Patent Owners’ Oral Hearing Demonstratives

IPR2014-00570 (USPN 8,214,097)
IPR2014-00571 (USPN 7,104,347)
IPR2014-00579 (USPN 7,104,347)
IPR2014-00875 (USPN 7,559,388)
IPR2014-00884 (USPN 7,104,347)
IPR2014-00904 (USPN 7,237,634)

Petitioner Ford Motor Company
v.
Paice LLC & The Abell Foundation, Inc.

Before Sally C. Medley, Kalyan K. Deshpande, and Carl M. DeFranco, Administrative Patent Judges

Agenda

- Introduction
- Patent/Technology Overview
- Claim Construction
- Three groups of IPRs:

I. IPR2014-00571 (‘347 Patent) and IPR2014-00904 (‘634 Patent)

II. IPR2014-00579 (‘347 Patent) and IPR2014-00884 (‘347 Patent)

III. IPR2014-00570 (‘097 Patent) and IPR2014-00875 (‘388 Patent)

Introduction

Introduction to the Patent Owners

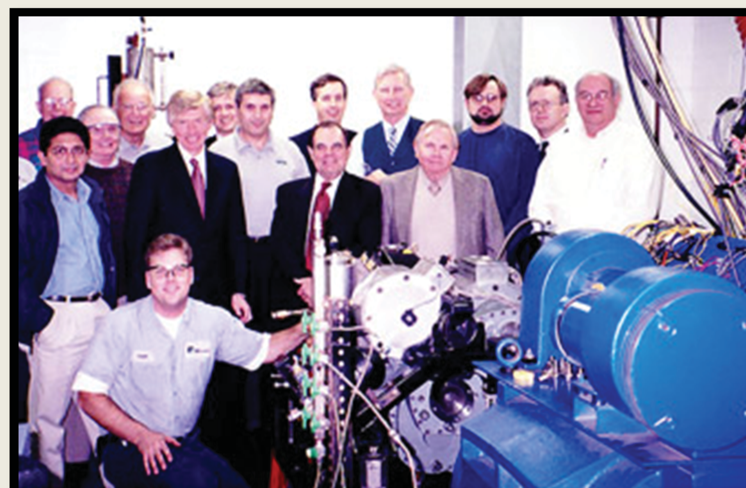
paice

THE ABELL FOUNDATION

Who is Paice?

- Paice was founded in 1992 by Dr. Alex Severinsky with support from the University of Maryland's small company incubator program.

- Paice's goal: develop the most fuel efficient and cost-effective hybrid electric vehicle system possible, while significantly lowering emissions.



See e.g. IPR '571, Paper No. 20, POR at 4

Who is The Abell Foundation?

- The Abell Foundation is a charitable organization that contributes millions of dollars to support worthwhile causes across Maryland.
- Traditionally focuses on caring for the underserved through education, healthcare, and human services initiatives.
- But occasionally invests in promising local companies — including those focused on environmental issues — with the goal of reinvesting any earnings back into the communities it serves.
- The Abell Foundation invested in Paice in 1998 and has since provided more than $30 million in support to help Paice achieve its goals.

See e.g. IPR ‘571, Paper No. 20, POR at 4

History of Paice and Ford

- Paice has been involved with the world's top automotive manufacturers in developing commercially viable hybrid vehicles.
- Between 1999 and 2004, Paice spent extensive time working with Ford to teach Ford Paice's hybrid vehicle technology, including detailed modeling of Paice's patented technology in actual and proposed Ford vehicles.
- In 2010, Paice reached a significant license on Paice's entire patent portfolio with Toyota, the world's most successful hybrid auto manufacturer.
- In 2010, Ford took a license to Paice's '970 patent, and entered into an Arbitration Agreement to resolve further disputes.
- Ford ultimately declined to arbitrate, and instead filed 25 separate Petitions for *Inter Partes* Review before this Board.

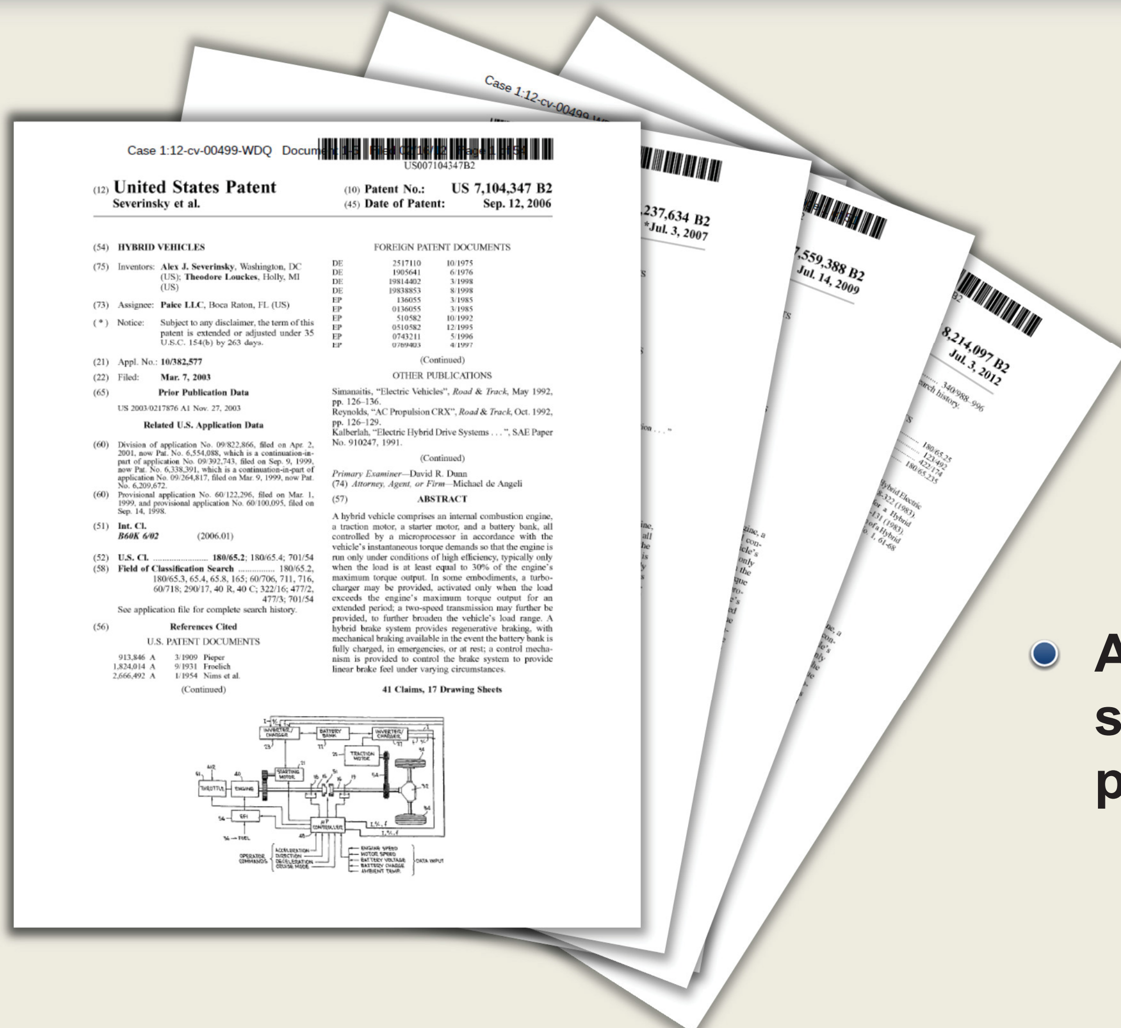
See e.g. IPR '904, Paper No. 22, POR at 4-5 (citing to Ex. 2011).

Patent/Technology Overview

Background of the Challenged Patents

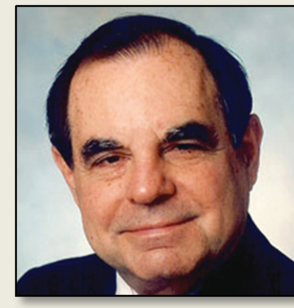
- Challenged Patents:
  - U.S. Patent No. 7,104,347 (“the ‘347 Patent”)
  - U.S. Patent No. 7,237,634 (“the ‘634 Patent”)
  - U.S. Patent No. 7,559,388 (“the ‘388 Patent”)
  - U.S. Patent No. 8,214,097 (“the ‘097 Patent”)

Background of the Challenged Patents



- Named Inventors:

Alex Severinsky



Theodore Louckes

- All patents share generally the same specification and claim priority to:
  - Provisional application No. 60/100,095, filed on Sep.14, 1998; and
  - Provisional application 60/122,296, filed on Mar. 1, 1999.

Paice's expert – Neil Hannemann

- Mr. Hannemann's career spans more than 25 years including specialty vehicle development positions with Ford, GM, DaimlerChrysler, Saleen, and McLaren.

- He has designed and worked with numerous actual hybrid vehicles including:
  - The Kepler Motion hybrid sports car (pictured bottom right)
  - The Chrysler Patriot
  - Hybrid configurations for the McLaren MP4/12C sports car

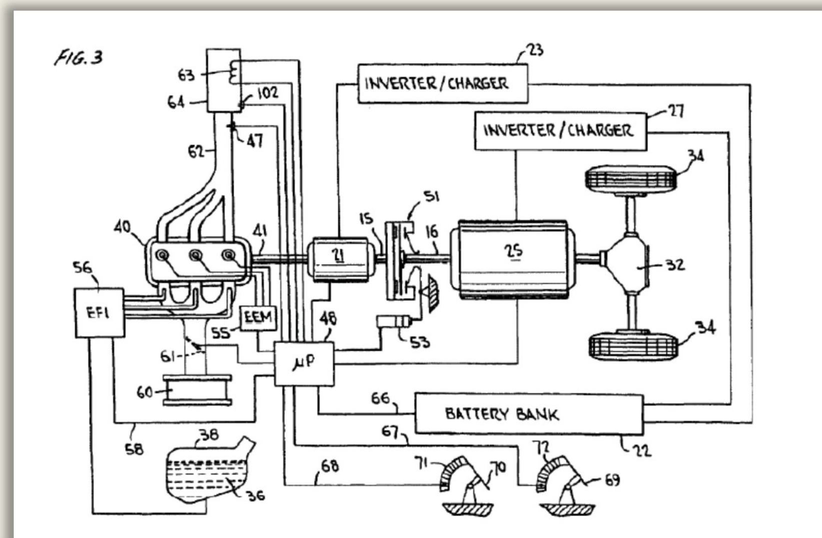
See e.g. IPR '884, Ex. 2215 at ¶¶ 10-23.

Background of the Challenged Patents

- **Inventions of the Challenged Patents are generally directed to hybrid electric vehicles and the control thereof:**

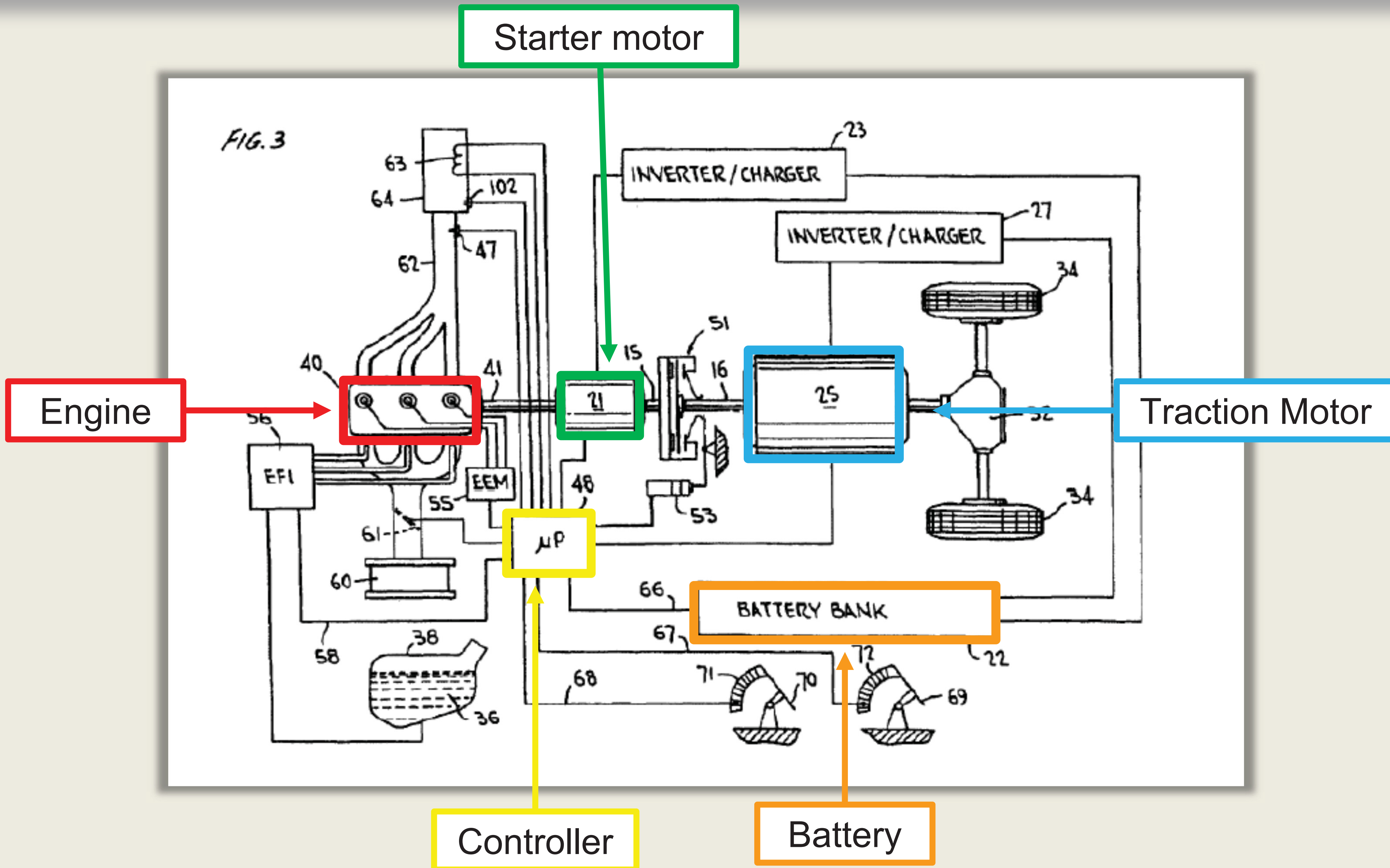
A hybrid vehicle comprises an internal combustion engine, a traction motor, a starter motor, and a battery bank, all controlled by a microprocessor in accordance with the vehicle's instantaneous torque demands so that the engine is run only under conditions of high efficiency…

***See e.g.* '347 Patent, Abstract**



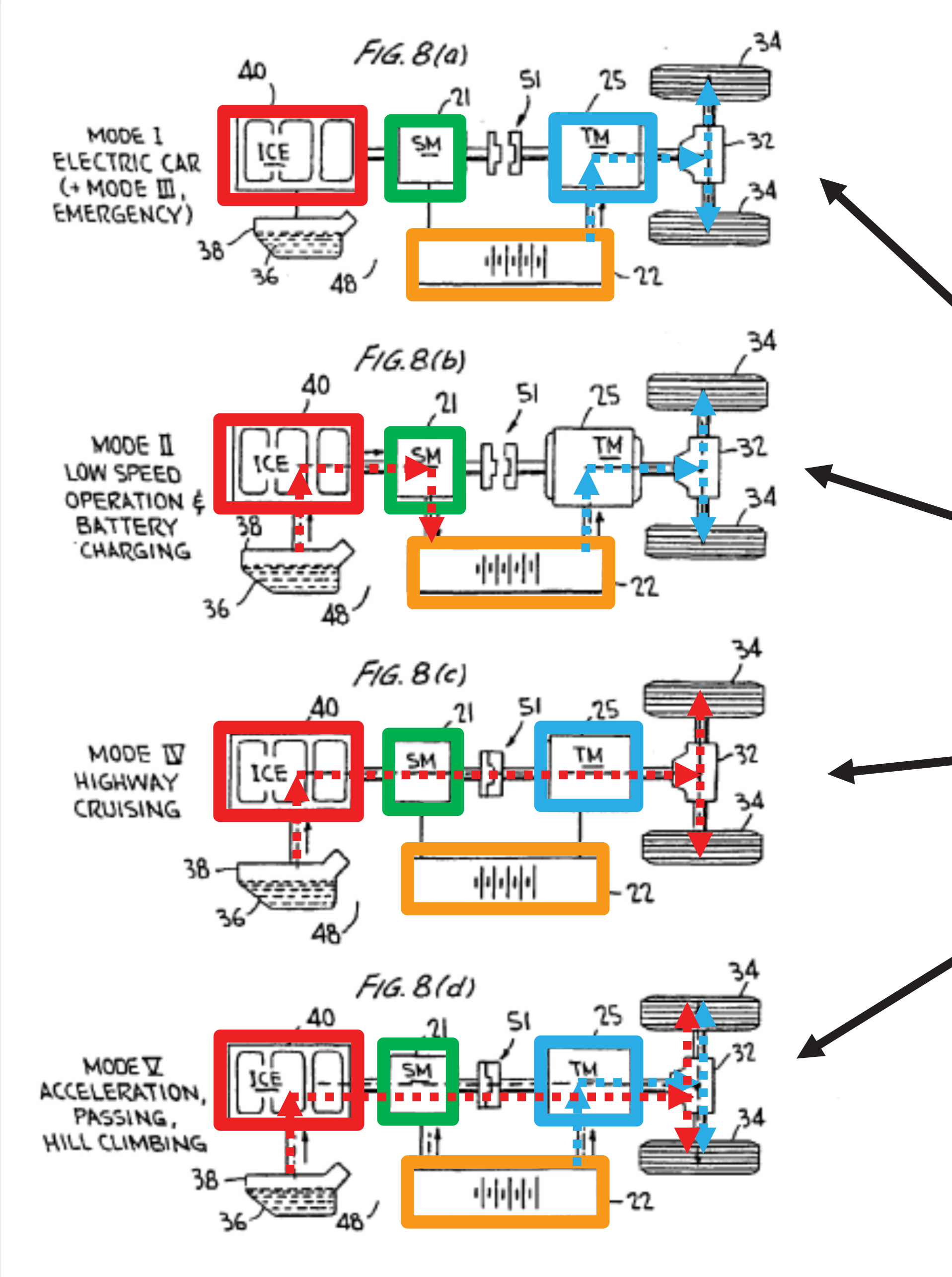
***See e.g.* '347 Patent, Fig. 3**

Technology Background



See *e.g.* IPR '875, Paper No. 19, POR at 5-6.

Technology Background

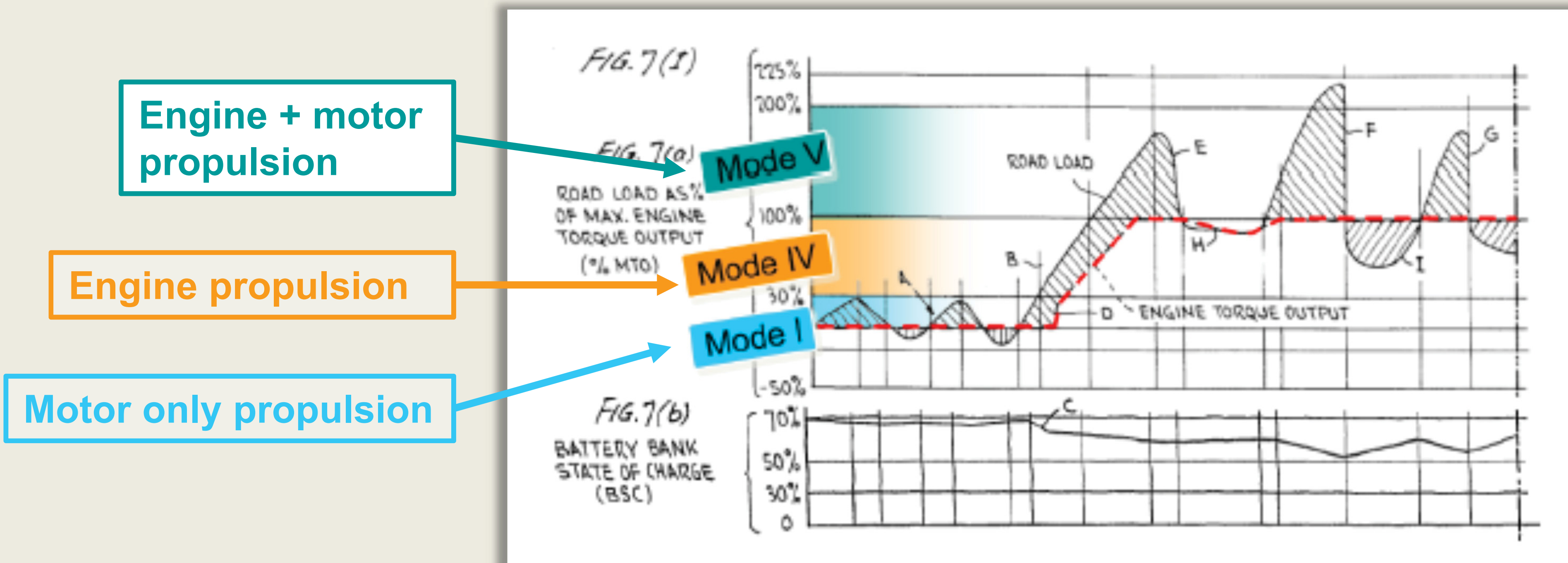


- The hybrid electric vehicle of the challenged patents can be operated in various "modes," *i.e.* different combinations of the motor, engine, or both, to propel the vehicle:
  - Mode I: motor only propulsion
  - Mode II: motor propulsion, engine charges the battery
  - Mode IV: engine propulsion
  - Mode V: engine and motor propulsion

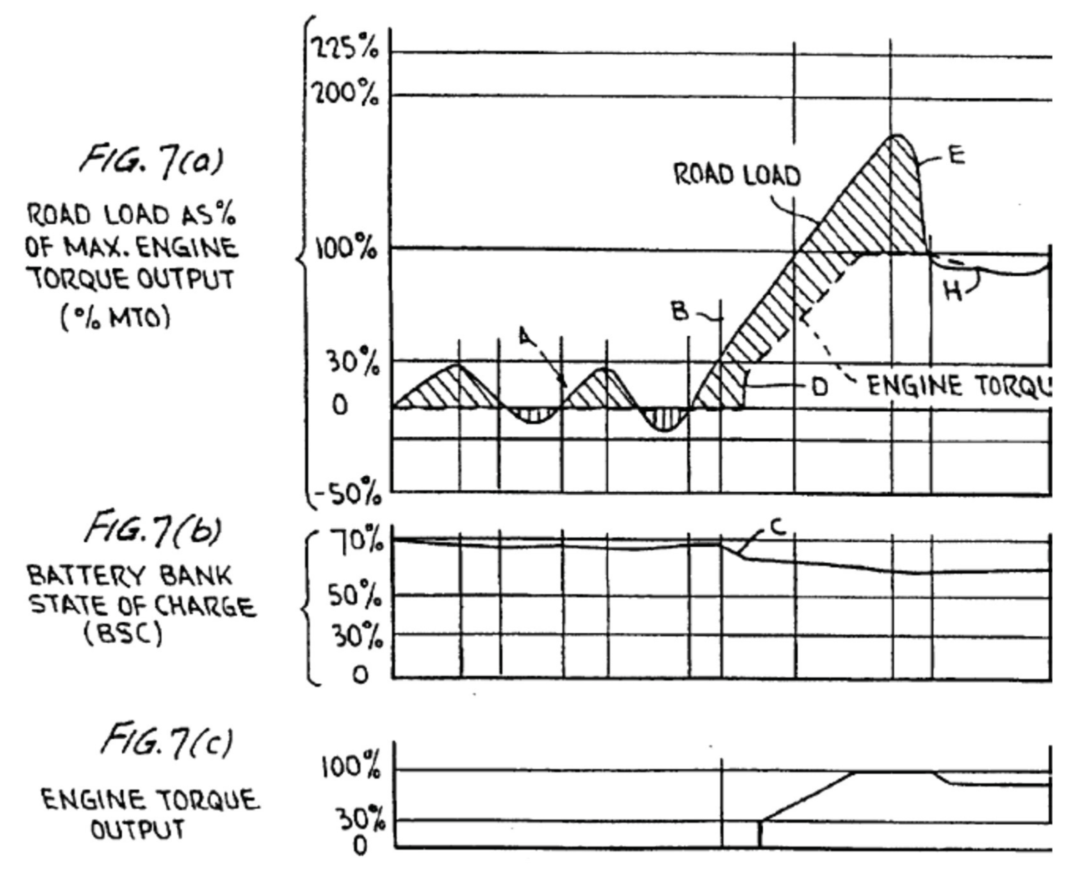
See e.g. IPR '571, Paper No. 20, POR at 2-3.

Technology Background

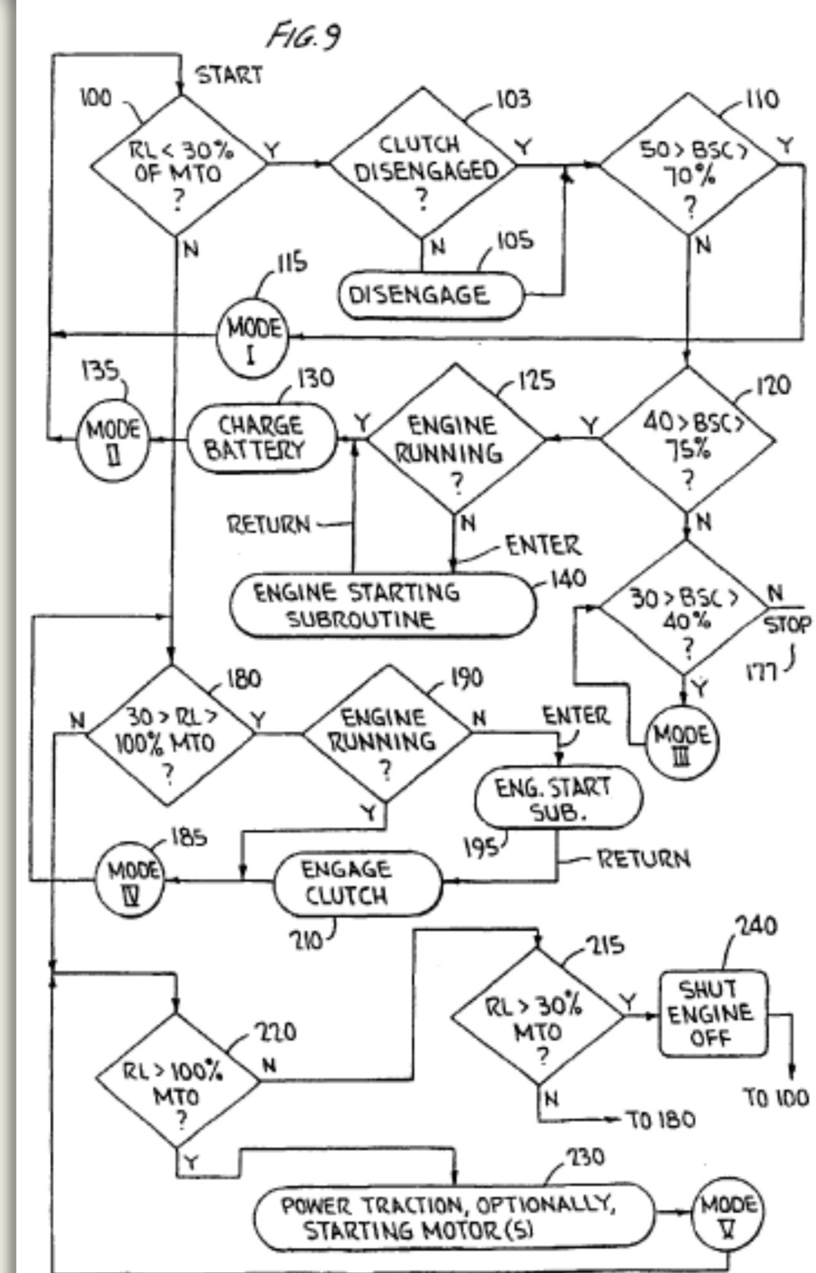
- **In a number of embodiments, switching between these modes depends on an innovative system that compares the "road load" (depicted as a solid line in the example from Fig. 7) to a "setpoint."**



Technology Background



'347 Patent, Fig. 7



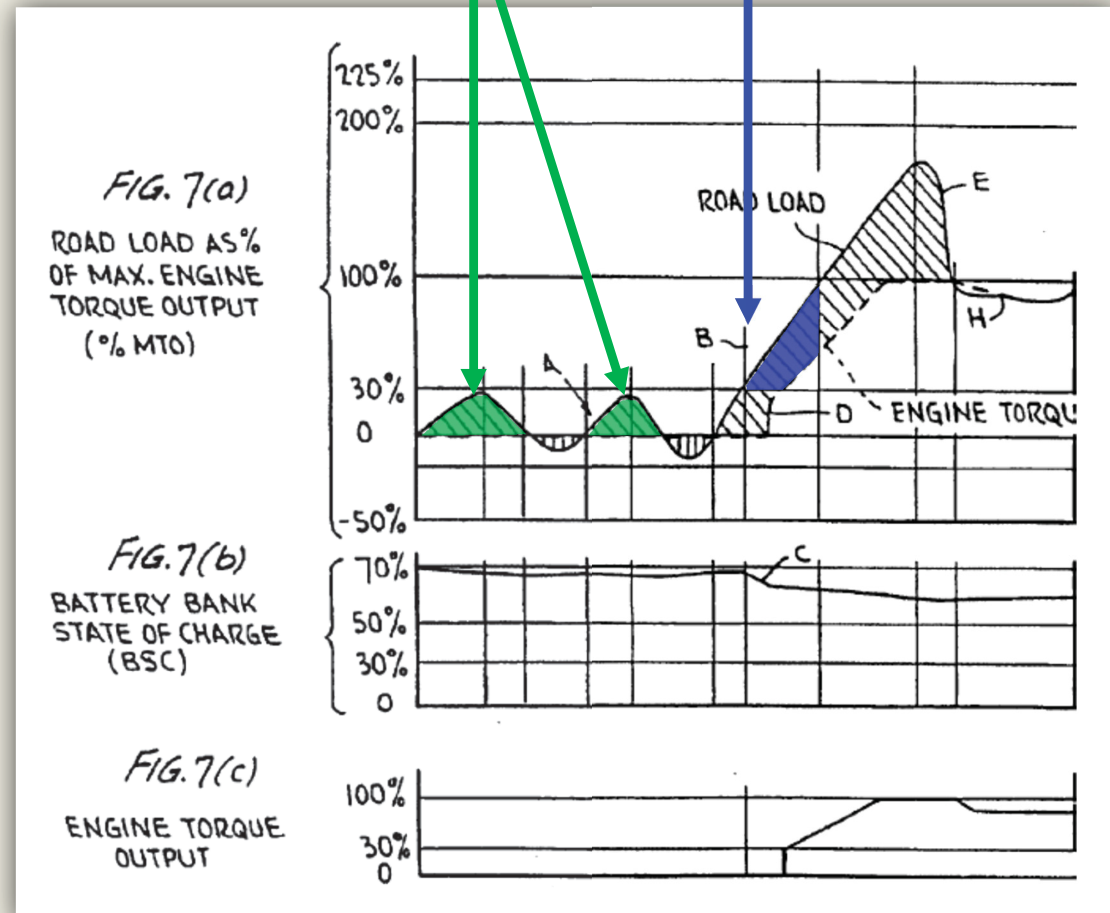
'347 Patent, Fig. 9

Technology Background

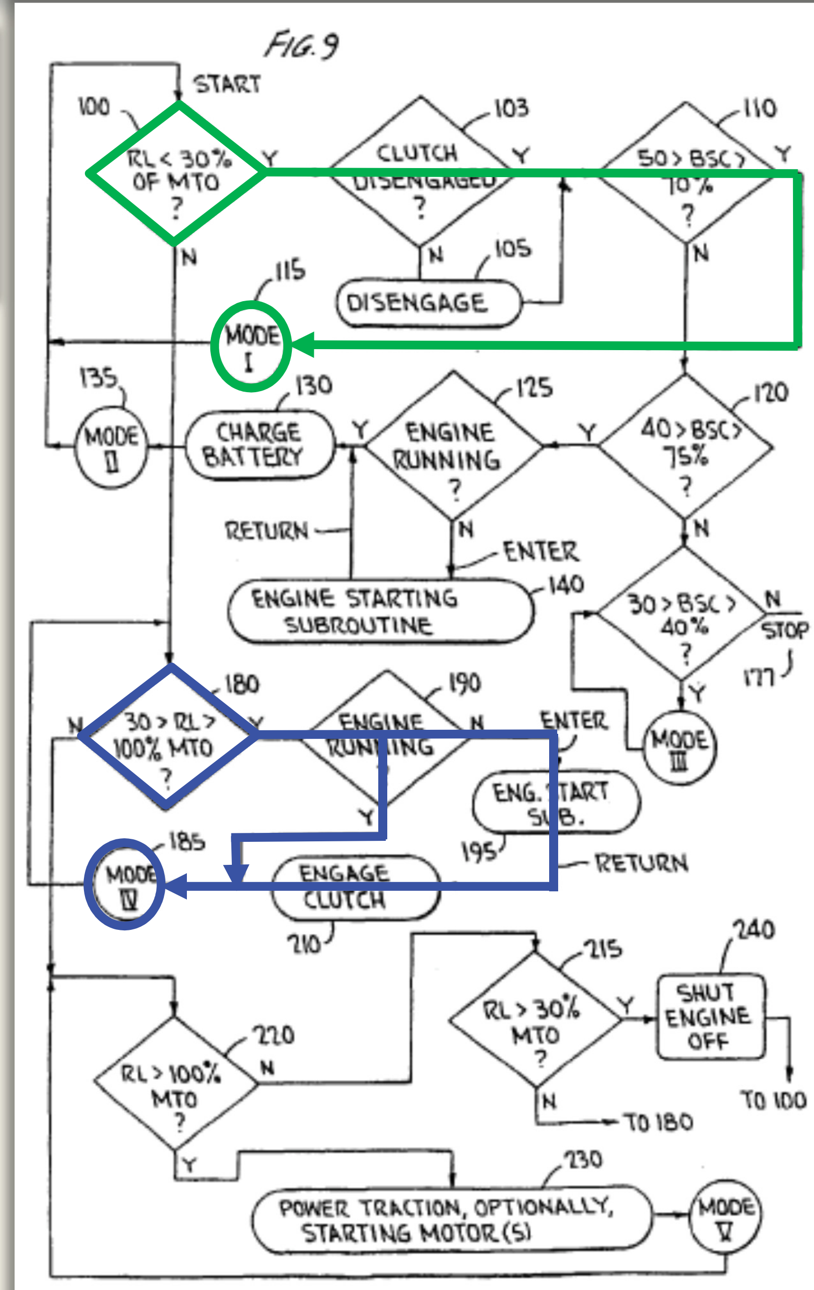
employing said at least one electric motor to propel said vehicle when the torque RL required to do so is less than said lower level SP;

employing said engine to propel said vehicle when the torque RL required to do so is between said lower level SP and MTO;

’347 Patent, Claim 23



’347 Patent, Fig. 7



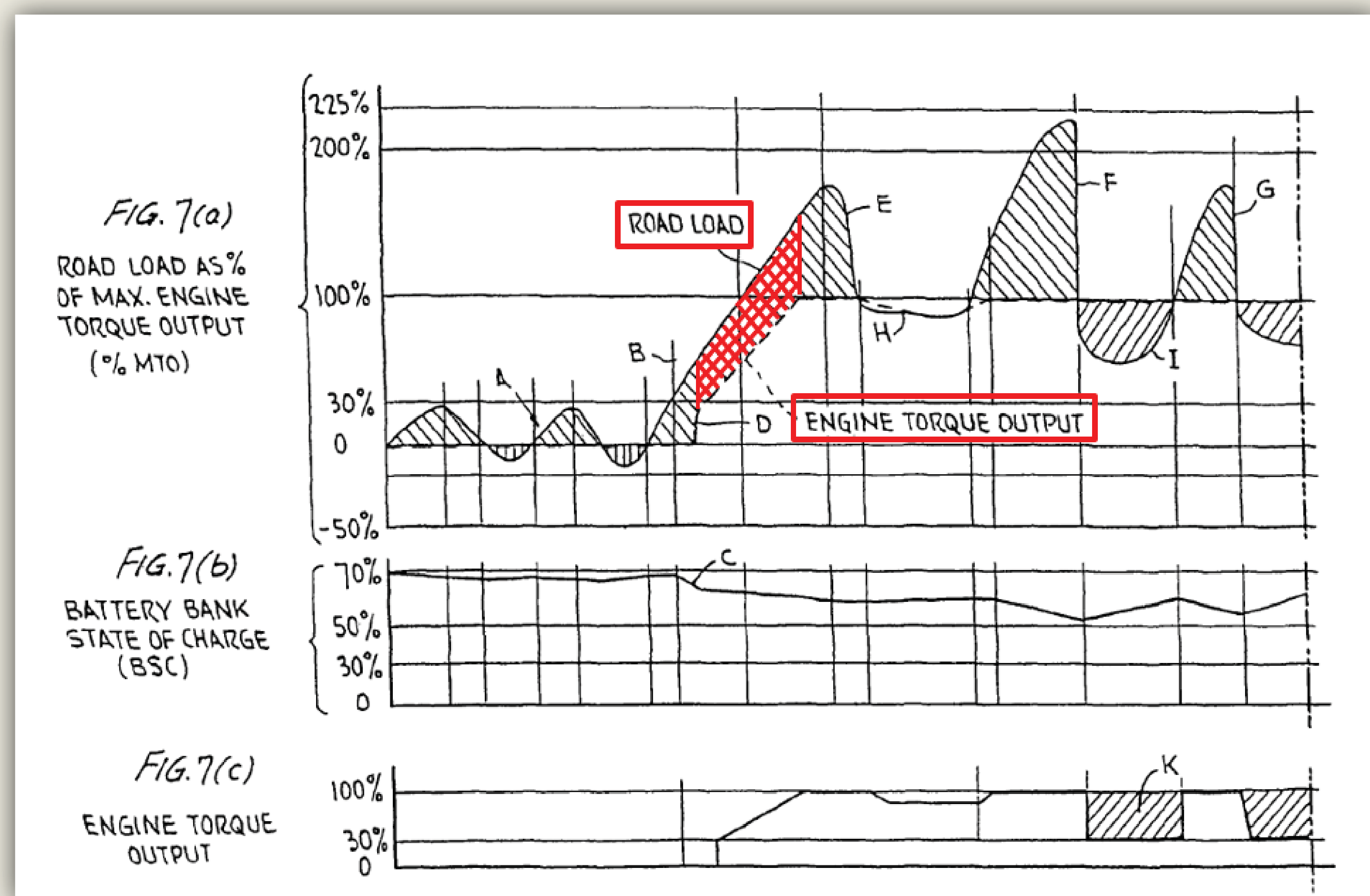
’347 Patent, Fig. 9

“Road load”

- Many of the challenged claims are directed to a vehicle control system that uses “road load” in a control system that determines the vehicle operating mode based on the “road load.”
- Prior art metrics however failed to recognize that the “vehicle operational mode should preferably be controlled in response to the vehicle's actual torque requirements, i.e., the road load.”
- “Road load” provides “superior performance, in terms of both vehicle response to operator commands and fuel efficiency, under the widely varying conditions encountered in ‘real world’ driving situations.”
- Some of the other control metrics used by Ford’s asserted prior art:
  - Vehicle speed
  - Pedal position
  - Power

See e.g. IPR2014-00884, Patent Owner’s Response at 17 (citing Ex. 1201, ’347 patent at col. 13:11-17).

Technology Background



’097 Patent at Fig. 7.

“The rate of change of the engine's torque output is limited, e.g., to 2% or less per revolution, as indicated by noting that the dashed line in FIG. 7(a), indicating the instantaneous engine output torque, lags the solid line indicating the vehicle's instantaneous torque requirement. Thus limiting the rate of change of engine output torque is preferred to limit undesirable emissions and improve fuel economy”

’097 Patent at 38:62-39:1

Claim Construction

Board’s Initial Claim Constructions

Claim Term:	Relevant Patents/IPRs:	Board’s Construction:
“road load”	‘347 Patent: IPR2014-00571 IPR2014-00579 IPR2014-00884 ‘388 Patent: IPR2014-00875 ‘634 Patent: IPR2014-00904	“the amount of instantaneous torque required to propel the vehicle, be it positive or negative.”
“setpoint (SP)”	‘347 Patent IPR2014-00571 IPR2014-00579 IPR2014-00884 ‘634 Patent: IPR2014-00904	“a predetermined torque value that may or may not be reset.”

Disputed Claim Constructions

- **Parties do not dispute the construction of "road load" in IPRs '571, '579, '875, '884, and '904.**
- **Patent Owner opposes the Board's construction of "setpoint (SP)" (in IPRs '571, '579, '884, and '904) and respectfully requests that the Board adopt Patent Owner's proposed construction:**

Claim term	Patent Owner's Proposed Construction
"setpoint (SP)"	"a definite, but potentially variable value at which a transition between operating modes may occur."

See: IPR '571, Paper No. 20, POR at 5-11; IPR '579, Paper No. 20, POR at 5-11; IPR '884, Paper No. 20, POR at 6-13; IPR '904, Paper No. 22, POR at 6-12.

Claim Construction Standards

- **The Board's "broadest" interpretation must be reasonable, and must be in conformity with the invention as described in the specification. *In re Vaidyanathan*, 381 Fed. Appx. 985, 995-96 (Fed. Cir. 2010)**

- **Board must consider the entirety of the claims and specification, and cannot limit its analysis to just a portion of the disputed claim phrase, which would be clear, reversible error.**

- ***See e.g. In re Abbott Diabetes Care Inc.*, 696 F.3d 1142, 1149 (Fed. Cir. 2012) (holding that Board's construction of "electrochemical sensor" was "unreasonable and inconsistent with the language of the claims and the specification").**

See e.g. **IPR '571, Paper No. 20, POR at 7.**

“Setpoint,” “SP”

Patent Owner’s Proposed Claim Construction	Board’s Construction
“a definite, but potentially variable value at which a transition between operating modes may occur.”	“a predetermined torque value that may or may not be reset.”

- The Board’s construction of “setpoint (SP)” is incorrect because it fails to recognize that “setpoint” represents a point at which a transition between different operating modes may occur.
- The U.S. District Court for the Eastern District of Texas and the U.S. District Court for the District of Maryland have both construed the term consistently with Patent Owner’s proposed construction.

See e.g. IPR ‘904, Paper No. 22, POR at 6-7.

"Setpoint," "SP" marks a transition between modes

- **Claim language makes clear that a "setpoint" marks a point at which the vehicle may transition between two modes, for example between a mode in which only the motor propels the vehicle, to modes in which the engine also can be used to propel the vehicle or charge the battery:**

16. The hybrid vehicle of claim **1**, wherein the controller is operable to implement a plurality of operating modes responsive to road load (RL) and the SP, wherein both the RL and the SP are expressed as percentages of the MTO of the engine when normally-aspirated, and wherein the operating modes comprise:

a low-load mode I, wherein, when the RL<the SP, the second electric motor is operable to provide torque to propel the hybrid vehicle;

a highway cruising mode IV, wherein, when the SP<the RL<the MTO, the engine is operable to provide torque to propel the hybrid vehicle, and wherein the controller is operable to start the engine if the engine is not running to enter the highway cruising mode IV; and

an acceleration mode V, wherein, when the RL>the MTO, the engine, the first electric motor, and/or the second electric motor is operable to provide torque to propel the hybrid vehicle, and wherein the controller is operable to start the engine if the engine is not running to enter the acceleration mode V.

'634 Patent, claim 16:

"Setpoint," "SP" marks a transition between modes

- **Claim language makes clear that a "setpoint" marks a point at which the vehicle may transition between two modes, for example between a mode in which only the motor propels the vehicle, to modes in which the engine also can be used to propel the vehicle or charge the battery:**

> determining the instantaneous torque RL required to propel said vehicle responsive to an operator command;
>
> monitoring the state of charge of said battery;
>
> employing said at least one electric motor to propel said vehicle when the torque RL required to do so is less than said lower level SP;
>
> employing said engine to propel said vehicle when the torque RL required to do so is between said lower level SP and MTO;
>
> employing both said at least one electric motor and said engine to propel said vehicle when the torque RL required to do so is more than MTO; and
>
> employing said engine to propel said vehicle when the torque RL required to do so is less than said lower level SP and using the torque between RL and SP to drive said at least one electric motor to charge said battery when the state of charge of said battery indicates the desirability of doing so; and

'347 Patent, claim 23:

"Setpoint," "SP" marks a transition between modes

- Specification makes clear that a "setpoint" is synonymous with a "transition point" between modes

> [I]n the example of the inventive control strategy discussed above, it is repeatedly stated that <u>the transition</u> from low-speed operation to highway cruising occurs when road load is equal to 30% of MTO. <u>This setpoint, referred to in the appended claims as "SP", and sometimes hereinafter as the transition point (i.e., between operation in modes I and IV)</u> is obviously arbitrary and can vary substantially, e.g., between 30- 50% of MTO, within the scope of the invention.

'347 Patent at col. 40:47-55

See e.g. IPR '571, Paper No. 20, POR at 9 (citing '347 patent); IPR '904, Paper No. 22, POR at 9-10 (citing '634 patent)

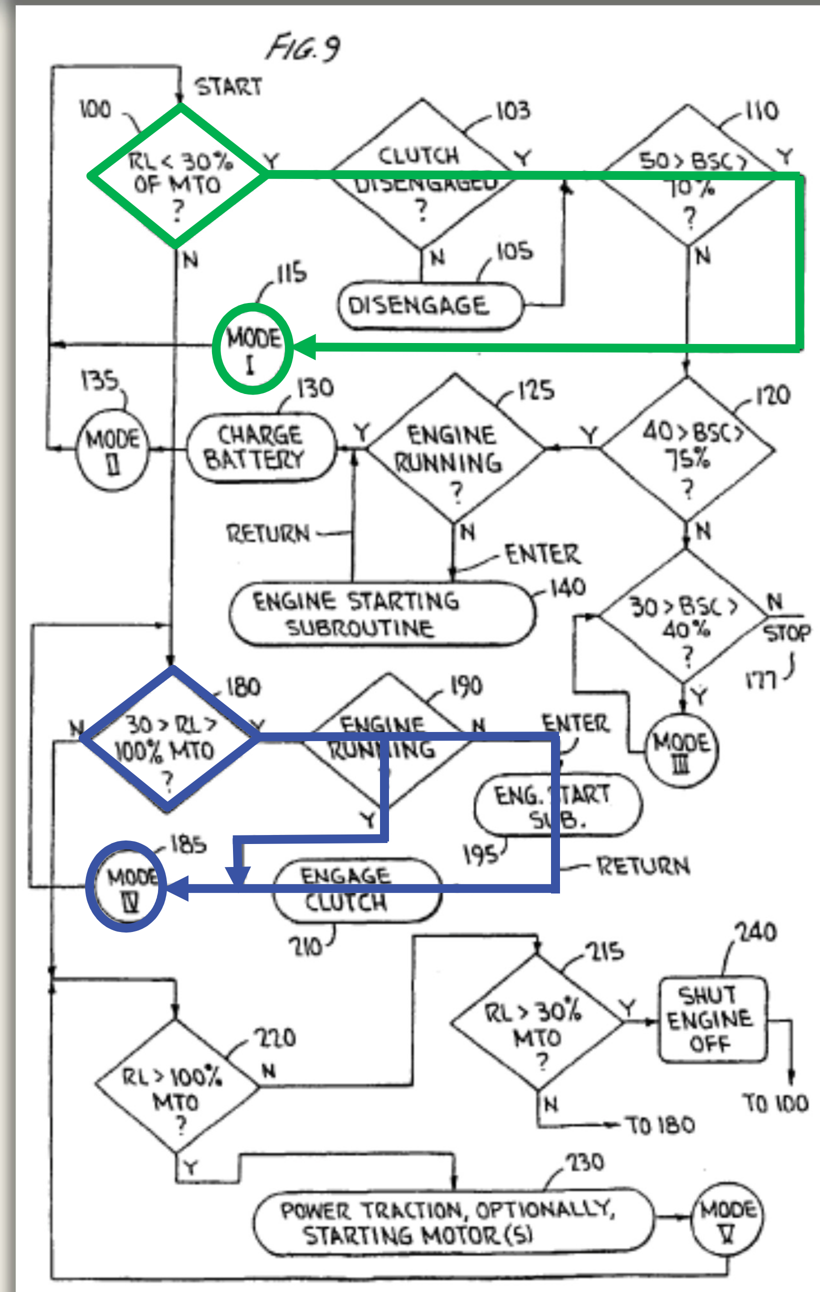
"Setpoint," "SP" marks a transition between modes

FIG. 9 thus shows the main decision points of the control program run by the microprocessor, **with the transition point between mode I, low-speed operation, and mode IV highway cruising**, set at a road load equal to 30% of MTO.

'347 Patent at col. 41:59-63

Further, as noted above **the transition points between modes I, IV, and V** in particular may vary in accordance with the operator's commands…

'347 Patent at col. 44:32-39



Board’s construction is unreasonably broad

- Board’s construction reads out a crucial limitation of the claims: the “setpoint” marks the amount of “road load” at which the claimed control system actively changes the vehicle from one mode to another (*e.g.* from motor propulsion to engine propulsion).

- Board’s failure to recognize the “transition” function of “setpoints” could rob the “mode” limitations of one of the key aspects of the invention, *i.e.* the significant efficiency to be gained by transitioning between motor propulsion to engine propulsion in response to “road load.”

- Under the Board’s improper construction, the claims could improperly be read to broadly cover hybrid vehicle systems where *transitions between modes never occur*.

- Such an unreasonably broad construction is fundamentally contrary to the specification of the challenged patents.

See e.g. IPR ‘571, Paper No. 20, POR at 10-11 (citing ‘347 patent); IPR ‘904, Paper No. 22, POR at 10-11 (citing ‘634 patent)

IPR2014-00571 AND IPR2014-00904

IPR2014-00571 – Introduction

- **U.S. Patent No. 7,104,347**
- **Ground 1 (§ 103):**
  - **Challenged claims: 23 and 36**
  - **Asserted Art: Severinsky**
- **Ground 2 (§ 103):**
  - **Challenged claims: 1, 6, 7, 9, 15 and 21**
  - **Asserted Art: Severinsky and Ehsani**
  - **Ford’s Ground 3 was included in Ground 2:**

> As such, we exercise our discretion under 37 C.F.R. § 42.108 to view Ford’s challenge based on “Ehsani and Severinsky” not as a different ground, but simply as additional support for the ground of “Severinsky and Ehsani” on which we institute trial.

IPR2014-00571, Paper 12, Institution Decision at 16.

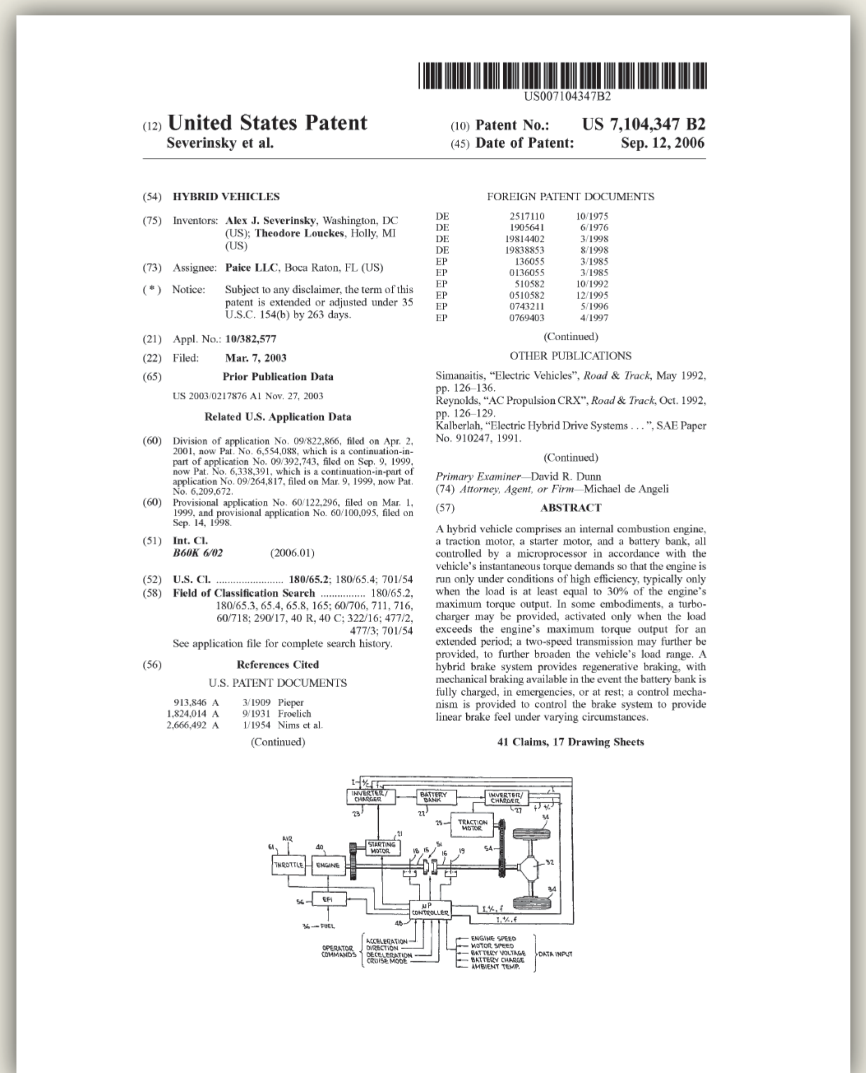
IPR2014-00904 – Introduction

- **U.S. Patent No. 7,237,634**
- **Ground 1 (§ 103):**
  - **Challenged claims: 1, 14, 16, 18 and 24**
  - **Asserted Art: Severinsky, Field, and SAE 1996**
- **The Board declined to institute Ground 2**

> And in the absence of Ford advancing some meaningful benefit to proceeding with the additional ground of Severinsky and Ehsani, we presume that it is the weaker of the two asserted grounds, and we exercise our discretion to deny institution of this presumably weaker ground. See 37 C.F.R. § 42.108(a).

IPR '904, Paper 13, Institution Decision at 13.

Introduction to the ’347 Patent



US007104347B2

(12) United States Patent
Severinsky et al.

(10) Patent No.: US 7,104,347 B2
(45) Date of Patent: Sep. 12, 2006

(54) HYBRID VEHICLES

(75) Inventors: **Alex J. Severinsky**, Washington, DC (US); **Theodore Louckes**, Holly, MI (US)

(73) Assignee: **Paice LLC**, Boca Raton, FL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 263 days.

(21) Appl. No.: **10/382,577**

(22) Filed: **Mar. 7, 2003**

(65) **Prior Publication Data**

US 2003/0217876 A1 Nov. 27, 2003

Related U.S. Application Data

(60) Division of application No. 09/822,866, filed on Apr. 2, 2001, now Pat. No. 6,554,088, which is a continuation-in-part of application No. 09/392,743, filed on Sep. 9, 1999, now Pat. No. 6,338,391, which is a continuation-in-part of application No. 09/264,817, filed on Mar. 9, 1999, now Pat. No. 6,209,672.

(60) Provisional application No. 60/122,296, filed on Mar. 1, 1999, and provisional application No. 60/100,095, filed on Sep. 14, 1998.

(51) **Int. Cl.**
B60K 6/02 (2006.01)

(52) **U.S. Cl.** **180/65.2**; 180/65.4; 701/54

(58) **Field of Classification Search** .... 180/65.2, 180/65.3, 65.4, 65.8, 165; 60/706, 711, 716, 60/718; 290/17, 40 R, 40 C; 322/16; 477/2, 477/3; 701/54

See application file for complete search history.

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Kalberlah, “Electric Hybrid Drive Systems . . . ”, SAE Paper No. 910247, 1991.

(Continued)

Primary Examiner—David R. Dunn
(74) *Attorney, Agent, or Firm*—Michael de Angeli

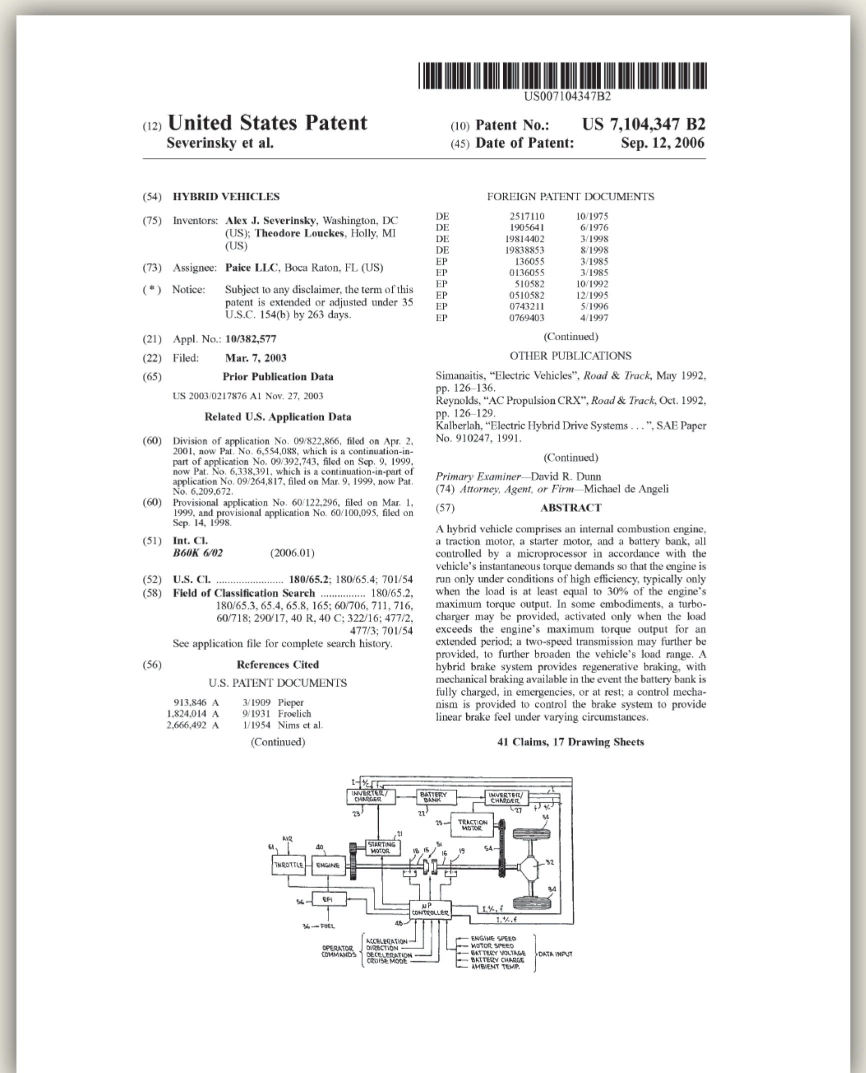
(57) **ABSTRACT**

A hybrid vehicle comprises an internal combustion engine, a traction motor, a starter motor, and a battery bank, all controlled by a microprocessor in accordance with the vehicle’s instantaneous torque demands so that the engine is run only under conditions of high efficiency, typically only when the load is at least equal to 30% of the engine’s maximum torque output. In some embodiments, a turbo-charger may be provided, activated only when the load exceeds the engine’s maximum torque output for an extended period; a two-speed transmission may further be provided, to further broaden the vehicle’s load range. A hybrid brake system provides regenerative braking, with mechanical braking available in the event the battery bank is fully charged, in emergencies, or at rest; a control mechanism is provided to control the brake system to provide linear brake feel under varying circumstances.

41 Claims, 17 Drawing Sheets

- The ’347 Patent (IPR ’571, Ex. 1001) is directed to hybrid vehicles and control systems thereof
- The ’347 patent recognized that the “vehicle operational mode should preferably be controlled in response to the vehicle's actual torque requirements, i.e., the road load.”
- Use of “road load” according to the patent provides “superior performance, in terms of both vehicle response to operator commands and fuel efficiency, under the widely varying conditions encountered in ‘real world’ driving situations.”

Introduction to the ’347 Patent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(12) United States Patent
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(10) Patent No.: US 7,104,347 B2
(45) Date of Patent: Sep. 12, 2006

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(52) U.S. Cl. 180/65.2; 180/65.4; 701/54

(58) Field of Classification Search .... 180/65.2, 180/65.3, 65.4, 65.8, 165; 60/706, 711, 716, 60/718; 290/17, 40 R, 40 C; 322/16; 477/2, 477/3; 701/54

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(Continued)

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Simanaitis, “Electric Vehicles”, *Road & Track*, May 1992, pp. 126-136.
Reynolds, “AC Propulsion CRX”, *Road & Track*, Oct. 1992, pp. 126-129.
Kalberlah, “Electric Hybrid Drive Systems . . . ”, SAE Paper No. 910247, 1991.

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Primary Examiner—David R. Dunn
(74) *Attorney, Agent, or Firm*—Michael de Angeli

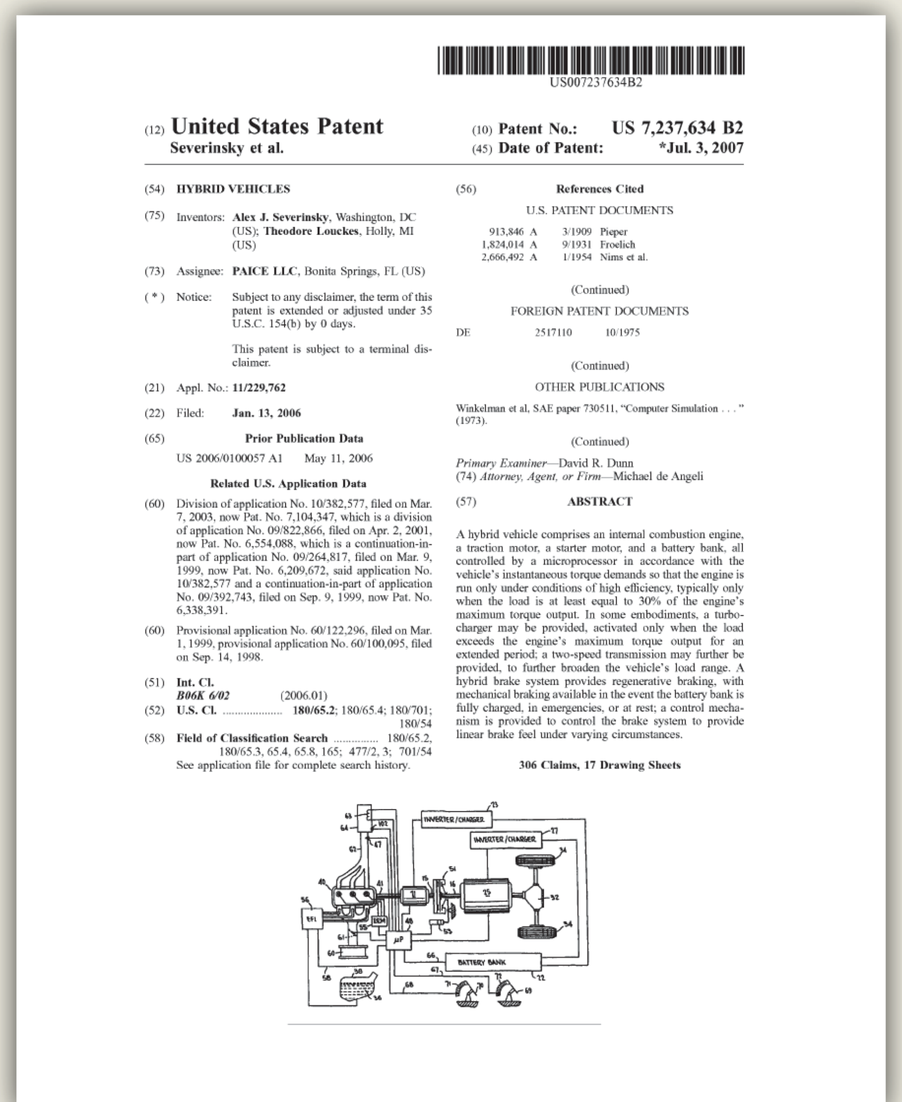
(57) ABSTRACT

A hybrid vehicle comprises an internal combustion engine, a traction motor, a starter motor, and a battery bank, all controlled by a microprocessor in accordance with the vehicle's instantaneous torque demands so that the engine is run only under conditions of high efficiency, typically only when the load is at least equal to 30% of the engine's maximum torque output. In some embodiments, a turbocharger may be provided, activated only when the load exceeds the engine's maximum torque output for an extended period; a two-speed transmission may further be provided, to further broaden the vehicle's load range. A hybrid brake system provides regenerative braking, with mechanical braking available in the event the battery bank is fully charged, in emergencies, or at rest; a control mechanism is provided to control the brake system to provide linear brake feel under varying circumstances.

41 Claims, 17 Drawing Sheets

- Independent claim 1 turns the engine on “when torque require[d] to be produced by said engine to propel the vehicle and/or to drive either one or both said electric motor(s) to charge said battery is at least equal to a setpoint (SP).
    - Dependent claim 7 recites a “vehicle [that] is operated in a plurality of operating modes responsive to the value for the road load (RL) and said setpoint SP.”
- Independent claim 23 similarly recites selecting various operating modes by comparing the “road load” to a “setpoint.”

Introduction to the ’634 Patent


US007237634B2

(12) United States Patent
Severinsky et al.

(10) Patent No.: US 7,237,634 B2
(45) Date of Patent: *Jul. 3, 2007

(54) HYBRID VEHICLES

(75) Inventors: Alex J. Severinsky, Washington, DC (US); Theodore Louckes, Holly, MI (US)

(73) Assignee: PAICE LLC, Bonita Springs, FL (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.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: 11/229,762

(22) Filed: Jan. 13, 2006

(65) Prior Publication Data

US 2006/0100057 A1 May 11, 2006

Related U.S. Application Data

(60) Division of application No. 10/382,577, filed on Mar. 7, 2003, now Pat. No. 7,104,347, which is a division of application No. 09/822,866, filed on Apr. 2, 2001, now Pat. No. 6,554,088, which is a continuation-in-part of application No. 09/264,817, filed on Mar. 9, 1999, now Pat. No. 6,209,672, said application No. 10/382,577 and a continuation-in-part of application No. 09/392,743, filed on Sep. 9, 1999, now Pat. No. 6,338,391.

(60) Provisional application No. 60/122,296, filed on Mar. 1, 1999, provisional application No. 60/100,095, filed on Sep. 14, 1998.

(51) Int. Cl.
B06K 6/02 (2006.01)

(52) U.S. Cl. 180/65.2; 180/65.4; 180/701; 180/54

(58) Field of Classification Search 180/65.2, 180/65.3, 65.4, 65.8, 165; 477/2, 3; 701/54
See application file for complete search history.

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Primary Examiner—David R. Dunn
(74) Attorney, Agent, or Firm—Michael de Angeli

(57) ABSTRACT

A hybrid vehicle comprises an internal combustion engine, a traction motor, a starter motor, and a battery bank, all controlled by a microprocessor in accordance with the vehicle’s instantaneous torque demands so that the engine is run only under conditions of high efficiency, typically only when the load is at least equal to 30% of the engine’s maximum torque output. In some embodiments, a turbocharger may be provided, activated only when the load exceeds the engine’s maximum torque output for an extended period; a two-speed transmission may further be provided, to further broaden the vehicle’s load range. A hybrid brake system provides regenerative braking, with mechanical braking available in the event the battery bank is fully charged, in emergencies, or at rest; a control mechanism is provided to control the brake system to provide linear brake feel under varying circumstances.

306 Claims, 17 Drawing Sheets

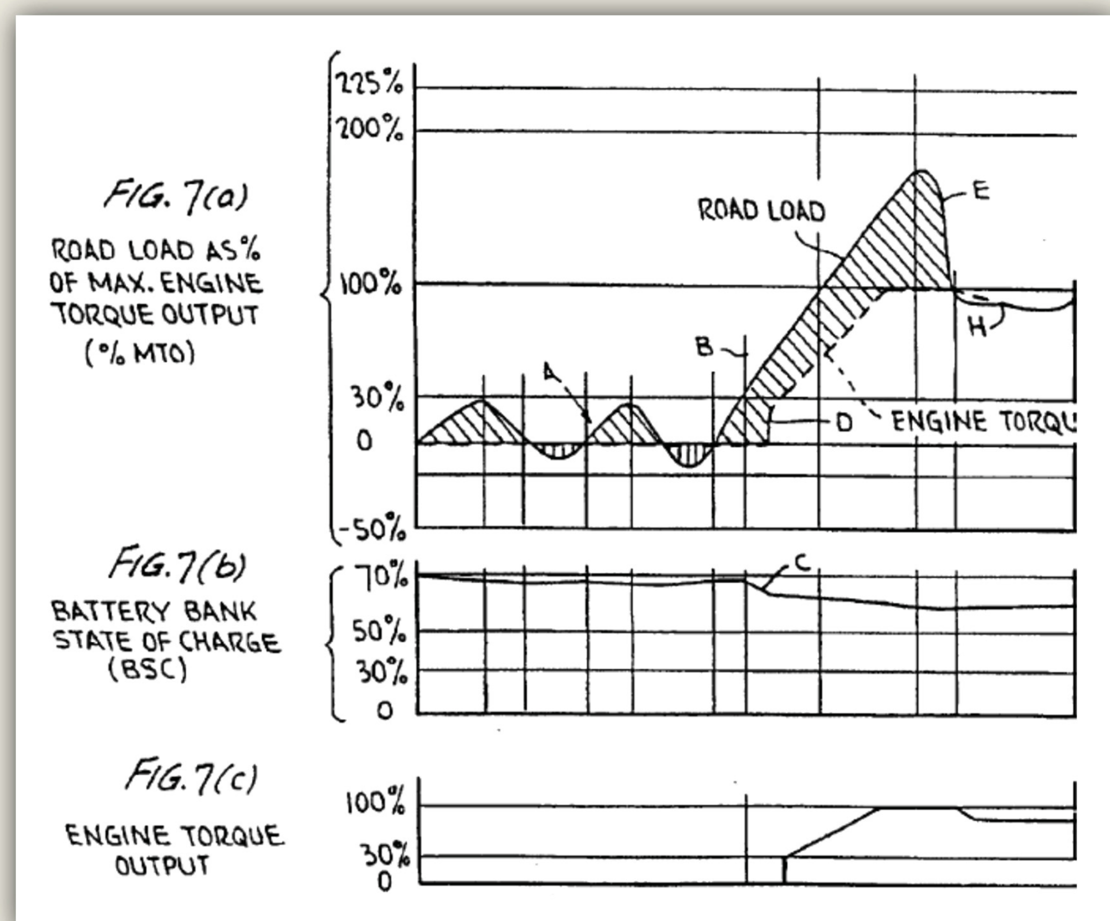
- The ’634 Patent (IPR ’904, Ex. 1001) is also directed to the control system of a hybrid vehicle and claims the use of road load to effect mode switching.
- Independent claim 1 operates the engine “when torque required from the engine to propel the vehicle and/or to drive one or more of the first or the second motors to charge the battery is at least equal to a setpoint (SP).”
  - Dependent claim 16 recites a “wherein the controller is operable to implement a plurality of operating modes responsive to road load (RL) and the SP.”

Introduction to the ’347 and ’634 Patents

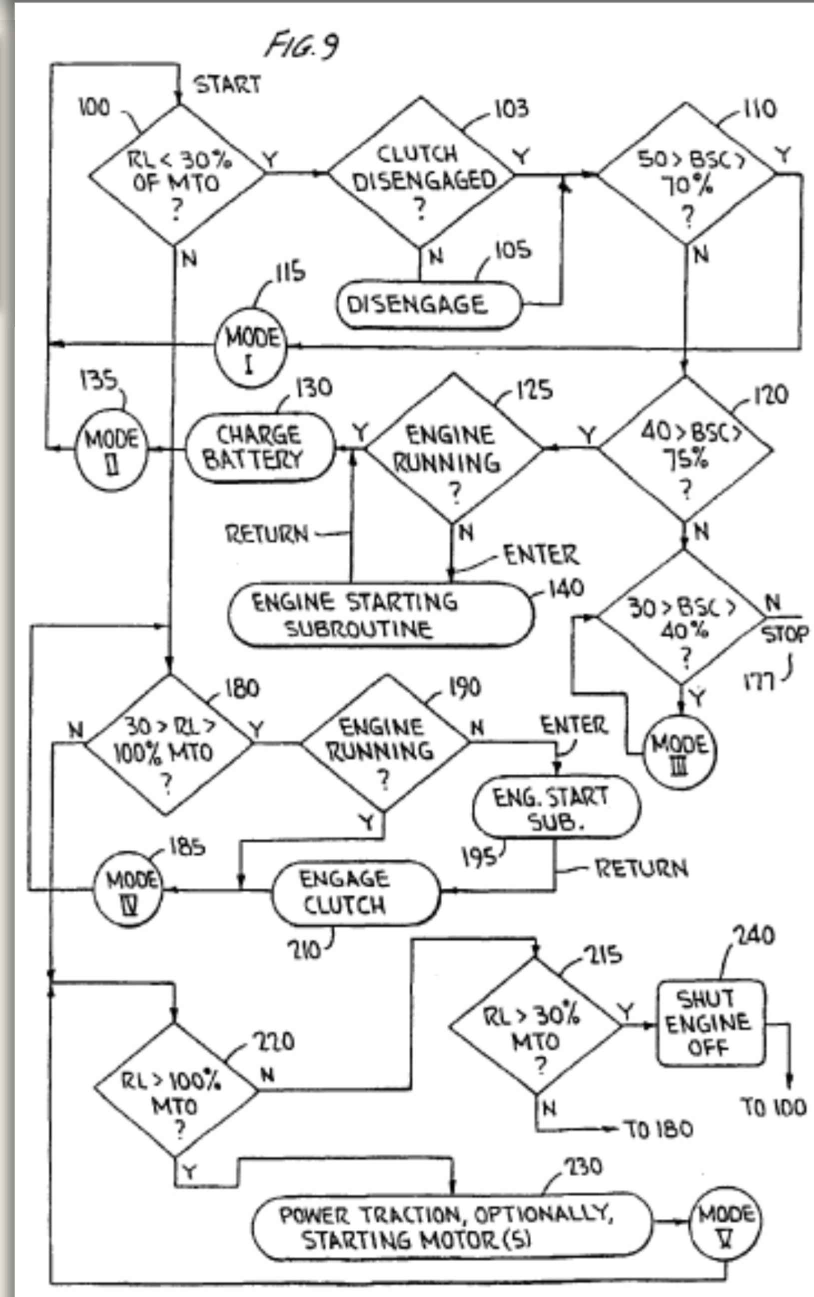
employing said at least one electric motor to propel said vehicle when the torque RL required to do so is less than said lower level SP;

employing said engine to propel said vehicle when the torque RL required to do so is between said lower level SP and MTO;

’347 Patent, Claim 23



’347 Patent, Fig. 7



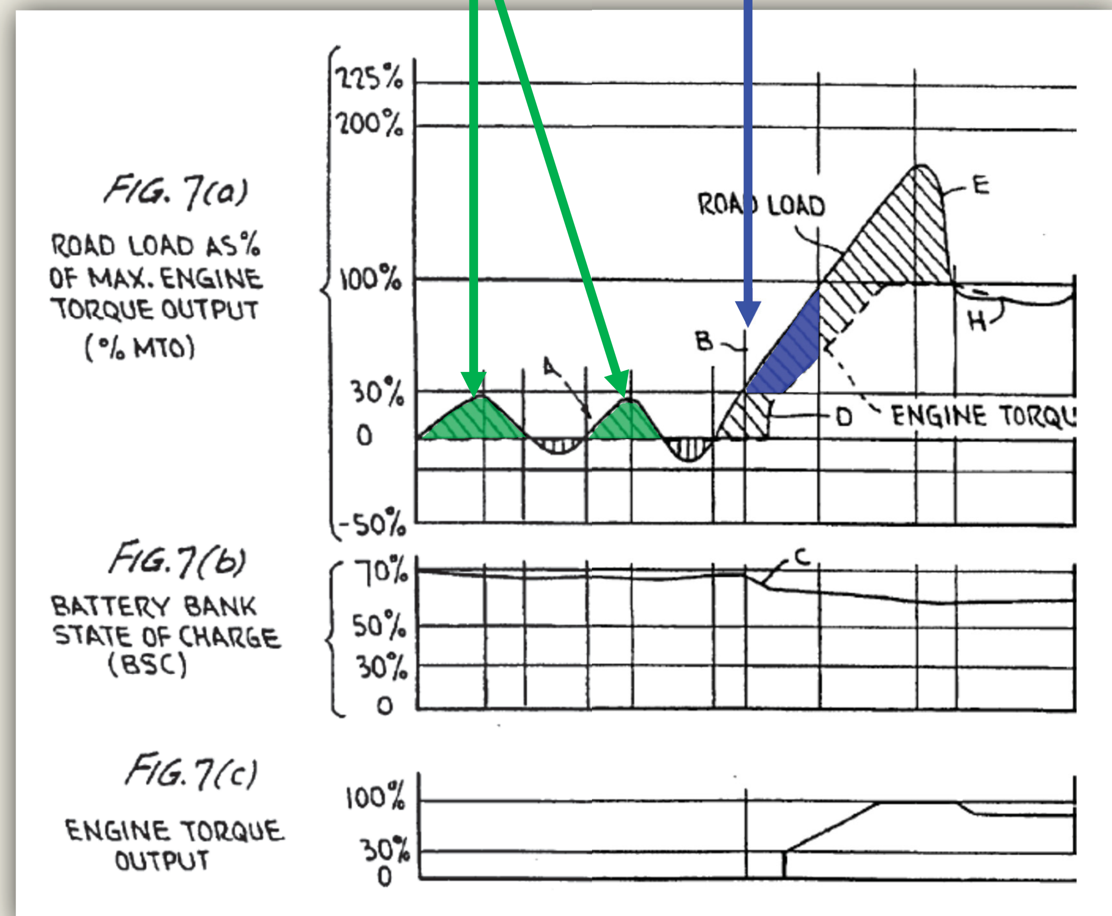
’347 Patent, Fig. 9

Introduction to the ’347 and ’634 Patents

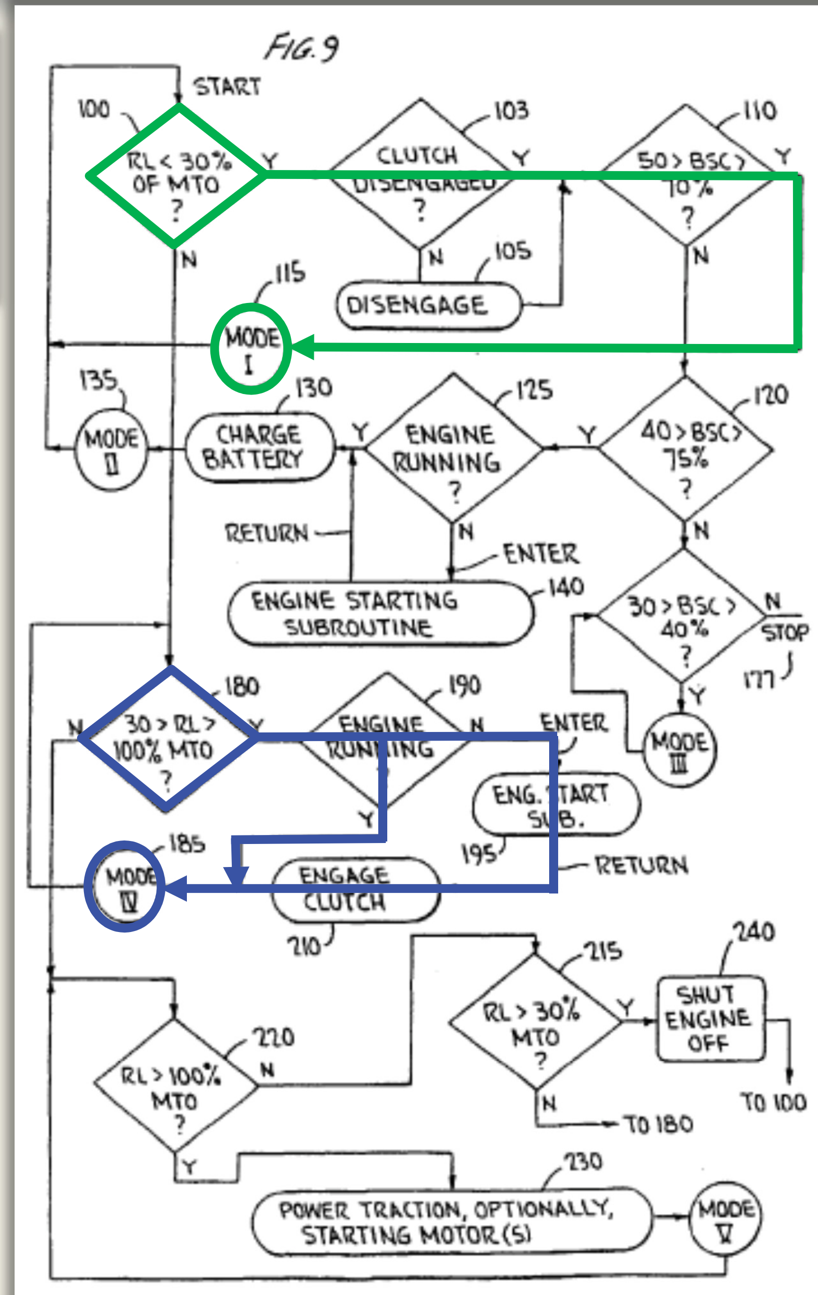
employing said at least one electric motor to propel said vehicle when the torque RL required to do so is less than said lower level SP;

employing said engine to propel said vehicle when the torque RL required to do so is between said lower level SP and MTO;

’347 Patent, Claim 23



’347 Patent, Fig. 7



’347 Patent, Fig. 9

Ground 1 - Severinsky Does Not Disclose or Render Obvious Claims 23 and 36 of the ’347 Patent

'347 Patent - Claim 23 Introduction

23. A method of control of a hybrid vehicle, said vehicle comprising an internal combustion engine capable of efficiently producing torque at loads between a lower level SP and a maximum torque output MTO, a battery, and one or more electric motors being capable of providing output torque responsive to supplied current, and of generating electrical current responsive to applied torque, said engine being controllably connected to wheels of said vehicle for applying propulsive torque thereto and to said at least one motor for applying torque thereto, said method comprising the steps of:

determining the instantaneous torque RL required to propel said vehicle responsive to an operator command;

monitoring the state of charge of said battery;

employing said at least one electric motor to propel said vehicle when the torque RL required to do so is less than said lower level SP;

employing said engine to propel said vehicle when the torque RL required to do so is between said lower level SP and MTO;

employing both said at least one electric motor and said engine to propel said vehicle when the torque RL required to do so is more than MTO; and

employing said engine to propel said vehicle when the torque RL required to do so is less than said lower level SP and using the torque between RL and SP to drive said at least one electric motor to charge said battery when the state of charge of said battery indicates the desirability of doing so; and

wherein the torque produced by said engine when operated at said setpoint (SP) is substantially less than the maximum torque output (MTO) of said engine.

'347 Patent, Claim 23

Claim 23 determines the "road load," *i.e.* the instantaneous torque required to propel the vehicle

'347 Patent - Claim 23 Introduction

23. A method of control of a hybrid vehicle, said vehicle comprising an internal combustion engine capable of efficiently producing torque at loads between a lower level SP and a maximum torque output MTO, a battery, and one or more electric motors being capable of providing output torque responsive to supplied current, and of generating electrical current responsive to applied torque, said engine being controllably connected to wheels of said vehicle for applying propulsive torque thereto and to said at least one motor for applying torque thereto, said method comprising the steps of:

determining the instantaneous torque RL required to propel said vehicle responsive to an operator command;

monitoring the state of charge of said battery;

employing said at least one electric motor to propel said vehicle when the torque RL required to do so is less than said lower level SP;

employing said engine to propel said vehicle when the torque RL required to do so is between said lower level SP and MTO;

employing both said at least one electric motor and said engine to propel said vehicle when the torque RL required to do so is more than MTO; and

employing said engine to propel said vehicle when the torque RL required to do so is less than said lower level SP and using the torque between RL and SP to drive said at least one electric motor to charge said battery when the state of charge of said battery indicates the desirability of doing so; and

wherein the torque produced by said engine when operated at said setpoint (SP) is substantially less than the maximum torque output (MTO) of said engine.

'347 Patent, Claim 23

Claim 23 compares the "road load" to "setpoint" to determine what operating mode to transition into

'347 Patent - Claim 23 Introduction

23. A method of control of a hybrid vehicle, said vehicle comprising an internal combustion engine capable of efficiently producing torque at loads between a lower level SP and a maximum torque output MTO, a battery, and one or more electric motors being capable of providing output torque responsive to supplied current, and of generating electrical current responsive to applied torque, said engine being controllably connected to wheels of said vehicle for applying propulsive torque thereto and to said at least one motor for applying torque thereto, said method comprising the steps of:

determining the instantaneous torque RL required to propel said vehicle responsive to an operator command;

monitoring the state of charge of said battery;

employing said at least one electric motor to propel said vehicle when the torque RL required to do so is less than said lower level SP;

employing said engine to propel said vehicle when the torque RL required to do so is between said lower level SP and MTO;

employing both said at least one electric motor and said engine to propel said vehicle when the torque RL required to do so is more than MTO; and

employing said engine to propel said vehicle when the torque RL required to do so is less than said lower level SP and using the torque between RL and SP to drive said at least one electric motor to charge said battery when the state of charge of said battery indicates the desirability of doing so; and

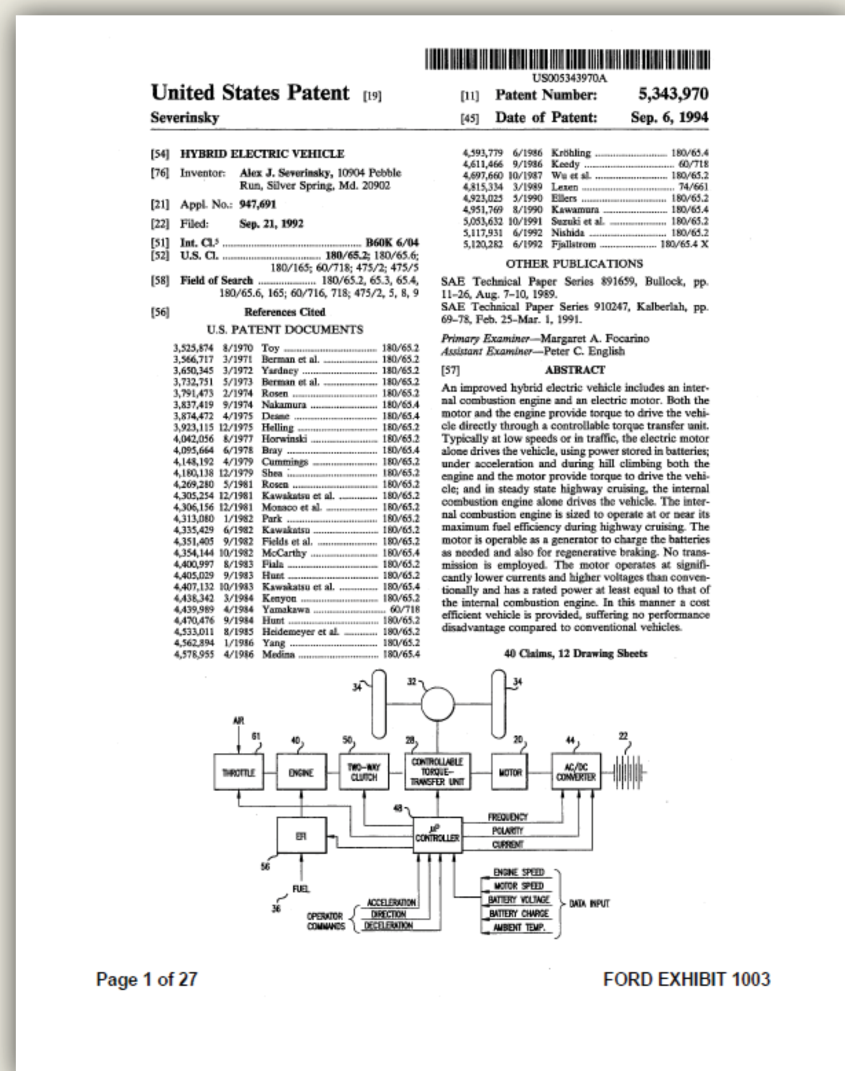
wherein the torque produced by said engine when operated at said setpoint (SP) is substantially less than the maximum torque output (MTO) of said engine.

'347 Patent, Claim 23

When the battery needs charging, and the "road load" is less than a "setpoint," claim 23 operates the engine at least at "setpoint" and uses the torque between "road load" and "setpoint" to charge the battery

Introduction to the Prior Art

Introduction to Severinsky



United States Patent [19]
Severinsky

US005343970A
[11] Patent Number: 5,343,970
[45] Date of Patent: Sep. 6, 1994

[54] HYBRID ELECTRIC VEHICLE

[76] Inventor: Alex J. Severinsky, 10904 Pebble Run, Silver Spring, Md. 20902

[21] Appl. No.: 947,691

[22] Filed: Sep. 21, 1992

[51] Int. Cl.[5] B60K 6/04

[52] U.S. Cl. 180/65.2; 180/65.6; 180/165; 60/718; 475/2; 475/5

[58] Field of Search 180/65.2, 65.3, 65.4, 180/65.6, 165; 60/716, 718; 475/2, 5, 8, 9

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Primary Examiner—Margaret A. Focarino
Assistant Examiner—Peter C. English

[57] ABSTRACT

An improved hybrid electric vehicle includes an internal combustion engine and an electric motor. Both the motor and the engine provide torque to drive the vehicle directly through a controllable torque transfer unit. Typically at low speeds or in traffic, the electric motor alone drives the vehicle, using power stored in batteries; under acceleration and during hill climbing both the engine and the motor provide torque to drive the vehicle; and in steady state highway cruising, the internal combustion engine alone drives the vehicle. The internal combustion engine is sized to operate at or near its maximum fuel efficiency during highway cruising. The motor is operable as a generator to charge the batteries as needed and also for regenerative braking. No transmission is employed. The motor operates at significantly lower currents and higher voltages than conventionally and has a rated power at least equal to that of the internal combustion engine. In this manner a cost efficient vehicle is provided, suffering no performance disadvantage compared to conventional vehicles.

40 Claims, 12 Drawing Sheets

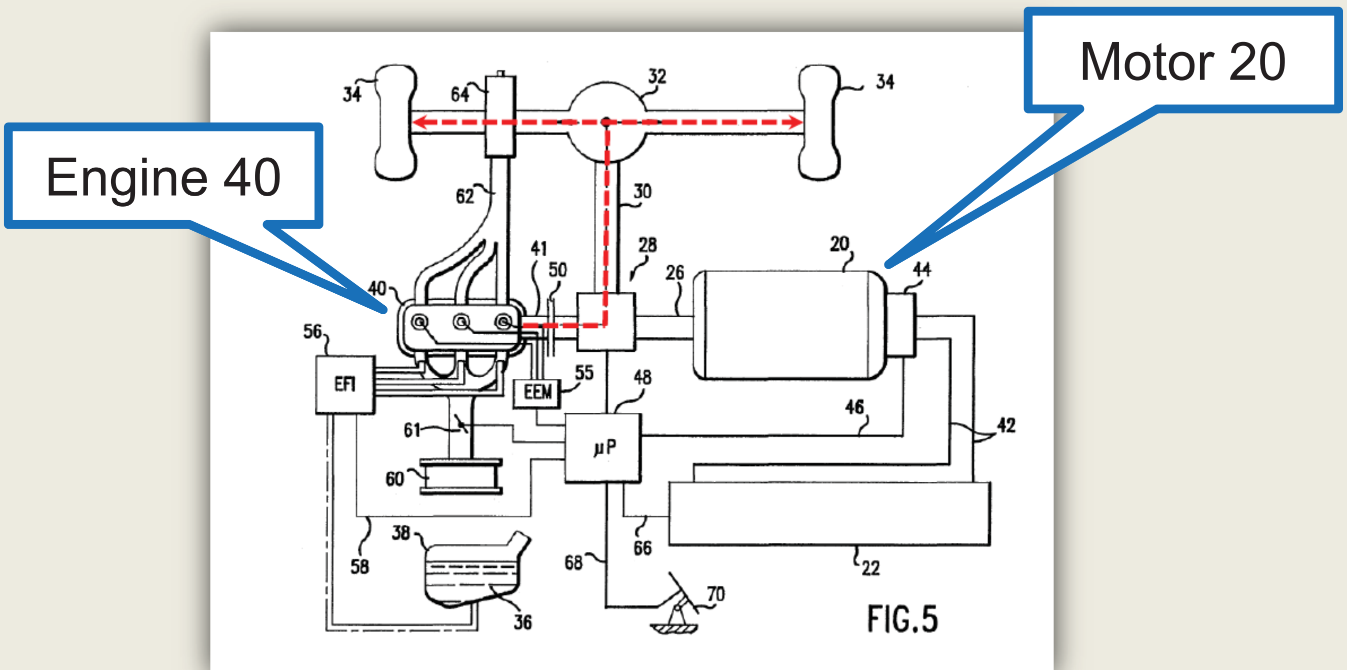
Page 1 of 27

FORD EXHIBIT 1003

- Severinsky (Ex. 1009) shares a common inventor with the ’347 and ’634 patents.
- Directed to a parallel hybrid architecture.
- Discloses three primary modes:
  - Motor only (“low speed”)
  - Engine only (“highway cruising”)
  - Motor + Engine (“high-speed acceleration and/or hill climbing”)

Introduction to Severinsky

- **Severinsky is directed to a parallel hybrid architecture, which utilizes a single electric motor.**



Severinsky, Ex. 1003 at Fig. 5.

Introduction to Severinsky

- **Severinsky's strategy to operate the engine efficiently.**
  - **Size the engine to operate over a given speed range. IPR '571, Paper No. 20, POR at 36-37**
  - **Utilize the engine when vehicle speed enters the given speed range. IPR '571, Paper No. 20, POR at 36-37**

As the road speed increases, the internal combustion engine is started, using torque provided by the electric motor through the torque transfer unit, such that no separate starter is required. The internal combustion engine is sized to operate near maximum efficiency during steady state cruising on the highway, at between about 35 and 65 mph; at these times the electric motor is not powered. When necessary for acceleration or hill

Severinsky, Ex. 1003 at 6:36-43.

At moderate speeds, as experienced in suburban driving, the speed of the vehicle on average is between 30–45 mph. The vehicle will operate in a highway mode with the engine running constantly after the vehicle reaches a speed of 30–35 mph. The engine will continue to run unless the engine speed is reduced to 20–25 mph for a period of time, typically 2–3 minutes. This speed-responsive hysteresis in mode switching will eliminate nuisance engine starts.

Severinsky, Ex. 1003 at 18:34-44.

Severinsky does not disclose all the limitations of claim 23 of the ‘347 Patent

Severinsky fails to disclose each and every claim limitation of claim 23:

1) **Severinsky uses speed, not “road load,” to determine when to turn the engine on and off.**

2) **Severinsky does not determine road load at all.**

3) **Severinsky’s battery charging mode does not use “road load” or a “setpoint” to determine when to run the engine while charging the battery**

IPR ’571, Paper No. 20, POR at 26, 43, 45, 50.

Severinsky does not disclose all the limitations of claim 23 of the ‘347 Patent

Severinsky fails to disclose each and every claim limitation of claim 23:

1) **Severinsky uses speed, not “road load,” to determine when to turn the engine on and off.**

2) Severinsky does not determine road load at all.

3) Severinsky’s battery charging mode does not use “road load” or a “setpoint” to determine when to run the engine while charging the battery

IPR ’571, Paper No. 20, POR at 26, 50.

Severinsky uses speed, not "road load," to determine when to turn the engine on and off.

23. A method of control of a hybrid vehicle, said vehicle comprising an internal combustion engine capable of efficiently producing torque at loads between a lower level SP and a maximum torque output MTO, a battery, and one or more electric motors being capable of providing output torque responsive to supplied current, and of generating electrical current responsive to applied torque, said engine being controllably connected to wheels of said vehicle for applying propulsive torque thereto and to said at least one motor for applying torque thereto, said method comprising the steps of:

determining the instantaneous torque RL required to propel said vehicle responsive to an operator command;

monitoring the state of charge of said battery;

employing said at least one electric motor to propel said vehicle when the torque RL required to do so is less than said lower level SP;

employing said engine to propel said vehicle when the torque RL required to do so is between said lower level SP and MTO;

employing both said at least one electric motor and said engine to propel said vehicle when the torque RL required to do so is more than MTO; and

employing said engine to propel said vehicle when the torque RL required to do so is less than said lower level SP and using the torque between RL and SP to drive said at least one electric motor to charge said battery when the state of charge of said battery indicates the desirability of doing so; and

wherein the torque produced by said engine when operated at said setpoint (SP) is substantially less than the maximum torque output (MTO) of said engine.

'347 Patent, Claim 23

'347 Patent, claim 23 compares the "road load" to a "setpoint" to determine when to employ the engine on and when to employ the motor.

Severinsky discloses turning the engine on and off based on speed

At moderate speeds, as experienced in suburban driving, the speed of the vehicle on average is between 30–45 mph. The vehicle will operate in a highway mode with the engine running constantly after the vehicle reaches a speed of 30–35 mph. The engine will continue to run unless the engine speed is reduced to 20–25 mph for a period of time, typically 2–3 minutes. This speed-responsive hysteresis in mode switching will eliminate nuisance engine starts.

When to turn the engine on

When to turn the engine off.

Severinsky, Ex. 1003 at 18:34-44.

IPR '571, Paper No. 20, POR at 19, 27-28; IPR '904, Paper No. 22, POR at 20, 29-30.

Severinsky discloses “speed-responsive hysteresis”

At moderate speeds, as experienced in suburban driving, the speed of the vehicle on average is between 30–45 mph. The vehicle will operate in a highway mode with the engine running constantly after the vehicle reaches a speed of 30–35 mph. The engine will continue to run unless the engine speed is reduced to 20–25 mph for a period of time, typically 2–3 minutes. This speed-responsive hysteresis in mode switching will eliminate nuisance engine starts.

Severinsky, Ex. 1003 at 18:34-44.

[H]ysteresis relates to the dependence of the state of a system on the history of past inputs in addition to the current input. Ex. 2009 at 3…. One of skill in the art would understand that a control system (such as that disclosed in Severinsky) would not use “speed responsive-hysteresis” if that same system uses road load to control engine starts and stops….

IPR ’571, Ex. 2002 at ¶ 52; IPR ’904, Ex. 2004 at ¶ 57.

Severinsky consistently throughout the specification teaches turning the engine on and off based on speed

- **Nowhere does Severinsky say that the engine is turned on or off based on road load or even pedal position.**

Typically, the electric motor operates under battery power during low speed operation, e.g., in traffic, during reverse operation, or the like. In this mode of operation, the energy transfer

...

As the road speed increases, the internal combustion engine is started, using torque provided by the electric motor through the torque transfer unit, such that no separate starter is required. The internal combustion engine is sized to operate near maximum efficiency during steady state cruising on the highway, at between about 35 and 65 mph; at these times the electric motor is not powered.

Severinsky, Ex. 1003 at 6:26-43, 17:43-48;
***see also* 10:52-53, 13:65 – 14:3.**

Severinsky's speed-based strategy cannot disclose or render obvious the claimed road load-based engine mode

At moderate speeds, as experienced in suburban driving, the speed of the vehicle on average is between 30–45 mph. The vehicle will operate in a highway mode with the engine running constantly after the vehicle reaches a speed of 30–35 mph. The engine will continue to run unless the engine speed is reduced to 20–25 mph for a period of time, typically 2–3 minutes. This speed-responsive hysteresis in mode switching will eliminate nuisance engine starts.

Severinsky, Ex. 1003 at 18:34-44.

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23. A method…

employing said engine to propel said vehicle <u>when the torque RL required to do so is between said lower level SP and MTO</u>;

'347 patent, claim 23.

Severinsky's speed-based strategy cannot disclose or render obvious the claimed road load-based motor mode

Typically, the electric motor operates under battery power during low speed operation, e.g., in traffic, during reverse operation, or the like. In this mode of operation, the energy transfer

...

As the road speed increases, the internal combustion engine is started, using torque provided by the electric motor through the torque transfer unit, such that no separate starter is required. The internal combustion engine is sized to operate near maximum efficiency during steady state cruising on the highway, at between about 35 and 65 mph; at these times the electric motor is not powered.

Severinsky, Ex. 1003 at 6:26-43.

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23. A method…

employing said at least one electric motor to propel said vehicle <u>when the torque RL required to do so is less than said lower level SP</u>;

'347 patent, claim 23.

Ford's effort to recast Severinsky as a road-load based reference is a classic example of hindsight bias

- **Ford's petition contains statements that are are misleading and unsupported by Severinsky's disclosure.**

Petition

> Severinsky '970 further discloses that the "microprocessor 48" determines that "the instantaneous torque required for propulsion of the vehicle" may be positive when the vehicle "starts to climb a hill." (Ex. 1003 at 10:36-37; Ex. 1005, Davis ¶289.)

IPR '904, Paper No. 1, Petition at 38; IPR '571, Paper No. 1, Petition at 25.

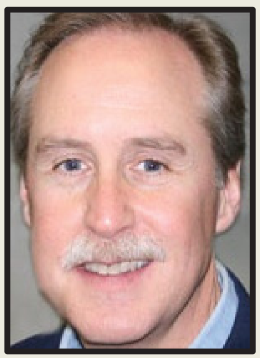
Quoted portion of Severinsky

> generator so as to charge the batteries. If the vehicle then starts to climb a hill, the motor 20 is used to supplement the output torque of engine 40. Similarly, the

Severinsky, Ex. 1003 at 10:36-37.

Dr. Davis's refusal to accept Severinsky's speed-based teaching reveals his hindsight bias

- **Dr. Davis agrees that Severinsky discloses "speed-responsive [sic] hysteresis in mode switching" but claims "there has to be more involved." Ex. 2005, Davis Tr. at 169:11-16, 171:21 – 172:4.**



"One of ordinary skill in the art would readily recognize that there's more involved here because this would not be a vehicle that's responsive to the driver's commands."

...

"[O]ne of ordinary skill would readily understand that there has to be more involved, especially, you know, by now we're at Column 18 and there's been a lot of discussion about meeting the torque demands as well; for example, some of the acceleration, hill [sic] climb modes, things like that."

Dr. Davis relies on discussion of "torque demands"

IPR '571, Ex. 2005 at 171:9-13, 171:21 – 172:4.

IPR '571, Paper No. 20, POR at 28; IPR '904, Paper No. 22, POR at 30.

The places from which Dr. Davis identifies disclosure of "torque demands" are unrelated to whether Severinsky uses road load to turn the engine on and off

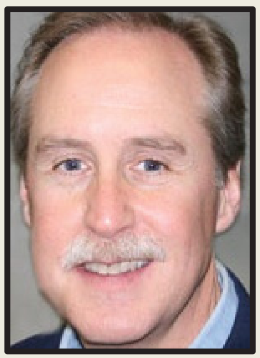
- **Col. 13:65 – 14:22 - relates to activating the electric motor to provide additional torque to the wheels when the engine is already in operation. IPR '571, Paper No. 20, POR at 29.**
- **Col. 17:7-15 – relates to providing torque from the engine to the electric motor to charge the battery when the engine is already in operation. *Id.* at 33.**
- **Col. 13:65-14:21 - merely states that the engine provides the torque required to drive the vehicle in engine only mode. *Id.* at 29.**
- **Col. 6:19-26 - simply states that the system is able to receive user inputs. *Id.***

One of skill in the art would understand that vehicle systems include a large number of power, speed, and torque parameters that are used for many different purposes, for example, fuel flow, air metering, emissions control, transmission control, and stabilization. Thus, one of skill in the art would expect many references discussing a vehicle to include these concepts. <u>However, the mention of torque as a concept does not tell one of skill in the art to use it as a control input in a hybrid system.</u>

IPR '904, Ex. 2004 at ¶ 82.

Dr. Davis's refusal to accept Severinsky's speed-based teaching reveals his hindsight bias

- **Dr. Davis agrees that Severinsky discloses "speed-responsive [sic] hysteresis in mode switching" but claims "there has to be more involved." Ex. 2005, Davis Tr. at 169:11-16, 171:21 – 172:4.**



"One of ordinary skill in the art would readily recognize that there's more involved here because this would not be a vehicle that's responsive to the driver's commands."

...

"[O]ne of ordinary skill would readily understand that there has to be more involved, especially, you know, by now we're at Column 18 and there's been a lot of discussion about meeting the torque demands as well; for example, some of the acceleration, hill [sic] climb modes, things like that."

Dr. Davis relies on the acceleration/ hill climbing mode.

IPR '571, Ex. 2005 at 171:9-13, 171:21 – 172:4.

Dr. Davis's reliance on "high-speed and/or acceleration hill climbing" mode is also unrelated to turning the engine on and off

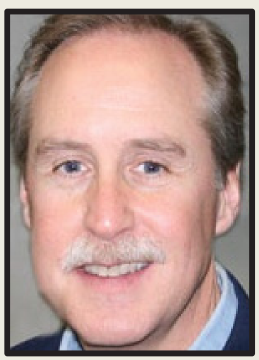
motor **20** to the wheels **34**. Under these circumstances, electric motor **20** provides all of the torque needed to move the vehicle. Other combinations of torque and energy flow required under other circumstances are detailed below in connection with FIGS. **5–9**. For example, if the operator continues to command acceleration, an acceleration/hill climbing mode illustrated in FIG. **6** may be entered, followed by a highway cruising mode illustrated in FIG. **5**.

Severinsky, Ex. 1003 at 10:66 – 11:6.

Dr. Davis's reliance on "high-speed and/or acceleration hill climbing" mode is also unrelated to turning the engine on and off

As Severinsky '970 discloses, this full acceleration request would result in the "acceleration mode" starting and employing both the engine and motor to propel the vehicle…. The operating situation I have described illustrates a situation where the engine would be started and employed to propel the vehicle because the torque required to propel the vehicle to meet the desired acceleration has increased above the 60% lower threshold.

IPR '571, Ex. 1038, Davis Dec. at ¶¶ 24-25.



Q. All right. Let me stop you there. 14:24:37
You said that it enters this 14:24:38
acceleration/hill climbing mode because the 14:24:41
torque required to propel the vehicle to meet 14:24:41
the desired acceleration has increased above 14:24:43
the 60 percent lower threshold. Is that right? 14:24:47
A. Probably a better way to say that is 14:24:50
to meet the desired accelerator pedal position, 14:24:54
the indication that that's what the operator 14:24:54
wants to do. He wants to achieve acceleration. 14:24:56

IPR '571, Ex. 1005, Davis Dec. at ¶¶ 286-87.

Dr. Davis's reliance on "high-speed and/or acceleration hill climbing" mode is also unrelated to turning the engine on and off

- **Dr. Davis's new testimony contradicts Severinsky and Dr. Davis's previous testimony. Indeed, Dr. Davis previously admitted that:**
  - **"High-speed and/or acceleration hill climbing" mode is related to when to turn on the motor.**
  - **In "high-speed and/or acceleration hill climbing" mode, the alleged road load is greater than the MTO.**

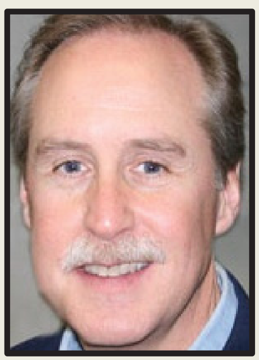
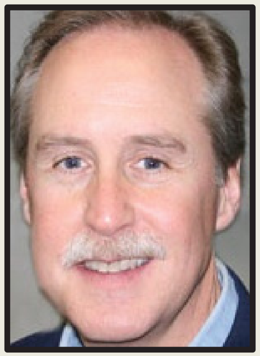


Fig. 6 of Severinsky '970 illustrates and discloses operating the motor to provide supplemental torque when the torque required for propulsion of the vehicle exceeds the capability (i.e. maximum torque output) of the engine…. Fig. 6, reproduced below and annotated, illustrates the acceleration/hill climbing modes where both the engine and motor provide torque to the wheels to propel the vehicle.

IPR '571, Ex. 1005, Davis Dec. at ¶¶ 286-87.

Dr. Davis's refusal to accept Severinsky's speed-based teaching reveals his hindsight bias

- **Dr. Davis states that Severinsky must use road load because otherwise at low speeds the vehicle of Severinsky would not enter hill climbing mode when going up a hill.**

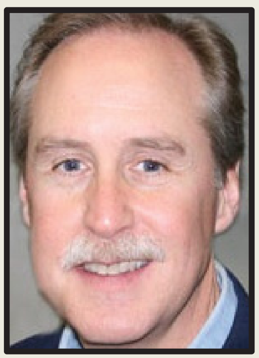


Q. Okay. So your opinion is, I think it's right here in your declaration, that Severinsky must consider torque road load to determine which mode to activate because otherwise the vehicle described in Severinsky '970 would be unable to determine when to enter into the engine plus motor hill climbing mode at lower speeds, is that fair? 04:41:16 04:41:20 04:41:25 04:41:29 04:41:37 04:41:39 04:41:42
A. Yeah, these low speeds. Yes, that's fair. In this example the engine or the system would not provide the additional torque needed to climb the hill. 04:41:42 04:41:45 04:41:48

IPR2014-00904, Ex. 2015 at 19:16-22.

Dr. Davis's refusal to accept Severinsky's speed-based teaching reveals his hindsight bias

- **When asked about another reference (U.S. Patent No. 5,842,534) that discloses speed-responsive hysteresis (Ex. 2016 8:9 – 9:13) and an engine plus motor hill climbing mode (id. at 23:2-23), Dr. Davis agreed that the disclosed vehicle would be unable to determine when to enter into the engine plus motor hill climbing mode (HEV mode) at lower speeds and would instead stay in motor only mode (ZEV mode) (*id.* at 4:6 – 5:9).**



tradeoff. You're making design decisions. And there
are tradeoffs involved in all of your design choices.
And I believe the design choices he made here would not
be the -- would not always lead to the best mode of
operation in really hilly terrain. You certainly
wouldn't have a problem approaching the hill and you
would probably climb some hills, but in extremely hilly
terrain the vehicle might not respond the way most
people would like.

IPR '904, Ex. 2016 at 40:21 – 41:4.

Ford's hindsight-driven read of Severinsky's disclosure of a "sweet spot" is also improper

- **Ford's reliance on Severinsky's disclosure about the engine's sweet spot for a disclosure about a control strategy is wrong. IPR '571, Paper No. 20, POR at 14.**
- **Paice's expert, Mr. Hannemann, testified that maintaining engine operation in the sweet spot is aspirational (i.e., the goal of hybrid vehicles), but identifying the sweet spot does not define the control strategy.**

> While it is possible to operate an engine at its sweet spot, such teachings of operating the engine within the sweet spot must be understood as aspirational…. In other words, while one of skill in the art understands that maintaining an engine only in its sweet spot would be advantageous, the control strategy employed to do so is not readily apparent. Indeed, much of hybrid control theory has sought to accomplish this goal with varying degrees of success.

IPR '571, Ex. 2002 at ¶ 34; *see also* ¶¶ 40-45, 53, 57.

Ford's hindsight-driven read of Severinsky is improper

- The "key" passage [Passage 1] on which Ford relies (and on which institution was granted) is:
  - Unrelated to mode switching or any type of hybrid control
  - Found at the very end of the specification and related to how improving fuel economy would reduce emissions.

It will be appreciated that according to the invention the internal combustion engine is run only in the near vicinity of its most efficient operational point, that is, such that it produces 60–90% of its maximum torque whenever operated. This in itself will yield improvement in fuel economy on the order of 200–300%. More specifically, a 200–300% reduction in fuel consumption will provide an equal reduction in carbon dioxide emissions, as the amount of carbon dioxide emitted is proportional to the amount of fuel used. If ethanol is used as a fuel, that is, if the fuel is derived from renewable plant life rather than fossil fuel, an overall reduction in global carbon dioxide emissions will be achieved since the plants consume carbon dioxide during growth.

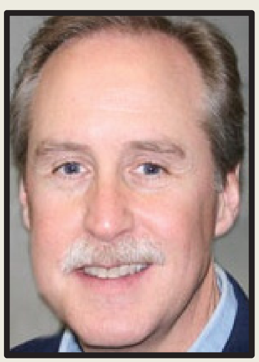
Severinsky '970 at 20:63 – 21:8.

Ford's "key" passage – that the engine is "only run" … "such that it produces 60-90%" MTO.

Proper Context

Both experts agree that "60-90%" MTO does not disclose when to operate the engine

- Both experts agree that:
  - "60-90%" MTO is a disclosure of the engine's sweet spot. Ex. 2002 at ¶¶ 58-61; Ex. 1005 at ¶¶ 259-60.
  - Maintaining engine operation in the sweet spot is aspirational (*i.e.*, the goal of hybrid vehicles). Ex. 2002 at ¶¶ 42-45; Ex. 2005 at 103:20 – 105:1.
  - There is not a single control strategy that would maintain the engine within its sweet spot. Ex. 2002 at ¶¶ 46-49; Ex. 2005 at 104:3-9, 106:4-8.
  - Dr. Davis admitted that defining the engine sweet spot does not tell a POSITA when to employ the engine. Ex. 2002 ¶¶ 58-61. (IPR '904, POR at 16)



Q. So the plain reading of this passage 13:51:49
is that the engine is operated near its sweet 13:51:51
spot, right? 13:51:55
A. The -- that's your goal, yes. 13:51:57
You're optimizing to try to ensure that 13:52:00
operation generally near the sweet spot, yes. 13:52:02
Q. But it doesn't tell us when you 13:52:05
start the engine, correct? 13:52:07
A. This paragraph does not. 13:52:09

Ex. 2005 at 164:22 – 165:7).

Ford's hindsight-driven read of Severinsky's disclosure of a "sweet spot" is also improper

- **Ford's hindsight-based reading of Passage 1 is based on confusing:**
  - **A teaching of how to run the engine (i.e., an aspirational sweet spot) with a teaching of when to run the engine (i.e., the actual control strategy)**
  - **The output torque of the engine and the road load**

> Severinsky '970 discloses that the engine is only operated under its "most efficient conditions of output power and speed" which are between "60-90% of [the engine's] maximum torque ..." (Ex. 1003 at 7:8-16; 20:63-66; Ex. 1005, Davis ¶¶278-280.) Again, the 60% of the engine's maximum torque output value would be understood by a POSA as a lower level predetermined torque value (i.e., "lower level SP"). (Ex. 1005, Davis ¶279.) Severinsky '970 thus discloses that the engine is employed to propel the vehicle when the "instantaneous torque required for propulsion of the vehicle" is between 60% and 90% of the maximum torque output of the engine. (Ex. 1005, Davis ¶¶278-280.)

IPR '571, Paper No. 1, Petition at 29-30; IPR '904, Paper No. 1, Petition at 42.

Ford's hindsight-driven read of Severinsky's disclosure of a "sweet spot" is also improper

- **Ford's second "key" passage supports Paice's position because highway cruising mode is defined in terms of speed.**

When the engine can be used efficiently to drive the vehicle forward, e.g. in highway cruising, it is so employed. Under other circumstances, e.g. in traffic, the electric motor alone drives the vehicle forward and the internal combustion engine is used only to charge the batteries as needed. No transmission is required. thus

IPR '571, Paper No. 1, Petition at 20 (citing Severinsky '970 at 7:11-16).

At moderate speeds, as experienced in suburban driving, the speed of the vehicle on average is between 30–45 mph. The vehicle will operate in a highway mode with the engine running constantly after the vehicle reaches a speed of 30–35 mph. The engine will continue to run unless the engine speed is reduced to 20–25 mph for a period of time, typically 2–3 minutes. This speed-responsive hysteresis in mode switching will eliminate nuisance engine starts.

Severinsky, Ex. 1003 at 18:34-44.

Ford's reliance on the '347 and '634 patent specifications is improper

- **The Federal Circuit has made clear that the proper comparison is between the claims of the patent at issue and the prior art.**
  - **Ford's use of the '347 patent to twist the disclosure of Severinsky runs afoul of *Clearwater*.**
  - **In subsequent IPRs Ford has stated that "Ford is relying on the quoted '634 Patent passages as patentee admissions regarding how a POSA would have understood the prior art Severinsky '970." IPR2015-00758 Petition at 13, FN 2. IPR '904, Paper No. 22, POR at 48.**

> *"This comparison is erroneously premised; the correct comparison is the actual claim language in both patents, not how the later patent describes the earlier patent. In other words, the district court erroneously found the #739 patent was anticipated by its own written description. Thus, we remand for a proper claim-by-claim analysis between the allegedly anticipated claims and the prior art reference.*

***Clearwater Sys. Corp. v. Evapco, Inc.*, 394 F. App'x 699, 705 (Fed. Cir. 2010).**

IPR '571, Paper No. 20, POR at 38-42; IPR '904, Paper No. 22, POR at 44-50.

Ford's reliance on the '347 and '634 Patent specifications is improper

engines.) According to an important aspect of the invention of the '970 patent, substantially improved efficiency is afforded by operating the internal combustion engine only at relatively high torque output levels, typically at least 35% and preferably at least 50% of peak torque. When the vehicle operating conditions require torque of this approximate magnitude, the engine is used to propel the vehicle; when less torque is required, an electric motor powered by electrical energy stored in a substantial battery bank drives the vehicle; when more power is required than provided by either the engine or the motor, both are operated simultaneously. The same advantages are provided by the system of the present invention, with further improvements and enhancements described in detail below.

According to one aspect of the invention of the '970 patent, the internal combustion engine of a hybrid vehicle is sized to supply adequate power for highway cruising, preferably with some additional power in reserve, so that the internal combustion engine operates only in its most efficient operating range. The electric motor, which is substantially equally efficient at all operating speeds, is used to supply additional power as needed for acceleration and hill climbing, and is used to supply all power at low speeds, where the internal combustion engine is particularly inefficient, e.g., in traffic.

'347 Patent at 25:4-27.

- **The passages from the '347 and '634 Patents on which Ford relies do not remedy Severinsky's noted deficiencies. IPR '571, Paper No. 20, POR at 38.**

Turning now to detailed discussion of the inventive control strategy according to which the hybrid vehicles of the invention are operated: as in the case of the hybrid vehicle system shown in the '970 patent, and as discussed in further detail below, the vehicle of the invention is operated in different modes depending on the torque required, the state of charge of the batteries, and other variables. Throughout, the object is to operate the internal combustion engine only under circumstances providing a significant load, thus ensuring efficient operation. In the following, the relationships

'347 Patent at 35:5-14.

The File History of the Related '097 Patent Confirms Severinsky's Use of Speed

As to claims 40 and 46, the Examiner states that the '970 patent teaches determination of road load (RL), comparing RL to SP, and determining whether to supply the torque required from the ICE, traction motor, or both. This is not in fact the case, as the '970 patent teaches making such "mode switching" determinations based on the vehicle speed, not the road load RL. See col. 18, lines 34 – 40:

> At moderate speeds, as experienced in suburban driving, the speed of the vehicle on average is between 30-45 mph. The vehicle will operate in a highway mode with the engine running constantly after the vehicle reaches a speed of 30-35 mph. The engine will continue to run unless the engine speed is reduced to 20-25 mph for a period of time, typically 2-3 minutes.

Likewise, at col. 17, lines 34 – 45:

> In further explanation of the operation of the vehicle of the invention, there are typically two modes of operation at slow speed, that is, at up to about 25-35 mph, depending on the state of charge of the battery 22. Because the engine 40 is cycled on and off in this speed range when the average power demand is small, in one mode the system is operated as a pure electric drive system (as in FIG. 4) and in the other mode it is operated as a differential drive system.
>
> When the battery 22 is fully charged, and the vehicle speed is below about 25-35 mph, the microprocessor 48 disconnects the engine 40 from the drive and shuts it off. Under these circumstances only the motor 20 provides power to drive the vehicle.

Thus it is clear that the '970 patent does not in fact teach mode switching based on RL, but on vehicle speed. Mode switching based on RL is fundamentally different from mode switching based on vehicle speed. RL may be a function of numerous factors, including desired

'097 File History, Ex. 2004 at 16-17.

Severinsky does not disclose all the limitations of claim 23 of the ‘347 Patent

Severinsky fails to disclose each and every claim limitation of claim 23:

1) Severinsky uses speed, not “road load,” to determine when to turn the engine on and off.

2) **Severinsky does not determine road load at all.**

3) Severinsky’s battery charging mode does not use “road load” or a “setpoint” to determine when to run the engine while charging the battery

IPR ’571, Paper No. 20, POR at 43.

Severinsky does not determine the road load.

23. A method of control of a hybrid vehicle, said vehicle comprising an internal combustion engine capable of efficiently producing torque at loads between a lower level SP and a maximum torque output MTO, a battery, and one or more electric motors being capable of providing output torque responsive to supplied current, and of generating electrical current responsive to applied torque, said engine being controllably connected to wheels of said vehicle for applying propulsive torque thereto and to said at least one motor for applying torque thereto, said method comprising the steps of:

determining the instantaneous torque RL required to propel said vehicle responsive to an operator command;

monitoring the state of charge of said battery;

employing said at least one electric motor to propel said vehicle when the torque RL required to do so is less than said lower level SP;

employing said engine to propel said vehicle when the torque RL required to do so is between said lower level SP and MTO;

employing both said at least one electric motor and said engine to propel said vehicle when the torque RL required to do so is more than MTO; and

employing said engine to propel said vehicle when the torque RL required to do so is less than said lower level SP and using the torque between RL and SP to drive said at least one electric motor to charge said battery when the state of charge of said battery indicates the desirability of doing so; and

wherein the torque produced by said engine when operated at said setpoint (SP) is substantially less than the maximum torque output (MTO) of said engine.

’347 Patent, Claim 23

‘347 Patent, claim 23 determines the “road load,” *i.e.* the instantaneous torque required to propel the vehicle

“Road load” is not pedal position

- While a pedal position can be an input into a system that calculates “road load,” the accelerator position alone is not determinative of “road load.” IPR ’571, Ex. 2002 at ¶ 85.
- Pedal position can cause the engine to produce more torque, a phenomenon familiar to anyone who drives conventional vehicles – when you want to accelerate, press down on the accelerator pedal. *Id.* at ¶¶ 81-84.

IPR ’571, Paper No. 20, POR at 33-34; IPR ’904, Paper No. 22, POR at 35

"Road load" is not pedal position

- **Severinsky's disclosure of measuring pedal position is unrelated to turning the engine on and off (*i.e.*, transitioning between "low speed" mode and "highway cruising" mode).**

The relationship between the accelerator pedal and engine output described above is true for all engines including conventional engines in non-hybrid vehicles. This relationship (that the engine varies in response to the accelerator pedal position), however, is not premised on the calculation of the road load. In nonhybrid vehicles, for example, the accelerator pedal is simply connected mechanically or electronically to the throttle, which controls the flow of air to the engine…. Moreover, there is not disclosure in Severinsky that the accelerator pedal position is used to turn the engine on or off. As I discuss above, the accelerator pedal position is simply used to determine how to operate the throttle as is true for conventional vehicles.

IPR '571, Ex. 2002 at ¶¶ 82-85; *see also* IPR '904, Ex. 2004 at ¶¶ 87-90.

IPR '571, Paper No. 20, POR at 31; IPR '904, Paper No. 22, POR at 35.

“Road load” is not pedal position

- Conventional non-hybrid vehicles going back to the Model T used the pedal to set engine output torque. Those vehicles did not determine or use “road load.”

- Unlike pedal position, “road load” can be different according to the operating conditions:

  - The “road load” could be vastly different according to the operating conditions at, for example, 30%. For example, if the vehicle is currently going five miles per hour, the road load will be much different than if the vehicle is traveling at 50 miles per hour at the same (in this case 30%) pedal position.

- Factors such as rolling resistance, grade resistance, and wind resistance affect the “road load,” but are not necessarily indicated by pedal position alone.

IPR ’571, Paper No. 20, POR at 32-33 (citing Ex. 2002 at ¶ 87-88); IPR ’904, Paper No. 22, POR at 35.

“Road load” is not pedal position

- **Pedal position is related to the internal power sources while “road load” is related to the external torque requirements.**

In terms of vehicle design, accelerator pedal position is scaled to the capability of the internal power source(s) (e.g., the engine and/or the motor). Road load, on the other hand, is not concerned with the capabilities of the internal power sources. Road load—the instantaneous torque required to propel the vehicle—is based on external torque requirements such as driving conditions.

IPR ’904, Ex. 2004 at ¶ 92.

“Road load” is not pedal position

- Dr. Davis admitted
  - i) one could not determine whether or not the instantaneous torque required to propel the vehicle would be positive or negative from looking at only the pedal position when the driver presses on the accelerator pedal from 0% to 10% because pedal position does not provide enough information.
  - ii) he would need to know “what speed is the vehicle going” and if the vehicle is “going down a hill.”

Q. So if the driver -- if the 13:01:07
accelerator pedal position is at zero percent 13:01:10
and the driver pushes it to 10 percent, that's 13:01:12
always going to indicate that the instantaneous 13:01:15
torque required to propel the vehicle is 13:01:22
positive. 13:01:23
MR. RONDINI: Objection, vague. 13:01:24
A. No. That's going to indicate an 13:01:25
increase. A desired increase from zero to 10 13:01:28
percent on the pedal position is an indication 13:01:32
there's an increase in desired instantaneous 13:01:34
torque required to propel the vehicle. 13:01:40
Q. But it could be a -- it could be 13:01:40
negative? The instantaneous torque could still 13:01:43
be negative? 13:01:46
A. I can't answer that without knowing 13:01:48
more. I mean you haven't given me enough. 13:01:50
Q. What more do you need? 13:01:52
A. Well, I mean what are the 13:01:53
conditions? What speed is the vehicle going? 13:01:55
Is it going down a hill, for example. 13:01:59

Ex. 2012 at 37:8 – 38:3.

Severinsky does not disclose all the limitations of claim 23 of the '347 Patent

Severinsky fails to disclose each and every claim limitation of claim 23:

1) Severinsky uses speed, not "road load," to determine when to turn the engine on and off.

2) Severinsky does not determine road load at all.

3) **Severinsky's battery charging mode does not use "road load" or a "setpoint" to determine when to run the engine while charging the battery**

IPR '571, Paper No. 20, POR at 45.

Severinsky fails to disclose the battery charging limitation

23. A method of control of a hybrid vehicle, said vehicle comprising an internal combustion engine capable of efficiently producing torque at loads between a lower level SP and a maximum torque output MTO, a battery, and one or more electric motors being capable of providing output torque responsive to supplied current, and of generating electrical current responsive to applied torque, said engine being controllably connected to wheels of said vehicle for applying propulsive torque thereto and to said at least one motor for applying torque thereto, said method comprising the steps of:

determining the instantaneous torque RL required to propel said vehicle responsive to an operator command;

monitoring the state of charge of said battery;

employing said at least one electric motor to propel said vehicle when the torque RL required to do so is less than said lower level SP;

employing said engine to propel said vehicle when the torque RL required to do so is between said lower level SP and MTO;

employing both said at least one electric motor and said engine to propel said vehicle when the torque RL required to do so is more than MTO; and

employing said engine to propel said vehicle when the torque RL required to do so is less than said lower level SP and using the torque between RL and SP to drive said at least one electric motor to charge said battery when the state of charge of said battery indicates the desirability of doing so; and

wherein the torque produced by said engine when operated at said setpoint (SP) is substantially less than the maximum torque output (MTO) of said engine.

’347 Patent, Claim 23

‘347 Patent, claim 23 - When the battery needs charging, and the “road load” is less than a “setpoint,” claim 23 operates the engine at least at “setpoint” and uses the torque between “road load” and “setpoint” to charge the battery

Severinsky fails to disclose the battery charging limitation

- **The battery charging limitation explicitly requires evaluating RL:**

and employing said engine to propel said vehicle when the torque RL required to do so is less than said lower level SP and using the torque between RL and SP to drive said at least one electric motor to charge said battery when the state of charge of said battery indicates the desirability of doing so

'347 Patent, Claim 23

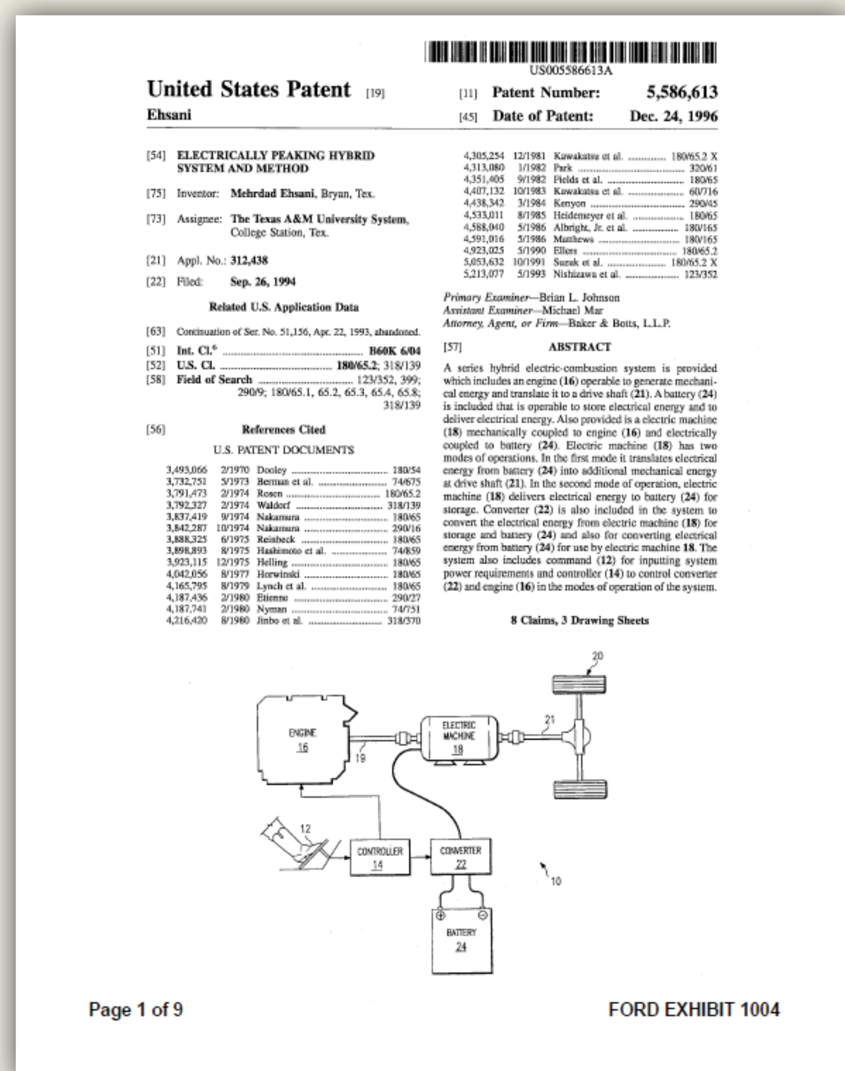
- **Severinsky clearly evaluates speed**

By comparison, if the battery is discharged by 10–20% and the vehicle speed is below 25–35 mph, the microprocessor **48** actuates the two-way clutch **50** (see FIG. **10**) to connect the engine **40** to the torque transfer unit. Then the motor **20** will start the engine **40** while driving the vehicle, with the microprocessor **48** providing optimal starting conditions as above. Locking devices **106** are released, such that the torque transfer unit **28** operates in differential mode. The microprocessor **48** then controls the speeds of both the engine **40** and the motor **20** such that the difference in speed of their output shafts is equal to the speed required by the driver for vehicle propulsion. As noted, engine speed is controlled

Severinsky, Ex. 1003 at 7:56-68.

IPR2014-00571 Grounds 2 and 3 - Severinsky and Ehsani Do Not Disclose or Render Obvious Claims 1, 6, 7, 9, 15 and 21 of the ’347 Patent

Introduction to Ehsani



US005586613A

United States Patent [19]
Ehsani

[11] **Patent Number: 5,586,613**
[45] **Date of Patent: Dec. 24, 1996**

[54] **ELECTRICALLY PEAKING HYBRID SYSTEM AND METHOD**

[75] Inventor: **Mehrdad Ehsani**, Bryan, Tex.

[73] Assignee: **The Texas A&M University System**, College Station, Tex.

[21] Appl. No.: **312,438**

[22] Filed: **Sep. 26, 1994**

Related U.S. Application Data

[63] Continuation of Ser. No. 51,156, Apr. 22, 1993, abandoned.

[51] **Int. Cl.**[6] **B60K 6/04**
[52] **U.S. Cl.** **180/65.2**; 318/139
[58] **Field of Search** 123/352, 399; 290/9; 180/65.1, 65.2, 65.3, 65.4, 65.8; 318/139

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Primary Examiner—Brian L. Johnson
Assistant Examiner—Michael Mar
Attorney, Agent, or Firm—Baker & Botts, L.L.P.

[57] **ABSTRACT**

A series hybrid electric-combustion system is provided which includes an engine (**16**) operable to generate mechanical energy and translate it to a drive shaft (**21**). A battery (**24**) is included that is operable to store electrical energy and to deliver electrical energy. Also provided is a electric machine (**18**) mechanically coupled to engine (**16**) and electrically coupled to battery (**24**). Electric machine (**18**) has two modes of operations. In the first mode it translates electrical energy from battery (**24**) into additional mechanical energy at drive shaft (**21**). In the second mode of operation, electric machine (**18**) delivers electrical energy to battery (**24**) for storage. Converter (**22**) is also included in the system to convert the electrical energy from electric machine (**18**) for storage and battery (**24**) and also for converting electrical energy from battery (**24**) for use by electric machine **18**. The system also includes command (**12**) for inputting system power requirements and controller (**14**) to control converter (**22**) and engine (**16**) in the modes of operation of the system.

8 Claims, 3 Drawing Sheets

Page 1 of 9

FORD EXHIBIT 1004

- **Ehsani (Ex. 1004) discloses a series-parallel hybrid architecture utilizing two motors instead of one.**

Grounds 2 and 3 – Severinsky and Ehsani

- **In Grounds 2 and 3, Ford combines the control strategy of Severinsky with Ehsani's teaching of a two-motor system—interchanging Severinsky and Ehsani as the primary reference.**
- **Because the basis for these grounds are premised upon the same misapplication of Severinsky, the deficiencies in Severinsky and the defects in Ford's reasoning also apply to Grounds 2 and 3.**
- **Ehsani does not remedy these noted deficiencies of Severinsky, and Ford does not contend otherwise. Dr. Davis confirmed this at his deposition. Ex. 2003 at 186:13-23.**

Q. You didn't rely on the Ehsani for 14:27:03
disclosure for set points, correct? 14:27:07
A. No. I think what I looked at Ehsani 14:27:13
for is that Severinsky discloses a one-motor 14:27:15
parallel hybrid system, and then I looked at 14:27:21
the idea that, you know, there's -- obviously 14:27:24
starter motors are, you know, widely known. 14:27:29
People have known about starter motors forever, 14:27:31
but Ehsani also goes further with a parallel 14:27:34
drive system where it's not just a starter 14:27:37
motor, but a motor generator that's added. 14:27:39

Ex. 2003 at 186:13-23.

Because Severinsky considers speed (not torque), Severinsky does not disclose '347 Patent, claim 1

What is claimed is:

1. A hybrid vehicle, comprising:

an internal combustion engine controllably coupled to road wheels of said vehicle;

a first electric motor connected to said engine nd operable to start the engine responsive to a control signal;

a second electric motor connected to road wheels of said vehicle, and operable as a motor, to apply torque to said wheels to propel said vehicle, and as a generator, for accepting torque from at least said wheels for generating current;

a battery, for providing current to said motors and accepting charging current from at least said second motor; and

a controller for controlling the flow of electrical and mechanical power between said engine, first and second motors, and wheels,

wherein said controller starts and operates said engine when torque require to be produced by said engine to propel the vehicle and/or to drive either one or both said electric motor(s) to charge said battery is at least equal to a setpoint (SP) above which said engine torque is efficiently produced, and wherein the torque produced by said engine when operated at said setpoint (SP) is substantially less than the maximum torque output (MTO) of said engine.

'347 Patent, Claim 1

Claim 1 compares the "torque require[d] to be produced by said engine to propel the vehicle and/or drive either one or both said electric motor(s) to charge said battery" to a "setpoint" to determine whether to "start and operate" the engine.

Because Severinsky considers speed (not torque), Severinsky does not disclose '347 Patent, claim 7

- **Claim 7 (like claim 23) requires comparing the "road load" to a "setpoint" to determine when to turn the engine on and when to turn the engine off and use the motor.**

7. The vehicle of claim **1**, wherein said vehicle is operated in a plurality of operating modes responsive to the value for the road load (RL) and said setpoint SP, both expressed as percentages of the maximum torque output of the engine when normally-aspirated (MTO), and said operating modes include:

a low-load mode I, wherein said vehicle is propelled by torque provided by said second electric motor in response to energy supplied from said battery, while RL<SP,

a highway cruising mode IV, wherein said vehicle is propelled by torque provided by said internal combustion engine, while SP<RL<MTO, and

an acceleration mode V, wherein said vehicle is propelled by torque provided by said internal combustion engine and by torque provided by either or both electric motor(s) in response to energy supplied from said battery, while RL>MTO.

'347 Patent, Claim 7

Dependent claim 7 requires a plurality of operating modes responsive to the value of RL and the setpoint

Dependent claim 7 operates the motor while RL<SP

Dependent claim 7 operates engine while SP<RL<MTO

Severinsky and Ehsani do not disclose or render obvious '347 Patent, claim 9

9. The vehicle of claim **7**, wherein said operating modes further include a low-speed battery charging mode II, entered while RL<SP and the state of charge of the battery is below a predetermined level, and during which said vehicle is propelled by torque provided by said second electric motor in response to energy supplied from said battery, and wherein said battery is simultaneously charged by supply of electrical energy from said first electric motor, being driven by torque in excess of SP by said internal combustion engine, the combination of said engine and said first motor being disengaged from said wheels during operation in mode II.

'347 Patent, Claim 9

Dependent claim 9 recites a battery charging mode entered while RL<SP

Dependent claim 9 recites that the battery is charged by energy from the motor, being driven by torque in excess of SP by the engine

The combination of Severinsky and Ehsani fails to disclose a first motor that can receive torque ≥ SP

- **Ehsani teaches the use of a small motor that receives torque during idling.**
- **The engine would produce torque < SP when idling.**

and electric motor **51**. Generator **50** is also electrically coupled to first converter **52**. First converter **52** is an AC to DC converter. First converter **52** is also electrically coupled to controller **14** and battery **24**. Second converter **54** is electrically coupled to controller **14**, electric motor **51** and battery **24**.

In operation of this embodiment, generator **50** can be much smaller than electric motor **51** because it only provides steady state charging at a much lower level than the peaking power of electric motor **51**. This allows charging of battery **24** even during idling of engine **16**. Furthermore, engine **16**

Ehsani, Ex. 1004 at 8:28-34.

IPR2014-00904 Ground 1 - Severinsky and Field and SAE 1996 Do Not Disclose or Render Obvious Claims 1, 14, 16, 18, and 24 of the ’634 Patent

IPR2014-00904

- **U.S. Patent No. 7,237,634**
- **Ground 1 (§ 103):**
  - **Challenged claims: 1, 14, 16, 18 and 24**
  - **Asserted Art: Severinsky, Field, and SAE 1996**
- **The Board declined to institute Ground 2**

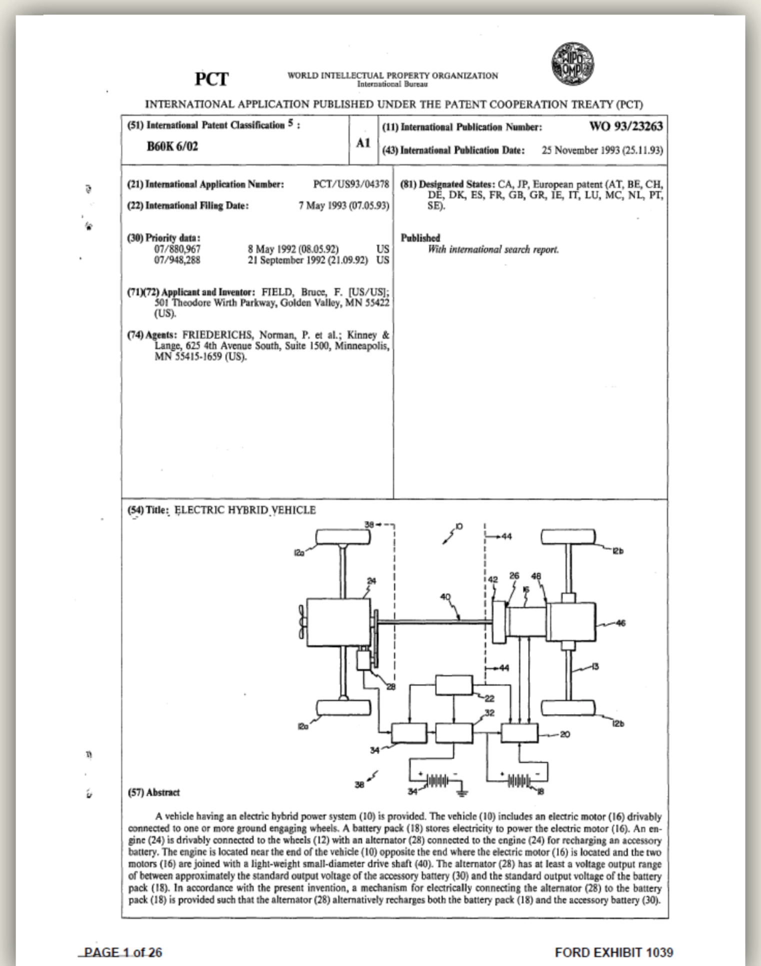
> And in the absence of Ford advancing some meaningful benefit to proceeding with the additional ground of Severinsky and Ehsani, we presume that it is the weaker of the two asserted grounds, and we exercise our discretion to deny institution of this presumably weaker ground. See 37 C.F.R. § 42.108(a).

IPR '904, Paper 13, Institution Decision at 13.

Introduction to Field and SAE 1996

- **Ford relies on Field (Ex. 1039) and SAE 1996 (Ex. 1025) in place of Ehsani for their disclosure of two motor hybrid vehicle topologies.**

Field



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(71)(72) Applicant and Inventor: FIELD, Bruce, F. [US/US]; 501 Theodore Wirth Parkway, Golden Valley, MN 55422 (US).

(74) Agents: FRIEDERICHS, Norman, P. et al.; Kinney & Lange, 625 4th Avenue South, Suite 1500, Minneapolis, MN 55415-1659 (US).

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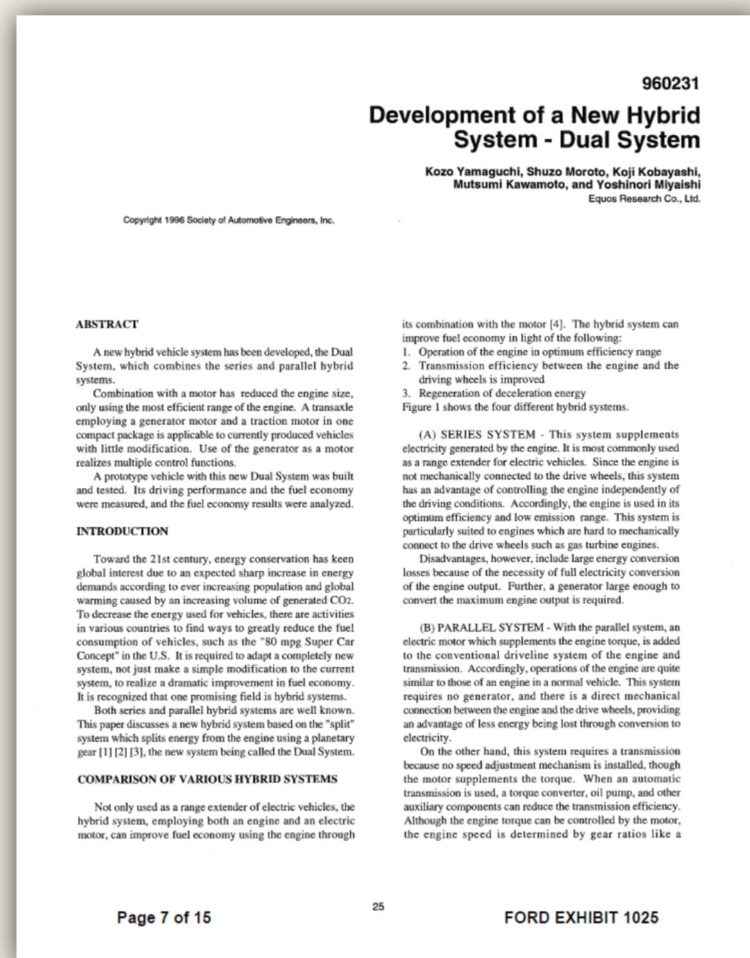
(54) Title: ELECTRIC HYBRID VEHICLE

(57) Abstract

A vehicle having an electric hybrid power system (10) is provided. The vehicle (10) includes an electric motor (16) drivably connected to one or more ground engaging wheels. A battery pack (18) stores electricity to power the electric motor (16). An engine (24) is drivably connected to the wheels (12) with an alternator (28) connected to the engine (24) for recharging an accessory battery. The engine is located near the end of the vehicle (10) opposite the end where the electric motor (16) is located and the two motors (16) are joined with a light-weight small-diameter drive shaft (40). The alternator (28) has at least a voltage output range of between approximately the standard output voltage of the accessory battery (30) and the standard output voltage of the battery pack (18). In accordance with the present invention, a mechanism for electrically connecting the alternator (28) to the battery pack (18) is provided such that the alternator (28) alternatively recharges both the battery pack (18) and the accessory battery (30).

PAGE 1 of 26 FORD EXHIBIT 1039

SAE 1996



960231

Development of a New Hybrid System - Dual System

Kozo Yamaguchi, Shuzo Moroto, Koji Kobayashi, Mutsumi Kawamoto, and Yoshinori Miyaishi
Equos Research Co., Ltd.

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ABSTRACT

A new hybrid vehicle system has been developed, the Dual System, which combines the series and parallel hybrid systems.

Combination with a motor has reduced the engine size, only using the most efficient range of the engine. A transaxle employing a generator motor and a traction motor in one compact package is applicable to currently produced vehicles with little modification. Use of the generator as a motor realizes multiple control functions.

A prototype vehicle with this new Dual System was built and tested. Its driving performance and the fuel economy were measured, and the fuel economy results were analyzed.

INTRODUCTION

Toward the 21st century, energy conservation has keen global interest due to an expected sharp increase in energy demands according to ever increasing population and global warming caused by an increasing volume of generated CO_2. To decrease the energy used for vehicles, there are activities in various countries to find ways to greatly reduce the fuel consumption of vehicles, such as the "80 mpg Super Car Concept" in the U.S. It is required to adapt a completely new system, not just make a simple modification to the current system, to realize a dramatic improvement in fuel economy. It is recognized that one promising field is hybrid systems.

Both series and parallel hybrid systems are well known. This paper discusses a new hybrid system based on the "split" system which splits energy from the engine using a planetary gear [1] [2] [3], the new system being called the Dual System.

COMPARISON OF VARIOUS HYBRID SYSTEMS

Not only used as a range extender of electric vehicles, the hybrid system, employing both an engine and an electric motor, can improve fuel economy using the engine through its combination with the motor [4]. The hybrid system can improve fuel economy in light of the following:

1. Operation of the engine in optimum efficiency range
2. Transmission efficiency between the engine and the driving wheels is improved
3. Regeneration of deceleration energy

Figure 1 shows the four different hybrid systems.

(A) SERIES SYSTEM - This system supplements electricity generated by the engine. It is most commonly used as a range extender for electric vehicles. Since the engine is not mechanically connected to the drive wheels, this system has an advantage of controlling the engine independently of the driving conditions. Accordingly, the engine is used in its optimum efficiency and low emission range. This system is particularly suited to engines which are hard to mechanically connect to the drive wheels such as gas turbine engines.

Disadvantages, however, include large energy conversion losses because of the necessity of full electricity conversion of the engine output. Further, a generator large enough to convert the maximum engine output is required.

(B) PARALLEL SYSTEM - With the parallel system, an electric motor which supplements the engine torque, is added to the conventional driveline system of the engine and transmission. Accordingly, operations of the engine are quite similar to those of an engine in a normal vehicle. This system requires no generator, and there is a direct mechanical connection between the engine and the drive wheels, providing an advantage of less energy being lost through conversion to electricity.

On the other hand, this system requires a transmission because no speed adjustment mechanism is installed, though the motor supplements the torque. When an automatic transmission is used, a torque converter, oil pump, and other auxiliary components can reduce the transmission efficiency. Although the engine torque can be controlled by the motor, the engine speed is determined by gear ratios like a

Page 7 of 15 25 FORD EXHIBIT 1025

Because Severinsky considers speed (not torque), Severinsky does not disclose '634 Patent, claim 1

1. A hybrid vehicle, comprising:
one or more wheels;
an internal combustion engine operable to propel the hybrid vehicle by providing torque to the one or more wheels;
a first electric motor coupled to the engine;
a second electric motor operable to propel the hybrid vehicle by providing torque to the one or more wheels;
a battery coupled to the first and second electric motors, operable to:
provide current to the first and/or the second electric motors; and
accept current from the first and second electric motors; and
a controller, operable to control the flow of electrical and mechanical power between the engine, the first and the second electric motors, and the one or more wheels;
wherein the controller is operable to operate the engine when torque required from the engine to propel the hybrid vehicle and/or to drive one or more of the first or the second motors to charge the battery is at least equal to a setpoint (SP) above which the torque produced by the engine is efficiently produced, and wherein the torque produced by the engine when operated at the SP is substantially less than the maximum torque output (MTO) of the engine.

'634 Patent, Claim 1

Claim 1 compares the "torque required from the engine to propel the hybrid vehicle and/or to drive one or more of the first or the second motors to charge the battery" to a "setpoint" to determine whether to "operate" the engine.

IPR '904, Paper No. 22, POR at 55.

Because Severinsky considers speed (not torque), Severinsky does not disclose '634 Patent, claim 16

- **Claim 16 (like claim 23 of the '347 patent) requires comparing the "road load" to a "setpoint" to determine when to turn the engine on and when to turn the engine off and use the motor.**

16. The hybrid vehicle of claim **1**, wherein the controller is operable to implement a plurality of operating modes responsive to road load (RL) and the SP, wherein both the RL and the SP are expressed as percentages of the MTO of the engine when normally-aspirated, and wherein the operating modes comprise:

a low-load mode I, wherein, when the RL<the SP, the second electric motor is operable to provide torque to propel the hybrid vehicle;

a highway cruising mode IV, wherein, when the SP<the RL<the MTO, the engine is operable to provide torque to propel the hybrid vehicle, and wherein the controller is operable to start the engine if the engine is not running to enter the highway cruising mode IV; and

an acceleration mode V, wherein, when the RL>the MTO, the engine, the first electric motor, and/or the second electric motor is operable to provide torque to propel the hybrid vehicle, and wherein the controller is operable to start the engine if the engine is not running to enter the acceleration mode V.

'634 Patent, Claim 16

Dependent claim 16 is operable to implement a plurality of operating modes responsive to the value of RL and the setpoint

Dependent claim 16 operates the motor when RL<SP

Dependent claim 16 operates engine while SP<the RL<the MTO

Severinsky and Ehsani do not disclose or render obvious ‘634 Patent, claim 18

18. The hybrid vehicle of claim **16**, wherein the plurality of operating modes further comprise a low-speed battery charging mode II, wherein, when the RL<the SP and a state of charge of the battery is below a predetermined level:

the controller is operable to decouple the engine and the first electric motor from the one or more wheels and start the engine if the engine is not running to enter the battery charging mode II;

the second electric motor is operable to provide torque to propel the hybrid vehicle; and

the engine is operable to provide torque at least equal to the SP to the first motor for charging the battery.

’634 Patent, Claim 18

Dependent claim 18 recites a battery charging mode entered while RL<SP

Dependent claim 18 recites that the battery is charged by energy from the motor, being driven by torque in excess of SP by the engine,

The combination of Severinsky, Field, and SAE 1996 fails to disclose a first motor that can receive torque ≥ SP

- The motor of SAE 1996 on which Ford relies is only 6 kW (8 hp) and is too small to accept torque equal to the alleged 60% setpoint of Severinsky
  - The engine of Severinsky has an MTO of "about 45 horsepower." Ex. 1003 at 6:63-66; 8:52-36. Thus, the engine could operate at best at roughly 18% MTO to charge the battery. Ex. 2004 at ¶¶ 148-49.
  - The relative fuel consumption of the engine of Severinsky at 8 hp is 210% of the most efficient value—far below a setpoint "above which the torque produced by the engine is efficiently produced." Ex. 2004 at ¶¶ 148-49.

> Generator Motor - The generator motor is a DC brushless motor with a maximum output of 6 kW. Using a motor with 8 poles, which is more than usual, the generator brake and the planetary gear are arranged inside the coil ends, causing the total length to be shortened.

SAE 1996, Ex. 1025 at 11.

END