor. For example:

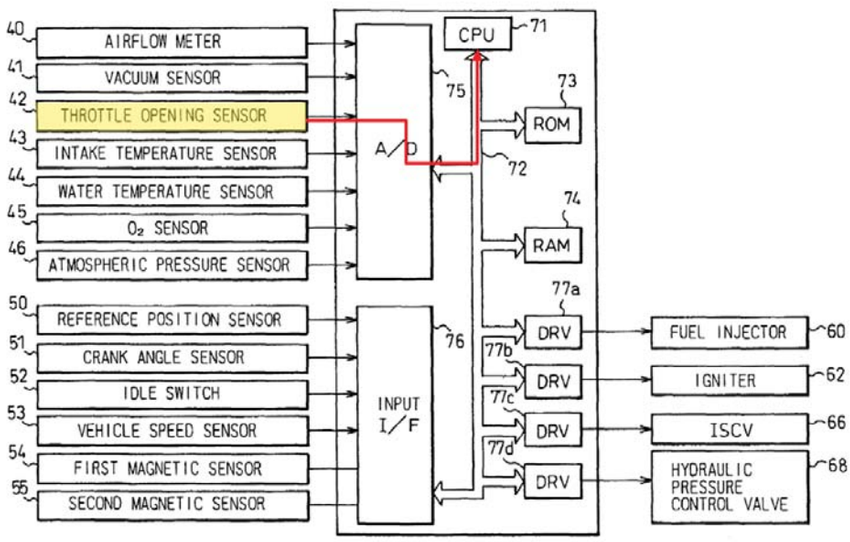
> A throttle valve 5 arranged in the throttle body 4 adjusts the quantity of intake air. An airflow meter 40 measures the mass flow rate of intake air…. A ***throttle sensor 42 detects the opening of the throttle valve*** 5.
>
> (Ex. 1004, '317 patent, col. 4, lines 13-15, 20-21 *emphasis added*)

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118. Yoshioka describes that the CPU 71 receives throttle opening information from the throttle opening sensor. For example, as illustrated in Figure 2, reproduced below with annotation.

Fig.2



(Ex. 1004, '317 patent, Fig. 2)

119. The throttle opening sensor measures the opening of the throttle, and, as mentioned in the background section of this declaration, a POSITA would understand that the throttle is controlled, at least in part, by the driver through the position of the accelerator pedal. Opening the throttle allows an increase in the volume of air-fuel mixture reaching the engine, thereby allowing it to generate more power. Thus, the throttle opening represents an engine performance command.

120. Yoshioka also describes that the engine load (actually engine load demand) is determined by measuring the mass air flow and the engine speed. For example:

> Step 104 reads an engine load (the mass of intake air per engine revolution) calculated according to the mass flow rate of intake air detected by the airflow meter 40 and the engine revolution speed provided by the crank angle sensor 51.
> (Ex. 1004, '317 patent, col. 7, lines 20-24)

121. I note that Yoshioka also describes steps 202 through 206 of Figure 9 as being the same as steps 10

> Steps 202 to 206 are the same as steps 102 to 106 of the first embodiment of FIG. 7.
> (Ex. 1004, '317 patent, col. 7, lines 55-56)

122. Yoshioka also describes that the mass air flow is related to the throttle opening. For example:

> A throttle valve 5 arranged in the throttle body 4 adjusts the quantity of intake air. An airflow meter 40 measures the mass flow rate of intake air.
> (Ex. 1004, '317 patent, col. 4, lines 13-15)

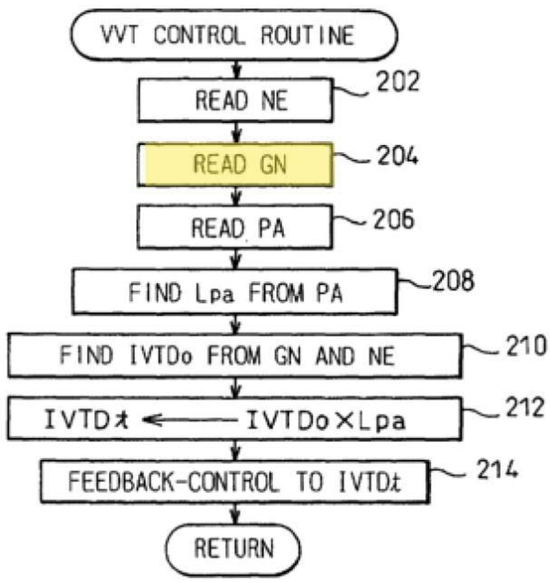
123. As described by Yoshioka, measuring the engine load includes measuring the mass air flow, which is controlled by the throttle valve opening (and the current road load on the engine), and thus the engine load GN described by Yoshioka represents an engine performance command.

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124. The reading (and thus receiving) of the engine load (and thus the engine performance command) is illustrated in Figure 9, reproduced below with annotation.

Fig. 9



(Ex. 1004, '317 patent, Fig. 9)

125. Jankovic describes measuring the throttle angle Θ. For example:

> In this application, the throttle angle is comprised of the throttle position due to the driver's request (Θ_O) and an additive term due to the compensation (Θ^*)
>
> $$\Theta = \Theta_O + \Theta^*.$$
>
> (Ex. 1005 p. 3, Jankovic p. 36)

126. Jankovic further describes that the throttle opening Θ_O is based on the position of the accelerator pedal. For example:

> Electronic control of the throttle provides an additional degree of control capability to affect emissions and fuel economy while providing the ***performance desired by the driver as interpreted from the accelerator pedal position***.
> (Ex. 1005 p. 2, Jankovic p. 35, *emphasis added*)

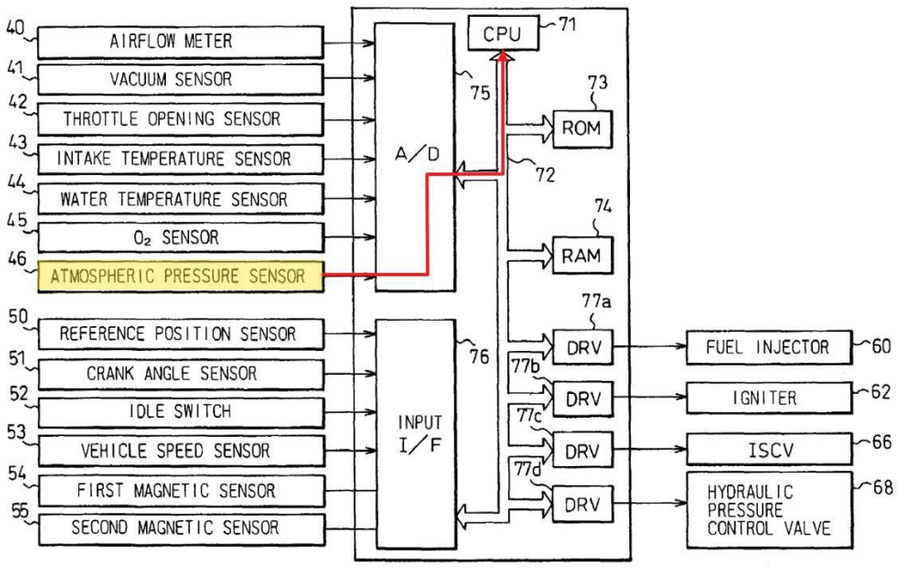
receiving an environmental conditions signal;

127. Yoshioka describes that the engine is equipped with an atmospheric pressure sensor. For example:

> Step 106 ***reads an atmospheric pressure PA*** detected by the atmospheric pressure sensor 46.
> (Ex. 1004, '317 patent, col. 7, lines 24-25, *emphasis added*)

128. Yoshioka describes that the CPU 71 receives atmospheric pressure information from the atmospheric pressure sensor. For example, as illustrated in Figure 2, reproduced below with annotation.

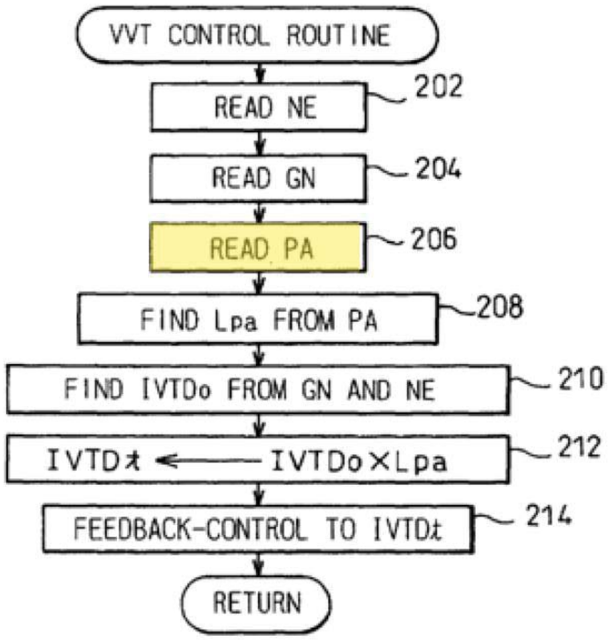
Fig. 2



(Ex. 1004, '317 patent, Fig. 2)

129. The reading (and thus receiving) of the atmospheric pressure signal; is illustrated in Figure 9, reproduced below with annotation.

Fig. 9



(Ex. 1004, '317 patent, Fig. 9 (annotated).)

130. As described in the background section of this declaration, a POSITA would understand that an atmospheric pressure sensor generates a signal indicative of the atmospheric pressure of the environment, and thus the output of the atmospheric pressure sensor is an environmental conditions signal.

131. While Jankovic does not describe measuring an environmental parameter directly, the paper does describe that measured operating parameters depend on environmental parameters. For example, Jankovic describes that mass air flow is dependent on the atmospheric pressure:

> The ***mass air flow through the throttle body into the manifold is a function of the upstream atmospheric pressure Pa, the manifold pressure, and the throttle angle***
> (Ex. 1005 p. 3, Jankovic p. 36, *emphasis added*)

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

132. Yoshioka describes determining a valve offset, $IVTD_t$, based on the detected engine load (engine performance command) and atmospheric pressure (environmental conditions signal). For example:

> The second embodiment ***sets a target displacement to be imposed on the open/close timing of the intake valve 24 according to a detected engine load and decreases the target displacement as an atmospheric pressure becomes lower***, to maintain the output of the engine at high altitudes under high load, similar to the first embodiment. FIG. 9 is a flowchart showing a variable valve timing (WT) control routine according to the second embodiment.
> (Ex. 1004, '317 patent, col. 7, lines 46-55, *emphasis added*)

133. Yoshioka describes that the initial valve offset $IVTD_0$ is read from a map (i.e. a table), and that this value is subsequently corrected using the atmospheric pressure measurement, to arrive at a target valve offset $IVTD_t$. For example:

> Step 208 refers to a map of FIG. 10 according to the atmospheric pressure PA and finds ***a correction coefficient L_{pa}***

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for correcting a displacement to be imposed on the open/close timing of the intake valve 24. The coefficient L_{pa} is 1.0 at low altitudes with PA=760 mmHg and decreases as the altitude increases, i.e., as the atmospheric pressure PA decreases. ***The map of FIG. 10 is stored in the ROM 73 in advance.***

(Ex. 1004, '317 patent, col. 7, lines 57-63, *emphasis added*)

Step 210 refers to the map of FIG. 4 according to the engine load GN and engine revolution speed NE and ***finds a displacement $IVTD_0$*** to be imposed on the open/close timing of the intake valve 24.

(Ex. 1004, '317 patent, col. 7, lines 63-67, *emphasis added*)

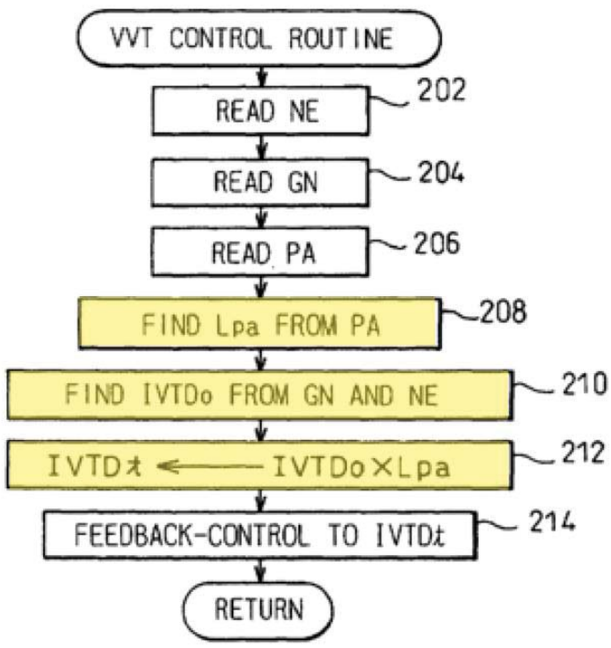
Step 212 ***corrects the displacement $IVTD_0$ and provides a target displacement $IVTD_t$ as follows:***

$$IVTD_t \leftarrow IVTD_0 \times L_{pa}$$

(Ex. 1004, '317 patent, col. 8, lines 1-4)

134. Yoshioka illustrates this process in Figure 9, reproduced below with annotation.

Fig. 9



(Ex. 1004, '317 patent, Fig. 9 (annotated).)

135. Jankovic describes that, based on the driver's throttle input Θ_0, and the engine speed N, the system selects a reference camshaft offset ζ_{REF} using a "cam schedule". For example:

> A block diagram in Fig. 2 shows the cam timing reference ζ_{REF}, scheduled on engine speed and driver demanded throttle Θ_0.
>
> (Ex. 1005 p. 3, Jankovic p. 36)

136. As described in the background section of this declaration, a POSITA would understand a "cam schedule" to be a table or map, typically stored in read only

memory (ROM) that relates combinations of throttle opening and engine speed to particular cam shaft offsets.

137. Jankovic also illustrates the determination of the cam phasing command $\square_{REF}$ using the cam schedule in Figure 2, reproduced below, with annotation. For example:

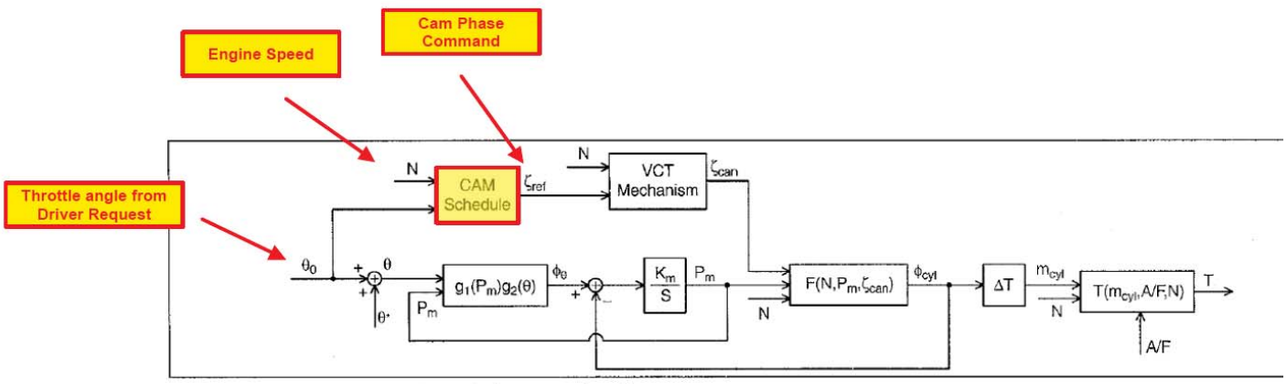


Fig. 2. Engine model with VCT and electronic throttle.

(Ex. 1005 p. 3, Jankovic p. 36 (annotated).)

receiving an engine performance feedback;

138. Yoshioka describes measuring the rotational position of the crankshaft and the cam shaft to determine the valve offset. For example:

> The crank shaft 81 has a buried magnet 82, so that a first magnetic sensor 54 arranged close to the crankshaft 81 may generate a reference pulse. The cam shaft 85 of the intake valve 24 has a buried magnet 93, so that a second magnetic sensor 55 arranged close to the cam shaft 85 generate a reference pulse.

(Ex. 1004, '317 patent, col. 5, lines 4-9)

139. Thus, the position of the camshaft as measured by magnetic sensor 55, relative to the crank shaft is, and the engine speed, as measured by the crankshaft sensor 54 represent engine performance feedback quantities as required by the claim.

140. Jankovic describes measuring multiple engine parameters, all of which meet the construction of "engine feedback". Specifically, Jankovic describes measuring the engine speed (which is specifically identified as "engine feedback" in the '540 patent), and actual camshaft offset ζ_{CAM} (which, in my opinion falls under the "other engine measurables", and "other suitable information" definitions provided by the '540 patent[5]). For example:

> From the controller design point of view, several prominent characteristics of this problem will dictate our approach:
>
> - The model of the plant is low order, nonlinear, with known nonlinearities available from the dynamometer mapping data.
> - ***The disturbance (cam phasing) is measured.***
> - The output (cylinder mass air flow, or cylinder air charge, or torque) is not measured.

[5] See, Ex. 1001, '540 patent, col 2, lines 36-47

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- Transient response is much more important than steady state accuracy

(Ex. 1005 p. 2, Jankovic p. 35, *emphasis added*)

141. Both the engine speed feedback and the camshaft phase feedback are also illustrated in Figure 8, reproduced with annotation below.

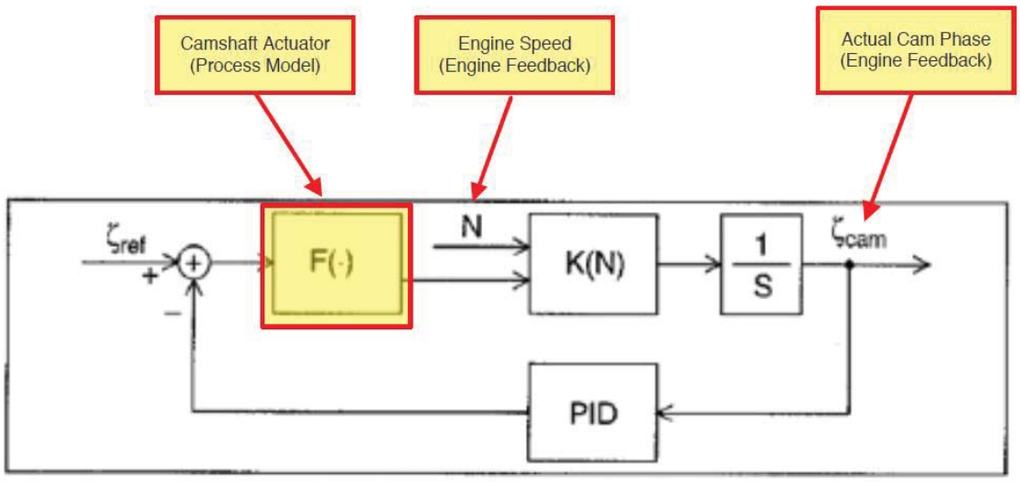


Fig. 8. Simplified controls-oriented model of the VCT mechanism.

(Ex. 1005 p. 8, Jankovic p. 41 (annotated).)

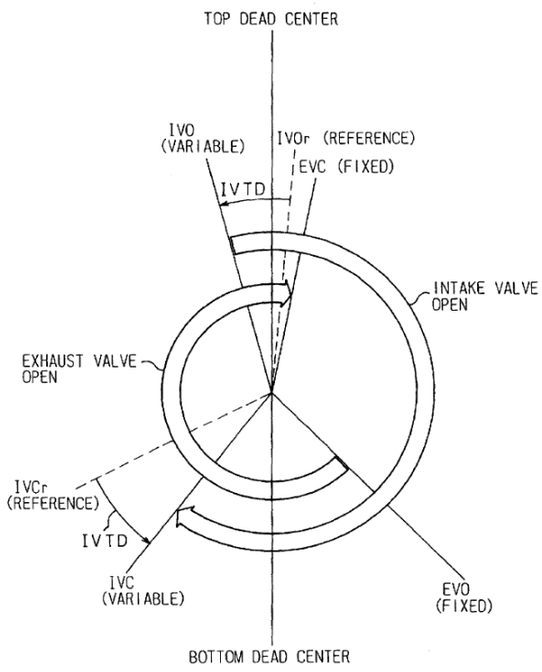
calculating a valve feedback term based on the engine performance command and the engine performance feedback;

142. Yoshioka also describes that the relative phase or timing of the crankshaft and cam shaft positions determines the valve offset. For example, in reference to Figure 3, reproduced below.

FIG. 3 is a timing chart showing crank angles corresponding to the open/close timing of the intake and exhaust valves 24 and 26.

(Ex. 1004, '317 patent, col. 6, lines 16-18)

Fig. 3



(Ex. 1004, '317 patent, Fig. 3)

143. Yoshioka describes measuring the relative phase of the crankshaft and the cam shaft to determine the valve offset. For example:

> The crank shaft 81 has a buried magnet 82, so that a first magnetic sensor 54 arranged close to the crankshaft 81 may generate a reference pulse. The cam shaft 85 of the intake valve 24 has a buried magnet 93, so that a second magnetic sensor 55 arranged close to the cam shaft 85 generate a reference pulse.

(Ex. 1004, '317 patent, col. 5, lines 4-9)

144. Thus, the relative position of the camshaft as measured by magnetic sensor 55, relative to the crank shaft as measured by sensor 54 represents the actual valve offset, and this is a calculated measure of the actual engine performance.

145. Yoshioka further teaches that this information is utilized "so that the cam shaft 85 of the intake valve 24 maintains a required rotational phase with respect to the crankshaft 81." Yoshioka, Ex. 1004 at col. 6 lines 8-13 (describing feedback control). To do so, Yoshioka further discloses that the hydraulic control valve 68 is feedback-controlled to bring the actual displacement of the intake valve, (as measured by magnetic sensors 84, 85) to be adjusted to the target displacement $IVTD_t$ (i.e., the "feedforward term"). A person of ordinary skill in the art would appreciate that this is done by comparing the target displacement $IVTD_t$ (i.e., the feedforward term, which is based, in part, on the engine performance command, as discussed above in ¶¶ 132-137) with the actual displacement of the intake valve (i.e., based on the engine performance feedback from the magnetic sensors 54, 55).

146. As mentioned above, in ¶ 47, a POSITA would well understand that when Yoshioka discloses "feedback-controll[ing]" the hydraulic pressure control valve 68 according to the signals from the magnetic sensors, what is meant by "feedback control" is to compare the actual displacement and the target displacement to

identify any error and adjust as needed. See above ¶ 47. A POSITA would understand that, in order to feedback control the hydraulic control valve in order to bring the actual displacement of the intake valve to the target displacement $IVTD_t$, such a comparison between the actual displacement and the target displacement is being made. Ex. 1013 pp. 12-13, McGraw-Hill Electronics Dictionary pp. 162, 168 (defining feedback controller as "A circuit or element in a closed loop system that controls the motor or other actuator in a closed loop system to correct an error signal" and defining error signal as "A voltage or current proportional to the difference between the desired and actual response in a closed loop system").

147. As a result, the actual valve offset comparison with the target displacement meets the limitation of an "valve feedback term" as required by the claim, because it is a calculated measure of the actual engine performance relative to a desired value of that performance, and is based on the "engine performance command" ($IVTD_t$—i.e., the feedforward term, which is based, in part, on the engine performance command, as discussed above in ¶¶ 132-137) and the "engine performance feedback" (position of the camshaft as measured by magnetic sensor 54, relative to the crank shaft as measured by magnetic sensor 55).

148. Alternatively, and additionally, Yoshioka explicitly describes that the valves are controlled using a feedback control. Yoshioka, Ex. 1004 at col. 6 lines 6-15. Meanwhile, Jankovic elaborates regarding calculating a valve feedback term based

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on the engine performance command and the engine feedback. And a POSITA would be motivated to combine the teachings of Jankovic, elaborating on calculating a valve feedback term, with the teachings of Yoshioka regarding feedback control of valve timing.

149. For example, Jankovic Figure 8, reproduced below with annotation, illustrates the valve control process, which includes the target camshaft phasing ζ_{REF}, which Jankovic earlier described as "scheduled on engine speed and driver demanded throttle Θ_0", and two variables of engine performance feedback: engine speed N and the actual camshaft phase ζ_{CAM}. These inputs are then processed in the PID (proportional, integral, derivative) calculation box shown in Figure 8 to arrive at a feedback term that is subsequently compared to the camshaft phase command. As is shown in annotated Figure 8, below, the valve feedback term is based on engine performance feedback (cam phase and/or engine speed) and an engine performance command (ζ_{REF}, which is based on driver demanded throttle Θ_0).

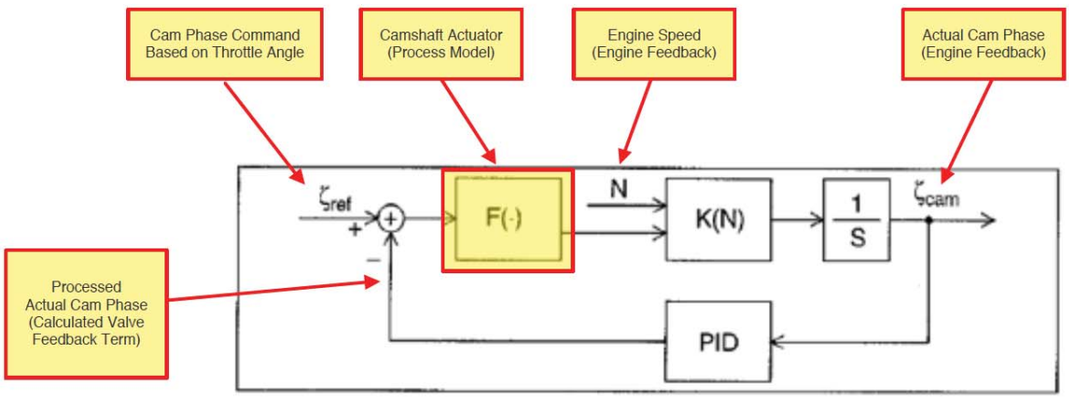


Fig. 8. Simplified controls-oriented model of the VCT mechanism.

(Ex. 1005 p. 8, Jankovic p. 41 (annotated).)

150. As described at the end of this section, a POSITA would be motivated to combine the Yoshioka and Jankovic references. Specifically, Yoshioka describes using feedback to control the valve timing to the commanded value. As a result, a POSITA reading the teachings of Yoshioka would be motivated to combine the valve control feedback system described in detail by Jankovic with Yoshioka, so as to implement Yoshioka's suggested system. In this combination the valve control feedback system of Jankovic would be serving the same function it served in the system described by Jankovic (assuring that the actual camshaft phase, and thus the actual valve offset, matched the commanded value), and the system of Yoshioka would be performing its original function (determining the valve offset (i.e., cam shaft phase)) to achieve a predictable result (assuring optimal engine performance at a variety of altitudes).

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

151. Yoshioka describes that the valve offset is achieved by determining a target valve offset, and using this to control the valve offset actuator (the feedforward term, $IVTD_t$). The actual valve offset (the engine performance feedback) is then determined from the magnetic sensors on the camshaft and crankshaft. This error term (the valve feedback term) is the added to the target valve offset $IVTD_t$ to cause the valve actuator to correct the error measured by the feedback loop. For example:

> Valve timing control sets the target open/close timing of the intake valve 24 according to operating conditions and controls the continuously variable mechanism 92. More precisely, the ***hydraulic pressure control valve 68 is feedback-controlled according to signals from the first and second magnetic sensors 54 and 55 so that the cam shaft 85of the intake valve 24 maintains a required rotational phase with respect to the crankshaft 81***
> (Ex. 1004, '317 patent, col. 6, lines 6-13, *emphasis added*)

152. So Yoshioka discloses calculating a valve timing command based on the valve feedforward term and the valve feedback term.

153. Jankovic describes calculating a valve timing command based on the cam shaft phase command ζ_{REF} (valve feedforward term), and the actual cam phase ζ_{CAM}

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processed through the PID control loop (valve feedback term). This valve command is comprised of the initial cam phase command ζ_{REF} and any error between the actual cam phase ζ_{CAM} and the initial cam phase $\zeta_{REF.}$ This is illustrated in Figure 8, reproduced with annotation below.

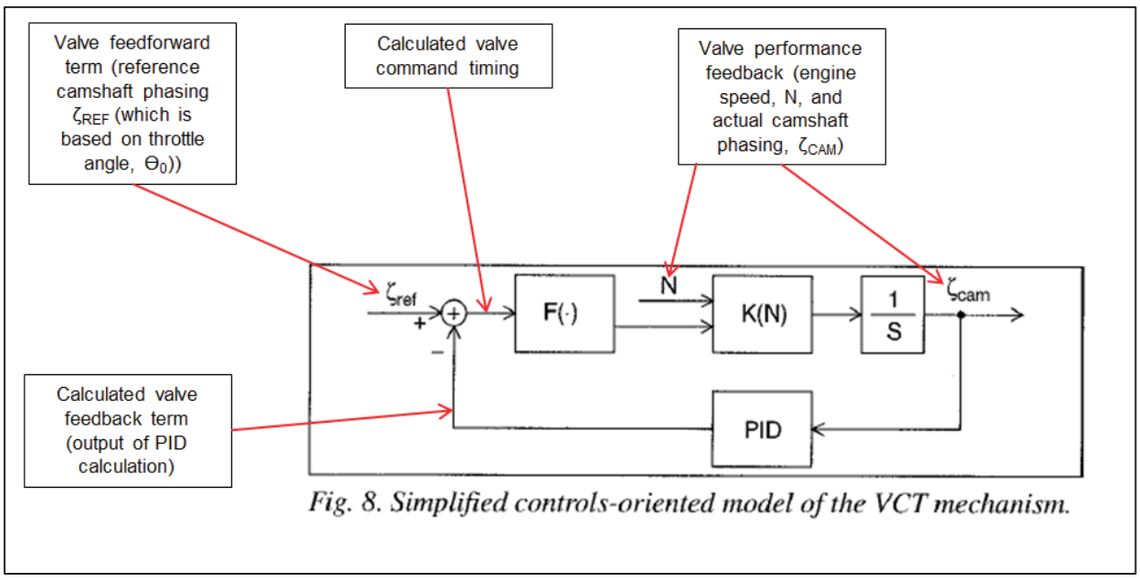


Fig. 8. Simplified controls-oriented model of the VCT mechanism.

(Ex. 1005 p. 8, Jankovic p. 41 (annotated).)

b. 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.

154. As described in connection to claim 1 above, Yoshioka describes that the engine is equipped with a throttle and a throttle opening sensor. As noted in the background section of this declaration, A POSITA would understand that the throttle opening valve measures the opening of the throttle, and the throttle is

controlled, at least in part, by the driver through the position of the accelerator pedal (a vehicle performance command).

155. As noted in connection with claim 1 above, Jankovic also describes that the throttle opening Θo is based on the position of the accelerator pedal. For example:

> Electronic control of the throttle provides an additional degree of control capability to affect emissions and fuel economy while providing the ***performance desired by the driver as interpreted from the accelerator pedal position***.
> (Ex. 1005 p. 1, Jankovic p. 35, *emphasis added*)

156. As noted in the section on claim construction, the '540 specifically describes the (accelerator) pedal position as an example of a vehicle performance command.

c. Claim 3

3. The method of claim 1 wherein said receiving an environmental conditions signal includes receiving ambient temperature data.

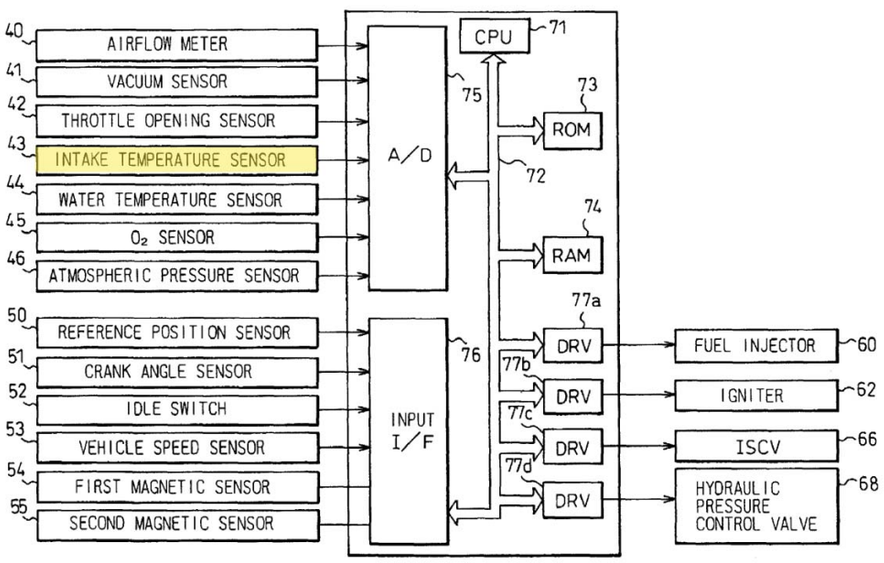
157. Yoshioka describes a variety of additional inputs to CPU 71 that are used to compute various engine control parameters. For example, Figure 2, reproduced below shows intake air temperature sensor 43. For example:

> A temperature sensor 43 detects the ***temperature of intake air.***
> (Ex. 1004, '317 patent, col. 4, lines 15-16, *emphasis added*)

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Fig.2

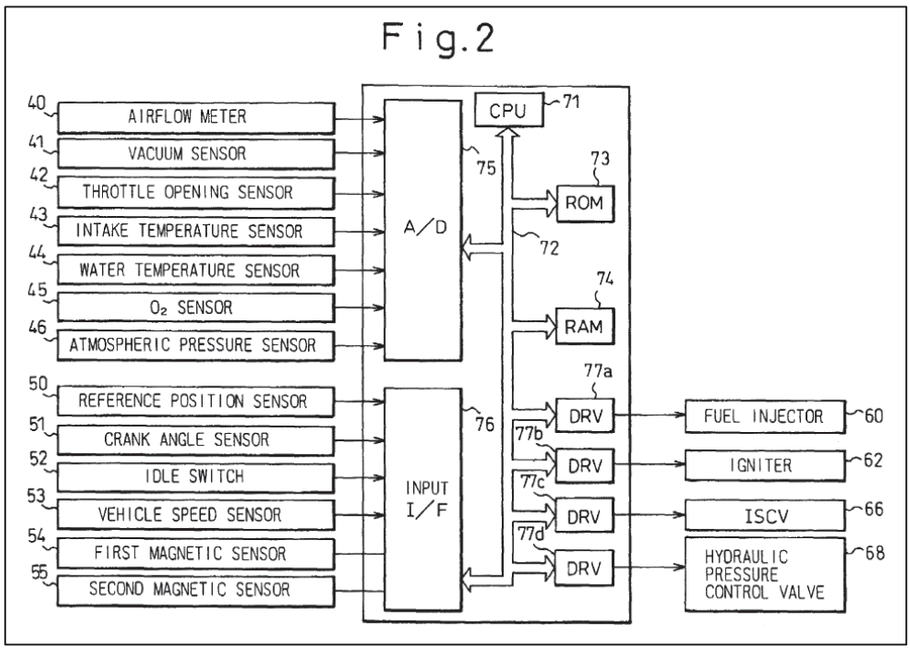


(Ex. 1004, '317 patent, Fig. 2 (annotated).)

d. Claim 7

7. The method of claim 1 wherein said receiving an engine performance feedback includes receiving engine speed data.

158. As described in connection with claim 1 above, Yoshioka describes using engine speed as one of the engine performance measures for determining the valve offset. This is also illustrated in figure 2, reproduced below, which shows engine speed (measured by the crank angle sensor 51) as an input to the system. (Ex. 1004 col. 7, lines 16-24.)



(Ex. 1004 Fig. 2.)

159. As described in connection with claim 1 above, Jankovic describes using engine speed as one of the engine performance measures for determining the actual cam phasing ζ_{CAM}, which is the engine performance feedback term of Jankovic.

e. 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.

160. Yoshioka describes that the system may also be used to control the timing of the exhaust valve opening and/or closing. For example:

> Although the embodiments ***variably control the open/close timing*** of the intake valve 24, the present invention is naturally ***applicable to control the exhaust valve 26 too***.
> (Ex. 1004, '317 patent, col. 9, lines 35-37, *emphasis added*).

> 1. A method of controlling a continuously variable valve timing mechanism of an internal combustion engine, to continuously and variably control an opening and closing timing of ***at least one of intake and exhaust valves of the engine***
> (Ex. 1004, '317 patent, claim 1, *emphasis added*); *see also* ¶¶ 142-144 above.

161. Jankovic describes that various configurations of variable valve timing systems are known. For example:

> Four versions of VCT are available for double overhead camshaft (DOHC) engines: phasing only the intake cam (intake only), phasing only the exhaust cam (exhaust only), phasing the intake and exhaust cams equally (dual equal), and phasing the two camshafts independently (dual independent). The dual independent VCT provides the best performance, but it is the most complex and expensive to implement.
> (Ex. 1005 p. 2, Jankovic p. 35)

162. Jankovic further illustrates varying the valve opening and closing intervals for the intake and exhaust valves, as shown in Figure 1, reproduced below.

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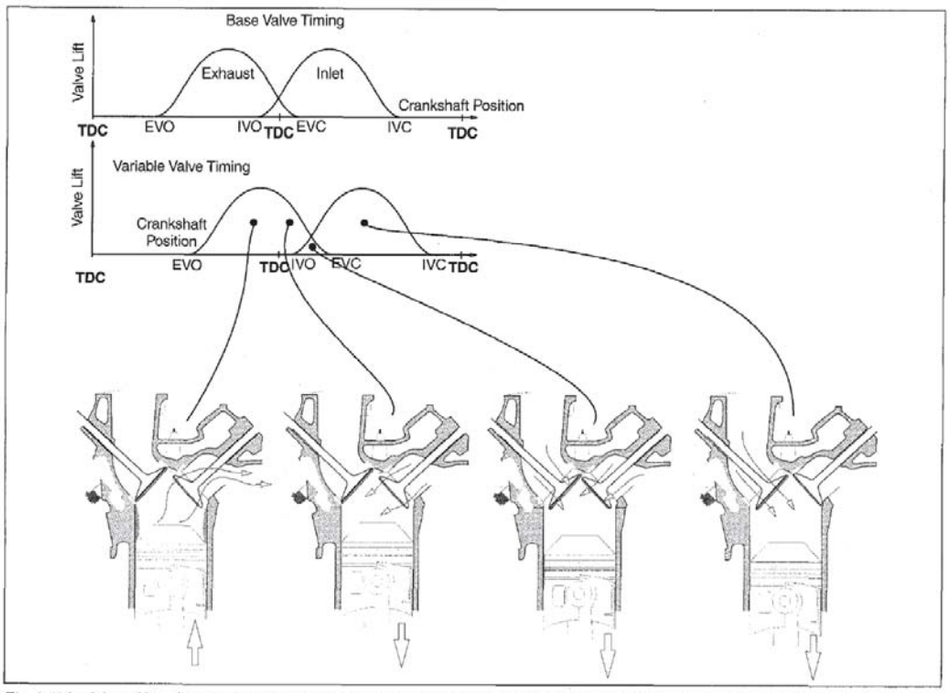


Fig. 1. Valve lift profiles of conventional and VCT engines. By retarding the cam phasing, the exhaust valve stays open during the intake event for a longer time period, retaining otherwise unburned HC and reducing the combustion temperature due to the dilution of the inert gas.

(Ex. 1005 p. 2, Jankovic p. 35)

f. Claim 11

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

163. Yoshioka describes receiving fuel conversion data. For example:

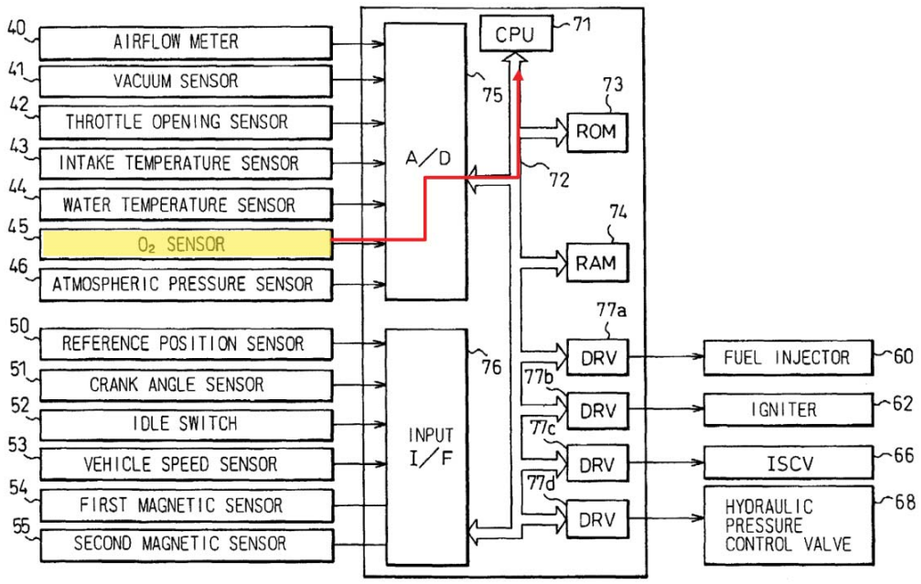
> The fuel injection quantity is subjected to corrections such as a basic correction according to signals from the throttle sensor 42, intake temperature sensor 43, water temperature sensor 44, etc., an air-fuel ratio feedback correction according to a signal from the O_2 sensor 45, and an air-fuel ratio learning correction to equalize a central feedback correction value to a theoretical air-fuel ratio.
>
> (Ex. 1004, '317 patent, col. 5, lines 47-55)

164. Yoshioka also describes that he CPU 71 receives data from the oxygen sensor, for example, as shown in Figure 2, reproduced with annotation below. For example:

> The exhaust pipe 34 has an O_2 sensor 45 to detect the concentration of oxygen in the exhaust gas.
> (Ex. 1004, '317 patent, col. 4, lines 49-52)

> An exhaust valve 26 discharges an exhaust gas of the combusted air-fuel mixture into an exhaust manifold 30 connected to an exhaust pipe 34. The exhaust pipe 34 has O_2 sensor 45 to detect the concentration of oxygen in the exhaust gas.
> (Ex. 1004, '317 patent, col. 4 , lines 48-52)

Fig.2



(Ex. 1004, '317 patent, Fig. 2 (annotated).)

165. Jankovic also describes receiving fuel conversion data. Figure 2, reproduced below, with annotation, illustrates that the air fuel ratio affects the torque output of the engine, and thus it is used together with other parameters to control engine torque. For example:

> The generation of torque depends on the cylinder air charge m_{cyl}, air-fuel ratio A/F, spark retard from MBT σ, and engine speed.
>
> (Ex. 1005 p. 3, Jankovic, p. 36)

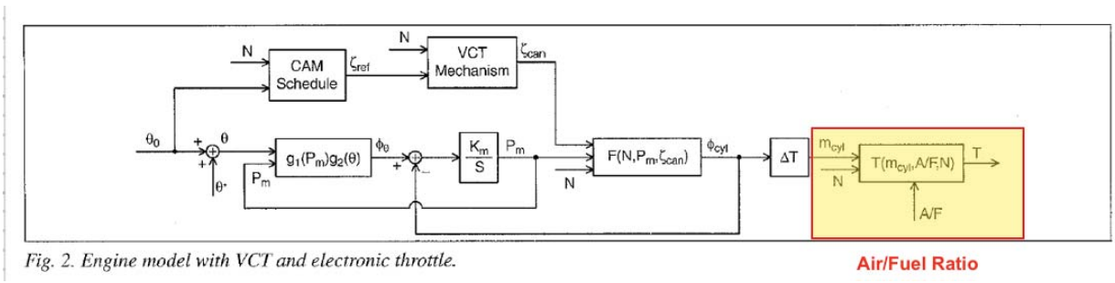


Fig. 2. Engine model with VCT and electronic throttle.

(Ex. 1005 p. 3, Jankovic, p. 36 (annotated).)

166. As described in the background section of this declaration, a POSITA would understand that Air Fuel Ratio is typically derived from the quantity of oxygen present in the exhaust gas, measured with an oxygen sensor, and this measurement.

g. Claim 14

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

167. Yoshioka describes receiving fuel conversion data. For example:

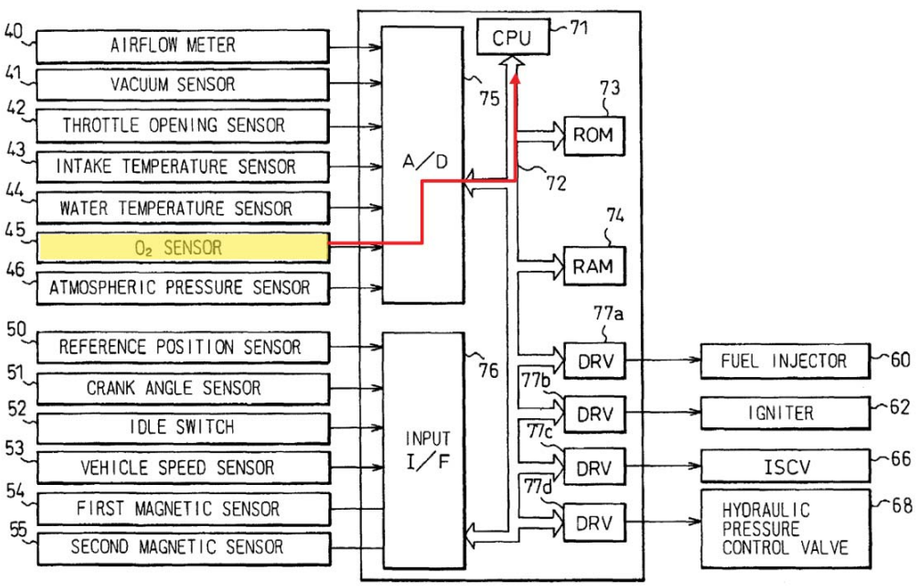
> The fuel injection quantity is subjected to corrections such as a basic correction according to signals from the throttle sensor 42, intake temperature sensor 43, water temperature sensor 44, etc., an air-fuel ratio feedback correction according to a signal from the O_2 sensor 45, and an air-fuel ratio learning correction to equalize a central feedback correction value to a theoretical air-fuel ratio.
>
> (Ex. 1004, '317 patent, col. 5, lines 47-55)

168. Yoshioka also describes that he CPU 71 receives data from the oxygen sensor, for example, as shown in Figure 2, reproduced with annotation below. For example:

The exhaust pipe 34 has an O_2 sensor 45 to detect the concentration of oxygen in the exhaust gas.
(Ex. 1004, '317 patent, col. 4, lines 49-51)

An exhaust valve 26 discharges an exhaust gas of the combusted air-fuel mixture into an exhaust manifold 30 connected to an exhaust pipe 34. The exhaust pipe 34 has O_2 sensor 45 to detect the concentration of oxygen in the exhaust gas.
(Ex. 1004, '317 patent, col. 4 , lines 47-52)

Fig.2



(Ex. 1004, '317 patent, Fig. 2 (annotated).)

169. Jankovic also describes receiving fuel conversion data. Figure 2, reproduced below, with annotation, illustrates that the air fuel ratio affects the torque output of

the engine, and thus it is used together with other parameters to control engine torque. For example:

> The generation of torque depends on the cylinder air charge m_{cyl}, air-fuel ratio A/F, spark retard from MBT σ, and engine speed.
> (Ex. 1005 p. 3, Jankovic p. 36)

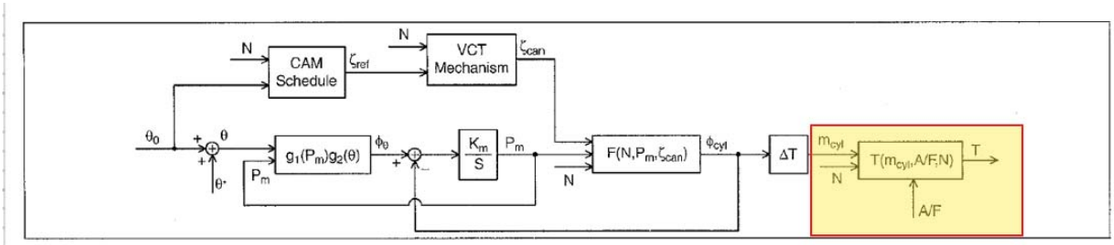


Fig. 2. Engine model with VCT and electronic throttle.

(Ex. 1005 p. 3, Jankovic p. 36 (annotated).)

170. As described in the background section of this declaration, a POSITA would understand that the quantity of oxygen present in the exhaust gas, measured with an oxygen sensor, represents the level of emissions in the exhaust gas.

171. Under the broadest reasonable interpretation of the term "engine emissions data", the oxygen sensor described by Yoshioka, and the measurement of air fuel ratio as described by Jankovic represent indirect measurements of engine emissions data.

iii. The Combination of Yoshioka and Jankovic

172. In my opinion, a person of ordinary skill in the art at the time of the invention of the '540 patent would have been motivated to combine the teachings of Yoshioka with the teachings of Jankovic.

173. Both Yoshioka and Jankovic address the same issue of providing engine management for engines with variable valve timing, so a POSITA would be familiar with both references and would have reason to consider them together.

174. For example, Yoshioka is directed toward controlling the valve timing of a variable valve timing engine using an electrohydraulic actuator to change the phase of the camshaft relative to the crankshaft in order to improve power output and reduce fuel consumption and emissions:

> An object of the present invention is to provide a method of and an apparatus for ***optimizing valve timing*** according to atmospheric pressure f***or a continuously variable valve timing mechanism of an internal combustion engine***.
> (Ex. 1004, '317 patent, col. 1, lines 39-42, *emphasis added*)
> The present invention intends ***to improve the output of an engine*** at high altitudes under high load, as well ***as reducing fuel consumption and improving exhaust purifying performance*** at high altitudes under low/medium load.
> (Ex. 1004, '317 patent, col. 1, lines 43-46, *emphasis added*)
> …the ***hydraulic pressure control valve 68*** is feedback-controlled according to signals from the first and second magnetic sensors 54 and 55 ***so that the cam shaft 85 of the***

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> ***intake valve 24 maintains a required rotational phase with respect to the crankshaf***t 81.
>
> (Ex. 1004, '317 patent, col. 6, lines 9-13, *emphasis added*)

175. Jankovic describes that its goal is to improve drivability[6] and emissions performance of an engine using a variable valve timing controller to rotate the cam shaft relative to the crankshaft.

> The variable cam timing (VCT) system with which this paper is concerned addresses both ***drivability and emissions performance*** by ***utilizing an electro-hydraulic mechanism to rotate the camshaft relative to the crankshaft*** in order to retard the cam timing with respect to the intake and exhaust strokes of the engine.
>
> (Ex. 1005 p. 1, Jankovic p. 34, *emphasis added*)

176. Moreover, both Yoshioka and Jankovic describe using feedback controllers to accomplish this valve timing control. For example, Yoshioka describes that the hydraulic pressure control valve is feedback controlled to ensure that the valve

---

[6]Drivability is the characteristic of an automobile to, among other things "provide smooth, trouble free performance under virtually any conditions while delivering power, fuel economy and controlled emissions." Ex. 1007 p. 16, Bosch Fuel Injection and Engine Management, by Charles O. Probst, © 1991, Robert Bentley Inc., ch. 2 p. 9.

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displacement (i.e. the offset between the cam shaft phase and the crankshaft phase) is set to the desired value:

> To bring the actual displacement of the intake valve 24 to the target displacement IVTDt, ***the hydraulic control valve 68 is feedback-controlled***.
> (Ex. 1004, '317 patent, col. 8, lines 5-7, *emphasis added*)

> Step 114 sets the displacement IVTDpa as a target displacement IVTDt. ***To bring an actual displacement to target displacement*** IVTDt, signals from the first and second valve timing magnetic sensors 54 and 55 are monitored to ***feedback control the hydraulic pressure control valve 68***.
> (Ex. 1004, '317 patent, col. 7, lines 41-45, *emphasis added*)

177. Similarly, Jankovic describes a feedback control scheme for the valve timing actuator. For example:

> The model based estimator uses $\square_{REF}$ and N as inputs to the model of ***the VCT mechanism (c.f. Fig. 2) which is itself a feedback loop consisting of the VCT actuator controlled by a PID regulator.***
> ***The VCT actuator system consists of a control valve and the actuator itself***. This control oriented model captures the dominant behavior of the VCT actuator system. These dominant dynamics can be reduced to a single integrator. Adding higher frequency components does not add much to the accuracy of this model. The static control valve behavior is

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captured in the function F(·). It is purely a function of the control input. ***The gain of the VCT actuator depends heavily on the engine speed N and is described by the static function K(N). A block diagram of the VCT mechanism model is shown in Fig. 8.***

*(*Ex. 1005 p. 7, Jankovic p. 40, *emphasis added)*

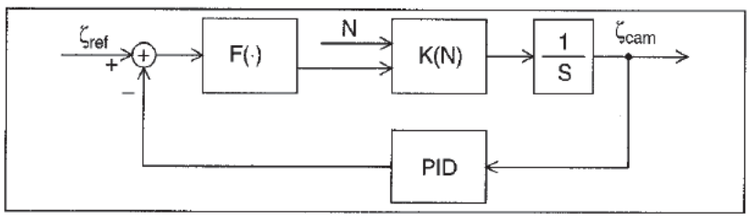


Fig. 8. Simplified controls-oriented model of the VCT mechanism.

*(*Ex. 1005 p. 1, Jankovic p. 41, *emphasis added)*

178. Thus, Yoshioka describes using a feedback control system to control the valve timing, and Jankovic provides a detailed mathematical model of a feedback controller. As a result, in my opinion a POSITA would have found Jankovic to be a highly useful reference to guide the implementation of the system as described by Yoshioka. This combination is nothing more than a combination of known elements and it would be expected by a POSITA to produce the predictable result of ensuring that the commanded valve timing was in fact achieved by the system, a goal described by both Yoshioka and Jankovic.

XIII. CONCLUSION

179. I declare that the foregoing is true and accurate to the best of my knowledge, and I will testify as such if called to do so.

Respectfully submitted,



Scott Andrews 5/14/18

Date

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U.S. **UTILITY** Patent Application

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Verified and Acknowledged Examiners's intials		

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U.S.DEPT. OF COMM./PAT.& TM-PTO-436L(Rev. 12-94)

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** FOREIGN APPLICATIONS ********** None ES

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1.	Application papers. + PTO		31.		
2.	IDS	12-11-01	32.		
3.	NDA	12/11/02	33.		
4.	Prior Art	6-12-03	34.		
7/8 5.	misletter	7/8/03	35.		
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HMC EXHIBIT 1003
PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

US006557540B1

(12) **United States Patent**
Mianzo et al.

(10) **Patent No.: US 6,557,540 B1**
(45) **Date of Patent: May 6, 2003**

(54) **METHOD OF CALCULATING A VALVE TIMING COMMAND FOR AN ENGINE**

(75) Inventors: **Lawrence A. Mianzo**, Plymouth, MI (US); **Brett D. Collins**, Ypsilanti, MI (US); **Ibrahim Haskara**, Brownstown, MI (US)

(73) Assignee: **Visteon Global Technologies, Inc.**, Dearborn, MI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/014,286**

(22) Filed: **Dec. 11, 2001**

(51) **Int. Cl.**[7] **F01L 1/34**
(52) **U.S. Cl.** **123/678**; 123/90.15; 701/103
(58) **Field of Search** 123/678, 90.15, 123/90.19; 701/103

(56) **References Cited**

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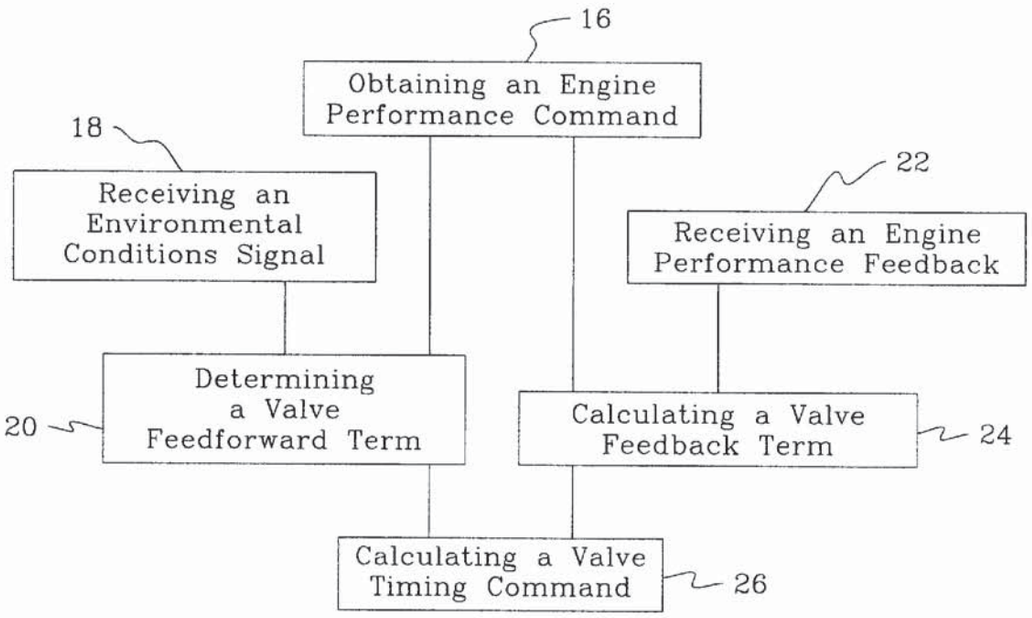
* cited by examiner

Primary Examiner—Erick Solis
(74) *Attorney, Agent, or Firm*—Brinks Hofer Gilson & Lione

(57) **ABSTRACT**

A method to calculate valve timing commands for an engine with variable valve timing is hereby disclosed. The method includes determining a valve feedforward term based on an engine performance command and an environmental conditions signal, calculating a valve feedback term based on the engine performance command and an engine performance feedback, and calculating a valve timing command based on the valve feedforward term and the valve feedback term.

16 Claims, 3 Drawing Sheets



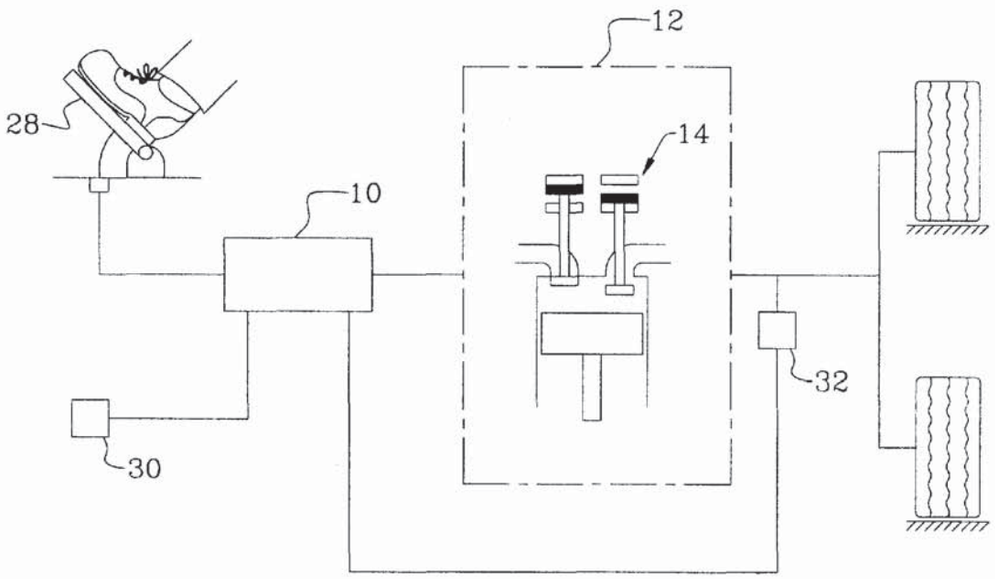


FIGURE 1

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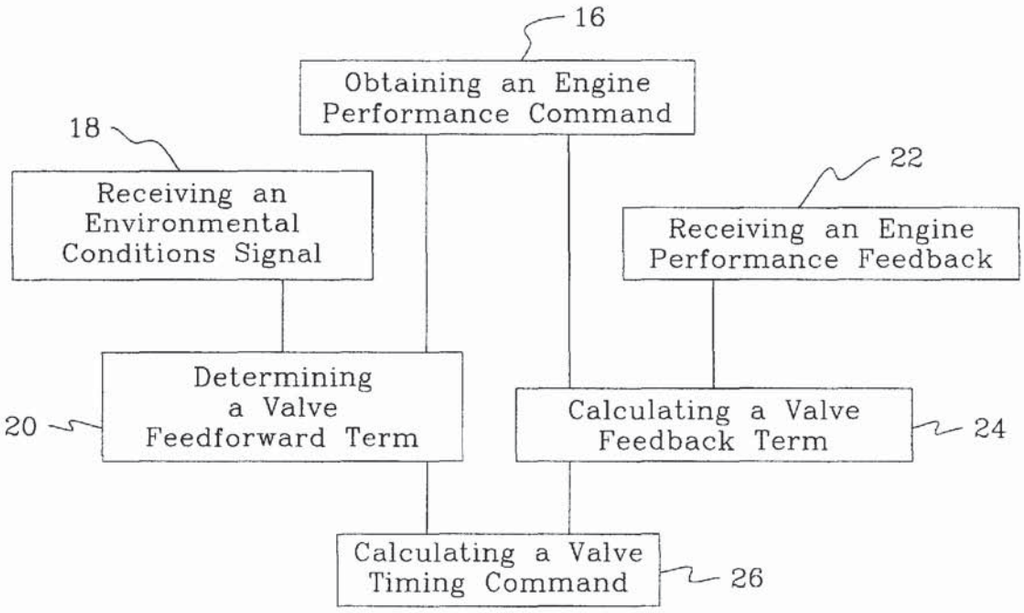


FIGURE 2

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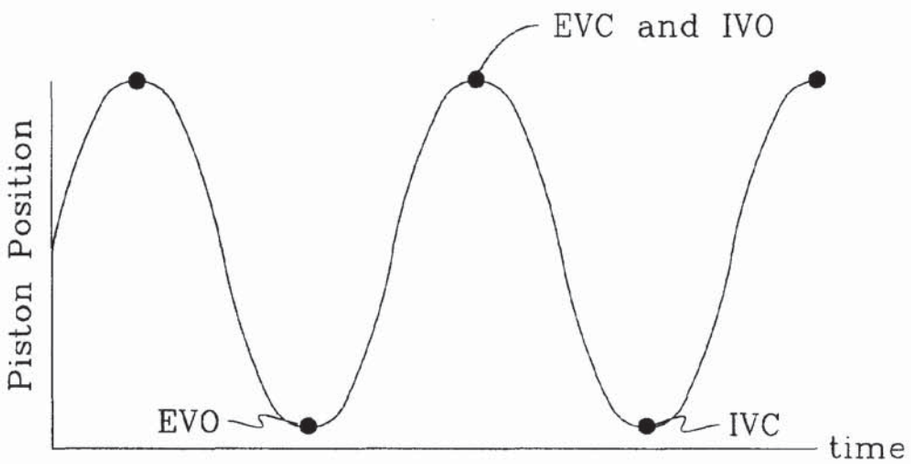


FIGURE 3A

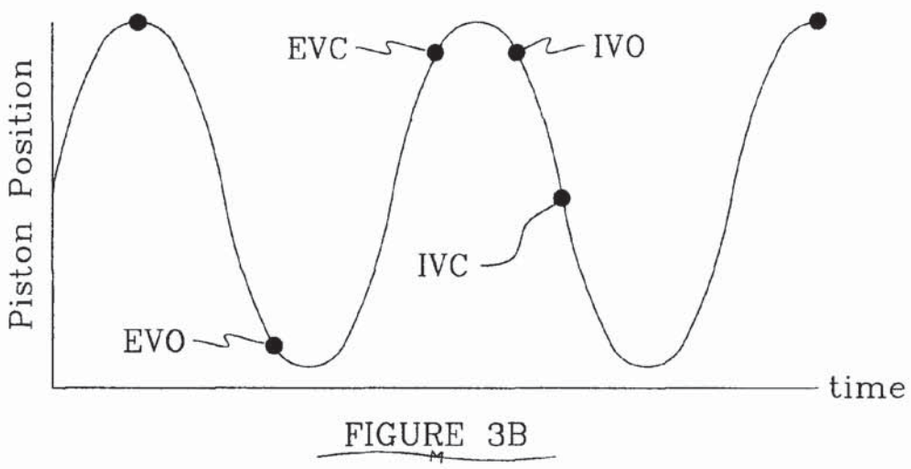


FIGURE 3B

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US PATENT NO. 6,557,540

METHOD OF CALCULATING A VALVE TIMING COMMAND FOR AN ENGINE

TECHNICAL FIELD

This invention relates generally to calculating commands for an engine and, more specifically, to calculating a valve timing command for an engine with variable timing valve actuators.

BACKGROUND

In gasoline engines of most vehicles, each cylinder of the engine cycles through four unique stages. In the first stage, an inlet valve opens and a piston draws air and fuel through the inlet valve and into the cylinder. The inlet valve closes and the piston reverses direction in the second stage to compress the air and fuel mixture. In the third stage, a spark combusts the mixture, which drives the piston (and powers the vehicle). An exhaust valve opens and the piston once again reverses direction, in the fourth stage, to push the combusted mixture through the exhaust valve and out of the cylinder.

The controlling of the inlet valve and the exhaust valve of each cylinder is a difficult task. The engine speed, which can exceed 6,000 rpm in most vehicles, dictates that the opening and closing of the inlet valve and the exhaust valve must be able to occur up to 50 times per second. In conventional engines, cams driven by the engine actuate the inlet valve and the exhaust valve. Modern research, however, has shown that fuel efficiency and power output of the engine may be optimized with an adjustment of the valve timing for a particular load on the engine. Some variable valve timing engines have been proposed, but the theoretical fuel efficiency and output power of these engines have not yet been reached.

BRIEF DESCRIPTION OF THE FIGURES

FIG. **1** is schematic of a vehicle having an engine controlled with the method of the preferred embodiment;

FIG. **2** is a flowchart of the method of the preferred embodiment; and

FIG. **3** is two timing charts of the valves of an engine.

DESCRIPTION OF THE PREFERRED METHODS

The following description of the two preferred method of the invention is not intended to limit the invention to these preferred methods, but rather to enable any person skilled in the art of variable valve timing control to make and use this invention.

As shown in FIG. **1**, the preferred method of the invention has been specifically created to be performed by a control unit **10** to calculate valve timing commands for an engine **12** with electromagnetic valve actuators **14**. The method, however, may be performed by any suitable device to calculate valve timing commands for any suitable engine with any suitable variable timing valves.

As shown in FIG. **2**, the preferred method of the invention has six principle actions: obtaining an engine performance command **16**; receiving an environmental conditions signal **18**; determining a valve feedforward term **20**; receiving an engine performance feedback **22**; calculating a valve feedback term **24**; and calculating a valve timing command **26** based on the valve feedforward term and the valve feedback term. The method performed by the control unit may, of course, include other suitable actions before, during, or after these principle actions.

The action of obtaining an engine performance command **16** preferably includes receiving a vehicle performance command from a driver. Preferably, the vehicle performance command is received from the foot of a driver with the use of a conventional pedal **28**, as shown in FIG. **1**. Alternatively, the vehicle performance command could be received from the driver with the use of any suitable device. The action of obtaining an engine performance command also preferably includes deriving the engine performance command from the vehicle performance command. The engine performance command is preferably based on the vehicle performance command, but may alternatively be based on additional suitable factors, such as a traction control signal or a cruise control signal. The engine performance command is preferably a desired engine torque and, for this reason, the engine performance command may be thought of as an engine torque command. The engine performance command, however, may alternatively be another suitable variable, such as a desired engine acceleration.

The action of receiving an environmental conditions signal **18** preferably includes receiving an environmental conditions signal from an environmental sensor **30** in the vehicle. The environmental sensor **30** preferably senses the ambient temperature outside the vehicle and communicates this data to the control unit **10**, which uses the data to determine the valve feedforward term. Other information, such as the ambient pressure, may be useful in the determination of the valve feedforward term. For this reason, the environmental sensor **30** may alternatively sense other suitable information. The environmental sensor **30** is preferably a conventional environmental sensor, but may alternatively be any suitable device.

Similarly, the action of receiving an engine performance feedback **22** preferably includes receiving the engine performance feedback from an engine sensor **32** in the vehicle. The engine sensor **32** preferably senses the engine speed and communicates this data to the control unit **10**, which uses the data to determine the valve feedforward term and the valve feedback term. Other engine measurables, such as engine torque data, may be useful in the determination of the terms. For this reason, the engine sensor **32** may alternatively sense other suitable information. The engine sensor **32** is preferably a conventional engine sensor, but may alternatively be any suitable sensor.

The action of determining a valve feedforward term **20** preferably includes determining the valve feedforward term based on the engine torque command, the ambient temperature data, and the engine speed data. The determination, however, may be based on other suitable factors, such as engine torque data, air-fuel ratio data, engine combustion stability data, or ambient pressure data. The control unit **10** preferably includes a look-up table, which has been optimized for fuel efficiency, power output, and engine emissions based on various engine torque commands, various ambient temperature data, and various engine speed data (or engine torque data). The control unit **10** may alternatively be programmed to perform a real-time optimization of the fuel efficiency, power output, and engine emission (or any other suitable measurement) based on the engine torque command, the ambient temperature data, and the engine speed data (or any other suitable commands and measurables).

The action of calculating the valve feedback term **24** preferably includes comparing the engine performance com-

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mand and the engine performance feedback. By the definition of the term, the valve feedback term functions to compare the input with the output and to calculate a correction term based on the difference, if any. The comparison and the calculation are preferably accomplished by the control unit **10**, but may alternatively be accomplished by a suitable separate device.

As shown in FIG. **3**A, the position of the piston in the cylinder can be traced as a sinusoidal wave over a time period. The events of the opening of the exhaust valve ("EVO"), the closing of the exhaust valve ("EVC"), the opening of the inlet valve ("IVO"), and the closing of the inlet valve ("IVC") can be placed on this sinusoidal wave. As shown in FIG. **3**B, the events of the EVO, the EVC, the IVO, and the IVC may be shifted within the time period (note that the shift in the EVC and the IVO preferably mirror each another, but may alternatively be separately controlled). The adjustment of the timing of the EVO, the EVC/IVO, and the IVC when used partially, separately, or together may provide the desired fuel efficiency, power output, and emissions from the engine **12** of the vehicle. The action of calculating a valve timing command **26** preferably includes calculating an EVO command, an EVC/IVO command, and an IVC command. The control unit **10**, of course, may alternatively include other suitable parameters for the control of the variable timing valves.

The second preferred method of the invention includes the principle actions of the first preferred method and the additional principle action of receiving fuel conversion data and engine emissions data. These preferably include receiving the fuel conversion data and engine emissions data from suitable emission sensors (not shown) in the cylinder or the exhaust port of the engine **12**. The emission sensors preferably sense the amount of NO_x in the exhaust and communicates this data to the control unit **10**. The control unit **10** preferably uses this information to modify the output value from the look-up table, but may alternatively use this information to continually adjust the values in the look-up table. The control unit **10** may alternatively use this information as another factor in the determination of the valve feedback term. The emission sensors are preferably conventional emission sensors, but may alternatively be any suitable sensor.

As any person skilled in the art of variable valve engine control will recognize from the previous detailed description and from the figures and claims, modifications and changes can be made to the preferred methods without departing from the scope of this invention defined in the following claims.

We claim:

1. 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.

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.

3. The method of claim **1** wherein said receiving an environmental conditions signal includes receiving ambient temperature data.

4. The method of claim **3** wherein said determining a valve feedforward term includes determining the valve feedforward term based on the ambient temperature data.

5. The method of claim **4** wherein said determining a valve feedforward term includes determining the valve feedforward term based on the engine performance feedback.

6. The method of claim **5** wherein said determining a valve feedforward term includes referencing a look-up table with the engine performance command, the ambient temperature, and the engine performance feedback.

7. The method of claim **1** wherein said receiving an engine performance feedback includes receiving engine speed data.

8. The method of claim **1** wherein said obtaining an engine performance command includes obtaining an engine torque command; and wherein receiving an engine performance feedback includes receiving engine torque data.

9. The method of claim **8** wherein calculating a valve feedback term includes calculating a valve feedback term based on the engine torque command and the engine torque data.

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.

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

12. The method of claim **11** wherein said determining a valve feedforward term includes determining a valve feedforward term based on the fuel conversion data.

13. The method of claim **11** wherein said calculating a valve feedback term includes calculating a valve feedback term based on the fuel conversion data.

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

15. The method of claim **14** wherein said determining a valve feedforward term includes determining a valve feedforward term based on the engine emissions data.

16. The method of claim **11** wherein said calculating a valve feedback term includes calculating a valve feedback term based on the engine emissions data.

* * * * *

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US PATENT NO. 6,557,540

12-14-01 A

J1054 U.S. PTO 12/11/01

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PTO/SB/05 (11-00)
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Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.	10541-070
First Inventor	Mianzo et al.
Title	Method of Calculating a Valve Timing Command for an Engine
Express Mail Label No.	ET718954276US

ADDRESS TO: Assistant Commissioner for Patents, Box Patent Application, Washington, D.C. 20231

J1050 U.S. PTO 10/014286 12/11/01

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

1. [✓] Fee Transmittal Form (e.g., PTO/SB/17) *(Submit an original, and a duplicate for fee processing)*
2. [ ] Applicant claims small entity status. See 37 CFR 1.27.
3. [✓] Specification *[Total Pages 10]* *(preferred arrangement set forth below)*
   - Descriptive title of the invention
   - Cross Reference to Related Applications
   - Statement Regarding Fed sponsored R & D
   - Reference to sequence listing, a table, or a computer program listing appendix
   - Background of the Invention
   - Brief Summary of the Invention
   - Brief Description of the Drawings *(if filed)*
   - Detailed Description
   - Claim(s)
   - Abstract of the Disclosure
4. [✓] Drawing(s) *(35 U.S.C. 113)* *[Total Sheets 3]*
5. Oath or Declaration *[Total Pages 3]*
   a. [✓] Newly executed (original or copy)
   b. [ ] Copy from a prior application (37 CFR 1.63(d)) *(for continuation/divisional with Box 18 completed)*
      i. [ ] DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).
6. [ ] Application Data Sheet. See 37 CFR 1.76
7. [ ] CD-ROM or CD-R in duplicate, large table or Computer Program *(Appendix)*
8. Nucleotide and/or Amino Acid Sequence Submission *(if applicable, all necessary)*
   a. [ ] Computer Readable Form (CRF)
   b. Specification Sequence Listing on:
      i. [ ] CD-ROM or CD-R (2 copies); or
      ii. [ ] paper
   c. [ ] Statements verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

9. [✓] Assignment Papers (cover sheet & document(s))
10. [ ] 37 CFR 3.73(b) Statement *(when there is an assignee)* [✓] Power of Attorney
11. [ ] English Translation Document *(if applicable)*
12. [✓] Information Disclosure Statement (IDS)/PTO-1449 [✓] Copies of IDS Citations
13. [ ] Preliminary Amendment
14. [✓] Return Receipt Postcard (MPEP 503) *(Should be specifically itemized)*
15. [ ] Certified Copy of Priority Document(s) *(if foreign priority is claimed)*
16. [ ] Request and Certification under 35 U.S.C. 122 (b)(2)(B)(i). Applicant must attach form PTO/SB/35 or its equivalent.
17. [✓] Other: Express Mailing Certificate. Additional Return Receipt Postcard

18. If a CONTINUING APPLICATION, *check appropriate box, and supply the requisite information below and in a preliminary amendment, or in an Application Data Sheet under 37 CFR 1.76:*

[ ] Continuation [ ] Divisional [ ] Continuation-in-part (CIP) of prior application No.: _____ / _____

Prior application information: Examiner _____ *Group / Art Unit* _____

For CONTINUATION OR DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 5b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

19. CORRESPONDENCE ADDRESS

[✓] *Customer Number or Bar Code Label* *(Insert Customer No. or Attach bar code label here)* 29074 PATENT & TRADEMARK OFFICE or [ ] *Correspondence address below*

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City	State		Zip Code	
Country	Telephone		Fax	

Name (Print/Type)	Jeffrey M. Cox	Registration No. (Attorney/Agent)	42,445
Signature		Date	11 December 2001

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PETITIONER'S EXHIBIT 1003
US PATENT NO. 6,557,540

PTO/SB/17 (XX-XX)
Approved for use through 10/31/2002. OMB 0651-0032
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE
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FEE TRANSMITTAL for FY 2002

Patent fees are subject to annual revision.

TOTAL AMOUNT OF PAYMENT $780.00

Complete if Known	
Application Number	
Filing Date	
First Named Inventor	Mianzo
Examiner Name	
Group Art Unit	
Attorney Docket No.	10541-070

METHOD OF PAYMENT

1. ☒ The Commissioner is hereby authorized to charge indicated fees and credit any overpayments to:

Deposit Account Number: 06-1500

Deposit Account Name:

☒ Charge Any Additional Fee Required Under 37 CFR §§ 1.16 and 1.17

☐ Applicant claims small entity status. See 37 CFR § 1.27

2. ☐ Payment Enclosed:

☐ Check ☐ Credit card ☐ Money Order ☐ Other

FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
101	740	201	370	Utility filing fee	740.00
106	330	206	165	Design filing fee	
107	510	207	255	Plant filing fee	
108	740	208	370	Reissue filing fee	
114	160	214	80	Provisional filing fee	
				SUBTOTAL (1)	$740.00

2. EXTRA CLAIM FEES

	Extra Claims			Fee from below		Fee Paid
Total Claims	16	-20** =	0	X	=	0.00
Independent Claims	1	- 3** =	0	X	=	0.00
Multiple Dependent					=	

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
103	18	203	9	Claims in excess of 20
102	84	202	42	Independent claims in excess of 3
104	280	204	140	Multiple dependent claim, if not paid
109	84	209	42	** Reissue independent claims over original patent
110	18	210	9	** Reissue claims in excess of 20 and over original patent
				SUBTOTAL (2) $0.00

**or number previously paid, if greater; For Reissues, see above

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
105	130	205	65	Surcharge - late filing fee or oath	
127	50	227	25	Surcharge - late provisional filing fee or cover sheet	
139	130	139	130	Non - English specification	
147	2,520	147	2,520	For filing a request for *ex parte* reexamination	
112	920*	112	920*	Requesting publication of SIR prior to Examiner action	
113	1,840*	113	1,840*	Requesting publication of SIR after Examiner action	
115	110	215	55	Extension for reply within first month	
116	400	216	200	Extension for reply within second month	
117	920	217	460	Extension for reply within third month	
118	1,440	218	720	Extension for reply within fourth month	
128	1,960	228	980	Extension for reply within fifth month	
119	320	219	160	Notice of Appeal	
120	320	220	160	Filing a brief in support of an appeal	
121	280	221	140	Request for oral hearing	
138	1,510	138	1,510	Petition to institute a public use proceeding	
140	110	240	55	Petition to revive - unavoidable	
141	1,280	241	640	Petition to revive - unintentional	
142	1,280	242	640	Utility issue fee (or reissue)	
143	460	243	230	Design issue fee	
144	620	244	310	Plant issue fee	
122	130	122	130	Petitions to the Commissioner	
123	50	123	50	Processing fee under 37 CFR § 1.17(q)	
126	180	126	180	Submission of Information Disclosure Statement	
581	40	581	40	Recording each patent assignment per property (times number of properties)	40.00
146	740	246	370	Filing a submission after final rejection (37 CFR § 1.129(a))	
149	740	249	370	For each additional invention to be examined (37 CFR § 1.129(b))	
179	740	279	370	Request for Continued Examination (RCE)	
169	900	169	900	Request for expedited examination of a design application	
Other fee (specify)					

*Reduced by Basic Filing Fee Paid — SUBTOTAL (3) $40.00

SUBMITTED BY

Complete *(if applicable)*

Name (Print/Type)	Jeffrey M. Cox	Registration No. (Attorney/Agent)	42,445	Telephone	(734) 302-6000
Signature				Date	11 December 2001

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PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540

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11 December 2001

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Box Patent Application
Washington, D.C. 20231

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EXPRESS MAILING CERTIFICATE

Applicant(s):	Mianzo et al
Title:	Method of Calculating a Valve Timing Command for an Engine
Attorney Docket:	10541-070
Attorney:	Jeffrey M. Cox

"Express Mail" Mailing Label No. ET718954276US

Date of Deposit .....11 December 2001

I hereby certify and verify that the accompanying **Utility Patent Application Transmittal, Fee Transmittal, Specification on ten (10) pages, Formal Drawings on three (3) sheets, Declaration and Power of Attorney, Recordation Cover Sheet, Assignment, Information Disclosure Statement, PTO Form 1449 with references, and two (2) Return Postcards** are being deposited with the United States Postal Service Express Mail Post Office To Addressee service under 37 C.F.R. 1.10 on the date indicated above and are addressed to Commissioner for Patents, Box Patent Application, Washington, D.C. 20231.

Ashley L. Rhoades

Signature of Person Mailing Document(s)

PETITIONER'S EXHIBIT 1003
US PATENT NO. 6,557,540

Attorney Docket No.: 10541-070
Visteon Disclosure No.: V200-0655

METHOD OF CALCULATING A VALVE TIMING COMMAND FOR AN ENGINE

TECHNICAL FIELD

[0001] This invention relates generally to calculating commands for an engine and, more specifically, to calculating a valve timing command for an engine with variable timing valve actuators.

BACKGROUND

[0002] In gasoline engines of most vehicles, each cylinder of the engine cycles through four unique stages. In the first stage, an inlet valve opens and a piston draws air and fuel through the inlet valve and into the cylinder. The inlet valve closes and the piston reverses direction in the second stage to compress the air and fuel mixture. In the third stage, a spark combusts the mixture, which drives the piston (and powers the vehicle). An exhaust valve opens and the piston once again reverses direction, in the fourth stage, to push the combusted mixture through the exhaust valve and out of the cylinder.

[0003] The controlling of the inlet valve and the exhaust valve of each cylinder is a difficult task. The engine speed, which can exceed 6,000 rpm in most vehicles, dictates that the opening and closing of the inlet valve and the exhaust valve must be able to occur up to 50 times per second. In conventional engines, cams driven by the engine actuate the inlet valve and the exhaust valve. Modern research, however, has shown that fuel efficiency and power output of the engine may be optimized with an adjustment of the valve timing for a particular load on the

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PETITIONER'S EXHIBIT 1003
US PATENT NO. 6,557,540

engine. Some variable valve timing engines have been proposed, but the theoretical fuel efficiency and output power of these engines have not yet been reached.

BRIEF DESCRIPTION OF THE FIGURES

[0004] FIGURE 1 is schematic of a vehicle having an engine controlled with the method of the preferred embodiment;

[0005] FIGURE 2 is a flowchart of the method of the preferred embodiment; and

[0006] FIGURE 3 is two timing charts of the valves of an engine.

DESCRIPTION OF THE PREFERRED METHODS

[0007] The following description of the two preferred method of the invention is not intended to limit the invention to these preferred methods, but rather to enable any person skilled in the art of variable valve timing control to make and use this invention.

[0008] As shown in FIGURE 1, the preferred method of the invention has been specifically created to be performed by a control unit 10 to calculate valve timing commands for an engine 12 with electromagnetic valve actuators 14. The method, however, may be performed by any suitable device to calculate valve timing commands for any suitable engine with any suitable variable timing valves.

[0009] As shown in FIGURE 2, the preferred method of the invention has six principle actions: obtaining an engine performance command 16; receiving an environmental conditions signal 18; determining a valve feedforward term 20; receiving an engine performance feedback 22; calculating a valve feedback term

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24; and calculating a valve timing command 26 based on the valve feedforward term and the valve feedback term. The method performed by the control unit may, of course, include other suitable actions before, during, or after these principle actions.

[00010] The action of obtaining an engine performance command 16 preferably includes receiving a vehicle performance command from a driver. Preferably, the vehicle performance command is received from the foot of a driver with the use of a conventional pedal 28, as shown in FIGURE 1. Alternatively, the vehicle performance command could be received from the driver with the use of any suitable device. The action of obtaining an engine performance command also preferably includes deriving the engine performance command from the vehicle performance command. The engine performance command is preferably based on the vehicle performance command, but may alternatively be based on additional suitable factors, such as a traction control signal or a cruise control signal. The engine performance command is preferably a desired engine torque and, for this reason, the engine performance command may be thought of as an engine torque command. The engine performance command, however, may alternatively be another suitable variable, such as a desired engine acceleration.

[00011] The action of receiving an environmental conditions signal 18 preferably includes receiving an environmental conditions signal from an environmental sensor 30 in the vehicle. The environmental sensor 30 preferably senses the ambient temperature outside the vehicle and communicates this data to the control unit 10, which uses the data to determine the valve feedforward term. Other information, such as the ambient pressure, may be useful in the determination

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of the valve feedforward term. For this reason, the environmental sensor 30 may alternatively sense other suitable information. The environmental sensor 30 is preferably a conventional environmental sensor, but may alternatively be any suitable device.

[00012] Similarly, the action of receiving an engine performance feedback 22 preferably includes receiving the engine performance feedback from an engine sensor 32 in the vehicle. The engine sensor 32 preferably senses the engine speed and communicates this data to the control unit 10, which uses the data to determine the valve feedforward term and the valve feedback term. Other engine measurables, such as engine torque data, may be useful in the determination of the terms. For this reason, the engine sensor 32 may alternatively sense other suitable information. The engine sensor 32 is preferably a conventional engine sensor, but may alternatively be any suitable sensor.

[00013] The action of determining a valve feedforward term 20 preferably includes determining the valve feedforward term based on the engine torque command, the ambient temperature data, and the engine speed data. The determination, however, may be based on other suitable factors, such as engine torque data, air-fuel ratio data, engine combustion stability data, or ambient pressure data. The control unit 10 preferably includes a look-up table, which has been optimized for fuel efficiency, power output, and engine emissions based on various engine torque commands, various ambient temperature data, and various engine speed data (or engine torque data). The control unit 10 may alternatively be programmed to perform a real-time optimization of the fuel efficiency, power output, and engine emission (or any other suitable measurement) based on the engine

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torque command, the ambient temperature data, and the engine speed data (or any other suitable commands and measurables).

[00014] The action of calculating the valve feedback term 24 preferably includes comparing the engine performance command and the engine performance feedback. By the definition of the term, the valve feedback term functions to compare the input with the output and to calculate a correction term based on the difference, if any. The comparison and the calculation are preferably accomplished by the control unit 10, but may alternatively be accomplished by a suitable separate device.

[00015] As shown in FIGURE 3A, the position of the piston in the cylinder can be traced as a sinusoidal wave over a time period. The events of the opening of the exhaust valve ("EVO"), the closing of the exhaust valve ("EVC"), the opening of the inlet valve ("IVO"), and the closing of the inlet valve ("IVC") can be placed on this sinusoidal wave. As shown in FIGURE 3B, the events of the EVO, the EVC, the IVO, and the IVC may be shifted within the time period (note that the shift in the EVC and the IVO preferably mirror each another, but may alternatively be separately controlled). The adjustment of the timing of the EVO, the EVC/IVO, and the IVC when used partially, separately, or together may provide the desired fuel efficiency, power output, and emissions from the engine 12 of the vehicle. The action of calculating a valve timing command 26 preferably includes calculating an EVO command, an EVC/IVO command, and an IVC command. The control unit 10, of course, may alternatively include other suitable parameters for the control of the variable timing valves.

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[00016] The second preferred method of the invention includes the principle actions of the first preferred method and the additional principle action of receiving fuel conversion data and engine emissions data. These preferably include receiving the fuel conversion data and engine emissions data from suitable emission sensors (not shown) in the cylinder or the exhaust port of the engine 12. The emission sensors preferably sense the amount of NO_x in the exhaust and communicates this data to the control unit 10. The control unit 10 preferably uses this information to modify the output value from the look-up table, but may alternatively use this information to continually adjust the values in the look-up table. The control unit 10 may alternatively use this information as another factor in the determination of the valve feedback term. The emission sensors are preferably conventional emission sensors, but may alternatively be any suitable sensor.

[00017] As any person skilled in the art of variable valve engine control will recognize from the previous detailed description and from the figures and claims, modifications and changes can be made to the preferred methods without departing from the scope of this invention defined in the following claims.

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CLAIMS

We Claim:

1. 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.

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.

3. The method of Claim 1 wherein said receiving an environmental conditions signal includes receiving ambient temperature data.

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4. The method of Claim 3 wherein said determining a valve feedforward term includes determining the valve feedforward term based on the ambient temperature data.

5. The method of Claim 4 wherein said determining a valve feedforward term includes determining the valve feedforward term based on the engine performance feedback.

6. The method of Claim 5 wherein said determining a valve feedforward term includes referencing a look-up table with the engine performance command, the ambient temperature, and the engine performance feedback.

7. The method of Claim 1 wherein said receiving an engine performance feedback includes receiving engine speed data.

8. The method of Claim 1 wherein said obtaining an engine performance command includes obtaining an engine torque command; and wherein receiving an engine performance feedback includes receiving engine torque data.

9. The method of Claim 8 wherein calculating a valve feedback term includes calculating a valve feedback term based on the engine torque command and the engine torque data.

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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.

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

12. The method of Claim 11 wherein said determining a valve feedforward term includes determining a valve feedforward term based on the fuel conversion data.

13. The method of Claim 11 wherein said calculating a valve feedback term includes calculating a valve feedback term based on the fuel conversion data.

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

15. The method of Claim 14 wherein said determining a valve feedforward term includes determining a valve feedforward term based on the engine emissions data.

16. The method of Claim 11 wherein said calculating a valve feedback term includes calculating a valve feedback term based on the engine emissions data.

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ABSTRACT

[00018] A method to calculate valve timing commands for an engine with variable valve timing is hereby disclosed. The method includes determining a valve feedforward term based on an engine performance command and an environmental conditions signal, calculating a valve feedback term based on the engine performance command and an engine performance feedback, and calculating a valve timing command based on the valve feedforward term and the valve feedback term.

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US PATENT NO. 6,557,540

Attorney Docket No.: 10541-070
Visteon Case No.: V200-0655

DECLARATION AND POWER OF ATTORNEY ORIGINAL APPLICATION

As a below named inventor, I hereby declare:

My residence, post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor or an original, first and joint inventor of the subject matter that is claimed and for which a patent is sought on the invention entitled:

METHOD OF CALCULATING A VALVE TIMING COMMAND FOR AN ENGINE

the specification of which is attached hereto.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge my duty to disclose to the United States Patent and Trademark Office all information that I know to be material to the patentability of this application as defined in Title 37 C.F.R. § 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s):			Priority Not Claimed
_____ (Number)	_____ (Country)	_____ (Filing Date)	☐
_____ (Number)	_____ (Country)	_____ (Filing Date)	☐
_____ (Number)	_____ (Country)	_____ (Filing Date)	☐

I hereby claim the benefit under 35 U.S. C. Section 119(e) of any United States provisional application(s) listed below:

_____ (Application Serial No.)	_____ (Filing Date)
_____ (Application Serial No.)	_____ (Filing Date)
_____ (Application Serial No.)	_____ (Filing Date)

PETITIONER'S EXHIBIT 1003
US PATENT NO. 6,557,540

I hereby claim the benefit un)5 U.S.C. Section 120 of any United St applications(s), or Section 365(c) of any PCT International Application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, C.F.R., Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

(Application Serial No.)	(Filing Date)	(Status: patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(Status: patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(Status: patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on 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 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorneys, agents, and each shareholder, attorney of counsel, associate, and employee of Brinks Hofer Gilson & Lione, who is a registered Patent Attorney or registered Patent Agent, my attorney with full power of substitution and revocation to prosecute this application and transact all business in the United States Patent and Trademark Office connected therewith and to act on my behalf before the competent International Authorities in connection with any and all international applications filed by me.

Steven L. Oberholtzer, Reg. No. 30,670
James E. Stephenson, Reg. No. 17,191
David D. Murray, Reg. No. 28,647
Eric J. Sosenko, Reg. No. 34,440
Jeffrey M. Cox, Reg. No. 42,445
Raymond J. Vivacqua, Reg. No. 45,369
J. Matthew Buchanan, Reg. No. 47,459
Sujatha Subramaniam, Reg. No. P48,739
Larry I. Shelton, Reg. No. 45,100
John Kajander, Reg. No. 47,693

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Sole or first inventor's signature	Lawrence A. Mianzo Date 11/21/2001
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Citizenship	US
Post Office Address	SAME AS RESIDENCE ADDRESS

PETITIONER'S EXHIBIT 1003
US PATENT NO. 6,557,540

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Second inventor's signature	Brett D. Collins Date 11/01/01
Residence	2298 Woodview Rd., #862, Ypsilanti, Michigan 48198
Citizenship	US
Post Office Address	SAME AS RESIDENCE ADDRESS

Full name of third inventor, if any	Ibrahim Haskara
Third inventor's signature	Date 11/02/01
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Citizenship	TR
Post Office Address	SAME AS RESIDENCE ADDRESS

Applicant's Docket

PETITIONER'S EXHIBIT 1003
IPR2015-00811
US PATENT NO. 6,557,540

3700

1-3

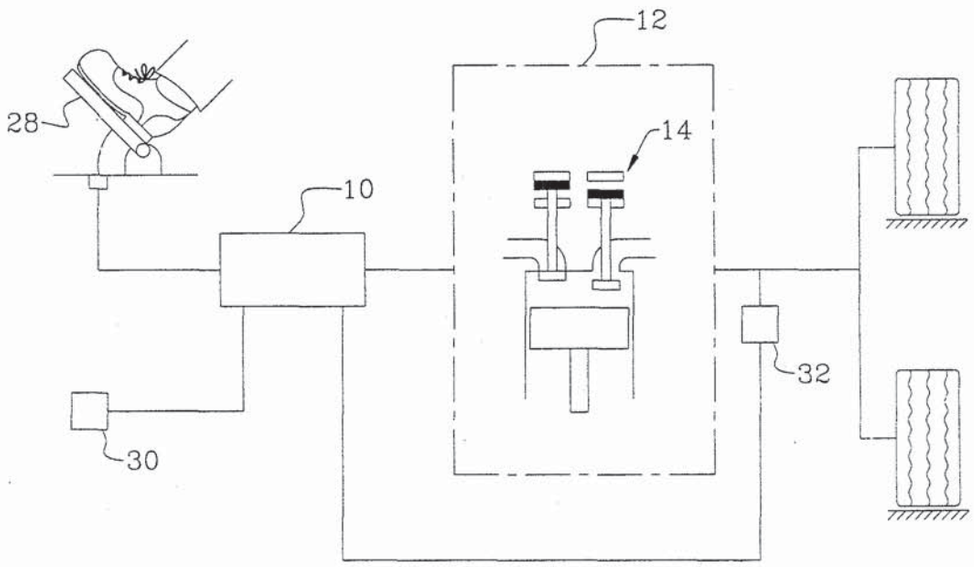


FIGURE 1

PRINT OF DRAWINGS
AS ORIGINALLY FII

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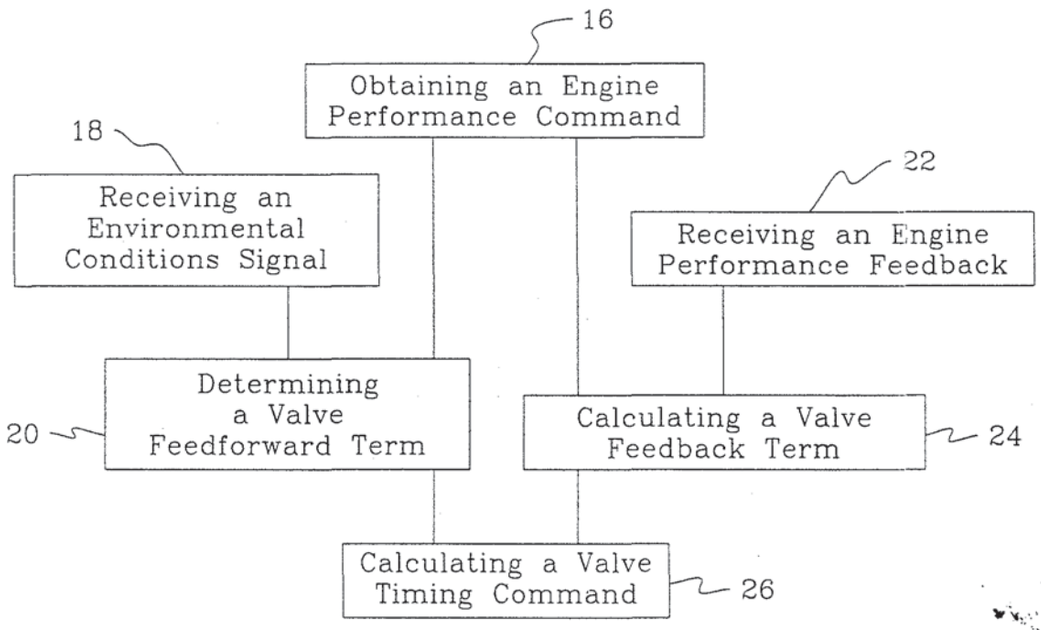


FIGURE 2

PETITIONER'S EXHIBIT 1003
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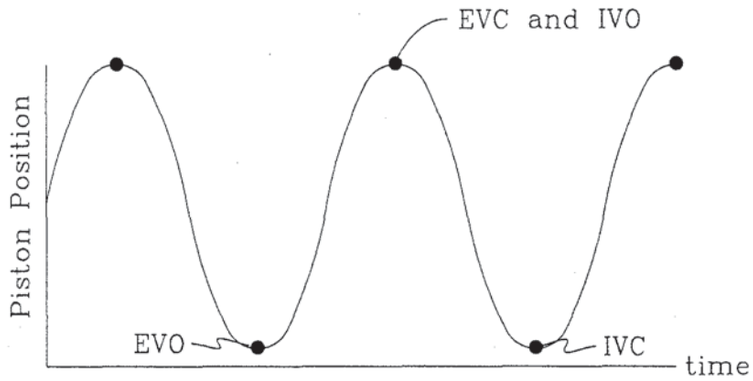


FIGURE 3A

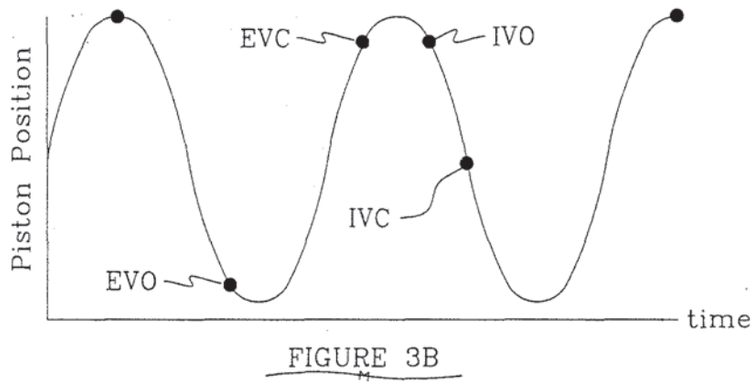


FIGURE 3B

PETITIONER'S EXHIBIT 1003
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6557540

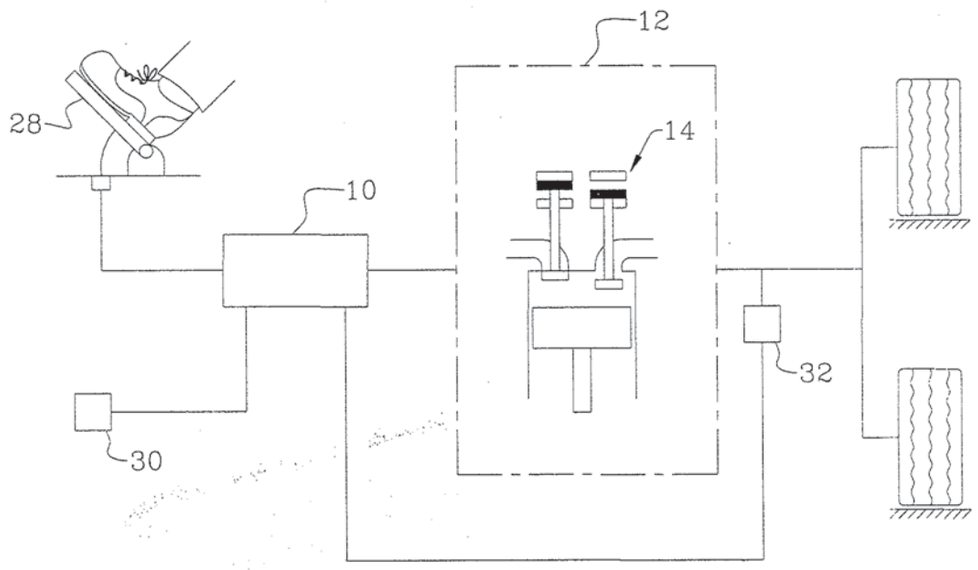


FIGURE 1

Document 1 of 1

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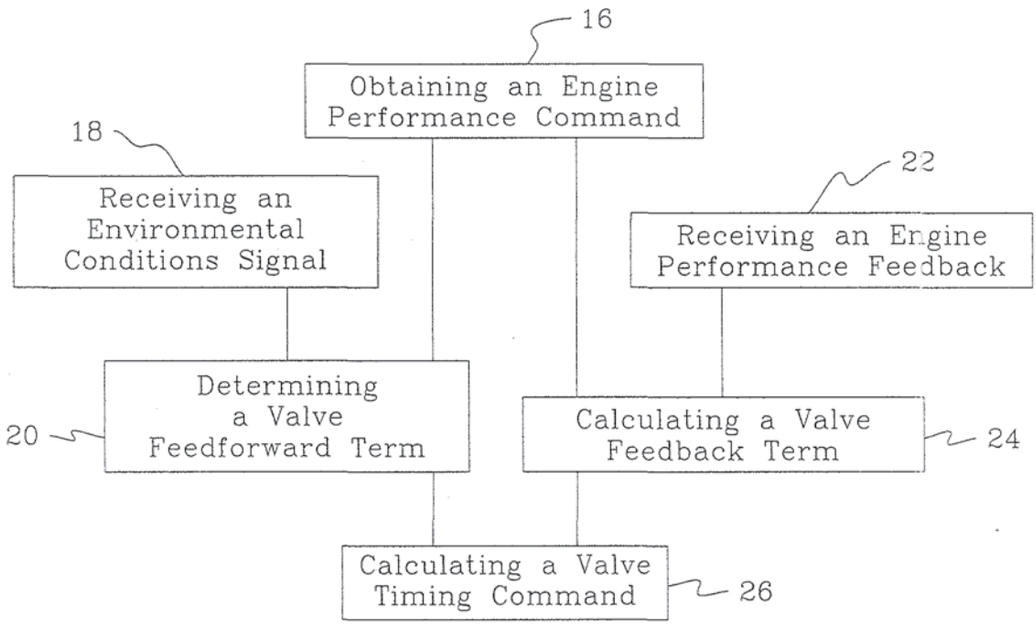


FIGURE 2

PETITIONER'S EXHIBIT 1003
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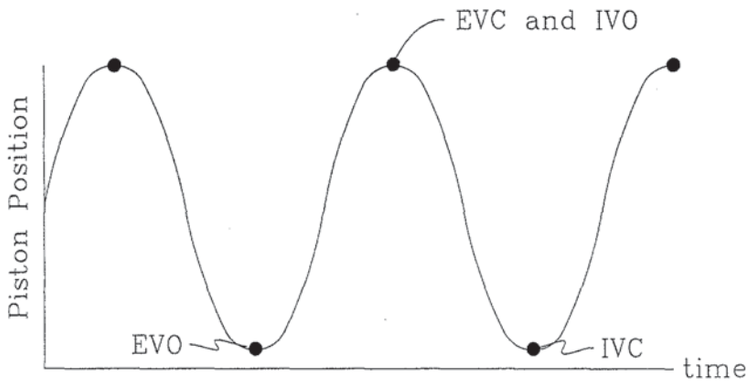


FIGURE 3A

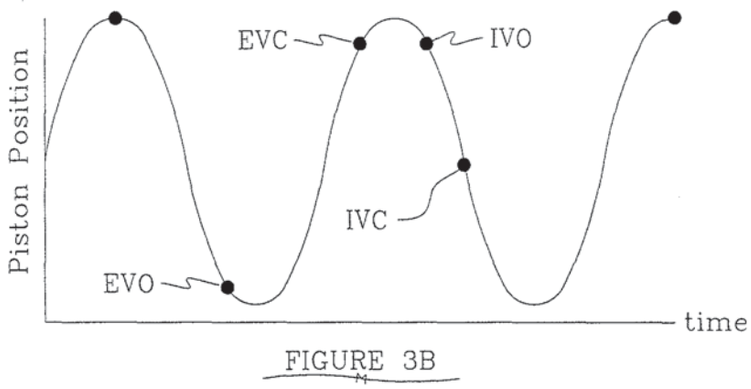


FIGURE 3B

PETITIONER'S EXHIBIT 1003
US PATENT NO. 6,557,540

PATENT
Attorney Docket No.: 10541-070

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

#2



Group Art Unit:	Unknown
Examiner:	Unknown
Inventors:	PENG, et al.
Serial No:	Unknown
Filed:	Concurrent Herewith
For:	METHOD OF CALCULATING A VALVE TIMING COMMAND FOR AN ENGINE

INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
Washington, DC 20231

Sir:

Under the duties of disclosure, candor, and good faith of 37 CFR §1.56, the Applicant hereby submits the references listed on the attached PTO-1449 form for consideration by the Examiner. In the opinion of the Applicant, the pending claims are patentably distinct from the listed references.

Under 37 CFR §1.97(b)(1), no fee should be required. If a fee is required, however, please charge any such fee pursuant to 37 CFR §1.16 or §1.17 to deposit account no. 06-1500.

Respectfully submitted,

Date: 11 December 2001

Jeffrey M. Cox
Reg. No. 42,445
Attorney for Applicant

BRINKS HOFER GILSON & LIONE
P.O. Box 10395
Chicago, IL 60610
(734) 302-6000

PETITIONER'S EXHIBIT 1003
US PATENT NO. 6,557,540

Notice of Allowability	Application No.	Applicant(s)	
	10/014,286	MIANZO ET AL.	
	Examiner	Art Unit	
	Erick R Solis	3747	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *the filing of 11 December 2001*.
2. ☒ The allowed claim(s) is/are *1-16*.
3. ☒ The drawings filed on *11 December 2001* are accepted by the Examiner.
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
      1. ☐ Certified copies of the priority documents have been received.
      2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
      3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.
5. ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).
   (a) ☐ The translation of the foreign language provisional application has been received.
6. ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application. **THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.**

7. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

8. ☐ CORRECTED DRAWINGS must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No. ____.
   (b) ☐ including changes required by the proposed drawing correction filed _____, which has been approved by the Examiner.
   (c) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No. _____.

Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the top margin (not the back) of each sheet. The drawings should be filed as a separate paper with a transmittal letter addressed to the Official Draftsperson.

9. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1☒ Notice of References Cited (PTO-892)
3☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
5☒ Information Disclosure Statements (PTO-1449), Paper No. *2*.
7☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
2☐ Notice of Informal Patent Application (PTO-152)
4☐ Interview Summary (PTO-413), Paper No.____ .
6☐ Examiner's Amendment/Comment
8☐ Examiner's Statement of Reasons for Allowance
9☐ Other

Erick R. Solis
Primary Examiner
Art Unit: 3747

PETITIONER'S EXHIBIT 1003
US PATENT NO. 6,557,540

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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Washington, D.C. 20231
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NOTICE OF ALLOWANCE AND FEE(S) DUE

29074 7590 12/11/2002

BRINKS HOFER GILSON & LIONE
P.O. BOX 10395
CHICAGO, IL 60611

EXAMINER	
SOLIS, ERICK R	
ART UNIT	CLASS-SUBCLASS
3747	123-679000

DATE MAILED: 12/11/2002

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/014,286	12/11/2001	Lawrence A. Mianzo	10541-070	3146

TITLE OF INVENTION: METHOD OF CALCULATING A VALVE TIMING COMMAND FOR AN ENGINE

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1280	$300	$1580	03/11/2003

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE REFLECTS A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE APPLIED IN THIS APPLICATION. THE PTOL-85B (OR AN EQUIVALENT) MUST BE RETURNED WITHIN THIS PERIOD EVEN IF NO FEE IS DUE OR THE APPLICATION WILL BE REGARDED AS ABANDONED.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:
A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status is changed, pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above and notify the United States Patent and Trademark Office of the change in status, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check the box below and enclose the PUBLICATION FEE and 1/2 the ISSUE FEE shown above.

☐ Applicant claims SMALL ENTITY status. See 37 CFR 1.27.

II. PART B - FEE(S) TRANSMITTAL should be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). Even if the fee(s) have already been paid, Part B - Fee(s) Transmittal should be completed and returned. If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Box ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PTOL-85 (REV. 04-02) Approved for use through 01/31/2004.

PETITIONER'S EXHIBIT 1003
US PATENT NO. 6,557,540

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail Box ISSUE FEE
Commissioner for Patents
Washington, D.C. 20231
Fax (703)746-4000

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 4 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Legibly mark-up with any corrections or use Block 1)

29074 7590 12/11/2002

BRINKS HOFER GILSON & LIONE
P.O. BOX 10395
CHICAGO, IL 60611

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Box Issue Fee address above, or being facsimile transmitted to the USPTO, on the date indicated below.

(Depositor's name)

(Signature)

(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/014,286	12/11/2001	Lawrence A. Mianzo	10541-070	3146

TITLE OF INVENTION: METHOD OF CALCULATING A VALVE TIMING COMMAND FOR AN ENGINE

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1280	$300	$1580	03/11/2003

EXAMINER	ART UNIT	CLASS-SUBCLASS
SOLIS, ERICK R	3747	123-679000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list (1) the names of up to 3 registered patent attorneys or agents OR, alternatively, (2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1_____

2_____

3_____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. Inclusion of assignee data is only appropriate when an assignment has been previously submitted to the USPTO or is being submitted under separate cover. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) ❑ individual ❑ corporation or other private group entity ❑ government

4a. The following fee(s) are enclosed:

❑ Issue Fee

❑ Publication Fee

❑ Advance Order - # of Copies _____

4b. Payment of Fee(s):

❑ A check in the amount of the fee(s) is enclosed.

❑ Payment by credit card. Form PTO-2038 is attached.

❑ The Commissioner is hereby authorized by charge the required fee(s), or credit any overpayment, to Deposit Account Number _____(enclose an extra copy of this form).

Commissioner for Patents is requested to apply the Issue Fee and Publication Fee (if any) or to re-apply any previously paid issue fee to the application identified above.

(Authorized Signature) (Date)

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, Washington, D.C. 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, Washington, DC 20231.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

TRANSMIT THIS FORM WITH FEE(S)

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/014,286	12/11/2001	Lawrence A. Mianzo	10541-070	3146

29074 7590 12/11/2002

BRINKS HOFER GILSON & LIONE
P.O. BOX 10395
CHICAGO, IL 60611

EXAMINER	
SOLIS, ERICK R	
ART UNIT	**PAPER NUMBER**
3747	

DATE MAILED: 12/11/2002

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The patent term adjustment to date is 0 days. If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the term adjustment will be 0 days.

If a continued prosecution application (CPA) was filed in the above-identified application, the filing date that determines patent term adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) system. (http://pair.uspto.gov)

Any questions regarding the patent term extension or adjustment determination should be directed to the Office of Patent Legal Administration at (703)305-1383.

PTOL-85 (REV. 04-02) Approved for use through 01/31/2004.

PETITIONER'S EXHIBIT 1003
US PATENT NO. 6,557,540

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/014,286	12/11/2001	Lawrence A. Mianzo	10541-070	3146

29074 7590 12/11/2002

BRINKS HOFER GILSON & LIONE
P.O. BOX 10395
CHICAGO, IL 60611
UNITED STATES

EXAMINER	
SOLIS, ERICK R	
ART UNIT	**PAPER NUMBER**
3747	

DATE MAILED: 12/11/2002

Notice of Fee Increase on January 1, 2003

If a reply to a "Notice of Allowance and Fee(s) Due" is filed in the Office on or after January 1, 2003, then the amount due will be higher than that set forth in the "Notice of Allowance and Fee(s) Due" since there will be an increase in fees effective on January 1, 2003. See Revision of Patent and Trademark Fees for Fiscal Year 2003; Final Rule, 67 Fed. Reg. 70847, 70849 (November 27, 2002).

The current fee schedule is accessible from: http://www.uspto.gov/main/howtofees.htm.

If the issue fee paid is the amount shown on the "Notice of Allowance and Fee(s) Due," but not the correct amount in view of the fee increase, a "Notice to Pay Balance of Issue Fee" will be mailed to applicant. In order to avoid processing delays associated with mailing of a "Notice to Pay Balance of Issue Fee," if the response to the Notice of Allowance and Fee(s) due form is to be filed on or after January 1, 2003 (or mailed with a certificate of mailing on or after January 1, 2003), the issue fee paid should be the fee that is required at the time the fee is paid. If the issue fee was previously paid, and the response to the "Notice of Allowance and Fee(s) Due" includes a request to apply a previously-paid issue fee to the issue fee now due, then the difference between the issue fee amount at the time the response is filed and the previously paid issue fee should be paid. See Manual of Patent Examining Procedure, Section 1308.01 (Eighth Edition, August 2001).

Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at (703) 305-8283.

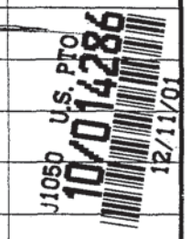
PTOL-85 (REV. 04-02) Approved for use through 01/31/2004.

PETITIONER'S EXHIBIT 1003
US PATENT NO. 6,557,540

INFORMATION DISCLOSURE CITATION *(Use several sheets if necessary)*	Docket Number (Optional) 10541-070	Application Number Unknown
	Applicant(s) Peng et al.	
	Filing Date Concurrent Herewith	Group Art Unit ~~Unknown~~ 3747

U.S. PATENT DOCUMENTS

*EXAMINER INITIAL	REF	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
ES		4,700,684	10/20/87	Pischinger et al.			
ES		5,743,221	04/28/98	Schmitz			
ES		5,752,491	05/19/98	Schmitz et al.			



FOREIGN PATENT DOCUMENTS

	REF	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS *(Including Author, Title, Date, Pertinent. Pages, Etc)*

EXAMINER	DATE CONSIDERED
Erik R Sole	12/9/2002

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP Section 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

FORM PTO-A820 P09A/REV04 Patent and Trademark Office*U.S. DEPARTMENT OF COMMERCE (also form PTO-1449)

SHEET 1 OF 1

PETITIONER'S EXHIBIT 1003
US PATENT NO. 6,557,540

Notice of References Cited	Application/Control No. 10/014,286	Applicant(s)/Patent Under Reexamination MIANZO ET AL.	
	Examiner Erick R Solis	Art Unit 3747	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
X	A	US-6,196,174	03-2001	Wada et al.	123/90.15
X	B	US-6,053,137	04-2000	Trzmiel et al.	123/90.17
X	C	US-2002/0092488	07-2002	Aoyama et al.	123/90.16
X	D	US-2001/0013324	08-2001	Yoshizawa et al.	123/90.16
X	E	US-2001/0004884	06-2001	Tachibana et al.	123/90.15
X	F	US-6,330,869	12-2001	Yoshiki et al.	123/90.15
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail Box ISSUE FEE
Commissioner for Patents
Washington, D.C. 20231
Fax (703)746-4000

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 4 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Legibly mark-up with any corrections or use Block 1)

29074 7590 12/11/2002

BRINKS HOFER GILSON & LIONE
P.O. BOX 10395
CHICAGO, IL 60611



Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Box Issue Fee address above, or being facsimile transmitted to the USPTO, on the date indicated below.

Jeffrey M. Cox	(Depositor's name)
	(Signature)
10 March 2003	(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/014,286	12/11/2001	Lawrence A. Mianzo	10541-070	3146

TITLE OF INVENTION: METHOD OF CALCULATING A VALVE TIMING COMMAND FOR AN ENGINE

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	~~$1280~~ $1300	$300	~~$1580~~ $1600	03/11/2003

EXAMINER	ART UNIT	CLASS-SUBCLASS
SOLIS, ERICK R	3747	123-679000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list (1) the names of up to 3 registered patent attorneys or agents OR, alternatively, (2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Brinks Hofer Gilson & Lione
2
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. Inclusion of assignee data is only appropriate when an assignment has been previously submitted to the USPTO or is being submitted under separate cover. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: Visteon Global Technologies, Inc.

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Dearborn, Michigan

Please check the appropriate assignee category or categories (will not be printed on the patent) ☐ individual ☒ corporation or other private group entity ☐ government

4a. The following fee(s) are enclosed:

☒ Issue Fee
☒ Publication Fee
☐ Advance Order - # of Copies _____

4b. Payment of Fee(s):

☐ A check in the amount of the fee(s) is enclosed.
☐ Payment by credit card. Form PTO-2038 is attached.
☒ The Commissioner is hereby authorized by charge the required fee(s), or credit any overpayment, to Deposit Account Number 06-1500 (enclose an extra copy of this form).

Commissioner for Patents is requested to apply the Issue Fee and Publication Fee (if any) or to re-apply any previously paid issue fee to the application identified above.

(Authorized Signature) Jeffrey M. Cox
Reg. No. 42,445

(Date) 3/10/2003

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

10/014,286

03/20/2003 STEUMEL2 00000072 061500 10014286

01 FC:1501 1300.00 CH
02 FC:1504 300.00 CH

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, Washington, D.C. 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, Washington, DC 20231.

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TRANSMIT THIS FORM WITH FEE(S)

PTOL-85 (REV. 04-02) Approved for use through 01/31/2004. OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

PETITIONER'S EXHIBIT 1003
US PATENT NO. 6,557,540

OIPE JC66 JUN 12 2003 PATENT & TRADEMARK OFFICE

3747

Attorney Docket No.: 10541-070

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:
Mianzo et al.

Serial No.: 10/014,286

Filed: December 11, 2001

For: METHOD OF CALCULATING A VALVE TIMING COMMAND FOR AN ENGINE

Examiner: Erick R. Solis

Group Art Unit: 3747

TRANSMITTAL

Commissioner for Patents
U.S. Patent and Trademark Office
P. O. Box 1450
Alexandria, VA 22313-1450

RECEIVED
JUN 16 2003
TECHNOLOGY CENTER R3700

Sir:

Attached is/are:

- ☒ Information Disclosure Statement
- ☒ Form PTO - 1449 with copy of references
- ☐
- ☒ Return Receipt Postcard

Fee calculation and payment:

- ☐ No additional fee is required.
- ☐ An extension fee in an amount of $_____ for a _____-month extension of time under 37 C.F.R. § 1.136(a).
- ☒ A petition or processing fee in an amount of $180.00 under 37 C.F.R. § 1.17(p).
- ☐ An additional filing fee has been calculated as shown below:

	Claims Remaining After Amendment		Highest No. Previously Paid For	Present Extra
Total		Minus		
Indep.		Minus		
First Presentation of Multiple Dep. Claim				

Small Entity		or	Other Than Small Entity	
Rate	Add'l Fee		Rate	Add'l Fee
x $9=			x $18=	
x 42=			x $84=	
+$140=			+ $280=	
Total	$		Total	$

- ☐ A check in the amount of $_____ to cover the above-identified fee(s) is enclosed.
- ☒ Please charge Deposit Account No. 06-1500 (VISTEON GLOBAL TECHNOLOGIES, INC.) in the amount of $180.00. A copy of this Transmittal is enclosed for this purpose.
- ☒ The Commissioner is hereby authorized to charge payment of any additional filing fees required under 37 CFR § 1.16 and any patent application processing fees under 37 CFR § 1.17 associated with this paper (including any extension fee required to ensure that this paper is timely filed), or to credit any overpayment, to Deposit Account No. 06-1500. A copy of this Transmittal is enclosed for this purpose.

Respectfully submitted,

June 9, 2003
Date

Eric J. Sosenko (Reg. No. 34,440)
☒ Attorney/Agent Of Record
☐ 37 C.F.R. 1.34(a)

CERTIFICATE OF MAILING UNDER 37 C.F.R. §1.8

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail, with sufficient postage, in an envelope addressed to: Commissioner for Patents, U.S. Patent and Trademark Office, P. O. Box 1450, Alexandria, VA 22313-1450, on the below date:

Date: June 9, 2003 Name: Ashley L. Rhoades Signature: Ashley L. Rhoades

BRINKS HOFER GILSON & LIONE
P.O. Box 10395
Chicago, IL 60610

PETITIONER'S EXHIBIT 1003
US PATENT NO. 6,557,540

PE JC66
JUN 12 2003
PATENT & TRADEMARK OFFICE

Attorney Docket No.: 10541-070

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Mianzo et al.	
Serial No.: 10/014,286	Examiner: Erick R. Solis
Filed: December 11, 2001	Group Art Unit: 3747
For: METHOD OF CALCULATING A VALVE TIMING COMMAND FOR AN ENGINE	

INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
U.S. Patent and Trademark Office
P. O. Box 1450
Alexandria, VA 22313-1450

RECEIVED
JUN 16 2003
TECHNOLOGY CENTER R3700

Sir:

In accordance with the duty of disclosure under 37 C.F.R. §1.56, and more particularly in accordance with 37 C.F.R. §1.97(d), Applicant cites the following references (each listed for the Examiner's convenience on the enclosed Form PTO-1449):

DOCUMENT NUMBER	DATE	NAME
5,123,397	06/23/1992	Richeson
5,967,115	10/19/1999	Konopka et al.

A copy of each listed reference for which a copy is required under 37 C.F.R. §1.98(a)(2) is also enclosed. Applicant respectfully solicits the Examiner's consideration of the listed references and entry thereof into the record of this application.

06/13/2003 SSESHE1 00000060 061500 10014286
01 FC:1806 180.00 CH

BRINKS HOFER GILSON & LIONE
P.O. Box 10395
Chicago, IL 60610

PETITIONER'S EXHIBIT 1003
US PATENT NO. 6,557,540

By submitting this Statement, Applicant is attempting to fully comply with the duty of candor and good faith mandated by 37 C.F.R. §1.56. As such, this Statement is not intended to constitute an admission that any of the enclosed references, or other information referred to therein, constitutes "prior art" or is otherwise "material to patentability," as that phrase is defined in 37 C.F.R. §1.56(a).

Applicant hereby certifies that each item of information in this Statement was first cited in a communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of this Statement.

Applicant has also calculated a processing fee in the amount of $180.00 to be due under 37 C.F.R. §1.17(p) in connection with the filing of this Statement. Applicant has enclosed a check covering this fee, or authorized charging the fee to a deposit account, as indicated in the Transmittal accompanying this Statement.

Respectfully submitted,

June 9, 2003
Date

Eric J. Sosenko (Reg. No. 34,440)

Enclosures: Form PTO-1449 (one sheet)
Copies of listed references

BRINKS HOFER GILSON & LIONE
P.O. Box 10395
Chicago, IL 60610

PETITIONER'S EXHIBIT 1003
US PATENT NO. 6,557,540

INFORMATION DISCLOSURE CITATION *(Use several sheets if necessary)*	Docket Number (Optional) 10541-070	Application Number 10/014,286
	Applicant(s) Mianzo et al.	
	December 11, 2001	Group Art Unit 3747

O I P E JC66 JUN 12 2003 PATENT & TRADEMARK OFFICE

RECEIVED
JUN 16 2003
TECHNOLOGY CENTER R3700

6/25/03

U.S. PATENT DOCUMENTS

*EXAMINER INITIAL	REF	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
		~~5,123,397~~	~~06/23/1992~~	~~Richeson~~			
		~~5,967,115~~	~~10/19/1999~~	~~Konopka et al.~~			

FOREIGN PATENT DOCUMENTS

	REF	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS *(Including Author, Title, Date, Pertinent. Pages, Etc)*

EXAMINER	DATE CONSIDERED

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP Section 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

UNITED STATES PATENT AND TRADEMARK OFFICE

111

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/014,286	12/11/2001	Lawrence A. Mianzo	10541-070	3146

29074 7590 07/08/2003

BRINKS HOFER GILSON & LIONE
P.O. BOX 10395
CHICAGO, IL 60611

EXAMINER	
SOLIS, ERICK R	
ART UNIT	**PAPER NUMBER**
3747	5

DATE MAILED: 07/08/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

PTO-90C (Rev. 07-01)

PETITIONER'S EXHIBIT 1003
US PATENT NO. 6,557,540

UNITED STATES DEPARTMENT OF COMMERCE
U.S. Patent and Tra ark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450

APPLICATION NO./ CONTROL NO.	FILING DATE	FIRST NAMED INVENTOR / PATENT IN REEXAMINATION	ATTORNEY DOCKET NO.

EXAMINER

ART UNIT	PAPER
	5

DATE MAILED:

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner for Patents

Aknowledgement of Receipt of Information Disclosure Statement

The Information Disclosure Statement received on 12 June 2003 has been received and entered into the file of this application. This Information Disclosure Statement does not comply with MPEP 609 as it has been received after the payment of the issue fee and as a matter of fact after the publication of the patent. Therefore, the cited references have not been considered.

Erick R Solis
Primary Examiner
Art Unit: 3747
(703) 308-2651

PTO-90C (Rev.04-03)

PETITIONER'S EXHIBIT 1003
US PATENT NO. 6,557,540

PATENT APPLICATION SERIAL NO. _____

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE
FEE RECORD SHEET

12/18/2001 MAHMED1 00000001 061500 10014286
01 FC:101 740.00 CH

PTO-1556
(5/87)

*U.S. GPO: 2000-468-987/39595

PETITIONER'S EXHIBIT 1003
US PATENT NO. 6,557,540

PATENT APPLICATION FEE DETERMINATION RECORD
Effective October 1, 2001

Application or Docket Number: 10014286

CLAIMS AS FILED - PART I

	(Column 1)	(Column 2)
TOTAL CLAIMS	16	
FOR	NUMBER FILED	NUMBER EXTRA
TOTAL CHARGEABLE CLAIMS	16 minus 20=	* —
INDEPENDENT CLAIMS	1 minus 3 =	* —
MULTIPLE DEPENDENT CLAIM PRESENT		☐

* If the difference in column 1 is less than zero, enter "0" in column 2

SMALL ENTITY TYPE ☐		OR	OTHER THAN SMALL ENTITY	
RATE	FEE		RATE	FEE
BASIC FEE	370.00	OR	BASIC FEE	740.00
X$ 9=		OR	X$18=	
X42=		OR	X84=	
+140=		OR	+280=	
TOTAL		OR	TOTAL	740

CLAIMS AS AMENDED - PART II

AMENDMENT A

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
RATE	ADDI-TIONAL FEE		RATE	ADDI-TIONAL FEE
X$ 9=		OR	X$18=	
X42=		OR	X84=	
+140=		OR	+280=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT B

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

RATE	ADDI-TIONAL FEE		RATE	ADDI-TIONAL FEE
X$ 9=		OR	X$18=	
X42=		OR	X84=	
+140=		OR	+280=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT C

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

RATE	ADDI-TIONAL FEE		RATE	ADDI-TIONAL FEE
X$ 9=		OR	X$18=	
X42=		OR	X84=	
+140=		OR	+280=	
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* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
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***If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3."
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

CLAIMS ONLY

SERIAL NO.	FILING DATE
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CLAIMS

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* *MAY BE USED FOR ADDITIONAL CLAIMS OR ADMENDMENTS*

FORM PTO-2022 (1-98)

U.S.DEPARTMENT OF COMMERCE
Patent and Trademark Office

PETITIONER'S EXHIBIT 1003
US PATENT NO. 6,557,540

ISSUE SLIP STAPLE AREA (for additional cross-references)

ISSUING CLASSIFICATION

ORIGINAL		CROSS REFERENCE(S)	
CLASS	SUBCLASS	CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)
123	878	123	90.15
INTERNATIONAL CLASSIFICATION		701	103
F01L	1134		
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INDEX OF CLAIMS

✓ ..... Rejected – (Through numeral) ... Canceled N ..... Non-elected A ..... Appeal
= ..... Allowed ÷ ..... Restricted I ..... Interference O ..... Objected

Claim Final	Claim Original	Date
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SEARCH

Class	Sub.	Date	Exmr.
123	678	12/9/02	ES
	90.15	↓	↓
	90.19		
701	103	12/9/02	ES

INTERFERENCE SEARCHED

Class	Sub.	Date	Exmr.
123	678	12/9/02	ES
	90.15		↓
	90.19	12/9/02	ES

SEARCH NOTES

(List databases searched. Attach search strategy inside.)

	Date	Exmr.
None	12/9/02	ES

HMC EXHIBIT 1003
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US PATENT NO. 6,557,540

US005713317A

United States Patent [19]

Yoshioka

[11] Patent Number: 5,713,317

[45] Date of Patent: Feb. 3, 1998

[54] **METHOD OF AND APPARATUS FOR CONTINUOUSLY AND VARIABLY CONTROLLING VALVE TIMING OF INTERNAL COMBUSTION ENGINE**

[75] Inventor: **Mamoru Yoshioka**, Susono, Japan

[73] Assignee: **Toyota Jidosha Kabushiki Kaisha**, Aichi, Japan

[21] Appl. No.: **684,592**

[22] Filed: **Jul. 15, 1996**

[30] **Foreign Application Priority Data**

Jul. 26, 1995 [JP] Japan 7-190524

[51] **Int. Cl.**[6] **F02D 13/02**; F01L 1/34

[52] **U.S. Cl.** **123/90.15**; 123/90.17

[58] **Field of Search** 123/90.15, 90.16, 123/90.17, 90.18, 90.31

[56] **References Cited**

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5,494,008 2/1996 Ohkawa et al. 123/90.15

FOREIGN PATENT DOCUMENTS

3-82845 8/1991 Japan .
3-99844 10/1991 Japan .
4-175430 6/1992 Japan .

Primary Examiner—Weilun Lo
Attorney, Agent, or Firm—Kenyon & Kenyon

[57] **ABSTRACT**

A method or an apparatus controls a continuously variable valve timing mechanism of an internal combustion engine to continuously and variably control the timing of an intake valve according to atmospheric pressure. The method or apparatus reads an engine revolution speed NE, an engine load GN, and an atmospheric pressure PA, refers to a map according to the atmospheric pressure PA, to find an atmospheric pressure correction coefficient Kpa, which is 1.0 at low altitudes with PA=760 mmHg and decreases as the altitude increases, i.e., as the atmospheric pressure PA decreases, calculates a corrected engine load GNpa as GNpa←GN/Kpa, and refers to a map according to the corrected engine load GNpa and engine revolution speed NE, to find a target displacement to be imposed on the open/close timing of the intake valve.

6 Claims, 15 Drawing Sheets

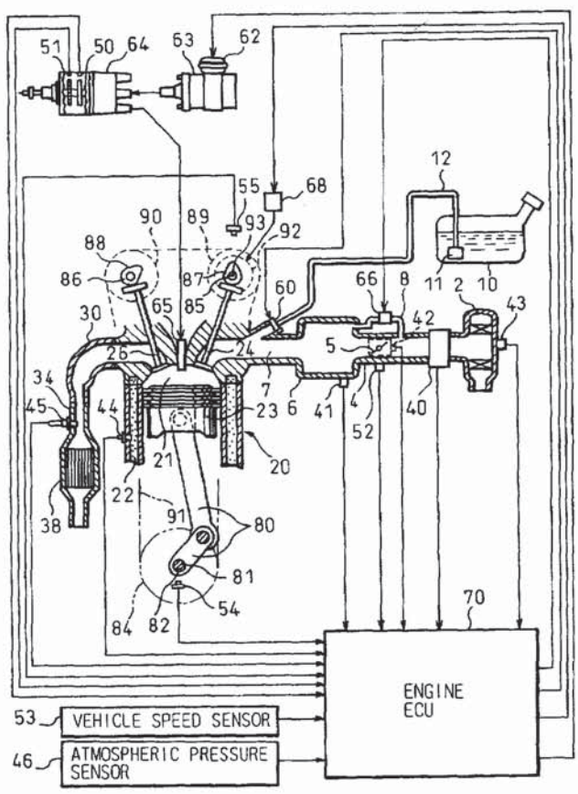
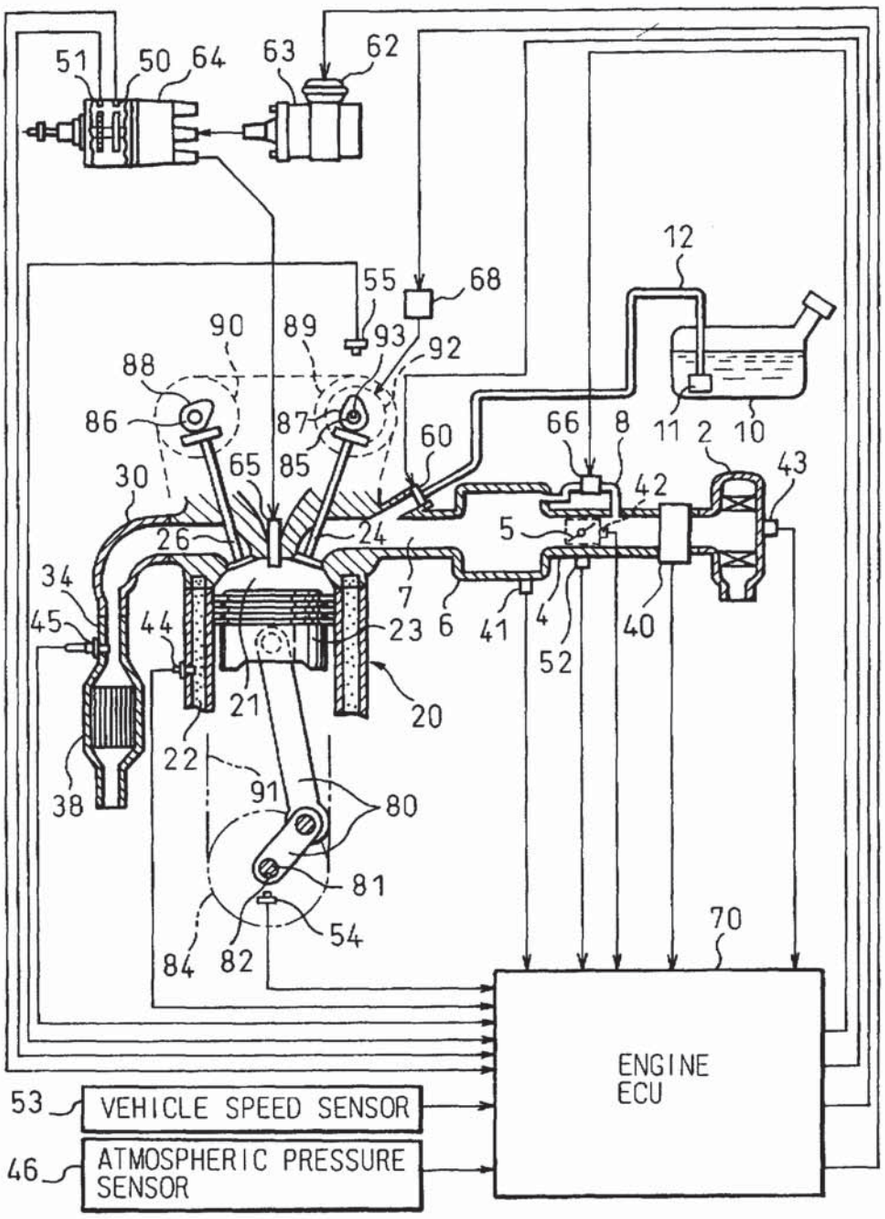
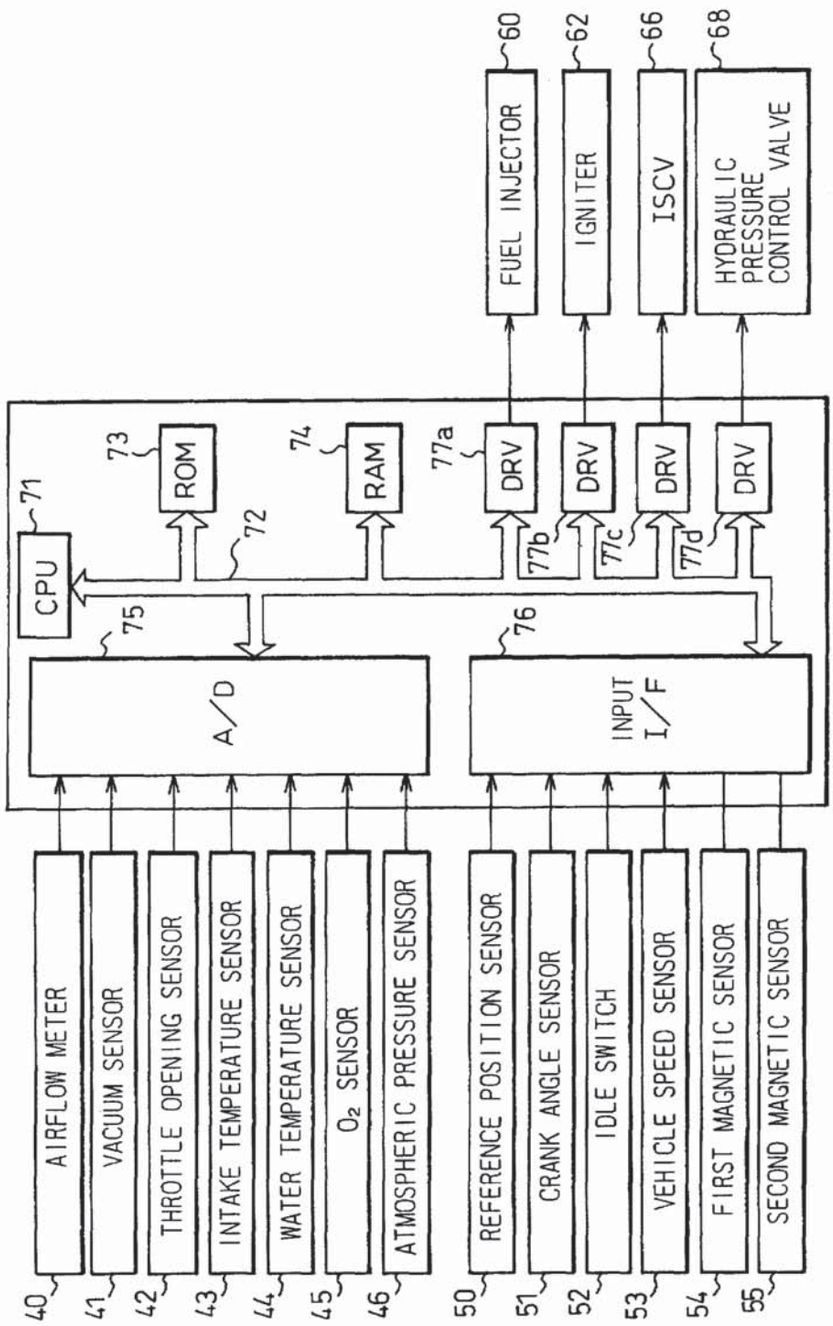


Fig. 1



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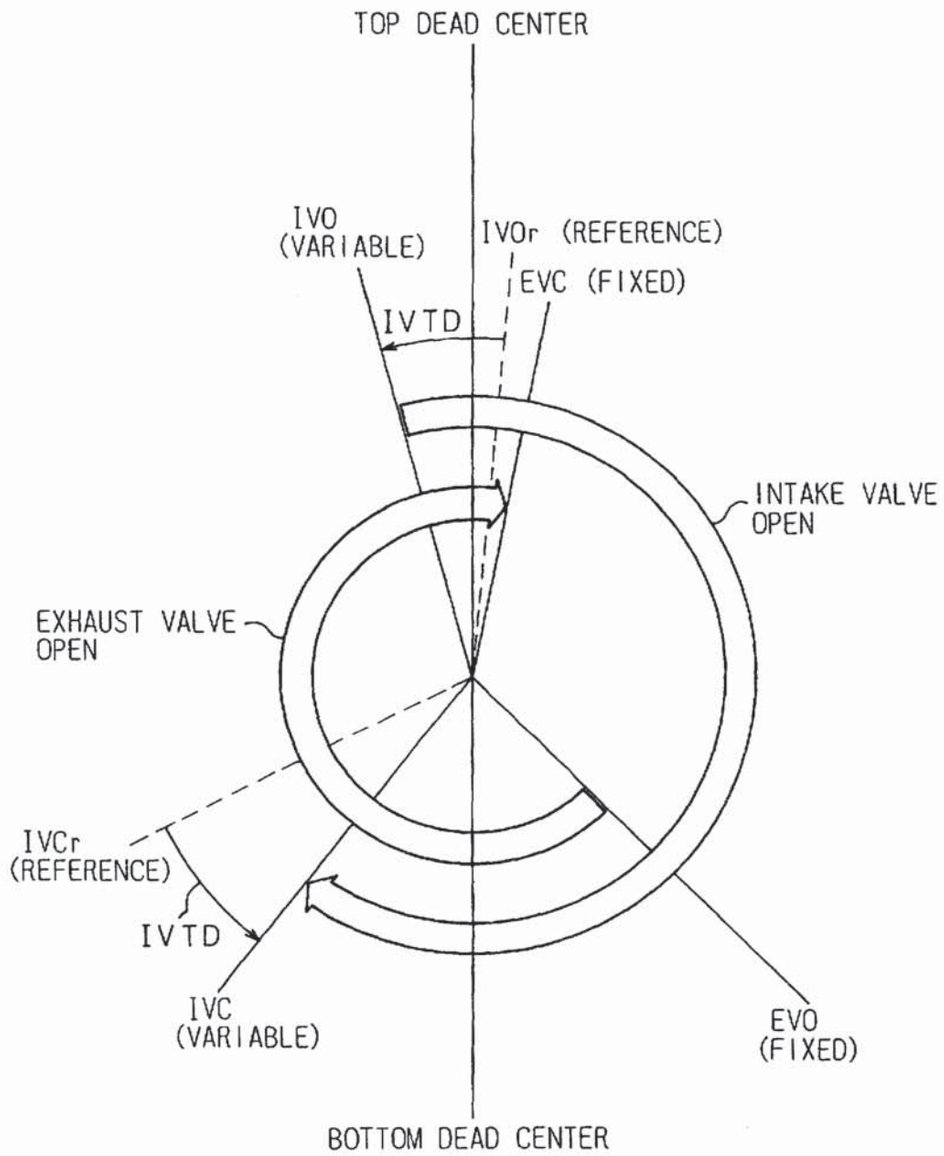
Fig.2



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Fig. 3



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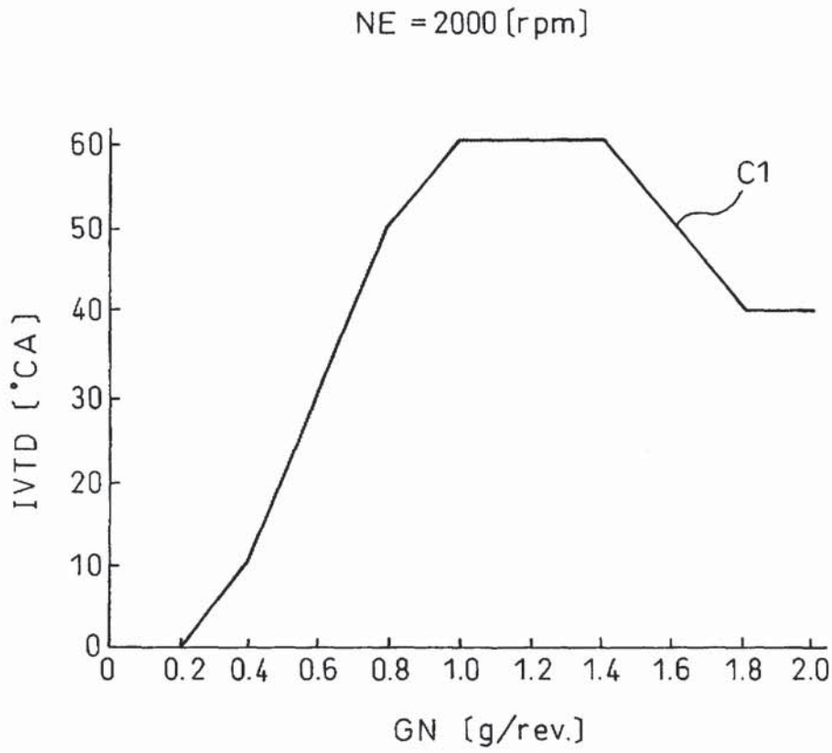
Fig. 4

ENGINE REVOLUTION SPEED NE [rpm]

ENGINE LOAD GN [g/rev.]	800	1200	1600	2000	~	6000	6400
0.2	0	0	0	0	~	0	0
0.4	0	5	10	10	~	5	5
0.6	5	20	30	30	~	10	10
0.8	20	40	50	50	~	20	20
1.0	35	55	60	60	~	20	20
1.2	40	60	60	60	~	10	10
1.4	30	55	60	60	~	5	5
1.6	30	50	50	50	~	5	5
1.8	30	50	40	40	~	5	0
2.0	30	50	40	40	~	5	0

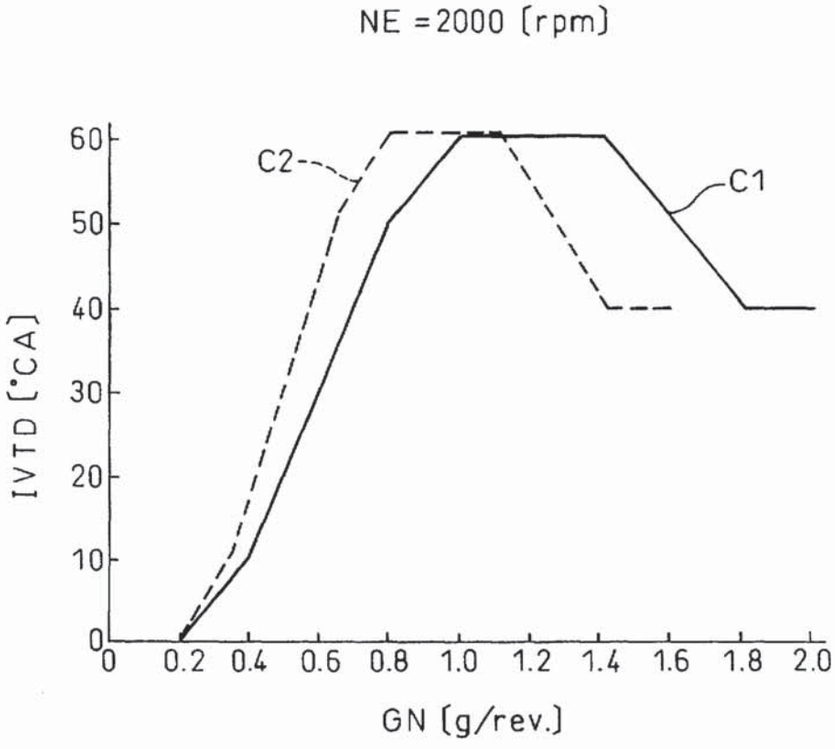
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Fig. 5



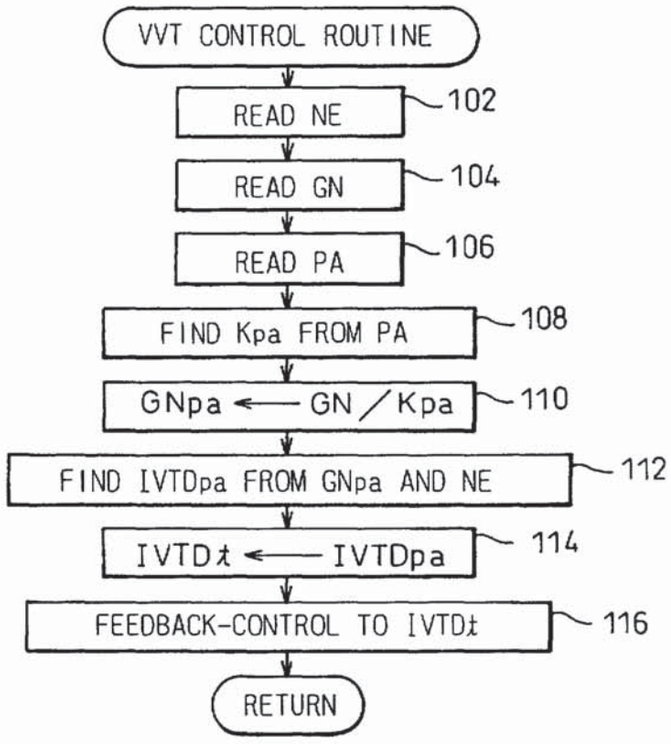
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Fig. 6



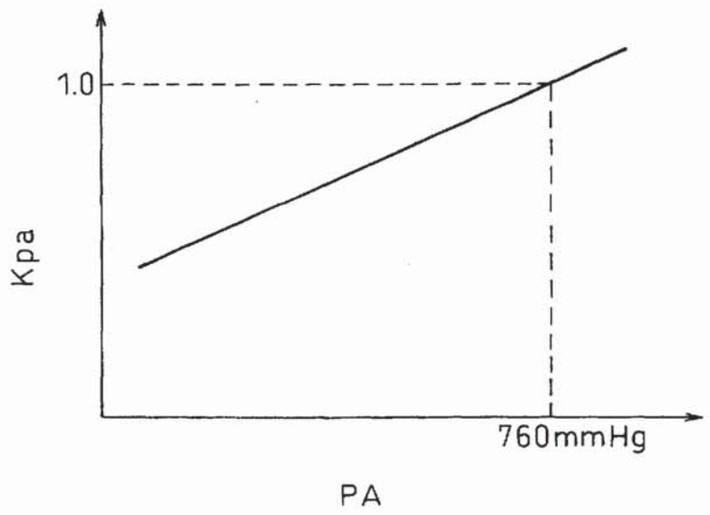
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Fig. 7



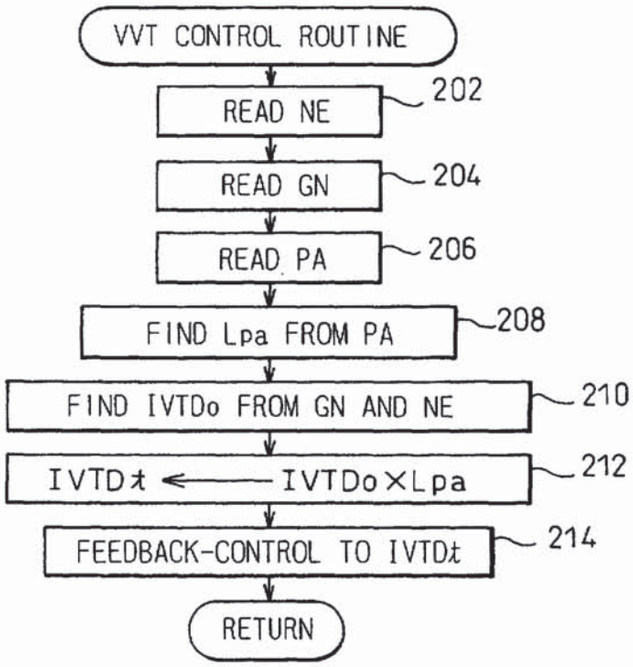
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Fig. 8



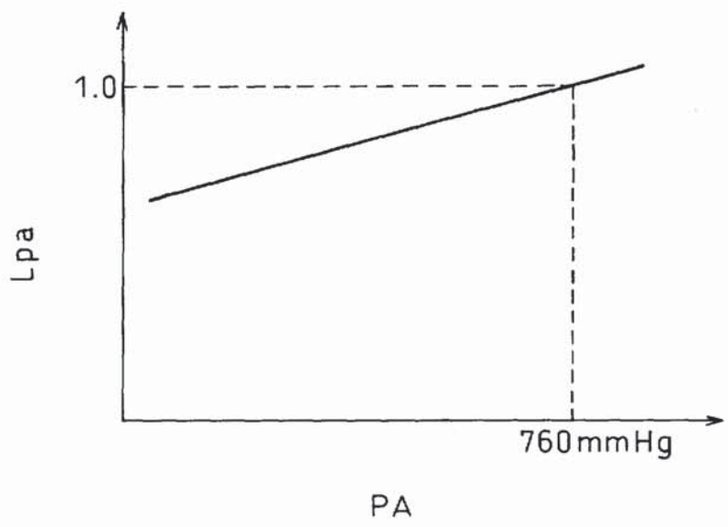
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Fig. 9



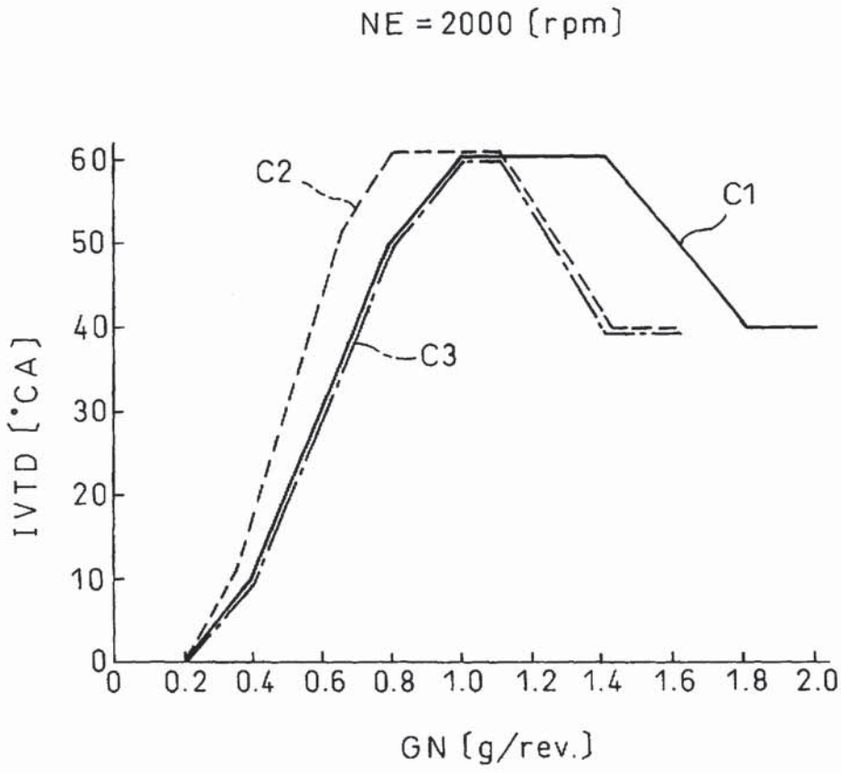
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Fig. 10



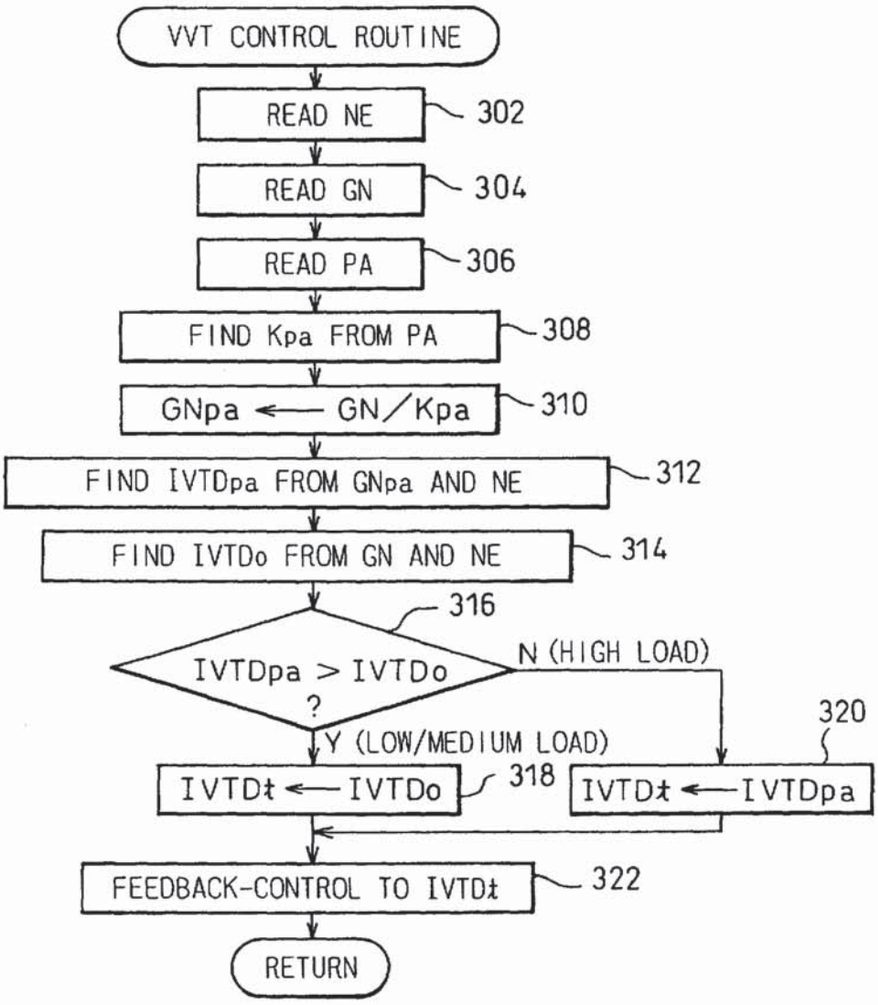
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Fig.11



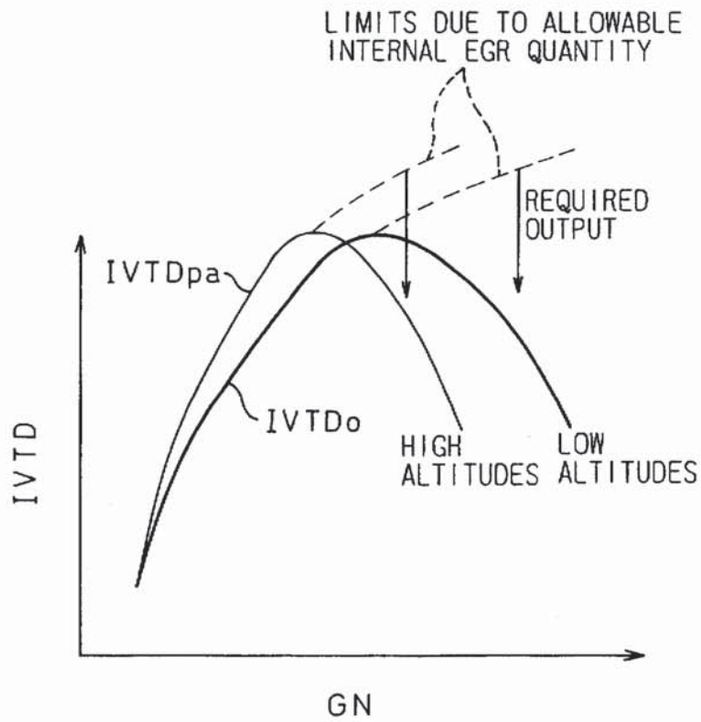
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Fig. 12



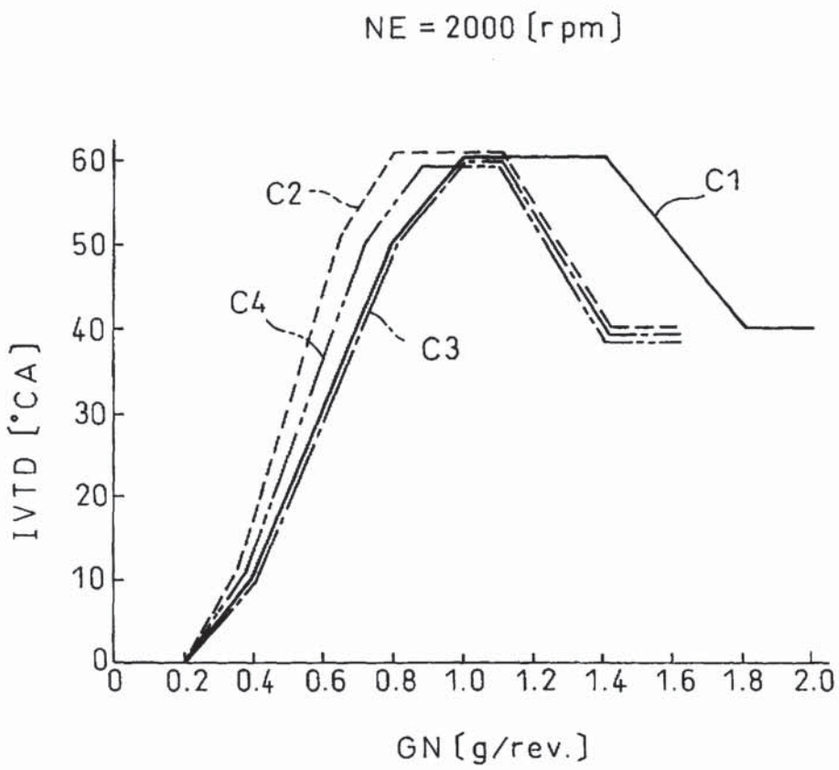
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Fig. 13



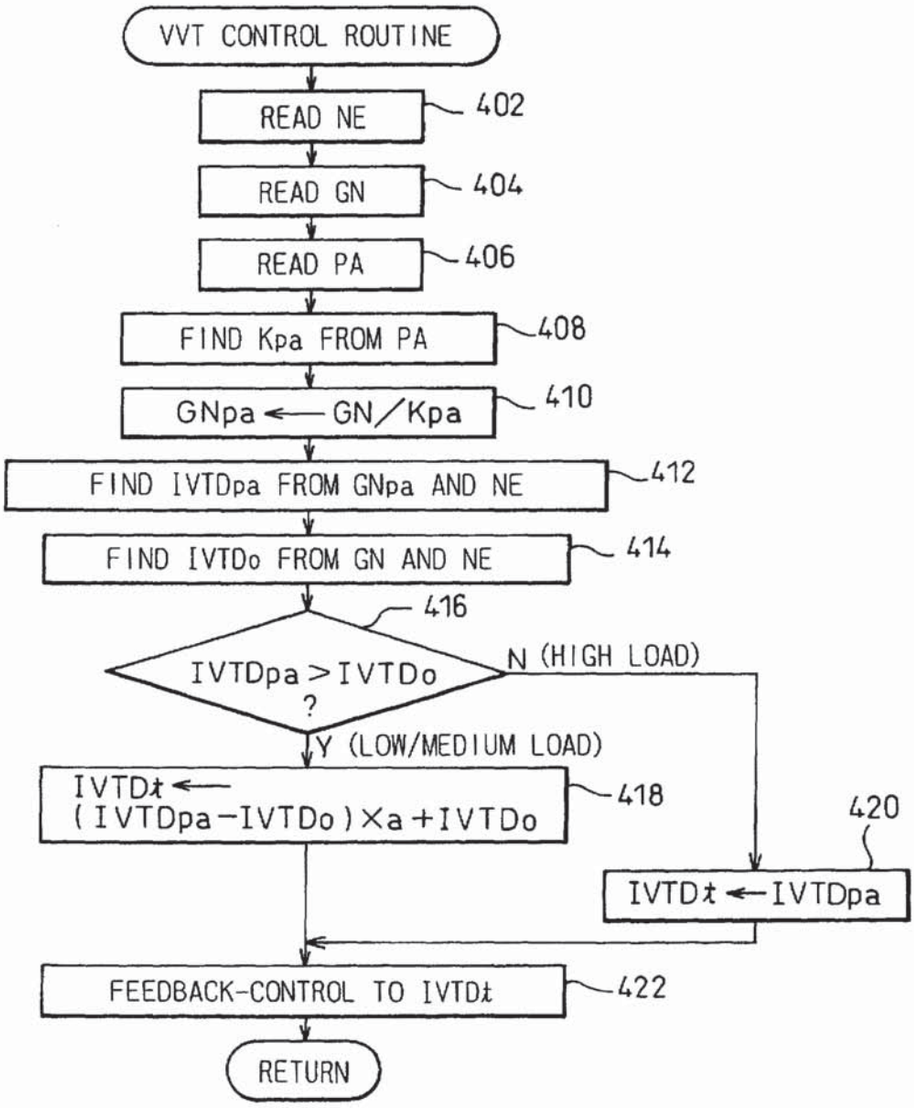
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Fig. 14



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Fig. 15



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METHOD OF AND APPARATUS FOR CONTINUOUSLY AND VARIABLY CONTROLLING VALVE TIMING OF INTERNAL COMBUSTION ENGINE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method of and an apparatus for controlling a continuously variable valve timing mechanism of an internal combustion engine, to continuously and variably control the open/close timing of an intake or exhaust valve of the engine according to a target timing.

2. Description of the Related Art

There are many variable mechanisms that optimize the open/close timing of a valve of an automobile engine according to driving conditions. One of them is an ON/OFF mechanism, which changes the timing of an intake valve of the engine from normal timing to early timing when an engine load exceeds a switching threshold. Japanese Unexamined Utility Model Publication No. 3-99844 decreases the switching threshold or increases a detected engine load in response to a decrease in atmospheric pressure, to optimize the valve timing.

To provide high-performance engines, continuously variable valve timing mechanisms for optimizing valve timing at all times have been developed in place of the ON/OFF mechanisms, as disclosed in Japanese Unexamined Patent Publication No. 4-175430 (corresponding to U.S. Pat. No. 5,271,360). This mechanism continuously changes the open/close timing of a valve, and therefore, never employs the idea of changing the switching threshold in response to a change in atmospheric pressure. There is a requirement, therefore, to provide a method of properly controlling the continuously variable valve timing mechanism.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a method of and an apparatus for optimizing valve timing according to atmospheric pressure for a continuously variable valve timing mechanism of an internal combustion engine.

The present invention intends to improve the output of an engine at high altitudes under high load, as well as reducing fuel consumption and improving exhaust purifying performance at high altitudes under low/medium load. In order to accomplish the objects, the present invention provides the following technical arrangements:

A first aspect of the present invention provides a method of controlling a continuously variable valve timing mechanism of an internal combustion engine, to continuously and variably control the open/close timing of at least one of the intake and the exhaust valves of the engine, including the steps of (a) detecting an engine load, (b) detecting an atmospheric pressure, (c) correcting the detected engine load such that the lower the detected atmospheric pressure the more the engine load is increased, and (d) setting a target valve timing for the valve timing mechanism according to the corrected engine load.

The first aspect also provides an apparatus for controlling valve timing of an internal combustion engine, having a valve timing mechanism for continuously and variably controlling the open/close timing of at least one of the intake and the exhaust valves of the engine, a load detector for detecting an engine load, a pressure detector for detecting an atmospheric pressure, a load corrector for correcting the detected engine load such that the lower the detected atmospheric pressure the more the engine load is increased, and a timing setter for setting target a valve timing for the valve timing mechanism according to the corrected engine load.

A second aspect of the present invention provides a method of controlling a continuously variable valve timing mechanism of an internal combustion engine, to continuously and variably control the open/close timing of at least one of intake and exhaust valves of the engine, including the steps of (a) detecting an engine load, (b) detecting an atmospheric pressure, (c) setting, according to the detected engine load, a displacement from a reference timing as a target valve timing for the valve timing mechanism, and (d) correcting the set displacement such that the lower the detected atmospheric pressure the more the displacement is reduced.

The second aspect also provides an apparatus for controlling valve timing of an internal combustion engine, having a valve timing mechanism for continuously and variably controlling the open/close timing of at least one of intake and exhaust valves of the engine, a load detector for detecting an engine load, a pressure detector for detecting an atmospheric pressure, a displacement setter for setting, according to the detected engine load, a displacement from a reference timing as target valve timing for the valve timing mechanism, and a displacement corrector for correcting the set displacement such that the lower the detected atmospheric pressure the more the set displacement is reduced.

When driving at high altitudes, an engine receives a smaller quantity of intake air due to the low concentration of air. The first and second aspects of the present invention are capable of optimizing valve timing to maintain the output of the engine at high altitudes.

A third aspect of the present invention provides a method including the step of, in addition to the steps of the first aspect, (e) prohibiting the correction in step (c) if the detected engine load is in a low/medium range.

The third aspect also provides an apparatus having, in addition to the components of the first aspect, a prohibition unit for prohibiting the correction carried out by the load corrector if the detected engine load is in a low/medium range.

The first aspect corrects an engine load in any range according to atmospheric pressure to maintain the output of the engine when driving at high altitudes. If such a correction is carried out under a low/medium engine load, the quantity of internally recirculated exhaust gas of an internal exhaust gas recirculation (EGR) system will increase excessively to cause incomplete combustion. The internal EGR system is employed to improve exhaust gas purifying performance and reduce pumping loss and fuel consumption. Accordingly, the third aspect prohibits the engine load correction under a low/medium engine load, thereby preventing an excessive amount of exhaust gas being recirculated.

A fourth aspect of the present invention provides a method including the step of, in addition to the steps of the first aspect, (e) correcting the target valve timing set in step (d) to an intermediate value between the target valve timing and valve timing determined according to the detected engine load, if the detected engine load is in a low/medium range.

The fourth aspect also provides an apparatus having, in addition to the components of the first aspect, a timing corrector for correcting the target valve timing set by the timing setter to an intermediate value between the target

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valve timing and valve timing determined according to the engine load detected by the load detector, if the detected engine load is in a low/medium range.

The third aspect simply prohibits the engine load correction according to atmospheric pressure if the engine load is in a low/medium range. When driving at high altitudes, the negative pressure of an intake duct of the engine decreases to reduce the quantity of internally recirculated exhaust gas. Accordingly, the fourth aspect corrects the engine load according to atmospheric pressure, to optimize the quantity of recirculated internal exhaust gas at high altitudes under the low/medium engine load.

BRIEF DESCRIPTION OF THE DRAWINGS

Further features and advantages of the present invention will be apparent from the following description with reference to the accompanying drawings, in which:

FIG. **1** is a general view showing an electronically controlled internal combustion engine having an apparatus for continuously and variably controlling valve timing according to an embodiment of the present invention;

FIG. **2** is a block diagram showing an electronic engine control unit according to the embodiment;

FIG. **3** is a timing chart showing crank angles representing the open/close timing of intake and exhaust valves;

FIG. **4** is a map used to determine a displacement to be imposed on the open/close timing of an intake valve according to the revolution speed and load of an engine (the load being represented by the mass of intake air per revolution);

FIG. **5** is a graph showing the relationship between an engine load and a target displacement to be imposed on the open/close timing of an intake valve at an engine speed (NE) of 2000 rpm;

FIG. **6** is a graph explaining a correction of an engine load according to atmospheric pressure according to a first embodiment of the present invention;

FIG. **7** is a flowchart showing a routine of variably controlling the open/close timing of a valve according to the first embodiment;

FIG. **8** is a map used to determine an atmospheric pressure correction coefficient Kpa according to an engine load GN;

FIG. **9** is a flowchart showing a routine of variably controlling the open/close timing of a valve according to a second embodiment of the present invention;

FIG. **10** is a map used to determine an atmospheric pressure correction coefficient Lpa according to a displacement to be imposed on the open/close timing of an intake valve;

FIG. **11** is a graph explaining a correction of an engine load according to atmospheric pressure according to a third embodiment of the present invention;

FIG. **12** is a flowchart showing a routine of variably controlling the open/close timing of a valve according to the third embodiment;

FIG. **13** is a graph showing the relationship between an engine load and a displacement to be imposed on the open/close timing of an intake valve at low altitudes (IVTD**0**) and high altitudes (IVTDpa);

FIG. **14** is a graph explaining a correction of an engine load according to atmospheric pressure according to a fourth embodiment of the present invention; and

FIG. **15** is a flowchart showing a routine of variably controlling the open/close timing of a valve according to the fourth embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The embodiments of the present invention will be explained with reference to the drawings.

FIG. **1** is a general view showing an electronically controlled internal combustion engine having an apparatus for continuously and variably controlling the open/close timing of a valve according to an embodiment of the present invention. An air cleaner **2** filters air necessary for combustion, a throttle body **4** passes the air, and a surge tank (intake manifold) **6** distributes the air to an intake duct **7** of each cylinder. A throttle valve **5** arranged in the throttle body **4** adjusts the quantity of intake air. An airflow meter **40** measures the mass flow rate of intake air. A temperature sensor **43** detects the temperature of intake air. A vacuum sensor **41** detects the pressure of the intake duct **7**. An atmospheric pressure sensor **46** is arranged so that it is not influenced by wind pressure during driving.

A throttle sensor **42** detects the opening of the throttle valve **5**. When the throttle valve **5** is completely closed, an idle switch **52** is turned on to generate a throttle closed signal. An idling adjusting path **8** bypasses the throttle valve **5** and has an idling speed control valve (ISCV) **66** for adjusting an airflow rate during an idling period.

Fuel in a fuel tank **10** is pumped up by a fuel pump **11**, is passed through a fuel pipe **12**, and is injected by a fuel injector **60**.

The intake duct **7** mixes fuel with air, and the air-fuel mixture is drawn into a combustion chamber **21** of a cylinder **20** through an intake valve **24**. The air-fuel mixture is compressed by a piston **23**, ignited, exploded, and combusted to produce power. Namely, an igniter **62** generates an ignition signal to control a primary current of an ignition coil **63**. A secondary current of the ignition coil **63** is supplied to a spark plug **65** through an ignition distributor **64**, to thereby ignite the air-fuel mixture in the combustion chamber **21**.

The ignition distributor **64** has a reference position sensor **50** and a crank angle sensor **51**. The reference position sensor **50** generates a reference position pulse for every 720 degrees of crank angle. The crank angle sensor **51** generates a position pulse for every 30 degrees of crank angle. A vehicle speed sensor **53** generates a pulse representing an actual running speed. A cooling water path **22** guides cooling water to cool the engine **20**. A water temperature sensor **44** detects the temperature of the cooling water.

An exhaust valve **26** discharges an exhaust gas of the combusted air-fuel mixture into an exhaust manifold **30** connected to an exhaust pipe **34**. The exhaust pipe **34** has an O_2 sensor **45** to detect the concentration of oxygen in the exhaust gas. A catalytic converter **38** is arranged in the exhaust pipe **34** downstream from the sensor **45**. The catalytic converter **38** contains a three-way catalyst for promoting the oxidization of unburned components such as HC and CO as well as the reduction of nitrogen oxides (NO_x). The purified exhaust gas from the catalytic converter **38** is discharged outside.

A mechanism for opening and closing the intake valve **24** and exhaust valve **26** will be explained. The piston **23** is connected to a crankshaft **81** through a connecting rod **80**. An end of the crankshaft **81** has a timing pulley **84**. The intake valve **24** is driven by a cam **87** attached to a cam shaft **85**. The exhaust valve **26** is driven by a cam **88** attached to a cam shaft **86**. An end of the cam shaft **85** has a timing pulley **89**. An end of the cam shaft **86** has a timing pulley **90**. The timing pulleys **89** and **90** are connected to the timing

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pulley **84** through a timing belt **91**. As a result, the crankshaft **81** drives the cam shafts **85** and **86** to open and close the intake valve **24** and exhaust valve **26** at predetermined crank angles. The crank shaft **81** has a buried magnet **82**, so that a first magnetic sensor **54** arranged close to the crankshaft **81** may generate a reference pulse. The cam shaft **85** of the intake valve **24** has a buried magnet **93**, so that a second magnetic sensor **55** arranged close to the cam shaft **85** may generate a reference pulse.

A continuously variable mechanism **92** having a known structure to determine the open/close timing of the intake valve **24** is arranged between the cam shaft **85** and the timing pulley **89**. The mechanism **92** turns the cam shaft **85** and timing pulley **89** relative to each other. More precisely, the mechanism **92** uses the cam shaft **85** and timing pulley **89** as external gears and connects them to each other through an intermediate helical gear. The helical gear is axially moved by hydraulic pressure, to drive the cam shaft **85** and timing pulley **89** relative to each other. The hydraulic pressure is controlled by a control valve **68**.

An electronic engine control unit (ECU) **70** is a microcomputer to control fuel injection, ignition timing, idling speed, and in addition, the open/close timing of a valve according to the present invention. FIG. **2** is a block diagram showing the hardware of the control unit **70**. A read-only memory (ROM) **73** stores programs and maps. A central processing unit (CPU) **71** receives signals from the sensors and switches through an A/D converter **75** and an interface **76**, processes the signals, and provides actuator control signals through drive control circuits **77***a* to **77***d*. A random-access memory (RAM) **74** temporarily stores data during the operation of the CPU **71**. These elements are connected to one another through a system bus **72** containing address, data, and control buses.

An engine control process carried out by the control unit **70** will be explained.

Fuel injection control refers to the mass of intake air per engine revolution, calculates the fuel injection quantity, i.e., injection period of the fuel injector **60** to achieve a target air-fuel ratio, and instructs the drive control circuit **77***a* to inject fuel from the fuel injector **60** at a given crank angle. The mass of intake air per engine revolution is calculated according to the mass flow rate of intake air measured by the airflow meter **40** and an engine revolution speed detected by the crank angle sensor **51**. Alternatively, it is estimated according to the pressure of the intake duct **7** detected by the vacuum sensor **41** and the engine revolution speed. The fuel injection quantity is subjected to corrections such as a basic correction according to signals from the throttle sensor **42**, intake temperature sensor **43**, water temperature sensor **44**, etc., an air-fuel ratio feedback correction according to a signal from the O_2 sensor **45**, and an air-fuel ratio learning correction to equalize a central feedback correction value with a theoretical air-fuel ratio.

Ignition timing control collectively checks engine conditions according to an engine revolution speed detected by the crank angle sensor **51** and signals from other sensors, calculates optimum ignition timing, and provides an ignition signal to the igniter **62** through the drive control circuit **77***b*.

Idling speed control detects an idling state according to a throttle closed signal from the idle switch **52** and a vehicle speed signal from the vehicle speed sensor **53**, calculates a target revolution speed according to the temperature of cooling water measured by the water temperature sensor **44**, compares the target speed with an actual revolution speed, determines a control quantity to attain the target revolution speed according to the difference between the target and actual revolution speeds, and controls the idling speed control valve **66** through the drive control circuit **77***c*, to thereby adjust the quantity of air and optimize the idling speed.

Valve timing control sets the target open/close timing of the intake valve **24** according to operating conditions and controls the continuously variable mechanism **92**. More precisely, the hydraulic pressure control valve **68** is feedback-controlled according to signals from the first and second magnetic sensors **54** and **55** so that the cam shaft **85** of the intake valve **24** maintains a required rotational phase with respect to the crankshaft **81**. The valve timing control according to the present invention will be explained in detail.

FIG. **3** is a timing chart showing crank angles corresponding to the open/close timing of the intake and exhaust valves **24** and **26**. The exhaust valve **26** is opened at fixed valve open timing EVO, for example, 50 degrees before a bottom exhaust dead center and is closed at fixed valve close timing EVC, for example, 3 degrees after a top exhaust dead center. On the other hand, the intake valve **24** involves a fixed open period and variable valve opening timing IVO and valve close timing IVC. The most delayed timing IVOr and IVCr of the intake valve **24** serve as reference positions. The open/close timing of the intake valve **24** is optionally set at positions ahead of the reference positions. A valve timing displacement IVTD serves as a control target quantity. The reference valve open timing IVOr is, for example, 3 degrees after the top exhaust dead center, and the reference valve close timing IVCr is, for example, 65 degrees after a bottom intake dead center. If the displacement IVTD is equal to a crank angle of 30 degrees, the valve open timing IVO is 27 degrees before the top exhaust dead center, and the valve close timing IVC is 35 degrees after the bottom intake dead center.

FIG. **4** is a map used to determine a displacement IVTD for optimizing the open/close timing of the intake valve **24**. The displacement IVTD is determined according to an engine revolution speed NE and an engine load GN, i.e., the mass of intake air per engine revolution.

FIG. **5** is a graph showing the relationship between an engine load GN and a displacement IVTD with NE=2000 rpm. In a low/medium range (GN←1.2 g/rev), a valve overlapping period in which the intake and exhaust valves are both open is increased to increase the quantity of internally recirculated exhaust gas, to thereby improve exhaust gas purifying performance and decrease a pumping loss to reduce fuel consumption. To achieve this, the displacement IVTD is gradually increased. In a high range (GN←1.2 g/rev), the displacement IVTD is adjusted to improve the output of the engine. When GN=2.0 g/rev corresponding to a full throttle condition, the displacement IVTD is set to a crank angle of 40 degrees.

Values of FIGS. **4** and **5** are for low altitudes. At high altitudes, air concentration is low to reduce the quantity of intake air. When driving at low altitudes with NE=2000 rpm and if the throttle valve **5** is fully opened, the quantity of intake air is 2.0 g/rev as shown in FIG. **5**. Namely, if GN=2.0 g/rev, it is determined that the throttle valve **5** is fully opened and that high output is required. To meet the requirement, the displacement IVTD is set to 40 degrees in crank angle. At high altitudes, the quantity of intake air is, for example, 1.6 g/rev even if the throttle valve **5** is fully opened. If the displacement IVTD is calculated normally under this situation, it will be 50 degrees in crank angle as shown in

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FIG. 5. This displacement will never provide high output. It is preferable to set IVTD=40 degrees in crank angle at high altitudes if the throttle valve 5 is fully opened. High-altitude corrections of atmospheric pressure and air concentration will be explained according to four embodiments of the present invention.

The first embodiment according to the first aspect of the present invention will be explained. The first embodiment increases an engine load as a detected atmospheric pressure becomes lower, to maintain the output of the engine at high altitudes under a high load. A curve C1 of FIG. 6, which is equal to the curve C1 of FIG. 5, is proper when driving at low altitudes. Atmospheric pressure is low at high altitudes, and therefore, the present invention employs a curve C2 of FIG. 6 to correct an engine load GN.

FIG. 7 is a flowchart showing a variable valve timing (VVT) control routine according to the first embodiment. This routine is carried out regularly. Step 102 reads an engine revolution speed NE calculated according to the output of the crank angle sensor 51. Step 104 reads an engine load (the mass of intake air per engine revolution) calculated according to the mass flow rate of intake air detected by the airflow meter 40 and the engine revolution speed provided by the crank angle sensor 51. Step 106 reads an atmospheric pressure PA detected by the atmospheric pressure sensor 46.

Step 108 refers to a map of FIG. 8 according to the atmospheric pressure PA and finds an atmospheric pressure (air concentration) correction coefficient Kpa. The coefficient Kpa is 1.0 at low altitudes with PA=760 mmHg and decreases as the altitude increases, i.e., as the atmospheric pressure PA decreases. The map of FIG. 8 is stored in the ROM 73 in advance. Step 110 calculates an engine load GNpa after the atmospheric pressure correction as follows:

$$GNpa \leftarrow GN/Kpa$$

Step 112 refers to the map of FIG. 4 according to the engine load GNpa and engine revolution speed NE, to find a displacement IVTDpa to be imposed on the open/close timing of the intake valve 24. The map of FIG. 4 is also stored in the ROM 73 in advance.

Step 114 sets the displacement IVTDpa as a target displacement IVTDt. To bring an actual displacement to the target displacement IVTDt, signals from the first and second magnetic sensors 54 and 55 are monitored to feedback-control the hydraulic pressure control valve 68.

The second embodiment according to the second aspect of the present invention will be explained. The second embodiment sets a target displacement to be imposed on the open/close timing of the intake valve 24 according to a detected engine load and decreases the target displacement as an atmospheric pressure becomes lower, to maintain the output of the engine at high altitudes under high load, similar to the first embodiment. FIG. 9 is a flowchart showing a variable valve timing (WT) control routine according to the second embodiment. Steps 202 to 206 are the same as steps 102 to 106 of the first embodiment of FIG. 7.

Step 208 refers to a map of FIG. 10 according to the atmospheric pressure PA and finds a correction coefficient Lpa for correcting a displacement to be imposed on the open/close timing of the intake valve 24. The correction coefficient Lpa is 1.0 at low altitudes with PA=760 mmHg and decreases as the altitude increases, i.e., as the atmospheric pressure PA decreases. The map of FIG. 10 is stored in the ROM 73 in advance. Step 210 refers to the map of FIG. 4 according to the engine load GN and engine revolution speed NE and finds a displacement IVTD0 to be imposed on the open/close timing of the intake valve 24.

Step 212 corrects the displacement IVTD0 and provides a target displacement IVTDt as follows:

$$IVTDt \leftarrow IVTD0 \times Lpa$$

To bring the actual displacement of the intake valve 24 to the target displacement IVTDt, the hydraulic control valve 68 is feedback-controlled.

The third embodiment according to the third aspect of the present invention will be explained. The first embodiment corrects an engine load in any range according to atmospheric pressure. If this correction is made when the engine load is in a low/medium range, a valve overlapping period increases to excessively increase the quantity of internally recirculated exhaust gas, to deteriorate combustion. Accordingly, the third embodiment prohibits the engine load correction based on atmospheric pressure if the engine load is in the low/medium range. As indicated with a curve C3 of FIG. 11, the third embodiment largely corrects an engine load when the engine load is in a high range with atmospheric pressure being low. However, it carries out no correction if the engine load is in the low/medium range. Curves C1 and C2 of FIG. 11 correspond to the curves C1 and C2 of FIG. 6.

FIG. 12 is a flowchart showing a variable valve timing (VVT) control routine according to the third embodiment. Steps 302 to 312 are the same as steps 102 to 112 of the first embodiment of FIG. 7. Step 314 refers to the map of FIG. 4 according to the engine load GN and engine revolution speed NE and finds a displacement IVTD0 to be imposed on the open/close timing of the intake valve 24.

Step 316 compares the displacement IVTDpa of step 312 with the displacement IVTD0 of step 314 and determines whether the engine load is in a low/medium range or in a high range. The reason why this comparison can determine a load range will be explained. As a displacement to be imposed on the open/close timing of the intake valve 24 increases, the quantity of internally recirculated exhaust gas increases, and an allowable quantity of internally recirculated exhaust gas increases as the engine load increases. Accordingly, a maximum valve timing displacement is in the high load range in principle. However, if the maximum valve timing displacement is kept until the throttle valve 5 is fully opened, combustion will deteriorate to lower the output of the engine. Accordingly, the valve timing displacement is adjusted to realize a required engine output in the high load range. As a result, the displacement map has a maximum in the middle load range. This is the reason why the displacement IVTDpa corrected for high altitudes is compared with the displacement IVTD0 without correction, as shown in FIG. 13. Then, it is determined as follows:

if IVTDpa>IVTD0 then engine load is in low/medium range

if IVTDpa←IVTD0 then engine load is in high range

If it is determined that it is in the low/medium range, step 318 sets the displacement IVTD0 as a target displacement IVTDt. If it is determined that it is in the high range, step 320 sets the displacement IVTDpa as the target displacement IVTDt. Step 322 feedback-controls the hydraulic pressure control valve 68 according to the target displacement IVTDt.

The fourth embodiment according to the fourth aspect of the present invention will be explained. The third embodiment only prohibits the engine load correction according to atmospheric pressure if the engine load is in the low/medium range. The quantity of internally recirculated exhaust gas decreases at high altitudes due to a decrease in the negative pressure of the intake duct 7, and the fourth embodiment

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considers this in correcting the engine load to optimize the quantity of internally recirculated exhaust gas in the low/medium range. As indicated with a curve C4 of FIG. **14**, the engine load is corrected between the curve C2 of the first embodiment and the curve C3 of the third embodiment when the engine load is in the low/medium range. Curves C1, C2, and C3 of FIG. **14** correspond to the curves C1, C2, and C3 of FIG. **11**.

FIG. **15** is a flowchart showing a variable valve timing (VVT) control routine according to the fourth embodiment. What is different from the third embodiment of FIG. **12** is only step **418** corresponding to step **318** of the third embodiment. Namely, step **418** sets a target displacement to be imposed on the open/close timing of the intake valve **24** when the engine load is in the low/medium range as follows:

$$IVTDt \leftarrow (IVTDpa - IVTD0) \times a + IVTD0 \quad (a=0.5, \text{ for example})$$

The fourth embodiment optimizes the quantity of internally recirculated exhaust gas at high altitudes with the engine load being in the high or low/medium range, similar to driving at low altitudes.

Each of the above embodiments uses the two-dimensional map of engine load and engine revolution speed, to continuously control the open/close timing of the intake valve both at low and high highlands, thereby smoothing the torque characteristics with respect to the engine load and the throttle opening.

Although the present invention has been described by way of embodiments, it is apparent to those skilled in the art that other embodiments and modifications of the present invention are possible without departing from the spirit or essential features thereof. For example, the electronic engine control unit **70** used by each embodiment to variably control valve timing may be a dedicated electronic control unit. Although the embodiments variably control the open/close timing of the intake valve **24**, the present invention is naturally applicable to control the exhaust valve **26**, too. An engine load may be represented with the pressure of the intake duct **7**.

As explained above, the present invention provides a method of and apparatus for setting optimum valve timing according to atmospheric pressure for a continuous variable valve timing mechanism of an internal combustion engine. The first and second aspects of the present invention are capable of setting optimum valve timing to maintain the output of the engine at high altitudes. The first aspect corrects an engine load in any range according to atmospheric pressure to maintain the output of the engine. If such a correction is carried out under a low/medium engine load, the quantity of internally recirculated exhaust gas of the internal EGR system will increase excessively to cause incomplete combustion. The internal EGR system is employed to improve exhaust gas purifying performance and reduce a pumping loss and fuel consumption. Accordingly, the third aspect of the present invention prohibits the engine load correction if it is in a low/medium range, thereby preventing an excessive exhaust gas to be recirculated and, at the same time, the third aspect is also capable of maintaining the output of the engine at high altitudes under a high load. The fourth aspect of the present invention maintains the output of the engine at high altitudes under a high load and corrects an engine load according to atmospheric pressure at high altitudes under a low/medium load in consideration of a decrease in the quantity of internally recirculated exhaust gas, thereby optimizing the quantity of internally recirculated exhaust gas at high altitudes.

What is claimed is:

1. A method of controlling a continuously variable valve timing mechanism of an internal combustion engine, to continuously and variably control an opening and closing timing of at least one of intake and exhaust valves of the engine, comprising the steps of:

(a) preparing a map for determining a target valve timing according to an engine load, in which map a valve overlapping period in which both an intake and an exhaust valve are open is set smaller in a high load range than in a medium load range;

(b) detecting an engine load;

(c) detecting an atmospheric pressure;

(d) correcting the detected engine load such that the lower the detected atmospheric pressure the more the engine load is increased; and

(e) referring to the map to set the target valve timing for the valve timing mechanism according to the corrected engine load.

2. The method as claimed in claim **1**, further comprising the step of:

(f) prohibiting the correction in step (d) if the detected engine load is in a low to medium range.

3. The method as claimed in claim **1**, further comprising the step of:

(f) correcting the target valve timing set in step (e) to an intermediate value between the target valve timing and a valve timing determined according to the detected engine load, if the detected engine load is in a low to medium range.

4. An apparatus for controlling valve timing of an internal combustion engine, comprising:

a valve timing mechanism for continuously and variably controlling an opening and closing timing of at least one of intake and exhaust valves of the engine;

a control map for determining a target valve timing according to an engine load, in which map a valve overlapping period in which both an intake and an exhaust valve are open is set smaller in a high load range than in a medium load range;

load detection means for detecting an engine load;

pressure detection means for detecting an atmospheric pressure;

load correction means for correcting the detected engine load such that the lower the detected atmospheric pressure the more the engine lead is increased; and

timing set means for setting the target valve timing for the valve timing mechanism by referring to the map according to the corrected engine load.

5. The apparatus as claimed in claim **4**, further comprising:

prohibition means for prohibiting the correction carried out by the lead correction means if the detected engine lead is in a low to medium range.

6. The apparatus as claimed in claim **4**, further comprising:

timing correction means for correcting the target valve timing set by the timing set means to an intermediate value between the target valve timing and a valve timing determined according to the engine lead detected by the lead detection means, if the detected engine lead is in a low to medium range.

* * * * *

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 5,713,317
DATED : February 3, 1998
INVENTOR(S) : Mamoru YOSHIOKA

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 2, line 3, change "setting target a" to --setting a target--.

Column 9, line 25, change "highlands" to --altitudes--.

Column 10, line 27, claim 3, change "(f)" to --(g)--.

Column 10, line 57, change "lead" to --load--.

Column 10, line 63, change "lead" to --load--.

Column 10, line 64, change "lead" to --load--.

Column 10, line 65, change "lead" to --load--.

Signed and Sealed this

Twenty-fourth Day of November, 1998

Attest:

BRUCE LEHMAN

Attesting Officer

Commissioner of Patents and Trademarks

Torque Management of Engines with Variable Cam Timing

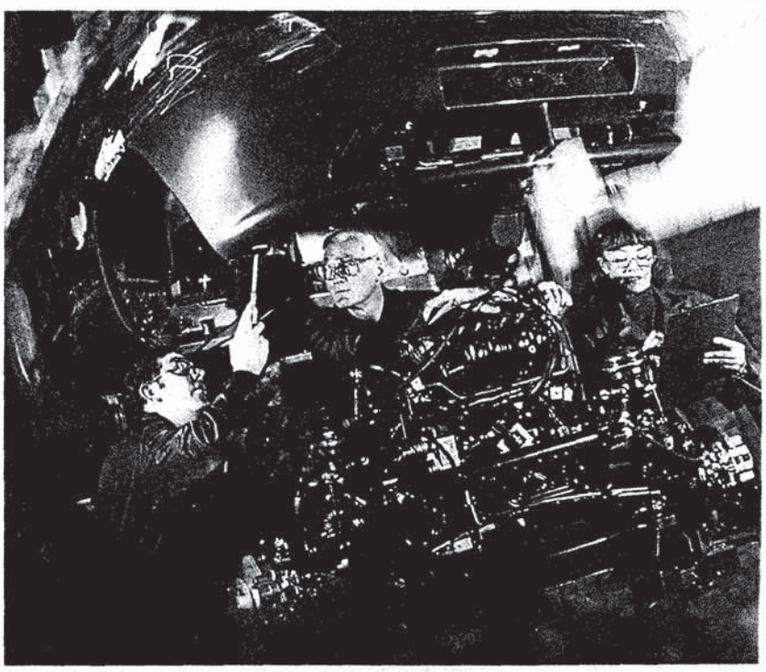
Mrdjan Jankovic, Florian Frischmuth, Anna Stefanopoulou, and Jeffrey A. Cook

Automotive powertrain control systems are subject to diverse and, usually, conflicting requirements. In particular, exhaust emissions must meet increasingly stringent Federal and California standards while fuel economy must meet customer expectations and contribute to Federally mandated Corporate Average Fuel Economy (CAFE) imperatives. Neither vehicle performance nor reliability may be compromised in attaining these goals (emission performance must be guaranteed for 100,000 miles). Of course, all these objectives must be achieved at the lowest possible cost and with the minimum number of sensors and actuators.

The conventional method of reducing feedgas oxides of nitrogen (NOx) emissions is by the application of exhaust gas recirculation (EGR). Formation of NOx during the combustion process is influenced by air-fuel ratio (*A/F*) and temperature. These variables are typically adjusted by directing exhaust gas from the high pressure exhaust manifold via a pulse-width modulated valve to the low pressure induction system where it serves to reduce the combustion temperature and dilute the air-fuel mixture in the cylinder. A desirable side-effect is that the presence of inert exhaust gas raises the intake manifold pressure reducing the pumping losses and improving fuel economy. Although effective, the dynamics associated with this system (transport delay, valve and intake manifold dynamics) can result in vehicle performance deterioration.

The variable cam timing (VCT) system with which this paper is concerned addresses both drivability and emissions performance by utilizing an electro-hydraulic mechanism to rotate the camshaft relative to the crankshaft in order to retard the cam timing with respect to the intake and exhaust strokes of the engine. Variable cam timing operation is illustrated in Fig. 1. By retarding the exhaust valve closing further into the intake stroke, more exhaust gas is drawn into the cylinder providing internal exhaust gas recirculation. In this manner, the amount of residual gas trapped in the cylinder at the end of the exhaust stroke is controlled by cam timing, suppressing NOx formation and reducing the pumping losses [1], [9], [14]. Furthermore, this residual contains some unburned hydrocarbons; consequently, retaining it in the cylinder through two combustion cycles also reduces hydrocarbon emissions [8].

In addition to the reduction of NOx and HC emissions, variable cam timing permits the engine designer to optimize cam timing over a wide range of engine operating conditions, providing both good idle quality (minimal overlap between the intake and exhaust events) and improved wide-open throttle performance (maximum inducted charge). In this article, we will assume that the camshaft position is continuously variable to



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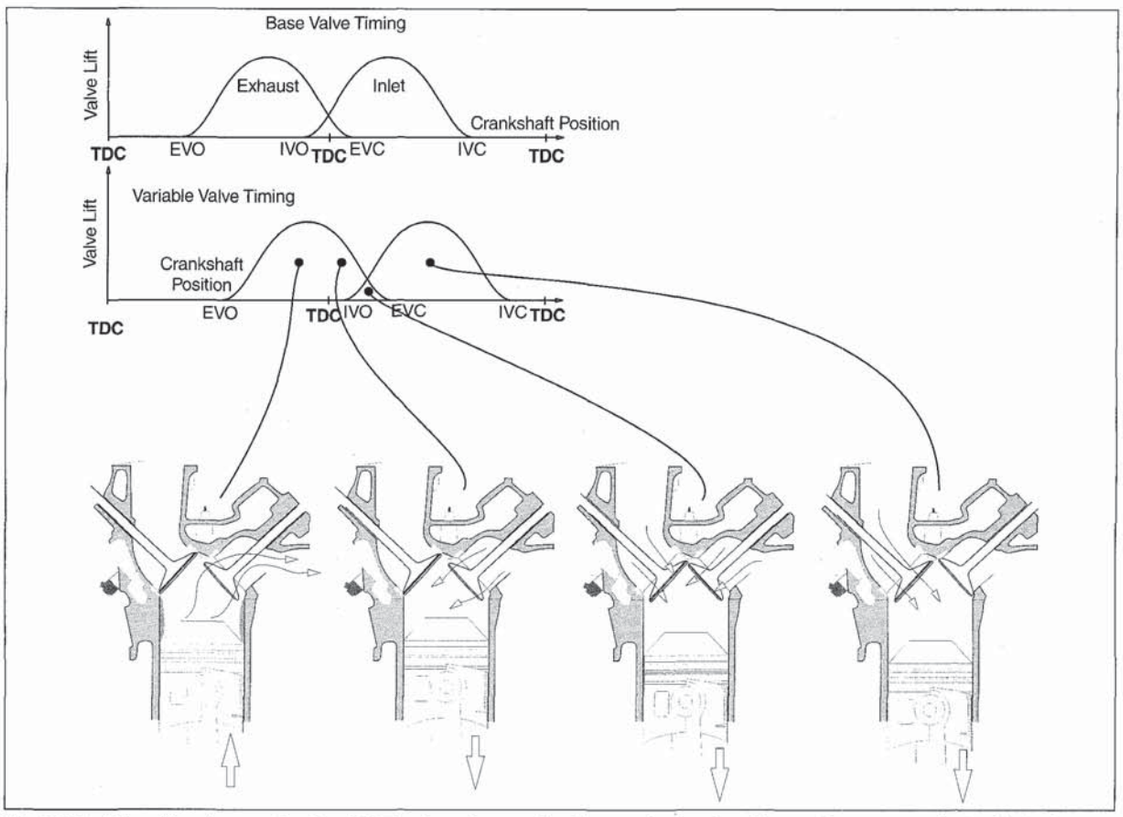


Fig. 1. Valve lift profiles of conventional and VCT engines. By retarding the cam phasing, the exhaust valve stays open during the intake event for a longer time period, retaining otherwise unburned HC and reducing the combustion temperature due to the dilution of the inert gas.

achieve the full benefits in emissions and torque. There are successful examples of simple, two-position VCT systems that address and partially resolve the idle versus wide-open throttle performance trade-off. Obviously, variable cam timing has a substantial effect on the breathing process of the engine. Properly controlled, the variable cam can be used to operate the engine at higher intake manifold pressures, reducing pumping losses at part throttle conditions and providing a fuel economy improvement as well [2], [4], [7].

Four versions of VCT are available for double overhead camshaft (DOHC) engines: phasing only the intake cam (intake only), phasing only the exhaust cam (exhaust only), phasing the intake and exhaust cams equally (dual equal), and phasing the two camshafts independently (dual independent). The dual independent VCT provides the best performance, but it is the most complex and expensive to implement. Of the remaining three, dual equal VCT, where the intake valve timing and exhaust valve timing are advanced or retarded equally, gives the best overall performance in terms of emissions and fuel economy [6]. On the other hand, the dual equal VCT causes the greatest disturbance to cylinder air-charge and air-fuel ratio which may result in drivability problems and increased tailpipe emissions above levels predicted by the steady state analysis [11].

One method of reducing the air-charge variation and improving drivability is to "detune the cam" by slowing down the response of the VCT mechanism. However, detuning the cam results in engine operation with lower levels of recirculated exhaust gas and increased NOx emissions. Drivability can also be improved by selecting a less aggressive (steady-state suboptimal) cam timing schedule, but again the price for this is increased NOx emissions and reduced fuel economy. Instead, in this article we pursue an active method of compensation for cylinder air-charge variation due to VCT which employs either an electronic throttle or an air-bypass valve. Electronic control of the throttle provides an additional degree of control capability to affect emissions and fuel economy while providing the performance desired by the driver as interpreted from the accelerator pedal position. The air-bypass valve is a conventional actuator of limited authority used to admit air flow to the engine under closed throttle operation, and to effect idle speed regulation [3], [5].

From the controller design point of view, several prominent characteristics of this problem will dictate our approach:

- The model of the plant is low order, nonlinear, with known nonlinearities available from the dynamometer mapping data.
- The disturbance (cam phasing) is measured.
- The output (cylinder mass air flow, or cylinder air charge, or torque) is not measured.
- Transient response is much more important than steady state accuracy.

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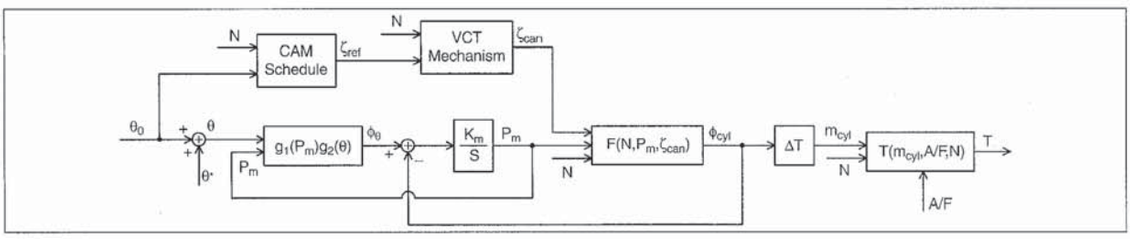


Fig. 2. Engine model with VCT and electronic throttle.

The first three items above suggest that a feedforward compensation may be the most appropriate, so this is the approach we adopt. Our compensator design is based on a low order nonlinear model of a VCT engine derived in [12]. Starting from the nonlinear model we develop a nonlinear control algorithm that rejects the air-charge (torque) disturbance and recovers the drivability of the conventional engine. (Note that the "conventional engine" in this context is the engine which corresponds to fixed cam at 0° (base cam). However, this algorithm requires a degree of control authority which is available only if the engine is equipped with an electronic throttle (ETC). If the engine is equipped only with an air-bypass valve (ABV), the limited control authority of this device forces us to change the design objective: rather than to emulate the conventional engine, our compensation tries to achieve the drivability of an engine with a different characteristic.

Because the relative degree from the disturbance to the output is smaller that the one from the control input to the output (the disturbance is closer to the output than the control), our compensation algorithm uses the derivative of the disturbance (cam phasing). We present two different methods of implementing this term in order to find a trade-off among the performance of the compensator, the sensitivity to measurement noise, and the sensitivity to parameter variation.

VCT Engine Model

The control design engine model described here is a continuous-time nonlinear, low-frequency phenomenological model developed in [10] and modified to incorporate VCT in [12]. Details about the VCT engine model can be found in [13]. A block diagram in Fig. 2 shows the cam timing reference ζ_{ref} scheduled on engine speed and driver demanded throttle θ_0.

Notation

A/F air-fuel ratio
N engine speed
P_m: manifold pressure
m_{cyl}: mass of air into cylinder
T: torque
ζ_{ref}: cam phasing command
ζ_{cam}: cam phasing
θ_0: throttle angle due to driver request
θ^*: additive throttle angle due to compensation
θ: total throttle angle
ϕ_θ: mass air flow rate into manifold
ϕ_{cyl}: mass air flow rate into cylinders
δ: opening of the air-bypass valve
ΔT: duration of the intake event
σ: spark retard from maximum braking torque (MBT) setting.

The engine breathing dynamics describe the filling and emptying of the manifold. The rate of change is proportional to the difference between mass air flow rate into the manifold through the throttle (ϕ_θ) and the mass air flow rate out of the manifold into the cylinders (ϕ_{cyl})

$$\dot{P}_m = K_m(\phi_\theta - \phi_{cyl}). \tag{1}$$

The mass air flow through the throttle body into the manifold is a function of the upstream atmospheric pressure P_a, the manifold pressure, and the throttle angle:

$$\phi_\theta = g_1(P_m / P_a)g_2(\theta, P_a),$$

where

$$g_1(P_m / P_a) = \begin{cases} \gamma^{1/2}\left(\frac{2}{\gamma+1}\right)^{\frac{\gamma+1}{2(\gamma-1)}} & \text{if } \frac{P_m}{P_a} \le \left(\frac{2}{\gamma+1}\right)^{\frac{\gamma}{\gamma-1}} \\ \sqrt{\frac{2\gamma}{\gamma-1}\left(\left(\frac{P_m}{P_a}\right)^{\frac{2}{\gamma}} - \left(\frac{P_m}{P_a}\right)^{\frac{\gamma+1}{\gamma}}\right)} & \text{if } \frac{P_m}{P_a} > \left(\frac{2}{\gamma+1}\right)^{\frac{\gamma}{\gamma-1}} \end{cases}, \tag{2}$$

with $\gamma = c_p/c_v = 1.4$. $g_2(\theta, P_a)$ is the throttle dependent mass air flow characteristic obtained from static engine data. We assume that $P_a = 1$ bar and suppress the dependence of g_1 and g_2 on P_a.

In this application, the throttle angle is comprised of the throttle position due to the driver's request (θ_0) and an additive term due to the compensation (θ^*)

$$\theta = \theta_0 + \theta^*.$$

It is important to observe in Fig. 2 that the cam is scheduled only on θ_0. The mass air flow rate into the cylinders can be represented as a function of cam phasing ζ_{cam}, manifold pressure P_m, and engine speed N:

$$\phi_{cyl} = F(N, P_m, \zeta_{cam}). \tag{3}$$

For our design model we approximate $F(N, P_m, \zeta_{cam})$ by a function linear in P_m:

$$\phi_{cyl} = \alpha_1(N, \zeta_{cam})P_m + \alpha_2(N, \zeta_{cam}), \tag{4}$$

where α_1 and α_2 are low order polynomials in N and ζ_{cam}.

The generation of torque depends on the cylinder air charge m_{cyl}, air-fuel ratio A/F, spark retard from MBT σ, and engine speed. This relationship is best captured by curve fitting of experimental data:

$$T = T(m_{cyl}, A/F, \sigma, N), \tag{5}$$

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PETITIONER'S EXHIBIT 1002
US PATENT NO. 6,557,540