UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

FORD MOTOR COMPANY

Petitioner,

v.

PAICE LLC & ABELL FOUNDATION, INC.

Patent Owner.

U.S. Patent No. 7,104,347 to Severinsky *et al.*

IPR Case No.: IPR2015-00794

DECLARATION OF DR. GREGORY W. DAVIS IN SUPPORT OF *INTER PARTES* REVIEW UNDER 35 U.S.C. § 311 *ET SEQ.* AND 37 C.F.R. § 42.100 *ET SEQ.* (CLAIMS 23-30, 32, AND 39-41 OF U.S. PATENT NO. 7,104,347)

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EXHIBIT LIST

Exhibit No.	Description	Date	Identifier
1401	US Patent 7,104,347	Sept. 12, 2006	’347 Patent
1402	Ford Letter to Paice	Sept. 2014	
1403	US Patent 5,789,882	Aug. 4, 1998	Ibaraki ’882
1404	US Patent 5,623,104	Apr. 22, 1997	Suga ’104
1405	US Patent 4,335,429	June 15, 1982	Kawakatsu ’429
1406	Automotive Electronics Handbook (Jurgen)		Jurgen
1407	US Patent 5,823,280	Oct. 20, 1998	Lateur
1408	Declaration of Gregory Davis		Davis Dec.
1409	US Application 60-100095	Filed Sept. 11, 1998	‘095 Provisional
1410	Excerpt of USPN 7,104,347 File History	n/a	‘347 File History
1411	U.S. Patent No. 7,237,634	July 3, 2007	’634 Patent
1412	7,237,634 File History (certified)	n/a	’634 Patent File History
1413	Toyota Litigations	2005	Toyota Litigation
1414	Hyundai Litigation	2013-2014	Hyundai Litigation
1415	PTAB Decisions & Preliminary Response in 2014-00571		
1416	Bosch Automotive Handbook (1996)	Oct. 1996	Bosch Handbook
1417	US Patent 5,934,395	Aug. 10, 1999	Koide
1418	US Patent 6,116,363	Sept. 12, 2000	Frank
1419	Engineering Fundamentals of the Internal Combustion Engine	1997	Pulkrabek
1420	Fiat Conceptual Approach to Hybrid Cars Design (Vittone)	Dec. 5-7, 1994	Vittone
1421	US Patent 5,865,263	Feb. 2, 1999	Yamaguchi
1422	US Patent 6,003,626	Dec. 21, 1999	Ibaraki ’626
1423	Innovations in Design: 1993 Ford Hybrid Electric Vehicle Challenge	Feb. 1994	
1424	1996 & 1997 Future Car Challenge	Feb. 1997 & Feb. 1998	

Exhibit No.	Description	Date	Identifier
1425	Introduction to Automotive Powertrain (Davis)		Davis Textbook
1426	History of Hybrid Electric Vehicle (Wakefield-1998)	1998	Wakefield
1427	SAE 760121 (Unnewehr-1976)	Feb. 1, 1976	Unnewehr
1428	SAE 920447 (Burke-1992)	Feb. 1, 1992	Burke 1992
1429	Vehicle Tester for HEV (Duoba-1997)	Aug. 1, 1997	Duoba 1997
1430	DOE Report to Congress (1994)	April 1995	1994 Report to Congress
1431	SAE SP-1331 (1998)	Feb. 1998	SAE SP-1331
1432	SAE SP-1156 (1996)	Feb. 1996	SAE SP-1156
1433	Microprocessor Design for HEV (Bumby-1988)	Sept. 1, 1988	Bumby/Masding 1988
1434	DOE HEV Assessment (1979)	Sept. 30, 1979	HEV Assessment 1979
1435	EPA HEV Final Study (1971)	June 1, 1971	EPA HEV Final Study
1436	Propulsion System for Design for EV (Ehsani-1996)	June 18, 2005	IEEE Ehsani 1996
1437	Propulsion System Design for HEV (Ehsani-1997)	Feb. 1997	IEEE Ehsani 1997
1438	Critical Issues in Quantifying HEV Emissions (An 1998)	Aug. 11, 1998	An 1998
1439	WO 9323263A1 (Field)	Nov. 25, 1998	9323263
1440	Toyota Prius (Yamaguchi-1998)	Jan. 1998	Toyota Prius Yamaguchi 1998
1441	US Patent 6,209,672	April 3, 2001	’672 Patent
1442	SAE SP-1089 (Anderson-1995)	Feb. 1995	SAE SP-1089
1443	1973 Development of the Federal Urban Driving Schedule (SAE 730553)	1973	SAE 1973
1444	Gregory Davis Resume		
1445	Gregory Davis Data		
1446	U.S. Patent No. 4,407,132	Oct. 4, 1983	Kawakatsu ’132

I, Gregory Davis, hereby declare as follows:

1. I am making this declaration at the request of Ford Motor Company in the matter of *inter partes* review of U.S. Patent No. 7,104,347 ("the '347 Patent") to Severinsky et al.

2. I am being compensated for my work in this matter at a rate of $315/hour. My compensation in no way depends on the outcome of this proceeding.

3. In preparation of this declaration, I have studied the exhibits as listed in the Exhibit List shown above in my report. Each of the exhibits listed are true and accurate copies. The Exhibit list also includes true and accurate citations for each exhibit I have reviewed including a weblink, library of congress number or other markings denoting authenticity where applicable.

4. In forming the opinions expressed below, I have considered:

(a) The documents listed above as well as additional patents and documents referenced herein;

(b) The relevant legal standards, including the standard for obviousness provided to me, and any additional documents cited in the body of this declaration; and

(c) My knowledge and experience based upon my work and study in this area as described below.

I. QUALIFICATIONS AND PROFESSIONAL EXPERIENCE

5. I have provided my full background in the curriculum vitae that is

attached as Exhibit 1444.

6. I received my Bachelor of Science Degree in Mechanical Engineering from the University of Michigan, Ann Arbor in 1982 and my Master of Science Degree in Mechanical Engineering from Oakland University in 1986.

7. Further, I am a licensed "Professional Engineer" in the state of Michigan.

8. As shown in my curriculum vitae, most of my career has been in the field of automotive engineering, including numerous positions in both the academia and industry settings.

9. After receiving my Master's degree, I began work at General Motors where I had several assignments involving automotive design, advanced engineering and manufacturing. Over the course of my years at General Motors, I was involved in all aspects of the vehicle design process, from advanced research and development to manufacturing.

10. Specifically, my work at General Motors included aspects of engine and fuel system design relating to the production of fuel sending units, and modeling the effects of fuels and EGR on vehicle performance and emissions.

11. After leaving General Motors, I continued my education at the University of Michigan where I was awarded a Ph.D. in Mechanical Engineering in 1991. My thesis was directed to automotive engineering including the design and development of systems and models for understanding combustion in automotive

engines.

12. Upon completion of my Ph.D., I joined the faculty of the U.S. Naval Academy where I led the automotive program in mechanical engineering. As part of my responsibilities while at the Academy, I managed the laboratories for Internal Combustion Engines and Power Systems.

13. I further taught automotive and mechanical engineering courses while at the U.S. Naval Academy. Some of the courses I taught were directed specifically to design and operation of internal combustion engines in both conventional and hybrid vehicles. I also taught courses pertaining to the design and operation of hybrid vehicles.

14. In addition to my work at the U.S. Naval Academy, I also served as faculty advisor for the USNA Society of Automotive Engineers (SAE). During this time, I served as project director for the research and development of hybrid electric vehicles.

15. My work with regards to hybrid electric vehicles included extensive design and modifications of the powertrain, chassis, and body systems. This development work included the design, modifications and implementation of alternate fuel delivery and injection systems.

16. Some of the hybrid electric vehicle work that I worked on at the U.S. Naval Academy was published in a bound 1994 SAE special publication. I have attached as Exhibit 1423 a true and accurate copy of the 1994 paper that was

submitted on behalf of my team for this competition. (Ex. 1423 [1993 Hybrid Challenge].)

17. While at the Naval Academy, I also taught classes in mechanical engineering at Johns Hopkins University.

18. In 1995, I joined the faculty of Lawrence Technological University where I served as Director of the Master of Automotive Engineering Program and Associate Professor in the Mechanical Engineering Department.

19. The master's program in automotive engineering is a professionally oriented program aimed at attracting and educating practicing engineers in the automotive industry.

20. In addition to teaching and designing the curriculum for undergraduate and graduate students, I also worked in the automotive industry closely with Ford Motor Company on the development of a hybrid electric vehicle.

21. Specifically, I served as project director on a cooperative research project to develop and design all aspects of a hybrid electric vehicle. While in many instances we used standard Ford components, we custom designed many automotive subsystems. As part of this project, we completely redesigned and replaced the existing powertrain including the fuel storage, delivery and injection systems. We also did analytical and actual testing of the systems.

22. While at Lawrence Technological University, I also served as the faculty advisor on several student based hybrid vehicle competitions that were sponsored

primarily by Ford Motor Company, General Motors Company, and Chrysler Corporation.

23. These competitions required the complete design of a hybrid vehicle, including the design of the powertrain. These competitions also required the complete design of the software and hardware required to control the hybrid vehicle.

24. Attached as Exhibit 1424 [1996 and 1997 Futurecar Challange] are true and accurate copies of the competition papers that were submitted for the 1996 and 1997 competitions for which I served as the faculty advisor. (Ex. 1424 [1996&1997 Futurecar Challenge].)

25. During my time at Lawrence Technological University, I further served as advisor for 145 automotive graduate and undergraduate project students. Many of the graduate students whom I advised were employed as full time engineers in the automotive industry. This service required constant interaction with the students and their automotive companies which included the major automotive manufacturers (*e.g.*, Ford, Chrysler, General Motors, Toyota, etc.) along with many automotive suppliers, including those that supply fuel delivery systems (*e.g.*, Denso, Delphi and Bosch).

26. Currently, I am employed as a Professor of Mechanical Engineering & Director of the Advanced Engine Research Laboratory (AERL) at Kettering University—formerly known as "General Motors Institute."

27. At Kettering University, I develop curriculum and teach courses in mechanical and automotive engineering to both undergraduate and graduate students.

For one of my classes on automotive powertrains, I and a fellow professor (Craig Hoff) co-authored a textbook titled "Introduction to Automotive Powertrains." A true and accurate copy of excerpts from this textbook is attached as Exhibit 1425 [Davis Textbook]. The full version of this textbook is around 400 pages long and is used in my course to give engineering students an introductory understanding of the fundamentals of automotive engines, automotive transmissions, and how to select those components to provide the optimum compromise between acceleration performance, gradeability performance and fuel economy performance. (Ex. 1425 [Davis Textbook] at 2.) Further, this textbook is based on my and Professor Hoff's personal collection of class notes that we had been using to teach such fundamental automotive principles as far back as the mid-1990's.

28. Since coming to Kettering, I have advised over 90 undergraduate and graduate theses in automotive engineering. Further, I actively pursue research and development activities within automotive engineering.

29. My work requires constant involvement with my students and their sponsoring automotive companies which have included not only those mentioned above, but also Walbro, Nissan, Borg Warner, FEV, Inc., U.S. Army Automotive Command, Denso, Honda, Dana, TRW, Tenneco, Navistar, and ArvinMeritor.

30. As is further shown by resume, I have published over 50 peer reviewed technical articles and presentations involving topics in automotive engineering.

31. Automotive and mechanical engineering topics covered in these articles

include development of hybrid vehicles, mechanical design and analysis of components and systems, vehicle exterior design including aerodynamics, development of alternative fueled vehicles and fuel systems, thermal and fluid system design and analysis, selection and design of components and sub-systems for optimum system integration, and system calibration and control.

32. I have also chaired or co-chaired sessions in automotive engineering at many technical conferences including sessions involving powertrain development and control in automotive engineering.

33. Additionally, while acting as director of the AERL, I am responsible for numerous laboratories and undergraduate and graduate research projects, which include On-road and Off-road engine and chassis testing laboratories. Projects have included the design and development of fuel injection systems for off-road vehicles, fuel compatibility studies of vehicle storage and delivery systems, modification of fuel delivery systems to accommodate alternative fuels, the development of electric vehicles, and other extensive modifications and development of vehicular powertrains.

34. I also serve as faculty advisor to the Society of Automotive Engineers International (SAE) of the local Student Branch and for the "SAE Clean Snowmobile Challenge," and "SAE Aero Design" collegiate design competitions. At the national level, I have served as a director on the SAE Board of Directors, the Engineering Education Board, and the Publications Board.

35. Further, I have chaired the Engineering Education Board and several of the SAE Committees.

36. I also actively develop and teach Continuing Professional Development (CPD) courses both for SAE and directly for corporate automotive clients. These CPD courses are directed to automotive powertrain, exterior body systems, hybrid electric vehicle design, and include extensive engine performance, emissions, and economy considerations. These courses are taught primarily to engineers who are employed in the automotive industry or governmental entities.

37. Finally, I am a member of the Advisory Board of the National Institute for Advanced Transportation Technology at the University of Idaho. In addition to advising, I also review funding proposals and project reports of the researchers funded by the center.

II. RELEVANT LEGAL STANDARDS

38. I have been asked to provide opinions on the claims of the '347 Patent in light of the prior art.

39. It is my understanding that a claimed invention is unpatentable under 35 USC § 102 if a prior art reference teaches every element of the claim. Further, it is my understanding that a claimed invention is unpatentable under 35 U.S.C. § 103 if the differences between the invention and the prior art are such that the subject matter as a whole would have been obvious at the time the alleged invention was made to a person having ordinary skill in the art to which the subject matter pertains. I also

understand that an obviousness analysis takes into account factual inquiries including the level of ordinary skill in the art, the scope and content of the prior art, and the differences between the prior art and the claimed subject matter.

40. It is my understanding that the Supreme Court has recognized several rationales for combining references or modifying a reference to show obviousness of the claimed subject matter. Some of these rationales include the following: combining prior art elements according to known methods to yield predictable results; simple substitution of one known element for another to obtain predictable results; a predictable use of prior art elements according to their established functions; applying a known technique to a known device to yield predictable results; choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success; and some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

III. QUALIFICATIONS OF ONE OF ORDINARY SKILL IN THE ART

41. I have reviewed the ’347 Patent, those patents cited in the ’347 Patent as well as the prior art documents. Based on this review and my knowledge of hybrid electric vehicles, including my work on multiple hybrid vehicles during the course of the 1990’s, it is my opinion that a person of ordinary skill in the art would have either: (1) a graduate degree in mechanical, electrical or automotive engineering with at least

some experience in the design and control of combustion engines, electric or hybrid electric vehicle propulsion systems, or design and control of automotive transmissions, or (2) a bachelor's degree in mechanical, electrical or automotive engineering and at least five years of experience in the design of combustion engines, electric vehicle propulsion systems, or automotive transmissions.

42. I understand that this determination is made at the time of the invention, which I understand that the patentee purports as being the September 14, 1998 filing of U.S. Provisional Application No. 60/100,095 ("the '095 Provisional," Ex. 1409). As I also discussed in my "Qualifications and Professional Experience" (¶¶5-37) above, I am familiar with the level of knowledge and the abilities of a person having ordinary skill in the art at the time of the claimed invention based on my experience in the industry (both as an employee and as a professor).

IV. STATE OF THE ART

43. It is my opinion that hybrid-electric vehicles (hybrid vehicle) were conceived over 100 years ago in an attempt to combine the power capabilities of electric motors and internal combustion engines[1] (ICE) to satisfy all the driver demand required to propel a vehicle. My opinion is supported by a true and accurate copy of excerpts from the 1998 textbook titled the "History of the Electric

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[1] An engine could also be referred to as a "heat engine" and is commonly known to be a part of the overall "Auxiliary Power Unit" of a hybrid vehicle (*i.e.*, "APU").

Automobile" authored by Ernest Wakefield. (Ex. 1426 [Wakefield] at 11.)[2]

44. For instance, Wakefield describes a functioning hybrid vehicle that was designed and built by Justus Entz in May 1897. (Ex. 1426 [Wakefield] at 11-13.)

45. My opinion is also supported by hybrid vehicle patents that I am aware extend as far back as 1909 for U.S. Patent No. 913,846 to Pieper that was granted for a "Mixed Drive Auto Vehicle."

46. As is explained by Wakefield, the hybrid vehicle disclosed by the Pieper patent was likewise assembled as a functioning hybrid vehicle that was publically used. (Ex. 1426 [Wakefield] at 13-14.)

47. As is explained by Wakefield, well-known hybrid vehicles were built and publically used by Baker and Woods in 1917. (Ex. 1426 [Wakefield] at 21-23.)

48. Based on my experience and knowledge a known goal of using hybrid vehicles is the possibility of operating the engine at its "optimum efficiency." For instance, a 1976 SAE paper states:

> From almost the beginning of the Automotive Age, various combinations of drive systems have been tried in order to achieve vehicle performance characteristics superior to those that can be obtained using a single type of drive. <u>**These efforts have been made in the name of many worthwhile goals such as increased vehicle**</u>

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[2] Ex. 1426 [Wakefield] is stated as being copyrighted in 1998 and available from the Society of Automotive Engineers (SAE). (Ex. 1426 [Wakefield] at 2.)

> **acceleration capability, audible noise reduction, operation of an engine or turbine at optimum efficiency, reduction of noxious emissions, and improved fuel economy**.

(Ex. 1427 [Unnewehr] at 1, emphasis added.)[3]

49. It is my understanding that based on events in the 1970's, a renewed interest in hybrid vehicles emerged as a means to combat the U.S. dependency on oil and to meet increased air pollution reduction goals. (*See e.g.*, Ex. 1428 [Burke 1992] at 3[4]; Ex. 1429 [Duoba 1997] at 3.)[5]

50. It is also my understanding that in 1976 the U.S. government enacted Public Law 94-413 pertaining to the "Electric and Hybrid Vehicle Research, Development, and Demonstration Act" that was to "encourage and support

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[3] Ex. 1427 [Unnewehr] is a true and accurate copy of an SAE paper titled "Hybrid Vehicle for Fuel Economy" that was published by L.E. Unnewehr et al. that I understand was published on February 1, 1976.

[4] Ex. 1428 [Burke 1992] is a true and accurate copy of a SAE paper titled "Hybrid/Electric Vehicle Design Options and Evaluations" authored by Andrew Burke that I understand was published on February 1, 1992.

[5] Ex. 1429 [Duoba 1997] is a true and accurate copy of a paper titled "Challenges for the Vehicle Tester in Characterizing Hybrid Electric Vehicles" authored by Michael Duoba that I understand was published by the U.S. DOE on August 1, 1997.

accelerated research into, and development of electric and hybrid vehicle technologies." (Ex. 1430 [1994 Report to Congress] at 4.)[6]

51. As a result of this law, it is my understanding that hybrid and electric vehicles were being developed by automotive corporations. (Ex. 1430 [1994 Report to Congress] at 4.)

52. It is my understanding that during the 1980's and 1990's, Ford Motor Company and Toyota Motor Company were involved in the design and development of both hybrid and electric vehicles. (*See e.g.,* Ex. 1427 [Unnewehr] at 1; Ex. 1431 [SAE SP-1331][7] at 4-5.)

53. It is further my understanding that collegiate competitions intensified hybrid vehicle research during the 1990's starting with the 1993 Ford Hybrid Electric Vehicle Challenge. As indicated by Ex. 1423 [1993 Hybrid Challenge] I personally participated in the 1993 Ford Hybrid Electric Vehicle Challenge. (Ex. 1423 [1993 Hybrid Challenge] at 6.) By 1994 these competitions had grown to include teams from

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[6] Ex. 1430 [1994 Report to Congress] is a true and accurate copy of the "Electric and Hybrid Vehicles Program – 18th Annual Report to Congress for Fiscal Year 1994" that I understand was published by the U.S. Department of Energy in April 1995.

[7] Ex. 1431 [SAE SP-1331] is a true and accurate copy of excerpts from a SAE special publication that I understand was published in February 1998. (Ex. 1431 [SAE SP-1331] at 2.)

over 30 universities representing more than 800 students. (Ex. 1430 [1994 Report to Congress] at 10.)

54. As I mentioned in my "Qualifications and Professional" section above, I was personally involved with the U.S. Naval Academy's hybrid vehicle design that was entered in the 1993 "Ford Hybrid Vehicle" and the 1994-1995 competitions. (Ex. 1423 [1993 Hybrid Challenge] at 6.)

55. I was also personally involved with Lawrence Technological University's hybrid vehicle design that was entered in the 1996 and 1997 "Future Car" hybrid electric vehicle competitions. (Ex. 1424 [1996&1997 Futurecar Challenge] at 6, 23.)

56. Based upon the level of research and development prior to 1998, it is my opinion that various hybrid vehicle "architectures" were well-known. (*See e.g.*, Ex. 1432 [SAE SP-1156] at 4, 7-8.)[8] As I explain in more detail below, hybrid vehicle "architectures" included: (1) "series" hybrid vehicles (¶¶61-69 below); and (2) "parallel" hybrid vehicles (¶¶70-72 below). As I further explain in detail below, "parallel" hybrid vehicle architectures were known to include: (1) one motor "parallel" hybrid vehicle architectures (¶¶73-86 below); and (3) two motor "parallel" hybrid vehicle architectures (¶¶87-107 below).

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[8] Ex. 1432 [SAE SP-1156] is a true and accurate copy of an SAE special publication titled "Strategies in Electric and Hybrid Vehicle Designs" that I understand was published in February 1996.

57. As I explain below, these varying hybrid vehicle architectures differed in how the powertrain (*i.e.*, the engines and motors) was arranged and connected to the wheels. It is my opinion that the various architectures were implemented to achieve many of the goals I mentioned above in ¶48, including operating the engine at its peak efficiency. (*See e.g.*, Ex. 1427 [Unnewehr] at 1; Ex. 1432 [SAE SP-1156] at 4, 7.)

58. It is my opinion that computer based microprocessor controllers were implemented to refine the control the engine, motor(s), transmission, and clutching mechanisms of the hybrid vehicle. For instance, my opinion is supported by a September 1988 paper which states:

> Automating the operation of a vehicle transmission allows the control of the engine and transmission system to be integrated, giving substantial benefits in terms of vehicle performance, energy efficiency and driveability. Although such a statement is applicable to internal combustion {sic} engine vehicles, electric vehicles and hybrid-electric vehicles the details relating to how the engine/transmission should be controlled are quite different. The main thrust of this paper is to consider the automation and control of a discrete ratio, synchromesh transmission for use in an electric or a hybrid-electric vehicle. As a hybrid-electric vehicle includes both an electric traction motor and an ic engine in its drive system it is relevant to outline briefly the benefits to be gained by automating the transmission system in both an ic engine and an electric vehicle.

(Ex. 1433 [Bumby/Masding 1988] at 2.)[9]

59. It is also my understanding that control strategies for hybrid vehicles varied based on the architecture being employed but the primary goal typically remained focused on operating the engine within its "sweet spot" or "optimum efficiency range." (*See e.g.*, Ex. 1427 [Unnewehr] at 1; Ex. 1431 [SAE SP-1331] at 4.)

60. It is my opinion that efficient engine control strategies were desired so as to meet the Federal government's reduced air pollution goals of 1976 and to meet California's "Low Emissions Vehicle" regulation that was enacted in 1990. (Ex. 1429 [Duoba 1997] at 3.)

A. "Series" Hybrid Vehicle

61. It is my opinion that a person of ordinary skill in the art understood certain design and operational advantages were possible with "series" hybrid vehicle architectures. My opinion is supported by Ex. 1434 [HEV Assessment 1979] which is a true and accurate copy of a September 1979 publication titled "Hybrid Vehicle Potential Assessment" authored by K.O. Leschly and a 1996 SAE publication. (Ex.

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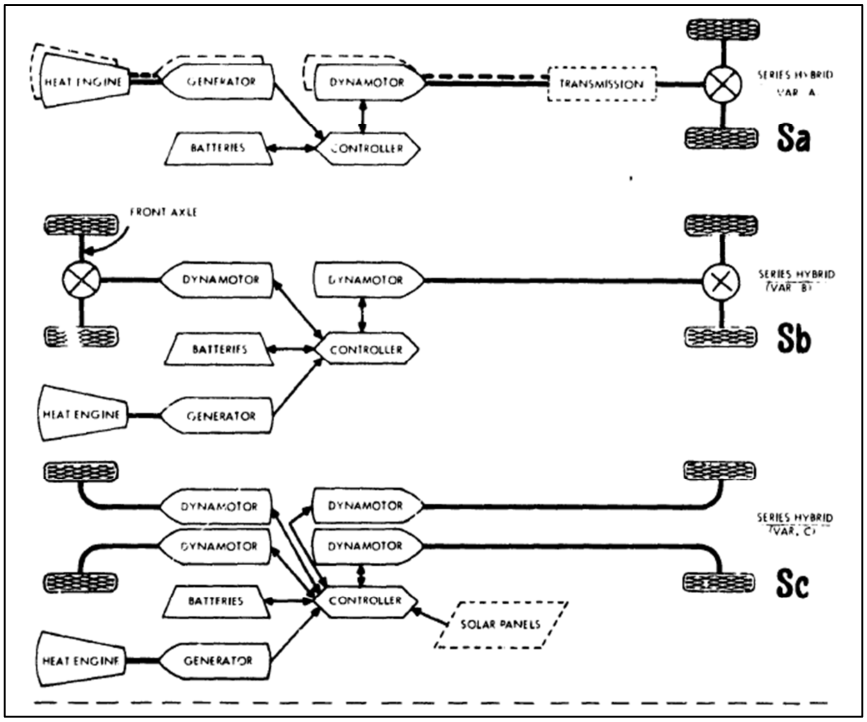
[9] Ex. 1433 [Bumby/Masding 1988] is a true and accurate copy of a September 1988 journal article titled "A microprocessor controlled gearbox for use in electric and hybrid electric vehicles." that is stated as being published in the journal of Transactions of the Institute of Measurement and Control and available through Sage publications at http://tim.sagepub.com/content/10/4/177.

1434 [HEV Assessment 1979][10]; Ex. 1432 [SAE SP-1156].)

62. As illustrated by the 1979 publication, is my opinion that a person having ordinary skill understood that "series" hybrid vehicles could be designed in various arrangements that could include one or more electric motors.[11] (Ex. 1434 [HEV Assessment 1979] at 17.)



Ex. 1434 [HEV Assessment 1979] at 17, Fig. 7

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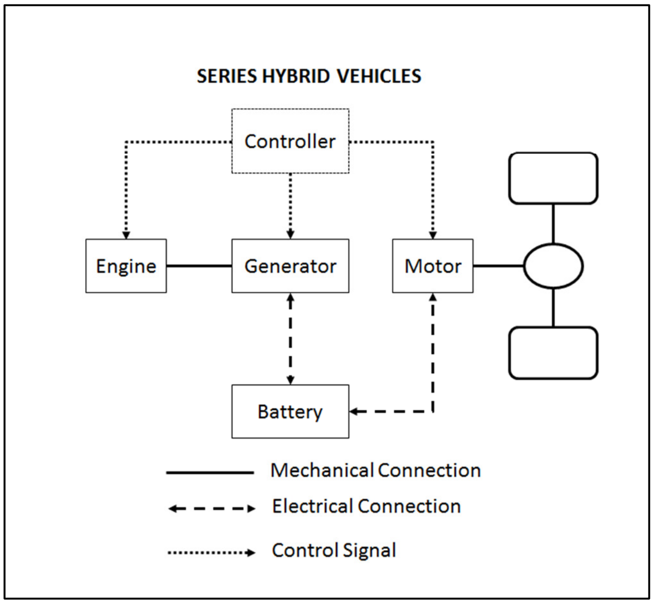
[10] Ex. 1434 [HEV Assessment 1979] is a true and accurate copy of a U.S. Department of Energy's OSTI paper that was published on Sept. 30, 1979.

[11] The term "dynamotor" was commonly used to describe an electric motor that was capable of operating both as (1) a motor for propulsion; and (2) as a generator that converts mechanical torque into electrical energy that is stored in the battery.

63. Although multiple configurations were known, I have provided the following exemplary figure that is based on my understanding, experience and knowledge to explain the general architecture and operation of a "series" hybrid vehicle.



64. As I illustrated, the traction motor is connected to the road wheels for a "series" hybrid vehicle as discussed in Ex. 1428 [Burke 1992] at page 6, and Ex. 1432 [SAE SP-1156] at pages 7-8.

65. In other words, it is my opinion that the **motor alone** provides the torque required to propel the vehicle. (Ex. 1428 [Burke 1992] at 6; Ex. 1432 [SAE SP-1156] at 15.)

66. The engine in a series hybrid, on the other hand, is not mechanically connected to the wheels and the engine is therefore controlled independently of driving conditions. (Ex. 1428 [Burke 1992] at 6; Ex. 1432 [SAE SP-1156] at 7-8.)

67. It is my opinion that the engine does not provide any of the torque required to propel the vehicle; rather, the engine powers the generator independent of road conditions to produce electrical energy that is stored in the battery and/or used by the motor.

68. It is my opinion that for a series hybrid, the "primary function of the engine/ generator is to extend the range of the electric vehicle beyond that possible on batteries alone." (Ex. 1428 [Burke 1992] at 6.) It is also my opinion that by including an engine, drivers were able to "fill up" at gas-stations that are common throughout the United States. Without the engine, drivers would have needed to find an electrical source to recharge the battery. It is my understanding that electrical sources were less common than gas stations and the time required to fully charge the battery could be longer than most drivers would be willing to wait.

69. It is my understanding that by having the engine controlled independently of the torque and speed requirements of the vehicle, "series operation has the advantage of allowing the engine to operate at a constant speed in the vicinity of its optimum (in terms of efficiency and emissions) operating point." (Ex. 1432 [SAE SP-1156] at 4.) However, during conditions of low battery state of charge, the engine could be operated outside its "sweet spot." Such efficient operation was performed for the sole purposes of operating the generator illustrated by the figure in ¶63. (Ex. 1428 [Burke 1992] at 6-7; Ex. 1432 [SAE SP-1156] at 7.)

B. "Parallel" Hybrid Vehicle

70. It is my opinion that a person of ordinary skill in the art understood certain design and operational advantages were possible with "parallel" hybrid vehicle architectures. (*See e.g.,* Ex. 1428 [Burke 1992] at 7-8; Ex. 1432 [SAE SP-1156] at 7-8.)

71. As is illustrated by the DOE paper, it is my opinion that a person having ordinary skill understood that "parallel" hybrid vehicles could be designed in various arrangements that could include one or more electric motors.[12] (Ex. 1434 [HEV Assessment 1979] at 18.)

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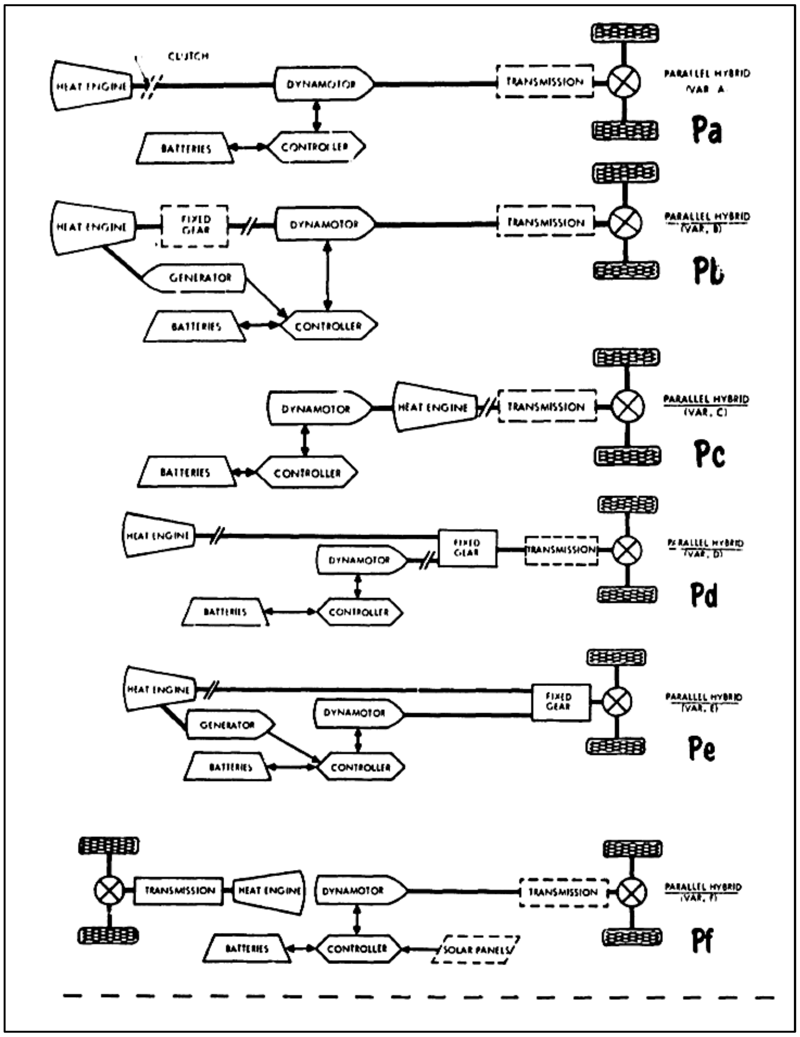
[12] The term "dynamotor" was commonly used to describe an electric motor that was capable of operating both as (1) a motor for propulsion; and (2) as a generator that converts mechanical torque into electrical energy that is stored in the battery.



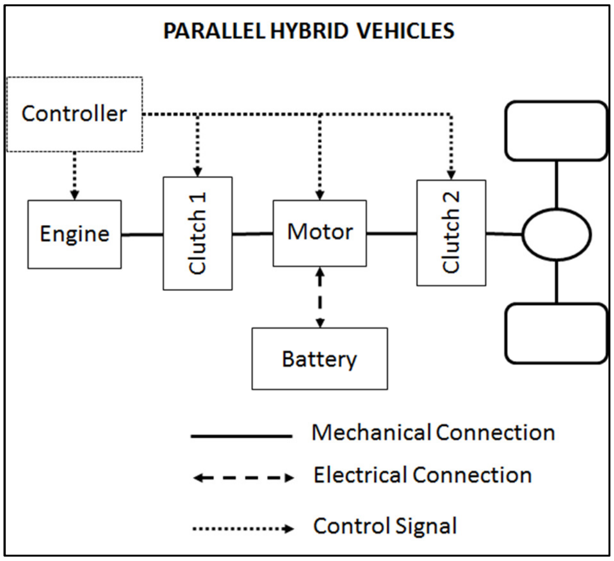
Ex. 1434 [HEV Assessment 1979] at 18, Fig.7

72. As illustrated above, it was known that there existed three generally known “parallel” hybrid vehicle architectures. The first architecture was a one-motor “parallel” hybrid vehicle as illustrated by “Pa,” “Pc,” and “Pd.” The second architecture is a two-motor “parallel” hybrid vehicle as illustrated by “Pb” and “Pe.”

(Ex. 1434 [HEV Assessment 1979] at 18.)[13]

1. One-Motor "Parallel" Hybrid Vehicle

73. Although multiple various configurations existed, I have provided the following exemplary figure that is based on my understanding, experience and knowledge in order to assist in explaining the general architecture and operation of a one-motor "parallel" hybrid vehicle.



74. As illustrated, "parallel" hybrid vehicles typically included one or more

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[13] The third type of "parallel" hybrid vehicle illustrated was an all-wheel drive platform that used a motor and engine to power both the front and rear wheels as shown by "Pf."

"clutches" that were controlled by a microprocessor (*i.e.*, controller).[14] These clutches selectively enabled either or both the engine and motor to provide drive torque to the wheels of the vehicle.

75. Generally, "parallel" hybrid vehicles were known to include a single traction motor that could be operated to provide torque required to propel the vehicle as explained, for example, by the following 1992 SAE paper.

> The parallel hybrid (Figure 5) [is one] in which both the electric motor and the engine provide torque to the wheels either separately or together and the motor can be used as a generator to recharge the batteries when the engine can produce more power than is needed to propel the vehicle…

(Ex. 1428 [Burke 1992] at 5.)

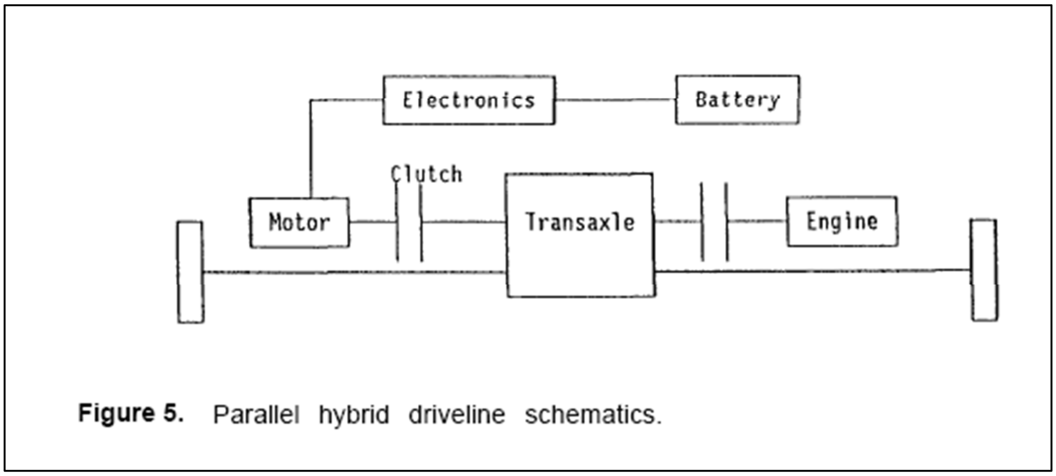

Figure 5. Parallel hybrid driveline schematics.

Ex. 1428 [Burke 1992] at 25, Fig. 5

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[14] It was also known that a transmission and/or fixed gear ratio could be used between the motors or engine and the wheels.

76. With reference back to my exemplary figure illustrated in ¶73, "parallel" hybrid vehicles engage the motor and/or engine by operating one or more clutches. For example, the controller could engage "clutch 1" and "clutch 2" which would connect the engine to the road wheels.

77. Alternatively, the controller could disengage "clutch 1" and engage "clutch 2" which would connect the motor to the road wheels. Either or both "clutch 1" and "clutch 2" could be engaged in order to connect either the motor or both the engine and the motor to the road wheels.

78. In another configuration of a "parallel" hybrid vehicle, either "clutch 1" or "clutch 2" could be removed from the system so that its respective power source (*i.e.*, the engine or motor) becomes the "prime mover" that is connected to the wheels at all times, with the additional power source being selectively connected/disconnected to the road wheels using a clutch.

79. For instance, the motor could be directly coupled to the wheels with the engine being selectively connected/disconnected to the wheels using a clutch.

80. It is also my opinion based on my knowledge and experience that, the engine in a "parallel" hybrid vehicle could be downsized and controlled to run only at speed and load ranges where engine operation was most efficient (*e.g.*, steady state or highway cruising).

81. It is also my opinion based on my knowledge and experience that, the traction motor in a "parallel" hybrid vehicle could be used to provide the extra power

required for vehicle acceleration so that the engine could be restricted solely to its most efficient operating region (*i.e.*, low or minimum specific fuel consumption region).

82. The typical operation of a one-motor "parallel" hybrid vehicle is explained by the following 1976 SAE article.

> The engine used in the [parallel] hybrid is operated in regions of minimum specific fuel consumption during a much greater portion of its operating time than in conventional drives. The engine is sized more for steady-state (constant speed) driving conditions than for vehicle acceleration requirements. The electrical system serves a function somewhat analogous to that of an infinitely variable transmission and also adds power during vehicle acceleration and stereo power during braking.

(Ex. 1427 [Unnewehr] at 17.)

83. In other words, it is my opinion that by September 1998 it was known that "parallel" hybrid vehicles could be controlled like a conventional vehicle except the engine would operate "much less frequently at low power, because the electric driveline will provide the power at low vehicle speeds and light loads." (Ex. 1428 [Burke 1992] at 7-8)

84. It was further known by September 1998 that efficient engine operation was typically accomplished using multiple "operating modes" in a control strategy. For instance, a well-known and commonly-cited SAE publication from 1976 discloses

a then-novel control strategy for a "parallel" hybrid vehicle that accounted for the overall efficiency with respect to the torque required to propel the vehicle. (Ex. 1427 [Unnewehr] at 3-4.) This 1976 control strategy disclosed a five-mode operating strategy, as shown below, that was used to improve the efficiency and fuel economy over a conventional vehicle.

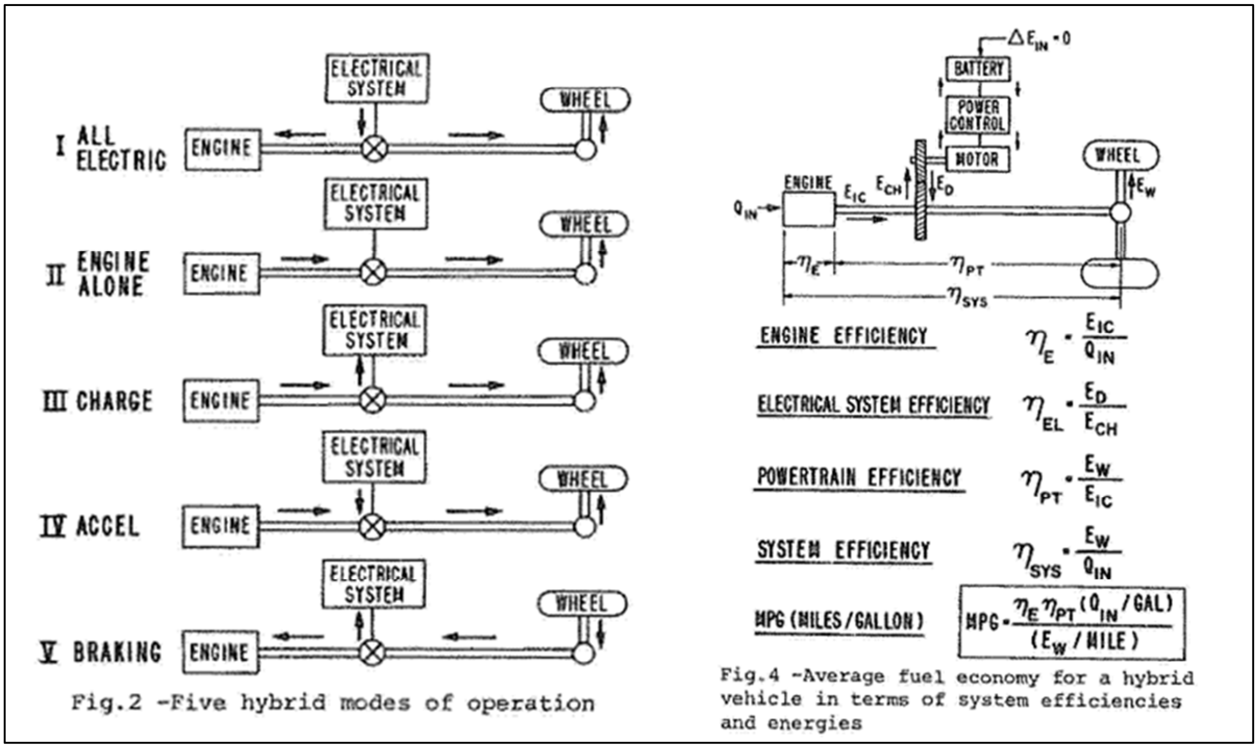

Fig.2 -Five hybrid modes of operation

Fig.4 -Average fuel economy for a hybrid vehicle in terms of system efficiencies and energies

(Ex. 1427 [Unnewehr] at 3-4, Fig. 2 & 4)

85. This disclosure supports my understanding that the control strategy increased the fuel economy over conventional vehicles by only operating the engine in regions of "minimum specific fuel consumption during a much greater portion of its operating time." (Ex. 1427 [Unnewehr] at 17.) In other words, the engine could be operated at "higher load factors" which provides "increased efficiencies." (Ex. 1427 [Unnewehr] at 4.)

86. It is also my opinion that it was known by September 1998 that a typical control strategy for a "parallel" hybrid vehicle would operate the motor alone at low loads and speeds where engine operation was inefficient. (Ex. 1427 [Unnewehr] at 17.)

2. Two-Motor "Series-Parallel" Hybrid Vehicle

87. As was illustrated in ¶ 72 above, two-motor "parallel" hybrid vehicles were also well known. (Ex. 1434 [HEV Assessment 1979] at 18; Ex. 1432 [SAE SP-1156] at 8.)

88. I have provided below an illustration from a true and accurate copy of a 1971 Department of Energy report that describes one well-known two motor "parallel" hybrid vehicle configuration. (Ex. 1435 [EPA HEV Final Study 1971] at 20.)[15]

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[15] Ex. 1435 [EPA HEV Final Study 1971] is true and accurate copy of a 1971 U.S. Environmental Protection Agency ("EPA") publication titled "Final Report Hybrid Heat Engine / Electric Systems Volume l: Sections l through 13 Study." (Ex. 1435 [EPA HEV Final Study 1971] at 1.)

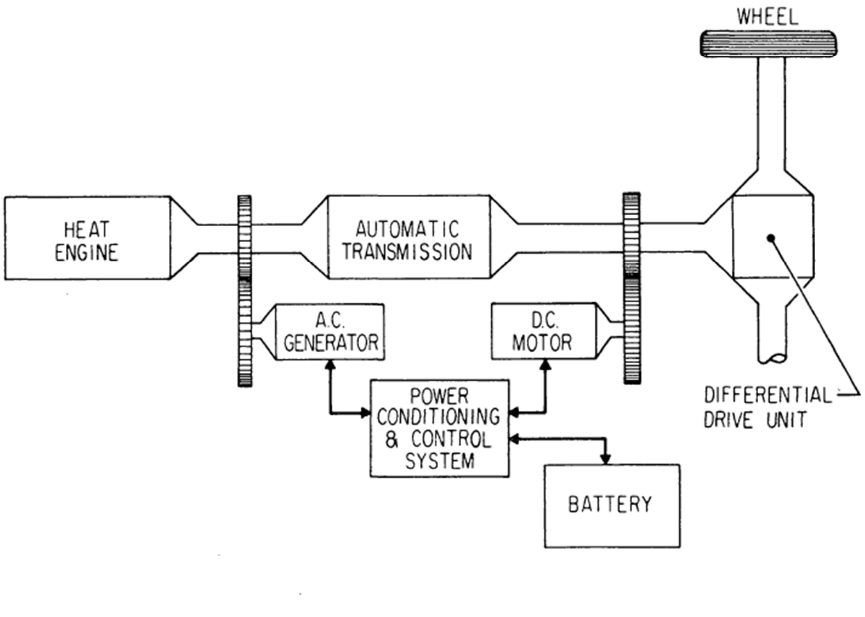

Figure 10- 7. Selected Baseline Parallel Configuration Concept

Ex. 1435 [EPA HEV Final Study] at 381, Fig. 10-7

89. It is my opinion that one known advantage of two-motor "parallel" hybrid vehicle architecture illustrated above is that the "generator can supply power to the batteries when heat engine power is in excess of wheel demand." (Ex. 1435 [EPA HEV Final Study 1971] at 380.)

90. In other words, it was known that a second motor could be operated as a generator to charge the battery when the engine torque required to propel the vehicle is greater than the actual torque needed to propel the vehicle.

91. By the mid-1990's two-motor "parallel" hybrid vehicles had begun to be referred to as "**<u>series-parallel" hybrid</u>** vehicles. (Ex. 1432 [SAE SP-1156] at 8.) In September 1998, it was well known that "series-parallel" hybrid architectures combined the functionality of both "series" and "parallel" systems to achieve the

advantages of both systems while overcoming the problems of either system when used individually. For instance a true and accurate copy of a 1993 PCT international patent application states:

> Prior hybrid propulsion systems were typically capable of operating in one or more of the following modes (but none were capable of operating in a choice of all of them): (1) a series hybrid, which is plugged in for recharge, and which uses the engine as a "range extender" when the electrical storage mechanism are depleted, and/or (2) a series hybrid which runs the engine in order to recharge its own electrical storage mechanism, typically via a generator/alternator, and/or (3) a parallel hybrid, which is plugged in for recharge, and which uses the engine and/ or the electric motor either separately or in unison, depending upon conditions, circumstances, and the process controller, in order to directly power the vehicle, and/or (4) a parallel hybrid similar to the one described in (3), directly above, but which recharges its own electrical storage system via the engine and, typically, a generator/alternator (see U.S. Patent No. 5,081,365). Each of these modes has its benefits and drawbacks, depending on circumstances, thus the industry is involved in debate over which system is the most promising.
>
> **The purpose of the series-parallel functionality is to overcome problems inherent to either concept when employed individually.** The advantages are increased range in the urban driving mode and a secondary method of range extension in highway mode without significantly increasing the bulk or cost of the base parallel

> system. In addition, the control of the operation of the drive motor is more versatile and efficient.

(Ex. 1439 [9323263], 7, line 8-29, emphasis added.)

92. Although multiple flavors of series-parallel architectures existed, I have provided the following non-limiting exemplary figures based on my understanding, experience and knowledge in order to explain the architecture and operation of the more common two-motor "series-parallel" hybrid vehicles that were known in the art prior to September 1998. (*See e.g.,* Ex. 1432 [SAE SP-1156] at 8.) Based on my understanding, experience and knowledge, one of the changes between a one-motor and two-motor "parallel" hybrid vehicle is the inclusion of a second motor/generator (illustrated as MG2).[16]

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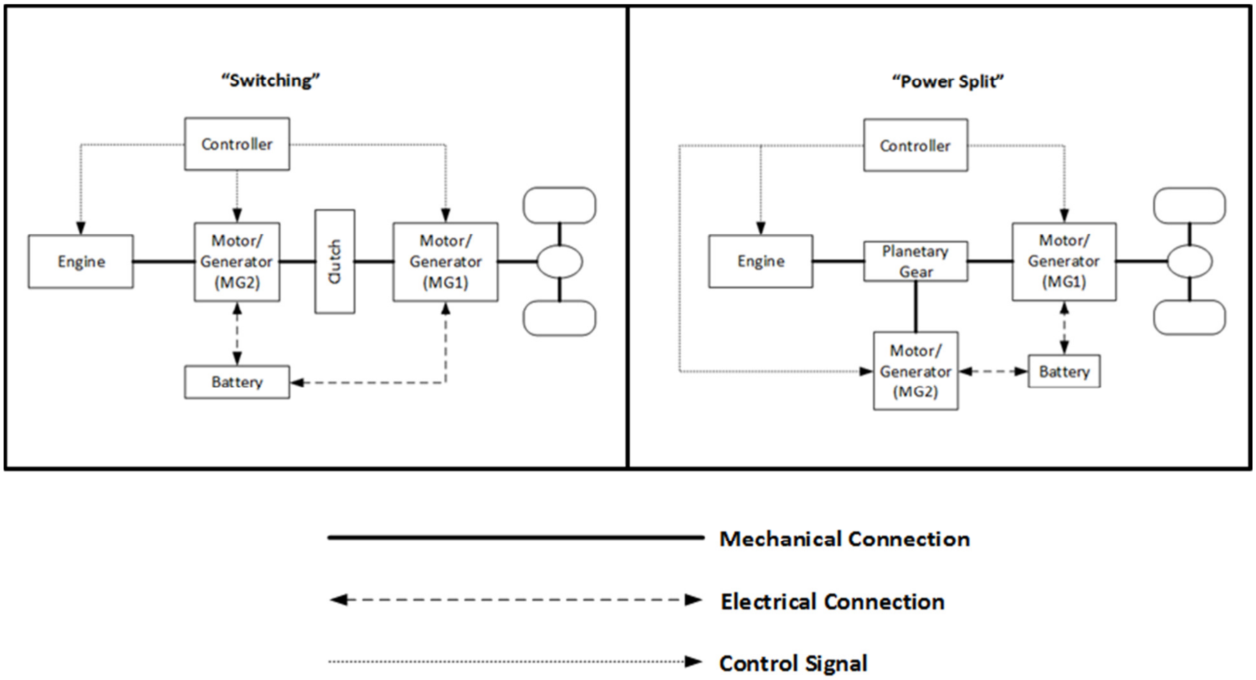
[16] While the prior art sometimes referenced MG2 simply as a "generator" it was known that these generators could operate as both a motor and generator. Again, historically such a component was referred to as a "dynamotor."



a. "Switching" Two-Motor "Series-Parallel" Hybrid Vehicles

93. As illustrated in ¶92 above, the two-motor "series-parallel" hybrid vehicle on the left has been classified as a "switching" system because it incorporated a clutch mechanism to selectively connect/disconnect the engine and MG2 to the road wheels.

94. As illustrated in ¶92 above, the two-motor "series-parallel" hybrid vehicle on the right has been classified as a "power split" system because it incorporated a planetary gear mechanism.

95. It was also known prior to September 1998 that the second "motor/generator" (*i.e.*, MG2) could operate as: (1) a starter motor, (2) a secondary motor for propulsion, or (3) a generator. (Ex. 1432 [SAE SP-1156] at 11.)

96. For "switching" two-motor systems it was known that a "clutch" was commonly included to controllably connect and/or disconnect the engine from the road wheels while the traction motor was generally coupled directly to the road wheels. (Ex. 1432 [SAE SP-1156] at 8.)

97. It was also known that the engine would be decoupled during operation in urban (city) driving where the load or torque required to propel the vehicle was low. (Ex. 1432 [SAE SP-1156] at 8.)

98. With the engine decoupled from the road wheels, the "switching" system could operate like a "series" hybrid vehicle with the engine powering the generator to recharge the battery when needed. (Ex. 1432 [SAE SP-1156] at 8.)

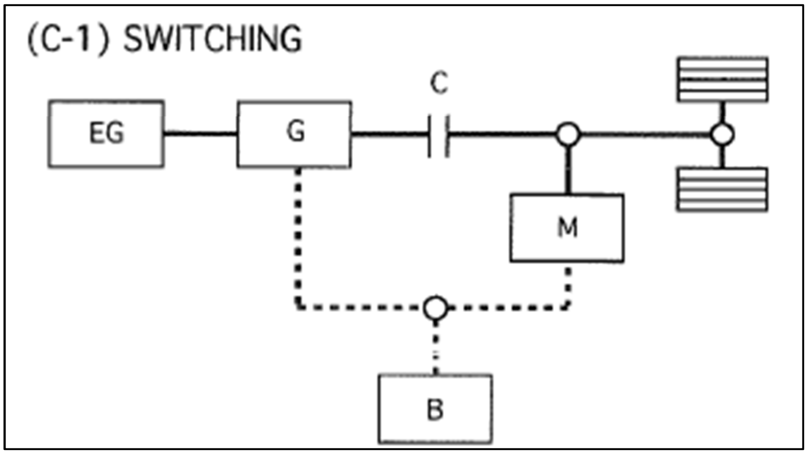
99. At higher loads, the engine could be reconnected to the road wheels and the "switching" system could use the engine and motor to provide the torque required to propel the vehicle. (Ex. 1432 [SAE SP-1156] at 8.)

100. For instance, a 1996 SAE publication discloses the following known benefits of a switching "series-parallel" hybrid vehicle.

> (C-1) SWITCHING SYSTEM - Application and release of the clutch switches between the series and parallel systems. For driving as by the series system, the clutch is released, separating the engine and the generator from the driving wheels. For driving with the parallel system, the clutch is engaged, connecting the engine with the driving wheels.
>
> For example, since city driving requires low loads for driving and low emissions, the series system is selected with the clutch released. For high

> speed driving where the series system would not work efficiently due to higher drive loads and consequently higher engine output is required, the parallel system is selected with the clutch applied.

(Ex. 1432 [SAE SP-1156] at 8.)



Ex. 1432 [SAE SP-1156] at 8, Fig. 1

101. Based on my understanding, experience and knowledge, one known advantage of the operation described in paragraph 100 is that the engine operates inefficiently at low loads so during such conditions (*e.g.*, city driving) the vehicle operates as a series vehicle with the electric motor propelling the vehicle. However, at higher loads where engine operation is efficient, the engine could be reconnected *via* the clutch and used to propel the vehicle. (Ex. 1432 [SAE SP-1156] at 8, 15.)

102. Also, at low loads where the engine is not mechanically connected to the road wheels, the engine is used at its optimum efficiency and low emission region to power the generator to charge the battery. (Ex. 1432 [SAE SP-1156] at 8.)

103. Based on my understanding, experience and knowledge, one-motor "parallel" hybrid vehicles were not able to operate in a series mode due to the absence

of the second motor/generator.

b. "Power-Split" Two-Motor "Series-Parallel" Hybrid Vehicles

104. "Power split" systems on the other hand, were known as being capable of operating as both a "series" ***and*** "parallel" hybrid at all times. (Ex. 1432 [SAE SP-1156] at 8.)

105. It was also known prior to September 1998 that "power split" systems typically used a planetary gear mechanism to connect the motors and engine. (Ex. 1432 [SAE SP-1156] at 8.)

106. It is my understanding that "power split" hybrids were developed as far back as 1970 by TRW and were commercially made available around 1997 by Toyota. My opinion is supported by a true and accurate copy of a July 1998 Automotive Engineering International article titled "Toyota Prius" that describes the original Toyota Prius platform. (Ex. 1440 [Toyota Prius Yamaguchi 1998] at 2.)

107. It was known that in 1997 Toyota commercially released the Prius "power split series-parallel" hybrid vehicle with a control strategy that determined operating modes based on the speed and load (*i.e.*, required driving torque) of the vehicle. (Ex. 1440 [Toyota Prius Yamaguchi 1998] at 2.)

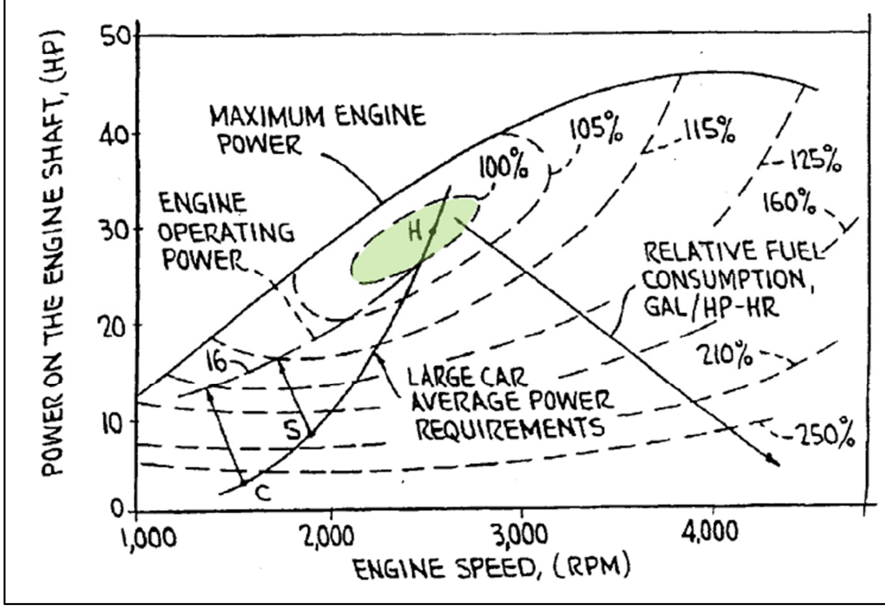
C. Hybrid Vehicle "Control Strategies"

108. It is also my opinion that a person having ordinary skill in the art understood that engines generally operate inefficiently and have high specific fuel

consumption at the low torque levels that are normally encountered at low vehicle speeds.

109. For instance, Figure 2 of the '347 Patent illustrates that the minimum operating range of the engine does not start until 1,000 RPM. The '347 Patent states this figure comes from the prior art U.S. Patent No. 5,343,970. Although this figure is not significantly discussed in the text of the '347 Patent, the parent '672 Patent does describe this figure. In particular, the '672 Patent states that 100% region which I have highlighted in green is "the most efficient region of operation of the engine" (*i.e.*, the engine's "sweet spot"). (Ex. 1441 ['672 Patent] at 17:16-19, Figure 2.)

FIG. 2



Ex. 1441 ['672 Patent] at Fig. 2 (annotated)

110. A September 1988 publication also illustrates an engine map showing efficiency curves for a typical gasoline engine. Based on my experience and knowledge, and shown below with annotations, the optimum engine efficiency, or

"sweet spot" (highlighted in green) is the desired range of conditions in which the engine would provide torque required to propel the vehicle or charge the battery. (Ex. 1433 [Bumby/Masding 1988] at Figure 1.)

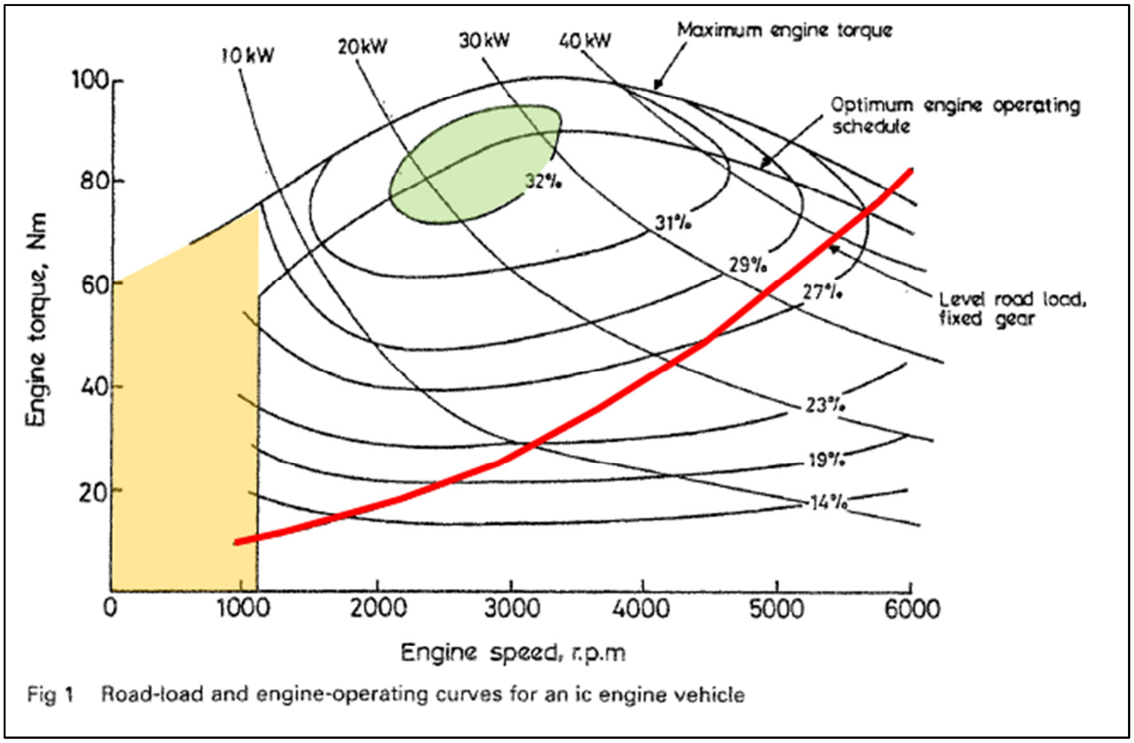


Fig 1 Road-load and engine-operating curves for an ic engine vehicle

Ex. 1433 [Bumby/Masding 1988] at 3, Fig. 1 (annotated)

111. With reference to the above figure, the 1988 reference states:

> Fig 1 shows a typical efficiency map for a 50 kW ic engine. Also shown on this diagram is a line corresponding to the road load seen by the engine when operating in a fixed gear. It is only at high loads that the engine operates at all efficiently. At low the operating point is well removed from the high-efficiency (low specific fuel-consumption) area. At a road load of 10 kW, the engine operates at about 3000 rev/min and is relatively inefficient. By reducing engine speed relative to the vehicle speed, through a suitable change in gear ratio, the engine operating point can be moved up, along the constant power line, towards the high-

> efficiency region. As the operating point moves up this constant power line it would, ultimately, reach the optimum engine operating line, the locus of which links the maximum engine efficiency points at each speed.

(Ex. 1433 [Bumby/Masding 1988] at 2.)

112. It is also my opinion that a person having ordinary skill understood that engines typically cannot operate at low engine speeds. This is shown by the region shaded in orange above. The exemplary 50 kW discussed in this reference shows that the engine could not produce torque below an engine speed of 1000 rpm. While the speed range can vary between different engines, all engines have a minimum threshold engine speed below which the engine cannot produce torque.

113. Also shown in this figure, the line highlighted in red corresponds to *road load* at a fixed gear. It is my opinion that it was well-known prior to September 1998 that the textbook definition of *road load* ($\mathbf{F_{RL}}$) is the sum of three external forces that act on the vehicle. These external forces are commonly referred to as the "aerodynamic drag" force (*i.e.*, wind resistance), "rolling resistance" force, and "grade resistance" force. (Ex. 1425 [Davis Textbook] at 9.)

114. For instance the *road load* definition disclosed in my textbook was also the definition that was well-known prior to September 1998. For example, a February 1997 IEEE publication supports the definition in my textbook that "road load (F_w) consists of rolling resistance (f_{ro}), aerodynamic drag (f_l), and climbing resistance (f_{st})."

(Ex. 1436 [IEEE Ehsani 1996] at 2[17]; *see also* Ex. 1437 [IEEE Ehsani 1997] at 2[18].)

115. Another well-known textbook used by a person of ordinary skill in the art prior to September 1998 is the "Bosch Automotive Handbook" (4th Edition, 1996). This textbook likewise supports my understanding that the textbook definition of *road load* forces are equal to the sum total of the "rolling resistance" force (F_{Ro}), the "aerodynamic drag" force (F_L), and the "climbing resistance" force (F_{ST}).

$$F_W = F_{Ro} + F_L + F_{ST}$$

(Ex. 1416 [1996 Bosch Handbook] at 15-18[19].)

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[17] It is my understanding that Ex. 1436 [IEEE Ehsani 1996] is a true and accurate copy of a 1996 Institute of Electrical and Electronics Engineers (IEEE) publication titled "Propulsion system design of electric vehicles" authored by Mehrdad Ehsani et al.

[18] It is my understanding that Ex. 1437 [IEEE Ehsani 1997] is a true and accurate copy of a 1997 IEEE publication entitled "Propulsion system design of electric and hybrid vehicles" authored by Mehrdad Ehsani et al.

[19] Ex. 1416 [1996 Bosch Handbook] is a true and accurate copy of excerpts from the 1996 Bosch Automotive Handbook that is published by the SAE. Ex. 1416 [1996 Bosch Handbook] is my personal copy that I have maintained without modifications throughout the years. Ex. 1416 [1996 Bosch Handbook] is identified as being

116. It is my opinion that such knowledge is necessary because automotive engineers must design a powertrain that is capable of providing sufficient "tractive effort" force at the wheels to overcome these *road load* forces. For instance, as further discussed in my textbook, "tractive effort" ($\mathbf{F_{TE}}$) is the force (or torque)[20] required by the powertrain to propel the vehicle. This "tractive effort" force is almost always in response to an operator command, such as operation of the accelerator pedal, brake pedal or cruise control setting.

117. Based on my experience and knowledge, during vehicle operation, the tractive effort ($\mathbf{F_{TE}}$) is generally used to overcome the road load forces ($\mathbf{F_{RL}}$) experienced by the vehicle.

118. Based on my experience and knowledge, if the tractive effort of the vehicle is greater than the road load forces ($\mathbf{F_{TE}} > \mathbf{F_{RL}}$), the vehicle is able to accelerate. Alternatively, if the tractive effort of the vehicle is less than the road load forces ($\mathbf{F_{TE}} < \mathbf{F_{RL}}$), the vehicle decelerates or does not move at all. It was further known that if the tractive effort is exactly equal to the road load forces ($\mathbf{F_{TE}} = \mathbf{F_{RL}}$) the vehicle will travel at a constant speed.

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published and copyrighted by Robert Bosch GmbH in 1996. (Ex. 1416 [1996 Bosch Handbook] at 2.)

[20] A person of ordinary skill in the art understands that Tractive Force = Torque /Radius of Tire (Ex. 1416 [Bosch Handbook] at 6-7).

119. Based on my experience and knowledge, when a vehicle is travelling up a hill or when the driver requests an increased demand for acceleration, tractive forces may become positive. For example, when a vehicle is climbing a hill, a large amount of "tractive effort" ($\mathbf{F}_{\mathbf{TE}}$) may be required to overcome the large *road load* ($\mathbf{F}_{\mathbf{RL}}$) forces due to the hill gradient effect. As a result the vehicle would begin to decelerate as the vehicle climbs the hill unless the driver demands a different amount of "tractive effort" from the powertrain. If the driver does not change the requested "tractive effort", the vehicle may begin to slow down as it ascends the hill. Alternatively, if the driver further presses down the accelerator pedal, the "tractive effort" force may become greater than the *road load* force that increased due to the hill gradient effect. As stated above, if the "tractive effort" equals the *road load* force the vehicle will continue to travel at the same constant speed and no further deceleration is experienced. If the tractive effort of the vehicle is greater than the road load forces ($\mathbf{F}_{\mathbf{TE}} > \mathbf{F}_{\mathbf{RL}}$), the vehicle is able to accelerate up the hill.

120. Further based on my experience and knowledge, when a vehicle is travelling down a hill, road load forces may become negative. For example, when a vehicle is climbing a hill, a large amount of "tractive effort" ($\mathbf{F}_{\mathbf{TE}}$) may be required to overcome the large *road load* ($\mathbf{F}_{\mathbf{RL}}$) forces due to the hill gradient effect. However, when the vehicle travels back down the hill, the previous provided uphill tractive effort would likely be much greater than the downhill road load forces. Additionally, if the hill is steep, the road load forces can act to accelerate the vehicle, even when the

tractive effort provided by the powertrain is zero. As a result the vehicle would begin to accelerate down the hill unless the driver demand changes (*i.e.* if the driver applies the brake pedal).

121. Referring to the figure below (which is the same figure shown in above in ¶ 110, with additional annotations), the line highlighted in red is the road load curve for the exemplary 50 kW engine operated in a fixed gear. At 10 kW of road load, as circled in blue, the engine is required to operate at roughly 3000 rpm, far removed from the efficient operating range that is highlighted in green. In other words, the engine would operate inefficiently at this point.

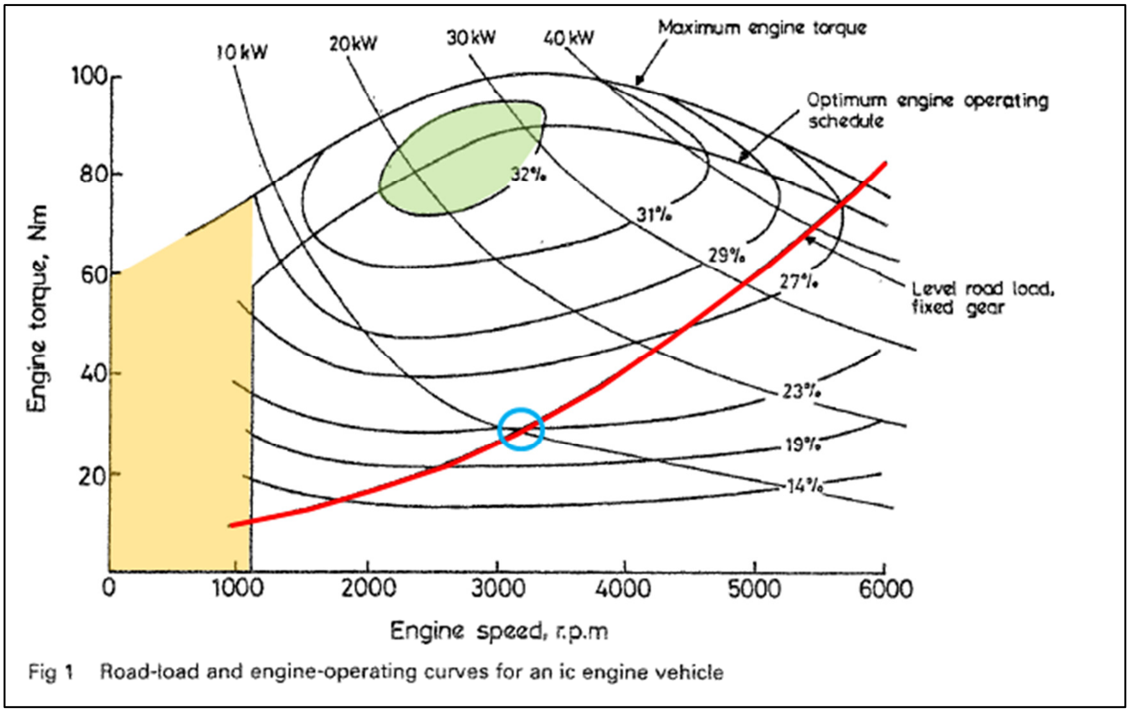

Fig 1 Road-load and engine-operating curves for an ic engine vehicle

Ex. 1433 [Bumby/Masding 1988] at 3, Fig. 1 (annotated)

122. In order to operate the engine more efficiently, a conventional non-hybrid vehicle would control a transmission. As further circled in blue (below), the

exemplary engine has used a transmission to shift engine operation along the 10kW constant power curve so that the engine operates more efficiently. However, changing gears in a conventional vehicle still does not shift the engine operation to the optimal range as highlighted in green.

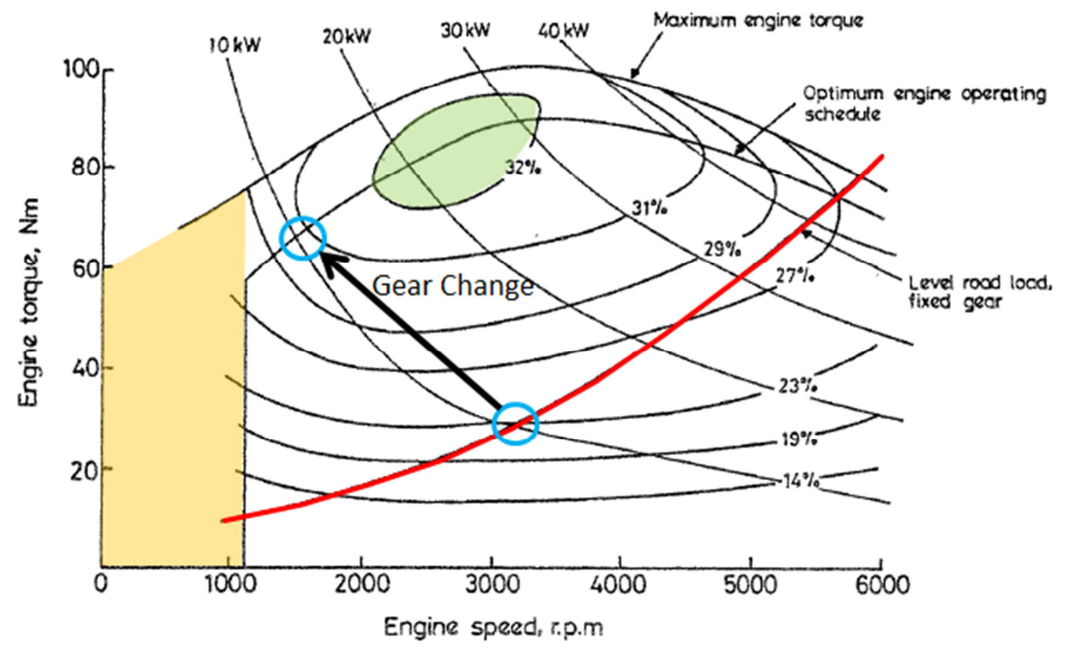

Fig 1 Road-load and engine-operating curves for an ic engine vehicle

Ex. 1433 [Bumby/Masding 1988] at 3, Fig. 1 (annotated)

123. It should also be noted that either of the circles around the 10 kW of power equates to the tractive effort required to propel the vehicle in order to overcome the road load forces. However, the first operating point before the transmission gear shift (blue circle to right) is provided at a lower engine efficiency. Therefore, the transmission is used to shift gears such that the amount of tractive effort required to maintain vehicle speed is provided at a more efficient engine operating point, which is closer to the engine's "sweet spot."

124. Based on my experience and knowledge, efficient usage of the engine may further be improved if a hybrid vehicle includes a motor which can be used to provide an additional power source for propelling the vehicle. The addition of a motor requires a control strategy for determining when to operate the engine, motor, or both in combination to propel the vehicle.

125. Based on my experience and knowledge, an advantage of hybrid vehicles having a motor was to be able to control the motor to propel the vehicle at low speeds and loads, so that the engine can be reserved or limited to operation in its "sweet spot."

126. Again, this known concept is noted by the '672 Patent which states that an engine "sized appropriately for highway cruising [has] substantial inefficiencies [] at lower speeds." (Ex. 1441 ['672 Patent] at 17:25-27.)

127. Other prior art references again support this well-known understanding of engines.

> The operation of the engine in the parallel hybrid is much like that in a conventional ICE vehicle except that it will operate much less frequently at low power, because the electric driveline will provide the power at low vehicle speeds and light loads.

(Ex. 1428 [Burke 1992] at 7-8.)

128. Hybrid vehicles sought to overcome such inefficient engine operation. As explained in Section IV.B. above, for hybrid vehicles, the control strategy of

utilizing the engine and motor was typically accomplished using a variety of modes that included: (1) an "electric" or "motor-only" mode where the motor propels the vehicle when engine operation is inefficient (*i.e.*, at low loads and vehicle speeds); (2) an "engine-only" mode where the engine propels the vehicle when engine operation is efficient (*i.e.*, higher loads and vehicle speeds); (3) a charging mode where the motor acts as a generator to provide electrical energy to recharge the battery; and (4) a "combined" or "acceleration" mode where the engine and motor are used to propel the vehicle when the demand is beyond the maximum torque capabilities of the engine. (*See e.g.*, Ex. 1427 [Unnewehr] at 3.)

129. A 1995 SAE article also supports my understanding that one advantage of a hybrid vehicle is the ability to limit operation of the engine to its "sweet spot" or "optimum efficiency range" while still meeting the load required for propelling the vehicle.

> The maximum power output of the [engine] will affect strategy design choices in a similar manner to the capacity of the battery. With a high power capability, one may design the strategy to operate more or less like a conventional car engine in a power following mode, whereas a low power capability will force the strategy to run the engine at its highest power level so that it can keep up with current demands and store extra energy for periods of high demand.

***

> The fuel efficiency of an [engine] generally varies as a function of the power level. The specific fuel consumption (SFC) of an engine is typically best at middle power levels and worst at the low and high power extremes. The [engine] operating strategy that will maximize fuel efficiency is one that runs the [engine] primarily in the range of powers over which the SFC is best (often termed the engine's "sweet spot").

(Ex. 1442 [SAE SP-1089] at 11.)[21]

130. In another example, a 1976 SAE paper emphasizes a few of the advantages of a hybrid vehicle for controlling efficient engine operation:

> It is important to understand the reasons why the average engine efficiency is improved with the hybrid configuration. **The key point is that the hybrid engine is operated at more efficient operating points**. This results in improved overall engine efficiency when averaged over the drive cycle. This improvement has two sources. The first is the elimination of all fuel consumed at idle, during braking and during the low speed all-electric mode. The equivalent driving modes for the conventional [vehicle] account for 25% to 30% of the fuel consumed []. The second source of improvement is the higher load factors and wider throttle openings required by a smaller hybrid engine.

(Ex. 1427 [Unnewehr] at 12, emphasis added.)

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[21] It is my opinion that Exhibit 1442 [SAE SP-1089] is a true and accurate copy of excerpts from the 1995 SAE Special Publication (SP) entitled "Design Innovations in Electric and Hybrid Electric Vehicles."

131. More specifically, based on my understanding, experience and knowledge, hybrid vehicles could be operated using a well-known "load-following charge-sustaining" control strategy. This control strategy limited operation of the engine to a defined efficient operating range using a predetermined lower and upper value threshold value. For instance, an August 1998 SAE article describing this "load-following charge-sustaining" control strategy that may restrict operation of the engine within a "lower motive power" and "higher motive power" value (highlighted in red below). (Ex. 1438 [An 1998] at 10.)[22] This control strategy operated so that: (1) the electric motor propelled the vehicle when the amount of power required to propel the vehicle was below the "lower motive power" value (highlighted in red below); (2) the engine alone propelled the vehicle when the amount of power required to propel the vehicle was between the "lower motive power" and "upper motive power" threshold values; and (3) the motor and engine are used together when the amount of power required to propel the vehicle was above the "higher motive power" value (highlighted in green below). As is described in the paper, this control strategy ensured that the engine was only used in a specified area where engine operation is most efficient. (Ex. 1438 [An 1998] at 10.)

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[22] Ex. 1438 [An 1998] is a true and accurate copy of a 1998 SAE paper titled "Critical Issues in Quantifying Hybrid Electric Vehicle Emissions and Fuel Consumption" authored by Feng An and Matthew Barth.

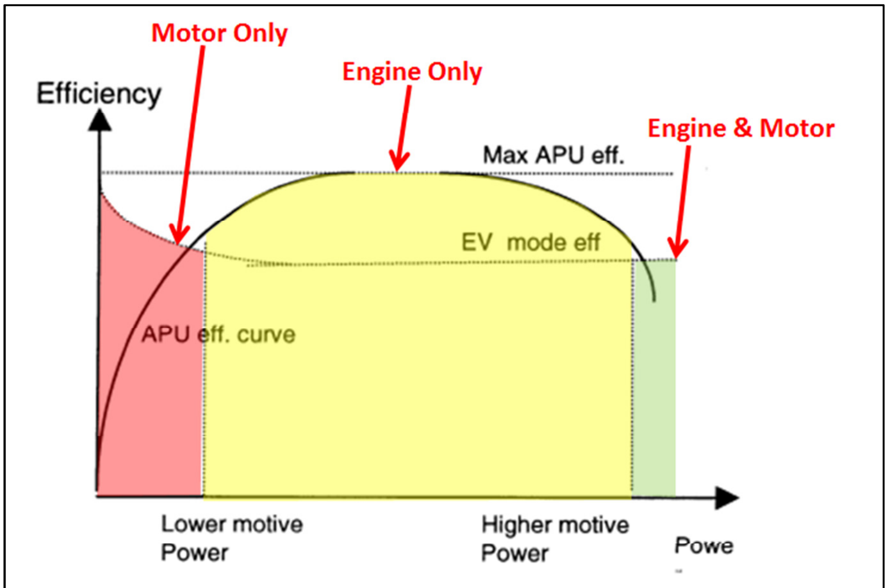


Figure 7. Load Following Control Strategy

Ex. 1438 [An 1998] at 10, Fig. 7 (annotated)

132. Based on my experience and knowledge hybrid vehicles were used to improve fuel efficiency by improving engine operation. Again, it is my understanding that this was typically accomplished using a set of operational modes that allowed the engine that to be operated at or near its "sweet spot" or efficient operating range.

133. Also based on my experience and knowledge, the electric motor could either (1) provide the tractive effort required to propel the vehicle alone when engine operation was not efficient (*i.e.* outside the "sweet spot"), or (2) in combination with the engine at high acceleration or driver demands.

134. Lastly, based on my experience and knowledge, control between these modes is done so that the required tractive effort is provided to the road wheels using the vehicle powertrain (*i.e.*, the motor(s) and engine) in order to order to overcome the external *road load* forces and thus propel the vehicle.

V. CHALLENGED CLAIMS OF THE '347 PATENT AND PROPOSED CLAIM CONSTRUCTIONS

135. I have been asked to review independent claims 1 and 23, and dependent claims 23-30, 32, and 39-41.

136. In order to properly evaluate these claims, I understand that the terms of the claims must first be construed. For purposes of this declaration, I have been provided with the following claim constructions for my analysis regarding unpatentability:

a. "**road load (RL)**" and "**RL**" as: "*amount of instantaneous torque required to propel the vehicle, be it positive or negative*"

b. "**SP**," "**Setpoint (SP)**" as: "*predetermined torque value.*"

c. **"mode I", "Low-load operation mode I"** as "*the mode of operation in which energy from the battery bank flows to the traction motor and torque (rotary force) flows from the traction motor to the road wheels*"

d. "**Highway Cruising operation mode IV**" as "*the mode of operation in which energy flows from the fuel tank into the engine and torque (rotary force) flows from the engine to the road wheels*"

e. "**Acceleration operation mode V**" as "*the mode of operation in which energy flows from the fuel tank to the engine and from the battery bank to at least one motor and torque (rotary force) flows from the engine and at least one motor to the road wheels*".

f. “**abnormal and transient**” as “*starting and stopping of the engine and provision of torque to satisfy drivability or safety considerations.*”

VI. OVERVIEW OF THE PRIOR ART

A. U.S. Patent No. 5,789,882 to Ibaraki et al. (Ibaraki ’882)

137. I understand that Exhibit 1403 [Ibaraki ’882] is a true and accurate copy of U.S. patent 5,789,882.

138. I understand Ibaraki ’882 was filed on July 22, 1996 and issued on August 4, 1998, and is therefore prior art to the claims of the ’347 Patent.

139. Generally speaking, and as I explain in greater detail below, Ibaraki ’882 relates to a torque-based control strategy for reducing the fuel consumption and gas exhaust emissions of a hybrid vehicle.

140. <Intentionally left blank>

141. <Intentionally left blank>

142. <Intentionally left blank>

B. U.S. Patent No. 6,116,363 to Frank (Frank)

143. I understand that Exhibit 1418 [Frank] is a true and accurate copy of U.S. patent 6,116,363.

144. I understand that Frank was filed on April 21, 1998 and issued on September 12, 2000, and is therefore prior art to the claims of the ’347 Patent.

145. Generally speaking, and as I explain in greater detail below, Frank relates to a hybrid vehicle having different operational modes in which the engine, the motor,

or both are used to propel the vehicle. Different on-off thresholds and time delays are used between the modes in order to reduce unnecessary engine starts and stops.

146. <Intentionally left blank>

147. <Intentionally left blank>

148. <Intentionally left blank>

C. Engineering Fundamentals of the Internal Combustion Engine (Pulkrabek)

149. It is my understanding that Exhibit 1419 [Pulkrabek] is a true and accurate copy of excerpts from a textbook published by Prentice Hall titled "Engineering Fundamentals of the Internal Combustion Engine authored by Willard Pulkrabek. I understand that Ex. 1419 has a 1997 copyright. Ex. 1419 is my personal copy that I have maintained without modifications through the years.

150. As the title invokes, this textbook explains basic fundamentals of internal combustion engines, with a focus on engines used in automobiles. An entire chapter (Chapter 9) is devoted to "Emissions and Air Pollution" and known strategies to mitigate these effects.

D. Fiat Conceptual Approach to Hybrid Chars Design (Vittone)

151. I understand that Exhibit 1420 [Vittone] is a true and accurate copy of a 1994 publication authored by Oreste Vittone titled "Fiat Conceptual Approach to Hybrid Cars Design."

152. This publication was one of multiple papers presented at the 12th

International Electric Vehicle Symposium ("EVS-12"). (Ex. 1420 [Vittone] at 1-2.) EVS-12 was publically held between December 5-7, 1994 at Disneyland's hotel and convention center in Anaheim California. (Ex. 1420 [Vittone] at 2.)

153. I am familiar with the EVS and understand it is a conference that is held every 1-2 years at a selected location around the world. I also understand that EVS is a technical conference that is used to present and showcase all forms of technology related to vehicles that include an electric drive system, such as electric vehicles and hybrid-electric vehicles.

154. I understand that the papers presented at each conference are publically available either at or shortly after each conference. It is my opinion that a person having ordinary skill in the art would have known and kept up-to-date on publications being presented and published at conferences like EVS.

155. In fact, Vittone is one of the two non-patent publications listed on the face of Ibaraki '882. (Ex. 1403 [Ibaraki '882] at Cover.)

156. It is therefore my understanding that Vittone is prior art to the claims of the '347 Patent.

E. U.S. Patent No. 5,865,263 to Yamaguchi et al. (Yamaguchi)

157. I understand that Exhibit 1421 [Yamaguchi] is a true and accurate copy of U.S. patent 5,865,263.

158. I understand that Yamaguchi was filed on February 23, 1996 and issued on February 2, 1999 and is therefore prior art to the claims of the '347 Patent.

159. Generally speaking, and as I explain in greater detail below, Yamaguchi relates to a hybrid vehicle having an electric motor that rotates the engine when the vehicle reaches a specified speed. Shortly thereafter, ignition occurs in the engine.

F. U.S. Patent No. 6,003,626 to Ibaraki et al. (Ibaraki '626)

160. I understand that Exhibit 1422 [Ibaraki '626] is a true and accurate copy of U.S. patent 6,003,626.

161. I understand that Ibaraki '626 was filed on October 4, 1996 and issued on Dec. 21, 1999 and is therefore prior art to the claims of the '347 Patent.

162. Generally speaking, and as I explain in greater detail below, Ibaraki '626 relates to a control strategy for reducing the fuel consumption and gas exhaust emissions of a hybrid vehicle. Ibaraki '626 also discusses operation of the hybrid vehicle during the "event of a failure of the electric generator[.]" (Ex. 1422 [Ibaraki '626] at 2:25-26.)

G. Automotive Electronics Handbook (Jurgen)

163. I understand that Exhibit 1406 [Jurgen] is a true and accurate copy of excerpts from the textbook by Ronald Jurgen titled "Automotive Electronics Handbook." (Ex. 1406 [Jurgen] at 3.) I understand that Ex. 1406 has a copyright 1995 copyright.

164. Exhibit 1406 is a copy of Jurgen that I have personally owned and maintained throughout the years without modification.

165. Jurgen is a reference textbook that is commonly known and used by

persons having ordinary skill in the automotive field.

166. I understand that Jurgen is prior art to the claims of the '347 Patent.

H. U.S. Patent No. 5,823,280 (Lateur)

167. I understand that Exhibit 1407 [Lateur] is a true and accurate copy of U.S. Patent No. 5,823,280.

168. I understand that Lateur was filed on January 12, 1995 and issued on October 20, 1998 and is therefore prior art to the claims of the '347 Patent.

VII. GROUND 1 – CLAIMS 23, 24, 28, 30, AND 32 ARE OBVIOUS OVER IBARAKI '882 IN VIEW OF THE KNOWLEDGE OF A PERSON HAVING ORDINARY SKILL IN THE ART

A. Independent Claim 23

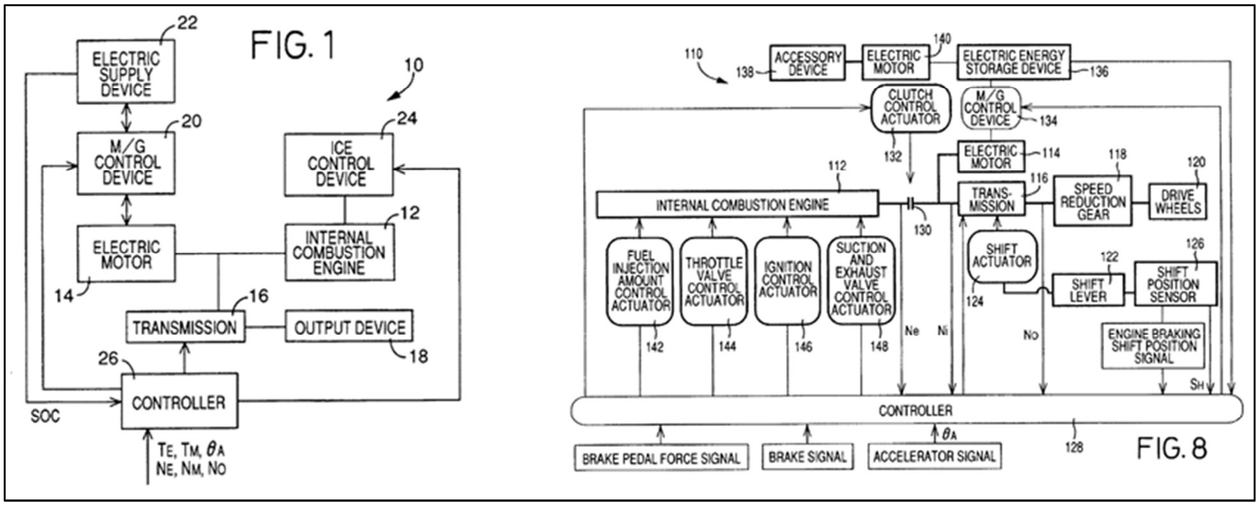
… ***[23.0] A method of control of a hybrid vehicle,***

169. Ibaraki '882 states that the "present invention" pertains to control strategies for hybrid vehicles that include an electric motor and an IC engine.

> The present invention relates in general to a drive control apparatus for an automotive vehicle, and more particularly to a drive control apparatus for a so-called "hybrid vehicle" equipped with two drive power sources consisting of an electric motor and an engine such as an internal combustion engine.

(Ex. 1403 [Ibaraki '882] at 1:9-14.)

170. For instance, as illustrated by Figures 1 and 8 below, Ibaraki '882 discloses a hybrid vehicle architecture having an internal combustion engine, an electric motor, a battery (*i.e.*, electric energy storage device 136) and a controller.



Ex. 1403 [Ibaraki '882] at Figures 1 & 8

171. Ibaraki '882 also discloses in the "SUMMARY OF THE INVENTION" section several of the alternative hybrid vehicle control strategies that are used to operate the electric motor and engine in order to "effective[ly] reduc[e]. . . the fuel consumption amount or exhaust gas amount of the engine." (Ex. 1403 [Ibaraki '882] at 2:55-56.)

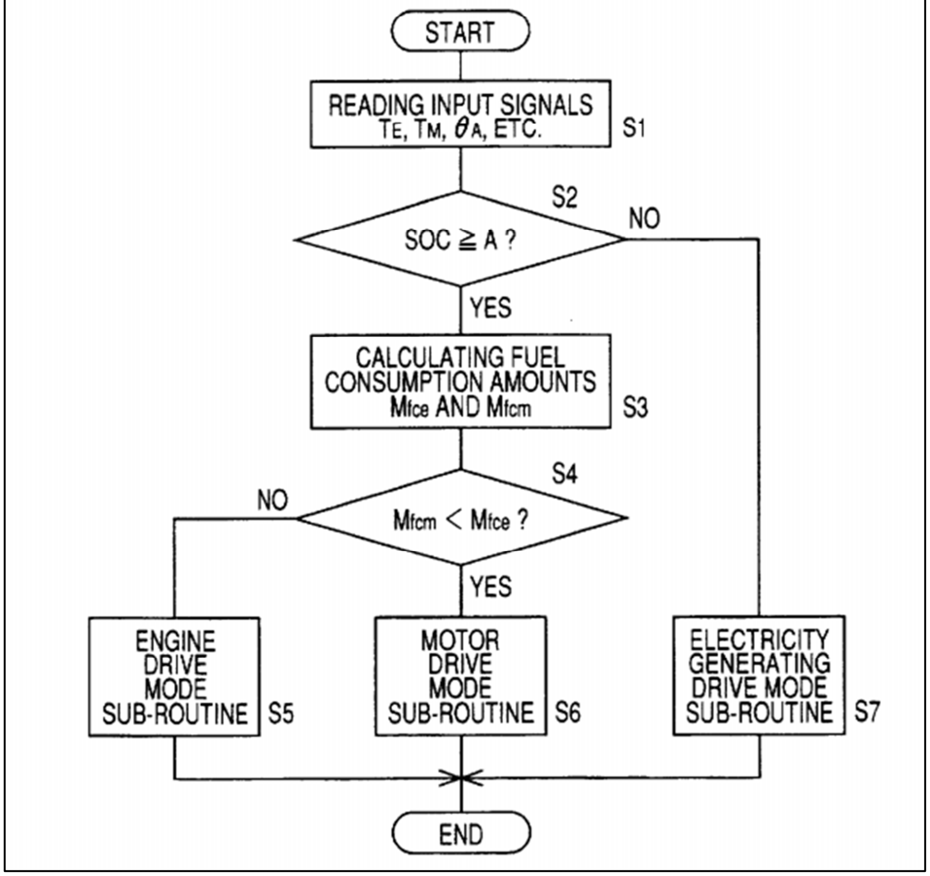
> According to a first aspect of the present invention, there is provided a drive control apparatus for an automotive vehicle having an electric generator for generating an electric energy, an electric energy storage device for storing the electric energy generated by the electric generator, an electric motor operated as a first drive power source by the electric energy, and an engine operated as a second drive power source by combustion of a fuel, the apparatus having an engine drive mode in which the vehicle is driven by the engine, a motor drive mode in which the vehicle is driven by the electric motor, and an electricity generating mode in which the electric generator is operated by the engine to charge the electric energy storage device, the apparatus selecting one of the

> engine drive mode, the motor drive mode and the electricity generating mode, depending upon a running condition of the vehicle, the apparatus being characterised by drive source selecting means for selecting one of the engine drive mode and the motor drive mode, on the basis of a first value in the engine drive mode of a physical quantity relating to a condition of the engine and a second value of the physical quantity reflecting energy conversion efficiencies of the electric generator, the electric motor and the electric energy storage device in the electricity generating mode, and according to a predetermined rule associated with the first and second values.

(Ex. 1403 [Ibaraki ’882] at 2:58-3:14, *see also* 5:13-26, 8:36-58, 9:44-59.)

172. Ibaraki ’882 particularly discloses a control strategy in the form of the flow diagram illustrated by Figure 3.

FIG. 3



Ex. 1403 [Ibaraki '882] at Figure 3

173. Ibaraki '882 discloses that the above illustrated control strategy is designed to effectively control the engine and electric motor in order to reduce the vehicle's overall fuel consumption and exhaust gas.

> The ENGINE DRIVE mode or the MOTOR DRIVE mode is selected so as to reduce the fuel consumption amount M_{fc}, and the engine 12 is controlled in the ELECTRICITY GENERATING DRIVE mode so as to maximize the overall fuel consumption efficiency η_T, whereby the fuel consumption amount M_{fc} is minimized and the exhaust gas amount is accordingly minimized.

(Ex. 1403 [Ibaraki '882] at 25:15-21 (emphasis added), 12:33-49.)

174. Ibaraki '882 discloses another control strategy as illustrated by the flow diagram below.

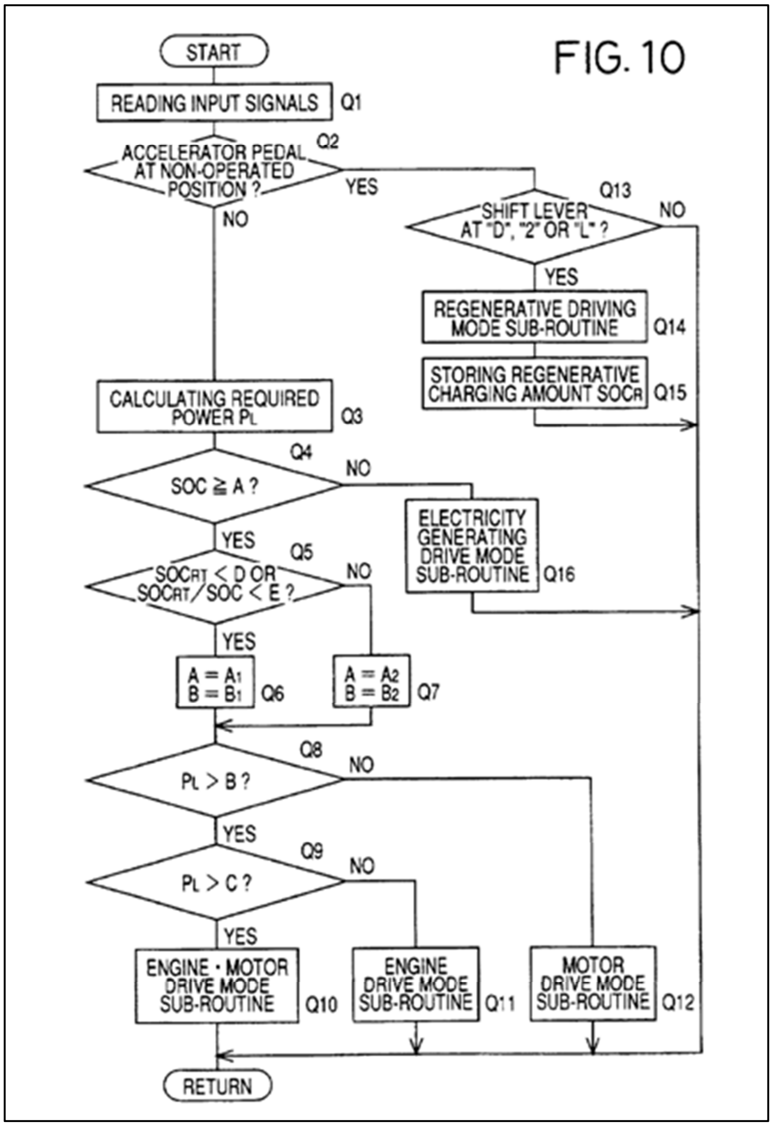


FIG. 10

Ex. 1403 [Ibaraki '882] at Figure 10

175. Ibaraki '882 discloses executing the control strategy of Figure 10 to select "one or both of the engine 112 and the motor 114 as the drive power source or sources, according to a drive source selecting data map stored in memory[.]" (Ex.

1403 [Ibaraki ’882] at 20:39-43.)

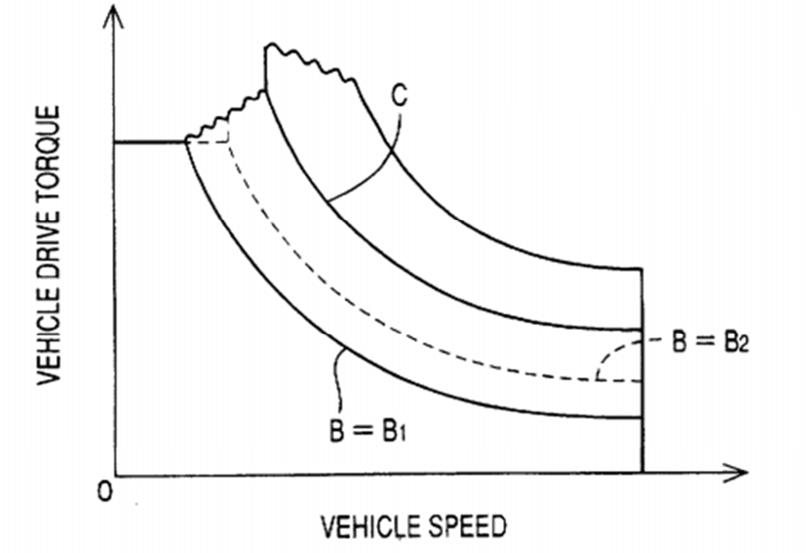
176. Specifically, Ibaraki ’882 discloses that the controller includes “drive source selecting means” that will use a stored “data map” to determine when the hybrid vehicle should be operated in a “MOTOR DRIVE mode,” an “ENGINE DRIVE mode” or an “ENGINE-MOTOR DRIVE mode.”

> The controller 128 includes drive source selecting means 160 illustrated in the block diagram of FIG. 9. The drive source selecting means 160 is adapted to select one or both of the engine 112 and the motor 114 as the drive power source or sources, according to a drive source selecting data map stored in memory means 162. That is, the controller 128 has a MOTOR DRIVE mode in which the motor 114 is selected as the drive power source, an ENGINE DRIVE mode in which the engine 112 is selected as the drive power source, and an ENGINE-MOTOR DRIVE mode in which both the engine 112 and the motor 114 are selected as the drive power sources.

(Ex. 1403 [Ibaraki ’882] at 20:38-49.)

177. Ibaraki ’882 discloses that this exemplary data map “is illustrated in the graph of FIG. 11, which represents a predetermined relationship between the vehicle drive torque and running speed V and the above-indicated three drive modes.” (Ex. 1403 [Ibaraki ’882] at 20:49-53.)

FIG. 11



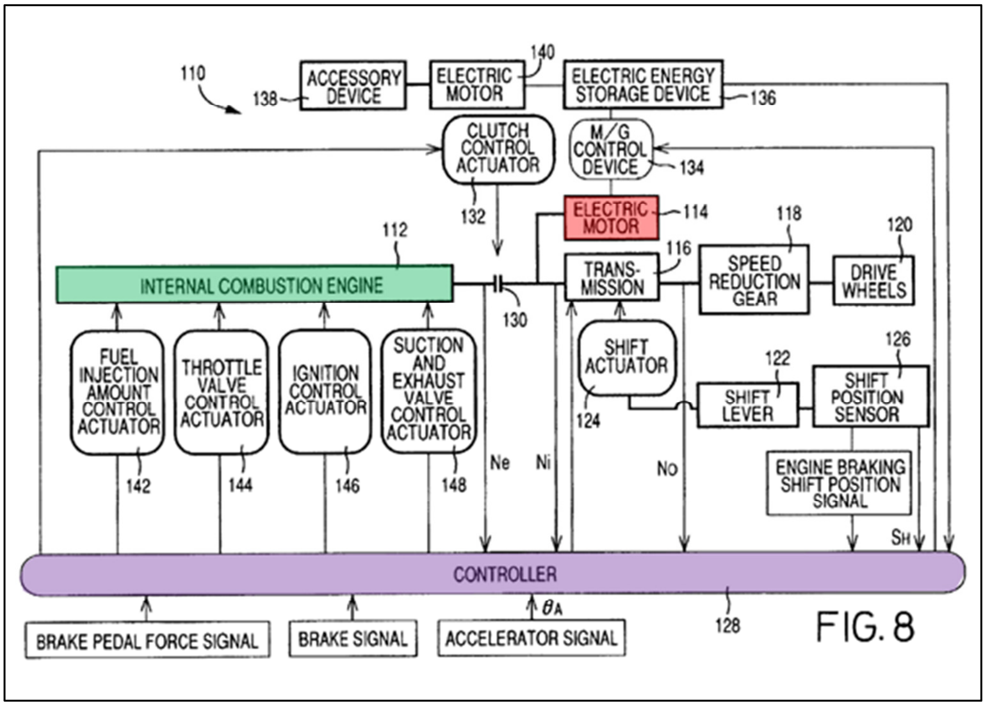
Ex. 1403 [Ibaraki '882] at Fig. 11

178. It is therefore my opinion that Ibaraki '882 therefore discloses *a method of control of a hybrid vehicle.*

> … ***[23.1] 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,***

179. I understand that the recited *setpoint (SP)* is proposed as being a "predetermined torque value."

180. As I have annotated below, Figure 8 discloses a hybrid vehicle architecture having a controller (highlighted in purple) and an internal combustion engine (highlighted in green).



Ex. 1403 [Ibaraki '882] at Fig. 8 (Annotated)

181. Ibaraki '882 describes an "internal combustion engine 112" that may be selectively operated to transfer propulsive power to the drive wheels. Ibaraki '882 also states that the engine 112 may be operated by combustion of fuel that a person having ordinary skill in the art would have understood as being supplied from a fuel tank.

> The vehicle drive control apparatus 110 is arranged to control a hybrid vehicle equipped with an internal combustion engine 112 such as a gasoline engine operated by combustion of a fuel, and a dynamo-electric motor 114 which functions as an electric motor operated by an electric energy and an electric generator or dynamo for generating electricity. Power of the internal combustion engine 112 and power of the electric motor 114 are simultaneously or selectively transferred to a transmission 116, and to right and left drive wheels 120 via a speed reduction gear 118 and a differential gear.

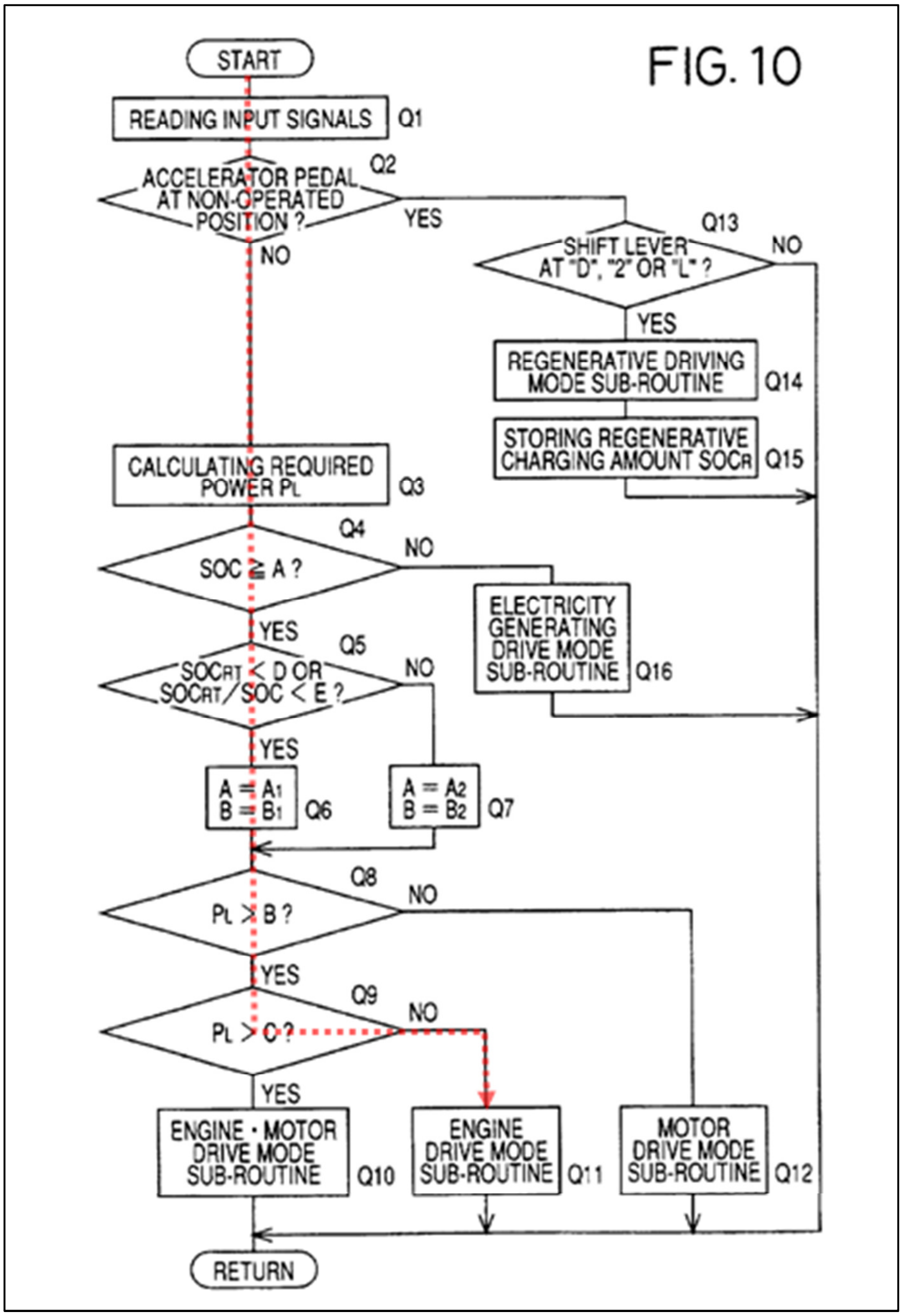
(Ex. 1403 [Ibaraki '882] at 19:18-27.)

182. Ibaraki '882 discloses that the controller includes control programs that determine whether the hybrid vehicle should be propelled in an "ENGINE DRIVE mode," in which the vehicle is propelled by operation of the engine alone.

> **That is, the controller 128 has** a MOTOR DRIVE mode in which the motor 114 is selected as the drive power source, **an ENGINE DRIVE mode in which the engine 112 is selected as the drive power source**, and an ENGINE-MOTOR DRIVE mode in which both the engine 112 and the motor 114 are selected as the drive power sources.

(Ex. 1403 [Ibaraki '882] at 20:43-53, emphasis added.)

183. Ibaraki '882 further discloses that a "flow chart showing a routine executed" by the controller is illustrated by Figure 10. (Ex. 1403 [Ibaraki '882] at 10:66-67, 22:1-3.) As I have annotated below, this control program includes logic allowing the controller to select the "ENGINE DRIVE mode" sub-routine.



Ex. 1403 [Ibaraki '882] at Fig. 10 (Annotated)

184. To select the "ENGINE DRIVE mode," Ibaraki '882 discloses the controller of the hybrid vehicle is "adapted to select one or both of the engine 112 and the motor 114 as the drive power P_L source or sources, **according to a drive source selecting data map stored in memory means 162**." (Ex. 1403 [Ibaraki '882]

at 20:39-43, emphasis added.)

185. Ibaraki ’882 for instance discloses that Figure 5 may be used in the same manner as the data map of Figure 11 to include a threshold line. Ibaraki ’882 discloses that Figure 5 may be adapted to operate like Figure 11 by setting a threshold line at “$0.7\eta_{ICEmax}$” (*i.e.* 70% of the maximum fuel consumption efficiency of the IC engine). Below the threshold line of “$0.7\eta_{ICEmax}$” the motor is used to propel the vehicle. Above the threshold line of “$0.7\eta_{ICEmax}$” the engine is used to propel the vehicle. Ibaraki ’882 discloses above *setpoint* (*SP*), less fuel is consumed in the ENGINE DRIVE mode than in the MOTOR DRIVE mode. That is, at and above *SP*, torque produced by the engine (in ENGINE DRIVE mode) is fuel efficient

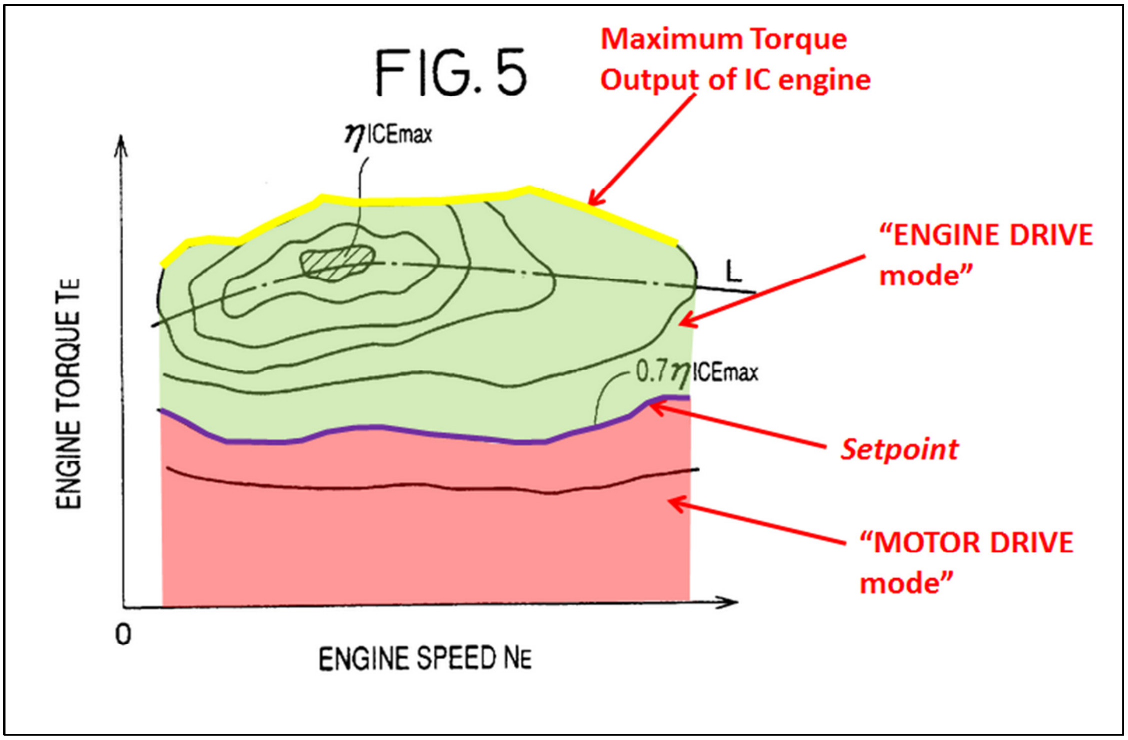
> In the first embodiment, the fuel consumption amounts M_{fcm}, M_{fce} are calculated in each cycle of execution of the routine of FIG. 3 depending upon the running condition of the vehicle such as the required drive power P_L. In this connection, it is noted that the maximum energy conversion efficiencies η_{GEN} and η_{MOT} (η_{MOTmax} indicated in FIG. 6) of the motor 14 are about 92%, while the input and output efficiency $\eta_{BIN} \times \eta_{BOUT}$ of the electric energy storage device 22 is about 85%, whereby the overall energy conversion efficiency of the electric control, system is about 0.72=0.92×0.85×0.92. **In view of this fact, it is possible to select the ENGINE DRIVE mode if the fuel consumption efficiency η_{ICE} for running the vehicle in the ENGINE DRIVE mode with the engine 12 selected as the drive power source is larger than a threshold $0.7\eta_{ICEmax}$ indicated in FIG. 5, which threshold is 70% of the maximum fuel consumption**

> **<u>efficiency η_{ICEmax}, and select the MOTOR DRIVE mode if the fuel consumption efficiency η_{ICE} is smaller than the threshold 0.7η_{ICEmax}</u>**. This modified arrangement, which also meets the principle of the present invention, facilitates the selection of the ENGINE. DRIVE mode and the MOTOR DRIVE mode, by simply obtaining the fuel consumption efficiency η_{ICEmax} in the ENGINE DRIVE mode. The threshold is not limited to 70% of the maximum fuel consumption efficiency η_{ICEmax}, but may be suitably determined depending upon the energy conversion efficiencies of the motor 14 and the electric energy storage device 22. The concept of this modification of the first embodiment is embodied as the data map shown in FIG. 11 used in the second embodiment. Where the overall energy conversion efficiency of the electric control system varies to a comparatively large extent, **<u>it is desirable to select the ENGINE DRIVE mode if the fuel consumption efficiency η_{ICE} in the ENGINE DRIVE mode is larger than the threshold, and select the ENGINE DRIVE mode or the MOTOR DRIVE mode by implementing steps S3-S6 of FIG. 3 if the fuel consumption efficiency η_{ICE} is smaller than the threshold</u>**. Similar modification is possible where the exhaust gas amount is reduced by replacing the fuel consumption efficiency η_{ICE} by the exhaust gas emission efficiency

(Ex. 1403 [Ibaraki ’882] at 25:36-26:8.)

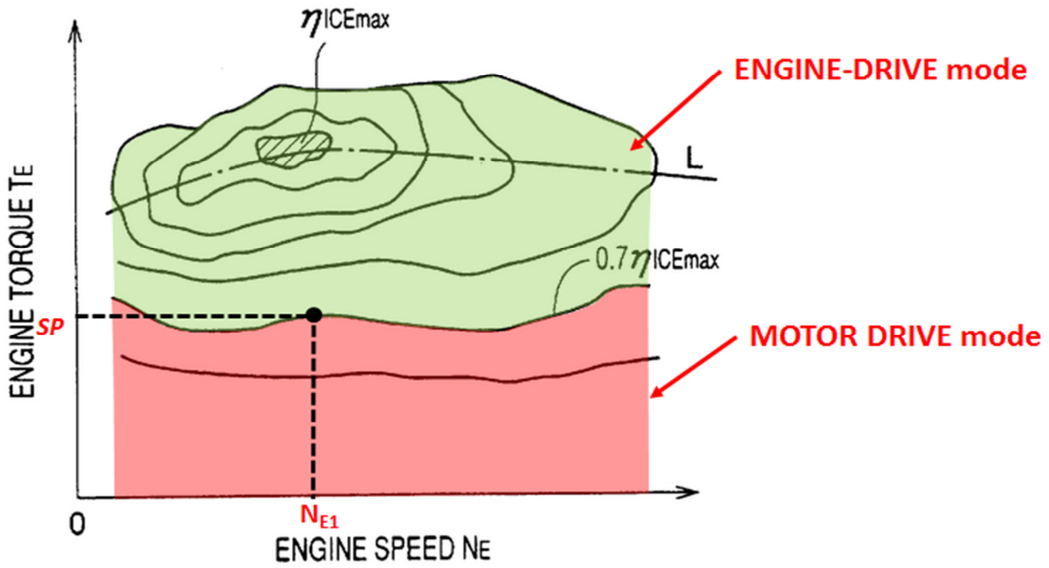
186. As I have annotated below, Ibaraki ’882 therefore discloses using the engine performance map of Figure 5 to determine when to operate the vehicle in the “ENGINE DRIVE mode” (highlighted in green) or “MOTOR DRIVE mode” (highlighted in red). The engine performance map is used to determine whether the

road load (in this case an "Engine Torque" at a given "engine speed") is *between a setpoint (SP)* (*i.e.*, a point along "threshold that is $0.7\eta_{ICEmax}$", highlighted in purple) and the *maximum torque output (MTO) of the engine* (highlighted in yellow).



Ex. 1403 [Ibaraki '882] at Fig. 5 (Annotated)

FIG. 5

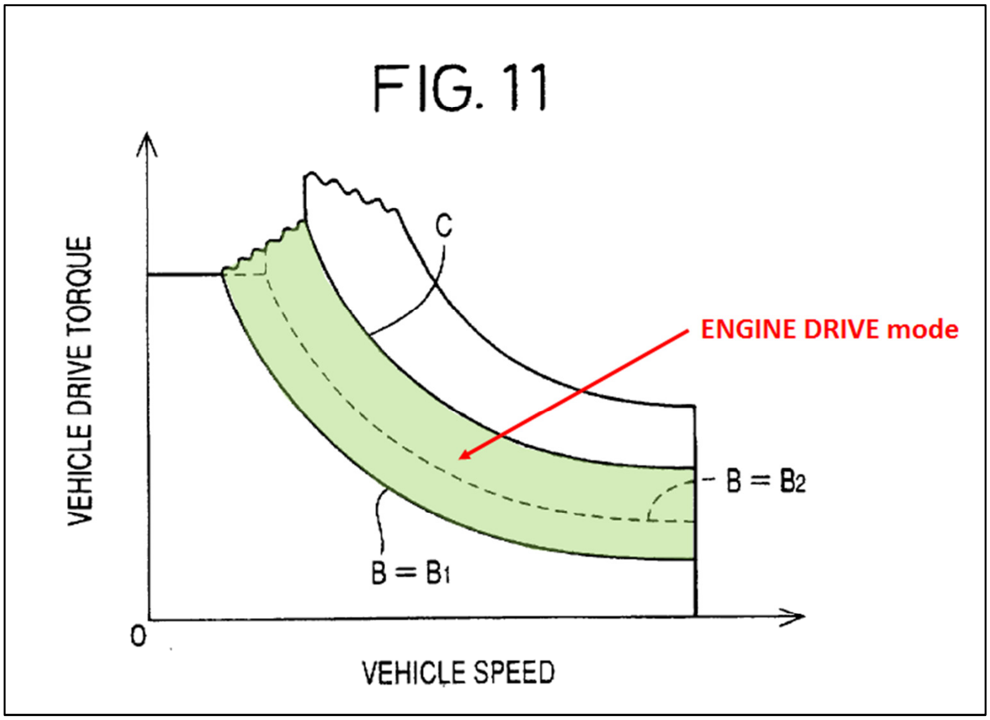


Ex. 1403 [Ibaraki '882] at Figure 5 (annotated).

187. Ibaraki '882 further states that this "modification of the first embodiment is embodied as the data map shown in FIG. 11 used in the second embodiment." (Ex. 1403 [Ibaraki '882] at 25:62-65.) This drive mode strategy is stated by Ibaraki '882 as being used to "select the ENGINE DRIVE mode if the fuel consumption efficiency η_{ICE} in the ENGINE DRIVE mode is larger than the threshold, and select the ENGINE DRIVE mode or the MOTOR DRIVE mode by implementing steps S3-S6 of FIG. 3 if the fuel consumption efficiency η_{ICE} is smaller than the threshold." (Ex. 1403 [Ibaraki '882] at 25:65-26:5.)

188. As I have annotated below, Ibaraki '882 discloses that the data map of Figure 11 is used to select the "ENGINE DRIVE mode" when the vehicle running condition "**as represented by the current vehicle drive torque and speed V**" is

"held within the range between the first and second boundary lines B and C" (highlighted in green). (Ex. 1403 [Ibaraki '882] at 20:55-65, emphasis added.)



Ex. 1403 [Ibaraki '882] at Fig. 11 (Annotated)

189. The controller is further disclosed as commanding the engine to propel the hybrid vehicle in the "ENGINE DRIVE mode" when a point corresponding to the "drive power P_L" is above the first "boundary line B" and equal to or below the "second boundary line C."

> Step Q6 and Q7 are followed by step Q8 to determine whether a point corresponding to the required drive power P_L (determined by the current vehicle drive torque and speed V) is located above the first boundary line B. If an affirmative decision (YES) is obtained in step Q8, the control flow goes to step Q9 to determine whether the point of the required drive power P_L is located above the second boundary line C. . . . **If the**

> **point of the required drive power P_L is located above the first boundary line B and on or below the second boundary line C**, that is, if a negative decision (NO) is obtained in step Q9, the control flow goes to step Q11 in which a sub-routine for running the vehicle in **the ENGINE DRIVE mode is executed**.

(Ex. 1403 [Ibaraki '882] at 23:66-24:16, emphasis added.)

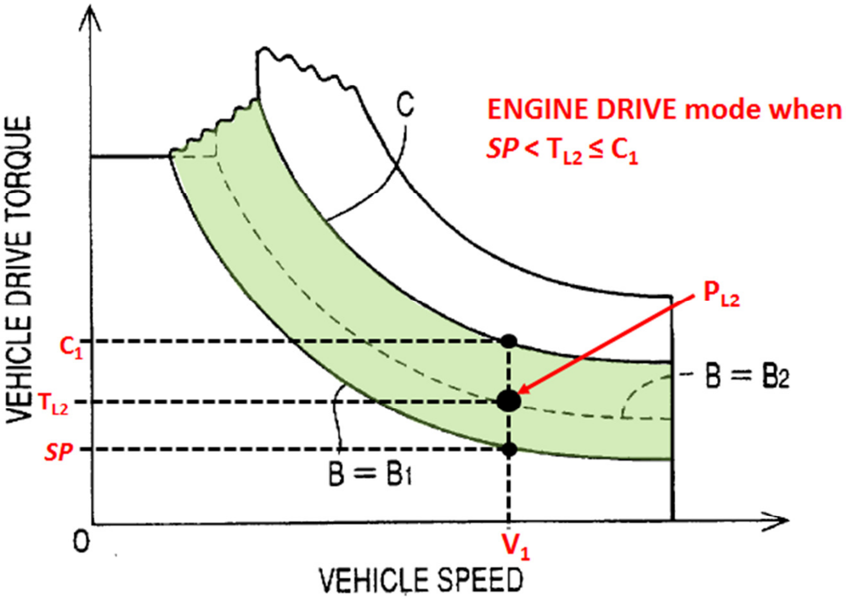
190. I have further annotated Figure 11 below. I have specifically illustrated how Figure 11 is used to determine when to operate the vehicle in the "ENGINE DRIVE mode" (highlighted in green below) at the given vehicle speed (annotated as V_1). A torque *setpoint* (annotated as *SP*) along boundary line B would be known at the current vehicle speed (V_1). This *setpoint* (*SP*) marks a transition between a "MOTOR DRIVE mode" (discussed below in claim [**23.7**]) and the "ENGINE DRIVE mode." Also, a torque point (annotated as C_1) along boundary line C would be known at the current vehicle speed (V_1). This torque value (C_1) marks a transition between the "ENGINE DRIVE mode" and the "ENGINE-MOTOR DRIVE mode" (discussed below in limitation **[23.9]**). A point[23] within the "ENGINE DRIVE mode" is also

---

[23] This plotted point is "a point corresponding to the required drive power P_L" which is "determined by the current vehicle drive torque and speed V." (Ex. 1403 [Ibaraki '882] at 23:66-24:2.) As I stated above, power = torque * rotational speed. The intersection of vehicle drive torque and vehicle speed thus relates to a corresponding point of required drive power.

illustrated, marking "the vehicle running condition as represented by the current vehicle drive torque [annotated as T_{L2}] and speed [V_1]." (Ex. 1403 [Ibaraki '882] at 20:55-63.) The "current vehicle drive torque" (T_{L2}) is the "instantaneous torque required to propel the vehicle," or *road load (RL)*, at this "vehicle running condition." Ibaraki '882 would operate the vehicle in the "ENGINE DRIVE mode" because the "current vehicle drive torque" (T_{L2}) is between the *setpoint* (*SP*) and the torque (C_1) in which a transition to "ENGINE-MOTOR DRIVE mode" occurs. (*See e.g.,* Ex. 1403 [Ibaraki '882] at 20:55-63.)

FIG. 11



Ex. 1403 [Ibaraki '882] at Fig. 11 (annotated)

191. It is my opinion that the *maximum torque output (MTO)* of the engine is *at least* equal to or greater than the torque point C_1 at the vehicle speed (V_1). Again, the ENGINE DRIVE mode where the IC engine drives the vehicle is stated as being

between *setpoint SP* and the torque point C_1 at a given vehicle speed (V_1). As will be further explained in regards to limitation **[23.9]** below, when the "vehicle drive torque" (*i.e. road load*) exceeds the point C_1 at a given vehicle speed (V_1), the vehicle operates in the "ENGINE-MOTOR DRIVE mode." The vehicle drive torque (C_1) would be less than or equal to the maximum torque output of the engine. The maximum torque output of the engine *cannot* be less than the point C_1 because the engine alone is operated to propel the vehicle between boundary lines B and C (shaded green above). In other words, the engine *cannot* operate or provide any output above its *maximum torque output (MTO)*, which every engine has. A person of ordinary skill in the art would have recognized this.

192. It is therefore my opinion that Ibaraki '882 discloses a hybrid vehicle having *an internal combustion engine capable of producing torque at loads between a lower level SP and a maximum torque output MTO.*

193. Additionally regarding the engine being *capable of* ***efficiently*** *producing torque at loads between the lower level SP and a maximum torque output MTO*, Ibaraki '882 discloses a hybrid control apparatus that seeks to reduce the fuel consumption or exhaust gas emissions of the IC engine.

> It is therefore an object of this invention to provide a drive control apparatus for a hybrid vehicle equipped with an electric motor and an engine as drive sources, which apparatus permits effective reduction in the fuel consumption amount or exhaust gas amount of the engine.

(Ex. 1403 [Ibaraki ’882] at 2:52-57.)

194. Because Ibaraki ’882 seeks to effectively reduce fuel consumption, it is my opinion that a person having ordinary skill in the art would have understood that at a given speed, a torque point along boundary line “B” (*i.e. setpoint*) is a threshold above which *the engine is operable to efficiently produce torque*. It is my opinion that a person having ordinary skill in the art would have understood that reducing the fuel consumption of the engine would indicate an efficiently running engine. It is also my opinion that the “ENGINE DRIVE mode” region would have been selected to achieve this reduction in fuel consumption.

195. <Intentionally left blank>

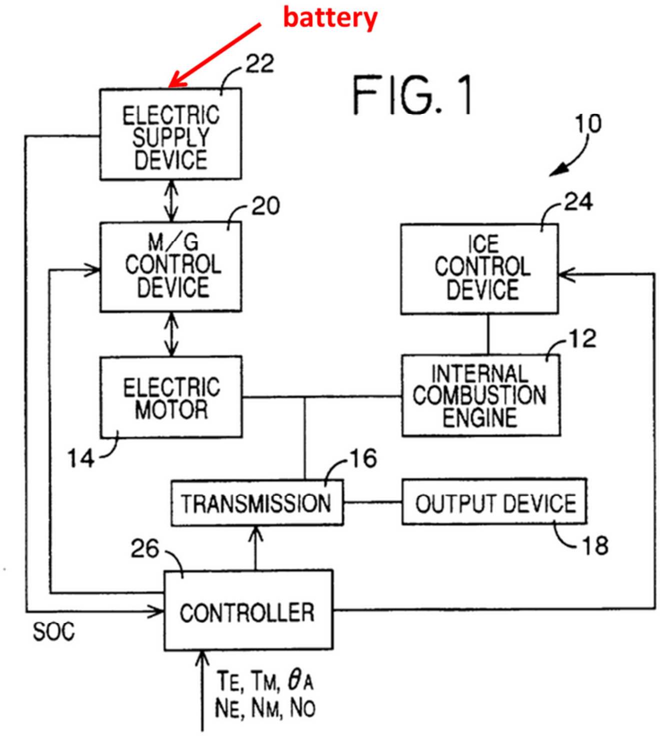
196. It is also known that decreased fuel consumption is a mark of an IC engine operating efficiently. Indeed, when an IC engine operates at or near its high-efficiency region (*e.g.*, η_{ICEmax} shown in Figure 5) the IC engine will be consuming less fuel: “At low loads the [engine] operating point is well removed from the **high-efficiency (low-specific-fuel-consumption)** area.” (Ex. 1433 [Bumby/Masding 1988] at 2, emphasis added.) At regions of lower torque (*e.g.*, below 0.7 η_{ICEmax}) the IC engine would be consuming more fuel and would likely be considered to be less efficient. It would therefore have been obvious that Figure 5 illustrates operating the IC engine only in a region of relatively high efficiency that corresponds to a region of low-specific fuel consumption.

197. It is therefore my opinion that Ibaraki ’882 discloses a hybrid vehicle

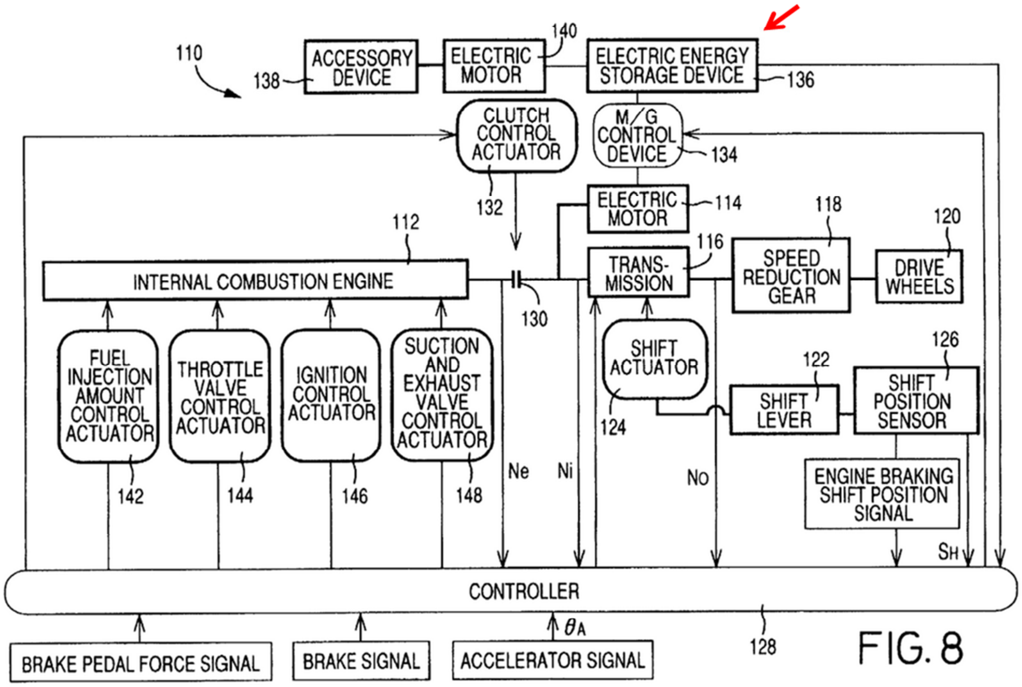
having *an internal combustion engine capable of efficiently producing torque at loads between a lower level SP and a maximum torque output MTO.*

… ***[23.2] a battery,***

198. Ibaraki '882 discloses "electric energy storage device (electric power supply device) 22 in the form of a **battery**." Ibaraki '882 also discloses "electric energy storage device 136," which can be "in the form of a **battery** or condenser." (Ex. 1403 [Ibaraki '882] at 11:31-33 and 19:55-57, emphasis added.)



Ex. 1403 [Ibaraki '882] at Fig. 1 (annotated)



battery

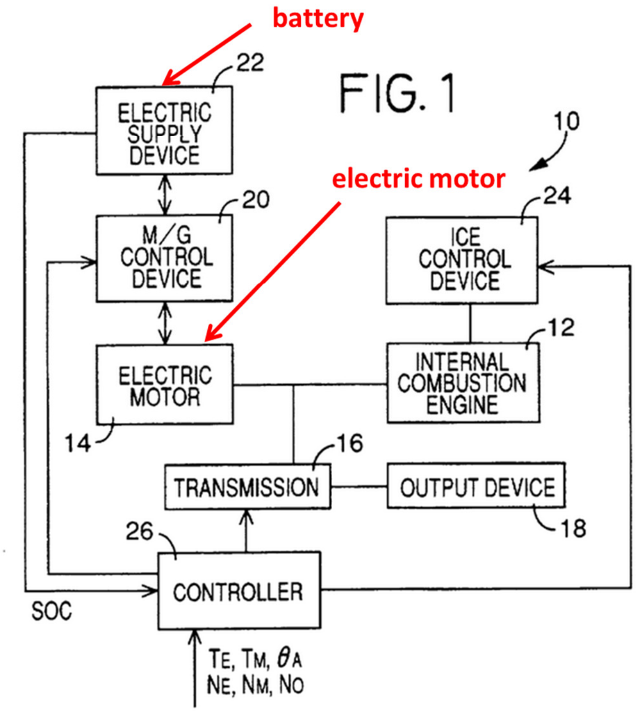
FIG. 8

Ex. 1403 [Ibaraki '882] at Fig. 8

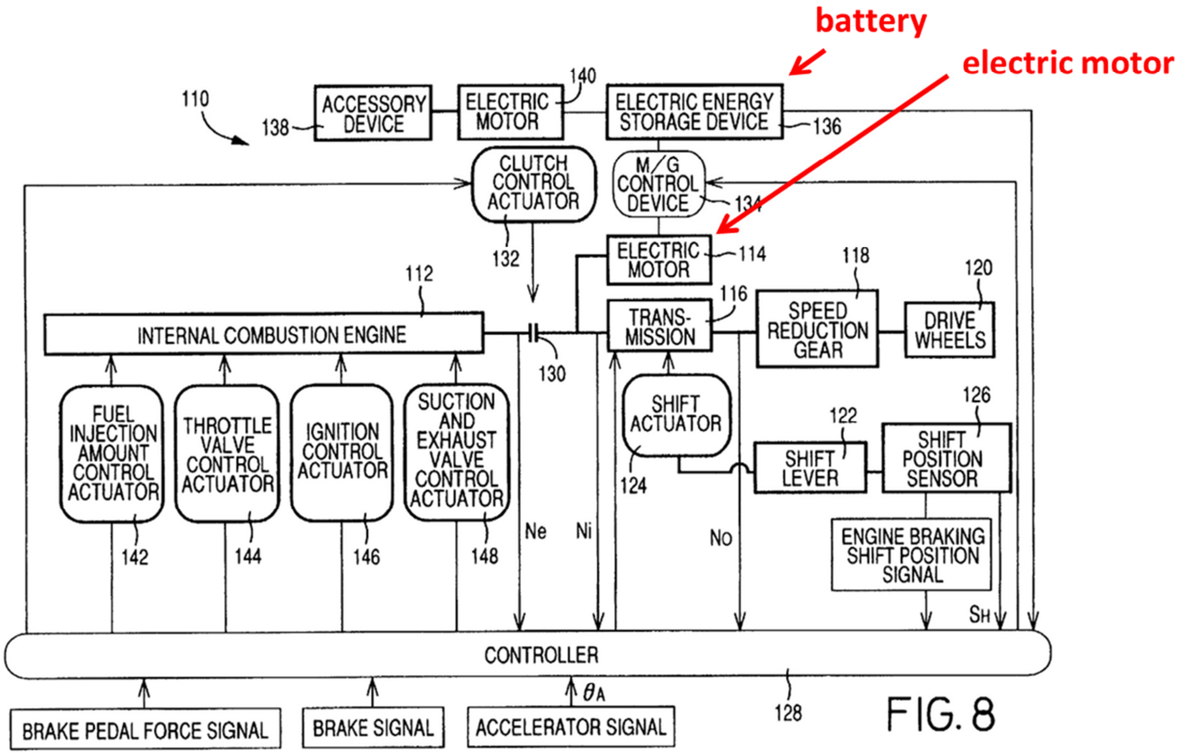
199. It is therefore my opinion that Ibaraki '882 discloses *a battery*.

… ***[23.3] 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,***

200. Figures 1 and 8 of Ibaraki '882 illustrate a hybrid vehicle having one dynamo-electric motor "14" or "114." The dynamo-electric motor is capable of being operated in a "DRIVE state," "CHARGING state," or "NON-LOAD state." (Ex. 1403 [Ibaraki '882] at 11:32-36 and 19:55-20:1.)



Ex. 1403 [Ibaraki '882] at Fig. 1 (annotated)



Ex. 1403 [Ibaraki '882] at Fig. 8 (annotated)

201. When operating in the "DRIVE state," the electric motor provides

output torque based on current supplied from the battery.

> The dynamo-electric motor 114 is connected to an electric energy storage device (electric power supply device) 136 in the form of a battery or condenser, for example, through a motor/generator control device (hereinafter abbreviated as "M/G control device["]) 134 so that the motor 114 is selectively placed in a DRIVE state, a CHARGING state, and a NON-LOAD state. **In the DRIVE state, the motor 114 is driven by an electric energy supplied from the electric energy storage device 136.**

(Ex. 1403 [Ibaraki '882] at 19:55-63, emphasis added.)

202. One of ordinary skill in the art would understand that when "electric energy" is supplied from the battery to the electric motor, the battery is *supplying current* to the electric motor.

203. As will be described below in **[23.7]**, the electric motor 14, 114 can be operated in a MOTOR DRIVE mode in which the motor alone propels the vehicle:

> **<u>That is, the controller 128 has a MOTOR DRIVE mode in which the motor 114 is selected as the drive power source</u>**, an ENGINE DRIVE mode in which the engine 112 is selected as the drive power source, and an ENGINE-MOTOR DRIVE mode in which both the engine 112 and the motor 114 are selected as the drive power sources.

(Ex. 1403 [Ibaraki '882] at 20:43-53, emphasis added.)

204. A person having ordinary skill in the art would have understood that power and torque are related as a function of speed (Power = Torque * Speed). Therefore, a person having ordinary skill in the art would have understood

that when power is transferred from the motor 114 acting as the "drive power source" to the wheels, the power is transferred by the torque from the motor shaft, which is applied to the drive shaft and ultimately the drive wheels 120. It is my opinion that Ibaraki '882 therefore discloses *one or more electric motors being capable of providing output torque responsive to supplied current.*

205. The electric motor can also operate as a generator to generate *electrical current responsive to applied torque.* For example, Ibaraki '882 discloses that regenerative braking can charge the battery by operating the electric motor as a generator due to braking torque:

> The dynamo-electric motor 114 is connected to an electric energy storage device (electric power supply device) 136 in the form of a battery or condenser, for example, through a motor/generator control device (hereinafter abbreviated as "M/G control device["]) 134 so that the motor 114 is selectively placed in a DRIVE state, a CHARGING state, and a NON-LOAD state. In the DRIVE state, the motor 114 is driven by an electric energy supplied from the electric energy storage device 136. **In the CHARGING state, the motor 114 functions as an electric generator or dynamo, with regenerative braking (braking torque electrically generated by the motor 114 itself), for storing an electric energy in the electric energy storage device 136**.

(Ex. 1403 [Ibaraki '882] at 19:55-67, emphasis added.)

> If an affirmative decision (YES) is obtained in step Q13, the control flow goes to step Q14 in which a sub-routine for running the vehicle in the **REGENERATIVE DRIVE mode** is executed under the control

> of the regenerative driving means 168 so that **the motor 114 is driven by the kinetic energy of the running vehicle to charge the electric energy storage device 136 while a brake is applied to the vehicle**. The regenerative braking torque of the motor 114 in this sub-routine is controlled depending upon the running condition of the vehicle, such as the vehicle running speed V and the brake pedal depression force.

(Ex. 1403 [Ibaraki '882] at 22:19-30, emphasis added.)

206. It is therefore my opinion that Ibaraki '882 discloses *one or more electric motors being capable of . . . generating electrical current responsive to applied torque*.

> … ***[23.4] 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:***

207. Regarding *said engine being controllably connected to wheels of said vehicle for applying propulsive torque thereto*, Fig. 8 of Ibaraki '882 illustrates the engine 112 (highlighted in green) and "drive wheels 120" (highlighted in red) as part of the described hybrid vehicle:

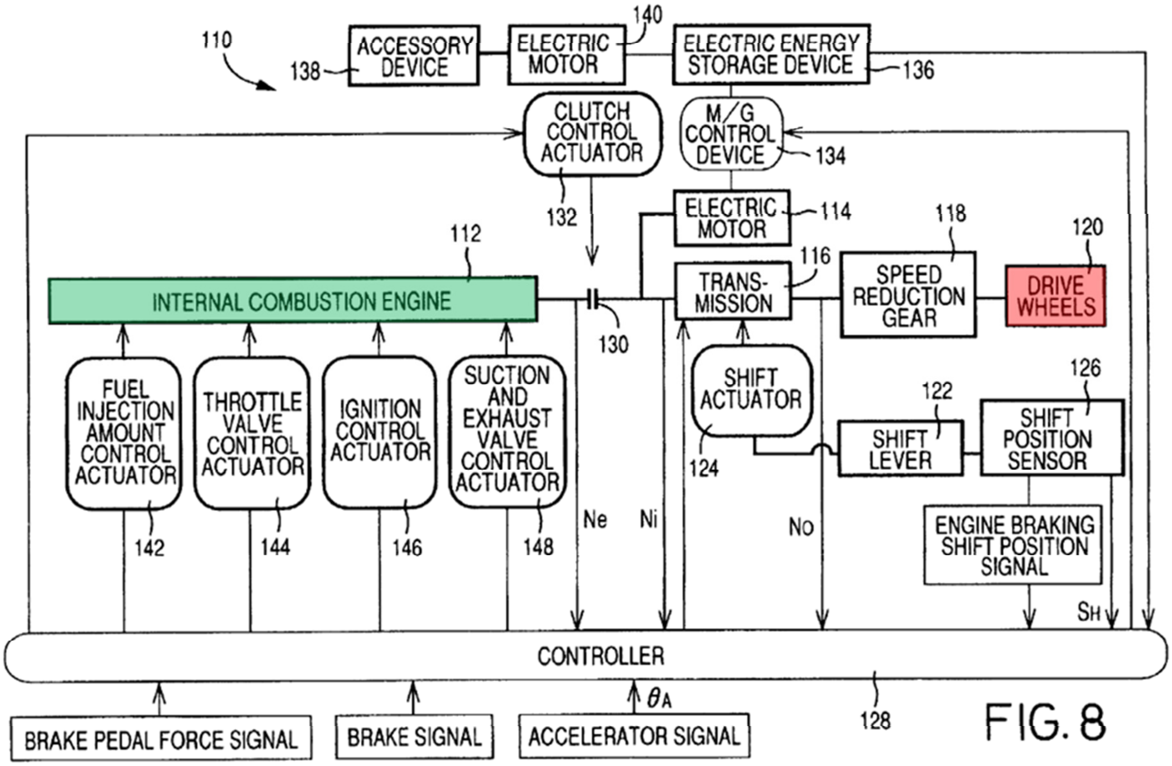


FIG. 8

Ex. 1403 [Ibaraki '882] at Figure 8 (annotated)

> The vehicle drive control apparatus 110 is arranged to control a hybrid vehicle equipped with an internal combustion engine 112 such as a gasoline engine operated by combustion of a fuel, and a dynamo-electric motor 114 which functions as an electric motor operated by an electric energy and an electric generator or dynamo for generating electricity. **<u>Power of the internal combustion engine 112 and power of the electric motor 114 are simultaneously or selectively transferred to a transmission 116, and to right and left drive wheels 120 via a speed reduction gear 118 and a differential gear</u>**.

(Ex. 1403 [Ibaraki '882] at 19:18-28, emphasis added.)

208. Ibaraki '882 also discloses a "clutch 130" highlighted in yellow below:

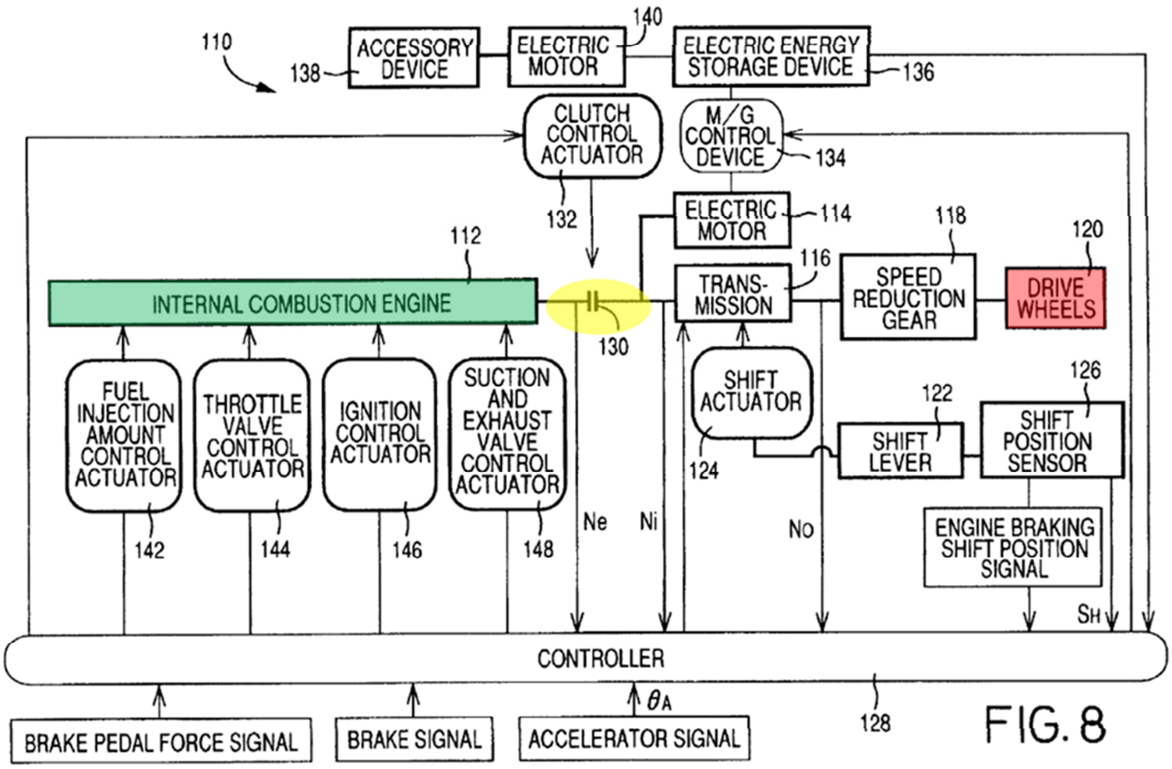


FIG. 8

Ex. 1403 [Ibaraki '882] at Figure 8 (annotated)

209. This clutch 130 is used to couple (*i.e.,* connect and disconnect) the IC engine 112 to the transmission 116, as illustrated above. And, the clutch 130 *controllably* couples the IC engine 112 to the transmission via a "control actuator 132."

> A clutch 130 is disposed between the engine 112 and the transmission 116, **for connecting and disconnecting the engine 112 and transmission 116. The clutch 130 is engaged and released by a clutch control actuator 132.** The clutch 130 is normally placed in the fully engaged state.

(Ex. 1403 [Ibaraki '882] at 19:50-54, emphasis added.)

210. As is clear in Fig. 8 of Ibaraki '882 above, the clutch control actuator 132 not only "engage[s] and release[s]" the clutch 130, but is also connected to the

controller 128. *Id.* Therefore, the engine 112 is *controllably coupled* to the transmission 116.

211. One of ordinary skill in the art would understand that, given the vehicle of Fig. 8 above, a clutch that controllably couples the engine 112 to the *transmission* 116 also selectively couples the engine to the *drive wheels* 120. This is true because the transmission 116 is coupled to the drive wheels 120, and the drive power from the engine must go through the transmission 116 to get to the drive wheels 120.

212. A person having ordinary skill in the art would have understood that power and torque are related as a function of speed. Therefore, a person having ordinary skill in the art would have understood that when power is transferred from the internal combustion engine to the transmission, and then to the right and left drive wheels, the power is transferred by the torque from the engine crank shaft, which is applied to the drive shaft and ultimately the drive wheels. Ibaraki '882 therefore discloses that the engine is *controllably connected to wheels of said vehicle for applying propulsive torque thereto*.

213. Regarding *said engine being controllably connected to . . . said at least one motor for applying torque thereto*, Fig. 8 below also shows the clutch 130 (highlighted yellow) being between the internal combustion engine 112 (highlighted green) and the electric motor 114 (highlighted red).

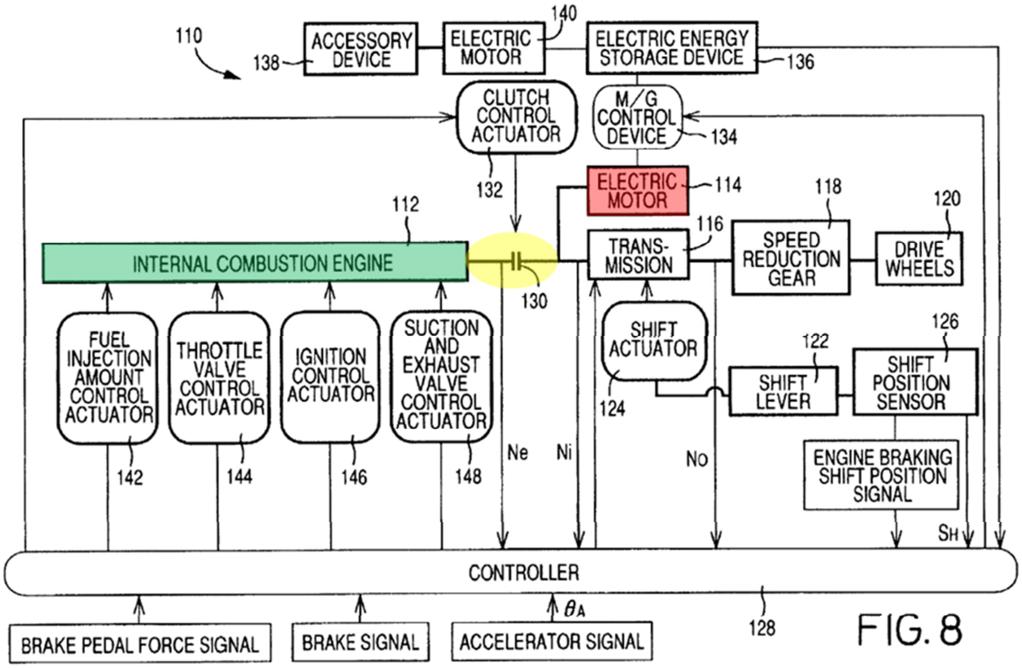


FIG. 8

Ex. 1403 [Ibaraki '882] at Figure 8 (annotated).

214. The electric motor 114 is on the same side of the clutch 130 as the transmission. One of ordinary skill in the art would therefore understand that the clutch 130 not only "connect[s] and disconnect[s] the engine 112 and transmission 116," but also connects and disconnects the engine 112 from the electric motor. (Ex. 1403 [Ibaraki '882] at 19:50-54.)

215. Ibaraki '882 discloses an "ELECTRICITY GENERATING DRIVE mode" which is shown in annotated Figure 10 below. The "ELECTRICITY GENERATING DRIVE mode" is executed when the monitored state of charge (SOC) is below a predetermined threshold "A."

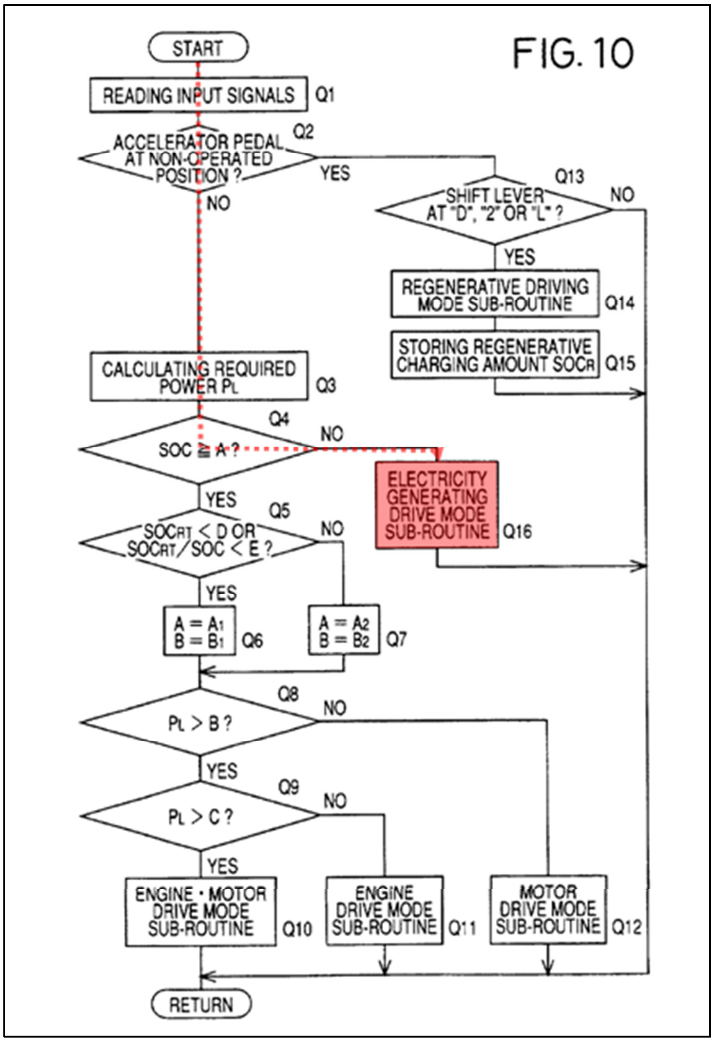


FIG. 10

Ex. 1403 [Ibaraki '882] at Fig. 10 (annotated)

216. Ibaraki '882 discloses that when the "ELECTRICITY GENERATING DRIVE mode" is executed by the controller, the engine will supply an output beyond the drive power (P_L) required to propel the vehicle. The vehicle uses the excess output provided by the engine to drive the electric motor as a generator to charge the battery.

> Step Q3 is followed by step Q4 to determine whether the charging amount SOC of the electric energy storage device 136 is equal to or larger than a predetermined lower limit A or not. . . . If a negative decision (NO) is obtained in step Q4, the control flow goes to step Q16

> in which a sub-routine for running the vehicle in the ELECTRICITY GENERATING DRIVE mode is implemented. . . . In the sub-routine of step Q16 implemented if the negative decision (NO) is obtained in step Q4, **the engine 112 is operated to provide a total output P_{ICE} not smaller than the required drive power P_L, so that the vehicle is driven by the required drive power P_L while the motor 114 is operated as the electric generator by the surplus power (P_{ICE} -P_L) to charge the electric energy storage device 136, as in the first embodiment**. Step Q16 is implemented in the same manner as step S7 of the first embodiment.

(Ex. 1403 [Ibaraki '882] at 23:6-32, emphasis added.)

> **In the ELECTRICITY GENERATING DRIVE mode in which the vehicle is run by the engine 12 while the motor 14 is operated by the surplus power (P_{ICE} -P_L) of the engine 12 to charge the electric energy storage device 22**, the engine output P_{ICE} is determined so as to maximize the overall fuel consumption efficiency n_T which reflects the energy conversion efficiencies η_{GEN} and η_{BIN} of the motor 14 and device 22, that is, to minimize the ratio of the fuel consumption amount Mfc to the output or power of the motor 14 during operation of the motor 14 by the electric energy which has been stored in the device 22 by the surplus power (P_{ICE} -P_L). The motor 14 is operated by the electricity generating power P_{GEN} which corresponds to the surplus power (P_{ICE} -P_L), which in turn is equal to the determined engine output P_{ICE} minus the required drive power P_L. Since the ratio of the fuel consumption amount Mfc to the output of the motor 14 during operation of the motor 14 by the electric energy stored in the device 22 by the surplus power (P_{ICE} -P_L) is reduced to a minimum, the fuel

> consumption amount Mfc per unit amount of electric energy to be stored in the device 22 is accordingly minimized, leading to maximum efficiency of charging of the device 22.

(Ex. 1403 [Ibaraki '882] at 17:65-18:19, emphasis added.)

217. Ibaraki '882 discloses that by cycling through the "ELECTRICITY GENERATING DRIVE mode," the engine torque "T_E" is incremented to a value that allows the engine to both propel the vehicle and drive the motor as a generator for charging the battery.

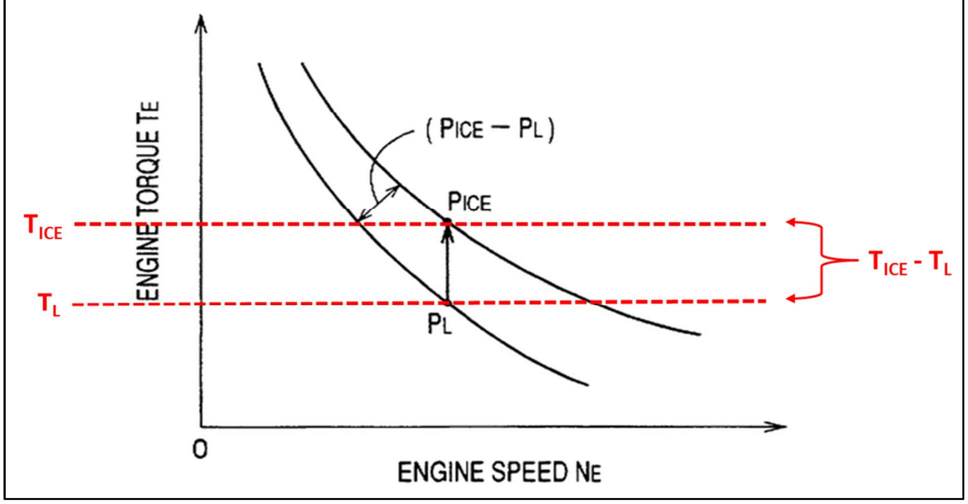
> The ELECTRICITY GENERATING DRIVE mode sub-routine in step S7 of the routine of FIG. 3 corresponds to means for determining the output of the engine 12 during charging of the electric energy storage device 22. This sub-routine is executed as illustrated in the flow chart of FIG. 4. The sub-routine is initiated with step R1 in which a candidate value of the output or power P_{ICE} of the engine 12 is determined to be equal to the required drive power P_L, in the first cycle of execution of the sub-routine, that is, when the sub-routine is executed for the first time. In the second and subsequent cycles of execution of the sub-routine of FIG. 4, the candidate value of the engine output P_{ICE} is incremented by a predetermined increment amount ΔP_{ICE} in step R1. Since the engine speed N_E is held constant depending upon the vehicle running speed, the engine torque T_E increases by an amount corresponding to the increment amount ΔP_{ICE} as indicated in FIG. 7. **Therefore, the surplus torque value of the engine 12 is obtained as a sum of the increment amounts ΔP_{ICE} in repeated implementation of step R1, that is, as a difference (P_{ICE} -P_L) between the candidate**

> **<u>value of the engine output P_{ICE} and the required drive power P_L.</u>** The graph of FIG. 7 shows iso-drive power lines of the engine 12, which indicate that the engine torque T_E for obtaining the same drive power changes with the engine speed N_E. The engine output P_{ICE} and the required drive power P_L are determined by the specific combination of the current engine speed N_E and torque T_E. Although the increment amount ΔP_{ICE} is a predetermined fixed value in the present embodiment, the increment amount ΔP_{ICE} may be changed depending upon the running condition of the vehicle, for example, depending upon the required drive power P_L. The engine torque T_E may be changed by a predetermined increment.

(Ex. 1403 [Ibaraki '882] at 15:24-56, emphasis added.)

218. Further, Figure 7 of Ibaraki '882 below illustrates "a graph indicating a relationship between engine output PICE and surplus power (P_{ICE} -P_L) used in the sub-routine of FIG. 4." (Ex. 1403 [Ibaraki '882] at 10:57-59.) As explained above, this "sub-routine of FIG. 4" is the ELECTRICITY GENERATING DRIVE mode in which torque from the engine is sent to the electric motor to generate electricity to be stored in the battery. I have annotated Figure 7 (discussed above) to illustrate the engine torque used to propel the vehicle (*i.e.*, T_L) and the surplus torque that is used to charge the battery (*i.e.*, $\Delta T_{ICE} = T_{ICE} - T_L$).

FIG. 7



Ex. 1403 [Ibaraki '882] at Fig. 7

219. It is therefore my opinion that Ibaraki '882 discloses a hybrid vehicle having an *engine being controllably connected to . . . said at least one motor for applying torque thereto*.

… ***[23.5] determining the instantaneous torque RL required to propel said vehicle responsive to an operator command;***

220. It is my understanding that *road load (RL)* is being construed as the "amount of instantaneous torque required to propel the vehicle, be it positive or negative."

221. Ibaraki '882 discloses a controller 128 that selects an operational mode (motor, engine, or both) according to a drive source selecting "data map" stored in memory:

> The controller 128 includes drive source selecting means 160 illustrated in the block diagram of FIG. 9. The drive source selecting means 160 is

> adapted to select one or both of the engine 112 and the motor 114 as the drive power source or sources, **according to a drive source selecting data map** stored in memory means 162. That is, the controller 128 has a MOTOR DRIVE mode in which the motor 114 is selected as the drive power source, an ENGINE DRIVE mode in which the engine 112 is selected as the drive power source, and an ENGINE-MOTOR DRIVE mode in which both the engine 112 and the motor 114 are selected as the drive power sources.

(Ex. 1403 [Ibaraki '882] at 20:38-49, emphasis added.)

222. Figure 11 below exemplifies this data map stating that: "An example of the drive source selecting data map is illustrated in the graph of FIG. 11, which represents a predetermined relationship between the vehicle drive torque and running speed V and the above-indicated three drive modes."[24] (Ex. 1403 [Ibaraki '882] at 20:49-53.)

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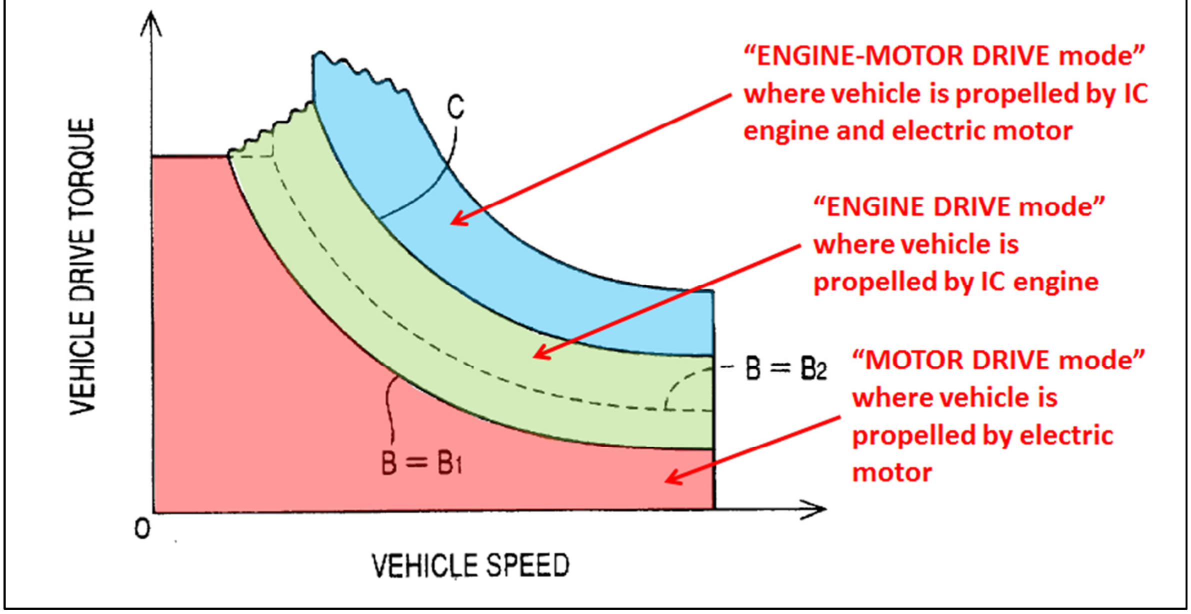
[24] Each of these "drive modes" is further explained in limitations **[23.7]-[23.9]** below.

FIG. 11



Ex. 1403 [Ibaraki '882] at Fig. 11 (Annotated)

223. In order to determine the correct "drive mode" the controller plots a point representing the "vehicle running condition" on the data map of Fig. 11. This "vehicle running condition" is represented by the "vehicle drive torque" (Y-axis) at the current "vehicle speed" (X-axis).

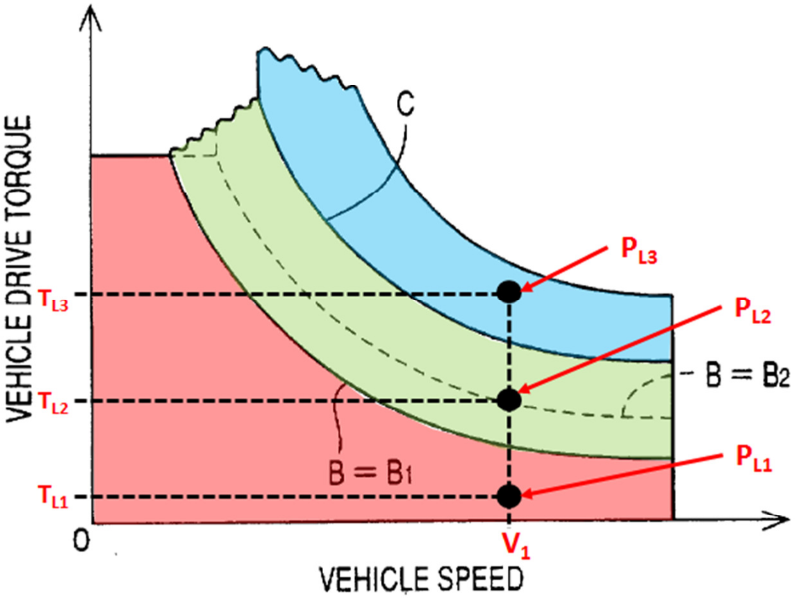
> Described more specifically, the drive source selecting means 160 selects the MOTOR DRIVE mode **when the vehicle running condition as represented by the current vehicle drive torque and speed V** is held within the range below the first boundary line B. When the **vehicle running condition** is held within the range between the first and second boundary lines B and C, the drive source selecting means 160 selects the ENGINE DRIVE mode. When the **vehicle running condition** is in the range above the second boundary line C, the drive

> source selecting means 160 selects the ENGINE[-MOTOR] DRIVE mode.

(Ex. 1403 [Ibaraki ’882] at 20:58-21:1, emphasis added.)

224. Based on Figure 11, I have plotted three points representing three different “vehicle running conditions” at a current vehicle speed (V_1) that represent operation within one of the three respective drive modes. These “vehicle running conditions” represent three different “vehicle drive torque” values (T_{L1}, T_{L2}, and T_{L3}) at a given vehicle speed (V_1).

FIG. 11



Ex. 1403 [Ibaraki ’882] at Fig. 11 (Annotated)

225. Ibaraki ’882 states that the “vehicle drove torque and speed” determine “a point corresponding to the required drive power P_L.” (Ex. 1403 [Ibaraki ’882] at 23:67-24:38.) As I have illustrated, this point of “required drive power P_L” (P_{L1}, P_{L2},

and P_{L3}) can be determined by the "vehicle drive torque" and "vehicle speed" due to the relationship between these values where "Power=Torque * Rotational Speed." Because Figure 11 is a graph expressed with "vehicle drive torque" along the y-axis and "vehicle speed" along the x-axis, a point on the graph of Figure 11 relates to a drive power value at a given speed.

226. As will be described in more detail in limitations **[23.7]-[23.9]**, the operational mode of the vehicle is commanded based on a point of "required drive power P_L" at a given "vehicle drive torque" and "vehicle speed." In particular, the "MOTOR DRIVE mode" (shaded red) is selected when the "vehicle drive torque" (T_{L1}) at a given vehicle speed (V_1) corresponds to a point of "required drive power P_L" (P_{L1}) located below a first boundary line B. Likewise, the "ENGINE DRIVE mode" (shaded green) is selected when the "vehicle drive torque" (T_{L2}) at a given vehicle speed (V_1) corresponds to a point of "required drive power P_L" (P_{L2}) that is above the first boundary line B and on or below a second boundary line C. Finally, the "ENGINE-MOTOR DRIVE mode" (shaded blue) is selected when the "vehicle drive torque" (T_{L3}) at a given vehicle speed (V_1) corresponds to the point of required drive power (P_{L3}) that is above the second boundary line C. (Ex. 1403 [Ibaraki '882] at 23:66-24:21.)

227. Ibaraki '882 discloses the points corresponding to the required drive power P_L (P_{L1}, P_{L2}, P_{L3}) are the "instantaneous drive power required for running the vehicle," which includes components for overcoming the air resistance experienced by

the vehicle and the rolling resistance of each vehicle wheel.

> P_L in the above equations (1) and (2) represents instantaneous drive power required for running the vehicle, which power includes components for overcoming an air resistance of the vehicle and a rolling resistance of the tire of each vehicle wheel.

(Ex. 1403 [Ibaraki '882] at 12:50-54.)

228. Since the plotted points of "required drive power P_L" (P_{L1}, P_{L2}, P_{L3}) represent the "instantaneous drive power required for running the vehicle," it is my opinion that the corresponding "vehicle drive torque" values (T_{L1}, T_{L2}, T_{L3}) are the *instantaneous road load (RL) [torque] required to propel the hybrid vehicle.*

229. Ibaraki '882 teaches that the points of "required drive power P_L" (P_{L1}, P_{L2}, P_{L3}) corresponding to the "instantaneous drive power required for running the vehicle" are determined on the basis of accelerator pedal operating amount θ_A, the rate of change of the accelerator pedal operating amount θ_A and vehicle speed.

> If a negative decision (NO) is obtained in step Q2, that is, if the operating amount θ_A of the accelerator pedal is not substantially zero, the control flow goes to step Q3 to calculate the required drive power P_L on the basis of the operating amount θ_A or a rate of change of this operating amount θ_A and the vehicle running speed V, according to a suitable equation or data map stored in the controller 128, as in the first embodiment.

(Ex. 1403 [Ibaraki '882] at 22:66-23:6, 12:54-59.)

230. Since the plotted points of "required drive power P_L" (P_{L1}, P_{L2}, P_{L3}) at

the current vehicle speed are determined on the basis of, among other things, the accelerator pedal operating amount and rate of change, it is my opinion that the corresponding "vehicle drive torque" values (T_{L1}, T_{L2}, T_{L3}), *i.e. road load*, are also determined on the basis of the accelerator pedal operating amount and rate of change.

231. Regarding whether the "torque required to propel the vehicle" may be "*positive or negative*," the data map of Figure 11 illustrates *positive* "vehicle drive torques." As the "vehicle drive torque" values (*e.g.*, T_{L1}, T_{L2}, T_{L3}) increase at a given vehicle speed, the operational mode of the vehicle changes.

232. It is therefore my opinion that Ibaraki '882 discloses determining *the instantaneous road load (RL) required to propel the hybrid vehicle* (*i.e.,* "vehicle drive torque") *responsive to an operator command.*

… ***[23.6] monitoring the state of charge of said battery;***

233. Ibaraki '882 discloses a hybrid vehicle that includes an "electric energy storage device 22." Ibaraki '882 states the "electric energy storage device" may be a battery.

> The dynamo-electric motor 114 **<u>is connected to an electric energy storage device (electric power supply device) 136 in the form of a battery or condenser</u>**, for example, through a motor/generator control device (hereinafter abbreviated as "M/G control device) 134 so that the motor 114 is selectively placed in a DRIVE state, a CHARGING state, and a NON-LOAD state.

(Ex. 1403 [Ibaraki '882] at 19:55-61.)

234. As highlighted with the red dashed line below, the battery (*i.e.*, electric energy storage device 136) provides information to the "controller 128."

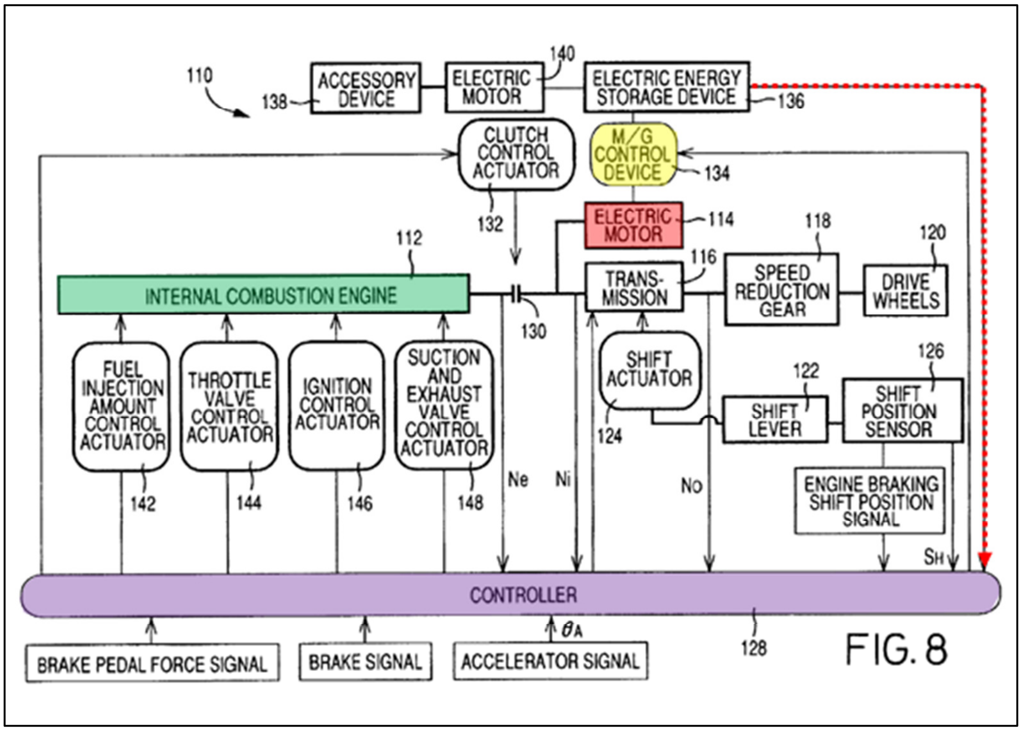


FIG. 8

Ex. 1403 [Ibaraki '882] at Fig. 8 (annotated)

235. Specifically, Ibaraki '882 discloses that the controller receives a state of charge (*i.e.*, "charging amount SOC") from the battery.

> The controller 128 includes a microcomputer incorporating a central processing unit (CPU), a random-access memory (RAM), and a read-only memory (ROM). The CPU operates according to control programs stored in the ROM while utilizing a temporary data storage function of the RAM. The controller 128 has various functions as illustrated in the block diagram of FIG. 9. The controller 128 is supplied with input signals from various detecting devices. These input signals include signals indicative of a speed Ne of the engine 112, an input speed Ni of the transmission 116 (speed of the motor 114), an output speed No of

> the transmission 116 (which corresponding to the running speed V of the vehicle), **<u>and a charging amount SOC of the electric energy storage device 136</u>**.

(Ex. 1403 [Ibaraki '882] at 20:10-23, emphasis added.)

236. Ibaraki '882 further discloses that the state of charge of the battery may be determined on the basis of charging energy received from the electric motor or based on the charging efficiency of the battery.

> The charging amount SOC of the electric energy storage device 136 may be determined on the basis of a current of the motor 114 during operation thereof as an electric generator to charge the device 136, or on the basis of the charging efficiency of the device 136.

(Ex. 1403 [Ibaraki '882] at 20:33-37.)

237. It is my opinion that a person having ordinary skill in the art would know that the *state of charge* or charging amount SOC is being determined by the electric energy storage device 136 or *battery* and this value is being sent via a signal to the controller. It is also my opinion that a person having ordinary skill in the art would understand that the controller is *monitoring* this signal in order to determine whether further action is required. For instance, the controller monitors the state of charge of the battery to determine whether the *setpoint* should be adjusted from being along boundary line "B_1" to boundary line "B_2" to increase the "MOTOR DRIVE mode" region, thereby preventing excessive charging of the battery.

> In the present vehicle drive control apparatus 110, **the range of the vehicle running condition in which the vehicle is driven in the MOTOR DRIVE mode by operation of only the motor 114 is enlarged by shifting the first boundary line B to the motor driving range enlarging position B2, if the sum SOC_{RT} of the electric energy stored in the electric energy storage device 136 during running of the vehicle in the REGENERATIVE DRIVE mode in step Q14 is equal to or larger than the reference value D, or if the ratio SOC_{RT} /SOC is equal to or larger than the reference value E**. As a result of enlargement of the motor driving range, the amount of consumption of the electric energy by the motor 114 is increased. The present arrangement is effective to **prevent excessive charging of the electric energy storage device 136** during running of the vehicle on a mountain path, thereby preventing reduction of the energy conversing efficiencies η_{BIN} and η_{BOUT} of the device 136 or a failure to charge the device 136. Further, the enlargement of the motor driving range results in reducing the frequency of operation of the engine 112, and consequent reduction of the fuel consumption by the engine 112 and the amount of exhaust gas emission from the engine 112.

(Ex. 1403 [Ibaraki '882] at 24:39-60, emphasis added; *see also* 7:47-52.)

238. It is therefore my opinion that Ibaraki '882 discloses *monitoring the state of charge of said battery*.

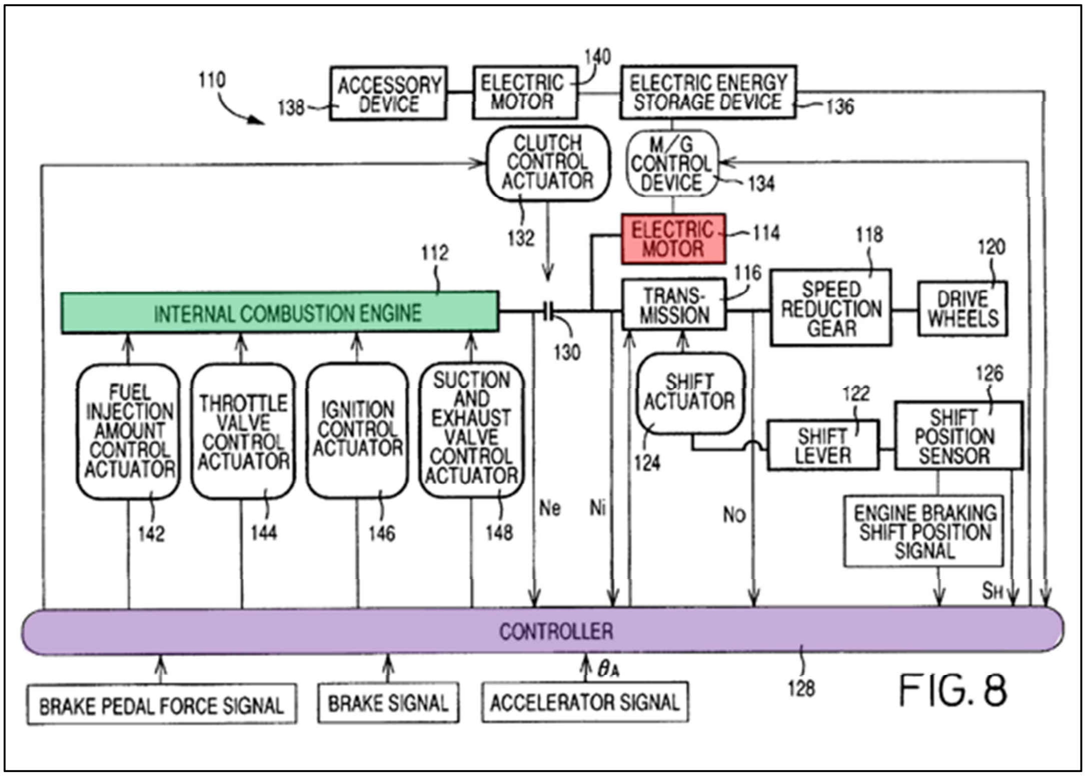
> … ***[23.7] employing said at least one electric motor to propel said vehicle when the torque RL required to do so is less than said lower level SP;***

239. It is my understanding that by reciting *at least one electric motor*, this limitation is satisfied by a hybrid vehicle having one electric motor.

240. I understand that the recited *setpoint (SP)* is proposed to mean a "predetermined torque value."

241. I understand the recited *RL* is proposed to mean "the amount of instantaneous torque required to propel the vehicle, be it positive or negative"

242. As I have annotated below, Figure 8 illustrates a hybrid vehicle architecture having a controller (highlighted in purple) and an electric motor (highlighted in red).



Ex. 1403 [Ibaraki '882] at Fig. 8 (Annotated)

243. Ibaraki '882 further discloses that the illustrated "electric motor 114" is a dynamo-electric motor that may be selectively operated: (1) as an electric motor in a "DRIVE state" to propel the vehicle; (2) as a generator in a "CHARGING state" for storing electrically generated charge in the battery; or (3) in a "NON-LOAD state" where the output shaft of the motor is permitted to rotate freely.

> The dynamo-electric motor 114 is connected to an electric energy storage device (electric power supply device) 136 in the form of a battery or condenser, for example, through a motor/generator control device (hereinafter abbreviated as "M/G control device) 134 so that the motor 114 is selectively placed in a DRIVE state, a CHARGING state, and a NON-LOAD state. In the DRIVE state, the motor 114 is driven by an electric energy supplied from the electric energy storage device 136. In

> the CHARGING state, the motor 114 functions as an electric generator or dynamo, with regenerative braking (braking torque electrically generated by the motor 114 itself), for storing an electric energy in the electric energy storage device 136. In the NON-LOAD state, the output shaft of the motor 114 is permitted to rotate freely.

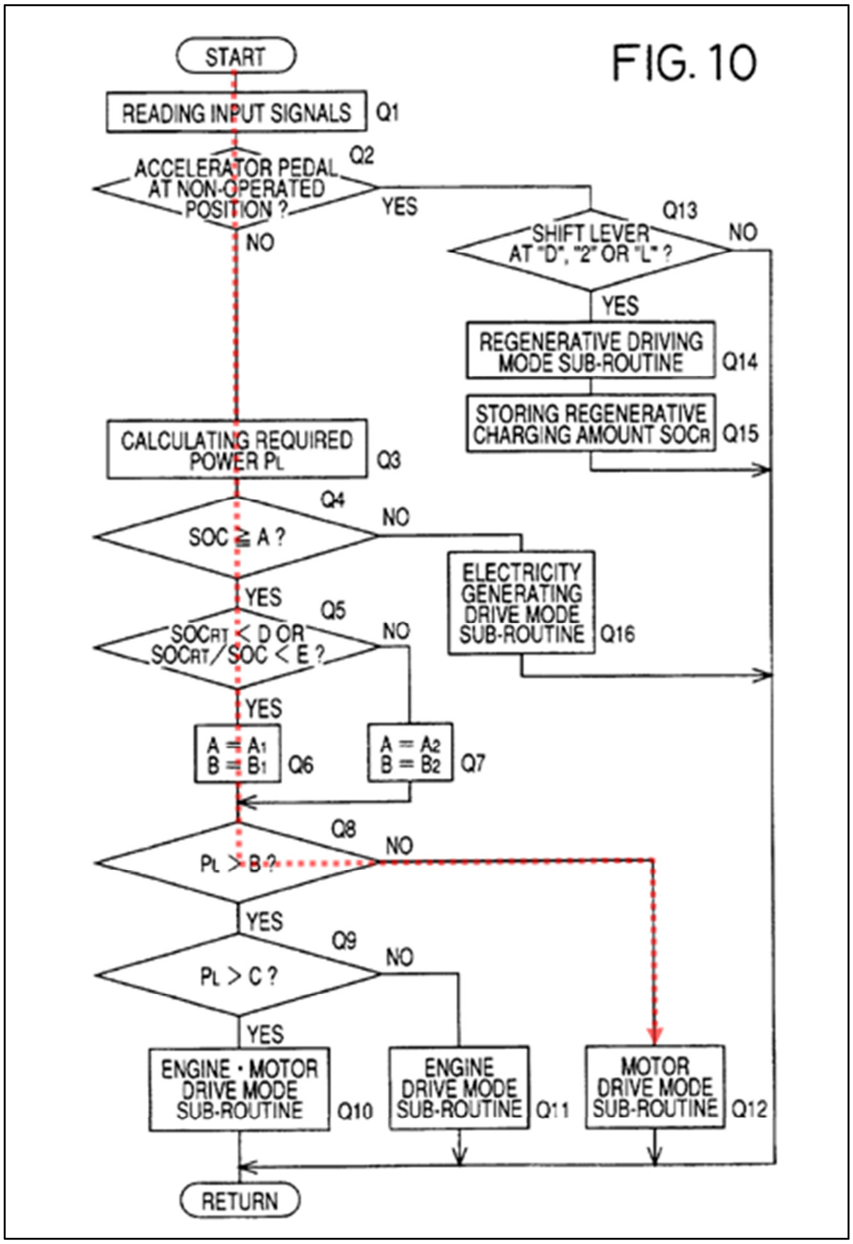
(Ex. 1403 [Ibaraki '882] at 19:55-20:9.)

244. Ibaraki '882 discloses that the controller includes control programs that determine whether the hybrid vehicle should be propelled in a "MOTOR DRIVE mode," in which the vehicle is propelled by operation of the electric motor alone.

> **That is, the controller 128 has a MOTOR DRIVE mode in which the motor 114 is selected as the drive power source**, an ENGINE DRIVE mode in which the engine 112 is selected as the drive power source, and an ENGINE-MOTOR DRIVE mode in which both the engine 112 and the motor 114 are selected as the drive power sources.

(Ex. 1403 [Ibaraki '882] at 20:43-53, emphasis added.)

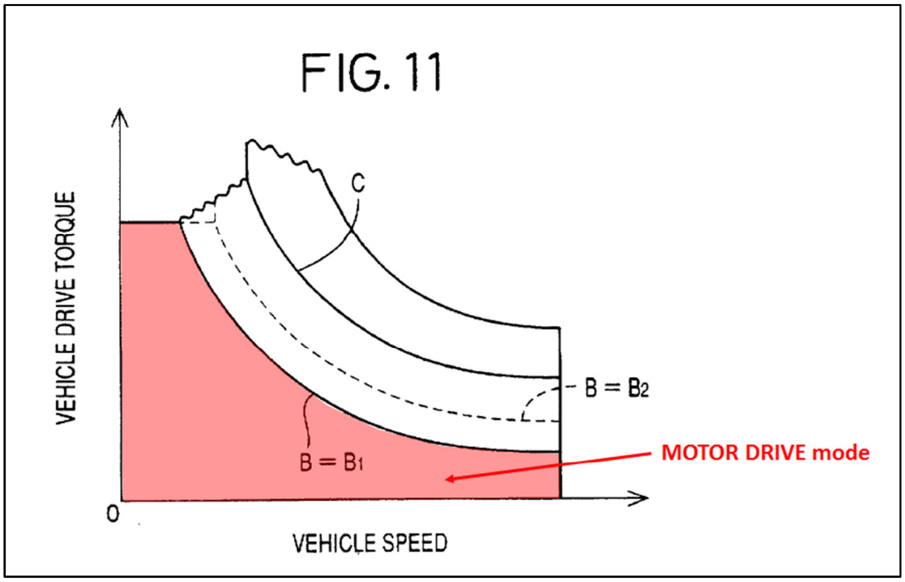
245. Ibaraki '882 further discloses that a "flow chart showing a routine executed" by the controller is illustrated by the Figure 10. (Ex. 1403 [Ibaraki '882] at 10:66-67, 22:1-3.) As I have annotated below, this control program includes logic allowing the controller to select the "MOTOR DRIVE mode" sub-routine.



Ex. 1403 [Ibaraki '882] at Fig. 10 (Annotated)

246. To select the "MOTOR DRIVE mode," Ibaraki '882 discloses the controller of the hybrid vehicle is "adapted to select one or both of the engine 112 and the motor 114 as the drive power P_L source or sources, **according to a drive source selecting data map stored in memory means 162**." (Ex. 1403 [Ibaraki '882] at 20:39-43, emphasis added.)

247. As I have annotated below, Ibaraki '882 discloses that the data map of Figure 11 is used to select "the MOTOR DRIVE mode when the vehicle running condition **as represented by the current vehicle drive torque and speed V** is held within the range below the first boundary line B" (highlighted in red). (Ex. 1403 [Ibaraki '882] at 20:55-63, emphasis added.)



Ex. 1403 [Ibaraki '882] at Fig. 11 (annotated)

248. The controller is further disclosed as commanding only the electric motor to propel the hybrid vehicle in the "MOTOR DRIVE mode" when a point corresponding to the "drive power P_L" (as determined by the current vehicle drive torque and vehicle speed) is below a corresponding point along "boundary line B."

> Step Q6 and Q7 are followed by step Q8 to determine whether a point corresponding to the required drive power P_L (**determined by the current vehicle drive torque and speed V**) is located above the first boundary line B. . . . If a negative decision (NO) is obtained in step Q8, that is, **<u>if the point of the required drive power P_L is located below</u>**

> **the first boundary line B** or in the motor driving range, the control flow goes to step Q12 in which a sub-routine for running the vehicle in **the MOTOR DRIVE mode is executed**. . . . The MOTOR DRIVE mode sub-routine of step Q12 is executed by the motor driving means 166 so that the vehicle is driven by operation of only the motor 114.

(Ex. 1403 [Ibaraki '882] at 23:66- 24:23, emphasis added.)

249. I have further annotated Figure 11 below to illustrate this logic. I have specifically illustrated how Figure 11 is used to determine when to operate the vehicle in the "MOTOR DRIVE mode" (highlighted in red below) at the given vehicle speed (V_1). For instance, a torque *setpoint* (*SP*) along boundary line B would be known at the current vehicle speed (V_1). This *setpoint* (*SP*) marks a transition between the MOTOR DRIVE mode and the ENGINE DRIVE mode (which is discussed below in limitation **[23.8]**). Also, a point[25] within the "MOTOR DRIVE mode" is illustrated, marking "the vehicle running condition as represented by the current vehicle drive torque [T_{L1}] and speed [V_1]." (Ex. 1403 [Ibaraki '882] at 20:55-63.) The "current vehicle drive torque" (T_{L1}) is the "instantaneous torque required to propel the

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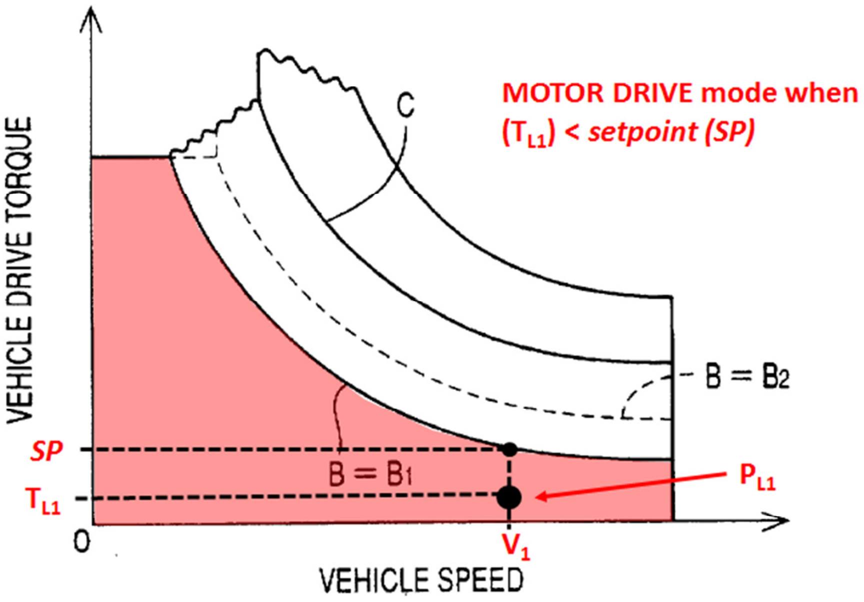
[25] This plotted point is "a point corresponding to the required drive power P_L" which is "determined by the current vehicle drive torque and speed V." (Ex. 1403 [Ibaraki '882] at 23:66-24:2.) As I stated above, power = torque * rotational speed. The intersection of vehicle drive torque and vehicle speed thus relates to a corresponding point of required drive power.

vehicle," or *road load (RL)*, at this "vehicle running condition." Because the "current vehicle drive torque" (T_{L1}) is less than the *setpoint* (*SP*) at the known vehicle speed (V_1), Ibaraki '882 would operate the vehicle in the "MOTOR DRIVE mode." (*See e.g.*, Ex. 1403 [Ibaraki '882] at 20:55-63.)

FIG. 11



Ex. 1403 [Ibaraki '882] at Fig. 11 (Annotated)

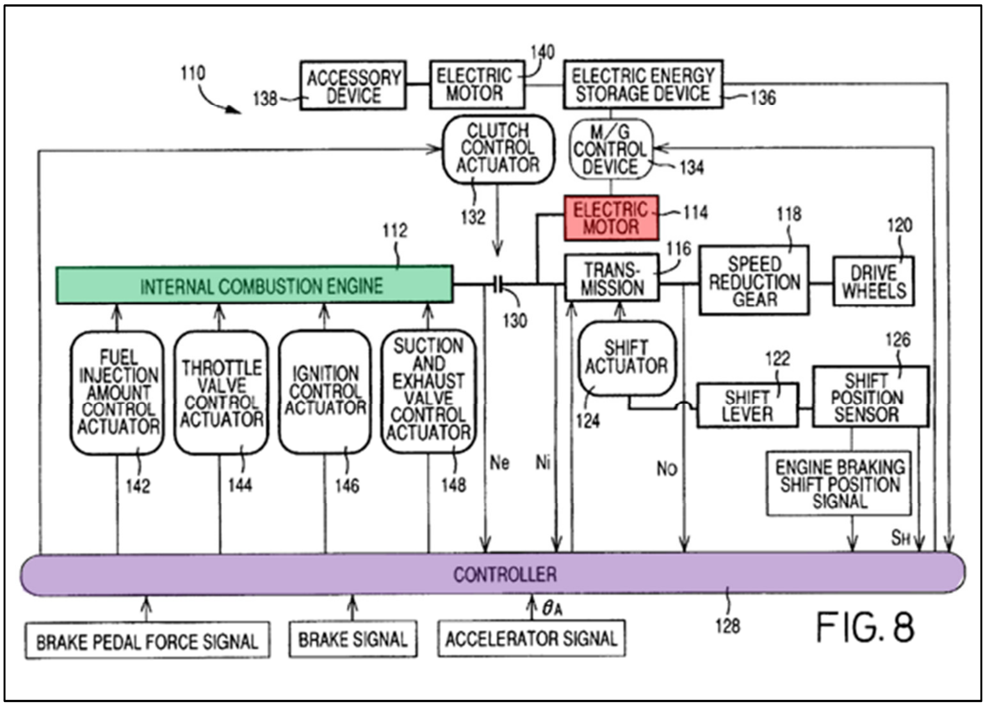
250. It is therefore my opinion that Ibaraki '882 discloses *employing said at least one electric motor to propel said vehicle when the torque RL required to do so is less than said lower level SP*.

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

251. I understand that the recited *setpoint (SP)* is proposed as being a "predetermined torque value."

252. I understand the recited *RL* is proposed to mean "the amount of instantaneous torque required to propel the vehicle, be it positive or negative."

253. As I have annotated below, Figure 8 discloses a hybrid vehicle architecture having a controller (highlighted in purple) and an internal combustion engine (highlighted in green).



Ex. 1403 [Ibaraki '882] at Fig. 8 (Annotated)

254. Ibaraki '882 describes an "internal combustion engine 112" that may be

selectively operated to transfer propulsive power to the drive wheels. Ibaraki ’882 also states that the engine 112 may be operated by combustion of fuel that a person having ordinary skill in the art would have understood as being supplied from a fuel tank.

> The vehicle drive control apparatus 110 is arranged to control a hybrid vehicle equipped with an internal combustion engine 112 such as a gasoline engine operated by combustion of a fuel, and a dynamo-electric motor 114 which functions as an electric motor operated by an electric energy and an electric generator or dynamo for generating electricity. Power of the internal combustion engine 112 and power of the electric motor 114 are simultaneously or selectively transferred to a transmission 116, and to right and left drive wheels 120 via a speed reduction gear 118 and a differential gear.

(Ex. 1403 [Ibaraki ’882] at 19:18-27.)

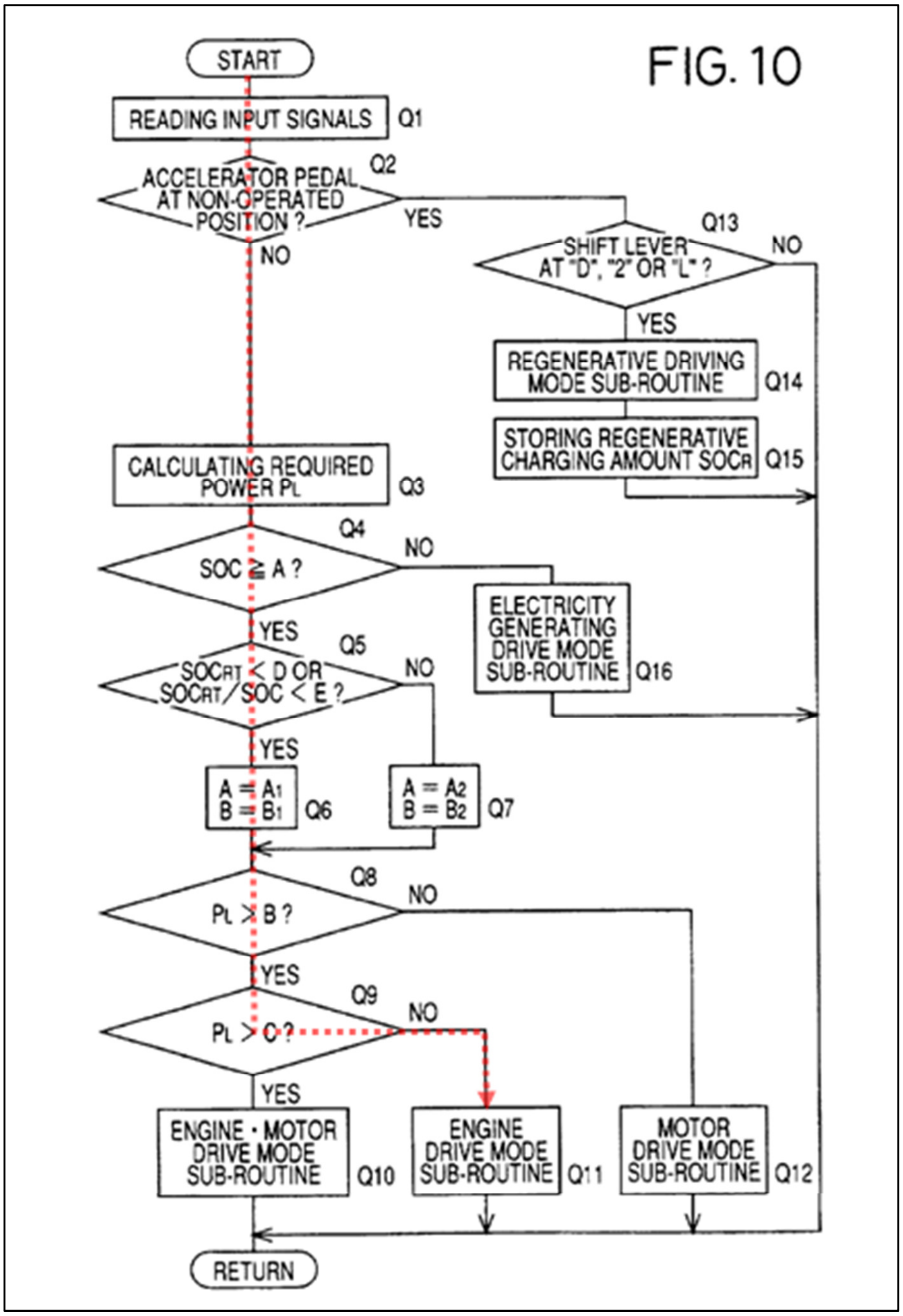
255. Ibaraki ’882 discloses that the controller includes control programs that determine whether the hybrid vehicle should be propelled in an “ENGINE DRIVE mode,” in which the vehicle is propelled by operation of the engine alone.

> **<u>That is, the controller 128 has</u>** a MOTOR DRIVE mode in which the motor 114 is selected as the drive power source, **<u>an ENGINE DRIVE mode in which the engine 112 is selected as the drive power source</u>**, and an ENGINE-MOTOR DRIVE mode in which both the engine 112 and the motor 114 are selected as the drive power sources.

(Ex. 1403 [Ibaraki ’882] at 20:43-53, emphasis added.)

256. Ibaraki ’882 further discloses that a “flow chart showing a routine executed” by the controller is illustrated by the Figure 10. (Ex. 1403 [Ibaraki ’882] at

10:66-67, 22:1-3.) As I have annotated below, this control program includes logic allowing the controller to select the "ENGINE DRIVE mode" sub-routine.



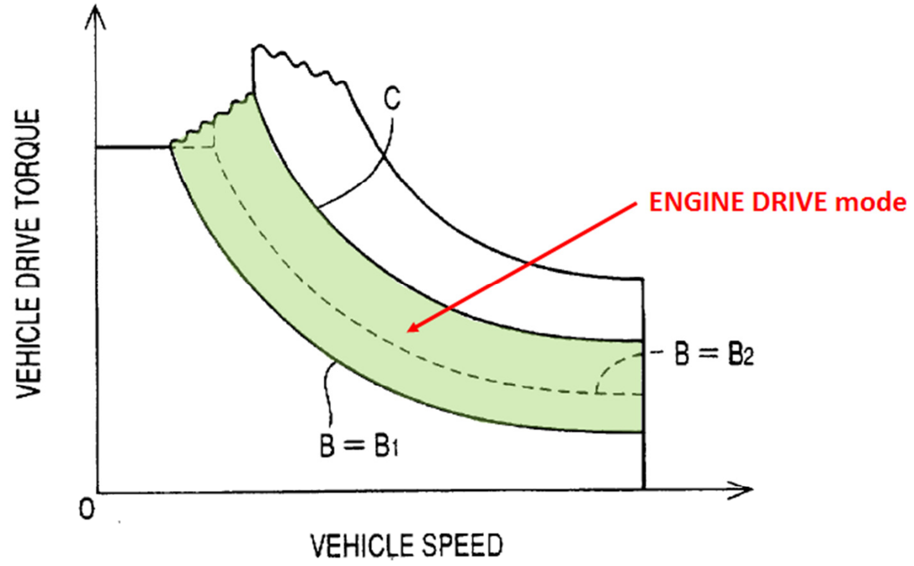
Ex. 1403 [Ibaraki '882] at Fig. 10 (Annotated)

257. To select the "ENGINE DRIVE mode," Ibaraki '882 discloses the controller of the hybrid vehicle is "adapted to select one or both of the engine 112

and the motor 114 as the drive power P_L source or sources, **according to a drive source selecting data map stored in memory means 162**." (Ex. 1403 [Ibaraki '882] at 20:39-43, emphasis added.)

258. As I have annotated below, Ibaraki '882 discloses that the data map of Figure 11 is used to select the "ENGINE DRIVE mode" when the vehicle running condition "**as represented by the current vehicle drive torque and speed V**" is "held within the range between the first and second boundary lines B and C" (highlighted in green). (Ex. 1403 [Ibaraki '882] at 20:55-65, emphasis added.)

FIG. 11



Ex. 1403 [Ibaraki '882] at Fig. 11 (Annotated)

259. The controller is further disclosed as commanding the engine to propel the hybrid vehicle in the "ENGINE DRIVE mode" when a point corresponding to the "drive power P_L" is above the first "boundary line B" and equal to or below the

"second boundary line C."

> Step Q6 and Q7 are followed by step Q8 to determine whether a point corresponding to the required drive power P_L (determined by the current vehicle drive torque and speed V) is located above the first boundary line B. If an affirmative decision (YES) is obtained in step Q8, the control flow goes to step Q9 to determine whether the point of the required drive power P_L is located above the second boundary line C. . . . **If the point of the required drive power P_L is located above the first boundary line B and on or below the second boundary line C**, that is, if a negative decision (NO) is obtained in step Q9, the control flow goes to step Q11 in which a sub-routine for running the vehicle in **the ENGINE DRIVE mode is executed**.

(Ex. 1403 [Ibaraki '882] at 23:66-24:16, emphasis added.)

260. I have further annotated Figure 11 below. I have specifically illustrated how Figure 11 is used to determine when to operate the vehicle in the "ENGINE DRIVE mode" (highlighted in green below) at the given vehicle speed (annotated as V_1). Once again, a torque *setpoint* (annotated as *SP*) along boundary line B would be known at the current vehicle speed (V_1). This *setpoint* (*SP*) marks a transition between the "MOTOR DRIVE mode" and the "ENGINE DRIVE mode." Also, a torque point (annotated as C_1) along boundary line C would be known at the current vehicle speed (V_1). This torque value (C_1) marks a transition between the "ENGINE DRIVE mode" and the "ENGINE-MOTOR DRIVE mode" (discussed below in limitation

[23.9]). A point[26] within the "ENGINE DRIVE mode" is also illustrated, marking "the vehicle running condition as represented by the current vehicle drive torque [annotated as T_{L2}] and speed [V_1]." (Ex. 1403 [Ibaraki '882] at 20:55-63.) The "current vehicle drive torque" (T_{L2}) is the "instantaneous torque required to propel the vehicle," or *road load (RL)*, at this "vehicle running condition." Ibaraki '882 would operate the vehicle in the "ENGINE DRIVE mode" because the "current vehicle drive torque" (T_{L2}) is between the *setpoint* (*SP*) and the torque (C_1) in which a transition to "ENGINE-MOTOR DRIVE mode" occurs. (*See e.g.,* Ex. 1403 [Ibaraki '882] at 20:55-63.)

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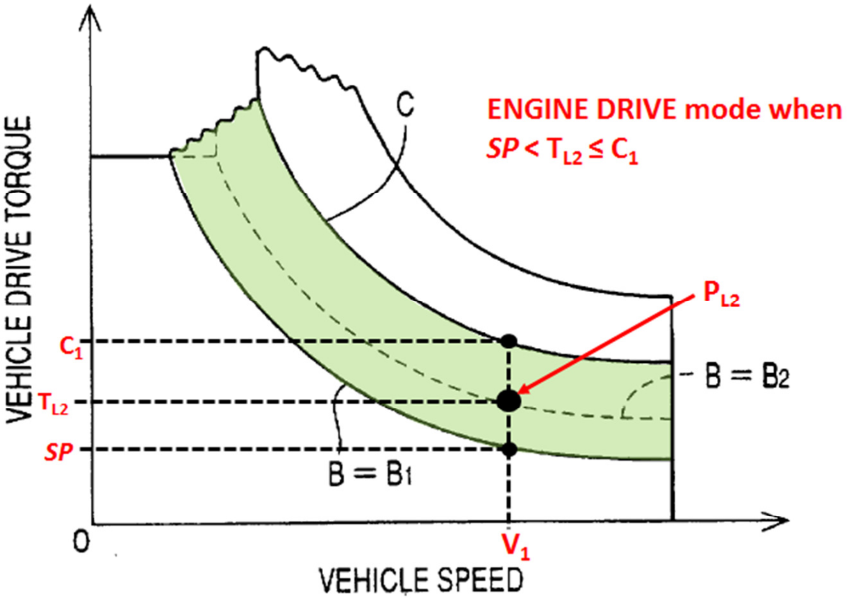
[26] This plotted point is "a point corresponding to the required drive power P_L" which is "determined by the current vehicle drive torque and speed V." (Ex. 1403 [Ibaraki '882] at 23:66-24:2.) As I stated above, power = torque * rotational speed. The intersection of vehicle drive torque and vehicle speed thus relates to a corresponding point of required drive power.

FIG. 11



Ex. 1403 [Ibaraki '882] at Fig. 11 (annotated)

261. All engines necessarily have a *maximum torque output*. It is my opinion that the *maximum torque output (MTO)* of the engine is *at least* equal to or greater than the torque point C_1 at the vehicle speed (V_1). Again, the ENGINE DRIVE mode where the IC engine drives the vehicle is stated as being between setpoint SP and the torque point C_1 at a given vehicle speed (V_1). As will be further explained in regards to limitation **[23.9]** below, when the "vehicle drive torque" (*i.e. road load*) exceeds the point C_1 at a given vehicle speed (V_1), the vehicle operates in the "ENGINE-MOTOR DRIVE mode." The vehicle drive torque (C_1) would be less than or equal to the maximum torque output of the engine. The maximum torque output of the engine *cannot* be less than the point C_1 because the engine alone is operated to propel the vehicle between boundary lines B and C (shaded green above). In other words,

the engine *cannot* operate or provide any output above its *maximum torque output (MTO)*, which every engine has. A person of ordinary skill in the art would have recognized this.

262. It is therefore my opinion that Ibaraki '882 discloses *employing said engine to propel said vehicle when the torque RL required to do so is between said lower level SP and MTO.*

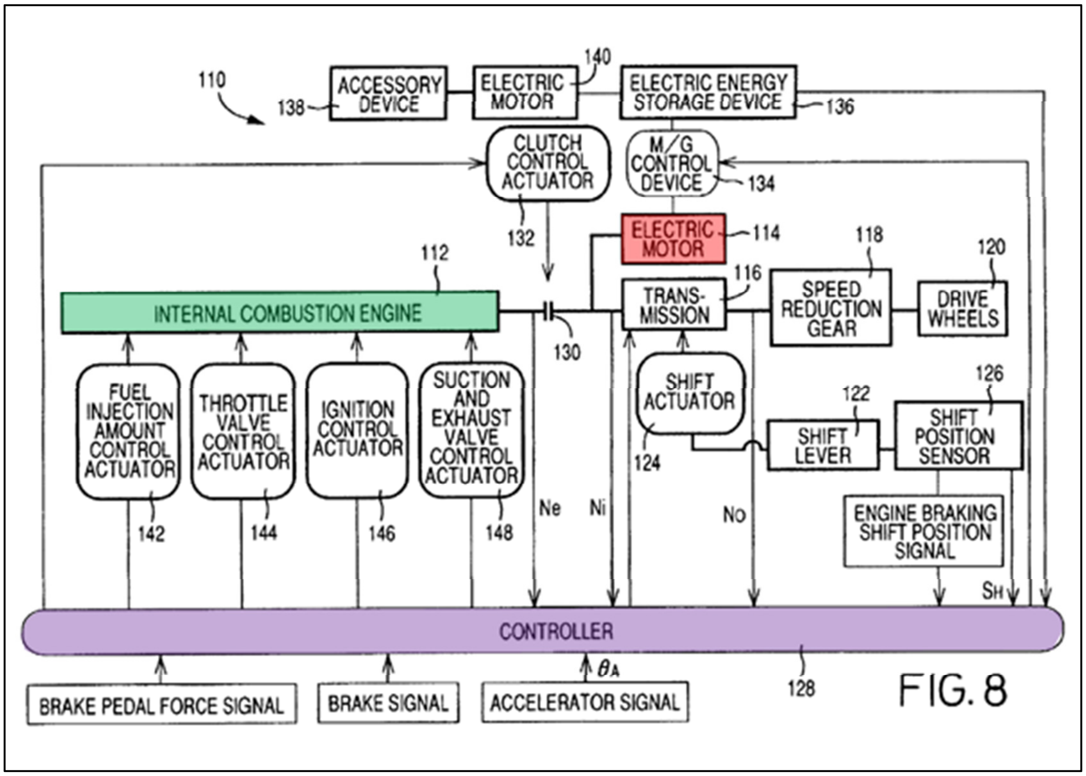
> … ***[23.9] employing both said at least one electric motor and said engine to propel said vehicle when the torque RL required to do so is more than MTO; and***

263. It is my understanding that by reciting *at least one electric motor*, this limitation is satisfied by a hybrid vehicle having one electric motor.

264. I understand that the recited *setpoint (SP)* is proposed to mean a "predetermined torque value."

265. I understand the recited *RL* is proposed to mean "the amount of instantaneous torque required to propel the vehicle, be it positive or negative."

266. As I have annotated below, Figure 8 discloses a hybrid vehicle architecture having a controller (highlighted in purple), an internal combustion engine (highlighted in green), and an electric motor (highlighted in red).



Ex. 1403 [Ibaraki '882] at Fig. 8 (Annotated)

267. Ibaraki '882 describes an "internal combustion engine 112" that may be selectively operated to transfer propulsive power to the drive wheels. Ibaraki '882 also states that the engine 112 may be operated by combustion of fuel that a person having ordinary skill in the art would have understood as being supplied from a fuel tank.

> The vehicle drive control apparatus 110 is arranged to control a hybrid vehicle equipped with an internal combustion engine 112 such as a gasoline engine operated by combustion of a fuel, and a dynamo-electric motor 114 which functions as an electric motor operated by an electric energy and an electric generator or dynamo for generating electricity. Power of the internal combustion engine 112 and power of the electric motor 114 are simultaneously or selectively transferred to a transmission 116, and to right and left drive wheels 120 via a speed reduction gear 118 and a differential gear.

(Ex. 1403 [Ibaraki ’882] at 19:18-28.)

268. Ibaraki ’882 further describes an “electric motor 114” being a dynamo-electric motor that may be selectively operated: (1) as an electric motor in a “DRIVE state” to propel the vehicle; (2) as a generator in a “CHARGING state” for storing electrically generated charge in the battery; or (3) in a “NON-LOAD state” where the output shaft of the motor is permitted to rotate freely.

> The dynamo-electric motor 114 is connected to an electric energy storage device (electric power supply device) 136 in the form of a battery or condenser, for example, through a motor/generator control device (hereinafter abbreviated as "M/G control device) 134 so that the motor 114 is selectively placed in a DRIVE state, a CHARGING state, and a NON-LOAD state. In the DRIVE state, the motor 114 is driven by an electric energy supplied from the electric energy storage device 136. In the CHARGING state, the motor 114 functions as an electric generator or dynamo, with regenerative braking (braking torque electrically generated by the motor 114 itself), for storing an electric energy in the electric energy storage device 136. In the NON-LOAD state, the output shaft of the motor 114 is permitted to rotate freely.

(Ex. 1403 [Ibaraki ’882] at 19:55-20:9.)

269. Ibaraki ’882 discloses a control strategy that determines whether the hybrid vehicle should be propelled in an “ENGINE-MOTOR DRIVE mode” where the vehicle is driven by operation of both the IC engine and the electric motor.

> **<u>That is, the controller 128 has</u>** a MOTOR DRIVE mode in which the motor 114 is selected as the drive power source, an ENGINE DRIVE

> mode in which the engine 112 is selected as the drive power source, and **an ENGINE-MOTOR DRIVE mode in which both the engine 112 and the motor 114 are selected as the drive power sources**.

(Ex. 1403 [Ibaraki '882] at 20:43-53, emphasis added.)

270. Ibaraki '882 states a "flow chart showing a routine executed" by the controller is illustrated by the Figure 10. (Ex. 1403 [Ibaraki '882] at 10:66-67, 22:1-3.) As I have annotated below, this control program includes logic allowing the controller to select the "ENGINE-MOTOR DRIVE mode" sub-routine.

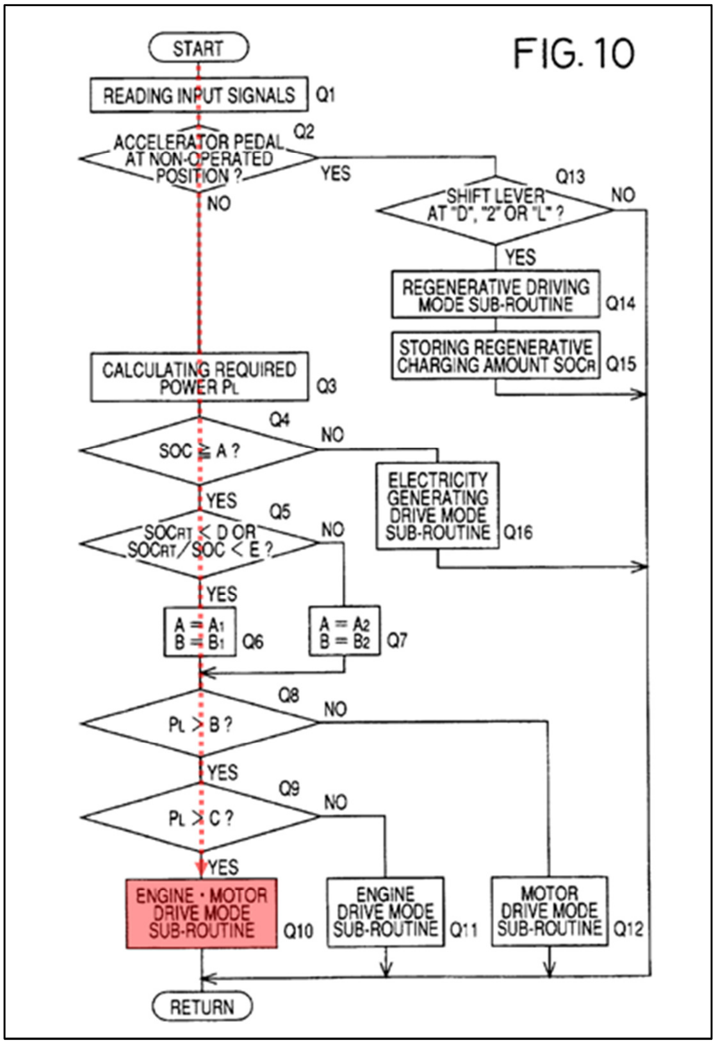


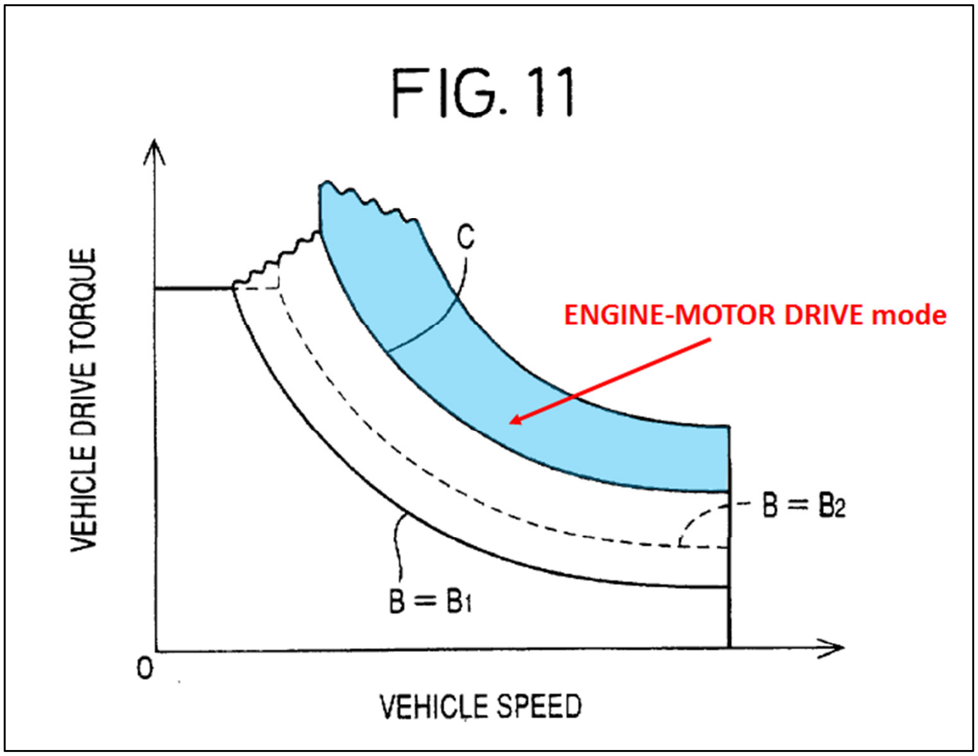
FIG. 10

Ex. 1403 [Ibaraki '882] at Fig. 10 (Annotated)

271. To select the "ENGINE-MOTOR DRIVE mode," Ibaraki '882 discloses the controller of the hybrid vehicle is "adapted to select one or both of the engine 112 and the motor 114 as the drive power P_L source or sources, **according to a drive source selecting data map stored in memory means 162.**" (Ex. 1403 [Ibaraki '882] at 20:39-43, emphasis added.)

272. Ibaraki '882 discloses that the data map of Figure 11 is used to select the "ENGINE-MOTOR DRIVE mode" when the vehicle running condition "**as represented by the current vehicle drive torque and speed V**" is "in the range above the second boundary line C." (Ex. 1403 [Ibaraki '882] at 20:55-21:1, emphasis added.)

FIG. 11



Ex. 1403 [Ibaraki '882] at Fig. 11 (annotated)

273. The controller is further disclosed as operating both the engine and the

motor in the "ENGINE-MOTOR DRIVE mode" when a point corresponding to the "drive power P_L" is above the "second boundary line C."

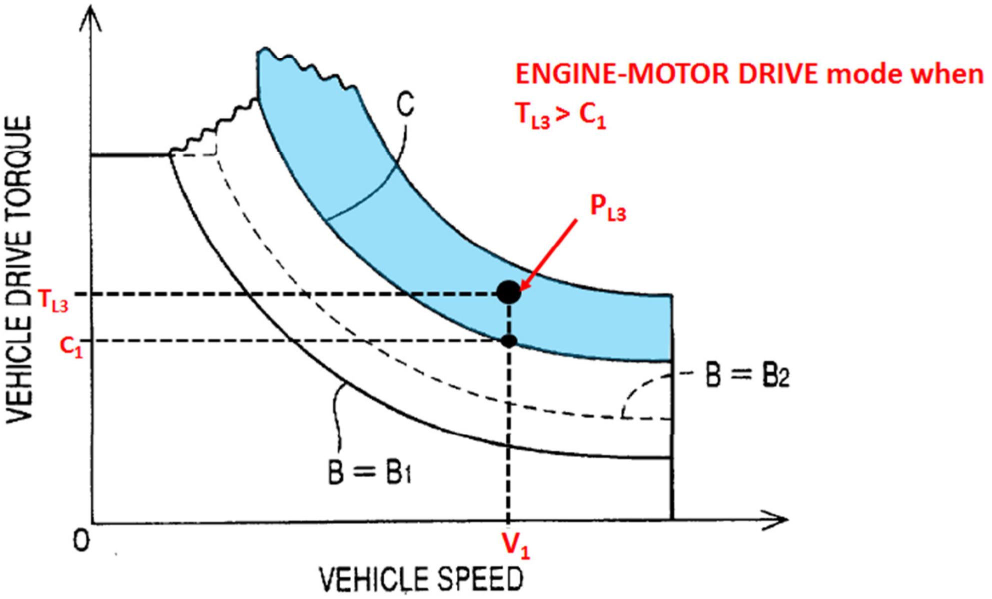
> Step Q6 and Q7 are followed by step Q8 to determine whether a point corresponding to the required drive power P_L (determined by the current vehicle drive torque and speed V) is located above the first boundary line B. If an affirmative decision (YES) is obtained in step Q8, the control flow goes to step Q9 to determine whether the point of the required drive power P_L is located above the second boundary line C. . . . **If the point of the required drive power P_L is located above the second boundary line**, that is if an affirmative decision (YES) is obtained in step Q9, the control flow goes to step Q10 in which **a sub-routine for running the vehicle in the ENGINE-MOTOR DRIVE mode is executed**. . . . The ENGINE-MOTOR DRIVE sub-routine of step Q10 is executed by the engine driving means 164 and the motor driving means 164 so that the vehicle is driven by operation of both the engine 112 and the motor 114.

(Ex. 1403 [Ibaraki '882] at 23:66- 24:30.)

274. I have further annotated Figure 11 below. I have specifically illustrated how Figure 11 is used to determine when to operate the vehicle in the "ENGINE-MOTOR DRIVE mode" (highlighted in blue below) at the given vehicle speed (annotated as V_1). Once again, a torque point (annotated as C_1) along boundary line C would be known at a given vehicle speed (V_1). This torque point (C_1) marks a transition between the "ENGINE DRIVE mode" and the "ENGINE-MOTOR DRIVE mode." A point within the "ENGINE-MOTOR DRIVE mode" is also

illustrated, marking "the vehicle running condition as represented by the current vehicle drive torque [annotated as T_{L3}] and speed [V_1]." (Ex. 1403 [Ibaraki '882] at 20:55-63.) The "current vehicle drive torque" (T_{L3}) is the "instantaneous torque required to propel the vehicle," or *road load (RL)*, at this "vehicle running condition." Ibaraki '882 would operate the vehicle in the "ENGINE-MOTOR DRIVE mode" because the "current vehicle drive torque" (T_{L3}) is above the torque (C_1) along boundary line C in which a transition to "ENGINE-MOTOR DRIVE mode" occurs. (*See e.g.,* Ex. 1403 [Ibaraki '882] at 20:55-63.)

FIG. 11



Ex. 1403 [Ibaraki '882] at Fig. 11 (Annotated)

275. It is also my opinion that a person having ordinary skill in the art would have understood the torque point C_1 along the predetermined "boundary line C" would be equal to or possibly less than the maximum torque output (MTO) at that

given vehicle speed (V_1). First, an IC engine **cannot** operate above the engine's MTO. Because the IC engine alone operates in the "ENGINE DRIVE mode" when the vehicle drive torque is between "boundary line B" and "boundary line C" the MTO cannot be less than the torque point C_1 at that given vehicle speed. It follows that the maximum torque output (MTO) of the engine is at minimum equal to the torque point C_1 when operated at a vehicle speed V_1, because the engine is still operating alone until the torque exceeds the point C_1.

276. Ibaraki '882 states that the "ENGINE-MOTOR DRIVE mode" is selected "when the vehicle load is comparatively high." (Ex. 1403 [Ibaraki '882] at 26:28-33.)

277. It is my opinion that a person of ordinary skill in the art would have understood that high "vehicle loads" would include vehicle drive torques above the engine's maximum torque output (MTO). It is also my opinion that a person having ordinary skill would have understood that a hybrid vehicle control strategy would at some point allow the IC engine to provide output torque up to and including its MTO. Otherwise, the system would be artificially limiting the performance of the vehicle. In other words, the hybrid vehicle would not be providing the full output capabilities of the IC engine and the motor under high loads. Thus, within the ENGINE-MOTOR DRIVE mode the system would eventually allow the IC engine to provide torque at its MTO and also allow the additional supplemental torque to be provided from the electric motor.

278. A person of ordinary skill in the art would have understood that it would be obvious to use the electric motor to provide additional output torque above the engine's maximum torque output (MTO) during such high vehicle load situations. As discussed above in the State of the Art in ¶¶128-134 the control techniques for using the motor above the engine's MTO were well known.

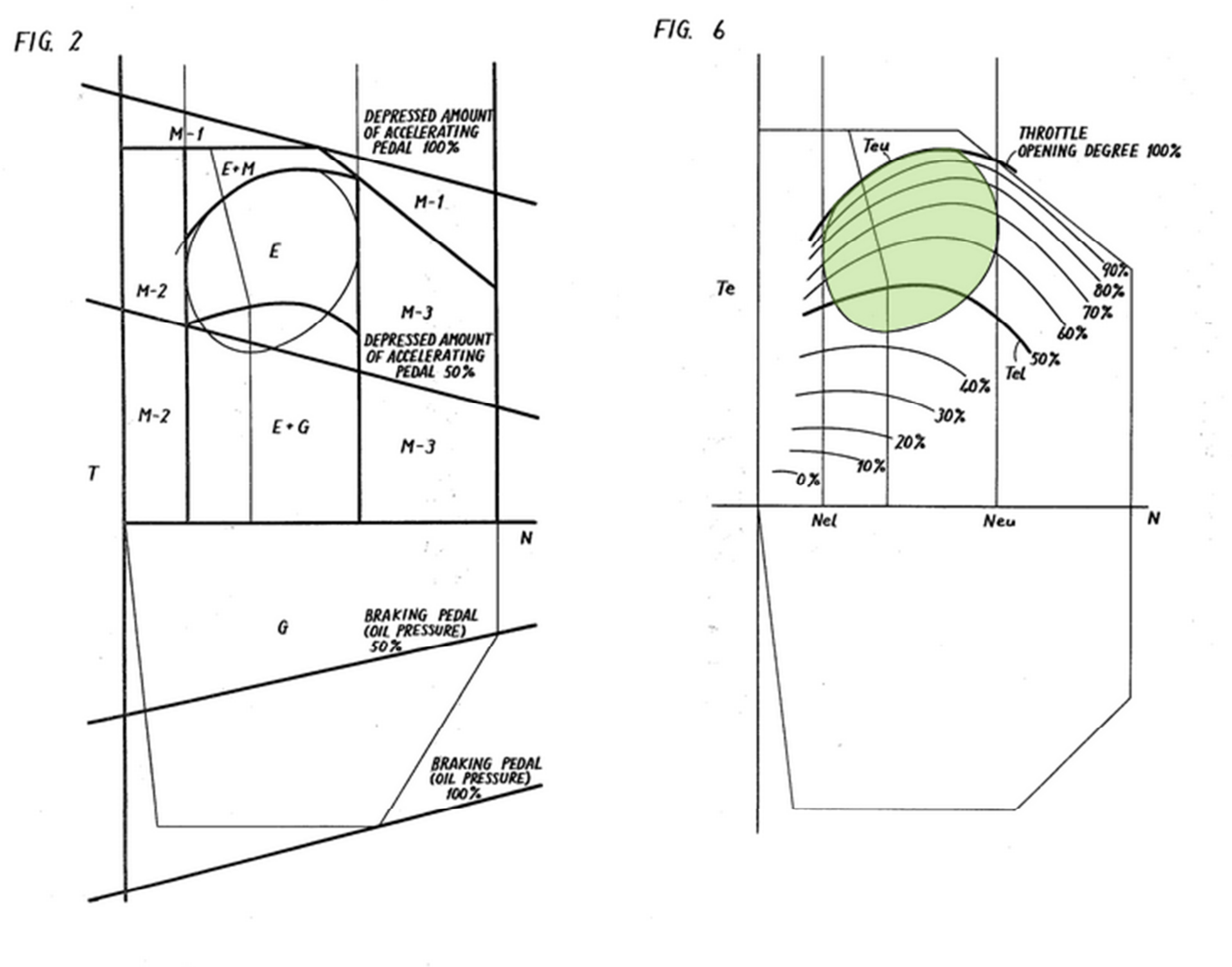
279. A person having ordinary skill in the art would have understood that the "ENGINE-MOTOR DRIVE mode" region (shaded blue above) is a region where two power sources (*i.e.* an electric motor and IC engine) are combined to produce an output vehicle drive torque that is greater than either source individually. It would have been understood that each power source includes a maximum output which that individual device could not exceed. However, the combined output exceeds the MTO of either device.

280. For instance, a hybrid vehicle may have an electric motor with a MTO at 30 Nm. The same vehicle may have an engine with a MTO at 50 Nm. The combined total available torque output if both devices are combined would be 80 Nm. In a hybrid vehicle where both devices are combined to provide torque output (*i.e.*, ENGINE-MOTOR DRIVE mode), the total combined output torque of 80 Nm is greater than the individual torque output of either device singularly. This is a design choice that would be obvious, because again a person having ordinary skill in the art would not want to artificially limit the torque output to less than the full 80 Nm capability of the system.

281. In fact, this example is confirmed by some of the prior art references cited on the face of Ibaraki ’882. For instance, cited U.S. Patent No. 4,407,132 (Ex. 1446 [Kawakatsu ’132]) discloses a drive strategy where the IC engine is restricted to a certain operating region like Ibaraki ’882. The prior art ’132 Patent discloses that the IC engine is operated within a region having a lower torque bound limit up to the IC engine’s MTO. Above the IC engine’s MTO, the motor is operated to provide the additional required torque. This is illustrated by Figures 2 and 6 from the ‘132 Patent below. Specifically, as shown by Figure 2, the region illustrated as “E+M” denotes the region where both the engine and motor are used to propel the vehicle. The region marked “E” is where the IC engine alone is operated to propel the vehicle. In Figure 6, the region where the IC engine alone operates is highlighted in green and continues up to the MTO.

> If and when the decision at the determining step 125 is "YES" i.e. if and when the required torque Tr is within the range from the upper limit value Teu(N) of the engine torque to the upper limit value Tmu(N) of the motoring torque, then at the step 126 the microcomputer 5 sets the engine torque Te(N) to the upper limit value Teu(N) and sets the motoring torque Tm(N) to the difference "Tr--Teu(N)".

(Ex. 1446 [Kawakatsu ’132] at 17:26-34.)



Ex. 1446 [Kawakatsu '132] at Figs. 2 and 6

282. It is therefore my opinion that Ibaraki '882, in view of the general knowledge of a person of ordinary skill in the art, discloses *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.*

… ***[23.10] 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***

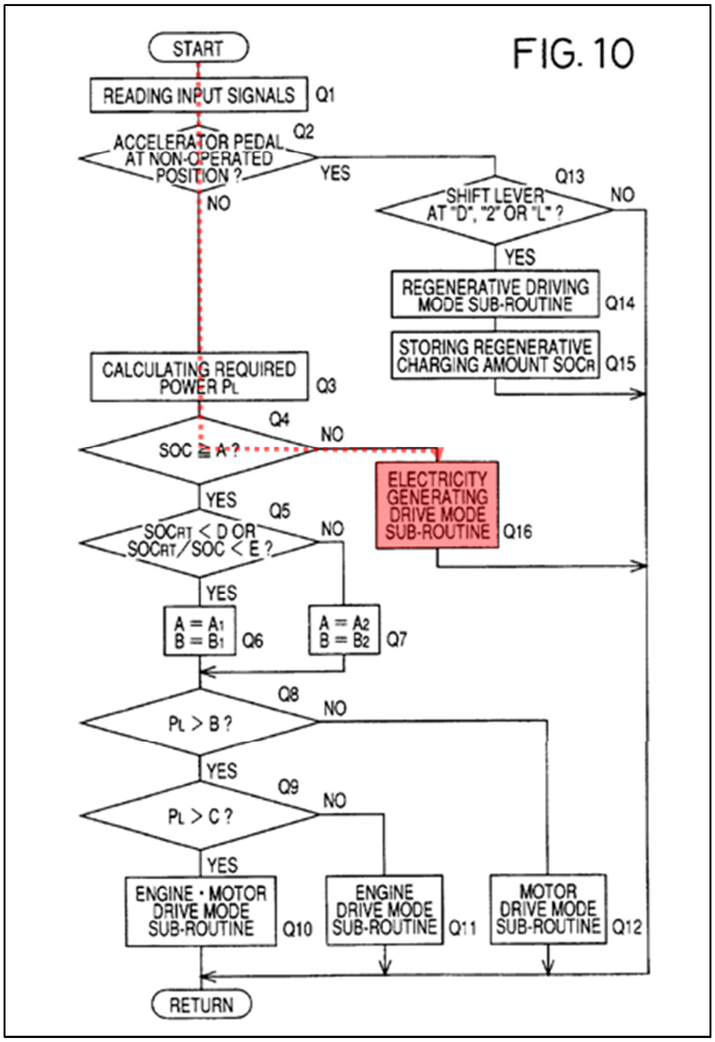
283. I understand that the recited *setpoint (SP)* is proposed as being a "predetermined torque value."

284. I understand the recited *RL* is proposed to mean "the amount of instantaneous torque required to propel the vehicle, be it positive or negative."

285. As discussed in claim **[23.6]** above, Ibaraki '882 discloses *monitoring the state of charge of the battery*.

286. As discussed in claim **[23.7]** above, when the torque *RL required to propel the vehicle is less than said lower level SP*, the vehicle normally operates in the MOTOR DRIVE mode in which the electric motor alone propels the vehicle. If, however, the battery SOC is low (*i.e.* SOC < "A") even when the *torque RL required to propel the vehicle is below the setpoint SP*, the vehicle will operate in the ELECTRICITY GENERATING DRIVE mode. In the ELECTRICITY GENERATING DRIVE mode, the engine provides torque to the electric motor to charge the battery while the engine also propels the vehicle, as described in claim **[23.4]** above. Figure 10 below shows the ELECTRICITY GENERATING DRIVE mode being commanded when the state of charge is below the threshold "A," regardless of the *torque RL required to propel the*

vehicle.



Ex. 1403 [Ibaraki '882] at Fig. 10 (annotated)

287. Particularly describing the action shown above in Fig. 10, Ibaraki '882 teaches that at Step Q4, the controller will compare the battery's state of charge to a "predetermined" threshold (*i.e.*, "lower limit A"). If the battery's state of charge is below threshold limit "A," the controller executes the ELECTRICITY GENERATING DRIVE mode (*i.e.*, Step Q16).

> Step Q3 is followed by **step Q4 to determine whether the charging amount SOC of the electric energy storage device 136 is equal to or larger than a predetermined lower limit A or not**. If an affirmative decision (YES) is obtained in step Q4, the control flow goes to step Q5 and the subsequent steps. **If a negative decision (NO) is obtained in step Q4, the control flow goes to step Q16 in which a sub-routine for running the vehicle in the ELECTRICITY GENERATING DRIVE mode is implemented**.

(Ex. 1403 [Ibaraki '882] at 23:6-14, emphasis added.)

288. As illustrated the engine output power is first set to a drive power (P_L) that is required to drive the vehicle. It is then incrementally increased as the flow diagram continues to loop until the engine output power (P_{ICE}) is greater than a predetermined threshold (P_E) as shown by step "R4" ("Q4" in second embodiment). Thus, as the strategy continues to loop from step "R1" to "R4", a point corresponding to the engine output power (P_{ICE}) becomes **greater** than the point corresponding to the required drive power (P_L). The **surplus** engine power (P_{ICE}-P_L) is then used to *operat[e] the engine to charge the battery*.[27]

> In the sub-routine of step Q16 implemented if the negative decision (NO) is obtained in step Q4, **the engine 112 is operated to provide a**

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[27] Ibaraki discloses that the ELECTRICITY GENERATING DRIVE mode is explained more fully within the first embodiment that is found earlier within the specification. (Ex. 1403 [Ibaraki '882] at 23:30-32.)

> **total output P_{ICE} not smaller than the required drive power P_L, so that the vehicle is driven by the required drive power P_L while the motor 114 is operated as the electric generator** by the surplus power (P_{ICE} -P_L) to charge the electric energy storage device 136, as in the first embodiment. Step Q16 is implemented in the same manner as step S7 of the first embodiment.

(Ex. 1403 [Ibaraki '882] at 23:23-30, emphasis added.)

> In the ELECTRICITY GENERATING DRIVE mode in which the vehicle is run by the engine 12 while the **motor 16 is operated by the surplus power (P_{ICE} -P_L) of the engine 12 to charge the electric energy storage device 16** . . ."

(Ex. 1403 [Ibaraki '882] at 17:65-18:1, emphasis added.)

289. As Ibaraki '882 more specifically explains, during ELECTRICITY GENERATING mode the controller holds the vehicle running speed constant while adjusting the <u>**engine torque**</u> (T_E) upward to provide the calculated surplus power (ΔP_{ICE} = P_{ICE} -P_L). At minimum, the engine is set a torque level (*i.e.*, T_E = T_{ICE}) is set just higher than the amount of engine torque needed to propel the vehicle (T_L or *road load*). Surplus engine torque (ΔT_{ICE} = T_{ICE}-T_L) is then generated and used to drive the *electric motor* as a generator for charging the battery.

> Since the engine speed N_E is held constant depending upon the vehicle running speed, the **engine torque T_E increases by an amount corresponding to the increment amount ΔP_{ICE}** as indicated in FIG. 7. Therefore, **the surplus torque value of the engine 12 is obtained as a sum of the increment amounts ΔP_{ICE} in repeated**

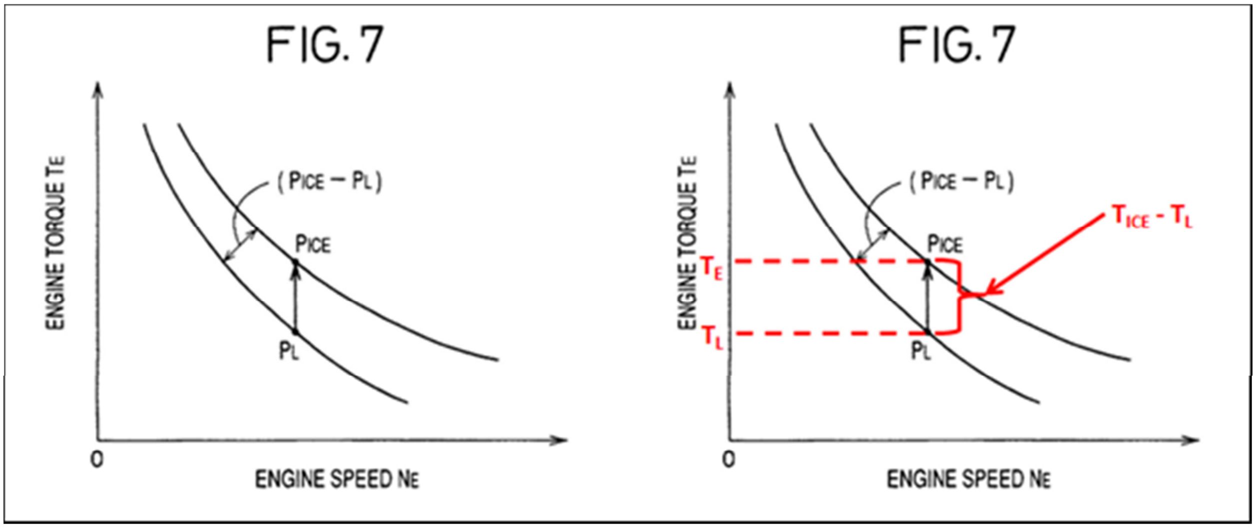
> **implementation of step R1**, that is, as a difference (P_{ICE} -P_L) between the candidate value of the engine output P_{ICE} and the required drive power P_L. The graph of FIG. 7 shows iso-drive power lines of the engine 12, which indicate that the engine torque T_E for obtaining the same drive power changes with the engine speed N_E. **The engine output P_{ICE} and the required drive power P_L are determined by the specific combination of the current engine speed N_E and torque T_E.**

(Ex. 1403 [Ibaraki '882] at 15:37-50, emphasis added.)

290. I have annotated Figure 7 (discussed above) to illustrate the engine torque used to propel the vehicle (*i.e.*, T_L) and the surplus torque that is used to charge the battery (*i.e.*, $\Delta T_{ICE} = T_{ICE} - T_L$).

FIG. 7

FIG. 7



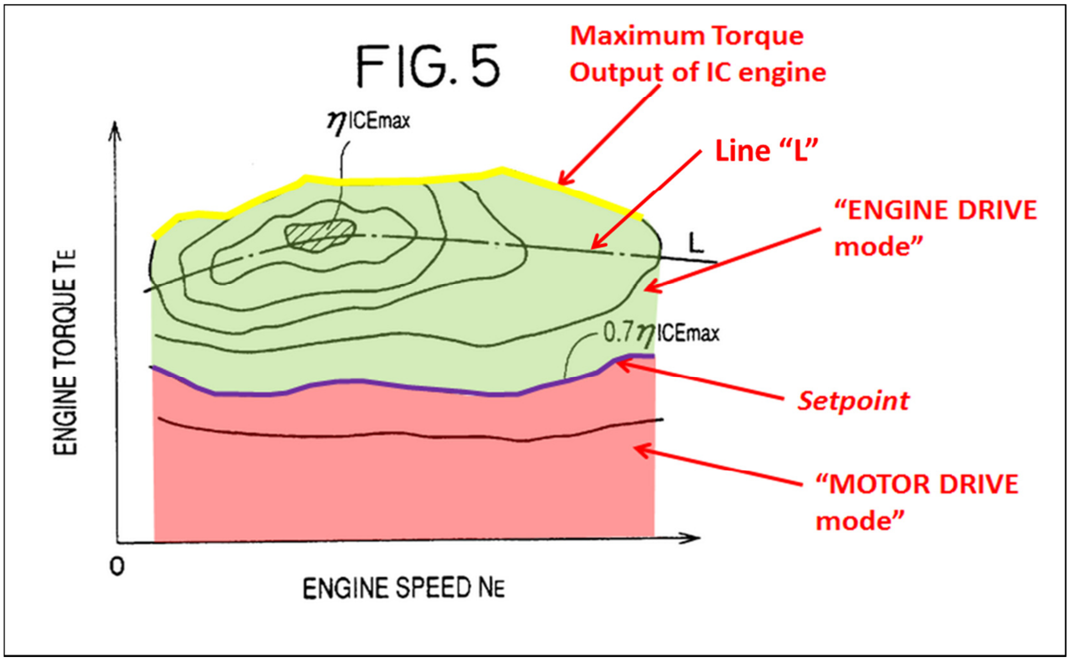
Ex. 1452 [Ibaraki '882] at Fig. 7 (Annotated)

291. Ibaraki '882 states that in order to ensure that the engine operates with low fuel consumption and emissions during this drive mode, the engine torque (T_E) should be set to a value greater than the engine torque required to propel the vehicle

(T_L). In order to achieve this and still ensure efficient operation of the engine, Ibaraki ’882 will operate within a predetermined torque range (T_{ICE}) along “line L” illustrated in Figure 5.

> In step R1 of the ELECTRICITY GENERATING DRIVE mode sub-routine of FIG. 4, the engine output P_{ICE} is initially set to be equal to the required drive power P_L, and is incremented by the predetermined amount ΔP_{ICE} each time the sub-routine is executed, so that the engine output P_{ICE} whose overall fuel consumption efficiency η_T is the highest is selected in step R5. However, the manner of determining the engine output P_{ICE} so as to maximize the overall fuel consumption efficiency $\eta_T$may be modified as needed. For example, the **engine output P_{ICE} may be selected within a predetermined range along a line L representative of the minimum fuel consumption rate as indicated by one-dot chain line in the graph of FIG. 5.** This predetermined range has a predetermined width in the direction of the engine torque T_E on the upper and lower sides of the line L.

(Ex. 1403 [Ibaraki ’882] at 26:9-24, emphasis added.)



Ex. 1403 [Ibaraki '882] at Fig. 5 (annotated)

292. Line "L" is disclosed as being "representative of the minimum fuel consumption rate" of the engine. (Ex. 1403 [Ibaraki '882] at 26:19-21.) Line "L" indicates the operating point for all engine speeds where the engine consumes the least amount of fuel. This is sometimes referred to by a person having ordinary skill in the art as being the "ideal operating line" for an engine.

293. As I have further annotated below, operating conditions may result in the amount of engine torque required to propel the vehicle (T_L) falling below the *setpoint* (SP). For example, Ibaraki '882 sets the engine torque to a value along line "L" (T_E=T_{ICE}) to ensure that the engine output (P_{ICE}) is greater than the amount of engine torque required to propel the vehicle (T_L). (Ex. 1403 [Ibaraki '882] at 26:19-21.) The surplus engine torque ($\Delta T_{ICE} = T_{ICE} – T_L$), which includes the *torque between RL and SP*, may then be used *drive the at least one electric motor to charge said battery* during the

ELECTRICITY GENERATION DRIVE mode.

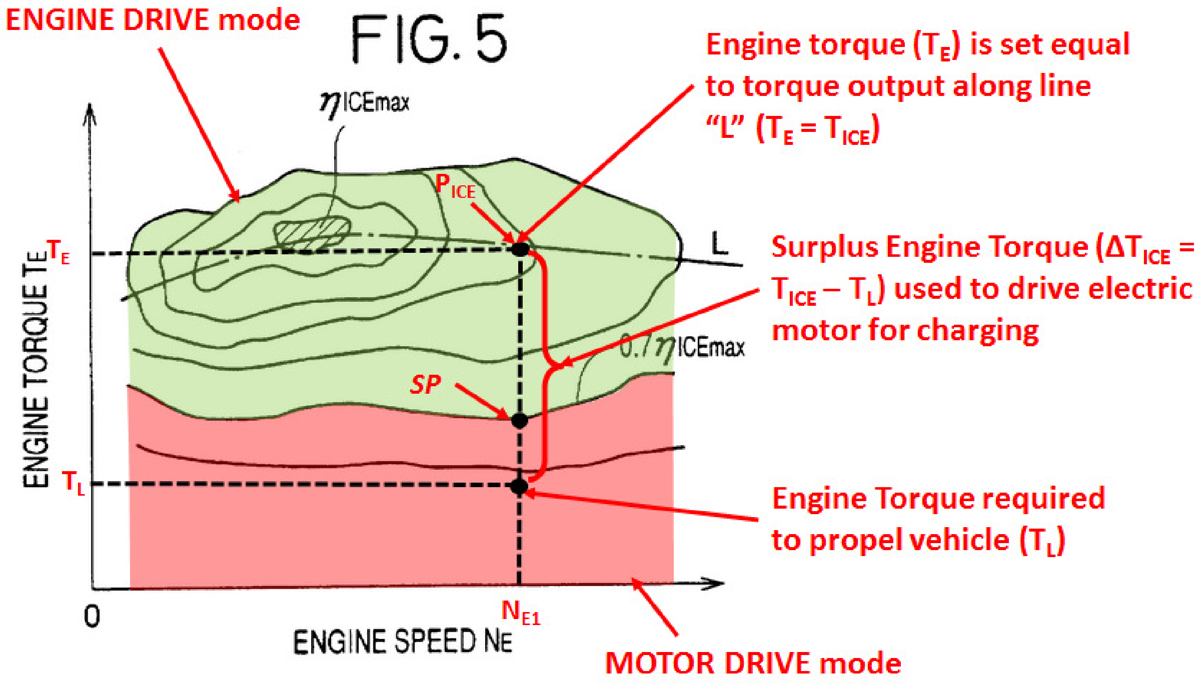


FIG. 5

Ex. 1403 [Ibaraki '882] at Fig. 5 (Annotated)

294. As illustrated above, Ibaraki '882 therefore discloses operating the engine above the *setpoint* in ELECTRICITY GENERATING DRIVE mode, even though normal operation would have dictated that the vehicle be operated in MOTOR DRIVE mode. If the engine was not operated above the *setpoint* (region highlighted in red), the engine would operate in a region having increased fuel consumption and exhaust gas emissions. This is contrary to Ibaraki '882's stated goal. (Ex. 1403 [Ibaraki '882] at 2:52-56.) It only logically follows that Ibaraki '882 discloses continuing to operate the engine in an efficient manner that would result in reduced emissions and fuel consumption **when** the engine is required to drive the motor to charge the battery.

295. It is therefore my opinion that Ibaraki ’882 discloses *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.*

… ***[23.11] 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.***

296. I understand that the recited *setpoint (SP)* is proposed as being a “predetermined torque value.”

297. I understand that claim **[23.11]** requires that this predetermined torque value is *substantially less than the maximum torque output (MTO) of the engine.* It is my opinion that Ibaraki ’882 discloses this limitation for several reasons.

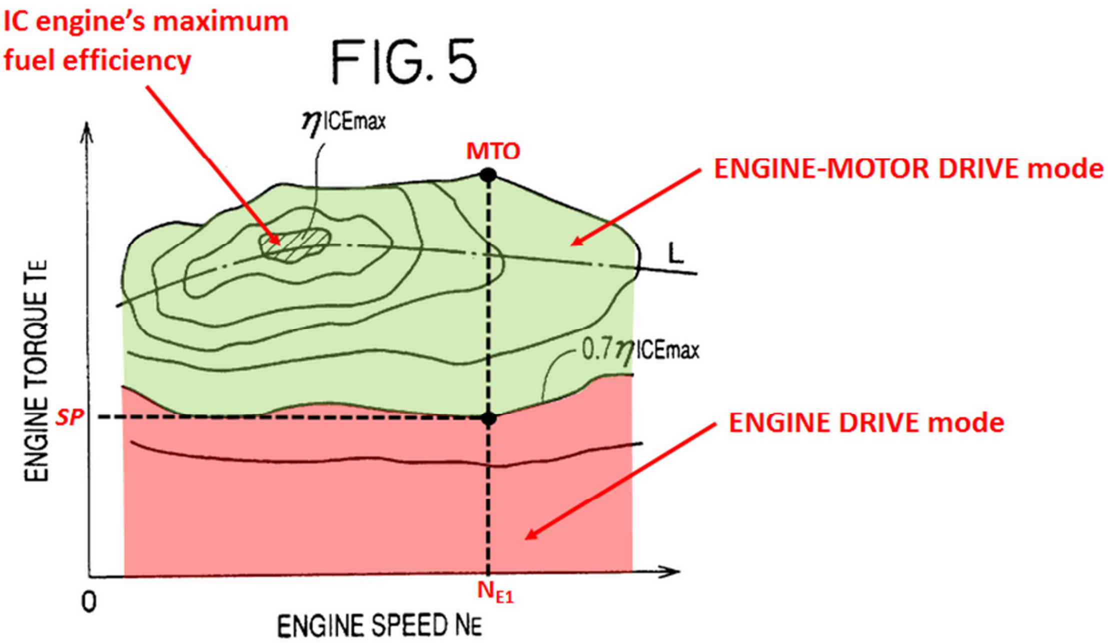
298. First, as I explained in limitation **[23.1]** above, Figure 5 of Ibaraki ’882 discloses an IC engine performance map that establishes a threshold value set at 70% of the engine’s maximum fuel efficiency for establishing when to transition between MOTOR DRIVE mode and ENGINE DRIVE mode.

> In view of this fact, it is possible to select the ENGINE DRIVE mode if the fuel consumption efficiency η_{ICE} for running the vehicle in the **ENGINE DRIVE mode with the engine 12 selected as the drive power source is larger than** **<u>a threshold of 0.7</u>**$\underline{\eta_{\mathbf{ICEmax}}}$ **indicated in FIG. 7, which threshold is 70% of the maximum fuel consumption efficiency** $\eta_{\mathbf{ICEmax}}$**, and select the MOTOR DRIVE mode if the fuel**

> **consumption efficiency η_{ICE} is smaller than <u>the threshold of 0.7η_{ICEmax}</u>**. The threshold is not limited to 70% of the maximum fuel consumption efficiency η_{ICEmax}, but may be suitably determined depending upon the energy conversion efficiencies of the electric motor 14 and the electric energy storage device 22. The concept of this modification of the first embodiment is embodied as the data map shown in FIG. 11 used in the second embodiment.

(Ex. 1403 [Ibaraki '882] at 25:46-65, emphasis added.)

299. As I have annotated below, the 70% threshold of the IC engine's maximum fuel efficiency η_{ICEmax} corresponds to a torque curve along the engine efficiency map of Figure 5. It further shows in Figure 5 that a *setpoint* (annotated below as *SP*) along the 0.7η_{ICEmax} threshold line at a given engine speed (annotated as N_{E1}) is substantially less than the maximum torque output (annotated as MTO) of the IC engine at that corresponding engine speed.



Ex. 1403 [Ibaraki '882] at Fig. 5 (Annotated)

300. Again, Figure 5 does not provide torque units, but it at least illustrates qualitatively that the setpoints (*e.g.*, *SP*) along the $0.7\eta_{\text{ICEmax}}$ threshold line are *substantially less than maximum torque output (MTO) of the engine.*

301. Second, a simple visual inspection of the Fig. 11's "data map" also illustrates that the setpoint (*SP*) is *substantially less* than MTO.[28]

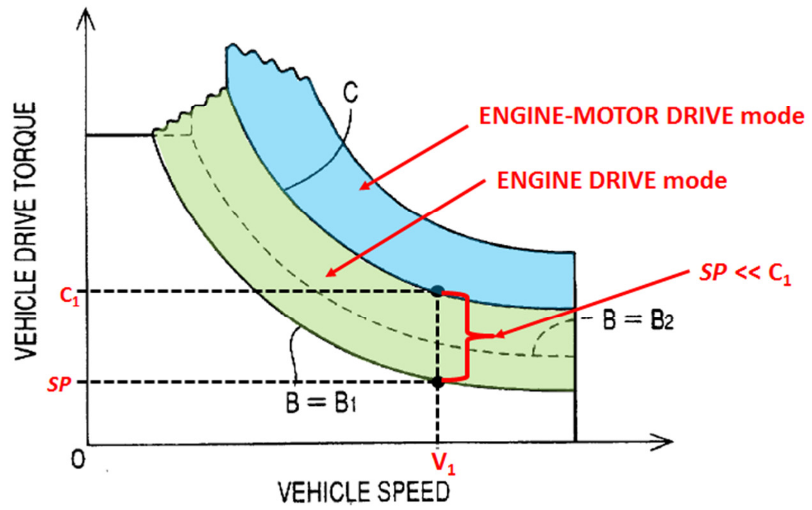
302. More specifically, Ibaraki '882 teaches one or more *setpoints* along boundary line "B" in Fig. 11. As the annotations below show, a person having ordinary skill would understand that Fig. 11 shows a *setpoint* (annotated below as *SP*) along boundary line "B" that is less than the *maximum torque output (MTO) of the engine.*

---

[28] Ibaraki '882 states that the $0.7\eta_{\text{ICEmax}}$ threshold line of Figure 5 "is embodied as the data map shown in FIG. 11." (Ex. 1403 [Ibaraki '882] at 25:63-65.)

For instance, at a vehicle speed V_1, a setpoint *SP* is illustrated along boundary line B, and a corresponding torque point (annotated below as C_1) is illustrated along boundary line "C." As explained for limitation **[23.8]**, when the "vehicle drive torque" is between setpoint *SP* and point $C_{1,}$ the hybrid vehicle operates in an "ENGINE DRIVE mode" (highlighted in green). (S*ee e.g.,* Ex. 1403 [Ibaraki '882] at 20:55-66.) The engine operates without motor assist throughout the ENGINE DRIVE mode. When the "vehicle drive torque" increases above the torque point C_1 the motor is activated to assist the engine in an ENGINE-MOTOR DRIVE mode (highlighted in blue). Because the engine operates without motor assist below torque point C_1, and because an engine cannot operate or provide torque above its own maximum torque output, the *maximum torque output (MTO)* of the engine at least equals and may exceed the torque point C_1 at vehicle speed V_1.

FIG. 11



Ex. 1403 [Ibaraki '882] at Figure 11

303. From a simple visual inspection of Fig. 11 above, it is clear that setpoint *SP* is *substantially less* than point C_1. Since the MTO of the engine is *at least* equal to the torque point C_1 when the vehicle is traveling at vehicle speed V_1, it follows that the setpoint *SP* is also *substantially less than the maximum torque output (MTO) of the engine*. If the MTO were not substantially less than the setpoint (or, if the ENGINE DRIVE mode were small), the IC engine would hardly ever be used as a primary drive source for the hybrid vehicle

304. I recognize that curve B does not include numeric values to allow for precise comparison of points on curve B to the IC engine's MTO. But the term *substantially less* is a vague, qualitative term and I understand that the term "substantially less than MTO" is not expressly defined by the '347 Patent. Figure 11 shows that, at least qualitatively, Ibaraki '882 teaches using a setpoint (*e.g., SP*) that is *substantially less than the maximum torque output (MTO) of the engine.*

305. It is therefore my opinion that Ibaraki '882 discloses *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.*

306. <Intentionally left blank>

307. <Intentionally left blank>

308. <Intentionally left blank>

309. <Intentionally left blank>

310. <Intentionally left blank>

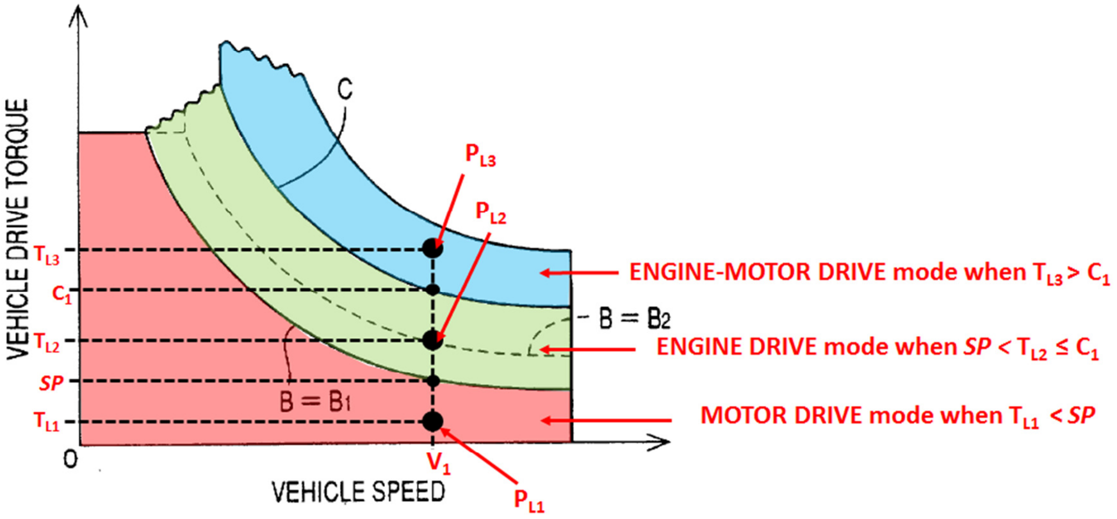
B. Dependent Claim 24

… ***[24] The method of claim 23, comprising the further step of employing said controller to monitor patterns of vehicle operation over time and vary said setpoint SP accordingly.***

311. I understand that the recited *setpoint (SP)* is proposed to mean a "predetermined torque value."

312. As I illustrate below and discussed regarding limitations **[23.5]** and **[23.7]-[23.9]** above, Ibaraki '882 discloses a control strategy that selects a "MOTOR DRIVE mode," "ENGINE DRIVE mode" and "ENGINE-MOTOR DRIVE mode" by determining the "current vehicle drive torque" (T_{L1}, T_{L2}, T_{L3}) corresponding to a point of "required drive power P_L" (P_{L1}, P_{L2}, P_{L3}) at a given vehicle speed (V_1). Ibaraki '882 discloses operating the vehicle in a "MOTOR DRIVE mode" (highlighted in red) when *road load* (T_{L1}) is less than *setpoint* (*SP*). Ibaraki '882 also discloses operating the vehicle in an "ENGINE DRIVE mode" (highlighted in green) when *road load* (T_{L2}) is between the *setpoint* (*SP*) and the torque C_1 on boundary line C, which, as explained above, is less than or equal to the engine's MTO. Ibaraki '882 also discloses operating the vehicle in an "ENGINE-MOTOR DRIVE mode" (highlighted in blue) when *road load* (T_{L3}) is greater than the torque C_1. The "ENGINE-MOTOR DRIVE mode" is operated when the road load (T_{L3}) is greater than the engine's MTO.

FIG. 11



Ex. 1403 [Ibaraki '882] at Fig. 11 (Annotated)

313. The background section of Ibaraki '882 explains that it was known to a person having ordinary skill in the art that operating hybrid vehicles on a mountain path may result in the vehicle being operated in the "ENGINE-DRIVE mode" more frequently thereby resulting in an unwanted overcharging of the vehicle's battery.

> During running of the vehicle on a mountain path, the vehicle load is generally high, and the vehicle is more frequently operated in the engine drive mode, whereby the electric energy storage device tends to be excessively charged by the engine through the electric generator while the vehicle is less frequently operated in the motor drive mode.

(Ex. 1403 [Ibaraki '882] at 2:34-40.)

314. Ibaraki '882 discloses *monitoring the patterns of vehicle operation over time* in order to determine when the vehicle is being operated on a mountain path and *adjusting the setpoint* from "B_1" to "B_2" in order to prevent such overcharging over the

battery. By *monitoring the pattern of vehicle operation over time*, Ibaraki '882 states the *setpoint (SP)* can be adjusted from boundary line "B_1" to "B_2" to increase the "MOTOR DRIVE mode" region, thereby preventing excessive charging of the battery when the vehicle travels in a mountainous area.

> In the present vehicle drive control apparatus 110, **the range of the vehicle running condition in which the vehicle is driven in the MOTOR DRIVE mode by operation of only the motor 114 is enlarged by shifting the first boundary line B to the motor driving range enlarging position B2**, if the sum SOC_{RT} of the electric energy stored in the electric energy storage device 136 during running of the vehicle in the REGENERATIVE DRIVE mode in step Q14 is equal to or larger than the reference value D, or if the ratio SOC_{RT} /SOC is equal to or larger than the reference value E. As a result of enlargement of the motor driving range, the amount of consumption of the electric energy by the motor 114 is increased. **The present arrangement is effective to prevent excessive charging of the electric energy storage device 136 during running of the vehicle on a mountain path**, thereby preventing reduction of the energy conversing efficiencies η_{BIN} and η_{BOUT} of the device 136 or a failure to charge the device 136. Further, the enlargement of the motor driving range results in reducing the frequency of operation of the engine 112, and consequent reduction of the fuel consumption by the engine 112 and the amount of exhaust gas emission from the engine 112.

(Ex. 1403 [Ibaraki '882] at 24:39-60, emphasis added; *see also* 7:47-52.)

315. In order to monitor the pattern of vehicle operation, Ibaraki '882 begins

at step "Q1" where the controller receives "various input signals including the signals indicative of the operating amount θ_A of the accelerator pedal, engine speed Ne, transmission input and output speeds N_i, No, charging amount SOC, engine torque T_E, motor torque T_M and currently selected position S_H of the shift lever 126." (Ex. 1403 [Ibaraki '882] at 22:3-9.)

316. At step "Q2," Ibaraki '882 determines "whether the accelerator pedal is placed at a fully retracted or non-operated position, namely, whether the operating amount θ_A of the accelerator pedal is substantially zero or not." (Ex. 1403 [Ibaraki '882] at 22:13-19.)

317. As I have illustrated below, if the controller determines that a driver has lifted their foot off the accelerator pedal (step "Q2" = YES) and the vehicle shift lever is placed in a driving state (step "Q13" = YES), the controller proceeds to step "Q14" to execute the "REGENERATIVE DRIVING mode" sub-routine. (Ex. 1403 [Ibaraki '882] at 22:34-37.)

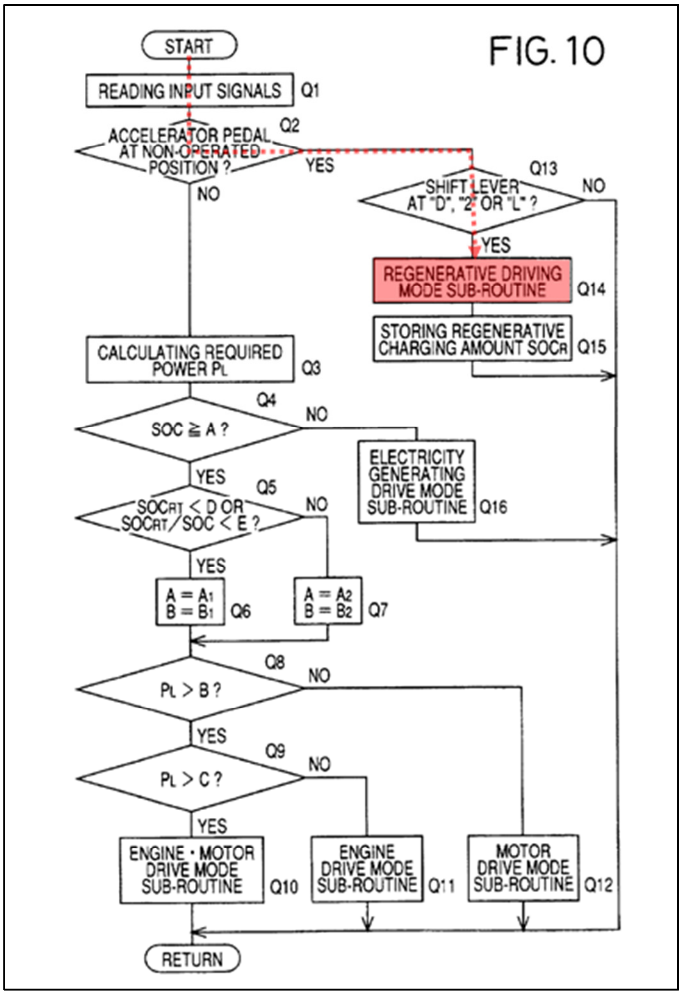


FIG. 10

Ex. 1403 [Ibaraki '882] at Fig. 10 (Annotated)

318. Ibaraki '882 explains that the "REGENERATIVE DRIVING mode" of step "Q14" is executed by the controller to recapture kinetic energy to charge the battery.

> If an affirmative decision (YES) is obtained in step Q13, the control flow goes to step Q14 in which a sub-routine for running the vehicle in the REGENERATIVE DRIVE mode is executed under the control of the regenerative driving means 168 so that the motor 114 is driven by the kinetic energy of the running vehicle to charge the electric energy storage device 136 while a brake is applied to the vehicle. The

> regenerative braking torque of the motor 114 in this sub-routine is controlled depending upon the running condition of the vehicle, such as the vehicle running speed V and the brake pedal depression force.

(Ex. 1403 [Ibaraki '882] at 22:19-30.)

319. The control strategy then proceeds to step "Q15" where the controller stores in memory the regenerative charging amount (SOC_R) that the battery received during "REGENERATIVE DRIVING mode" of step "Q14."

> Then, the control flow goes to step Q15, which is implemented by the regenerative charging amount detecting means 172 to detect the regenerative charging amount SOC_R of the electric energy storage device 136 in the REGENERATIVE DRIVE mode. The detection of the amount SOC_R is based on the current of the motor 114 and the charging efficiency η_{BIN} of the device 136. **The detected amount $SOC\eta_R$ [*sic* "SOC_R") is stored in the memory means 174**. The charging efficiency η_{BIN} may be obtained on the basis of the charging amount SOC and according to a predetermined relationship between the efficiency η_{BIN} and the charging amount SOC, which relationship is represented by a data map stored in a suitable memory means such as the RAM of the controller 128.

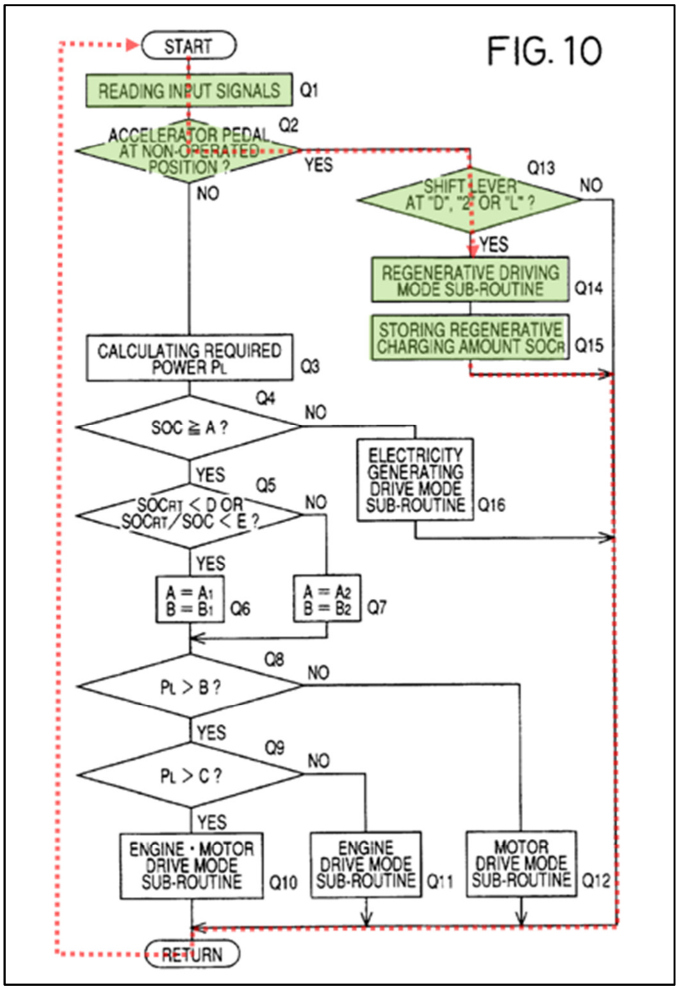
(Ex. 1403 [Ibaraki '882] at 22:43-56, emphasis added.)

320. Each time the controller executes step "Q15," the regenerative charging amount (SOC_R) is summed with prior regenerative charging amounts and a sum regenerative charging amount (SOC_{RT}) is maintained in memory.

> As indicated above, the regenerative charging amount memory means 174 stores the sum SOC_{RT} of the regenerative charging amount values SOC_R which have been detected for the predetermined time duration or during vehicle running by the predetermined distance. Namely, a predetermined number of the data values SOC_R are always stored in the memory means 174 such that the oldest data value is erased each time the new data value is stored in step Q15, so that the sum SOC_{RT} is updated with the vehicle running time or distance.

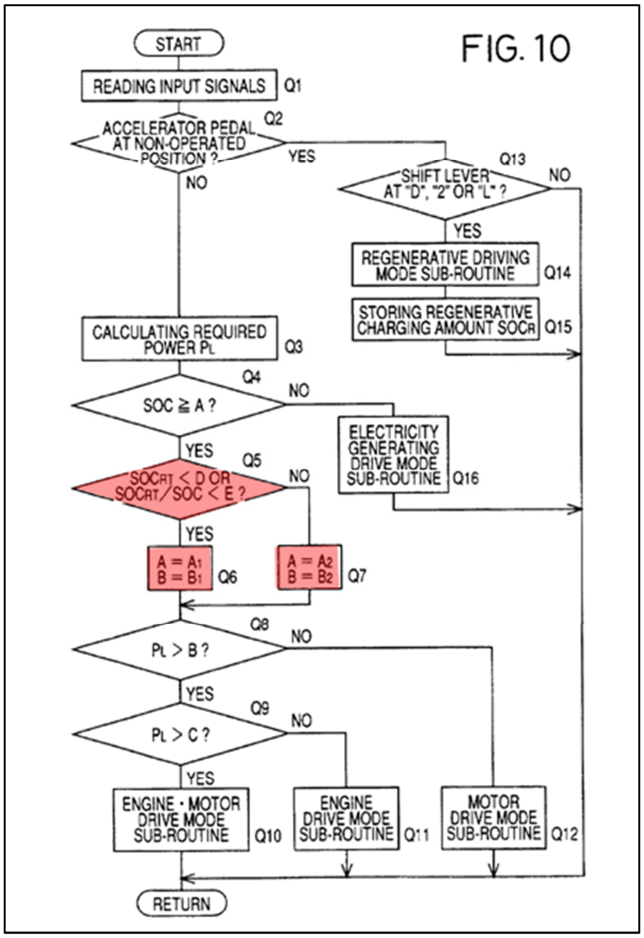
(Ex. 1403 [Ibaraki '882] at 22:56-65.)

321. As I have annotated below, Ibaraki '882 continues to update and store the sum regenerative charging amount (SOC_{RT}) in memory as the vehicle continually enters the "REGENERATIVE DRIVING mode."



Ex. 1403 [Ibaraki '882] at Fig. 10 (Annotated)

322. Once the driver begins to press down on the accelerator pedal, the control strategy will depart from this routine and eventually may proceed to step "Q5" where a set of equalities are evaluated using the stored sum regenerative charging amount (SOC_{RT}).



Ex. 1403 [Ibaraki '882] at Fig. 10 (Annotated)

323. Step "Q5" then determines whether the *setpoint* should remain at boundary line "B_1" or whether the *setpoint* should be adjusted to boundary line "B_2" using the stored sum regenerative charging amount (SOC_{RT}).

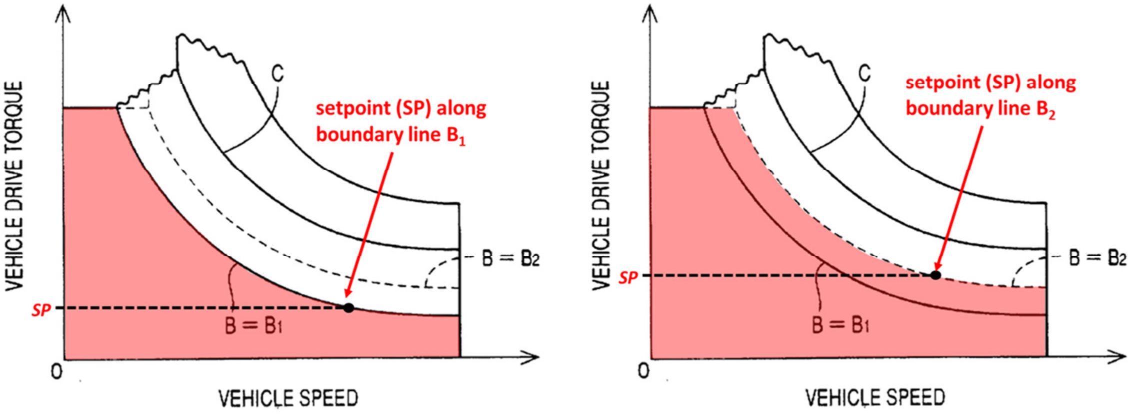
> If the affirmative decision (YES) is obtained in step Q4, the control flow goes to step Q5, which is implemented by the regenerative charging amount determining means 176, to determine whether the sum SOC_{RT} of the regenerative charging amount values SOC_R stored in the memory means 174 is smaller than the reference value D, or whether the ratio SOC_{RT}/SOC is smaller than the reference value E. If an affirmative decision (YES) is obtained in step Q5, that is, if SOC_{RT} <D and/or if

> SOC_{RT} /SOC<E, step Q6 is implemented to determine the lower limit A at the standard value A1 and locate the first boundary line B at the normal position B1. If a negative decision (NO) is obtained in step Q5, that is if SOC_{RT} ≧D and/or if SOC_{RT} /SOC≧E, step Q7 is implemented to reduce the lower limit A from the standard value A1 to a smaller value A2 and shift the first boundary line B from the normal position B1 to the motor driving range enlarging position B2.

(Ex. 1403 [Ibaraki '882] at 23:33-49.)

324. As I have annotated below, Figure 11 illustrates when the *setpoint(s)* remain at boundary line "B$_1$" and when the *setpoint(s)* are adjusted to boundary line "B$_2$." When the *setpoint(s)* are adjusted to boundary line "B$_2$" the "MOTOR DRIVE mode" region is enlarged so that the electric motor will be used to propel the vehicle at higher *road load* levels (*i.e.*, higher "vehicle drive torque" levels).

FIG. 11 FIG. 11



Ex. 1403 [Ibaraki '882] at Fig. 11 (Annotated)

325. Ibaraki '882 explains that enlarging the "MOTOR DRIVE mode" region will effectively reduce the amount of stored energy captured when the vehicle is

operated on a mountain path. A person having ordinary skill in the art would therefore understood that Ibaraki '882 monitors and stores in memory the sum regenerative charging amount (SOC_{RT}) that is acquired while the vehicle is operated in the "REGENERATIVE CHARGING mode." The control strategy then evaluates this stored regenerative charging amount (SOC_{RT}) against a pair of equalities to determine whether the *pattern of vehicle operation* indicates the vehicle has been operated on a mountain path. If the vehicle has been operated on a mountain path and the regenerative charging amount is large, Ibaraki '882 discloses that the *setpoint* can be adjusted to be along the threshold "B_2" to effectively use the excessive charging energy that was acquired when the vehicle was operated on a mountain path. This excessive charging energy is used by enlarging the operating region of the "MOTOR DRIVE mode."

> This arrangement is advantageous to effectively utilize the electric energy stored in the electric energy storage device 136 during running of the vehicle on a mountain path in which the sum SOC_{RT} of the regenerative charging amount values SOC_R tends to be large.

(Ex. 1403 [Ibaraki '882] at 23:57-62.)

326. Ibaraki '882 also discloses *monitoring the pattern of vehicle operation over time* to determine if the vehicle is being operated according to a predetermined condition, such as on a mountain path. If the controller determines that the *pattern of vehicle operation over time* along a mountain path is detected due to an increased stored sum

regenerative charging amount (SOC_{RT}), the *setpoint* is adjusted so that the "MOTOR DRIVE mode" region will be used when the vehicle is ascending a mountain path.

> As indicated above, the regenerative charging amount memory means 174 stores the sum SOC_{RT} of the regenerative charging amount values SOC_R which have been detected for the predetermined time duration or during vehicle running by the predetermined distance. Namely, a predetermined number of the data values SOC_R are always stored in the memory means 174 such that the oldest data value is erased each time the new data value is stored in step Q15, so that the sum SOC_{RT} is updated with the vehicle running time or distance.

(Ex. 1403 [Ibaraki '882] at 22:56-65.)

327. It is therefore my opinion that Ibaraki '882 discloses *wherein said controller monitors patterns of vehicle operation over time and varies said setpoint SP accordingly.*

328. <Intentionally left blank>

329. <Intentionally left blank>

C. Dependent Claim 28

> … ***[28.0] The method of claim 23, wherein said vehicle is operated in a plurality of operating modes responsive to the values for the road load RL and said setpoint SP, said operating modes including:***

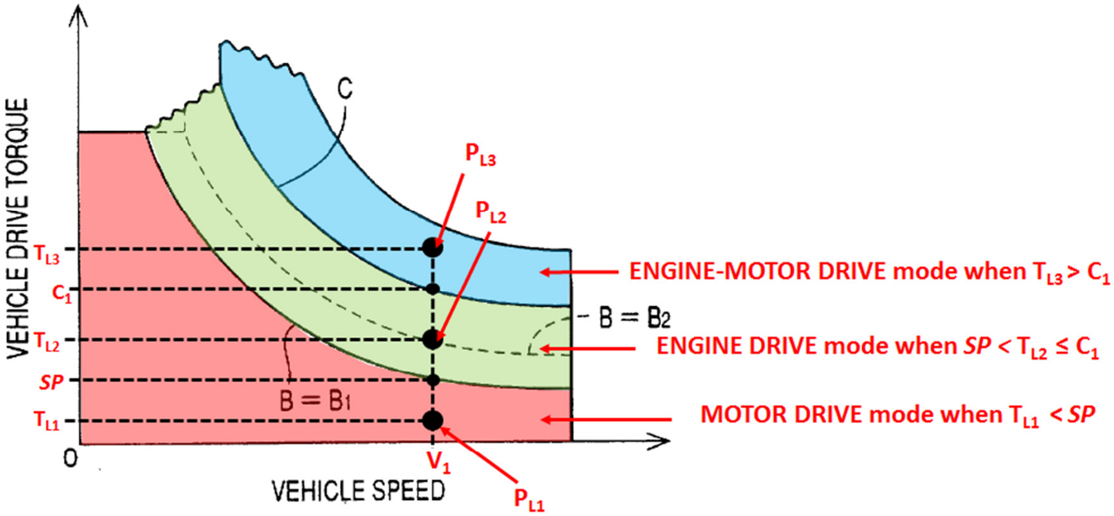
330. As discussed above with regard to claims **[23.7] - [23.9]**, Ibaraki '882 discloses a plurality of operating modes based on the "vehicle running condition as represented by the current vehicle drive torque," which is *road load*, "and speed V"

shown in Figs. 10 and 11. (*See*, *e.g.*, Ex. 1403 [Ibaraki '882] at 20:38-21:1.)

331. As I also explained in paragraphs 190-197, for example, a torque *setpoint* (*SP*) along boundary line B would be known at the current vehicle speed (V_1). This *setpoint* (*SP*) marks a transition between the MOTOR DRIVE mode (discussed in limitation **[23.7]**) and the ENGINE DRIVE mode (discussed in limitation **[23.8]**).

332. As I have annotated below, Ibaraki '882 uses the exemplary data map of Figure 11 to determine when to operate the vehicle in a *plurality of operating modes* that include: (1) a "MOTOR DRIVE mode" (highlighted in red); (2) an "ENGINE DRIVE mode" (highlighted in green); or (3) an "ENGINE-MOTOR DRIVE mode" (highlighted in blue). (Ex. 1403 [Ibaraki '882] at 23:66-24:24:27.) As further annotated below, these operating modes are based on the determined *road load* (corresponding to T_{L1}, T_{L2}, T_{L3}) and the *setpoint (SP)* along boundary line B.

FIG. 11



Ex. 1403 [Ibaraki '882] at Fig. 11 (annotated)

333. It is therefore my opinion that Ibaraki '882 discloses that the *vehicle is operated in a plurality of operating modes responsive to the values for the road load* RL *and said setpoint SP*.

334. <Intentionally left blank>

335. <Intentionally left blank>

> … ***[28.1] 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,***

336. It is my understanding the term *low-load mode I* as used in the claims is proposed to mean "the mode of operation in which energy from the battery bank flows to the traction motor and torque (rotary force) flows from the traction motor to the road wheels."

337. As I discussed in limitation **[23.3]** and **[23.7]**, Ibaraki '882 discloses an "electric motor 114" that may be selectively operated in a "DRIVE state" where the motor uses electric energy supplied from the battery to propel the vehicle.

> The **dynamo-electric motor 114 is connected to an electric energy storage device (electric power supply device) 136 in the form of a battery or condense**r, for example, through a motor/generator control device (hereinafter abbreviated as "M/G control device) 134 so that the motor 114 is selectively placed in a DRIVE state, a CHARGING state, and a NON-LOAD state. **In the DRIVE state, the motor 114 is driven by an electric energy supplied from the electric energy**

> **<u>storage device 136.</u>** In the CHARGING state, the motor 114 functions as an electric generator or dynamo, with regenerative braking (braking torque electrically generated by the motor 114 itself), for storing an electric energy in the electric energy storage device 136. In the NON-LOAD state, the output shaft of the motor 114 is permitted to rotate freely.

(Ex. 1403 [Ibaraki ’882] at 19:55-20:9, emphasis added.)

338. Ibaraki ’882 discloses that the “DRIVE state” is used when the vehicle is operated in a “MOTOR DRIVE mode” where the hybrid vehicle is propelled using the electric motor when *road load* (*i.e.*, T_{L1}) is less than *setpoint* (boundary line “B”).

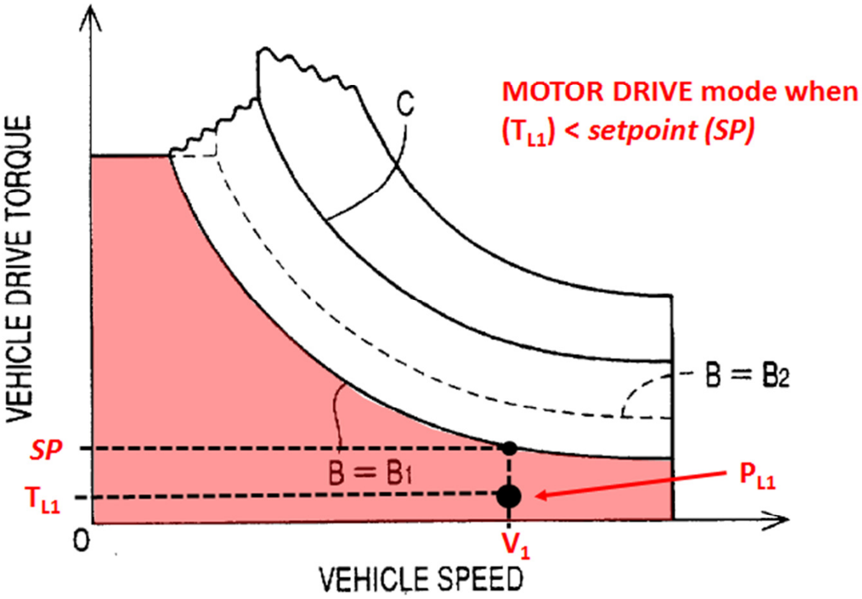
> Step Q6 and Q7 are followed by step Q8 to determine whether a point corresponding to the required drive power P_L (determined by the current vehicle drive torque and speed V) is located above the first boundary line B. . . . If a negative decision (NO) is obtained in step Q8, that is, if the point of the required drive power P_L is located below the first boundary line B or in the motor driving range, the control flow goes to step Q12 in which a sub-routine for running the vehicle in the MOTOR DRIVE mode is executed. . . . **<u>The MOTOR DRIVE mode sub-routine of step Q12 is executed by the motor driving means 166 so that the vehicle is driven by operation of only the motor 114</u>**.

(Ex. 1403 [Ibaraki ’882] at 23:66- 24:23, emphasis added.)

339. As discussed in limitation [23.7], and as I have annotated below, Ibaraki ’882 discloses using the following exemplary data map to determine when to operate the vehicle in a “MOTOR DRIVE mode” (highlighted in red) based on whether the

determined *road load* (*i.e.*, torque T_{L1}) is below the *setpoint* (*SP*) along boundary line "B". (*See e.g.,* Ex. 1403 [Ibaraki '882] at 20:55-63.)

FIG. 11



Ex. 1403 [Ibaraki '882] at Fig. 11 (Annotated)

340. It is therefore my opinion that Ibaraki '882 discloses *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*.

> … ***[28.2] a highway cruising mode IV, wherein said vehicle is propelled by torque provided by said internal combustion engine, while SP<RL<MTO, and***

341. It is my understanding the "high-way cruising operation mode IV" as used in the claims is proposed to mean "the mode of operation in which energy flows

from the fuel tank into the engine and torque (rotary force) flows from the engine to the road wheels."

342. As I discussed in limitations **[23.1]** and **[23.8]**, Ibaraki '882 discloses an "internal combustion engine 112" that may be selectively operated to transfer propulsive power to the drive wheels. Ibaraki '882 also states that the gasoline engine may be operated by combustion of fuel that a person having ordinary skill in the art would have understood as being supplied from a fuel tank.

> The vehicle drive control apparatus 110 is arranged to control a hybrid vehicle **equipped with an internal combustion engine 112 such as a gasoline engine operated by combustion of a fuel**, and a dynamo-electric motor 114 which functions as an electric motor operated by an electric energy and an electric generator or dynamo for generating electricity. **Power of the internal combustion engine 112** and power of the electric motor 114 **are simultaneously or selectively transferred to a transmission 116, and to right and left drive wheels 120** via a speed reduction gear 118 and a differential gear.

(Ex. 1403 [Ibaraki '882] at 19:18-27.)

343. As I also discussed above in limitation **[23.8]**, Ibaraki '882 discloses an "ENGINE DRIVE mode" where the engine is operated to propel the vehicle.

> **That is, the controller 128 has** a MOTOR DRIVE mode in which the motor 114 is selected as the drive power source, **an ENGINE DRIVE mode in which the engine 112 is selected as the drive power source**, and an ENGINE-MOTOR DRIVE mode in which both the engine 112 and the motor 114 are selected as the drive power sources.

(Ex. 1403 [Ibaraki '882] at 20:43-53, emphasis added.)

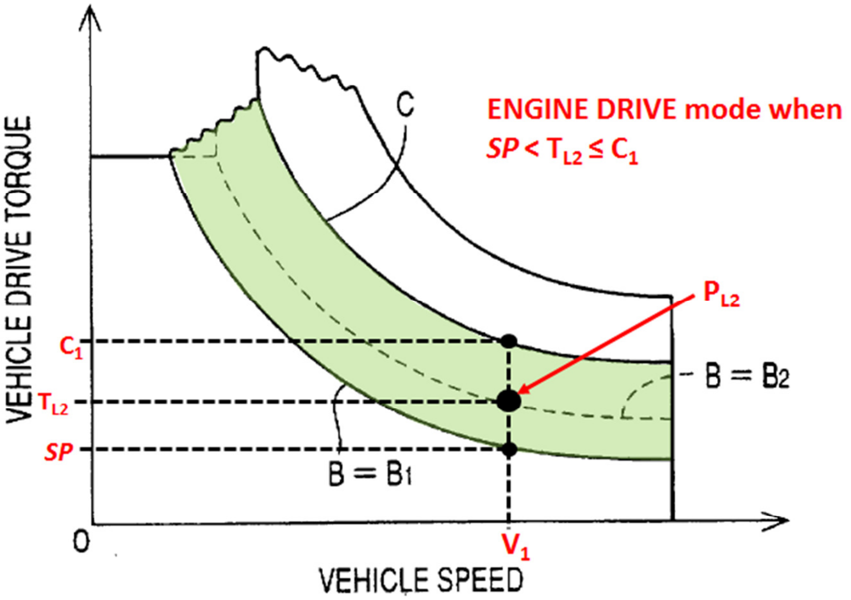
344. Ibaraki '882 discloses that the "ENGINE DRIVE mode" uses the engine to propel the vehicle when the *road load* (T_{L1}) is above the *setpoint* (boundary line "B") and equal to or below a corresponding torque along boundary line "C" (*i.e. setpoint* < *road load* ≤ C).

> Step Q6 and Q7 are followed by step Q8 to determine whether a point corresponding to the required drive power P_L (determined by the current vehicle drive torque and speed V) is located above the first boundary line B. If an affirmative decision (YES) is obtained in step Q8, the control flow goes to step Q9 to determine whether the point of the required drive power P_L is located above the second boundary line C. . . . **If the point of the required drive power P_L is located above the first boundary line B and on or below the second boundary line C**, that is, if a negative decision (NO) is obtained in step Q9, the control flow goes to step Q11 in which a sub-routine for running the vehicle in the ENGINE DRIVE mode is executed.

(Ex. 1403 [Ibaraki '882] at 23:66-24:16, emphasis added.)

345. As I have annotated below, Ibaraki '882 discloses using the following exemplary data map to determine when to operate the vehicle in a "ENGINE DRIVE mode" (highlighted in green) based on whether the determined *road load* (*i.e.,* torque (T_{L2}) is above the *setpoint* (*SP*) and below the torque C_1 along the boundary line "C." (*See e.g.,* Ex. 1403 [Ibaraki '882] at 20:55-66.)

FIG. 11



Ex. 1403 [Ibaraki '882] at Fig. 11 (Annotated)

346. It is therefore my opinion that Ibaraki '882 discloses *a highway cruising mode IV, wherein said vehicle is propelled by torque provided by said internal combustion engine, while SP<RL<MTO.*

347. <Intentionally left blank>

348. <Intentionally left blank>

… ***[28.3] 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.***

349. It is my understanding the "acceleration mode V" as used in the claims is proposed to mean "the mode of operation in which energy flows from the fuel tank

to the engine and from the battery bank to at least one motor and torque (rotary force) flows from the engine and at least one motor to the road wheels."

350. As discussed above in **[23.9]**, Ibaraki '882 discloses an "ENGINE-MOTOR DRIVE mode" where both the IC engine and electric motor are operated to propel the vehicle.

> **That is, the controller 128 has** a MOTOR DRIVE mode in which the motor 114 is selected as the drive power source, an ENGINE DRIVE mode in which the engine 112 is selected as the drive power source, and **an ENGINE-MOTOR DRIVE mode in which both the engine 112 and the motor 114 are selected as the drive power sources**.

(Ex. 1403 [Ibaraki '882] at 20:43-53, emphasis added.)

351. Ibaraki '882 discloses that the "ENGINE-MOTOR DRIVE mode" uses both the IC engine and electric motor to propel the vehicle when the *road load* (*i.e.*, torque T_{L3}) is greater than the torque (C_1) along the boundary line "C" (*i.e.* *road load* > "C").

> Step Q6 and Q7 are followed by step Q8 to determine whether a point corresponding to the required drive power P_L (determined by the current vehicle drive torque and speed V) is located above the first boundary line B. If an affirmative decision (YES) is obtained in step Q8, the control flow goes to step Q9 to determine whether the point of the required drive power P_L is located above the second boundary line C. . . . **If the point of the required drive power P_L is located above the second boundary line, that is if an affirmative decision (YES) is obtained in step Q9, the control flow goes to step Q10 in which a sub-**

> **<u>routine for running the vehicle in the ENGINE-MOTOR DRIVE mode is executed</u>**. . . . The ENGINE-MOTOR DRIVE sub-routine of step Q10 is executed by the engine driving means 164 and the motor driving means 164 so that the vehicle is driven by operation of both the engine 112 and the motor 114.

(Ex. 1403 [Ibaraki '882] at 23:66- 24:30, emphasis added.)

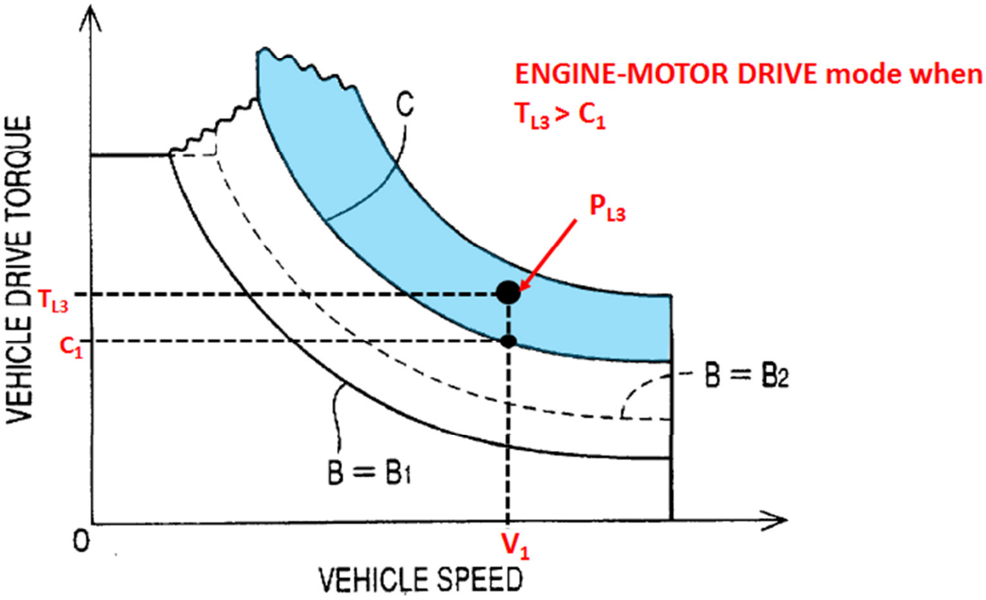
352. Again, it is my opinion that a person having ordinary skill in the art would have understood the torque points along the predetermined boundary line "C" would be at or below the maximum torque output (MTO) of the engine since the engine **<u>cannot</u>** operate past its MTO. As such, because the engine operates in the "ENGINE-DRIVE mode" at each point between boundary lines "B" and "C", a person having ordinary skill in the art would have understood that boundary line "C" is at or below the IC engine's MTO.

353. As I stated in paragraphs 276-279 above, a person having ordinary skill in the art would have further understood that the "ENGINE-MOTOR DRIVE mode" would have provided vehicle drive torque beyond that of the IC engine's maximum torque output and the electric motor's maximum torque output. A person having ordinary skill would have understood that one advantage of hybrid vehicles is the ability to combine the output of both power sources individual output capabilities. As such, a person having ordinary skill in the art would have understood that the "ENGINE-MOTOR DRIVE mode" would have included a region where the vehicle is propelled by the IC engine and electric motor when the *road load* is beyond the IC

engine's maximum torque output.

354. As I have annotated below, Ibaraki '882 therefore discloses using the following exemplary data map to determine when to operate the vehicle in a "ENGINE-MOTOR DRIVE mode" (highlighted in blue) based on whether the determined *road load* (torque T_{L3}) is above point C_1 along the boundary line "C." (*See e.g.,* Ex. 1403 [Ibaraki '882] at 20:55-63.)

FIG. 11



Ex. 1403 [Ibaraki '882] at Fig. 11 (Annotated)

355. It is therefore my opinion that Ibaraki '882 discloses *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.*

356. <Intentionally left blank>

357. <Intentionally left blank>

D. Dependent Claim 30

… ***[30.0] The method of claim 28, comprising the further step of decoupling said engine from said wheels during operation in mode I and***

358. As discussed in claim **[23.4]** above, Ibaraki ’882 illustrates a “clutch 130” which is highlighted yellow below.

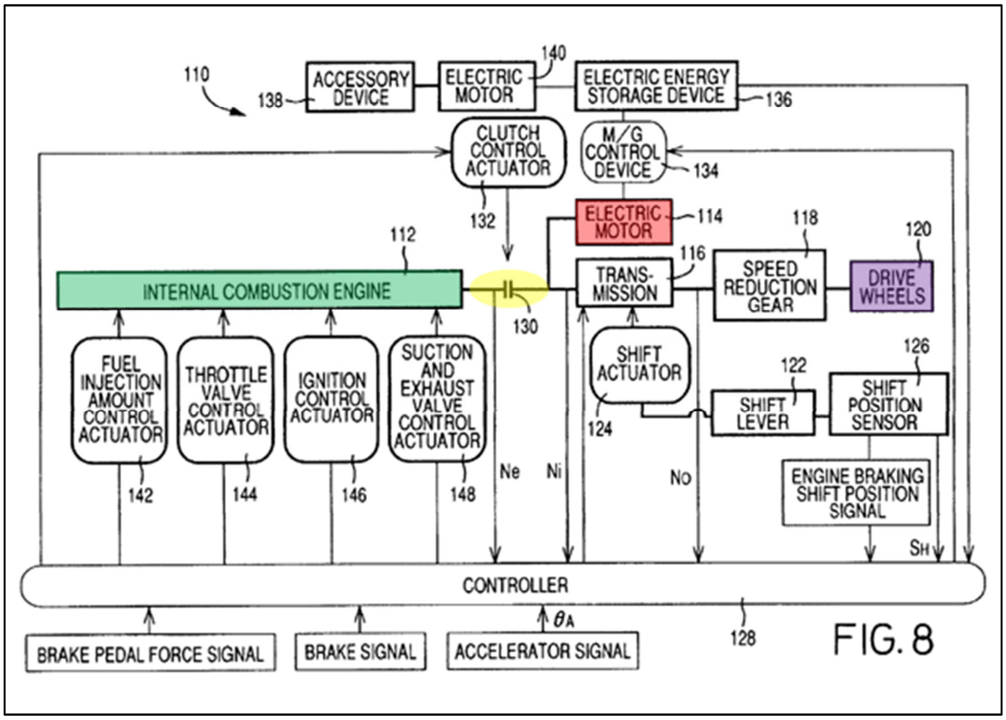


FIG. 8

Ex. 1403 [Ibaraki ’882] at Fig. 8 (annotated)

359. Ibaraki ’882 further discloses that the “clutch 130” is used to couple (*i.e.*, connect and disconnect) the IC engine to the drive wheels.

> A clutch 130 is disposed between the engine 112 and the transmission 116, for connecting and disconnecting the engine 112 and transmission

> 116. **The clutch 130 is engaged and released by a clutch control actuator 132**. The clutch 130 is normally placed in the fully engaged state.

(Ex. 1403 [Ibaraki '882] at 19:50-54, emphasis added.)

360. Ibaraki '882 further discloses that when the vehicle is operated in "MOTOR DRIVE mode" or *mode I*, the clutch is used to decouple (disconnect) the engine from the drive wheels. The engine is disconnected so that the electric motor can be used to propel the vehicle.

> When the vehicle is operated in the MOTOR DRIVE mode in step Q12, **the clutch 130 is placed in the fully released state to disconnect the engine 112** and the motor 114 from each other.

(Ex. 1403 [Ibaraki '882] at 24:35-38, emphasis added.)

361. Ibaraki '882 therefore discloses *decoupling said engine from said wheels during operation in mode I*.

362. <Intentionally left blank>

363. <Intentionally left blank>

364. <Intentionally left blank>

… ***[30.1] coupling said engine to said wheels during operation in modes IV and V.***

365. Again, Ibaraki '882 discloses that the clutch is placed in a fully released state in "MOTOR DRIVE mode" to disconnect the engine from the drive wheels. (Ex. 1403 [Ibaraki '882] at 24:35-38.)

366. Ibaraki ’882 also discloses that the clutch is normally placed in the fully engaged state.

> A clutch 130 is disposed between the engine 112 and the transmission 116, for connecting and disconnecting the engine 112 and transmission 116. **The clutch 130 is engaged and released by a clutch control actuator 132. The clutch 130 is normally placed in the fully engaged state**.

(Ex. 1403 [Ibaraki ’882] at 19:49-54, emphasis added.)

367. A person having ordinary skill would have therefore understood that the clutch would be engaged at all times except during operation in the “MOTOR DRIVE mode.”

368. A person having ordinary skill would have understood that the clutch would be engaged during operation in both (1) the “ENGINE DRIVE mode” or *mode IV*; and (2) the “ENGINE-MOTOR DRIVE mode” or *mode V*. In particular, a person having ordinary skill in the art would have understood that the clutch would be engaged during the “ENGINE DRIVE mode” and “ENGINE-MOTOR DRIVE mode” so that the IC engine could provide propulsive power to the drive wheels. Such a person having ordinary skill would have understood that if the clutch was not engaged the IC engine would have been disconnected from the drive wheels and would not be capable of providing propulsive power.

369. It is therefore my opinion that Ibaraki ’882 discloses *coupling said engine to said wheels during operation in modes IV and V*.

370. <Intentionally left blank>

371. <Intentionally left blank>

E. Dependent Claim 32

… ***[32.0] The method of claim 28, comprising the further step of operating said controller to monitor RL over time, and***

372. I understand the term *RL* as used in the '347 Patent should be interpreted as "instantaneous torque required to propel the vehicle, be it positive or negative in value."

373. As described in greater detail in claims **[23.7] – [23.9]** above and briefly illustrated below, Ibaraki '882 discloses a "controller 128," which compares the vehicle drive torque (RL) (annotated as T_{L1}, T_{L2} and T_{L3} below) at a given vehicle speed (V_1) to a corresponding *setpoint* (annotated as SP below) along boundary line B to determine whether the vehicle should operate in a MOTOR DRIVE mode or ENGINE DRIVE mode.[29] Ibaraki '882 also discloses comparing the *road load (i.e.*, "vehicle drive torque" annotated as T_{L1}, T_{L2} and T_{L3} below) at a given vehicle speed

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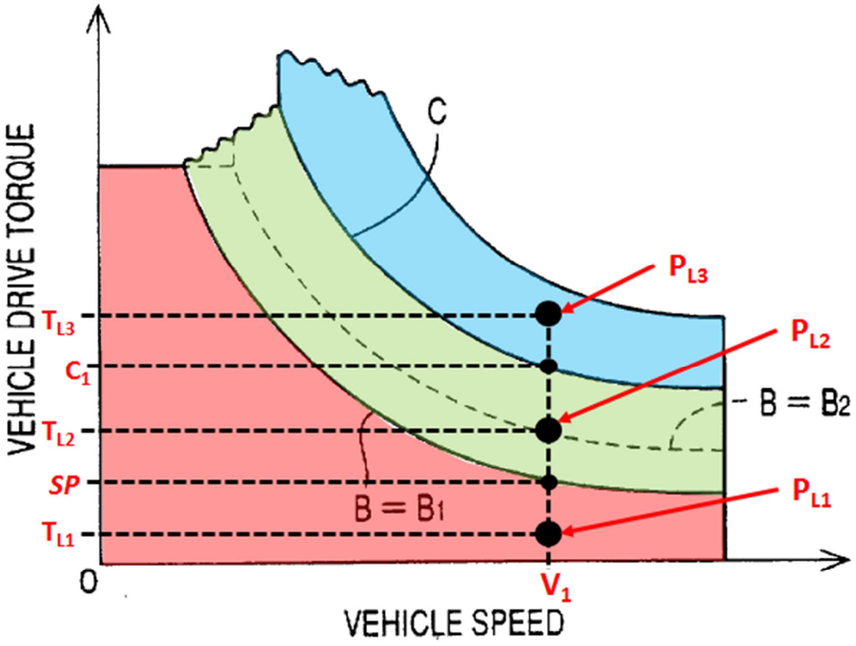
[29] Again, the "vehicle drive torque" at a given vehicle speed is disclosed as being used to determine "a point corresponding to the required drive power P_L" that is annotated on Figure 11 as (P_{L1}, P_{L2}, P_{L3}). (Ex. 1403 [Ibaraki '882] at 23:66-24:2.) The "required drive power P_L" point would have been understood as being "determined" based on a known relationship where Power = Torque * Speed.

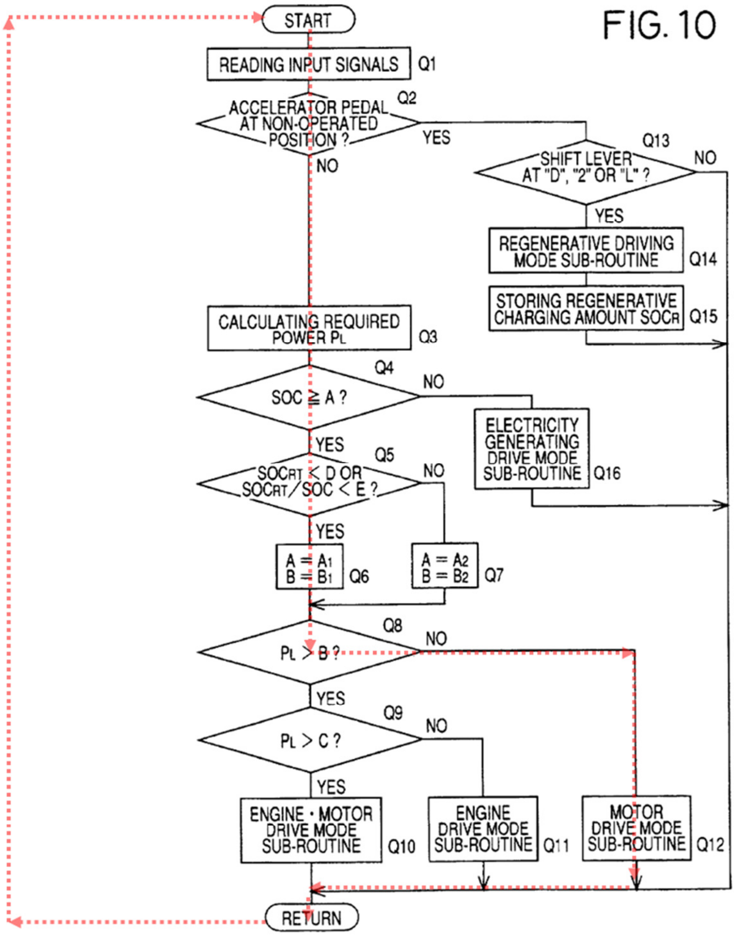
(V_1) to a corresponding torque point (annotated as C_1 below) along boundary line C to determine whether the vehicle should operate in an ENGINE DRIVE mode or ENGINE-MOTOR DRIVE mode.

FIG. 11



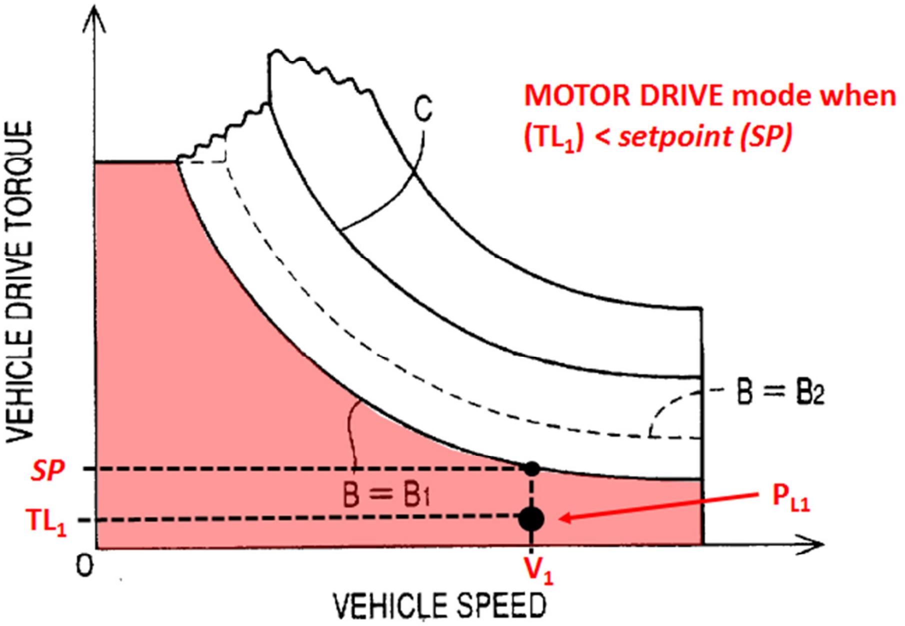
374. A person having ordinary skill in the art would have understood that "controller 128" of Ibaraki '882 must continuously monitor the *road load (RL)* during vehicle operation (*i.e., over time*) so that the controller 128 has the most updated information needed to determine which "drive mode" the vehicle should operate in. The continuous monitoring of the *road load* (RL) is important because it allows the vehicle to more quickly adapt to changing conditions in vehicle operation to ensure that the vehicle is operating in the correct drive mode to maximize both efficiency and the driving experience.

375. Figure 10 of Ibaraki ’882 illustrates a “flow chart showing a routine executed” by the controller 128 for determining which “drive mode” to command the vehicle to operate in. (Ex. 1403 [Ibaraki ’882] at 10:66-67.) As I have annotated below, the control logic of Fig. 10 dictates that the motor propels the vehicle in the “MOTOR DRIVE mode” at step Q12 when the vehicle drive torque (*i.e. road load* and annotated in Fig. 11 as T_{L1} below) corresponding to a point of “required drive power P_L” (annotated as P_{L1} on figure 11 below) is less than a *setpoint* (annotated as *SP* in Figure 11 below) along boundary line B.



Ex. 1403 [Ibaraki ’882] at Fig. 10 (Annotated)

FIG. 11

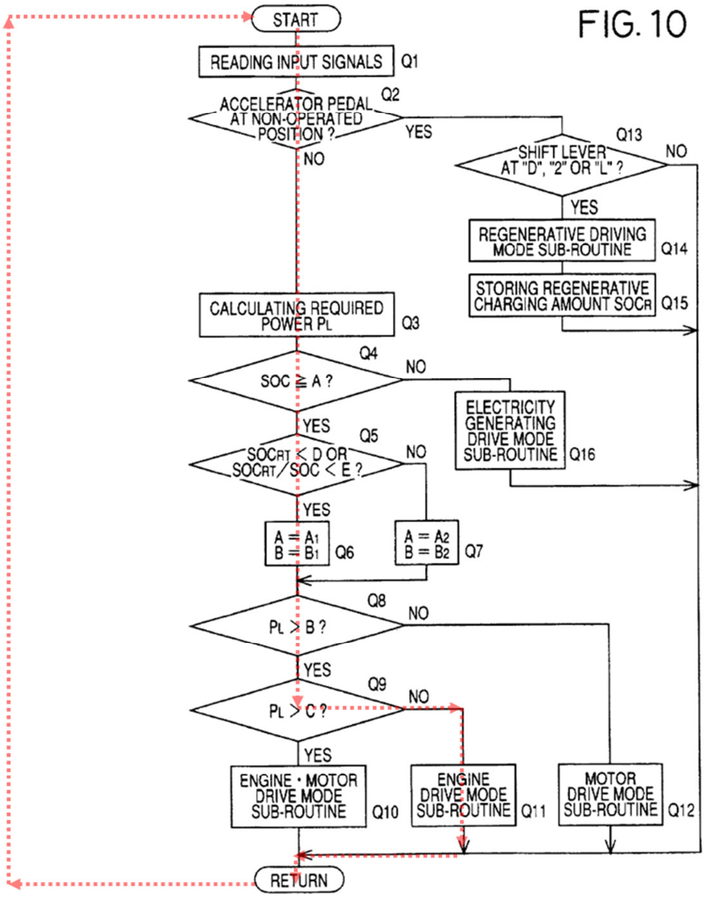


Ex. 1403 [Ibaraki '882] at Fig. 11 (Annotated)

376. As clearly seen in Fig. 10 above, the control strategy of Fig. 10 ends with a step labeled "RETURN." A person having ordinary skill in the art would have understood that logically the "return" step goes back to the "start" step and again analyzes the *road load (RL)* to determine which drive mode to operate in. This is important as vehicle conditions (*e.g.*, vehicle drive torque) may be constantly changing, making it critical that the vehicle continuously update its information to determine the most efficient drive mode in which to operate.

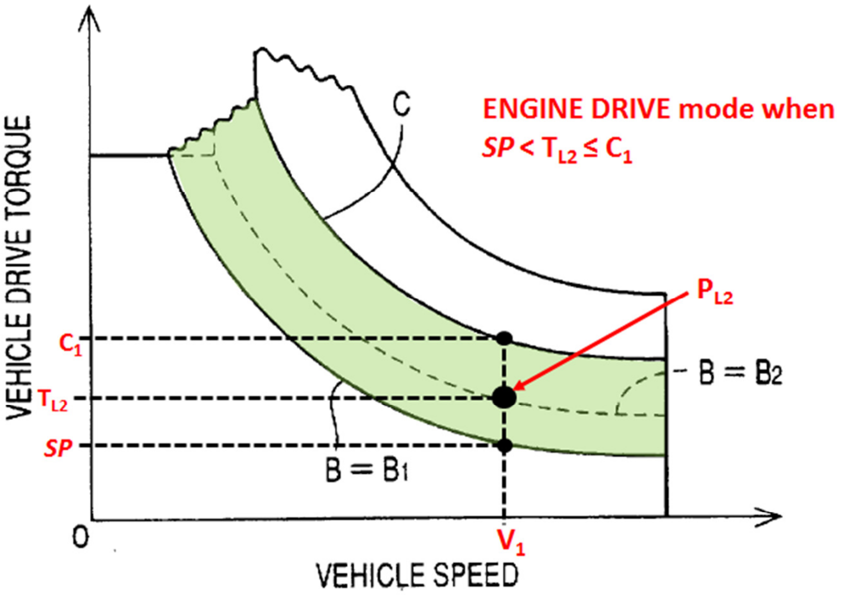
377. Based on the changing of the *road load (RL)*, and as described in above, a subsequent utilization of the control logic of Fig. 10 dictates that the engine propels the vehicle in the "ENGINE DRIVE mode" at step Q11 when the vehicle drive

torque (*i.e.* *road load* and annotated in Fig. 11 as T_{L2} below) associated with a plotted point P_L (annotated as P_{L2} on figure 11 below) is greater than a *setpoint* (annotated as *SP* in Figure 11 below) along "boundary line B" and less than a torque point (C_1) along boundary line C.



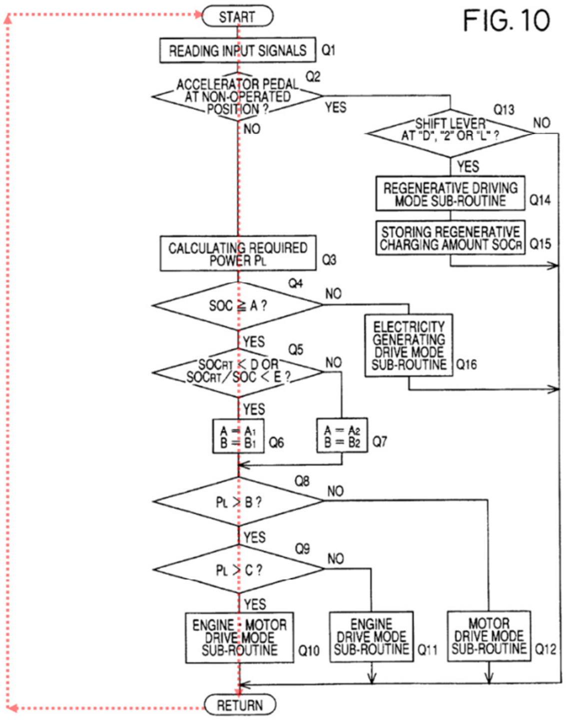
Ex. 1403 [Ibaraki '882] at Fig. 10 (Annotated)

FIG. 11

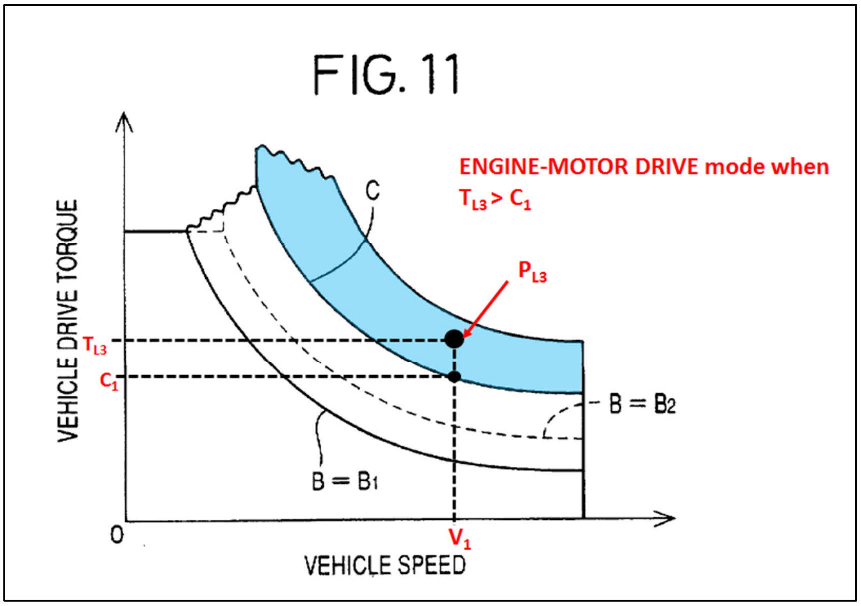


Ex. 1403 [Ibaraki '882] at Fig. 11 (Annotated)

378. As seen again in annotated Fig. 10 above and for the reasons discussed above, the control strategy "returns" to the "start" and again analyzes the *road load (RL)* to determine which drive mode to operate in. Based on the changing of the *road load (RL)*, a subsequent utilization of the control logic of Fig. 10 dictates that the engine propels the vehicle in the "ENGINE-MOTOR DRIVE mode" at step Q10 when the vehicle drive torque (*i.e. road load* and annotated in Fig. 11 as T_{L3} below) associated with a plotted point P_L (annotated as P_{L3} on figure 11 below) is greater than a *setpoint* (annotated as *SP* in Figure 11 below) along "boundary line B" and greater than a torque point (C_1) along boundary line C.



Ex. 1403 [Ibaraki '882] at Fig. 10 (Annotated)



Ex. 1403 [Ibaraki '882] at Fig. 11 (Annotated)

379. It is therefore my opinion that Ibaraki '882 discloses *operating said controller to monitor RL over time.*

380. <Intentionally left blank>

381. <Intentionally left blank>

… ***[32.1] to control the operating mode to change from operation in mode I directly to operation in mode V where a rapid increase in the torque to be applied to the wheels as desired by the operator is detected.***

382. As explained in limitation **[23.3]** (¶¶200-206) above, if Ibaraki '882 determines that the *road load* is below the *setpoint* along boundary line "B" the vehicle is operated in a "MOTOR DRIVE mode" or *mode I*.

383. As I also explained in limitation **[23.5]** (¶¶220-232) above, if Ibaraki '882 determines that the *road load* is above boundary line "C" the vehicle is operated in an "ENGINE-MOTOR DRIVE mode" or *mode V*.

384. Again, Ibaraki '882 discloses determining the operation of the vehicle according to the control strategy that is illustrated in by the flow chart of Figure 10.

> FIG. 10 is a flow chart showing a routine executed by the vehicle drive control apparatus of FIG. 8;

(Ex. 1403 [Ibaraki '882] at 10:66-67.)

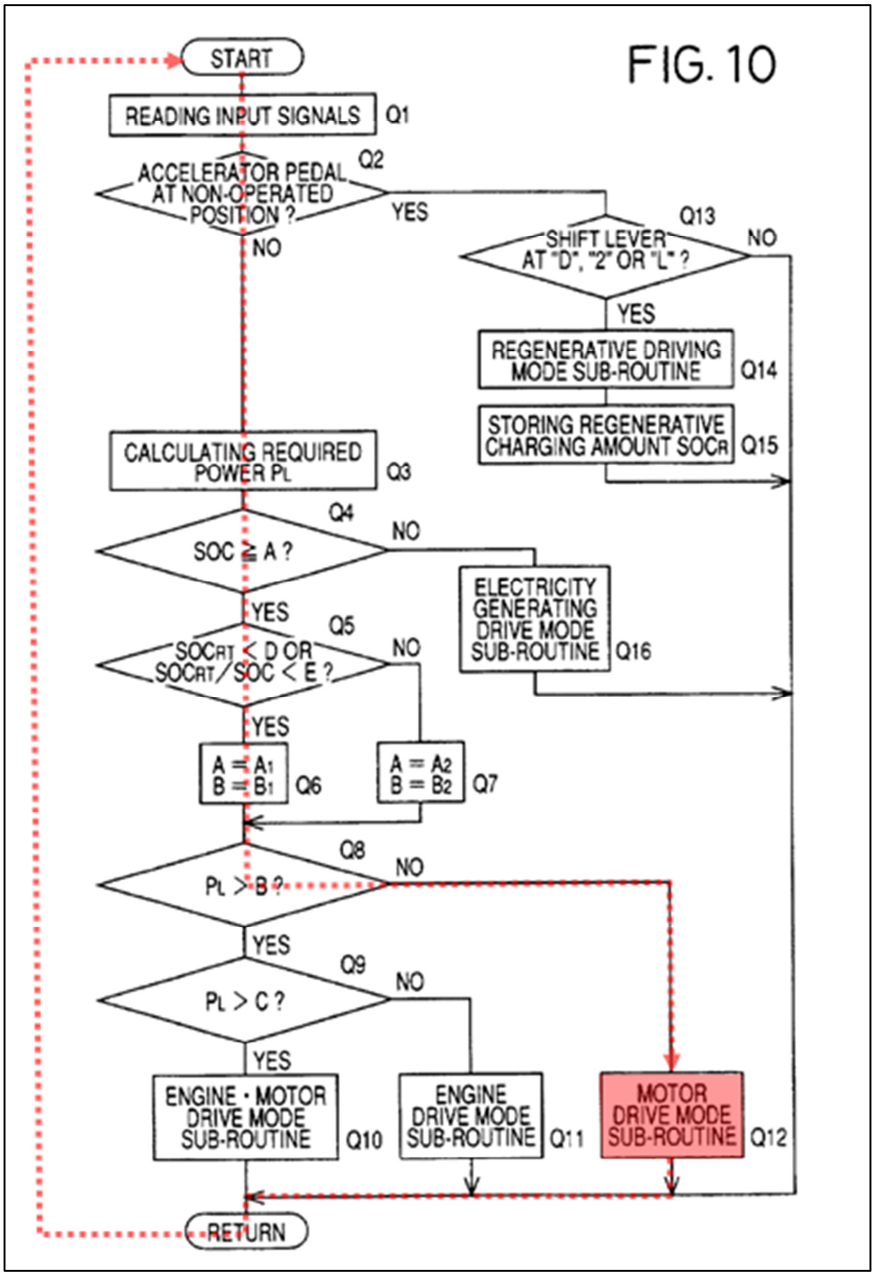
> Referring next to the flow chart of FIG. 10, there will be described an operation of the controller 128 which includes the various functional means shown in FIG. 9.

(Ex. 1403 [Ibaraki '882] at 22:1-3.)

385. Figure 10 illustrates a "RETURN" command that a person having

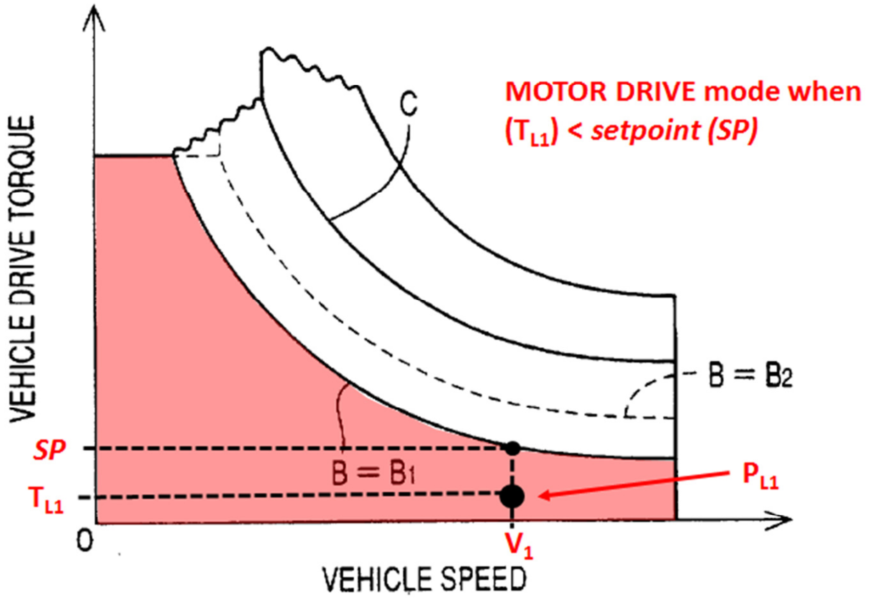
ordinary skill in the art would understand as meaning that the control strategy continually loops through the control strategy to determine whether a condition has changed requiring a different operational mode.

386. For instance, as I have annotated below the control strategy could continually loop through a steps "Q1" to "Q8" and determine that the vehicle should be operated in the disclosed "MOTOR DRIVE mode" or *mode I*. Again, the decision made at step "Q8" is executed by the controller using the "data map" of Figure 11. Figure 11 also annotated below, illustrates when the "vehicle drive torque" at a given "vehicle speed" (which corresponds to a point of "required drive power P_L") is below a *setpoint* (SP). In the given example below, the controller would proceed to step "Q12" to execute the MOTOR DRIVE mode.



Ex. 1403 [Ibaraki '882] at Fig. 10 (annotated)

FIG. 11

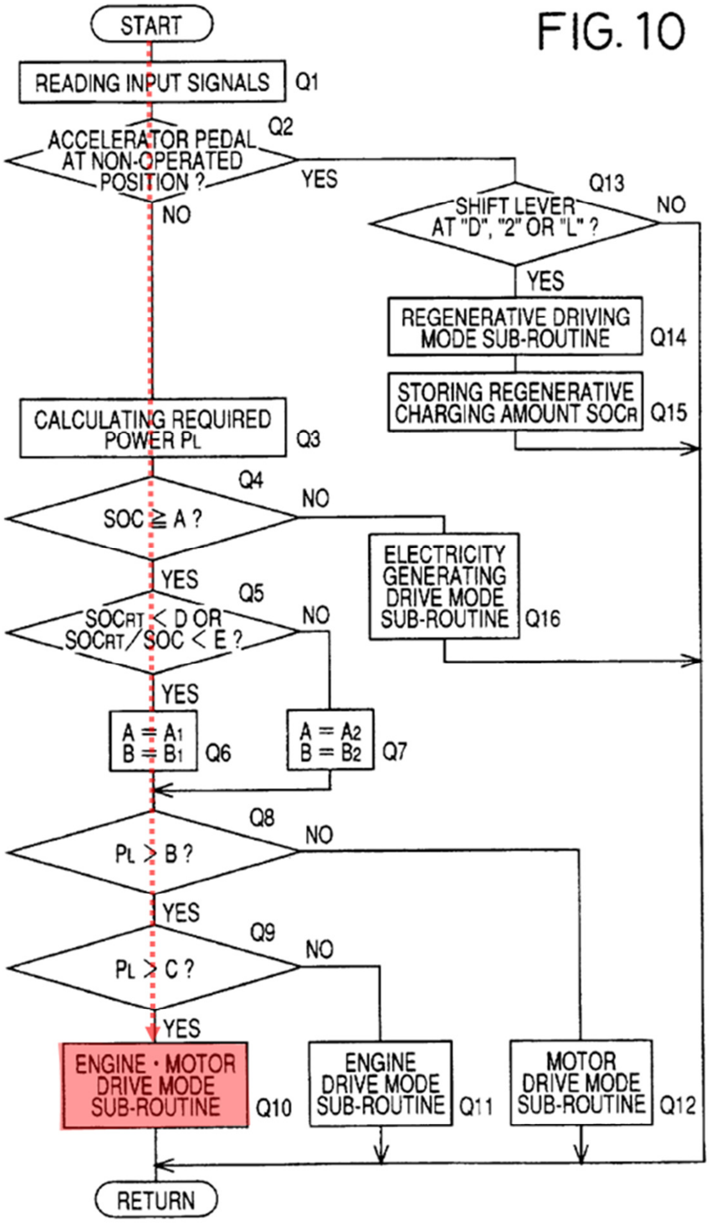


Ex. 1403 [Ibaraki '882] at Fig. 11 (annotated)

387. As I have further annotated below, the control strategy might exit step "Q12" return to the start of the control strategy and during the subsequent loop Ibaraki '882 may then proceed through steps "Q8" and step "Q9" and operate the vehicle in an ENGINE-MOTOR DRIVE mode or *mode V* where "the vehicle is driven by operation of both the engine 112 and the motor 114." (Ex. 1403 [Ibaraki '882] at 24:26-30.) The ENGINE-MOTOR DRIVE mode is again determined using Figure 11 when the "vehicle running condition as represented by the current vehicle drive torque and speed V" is determined to be "above the second boundary line C." (Ex. 1403 [Ibaraki '882] at 20:58-21:1.) I have further annotated below how the controller uses Figure 11 to select the ENGINE-MOTOR DRIVE mode below. As shown, the ENGINE-MOTOR DRIVE mode is selected when the "vehicle drive

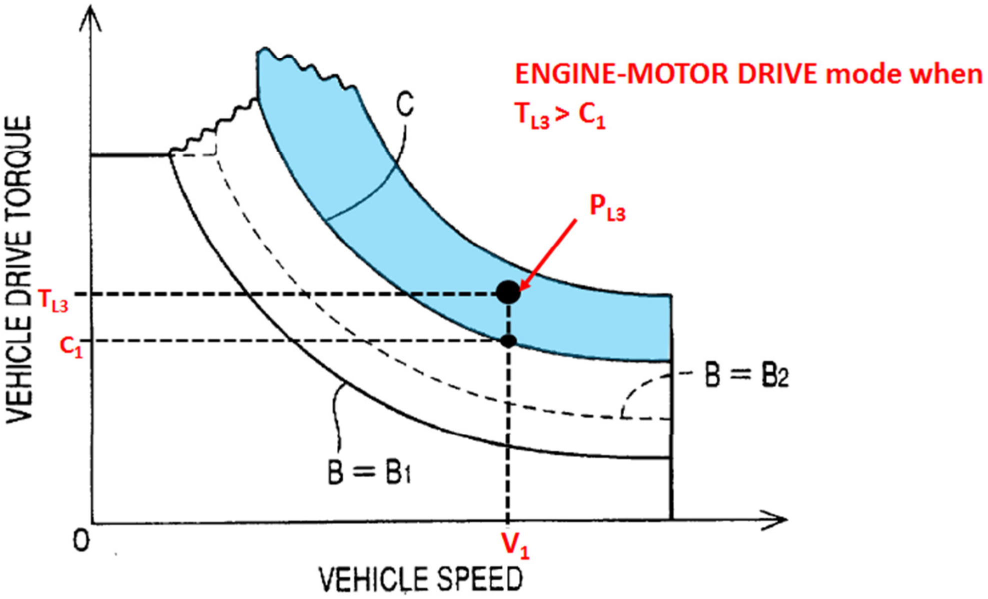
torque" (annotated as T_{L3}) at a given vehicle speed (annotated as V_1) (which again corresponds to a point that is the "required drive power P_L") is greater than a corresponding *setpoint* (annotated below as *SP*) and a point (C_1) along boundary line C.

FIG. 10



Ex. 1403 [Ibaraki '882] at Fig. 10 (annotated)

FIG. 11



Ex. 1403 [Ibaraki '882] at Fig. 11 (Annotated)

388. Again, the determination made at steps "Q8" and "Q9" are determined by the current vehicle driving conditions as represented by the current vehicle drive torque. (Ex. 1403 [Ibaraki '882] at 20:58-21:1.) More specifically, a point corresponding to the "required drive power P_L" is calculated based upon the sensed accelerator pedal position. Ibaraki '882 states that this "required drive power P_L" point is determined based on the "vehicle drive torque" and "vehicle speed" as I have illustrated with Figure 11 above. (Ex. 1403 [Ibaraki '882] at 23:66-24:2.) The accelerator pedal is therefore used by Ibaraki '882 to indicate increases in the amount of vehicle drive torque that is needed to propel the vehicle. If the request indicated a significant increase in "vehicle drive torque" the controller could proceed from MOTOR-DRIVE mode directly to ENGINE-MOTOR DRIVE mode. The

annotated flow charts of Fig. 10 above show that the transition from MOTOR DRIVE mode to ENGINE-MOTOR DRIVE mode can be done directly, without executing the ENGINE DRIVE mode. This would occur with a rapid increase in the required torque due to rapid depression of the accelerator pedal, for example.

389. Because the controller uses the accelerator pedal position as one sensed input that is used in deciding the point of "required drive power P_L", it is my opinion that Ibaraki '882 discloses controlling *the operating mode to change from operation in mode I directly to operation in mode V where a rapid increase in the torque to be applied to the wheels as desired by the operator is detected.*

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391. <Intentionally left blank>

VIII. GROUND 2 – CLAIM 29 IS OBVIOUS OVER IBARAKI '882 IN VIEW OF THE KNOWLEDGE OF A PERSON HAVING ORDINARY SKILL IN THE ART AND THE TEACHINGS OF KNOWN PRIOR ART SYSTEMS

A. Dependent Claim 29

… ***[29.0] The method of claim 28, wherein said setpoint SP is at least approximately 30% of MTO.***

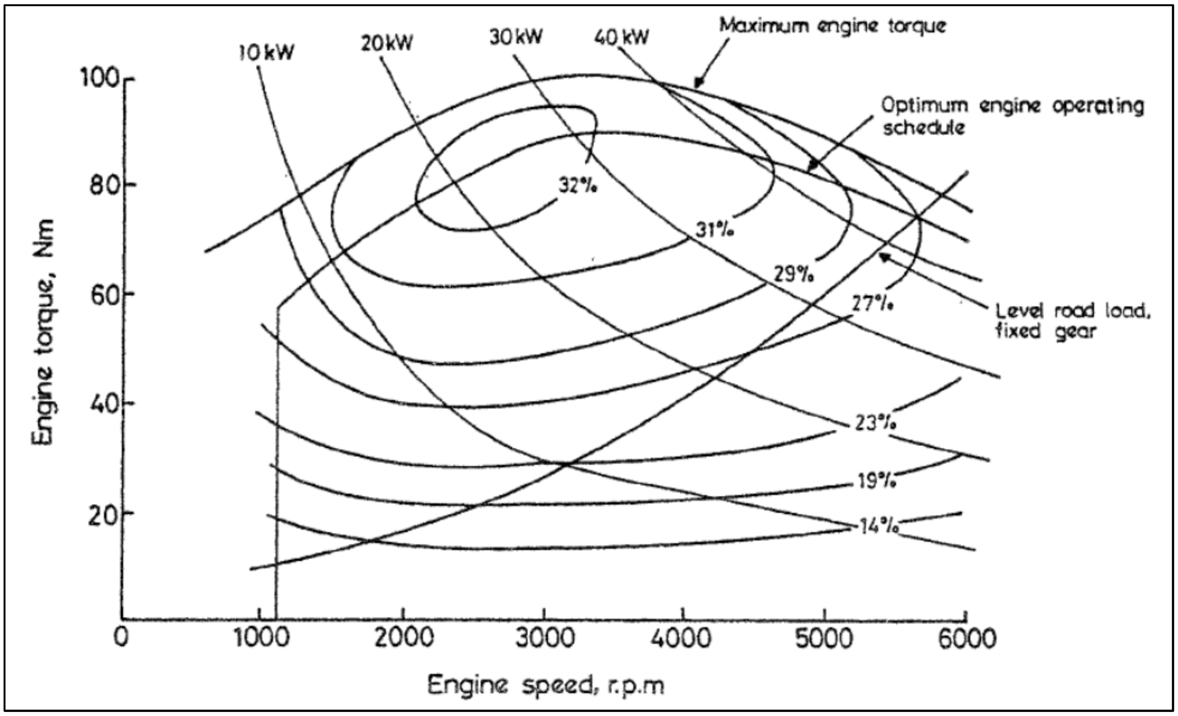
392. As explained in **[23.11]** above, although Figure 5 of Ibaraki '882 do not provide torque units, it illustrates qualitatively that the setpoints (*e.g.*, *SP*) along the $0.7\eta_{ICEmax}$ threshold line are *substantially less than maximum torque output (MTO) of the engine.* It would have been an obvious design choice to apply Ibaraki '882's $0.7\eta_{ICEmax}$

setpoint to commonly-known prior art IC engines (discussed below), which would yield *setpoints* that are *at least approximately 30% of the MTO*

393. Other prior art documents show that for common prior art IC engines, basing *setpoint*(s) on 70% relative efficiency, as Ibaraki '882 discloses, leads to a *setpoint*(s) that is approximately 30-40% of the *maximum torque output (MTO) of the engine.*

394. More specifically, IC engine performance or "efficiency maps" were common and well known long before the '347 Patent.

395. For example, a 1988 publication that I have discussed in the "State of the Art" section above shows a performance map for a standard IC engine that was disclosed as being employed within a hybrid vehicle:



Ex. 1433 [Bumby/Masding 1988] at Fig. 1

396. The above graph maps the IC engine performance in absolute efficiency

(*i.e.*, curves denoted as "32%," "31%," *etc.*). The most efficient area for this IC engine is the region marked as 32% absolute efficiency. When the engine torque and speed are within the 32% absolute efficiency region, the IC engine is capable of using 32% of the energy from the consumed fuel (*e.g.*, gasoline) for propelling the vehicle. The remaining 68% of the energy is lost, for example to heat in the coolant and exhaust.

397. Likewise, the above IC engine performance map illustrates that lower engine torque levels (*e.g.* around 20 Nm) mark the region where the IC engine has a value of 14% absolute efficiency. Within the 14% absolute efficiency region, the IC engine is able to use 14% of the available gasoline energy for propelling the vehicle. The remaining 86% of the energy is lost.

398. Ibaraki '882, however, describes Figure 5 in terms of "relative efficiency," meaning efficiency relative to the maximum efficiency and not "absolute efficiency."

399. Therefore, in order to better correlate the prior art IC engine performance map shown in paragraph 397 to that disclosed by Figure 5 of Ibaraki '882, I have included "relative efficiency" values. I calculated the "relative efficiency" values by dividing each absolute efficiency value (for example 29%) by the maximum 32% absolute efficiency, which represents the region of 100% relative efficiency. For example, at 29% absolute efficiency, the relative efficiency is 29/32 or 91% relative efficiency. As illustrated below, the 32% absolute efficiency region would now correspond to a region of 100% relative efficiency.

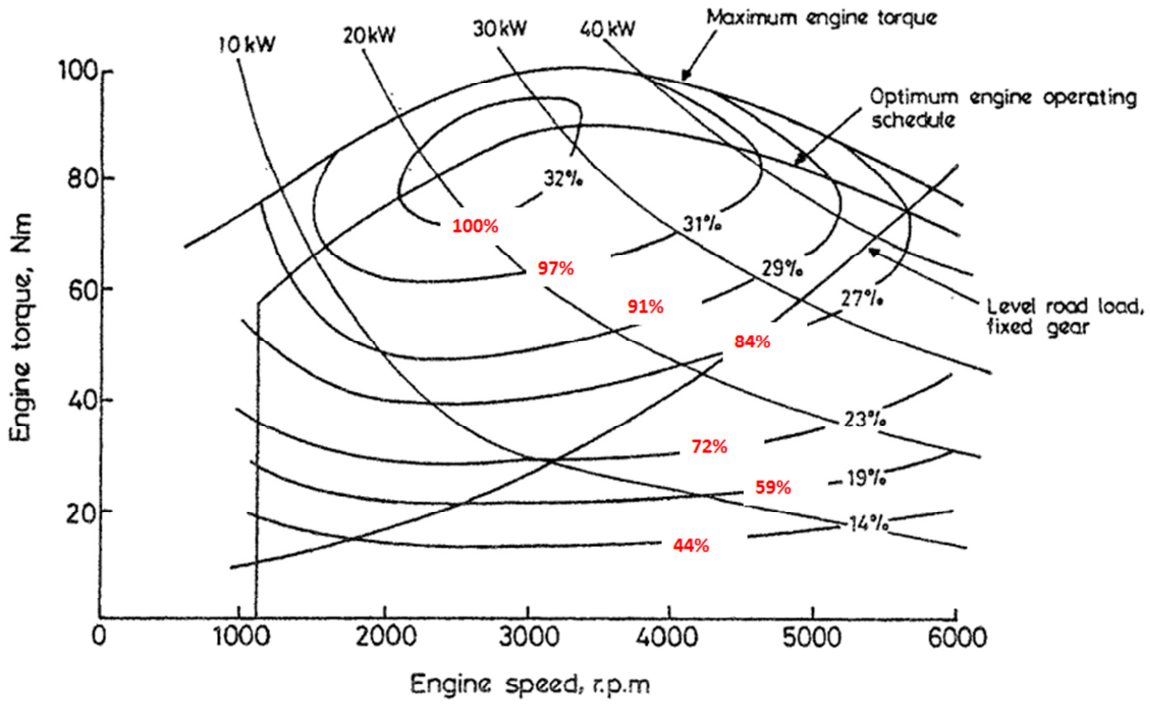


Fig 1 Road-load and engine-operating curves for an ic engine vehicle

Ex. 1433 [Bumby/Masding 1988] at Fig. 1 (Annotated)

400. Again, Ibaraki '882 discloses a threshold line for switching between a MOTOR DRIVE mode and ENGINE DRIVE mode at relative efficiency of $0.7\eta_{ICEmax}$. For the IC engine illustrated above, 70% relative efficiency (*i.e.*, $0.7\eta_{ICEmax}$) would occur around a region of 22.4% absolute efficiency (*i.e.*, 0.7 * .32 = .224 or 22.4%). While this IC engine performance map does not include a 22.4% absolute efficiency curve, the map does include a curve at 23% absolute efficiency (72% relative efficiency). Thus, creating *setpoints* based on this 23% absolute efficiency curve would be roughly equivalent to Ibaraki '882's disclosure of creating setpoints based on 70% relative efficiency.

401. Based on this determination I have further illustrated below that the 23% absolute efficiency curve includes a lower torque value of approximately 30 Nm

at an engine speed of about 2100 rpm. At that point, the MTO for the IC engine is approximately 90 Nm. Thus, the *setpoint* value at this particular engine speed is approximately 33% of the IC engine's MTO (*i.e.*, 30 Nm/90 Nm = .33 or 33%).

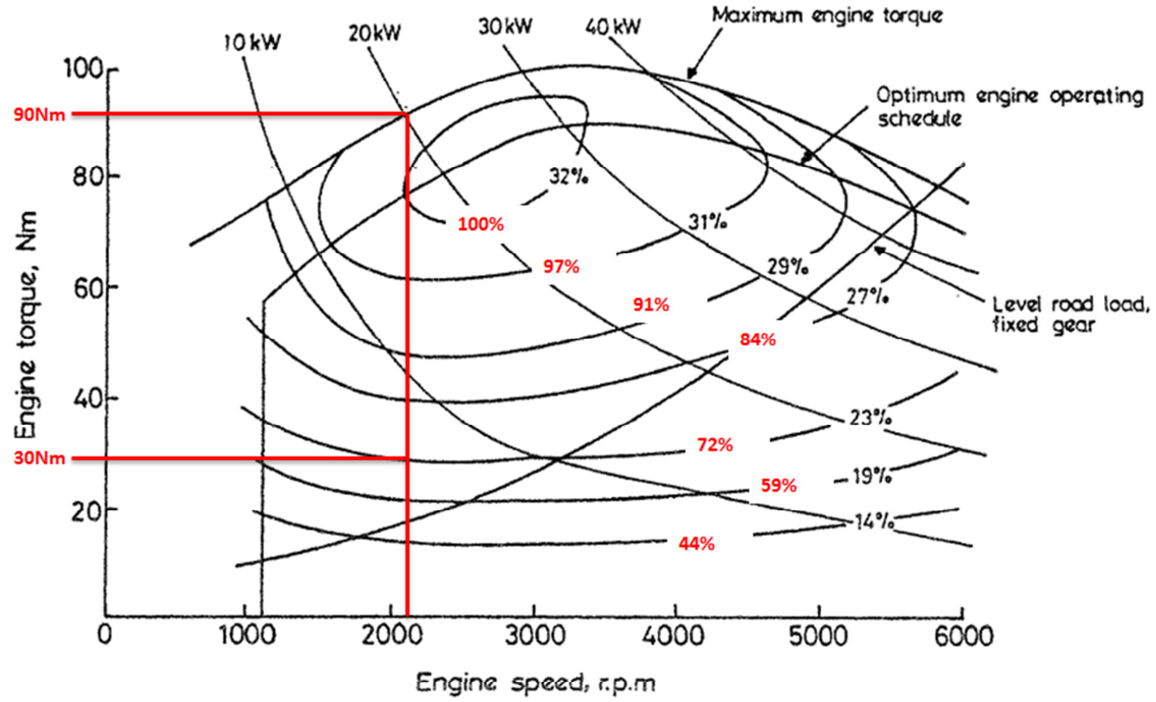


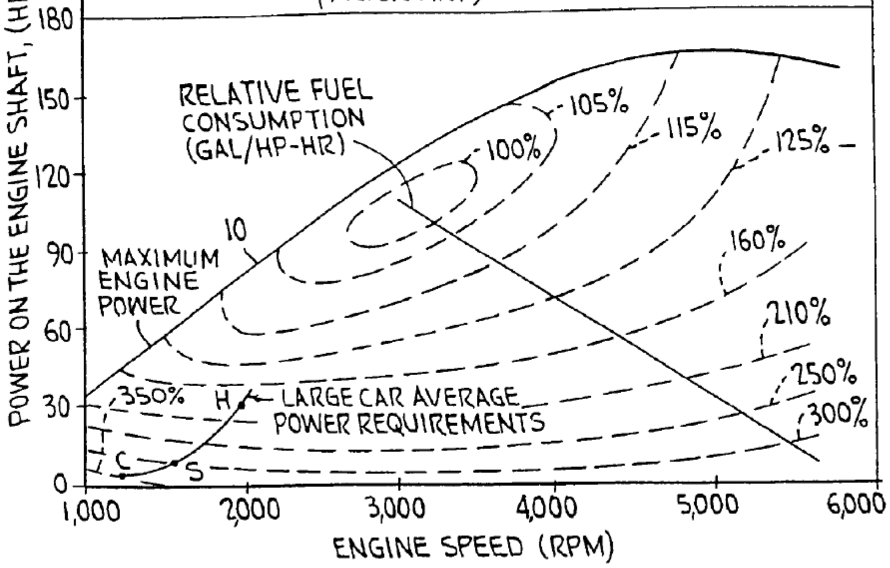
Fig 1 Road-load and engine-operating curves for an ic engine vehicle

Ex. 1433 [Bumby/Masding 1988] at Fig. 1 (Annotated)

402. The '347 Patent itself also discloses the efficiency characteristics of typical prior art IC engines. Figures 1 and 2 are disclosed as being taken from the prior art Severinsky '970 Patent (U.S. Patent No. 5,343,970). (Ex. 1401 ['347 Patent] at 23:12-19, 24:64-25:2.) Figure 1 is disclosed by the '347 Patent as showing the fuel efficiency characteristics of "a typical spark ignition gasoline-fueled internal combustion engine as used with an automatic transmission in a typical sedan of 3,300 pounds." (Ex. 1401 ['347 Patent] at 23:13-18.) Figure 2 is likewise disclosed as

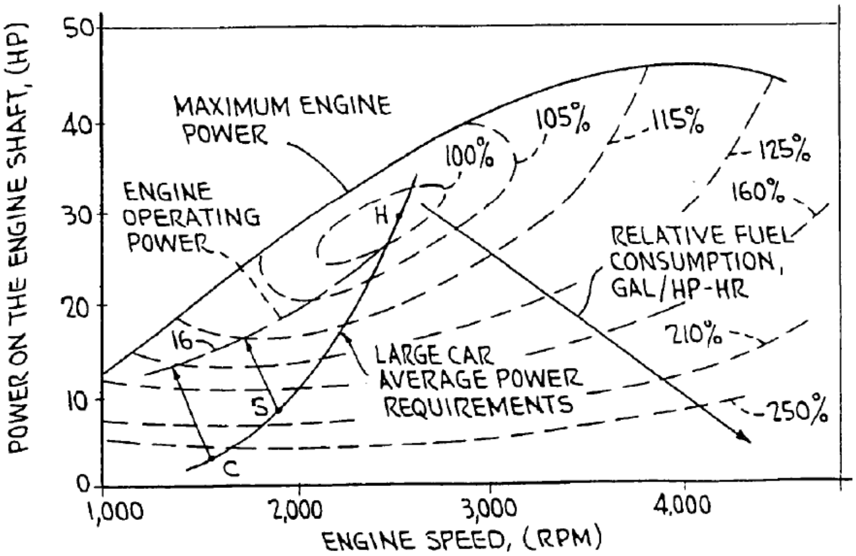
illustrating "the operational characteristics of the same 3,300 pound car if driven by a relatively small engine having a maximum horsepower rating of about 45 horsepower at 4,000 RPM." (Ex. 1401 ['347 Patent] at 23:65-24:2.) I have compared Figures 1 and 2 from the '347 Patent with corresponding Figures 1 and 2 from the prior art Severinsky '970 Patent and concluded that they are substantively identical. Thus, my analysis of Figures 1 and 2 from the '347 Patent would be the same for Figures 1 and 2 from the '970 Patent.

FIG. 1
(PRIOR ART)



Ex. 1401 ['347 Patent] at Fig. 1 – Large Engine

FIG. 2

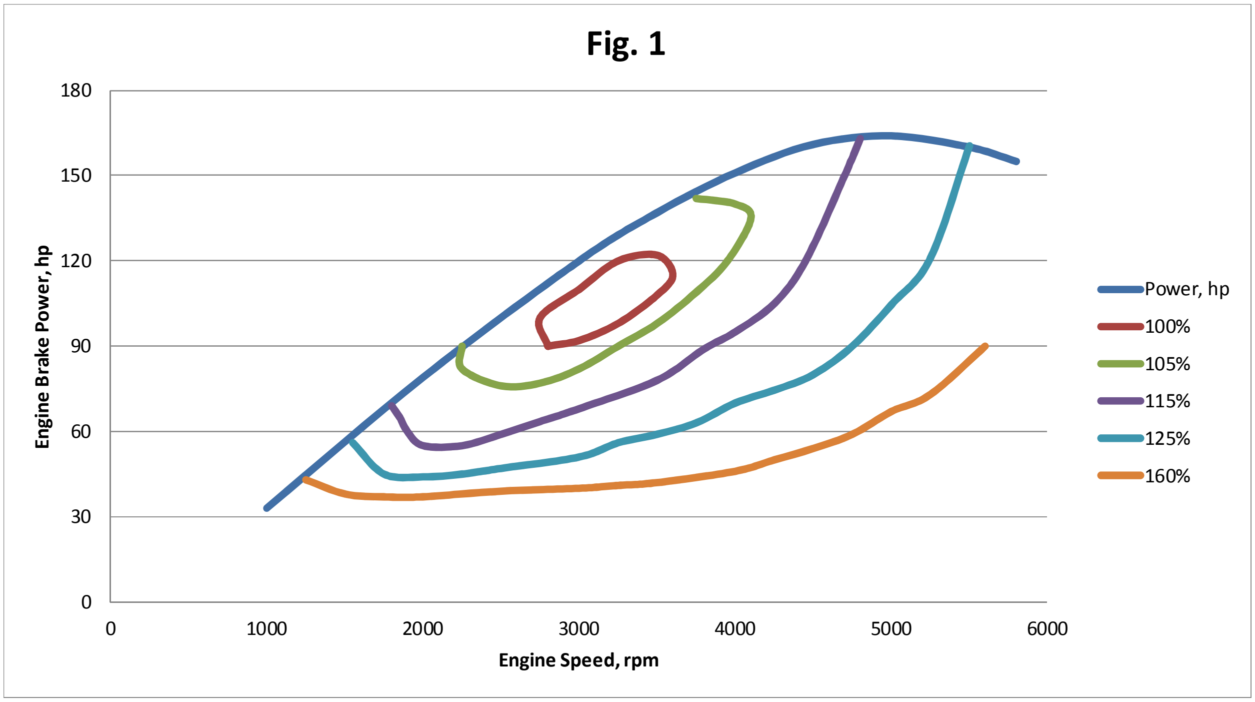


Ex. 1401 ['347 Patent] at Fig. 2 – Small Engine

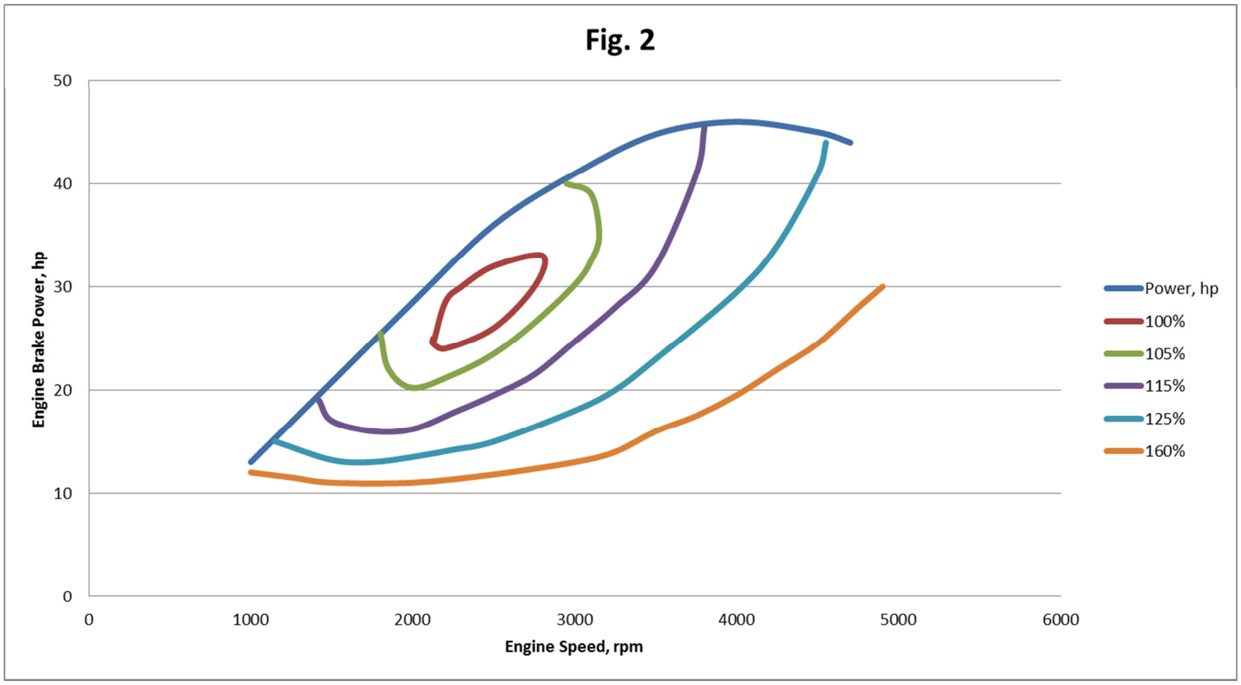
403. The graphs of Figures 1 and 2 are disclosed in power-based units and use relative fuel **consumption** rather than relative fuel **efficiency**. Power and torque are related in that power = torque * speed. Relative fuel consumption and relative fuel efficiency are also related because they are reciprocal of one another (*i.e.*, relative fuel efficiency = 1/relative fuel consumption). For example, a relative fuel consumption of 125% means the engine consumes 125% of "ideal" (*i.e.* 100%) fuel consumption. Thus, 125% relative fuel consumption equates to 80% relative fuel efficiency (1/1.25), *i.e.* where the engine is 80% as efficient as compared to the maximum (100%) relative fuel efficiency.

404. I have converted the power-based relative fuel consumption graphs to the analogous torque-based relative fuel efficiency graphs used by Ibaraki '882. To do so, I first recreated the power curves of Fig. 1 and Fig. 2 using the values

corresponding to power and speed at the disclosed relative fuel consumption, as shown below.



Ex. 1445 [Davis Data] at Fig. 1 – Large Engine

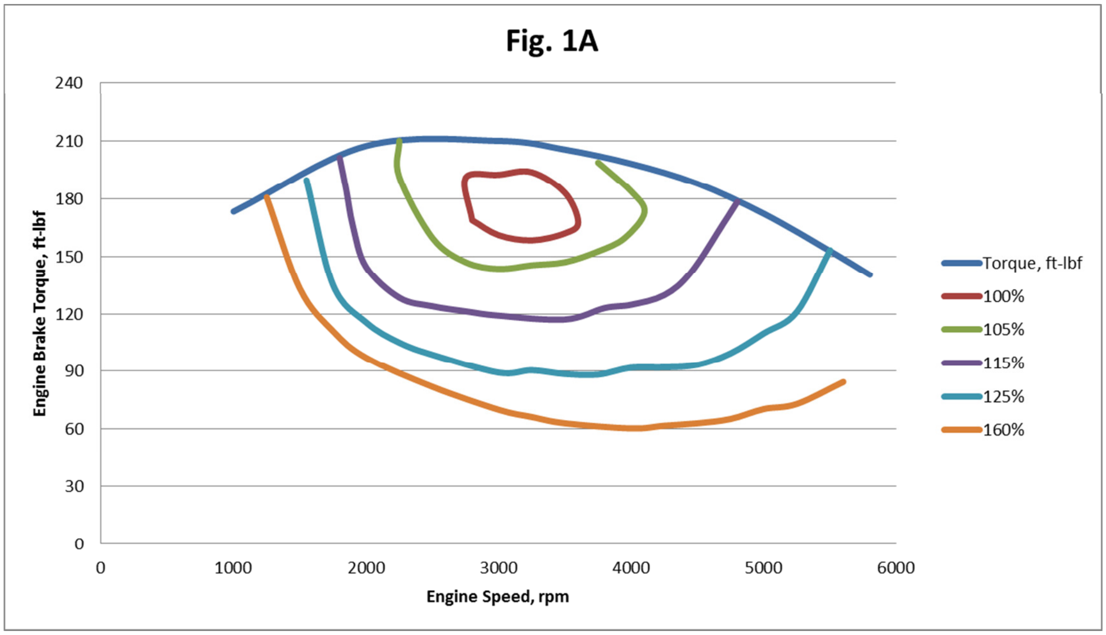


Ex. 1445 [Davis Data] at Fig. 2 – Small Engine

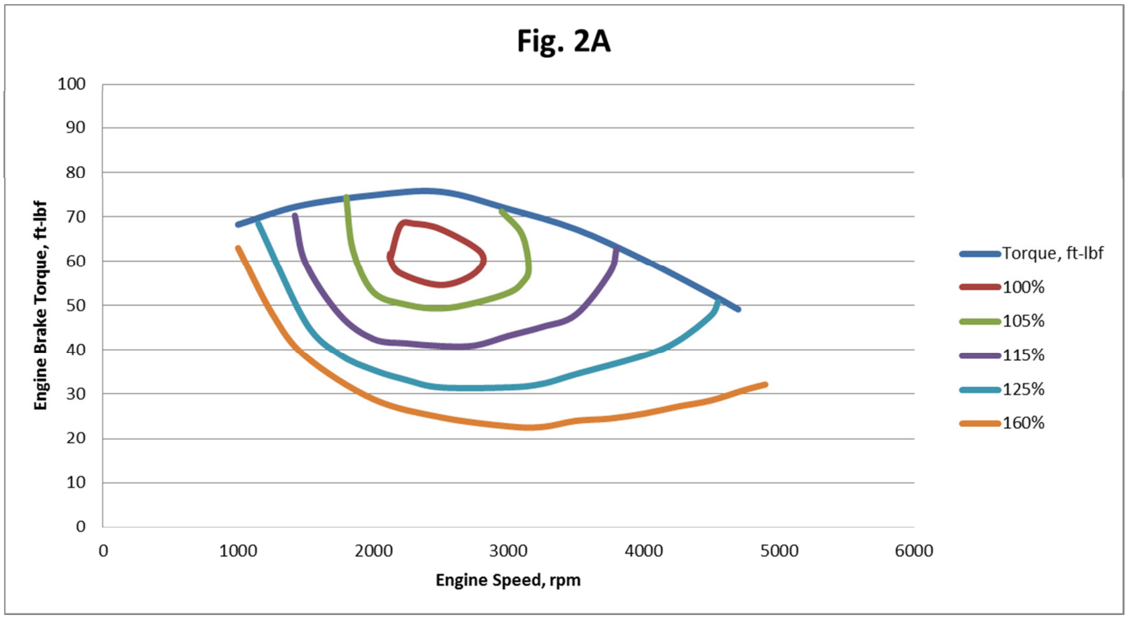
405. I then converted the power values to equivalent torque values according to the following well-known equation:

406. Power (hp) = (torque (ft-lbf) * engine speed (rpm))/[5252(ft-lbf*rpm/hp)]

407. Plotting the converted torque values versus speed illustrates the "typical" engines' performance in a torque-based engine map, as shown below in Fig. 1A and 2A, respectively.



Ex. 1445 [Davis Data] at Fig. 1A – Large Engine

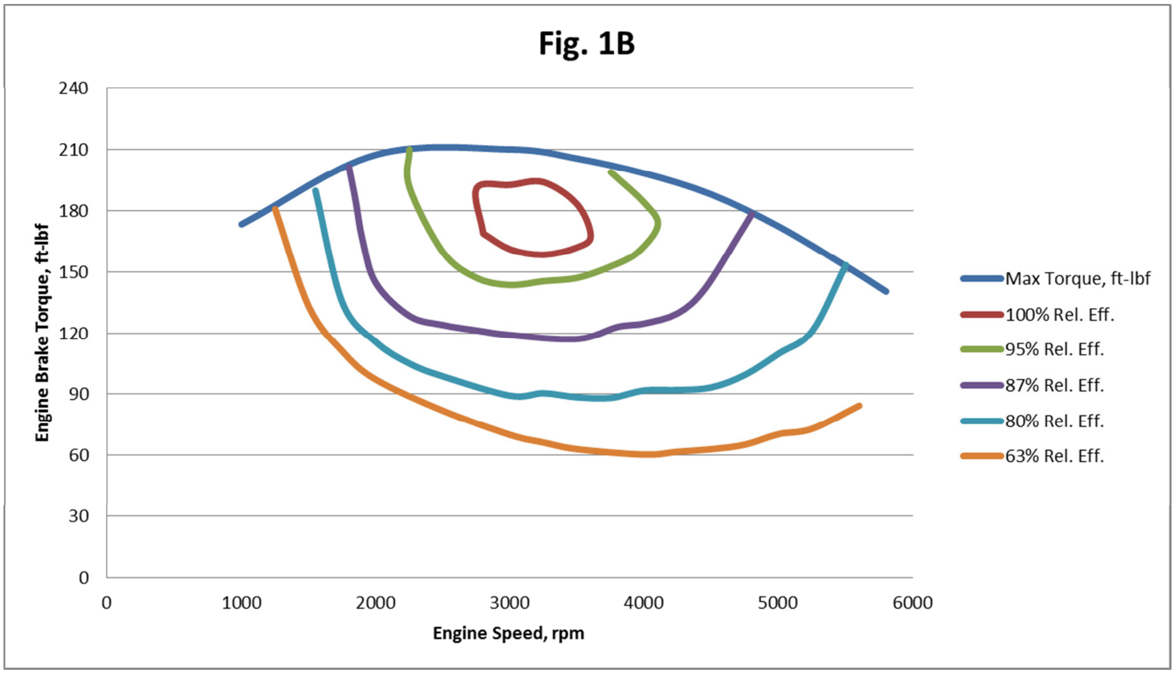


Ex. 1445 [Davis Data] at Fig. 2A – Small Engine

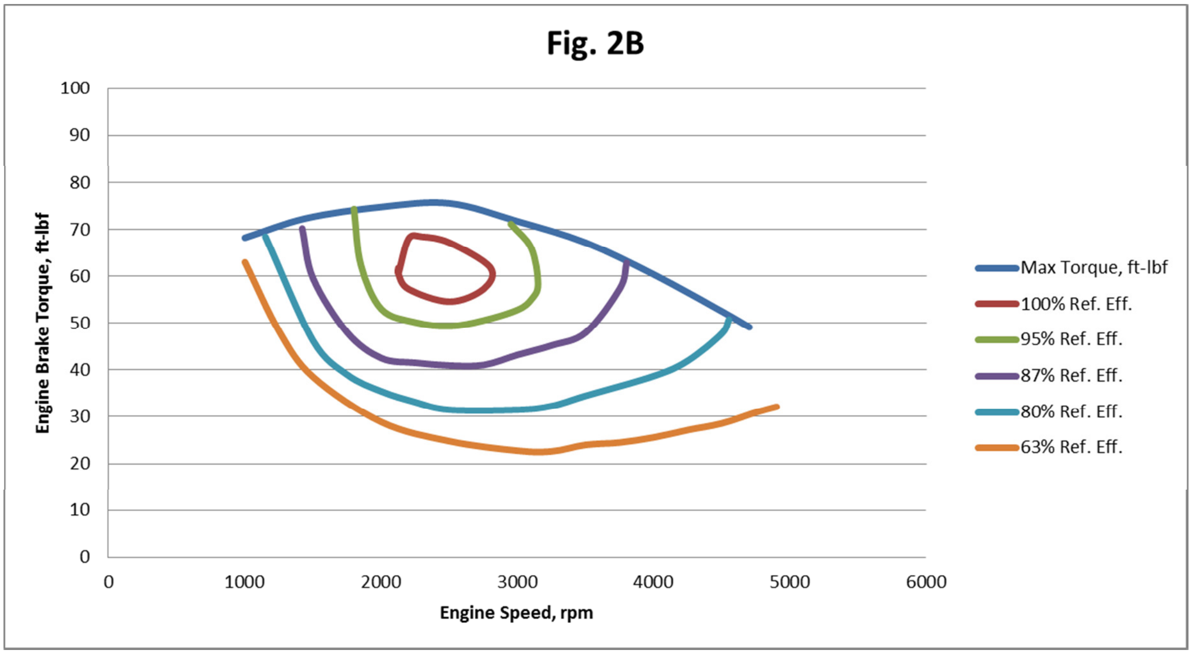
408. Finally, I converted the relative fuel consumption values (100% to 160%) to relative fuel efficiency values. As I said, the relative fuel efficiency is simply the reciprocal of the relative fuel consumption. The conversions are summarized below.

Relative Fuel Consumption, %	Relative Efficiency, %
100%	100%
105%	95%
115%	87%
125%	80%
160%	63%

409. Figures 1B and 2B below are the same as Figs. 1A and 2A above, except the values for "relative efficiency" now replaces the corresponding values for "relative fuel consumption" of Figures 1A and 2A.



Ex. 1445 [Davis Data] at Fig. 1B – Large Engine



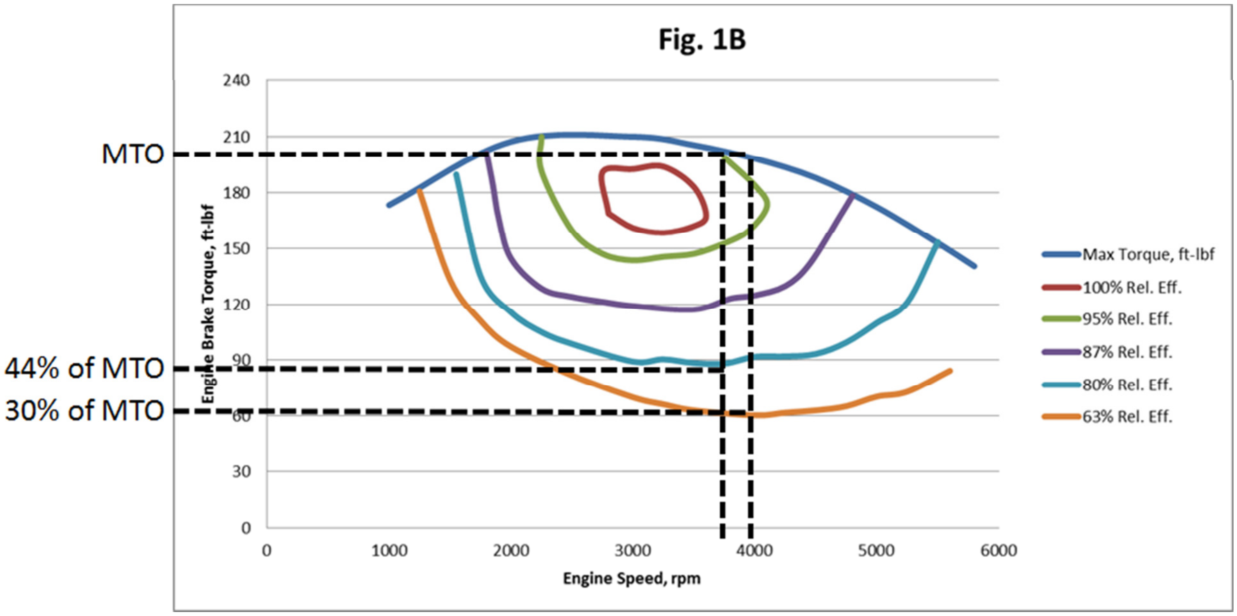
Ex. 1445 [Davis Data] at Fig. 2B – Small Engine

410. The top line labeled "Max. Torque" in FIGS 1B and 2B represents the MTO at all IC engine speeds.

411. Figure 1B includes curves for 63% "relative efficiency" and 80%

"relative efficiency." These correspond directly to the "relative fuel consumption" curves labeled 125% and 160% in Fig. 1 of the '347 Patent (which again was taken from the prior art Severinsky '970 Patent.)

412. As the annotated version of Fig. 1B (below) shows, the lower bound of the 80% relative efficiency curve equates to torque value of 44% of MTO, and the lower bound of the 63% relative efficiency curve equates to a torque value of approximately 30% of MTO.

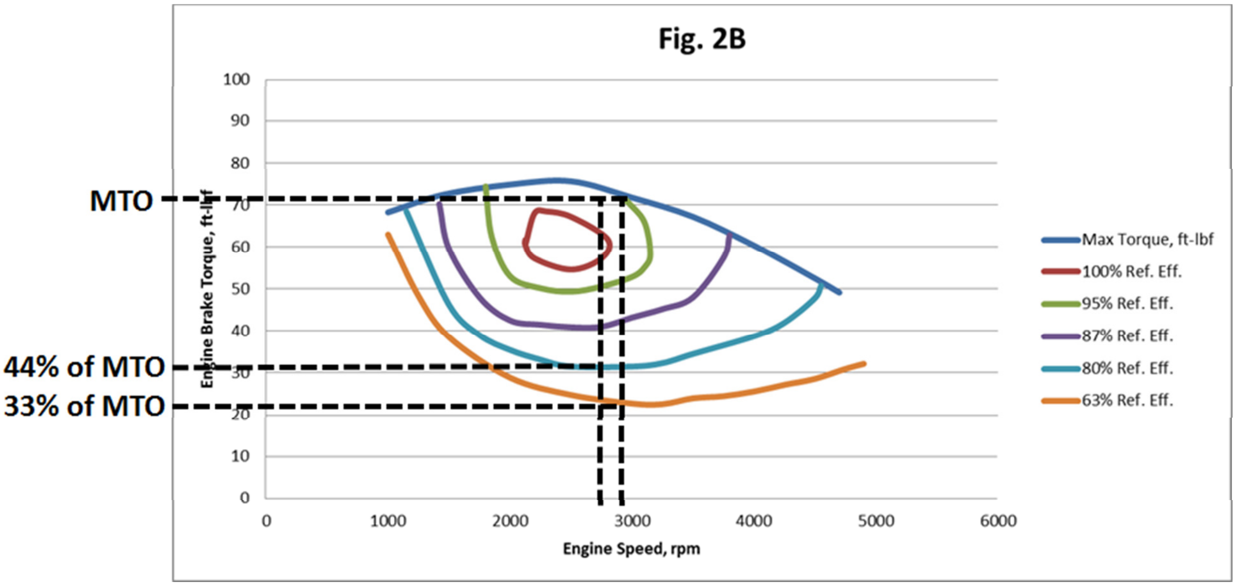


Ex. 1445 [Davis Data] at Fig 1B (Annotated)

413. As mentioned, Ibaraki '882 teaches a setpoint based on 70% relative fuel efficiency (*i.e.* $0.7\eta_{ICEmax}$). FIG 1B shows that for a typical prior art engine, a setpoint based on 70% relative fuel efficiency corresponds to a *setpoint* between 30% MTO and 44% MTO. My calculations also indicate the threshold for 70% relative fuel efficiency would provide a torque value of approximately 36% of MTO.

414. Figure 2B also includes curves for 63% "relative efficiency" and 80% "relative efficiency." These correspond directly to the "relative fuel consumption" curves labeled 125% and 160% in Fig. 2 of the '347 Patent (which was also taken from the prior art Severinsky '970 Patent.)

415. As the annotated version of Fig. 2B shows, the lower bound of the 80% relative efficiency curve equates to a torque of approximately 44% of MTO (*i.e.*, 32Nm/72Nm = 44%). Also, the lower bound of the 63% relative efficiency curve equates to a torque of approximately 33% of MTO (*i.e.*, 23/69.5 = 33%).



Ex. 1445 [Davis Data] at Fig 2B (Annotated)

416. Therefore, the setpoint torque for a common, prior art small engine based on 70% relative fuel efficiency was between 33% MTO and 44% MTO. My calculations indicate the torque setpoint value for 70% relative fuel efficiency would be approximately 38% of MTO. Accordingly, a person having ordinary skill would have understood that when Ibaraki '882's $0.7\eta_{ICEmax}$ setpoint is applied to

conventional prior art engines, the torque produced by the engine would be approximately 33% of MTO (based on Bumby) to about 36-38% of MTO (based on the prior art figures described in the ’347 and ’970 Patents).

417. It is therefore my opinion that based on Ibaraki ’882, it would have been an obvious design choice to use a setpoint that *is at least approximately 30% of MTO.*

418. <Intentionally left blank>

419. <Intentionally left blank>

420. <Intentionally left blank>

IX. GROUND 3 – CLAIM 39 IS OBVIOUS OVER IBARAKI ’882 IN VIEW VITTONE, AND THE KNOWLEDGE OF A PERSON HAVING ORDINARY SKILL IN THE ART

A. Dependent Claim 39

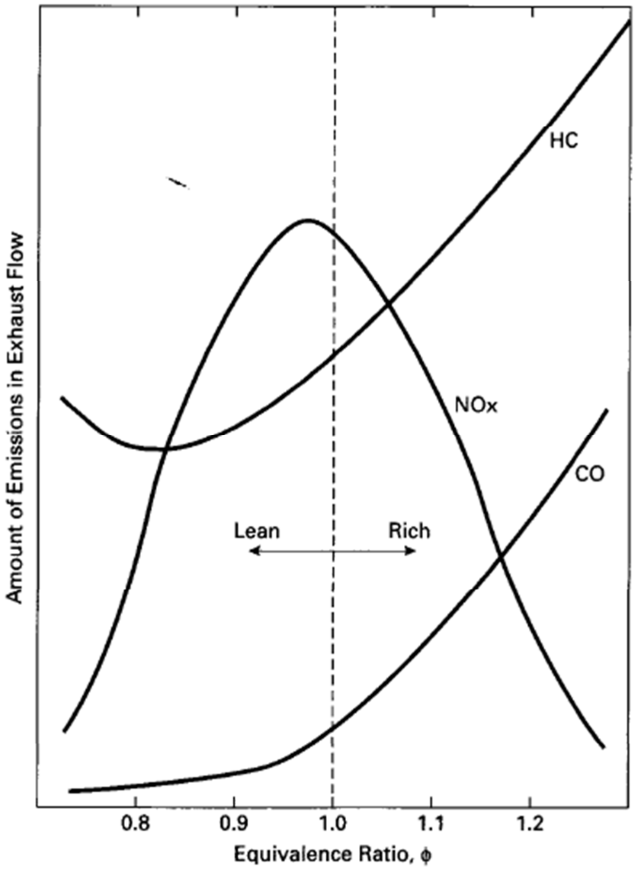
1. Reason to Combine

421. Claim 39 relates to emission problems experienced by IC engines during transient conditions. It was well-known that one of the major causes of vehicle emissions is operating the engine at “non-stoichiometric combustion.” (Ex. 1419 [Pulkrabek] at 31-33.) An IC engine’s stoichiometric ratio simply means that just enough air (e.g. oxygen) is provided to complete combustion with the provided fuel (e.g., gasoline). That is, at a stoichiometric air-fuel ratio there is neither excess air (lean) nor too little air (rich) for complete combustion. (Ex. 1419 [Pulkrabek] at 19-22.) Deviation away from the *stoichiometric ratio* can result in increased exhaust gas emissions (*e.g.*, unburned hydrocarbons (HC), carbon monoxide (CO), and nitrogen

oxides (NO_x)). (Ex. 1406 [Jurgen] at 12) In fact, for gasoline engines it was well-known that deviating away from the engine's *stoichiometric ratio* was generally unacceptable from a vehicle design standpoint because of the stringent exhaust emission requirements that have been imposed on automotive manufacturers. (Ex. 1419 [Pulkrabek] at 31-32.)

422. In conventional vehicles, during times of rapid acceleration, i.e., transient conditions, it was a well-known to use a control strategy of "acceleration enrichment" to provide extra fuel to achieve the vehicle's "desired performance." (Ex. 1406 [Jurgen] at 27.) Operator desire for rapid vehicle acceleration leads to a rapid increase in torque demand on the engine, this rapid increase leads to a "corresponding increase in fuel mixture richness." (Ex. 1406 [Jurgen] at 27.) However, providing extra-fuel leads to a non-stoichiometric, fuel-rich environment, which causes higher levels of exhaust emissions. This is because a "fuel-rich air-fuel ratio does not have enough oxygen to react with all the carbon and hydrogen, and both HC and CO emissions increase." (Ex. 1419 [Pulkrabek] at 33.) This simply means that there is not enough air present in the mixture to completely burn all of the fuel

423. This concept is illustrated in the Figure below, which shows significant increases in HC and CO when the vehicle operates with a fuel-rich mixture, and an increase in HC with a very-lean mixture.



Ex. 1419 [Pulkrabek] at Figure 9-1.

424. Again, Ibaraki '882's stated goal is to reduce both gas consumption and exhaust gas emissions. It is therefore my opinion that a person of ordinary skill in the art would have understood that transient conditions, such as during rapid acceleration, could increase exhaust gas emissions, which is counter to Ibaraki '882's stated goal.

> It is therefore an object of this invention to provide a drive control apparatus for a hybrid vehicle equipped with an electric motor and an engine as drive sources, which apparatus **permits effective reduction in the** fuel consumption amount or **exhaust gas amount of the engine**.

(Ex. 1403 [Ibaraki '882] at 2:52-56, emphasis added.)

425. Like Ibaraki ’882, Vittone discloses a hybrid vehicle having a parallel-hybrid powertrain configuration with a goal to “lower emissions.” (Ex. 1420 [Vittone] at Abstract.) A comparison of the hybrid layouts of Ibaraki ’882 and Vittone is illustrated below, where common colors correspond to common features.

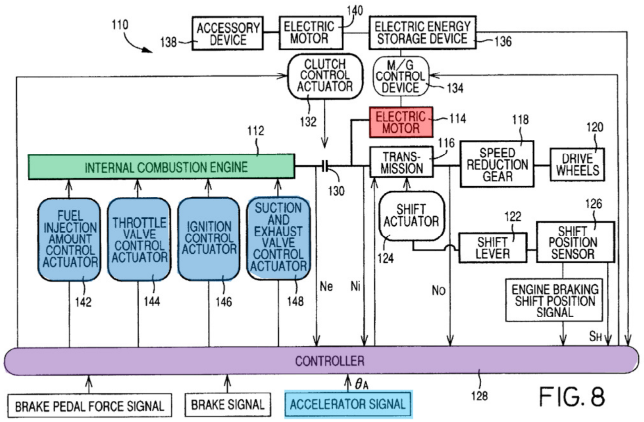


FIG. 8

(Ibaraki ’882 - Annotated)

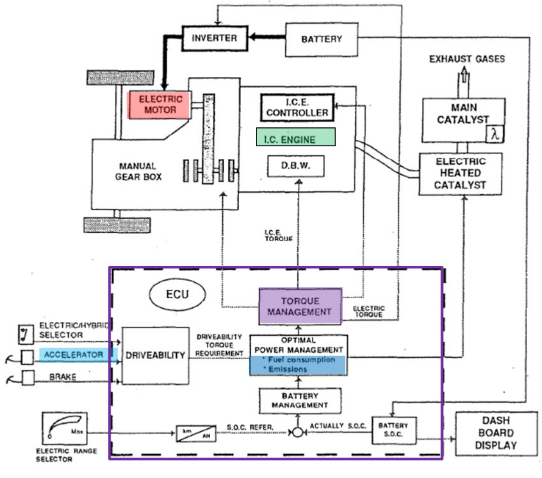


FIGURE 5
HYBRID CONTROL SYSTEM LAYOUT

(Vittone- Annotated)

426. Also like Ibaraki ’882, Vittone discloses determining the torque required for propulsion of the vehicle based on an operator command (*i.e. road load*): “The driver, through the accelerator pedal position, sets the total traction torque; this is splitted between the two drivelines.” (Ex. 1420 [Vittone], at 26.)

427. As illustrated in Fig. 5 of Vittone, the input of accelerator pedal position provides the vehicle “driveability torque requirement.” Fig. 5 further illustrates that the electronic control unit (ECU) implements the “torque management” control strategy and splits the total traction torque (i.e. “driveability torque requirements” or *road load*) between the IC engine and the electric motor. (Ex. 1420 [Vittone] at 26.) Vittone also graphically illustrates the “torque management” control strategy in Figure

8 which has the stated objective "to reduce emissions." (Ex. 1420 [Vittone] at 26.) Figure 5 and Figure 8 of Vittone are shown below.

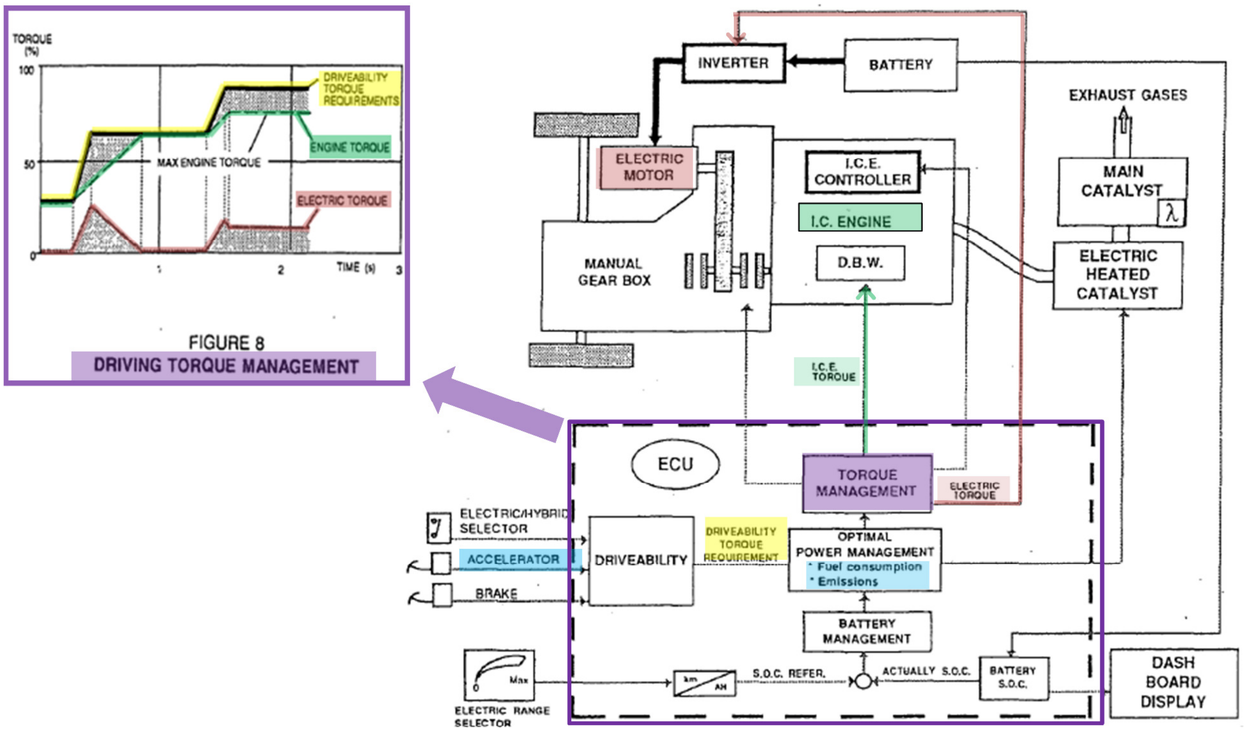


FIGURE 8
DRIVING TORQUE MANAGEMENT

FIGURE 5
HYBRID CONTROL SYSTEM LAYOUT

Ex. 1420 [Vittone] at Fig. 5 and Fig. 8

428. In particular, Vittone recognizes that a hybrid vehicle provides the capability of "<u>reduc[ing] the emissions both in **transient and starting conditions**</u>, through an appropriate control strategy." (Ex. 1420 [Vittone] at 25, emphasis added.) By limiting the rate of change of torque delivered by the engine under transient conditions, Vittone discloses controlling the engine to operate substantially at its *stoichiometric ratio* under all conditions.

> The thermal engine defined for this application (1242 c.c.) is taken from the series production and features an injection system MPI, which allows

> better potential in terms of emission control. The software of the electronic unit (WEBER IAW) has been modified to implement new **control strategies in the transients and to achieve the stoichiometric control over the whole working range**.

(Ex. 1420 [Vittone] at 463, emphasis added.)

429. It is therefore my opinion that a person of ordinary skill in the art would have understood that applying the "torque management" control strategy disclosed in Vittone to the hybrid vehicle in Ibaraki '882 would have furthered Ibaraki '882's stated goal of reducing exhaust gas emissions by ensuring the IC engine operates at its *stoichiometric ratio* during transient conditions.

430. Incorporating Vittone's "torque management" control strategy for transient conditions would require applying the well-known technique of operating the engine at its stoichiometric ratio to a similar engine in the same way. Vittone even teaches that this modification simply requires a software change without having to modify any vehicle components.

> The thermal engine defined for this application (1242 c.c.) is taken from the series production and features an injection system MPI, which allows better potential in terms of emission control. **The software of the electronic unit (WEBER IAW) has been modified to implement new control strategies in the transients and to achieve the stoichiometric control over the whole working range.**

(Ex. 1420 [Vittone] at 463, emphasis added.)

431. As discussed in claim 23, Ibaraki '882 discloses that the base-control

strategy is implemented by the controller 128, like the ECU in Vittone. Therefore, a person of ordinary skill in the art would have understood that Ibaraki '882's base-control strategy could be modified to include additional control strategy disclosed in Vittone, to operate the engine at its stoichiometric ratio during transient conditions in order to reduce emissions. Therefore, it is my opinion that a person having ordinary skill in the art would have had a reason to combine Ibaraki '882 with the control strategy in Vittone to thereby gain this improvement in reduced emission by controlling or limiting the torque output of engine so that it can be operated at its stoichiometric ratio.

432. <Intentionally left blank>

433. <Intentionally left blank>

2. Analysis

… ***[39.0] The method of claim 23, wherein the rate of change of torque produced [output] by said engine is limited, such that combustion of fuel within said engine can be controlled to occur substantially at the stoichiometric ratio,***

434. To the extent Ibaraki '882 does not specifically disclose *combustion of fuel within said engine can be controlled to occur substantially at the stoichiometric ratio*, Vittone exemplifies that it was well-known to control the engine to operate *substantially at the stoichiometric ratio*.

435. Vittone discloses providing controlling an engine for a hybrid vehicle to

achieve "stoichiometric control."

> The thermal engine defined for this application (1242 c.c.) is taken from the series production and features an injection system MPI, which allows better potential in terms of emission control. The software of the electronic unit (WEBER IAW) has been modified to implement new <u>control strategies in the transients and **to achieve the stoichiometric control** over the whole working range</u>.

(Ex. 1420 [Vittone] at 463, emphasis added.)

436. A person of ordinary skill in the art would have understood the benefits of combining Vittone's "stoichiometric control" strategy with the control strategy of Ibaraki '882. Indeed, Vittone's control of the stochiometirc ratio during the transient conditions in the system of Ibaraki '882 would lead to increased fuel efficiency and reduced emissions of the vehicle disclosed in Ibaraki '882, further promoting the objectives described in Ibaraki '882.

437. It would have therefore been obvious based on the combined teachings of Ibaraki '882 and Vittone to control the engine *such that combustion of fuel within said engine* occurs *substantially at the stoichiometric ratio.*

438. Vittone also illustrates and discloses a "driving torque management" control strategy in Figure 8 *wherein the rate of change of torque output by said engine is limited.*

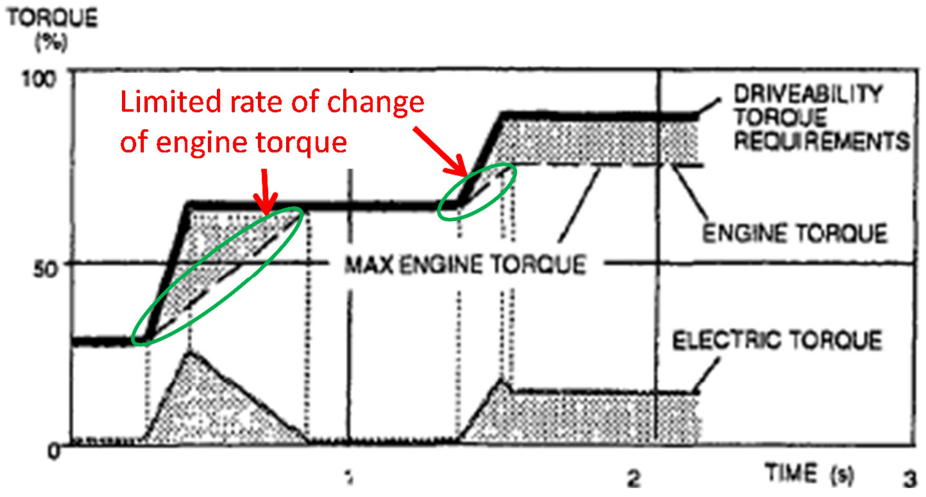


FIGURE 8
DRIVING TORQUE MANAGEMENT

Ex. 1420 [Vittone] at Fig. 8

439. One of the main "objectives" of Vittone's "driving torque management" control strategy in Figure 8 is to reduce emissions by limiting the rate of torque output of the engine during transient conditions. Vittone discloses that the engine controls during transient conditions include "steady state management" of the engine in order to maintain a stoichiometric air-fuel ratio over the whole working range of the engine. During transient conditions, Vittone operates the electric motor to provide any shortfall in the driveability torque requirements as a result of limiting the engine's output.

440. <Intentionally left blank>

> The driver, through accelerator pedal position, sets the total traction torque; this is splitted between the two drivelines in such a way to meet the following **objectives**:
>
> To **reduce the emissions**:
>
> ***
>
> A **further contribution to the emissions reduction is achieved through the "steady state" management of the thermal engine in transient phases, while the torque demand is assured by the electric motor support (Fig 8).**

(Ex. 1420 [Vittone] at 464, emphasis added.)

441. As explained above, Vittone's disclosure of "steady state management" of the engine is referring to limiting the rate of engine output torque during transient conditions to maintain stoichiometric combustion. This driving torque management control strategy disclosed by Vittone is illustrated in Figure 8, as annotated below.

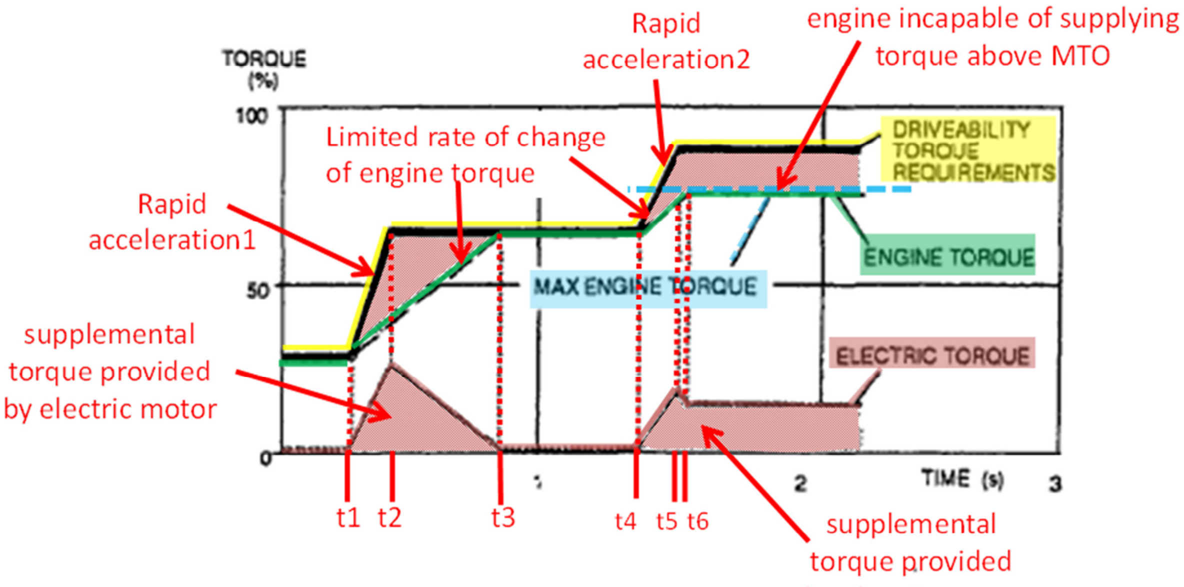


FIGURE 8
DRIVING TORQUE MANAGEMENT

Ex. 1420 [Vittone] at Fig. 8 (annotated)

442. As I have further annotated, between t=0s and t1, the engine alone is providing the torque necessary to propel the vehicle and the electric motor is not providing any propulsive torque. Then, between t1 and t2, there is a rapid increase in the torque required to propel the vehicle (i.e., “driveability torque requirements”, highlighted in yellow) indicting rapid acceleration. In response to the rapid transient, Vittone’s control strategy limits the rate of change of the engine torque between t1 and t3 so that the engine maintains operation at its stoichiometric ratio. To maintain the stoichiometric ratio of the engine, while also providing rapid acceleration, Vittone discloses (as shown from t1 to t3 in Figure 8 above), that the electric motor is used to supplement the engine torque to fulfil the increased torque requirements while the engine output is limited. Similar engine supplementation by the motor during a

second rapid increase in "driveability torque requirements" to propel the vehicle, such as occurs during a rapid acceleration, is illustrated between t4 and t5. Again, Vittone's control strategy limits the rate of change of the engine between t4 and t6 so that the engine maintains stoichiometric combustion.

443. It would have therefore been obvious based on the combined teachings of Ibaraki '882 and Vittone to provide a vehicle *wherein the rate of change of torque output by said engine is limited, such that combustion of fuel within said engine can be controlled to occur substantially at the stoichiometric ratio.*

444. <Intentionally left blank>

445. <Intentionally left blank>

… ***[39.1] and wherein if said engine is incapable of supplying the instantaneous torque required, the additional torque required is supplied by either or both of said motor(s).***

446. Figure 8 of Vittone illustrates the "driving torque management" control strategy where the "steady state management" of the engine between t1 and t3 limits the rate of change of engine output to maintain stoichiometric combustion. Instead, during the transient period of rapid acceleration demand, the electric motor is used to provide the additional propulsive torque requirements while the engine output is limited between t1 and t3. Likewise, during a second transient period between t4 and t5, Vittone further discloses using the electric motor to provide additional torque when the "driveability torque requirements" exceed the "max engine torque" (shown

in purple). A person of ordinary skill in the art would have understood that in this range additional torque from the electric motor is transferred by the controller to fulfill torque requirements above the engine's MTO, *i.e.*, provide supplemental torque when the engine is incapable of supplying the "instantaneous torque required." (Ex. 1320 [Vittone] at 464.)

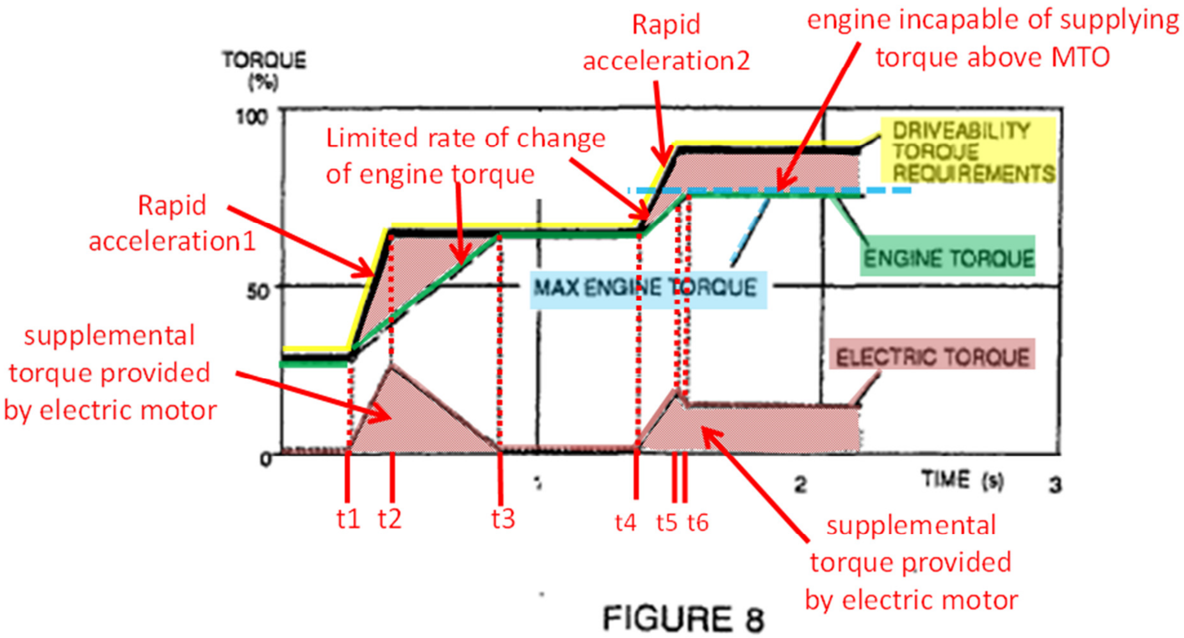


FIGURE 8
DRIVING TORQUE MANAGEMENT

Ex. 1420 [Vittone] at Fig. 8 (annotated)

447. Indeed, Vittone states that it is during these transient events that the electric motor provides supplemental torque demand.

> A further contribution to the emission reduction is achieved through the "steady state" management of the thermal engine in **transient phases**, while the **torque demand is assured by the electric motor** support (Fig. 8).

(Ex. 1420 [Vittone] at 464, emphasis added.)

448. Therefore, it is my opinion that Ibaraki '882 in view of Vittone discloses that *if said engine is incapable of supplying the instantaneous torque required, the additional torque required is supplied by either or both of said motor(s).*

449. <Intentionally left blank>

450. <Intentionally left blank>

451. <Intentionally left blank>

X. GROUND 4 – CLAIM 40 IS OBVIOUS OVER IBARAKI '882 IN VIEW OF YAMAGUCHI, AND THE KNOWLEDGE OF A PERSON HAVING ORDINARY SKILL IN THE ART

A. Dependent Claim 40

… ***[40] The method of claim 23, wherein said engine is rotated before starting such that its cylinders are heated by compression of air therein.***

452. Claim 40 is directed to rotating the engine to heat the engine before starting the engine. Such actions in the engine would be intended to reduce emission problems experienced by IC engines during cold-start conditions by preheating the engine to avoid cold-start emission problems.

453. It was well-known to preheat the engine and/or the catalyst to reduce engine emissions during a cold start.

> A major reduction in emissions is therefore possible if catalytic converters could be preheated, at least to light-off temperature, before engine startup.

(Ex. 1419 [Pulkrabek] at 52.)

> A preheated engine starts quicker with less wear and wasted fuel. The warmed cylinder walls and intake manifold promote better fuel evaporation, and combustion starts quicker. Also, the overrich intake mixture used to start a cold engine can be lessened, saving fuel and causing less emissions.

(Ex. 1419 [Pulkrabek] at 62.)

454. It was widely known that pre-heating the engine and/or catalyst before starting could improve cold-start emissions and even in 1998 there were many known methods of preheating the engine. (Ex. 1419 [Pulkrabek] at 51-54 and 62-64.)

455. Again, Ibaraki ’882’s stated goal is to reduce both gas consumption and exhaust gas emissions. It is therefore my opinion that a person having ordinary skill in the art would have understood that engine cold-starts without preheating would increase exhaust gas emissions, contrary to Ibaraki ’882’s stated goal.

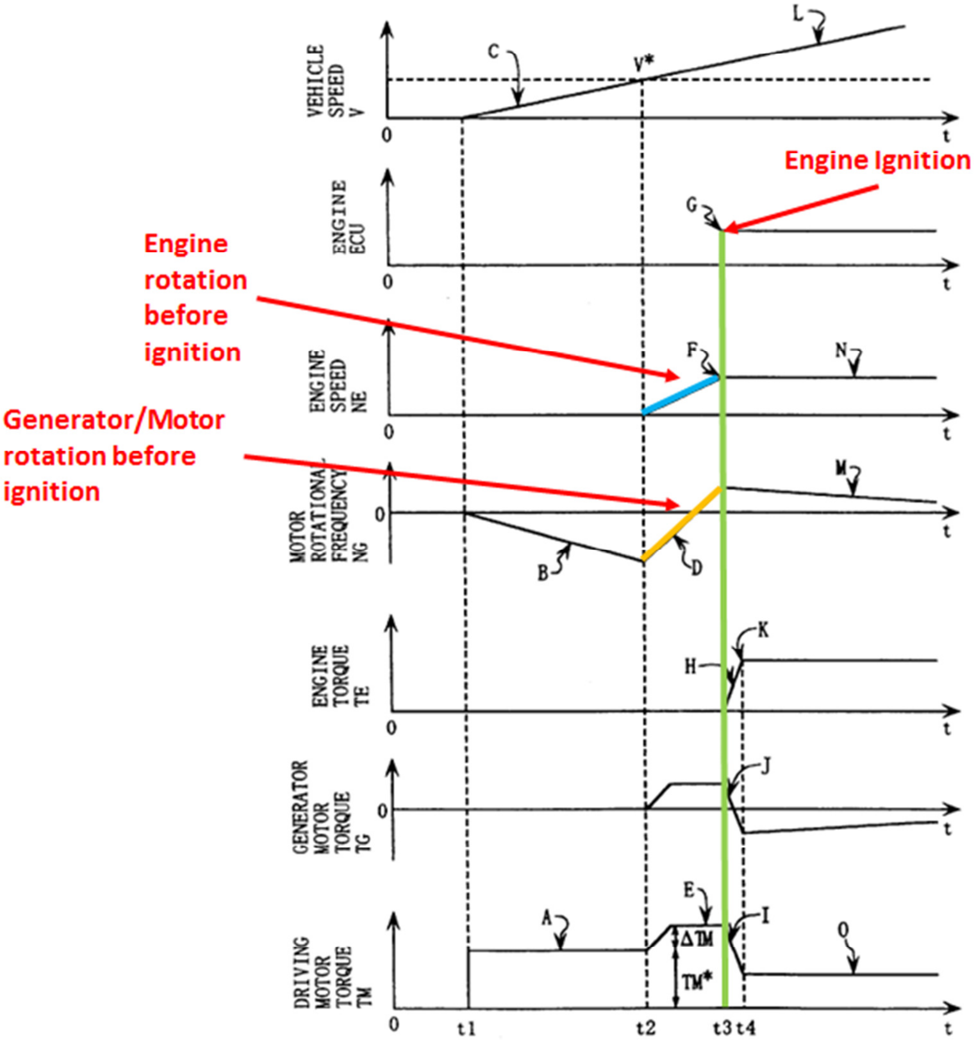
> It is therefore an object of this invention to provide a drive control apparatus for a hybrid vehicle equipped with an electric motor and an engine as drive sources, which apparatus **<u>permits effective reduction in the</u>** fuel consumption amount or **<u>exhaust gas amount of the engine</u>**.

(Ex. 1403 [Ibaraki ’882] at 2:52-56, emphasis added.)

456. Like Ibaraki ’882, Yamaguchi discloses a hybrid vehicle having a parallel-hybrid architecture that controls the engine so that “exhaust gas amount is decreased and fuel consumption is improved.” (Ex. 1421 [Yamaguchi] at 1:34-35.)

457. Yamaguchi discloses rotating the engine **before** the "engine ECU is switched to ON to allow the engine to ignite (Arrow G)." (Ex. 1421 [Yamaguchi] at 8:62-65.) Indeed, as shown in the annotated version of Figure 8 below between times "t2" and "t3", Yamaguchi discloses that the engine speed increases from "0" to a non-zero amount (line highlighted in blue below) **before** the engine is even ignited (line highlighted in green).

FIG. 8



Engine Ignition

Engine rotation before ignition

Generator/Motor rotation before ignition

Ex. 1421 [Yamaguchi] at Figure 8 (annotated)

458. A person having ordinary skill in the art would have therefore

understood that Yamaguchi discloses rotating the engine before the engine is ignited, *i.e.*, before the engine is *started*.

459. It was also known by a person having skill in the art that rotating engine before ignition would lead to heat being generated as a result of friction between the cylinder walls and the pistons. Friction being converted into heat is a natural physical phenomenon. It follows that friction between the cylinder walls and the pistons would clearly heat the engine before ignition. Further, it was known to a person having ordinary skill in the art that compression of air within the cylinder during rotation "rais[es] both the pressure and temperature in the cylinder." (Ex. 1419 [Pulkrabek] at p. 17, 26.) Also, Yamaguchi discloses rotating the engine up to 600 rpm before ignition, which provides higher increases in temperature in the cylinder due to the compression occurring faster.

460. Yamaguchi further discloses that the "generator/motor 3" can be used for starting the engine. (Ex. 1421 [Yamaguchi] at 8:41-44.) As discussed in limitation [23._], Ibaraki '882 discloses a dynamo-motor, which functions "as an electric motor and an electric generator (dynamo)." (Ex. 1403 [Ibaraki '882] at 11:11-13.)

461. A person of ordinary skill in the art would have had reasons to combine Yamaguchi's teachings of using the "generator/motor 3" to rotate the engine before starting with the "electric generator (dynamo)" disclosed in Ibaraki '882 in order to gain the well-known advantages of pre-heating the engine. Indeed, adding this functionality to Ibaraki '882 would further promote the objective of the invention in

Ibaraki '882 to "permit . . . **effective reduction in the** fuel consumption amount or **exhaust gas amount of the engine**." (Ex. 1403 [Ibaraki '882] at 2:52-56, emphasis added.) By pre-heating the engine in Ibaraki '882, the vehicle would be less likely to run in a fuel-rich environment, thus minimizing vehicle emissions.

462. It is my opinion that this combination discloses the limitations of claim 40, which depends from claim 23.

463. Therefore, it is my opinion that Ibaraki '882 in view of Yamaguchi discloses the limitations of claim 40 – *i.e.*, *engine is rotated before starting such that its cylinders are heated by compression of air therein.*

464. <Intentionally left blank>

465. <Intentionally left blank>

466. <Intentionally left blank>

XI. GROUND 5 – CLAIM 41 IS OBVIOUS OVER IBARAKI ’882 IN VIEW OF IBARAKI ’626, AND THE KNOWLEDGE OF A PERSON HAVING ORDINARY SKILL IN THE ART

A. Dependent Claim 41

… ***[41] The method of claim 23, wherein said engine can be operated at torque output levels less than SP under abnormal and transient conditions, said conditions comprising starting and stopping of the engine and provision of torque to satisfy drivability or safety considerations.***

1. Reason to Combine

467. It is my opinion that it would have been obvious for a person having ordinary skill in the art to combine, and such person would have understood that there was a reason to combine, Ibaraki ’882 with Ibaraki ’626.

468. First, the quotes below show Ibaraki ’882 and Ibaraki ’626 both disclose the “field of invention” as being related to a hybrid vehicle having two power sources that include an internal combustion engine and electric motor.

Ibaraki ’882 Patent	Ibaraki ’626 Patent
The present invention relates in general [] to a drive control apparatus for a so-called "hybrid vehicle" equipped with two drive power sources consisting of	The present invention relates in general to a so-called hybrid drive system for driving a motor vehicle, which drive system includes an engine and an electric motor as

an electric motor and an engine such as an internal combustion engine. (Ex. 1403 [Ibaraki '882] at 1:9-14.)	two drive power sources. (Ex. 1422 [Ibaraki '626] at 1:9-19.)

469. Figure 8 of Ibaraki '882 (reproduced to the left below) and Figure 1 of Ibaraki '626 (reproduced to the right below) also illustrates virtually the same hybrid vehicle. A person having ordinary skill in the art would have understood that Figure 8 of Ibaraki '882 and Figure 1 of Ibaraki '626 illustrate what is commonly known as a parallel-hybrid vehicle.

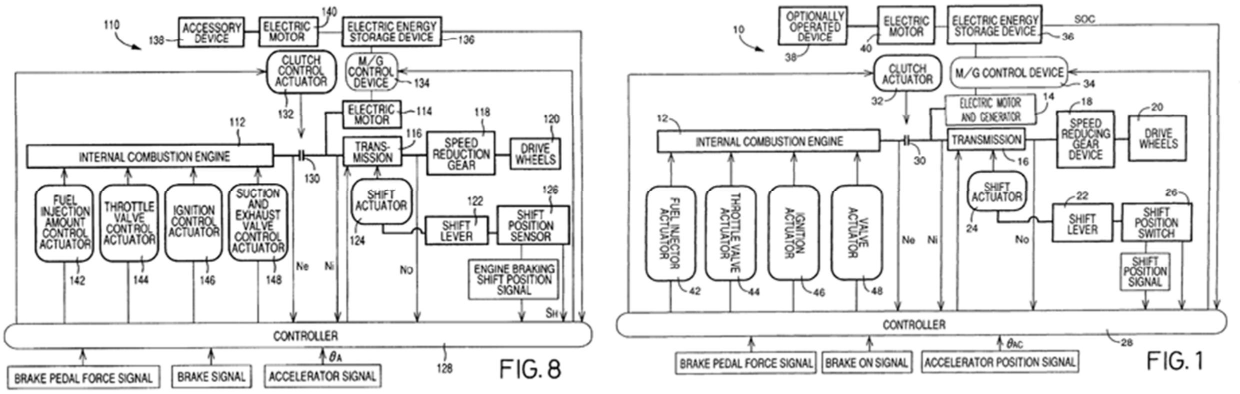


FIG. 8 FIG. 1

Ex. 1403 [Ibaraki '882] at Fig. 8 & Ex. 1422 [Ibaraki '626] at Fig. 1

470. Second, I have noted that Ibaraki '882 and Ibaraki '626 both disclose a parallel hybrid vehicle operated using a calculated drive power (P_L)[30] that is disclosed as being the amount of power required to run (drive) the vehicle.

---

[30] As discussed above, power and torque are related in that Power = Torque * Speed.

> P_L in the above equations (1) and (2) represents instantaneous drive power required for running the vehicle, which power includes components for overcoming an air resistance of the vehicle and a rolling resistance of the tire of each vehicle wheel.

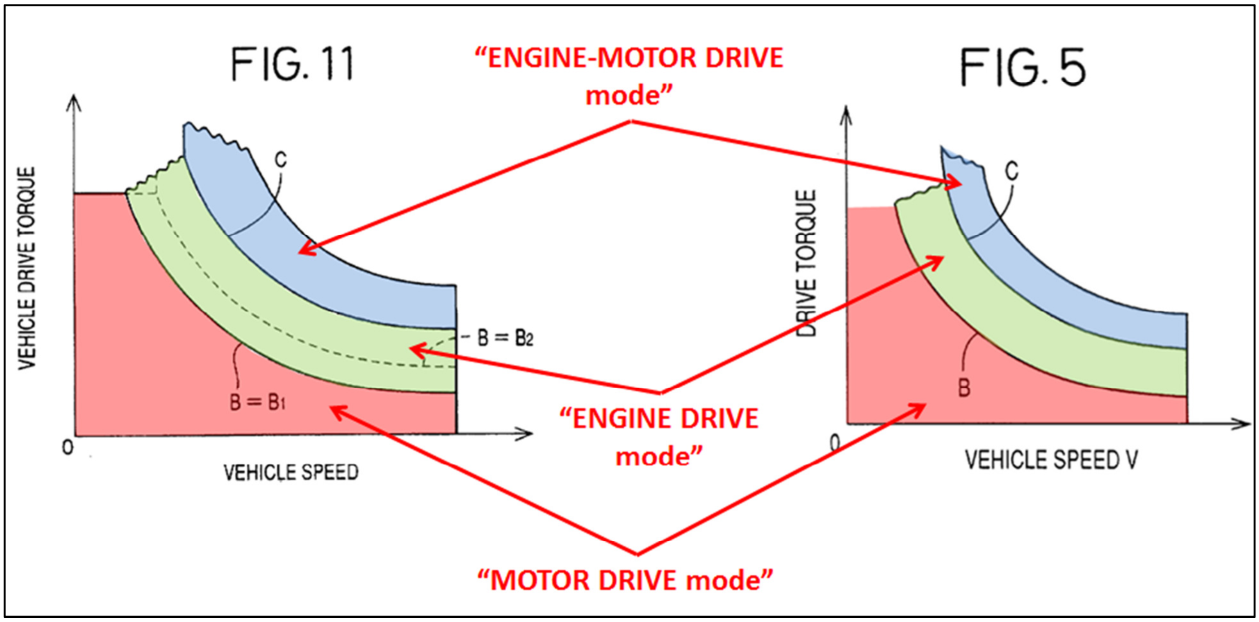
(Ex. 1403 [Ibaraki '882] at 12:50-54.)

> This routine is initiated with step S3-1 to calculate a required power P_L necessary to drive the motor vehicle in the present running condition of the vehicle.

(Ex. 1422 [Ibaraki '626] at 5:50-53.)

471. As annotated below, Ibaraki '882 and Ibaraki '626 also disclose substantially the same control strategy to determine whether: (1) the vehicle should be operated in a "MOTOR DRIVE mode"; (2) the vehicle should be operated in a "ENGINE DRIVE mode"; or (3) the vehicle should be operated in a "ENGINE-MOTOR DRIVE mode". (*See e.g.*, Ex. 1403 [Ibaraki '882] at 23:66-24:38; Ex. 1422 [Ibaraki '626] at 6:37-7:17.)

472. As also annotated below, Ibaraki '882 and Ibaraki '626 also disclose using a data map that that includes a first boundary line or threshold "B" and a second boundary line or threshold "C" that is used to determine whether: (1) the vehicle should be operated in a "MOTOR DRIVE mode"; (2) the vehicle should be operated in a "ENGINE DRIVE mode"; or (3) the vehicle should be operated in a "ENGINE-MOTOR DRIVE mode." (*See e.g.*, Ex. 1403 [Ibaraki '882] at 20:43-21-4; Ex. 1422 [Ibaraki '626] at 7:18-49.)



Ex. 1403 [Ibaraki '882] at Fig. 11 & Ex. 1422 [Ibaraki '626] at Fig. 5 (annotated)

473. Finally, I have noted that both Ibaraki '882 and Ibaraki '626 include many commonly named inventors, including: Ryuji Ibaraki, Yutaka Taga, and Atsushi Tabata. Ibaraki '882 and Ibaraki '626 are also commonly assigned to Toyota Jidosha Kabushiki Kaisha which I understand to be Toyota Motor Company. Ibaraki '882 and Ibaraki '626 were also filed just months apart in July 1996 and September 1996, respectively.

474. It is my opinion that a person having ordinary skill in the art of hybrid vehicles would have therefore understood that Ibaraki '882 and Ibaraki '626 not only both apply to the area of hybrid vehicles, but also disclose substantially the same general control strategy for operating a parallel hybrid vehicle.

475. It is my opinion that a person having ordinary skill in the art in the field of hybrid vehicles would have likely noticed these similarities and examined whether

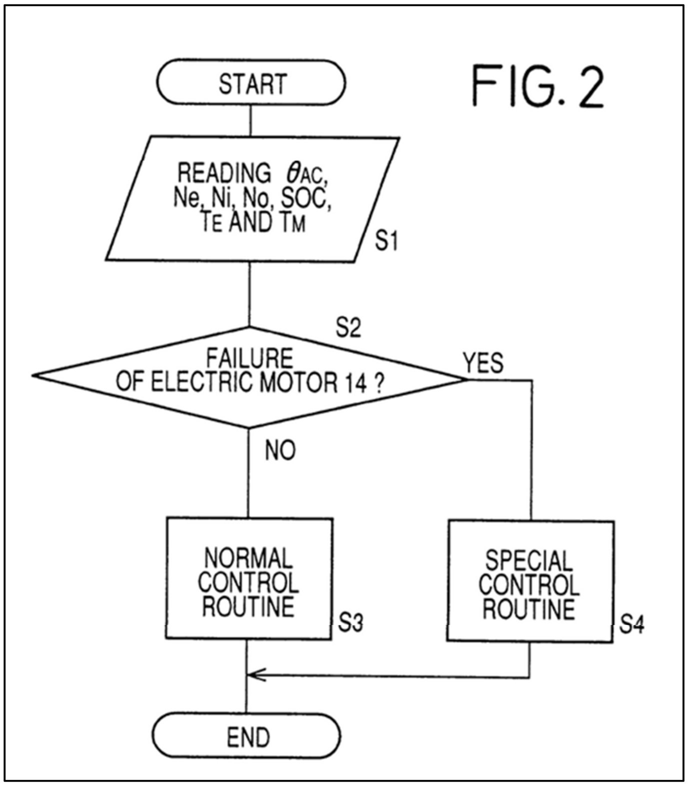
the two references to see if the combination of information provided within both patents could improve or enhance a hybrid vehicle design.

476. It is also my opinion that a person having ordinary skill in the art would have understood that Ibaraki ’626 discloses an improvement over the general control strategy for a hybrid vehicle. A person having ordinary skill would have particularly understood that Ibaraki ’626 discloses additional control logic that seeks to determine whether the electric motor is not operable due to some type of a failure.

> It is therefore an object of the present invention to provide a hybrid drive system for a motor vehicle, which does not suffer from an undesirable change in the running performance of the vehicle even in the event of a failure of the electric motor.

(Ex. 1422 [Ibaraki ’626] at 1:59-63.)

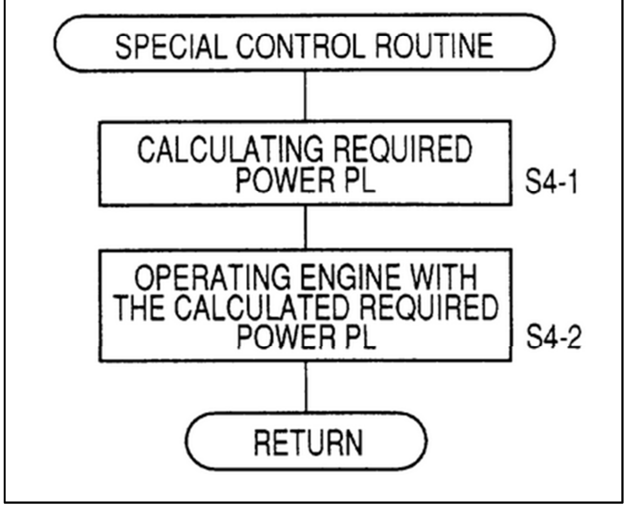
477. As illustrated below, Ibaraki ’626 first determines whether the electric motor is operating properly. If yes, the hybrid vehicle’s “Normal Control Routine” (Step “S3”) is selected where the vehicle may be operated in a “MOTOR DRIVE mode,” “ENGINE-DRIVE mode,” or “ENGINE-MOTOR DRIVE mode”. (Ex. 1422 [Ibaraki ’626] at 5:25-48, 6:37-62.) If the electric motor is not operable, however, Ibaraki ’626 selects a “Special Control Routine” for operating the hybrid vehicle. (Ex. 1422 [Ibaraki ’626] at 5:25-48.)



Ex. 1422 [Ibaraki '626] at Fig. 2

478. As is further illustrated by Figure 4 of Ibaraki '626, when the "Special Control Routine" is executed the hybrid vehicle uses the engine to supply all the drive power (P_L) required to propel the vehicle. (Ex. 1422 [Ibaraki '626] at 7:50-61.)

FIG. 4



Ex. 1422 [Ibaraki '626] at Fig. 4

479. Ibaraki '626 explains that the normal drive control strategy would cause excessive acceleration of the vehicle in the event of an electric generator failure. Ibaraki '626 also explains that such excessive acceleration would be unexpected and undesirable by the driver of a hybrid vehicle.

> In the event of some failure of the electric generator in the conventional hybrid drive system, the overall output of the engine produced in the electricity generating drive mode is used as the power to drive the motor vehicle. Since the overall output is greater than the power required to run the vehicle, the vehicle tends to be accelerated to an excessively larger extent than in the normal condition of the hybrid drive system. This excessive acceleration of the vehicle is not expected by the vehicle operator and is not desirable.

(Ex. 1422 [Ibaraki '626] at 1:47-56.)

480. Ibaraki '626 further explains that the "special control routine" disclosed

will ensure that the vehicle is operated in a safe and desired operational manner. In other words, Ibaraki '626 explains that unwanted and unexpected acceleration due to the failure of the electric motor will not be noticed by the driver of the vehicle.

> In the hybrid drive system of the present invention constructed as described above, the electricity generating drive mode is not selected in the event of a failure of the electric generator, even when the predetermined condition for selecting the electricity generating drive mode is satisfied. In this event, the controller selects the engine drive mode in which the vehicle is driven by the engine with the required power just enough to run the vehicle. Thus, the acceleration value of the vehicle in the above event remains the same as in the normal state of the electric generator. That is, the present hybrid drive system does not suffer from excessive acceleration of the vehicle unexpected by the vehicle operator, even when the electric generator is defective.

(Ex. 1422 [Ibaraki '626] at 2:23-36.)

481. It is my opinion a person having ordinary skill in the art would have known that electric motor (generator) failures might occur during operation of any type of hybrid vehicle. It is also my opinion that a person having ordinary skill in the art prior to 1998 would have included fault mode scenarios within a vehicle (including hybrid vehicles) in order to handle any number of failures.

482. Based on my knowledge and experience, for example, it is my opinion that a person having ordinary skill in the art would have known that special control strategies for transmission and engine failures existed on conventional vehicles. Such

an ordinary person having skill in the art would have further known that these special control strategies would have been implemented to ensure that the vehicle is not operated in an undesirable or unsafe manner when a failure occurs.

483. It is my opinion that a person having ordinary skill in the art would have further understood that the special control strategy of Ibaraki ’626 could be implemented within the normal control strategy for operating a hybrid vehicle in order to allow for continued performance of the vehicle even in the event of a failure of the electric motor.

484. It is therefore my opinion that a person having ordinary skill would have understood that there would be a reason to combine the special control strategy described in Ibaraki ‘626 with the hybrid vehicle described in Ibaraki ‘882. Indeed, a person having ordinary skill in the art would have understood that adding the special control strategy from Ibaraki ‘626 to the generally similar control strategy of Ibaraki ‘882 would allow the vehicle to maintain regular driving performance in the event of motor failure so that the vehicle remain safe for driving.

485. <Intentionally left blank>

486. <Intentionally left blank>

2. Analysis

487. It is my opinion that a person having ordinary skill in the art would understand that Ibaraki ’882 recognizes a *setpoint* that may be adjusted to meet certain vehicle operations or conditions. As I further discuss below, it is also my opinion that

Ibaraki ’626 discloses operating the IC engine at torque output levels that are less than *setpoint* when a failure with the electric motor is detected.

488. First, Ibaraki ’626 discloses calculating a “drive power P_L”[31] that is the power required to propel the vehicle.

> The normal control routine will be described by reference to the flow chart of FIG. 3. This routine is initiated with step S3-1 to calculate a required power P_L necessary to drive the motor vehicle in the present running condition of the vehicle. This required power P_L may be calculated based on the detected amount of operation θAC of the accelerator pedal or a rate of change of this amount θAC and the vehicle running speed V, for example, and according to a predetermined relationship between the required power P_L and the amount θAC (or rate of change thereof) and vehicle running speed V). This relationship may be represented by an equation or data map stored in the ROM of the controller 28.

(Ex. 1422 [Ibaraki ’626] at 5:49-60.)

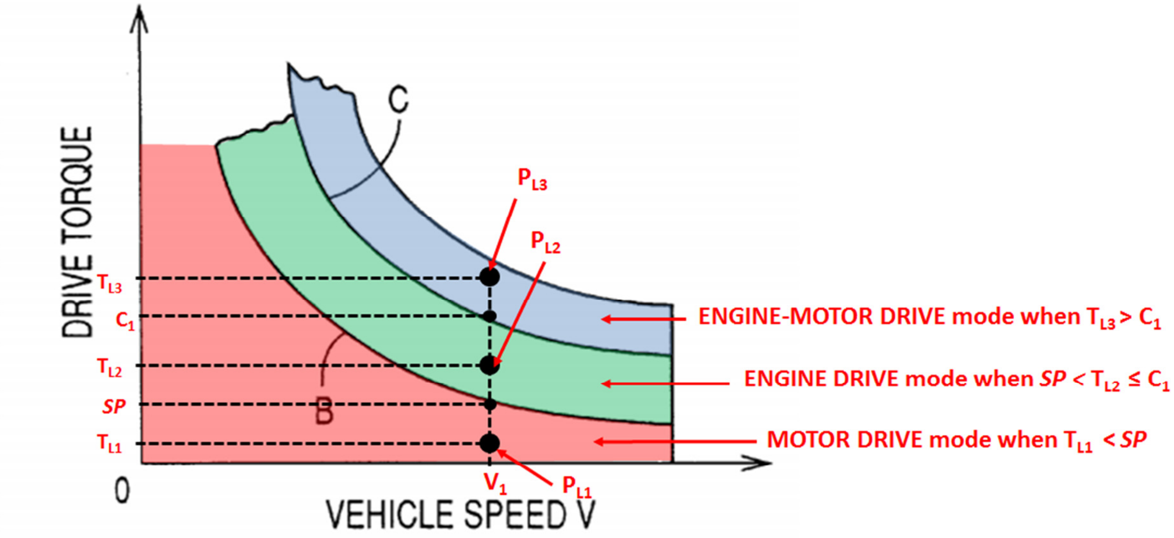
489. Ibaraki ’626 discloses a vehicle driving logic that is used by the controller to determine when the vehicle should be operated in a “motor drive mode,” “engine drive mode,” or “engine-motor drive mode.” (Ex. 1422 [Ibaraki ’626] at 7:18-49.) As annotated below, Figure 5 of Ibaraki ’626 illustrates the “predetermined relationship” between the threshold lines “B” and “C” and each of the corresponding drive modes.

---

[31] Again, power is related to torque in that Power = Torque * Speed.

And, like Ibaraki '882, the points of power P_L are determined from the torque and speed of the vehicle. These points are then compared to the threshold lines "B" and "C" to determine which mode the vehicle should operate in.

FIG. 5



Ex. 1422 [Ibaraki '626] at Fig. 5 (annotated)

> Step S3-3 implemented when the affirmative decision (YES) is obtained in step S3-2 is provided to determine whether the required power P_L is larger than a predetermined first threshold value B. If an affirmative decision (YES) is obtained in step S3-3, the control flow goes to step S3-4 to determine whether the required power P_L is larger than a predetermined second threshold value C which is larger than the first threshold value B. If the negative decision (NO) is obtained in step S3-3, that is, if the required power P_L is equal to or smaller than the first threshold value B, it means that the motor vehicle is currently running under a relatively low load. In this case, the control flow goes to step S3-7 to implement a motor drive mode sub-routine. If an affirmative

> decision (YES) is obtained in step S3-3 while a negative decision (NO) is obtained in step S3-4, that is, if the required power P_L is larger than the first threshold value B and is equal to or smaller than the second threshold value C, it means that the vehicle is currently running under a medium load. In this case, the control flow goes to step S3-6 to implement an engine drive mode sub-routine. If an affirmative decision (YES) is obtained in step S3-4, that is, the required power P_L is larger than the second threshold value C, it means that the vehicle is running under a relatively high load. In this case, the control flow goes to step S3-5 to implement an engine-motor drive mode sub-routine.

(Ex. 1422 [Ibaraki '626] at 6:37-63.)

> Each of the first and second threshold values B and C may be determined depending upon the current running condition of the vehicle, for instance, on the basis of the vehicle drive torque and the vehicle speed V and according to a predetermined relationship as shown in FIG. 5 by way of example. This relationship is provided for each of the forward-drive positions of the transmission 16. When the running condition of the vehicle as represented by the drive torque and speed V is in an area on a lower load side of a curve representative of the first threshold B, namely, on the side nearer to the origin "0", it means that the required power P_L is equal to or smaller than the first threshold B. In this case, step S3-7 is implemented to execute the motor drive mode sub-routine. When the running condition is in an area between the curve representative of the first threshold B and a curve representative of the second threshold C, it means that the required power P_L is larger than the first threshold B and is equal to or smaller than the second threshold C. In this case, step S3-6 is implemented to execute the engine drive

> mode sub-routine. When the running condition is in an area on a higher load side of the curve representative of the second threshold C, it means that the required power P_L is larger than the second threshold C. In this case, step S3-5 is implemented to execute the engine·motor drive mode sub-routine. The above relationship may be determined to determine the first threshold value B on the basis of the fuel consumption efficiency (amount of consumption of fuel per unit power) and emission gas ratio (amount of the emission gas per unit power) of the engine 12 and the energy conversion efficiency of the electric motor 14, for minimizing the amount of fuel consumption and the amount of emission gas of the engine 12.

(Ex. 1422 [Ibaraki '626] at 7:18-49, emphasis added.)

490. Like Ibaraki '882, Ibaraki '626 discloses that threshold line "B" may be established to minimize the amount of fuel consumed and to reduce the exhaust gas emission of the IC engine.

> The above relationship may be determined to determine the first threshold value B on the basis of the fuel consumption efficiency (amount of consumption of fuel per unit power) and emission gas ratio (amount of the emission gas per unit power) of the engine 12 and the energy conversion efficiency of the electric motor 14, for minimizing the amount of fuel consumption and the amount of emission gas of the engine 12.

(Ex. 1422 [Ibaraki '626] at 7:42-49.)

491. It is my opinion that a person having ordinary skill in the art would have understood the threshold line "B" as being a series of points that relate to a vehicle

drive torque value at each given vehicle speed point. A person having ordinary skill in the art would have understood that each point along the boundary line B relates to a power value. This power point is related to the vehicle drive torque at a given speed based on the known equation where Power=Torque*Speed. A person having ordinary skill in the art would have therefore understood that each point along boundary line B for a given vehicle speed relates to a torque value or *setpoint (SP)*. Further, Ibaraki ’626 states that the torque is compared to the thresholds when plotting the points of power P_L: “**When the running condition of the vehicle as represented by the drive torque and speed V is in an area on a lower load side of a curve representative of the first threshold B**, namely, on the side nearer to the origin "0", **it means that the required power P_L is equal to or smaller than the first threshold B**.” (Ex. 1422 [Ibaraki ’626] at 7:24-29, emphasis added.)

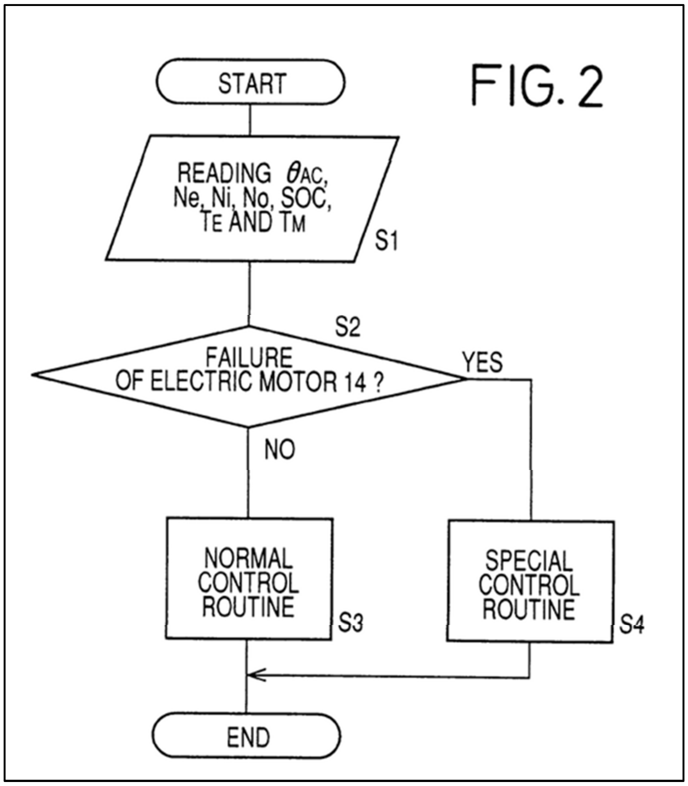
492. Ibaraki ’626 then discloses a control strategy that seeks to ensure that the hybrid vehicle operates as desired even when the electric motor becomes inoperable.

> It is therefore an object of the present invention to provide a hybrid drive system for a motor vehicle, which does not suffer from an undesirable change in the running performance of the vehicle even in the event of a failure of the electric motor.

(Ex. 1422 [Ibaraki ’626] at 1:59-63.)

493. Figure 2 specifically illustrates the overall control logic disclosed by Ibaraki ’626 for determining the overall operating routine that will be used to operate

the hybrid vehicle.



Ex. 1422 [Ibaraki '626] at Fig. 2

494. Specifically, Ibaraki '626 discloses that the controller will first receive sensed and stored values at step "S1."

> The routine is initiated with step S1 to read the amount of operation θ_{AC} of the accelerator pedal, the engine speed Ne, the input shaft speed Ni and output shaft No of the transmission 16, the amount of electric energy SOC stored in the electric energy storage device 36, a torque T_E of the engine 12 and a torque T_M of the electric motor 14. The engine torque T_E may be calculated on the basis of the opening angle of the throttle valve, or the amount of fuel injection into the engine 12, for example. The motor torque T_M may be calculated on the basis of an electric current of the electric motor 14, for example.

(Ex. 1422 [Ibaraki '626] at 5:15-25.)

495. The controller will then proceed to step "S2" where the controller uses some of the received sensed values in order to determine if the electric motor is malfunctioning.

> Then, the control flow goes to step S2 to determine whether the electric motor 14 fails to normally function as the drive power source (for driving the motor vehicle) and/or the electric generator 14 (for generating an electric energy to be stored in the electric energy storage device 36). The failure of the electric motor or generator 14 includes a failure of the MG control device 34, and other defects that prevent normal functioning of the electric motor or generator 14. The determination in step S2 may be effected, for example, on the basis of a relationship between the motor torque T_M (which is calculated from the electric current of the motor 14) and the actual rotating speed of the electric motor 14 (i.e., input shaft speed Ni of the transmission 16), or on the basis of a relationship between the engine speed Ne during operation of the electric motor 14 as the electric generator and a selected one of the electric current of the motor 14, input shaft speed Ni and output shaft speed No.

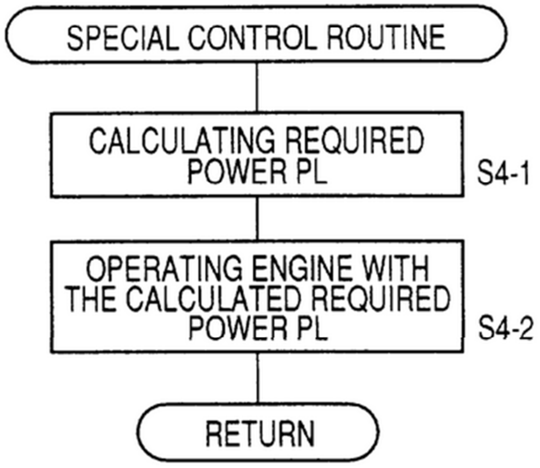
(Ex. 1422 [Ibaraki '626] at 5:25-42.)

496. Ibaraki '626 then discloses that step "S2" will determine whether the electric motor is properly functioning. If the electric motor is operating properly, the hybrid vehicle will execute a "Normal Control Routine" at step "S3" where the vehicle may be operated in a "MOTOR DRIVE mode," "ENGINE-DRIVE mode,"

or "ENGINE-MOTOR DRIVE mode" based on the current vehicle drive torque at a given vehicle speed which again corresponds to a point of required drive power (P_L). (Ex. 1422 [Ibaraki '626] at 5:25-48, 6:37-62.) If the electric motor is malfunctioning or inoperable, Ibaraki '626 deviates from the "Normal Control Routine" and instead selects a "Special Control Routine" at step "S4" for operating the hybrid vehicle. (Ex. 1422 [Ibaraki '626] at 5:25-48.)

497. Ibaraki '626 discloses that the "Special Control Routine" is illustrated by the flow diagram of Figure 2 below.

FIG. 4



Ex. 1422 [Ibaraki '626] at Fig. 4

498. Ibaraki '626 then discloses that this "Special Control Routine" will ensure that the IC engine provides the required drive power regardless of the vehicle driving condition.

> The special control routine in step S4 of FIG. 2 which is executed in the event of a failure of the electric motor 14 will be described by reference to the flow chart of FIG. 4. This special control routine is initiated with step S4-1 to calculate a required power P_L necessary to drive the motor vehicle in the present running condition of the vehicle, as in step S3-1 of FIG. 3. **<u>Then, the control flow goes to step S4-2 to operate the engine 12 with the calculated required power P_L for driving the vehicle, irrespective of the magnitude of the required power P_L</u>**. In this case, too, the output of the engine 12 is controlled depending upon the currently selected position of the transmission 16 and the expected power loss.

(Ex. 1422 [Ibaraki '626] at 7:50-61, emphasis added.)

499. Ibaraki '626 specifically discloses that the "Special Control Routine" will operate the IC engine at all driving conditions irrespective of whether the vehicle speed and driving torque would have indicated that the vehicle should be operated in a "motor drive mode" or "engine-motor drive mode."

> It will be understood that when the electric motor 14 is not normally functioning, the hybrid drive system 10 is **<u>placed in the engine drive mode</u>** and the engine 12 is operated so as to provide the required power P_L for driving the motor vehicle, **<u>regardless of the current running condition of the vehicle as represented by the drive torque and speed V, that is, regardless of the current running load of the vehicle</u>**. Thus, the vehicle can be driven by the engine 12 with the required power P_L, in a suitable fashion without excessive acceleration, even in the event of a failure of the electric motor 14.

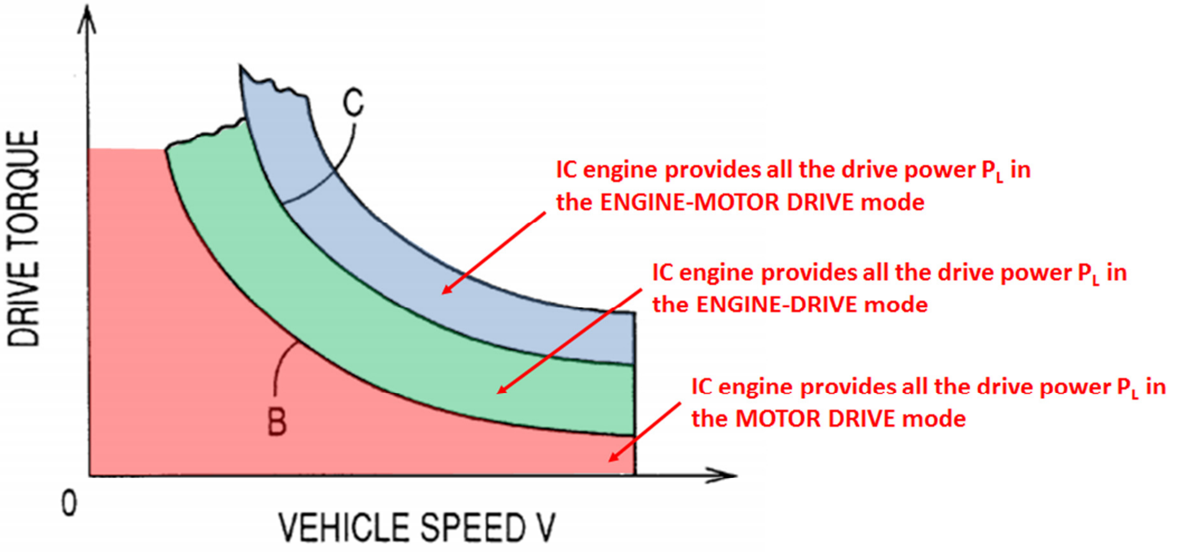
(Ex. 1422 [Ibaraki '626] at 7:62-8:5, emphasis added.)

500. A person having ordinary skill in the art would have understood Ibaraki '626 as disclosing that the IC engine would operate at all levels of the required drive power P_L.

501. With respect to the drive mode selection map of Figure 5, a person having ordinary skill in the art would have understood that when the electric motor was not functioning the engine would be operated below the *setpoint* (threshold line "B").

502. As I have annotated below, a person having ordinary skill in the art would have understood that when the electric motor was malfunctioning or inoperable, the IC engine would supply the "drive torque" at a given vehicle speed (*i.e.*, required drive power P_L) in the "motor drive mode" region and the "engine drive mode" region.

FIG. 5



IC engine provides all the drive power P_L in the ENGINE-MOTOR DRIVE mode

IC engine provides all the drive power P_L in the ENGINE-DRIVE mode

IC engine provides all the drive power P_L in the MOTOR DRIVE mode

Ex. 1422 [Ibaraki '626] at Fig. 5 (annotated)

503. A person having ordinary skill in the art would have understood that the IC engine would operate below the disclosed *setpoint* (*i.e.*, vehicle drive torque at a given speed along boundary line B) in order to *satisfy drivability and/or safety considerations* that the driver does not suffer excessive acceleration and so that the vehicle operates the same as if the electric motor had not become inoperable.

> In the hybrid drive system of the present invention constructed as described above, the electricity generating drive mode is not selected in the event of a failure of the electric generator, even when the predetermined condition for selecting the electricity generating drive mode is satisfied. **In this event, the controller selects the engine drive mode in which the vehicle is driven by the engine with the required power just enough to run the vehicle**. **Thus, the acceleration value of the vehicle in the above event remains the same as in the normal state of the electric generator**. That is, the

> present hybrid drive system does not suffer from excessive acceleration of the vehicle unexpected by the vehicle operator, even when the electric generator is defective.

(Ex. 1422 [Ibaraki '626] at 2:23-36, emphasis added.)

504. A person having ordinary skill in the art would therefore have recognized that the "Special Control Routine" of Ibaraki '626 ensures that the IC engine operates at all required drive torque levels, including below *setpoint* in order *satisf[ies] drivability and/or safety considerations.* A person having ordinary skill in the art would have also understood that the "Special Control Routine" is only executed when the electric motor has malfunctioned. A person having ordinary skill in the art would have understood this "Special Control Routine" as being similar to when a conventional vehicle might be programmed to recognize a failure in the transmission and ensure that the vehicle is still operable to allow a driver the capability of getting to an automotive mechanic shop.

505. It is therefore my opinion that the combination of Ibaraki '882 and Ibaraki '626 discloses operating the engine *at torque output levels less than SP under abnormal and transient conditions, said conditions comprising starting and stopping of the engine and provision of torque to satisfy drivability or safety considerations.*

506. <Intentionally left blank>

507. <Intentionally left blank>

508. <Intentionally left blank>

XII. GROUND 6 – CLAIM 27 IS OBVIOUS OVER IBARAKI '882 IN VIEW OF LATEUR, AND THE KNOWLEDGE OF A PERSON HAVING ORDINARY SKILL IN THE ART

A. Reasons to Combine

509. Claim 27 is directed to accepting an *operator input of a desired cruising speed.* Further, claim 14 recites controlling the *instantaneous torque output by the engine and by either of both motor(s)* based on a *variation in road load (RL).* Doing so maintains vehicle speed substantially constant.

510. It is my opinion that Claim 27 discloses what was well-known to a person having ordinary skill in the art as a "cruise control" device for maintaining the vehicle speed of a hybrid vehicle. It is my opinion that a person having ordinary skill in the art would have understood that by 1998 cruise control devices were well-known and available on commercial vehicles. It is also my opinion that cruise control devices had already been widely implemented in conventional vehicles. It is therefore my opinion that a person having ordinary skill in the art would have understood that a cruise control device could be implemented within a hybrid vehicle like that of Ibaraki '882.

511. For instance, Jurgen discloses that cruise control devices were well-known prior to September 1998. (Ex. 1406 [Jurgen] at 14.) As Jurgen explains, cruise control devices provided driver convenience by regulating vehicle powertrain output to maintain a desired constant speed as set by the driver. (Ex. 1406 [Jurgen] at 14-15.) Cruise control devices were known to use a controller for adjusting the torque being

produced by the IC engine in response to varying driving conditions. (Ex. 1406 [Jurgen] at 14-15.) These adjustments would be made to increase or decrease engine output in order to maintain the vehicle speed as close to the desired speed that was set by the driver. (Ex. 1406 [Jurgen] at 14-15.)

512. It was also known by 1998 that cruise control devices could be implemented in a hybrid vehicle. For instance, Lateur discloses implementing a cruise control device on a hybrid vehicle where the driver is able to set a desired cruising speed.

> A plurality of switch inputs are provided within the operator compartment of the vehicle to allow the operator to control the drive system 10. A speed 'cruise' control switch 36 is one of them. It is provided for **producing a 'cruise control on' signal or a 'cruise control off' signal in response to a selection made by the operator**.

(Ex. 1407 [Lateur] at 4:25-30, emphasis added, Figure 7.)

513. Lateur explains that the vehicle's control strategy could then adjust the output of the IC engine and electric motor(s) to maintain the desired speed setting. Lateur also explains that the desired speed could be maintained in response to varying driving conditions (*e.g.*, when the vehicle begins to ascend a hill).

> Similarly, when microprocessor 26 determines that the present speed should be maintained but the load required to maintain that speed changes, e.g., the vehicle starts going up a hill, microprocessor 26 sends a signal to power controller 16 causing it to make the appropriate changes to the current flowing in the first and second motor/generators 12, 14 to

> change the torque being applied to output shaft 62 such that the desired speed is maintained."

(Ex. 1407 [Lateur] at 10:36-43, Figure 7.)

514. It is therefore my opinion that by September 1998, cruise control was well-known and a person having ordinary skill in the art understood how to implement such systems on hybrid vehicles. It is my opinion that to add such a commonly known device to Ibaraki '882 would have been a simple design choice.

515. It is also my opinion that a person having ordinary skill in the art would have understood that cruise control devices provide the added benefits of (1) "allowing the vehicle operator to relax from constant foot throttle manipulation" and (2) potential "improve[ment of] the vehicle's fuel efficiency value by limiting throttle excursions to small steps." (Ex. 1406 [Jurgen] at 14.) Therefore, a person having ordinary skill in the art would have understood that there was a reason to combine the cruise control functionality disclosed in Lateur and Jurgen with the hybrid vehicle disclosed in Ibaraki '882 in order to achieve these stated benefits. Including cruise control in the vehicle of Ibaraki '882 could further reduce fuel consumption, one of the stated goals of Ibaraki '882. (Ex. 1403 [Ibaraki '882] at 2:52-57.)

516. Once modified, the vehicle described in Ibaraki '882 would have been operable to execute the control strategy discussed above in claim 27 in order to maintain the driver's desired speed setting.

517. <Intentionally left blank>

518. <Intentionally left blank>

519. <Intentionally left blank>

B. Analysis

… ***[27.0] The method of claim 23, comprising the further step of operating said controller to accept operator input of a desired cruising speed,***

520. Again, Ibaraki ’882 discloses a hybrid vehicle that includes a controller that receives an operator *input* signals that include accelerator pedal operation, brake pedal operation and shift lever operation.

> The controller 128 includes a microcomputer incorporating a central processing unit (CPU), a random-access memory (RAM), and a read-only memory (ROM). . . . The controller 128 is supplied with input signals from various detecting devices. . . . The input signals include: an ACCELERATOR signal indicative of an operating amount θA of an accelerator pedal of the vehicle; a BRAKE signal indicating that a brake pedal of the vehicle has been depressed; a BRAKE PEDAL FORCE signal indicative of a force acting on the brake pedal; and ENGINE BRAKING SHIFT POSITION signal indicating that the shift lever 122 is placed in any one of engine braking shift positions, that is, in any one of the drive, second-speed and low-speed positions D, 2, L in which engine braking may be applied to the vehicle.

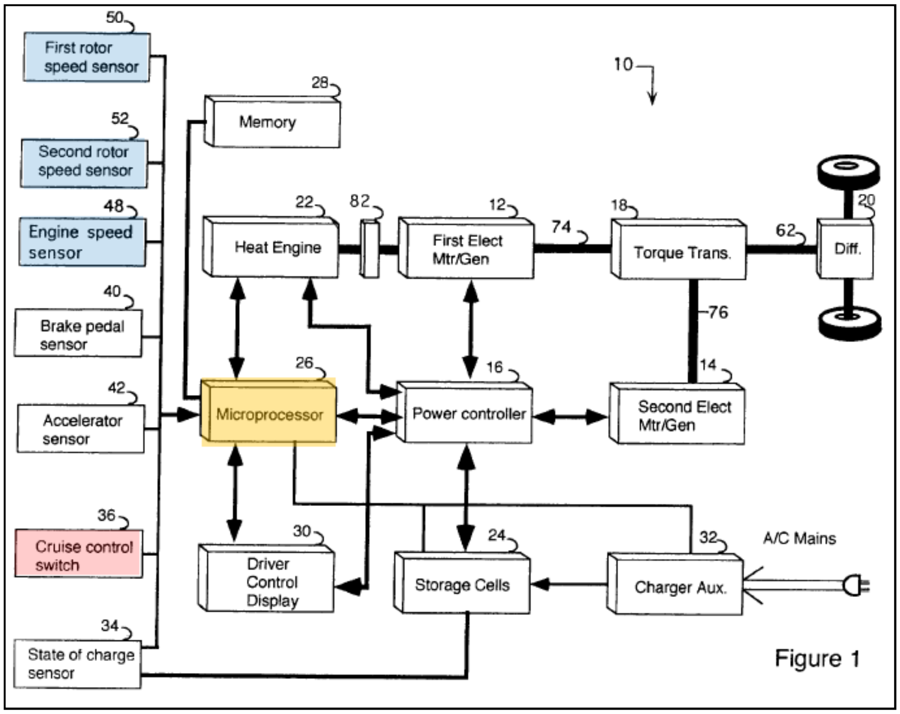
(Ex. 1403 [Ibaraki ’882] at 20:10-33.)

521. Ibaraki ’882 does not disclose accepting an *operator input of a desired cruising*

speed from a "cruise control" device. Both Lateur and Jurgen, however, explain that it was known to design a cruise control device which provided a controller with *operator input specifying a desired speed.*

> **Microprocessor 26 determines whether the speed control switch is producing a 'cruise control on' signal or a 'cruise control off' signal. If the 'cruise control on' signal is received, then the microprocessor determines the present speed** and load on output shaft 62 by sensing the characteristics of the current flowing to the motor/generators 12,14. Such microprocessor determines whether the operator desires to accelerate, decelerate, or maintain the present speed by checking the signals from brake pedal and accelerator sensors 40, 42.

(Ex. 1407 [Lateur] at 9:47-50-57, emphasis added.)



Ex. 1407 [Lateur] at Figure 1 (annotated)

> **The cruise control system is a closed-loop speed control as shown in Fig. 14.1. The key input signals are the driver's speed setpoint and the vehicle's actual speed**. Other important inputs are the faster-accel/slower-coast driver adjustments, resume, on/off, brake switch, and engine control messages. The key output signals are throttle control servo actuator values. Additional output signals include cruise ON and service indicators, plus messages to the engine and/or transmission control systems and possibly data for diagnostics.

(Ex. 1406 [Jurgen] at 14, emphasis added.)

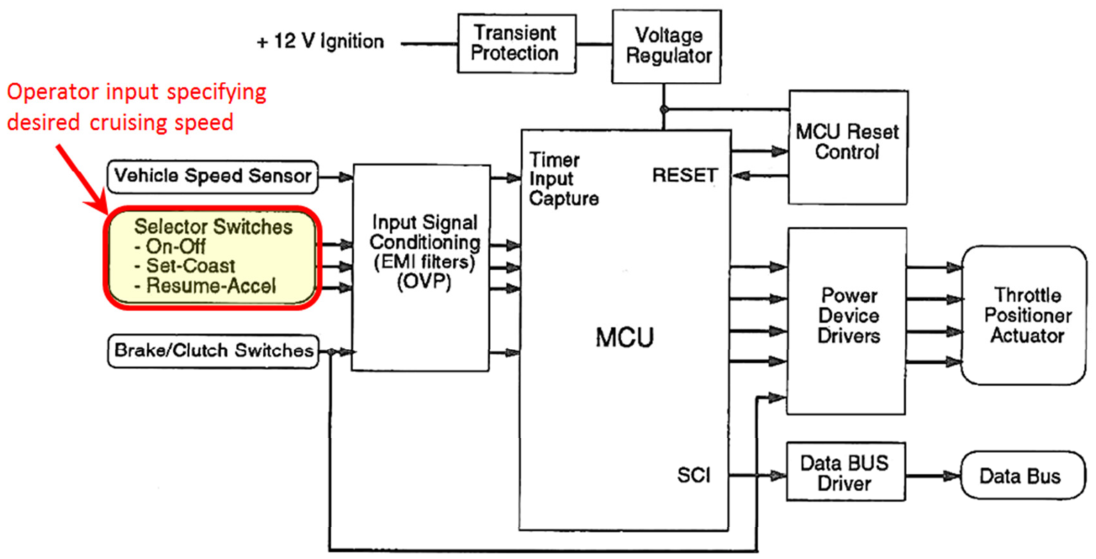


FIGURE 14.1 Cruise control system.

Ex. 1406 [Jurgen] at Figure 14.1 (annotated)

522. It is my opinion that a person having ordinary skill in the art would have understood that there would be a reason to combine the cruise control functionality described in Jurgen and Lateur with the hybrid vehicle described in Ibaraki '882. Specifically, a person having ordinary skill in the art would have recognized cruise control may "improve[e] the vehicle's fuel efficiency value by limiting throttle

excursions to small steps." (Ex. 1406 [Jurgen] at 14.) Improved fuel efficiency is Ibaraki '882's stated design goal. (Ex. 1403 [Ibaraki '882] at 2:52-56.)

523. Further, Ibaraki '882 already describes a controller that executes the drive modes for the vehicle. Adding cruise control would merely require providing input signals to the controller that could be used in place of the operator input signal supplied *via* accelerator pedal operation. The core functionality of selecting drive modes would remain unchanged.

524. As illustrated and disclosed by Jurgen and Lateur, the input signals could include a cruise control "on-off" switch that would indicate to the controller that the driver wishes to operate the vehicle using the cruise control device. Once the controller places the vehicle into a cruise mode, a "driver's speed setpoint" could also be provided. (Ex. 1406 [Jurgen] at 14.)

> A plurality of switch inputs are provided within the operator compartment of the vehicle to allow the operator to control the drive system 10. **A speed "cruise" control switch 36** is one of them. It is provided for producing a **"cruise control on" signal or a "cruise control off" signal in response to a selection made by the operator**.

(Ex. 1407 [Lateur] at 4:25-31.)

> **The cruise control system is a closed-loop speed control as shown in Fig. 14.1**. The key input signals are the **driver's speed setpoint** and the vehicle's actual speed. **Other important inputs are** the faster-accel/slower-coast driver adjustments, resume, **on/off**, brake switch, and engine control messages. The key output signals are throttle control

> servo actuator values. Additional output signals include cruise ON and service indicators, plus messages to the engine and/or transmission control systems and possibly data for diagnostics.

(Ex. 1406 [Jurgen] at 14.)

525. Therefore, it is my opinion that it would have been obvious to modify Ibaraki '882's controller to receive an additional input signal from the operator. It is my opinion that such a modification would have simply required providing an additional input signal to the controller in addition to the signals already being received.

526. It is therefore my opinion that it would be obvious to modify Ibaraki '882 so that the controller could *accept operator input of a desired cruising speed.*

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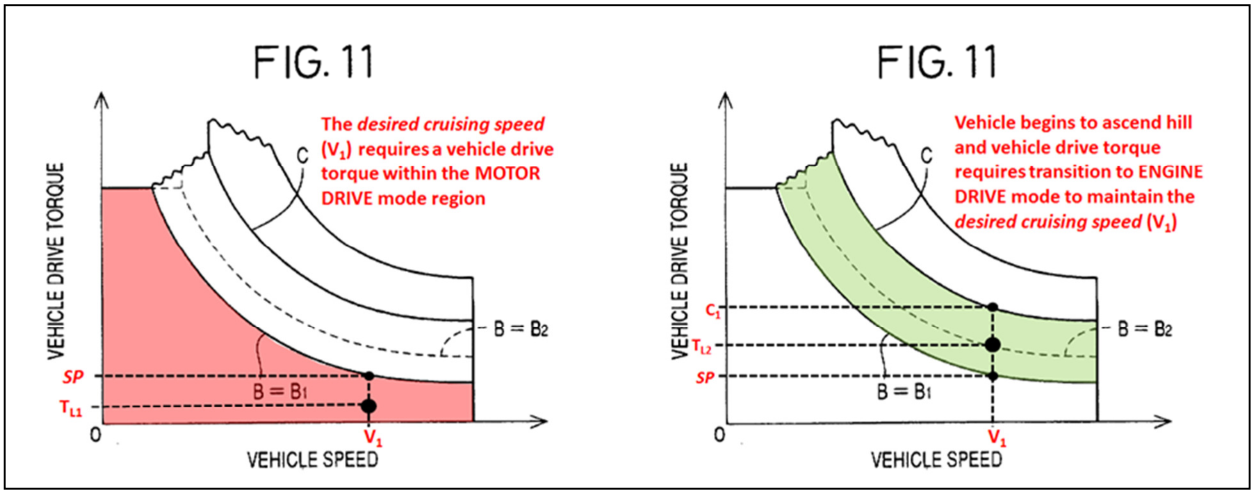
… ***[27.1] said controller thereafter controlling the instantaneous engine torque output and operation of said motor(s) to supply additional torque as needed in accordance with variation in RL to maintain the speed of said vehicle substantially constant.***

530. Once an input signal *specifying a desired cruising speed* had been received, it is my opinion that the control strategy of Ibaraki '882 would have essentially remained unchanged. Specifically, it is my opinion that Ibaraki '882 would have still

implemented the data map illustrated by Figure 11 in order to maintain the *desired cruising speed* over various vehicle driving conditions.

531. As I have illustrated below, Ibaraki '882 would have used the data map of Figure 11 to maintain the *desired cruising speed*. As shown to the left, at the *desired cruising speed* (V_1) Ibaraki '882 may have been operating on a flat road where the "vehicle drive torque" required that the vehicle be driven by the electric motor alone (MOTOR DRIVE mode). As is further illustrated to the right, however, the vehicle may begin ascending a hill whereby the "vehicle drive torque" may increase. During this ascent, the "vehicle drive torque" may increase past the *setpoint* (SP) and the controller would transition to an ENGINE DRIVE mode where the vehicle is driven by the IC engine alone. As shown, this increase in "vehicle drive torque" occurs at the same *desired cruising speed* (V_1) the operator had set using the cruise control device.



Ex. 1403 [Ibaraki '882] at Fig. 11 (annotated)

532. It would have been obvious for the controller to operate in this fashion in order to maintain the desired *cruising speed*. Indeed, this is the typical operation of

cruise control devices as taught by Jurgen and Lateur. If the vehicle controller did not transition control between MOTOR DRIVE mode and ENGINE DRIVE mode, the vehicle would begin to slow down due to the torque limitations of the motor acting alone in the MOTOR DRIVE mode. This would be contrary to the primary goal of a cruise control device. In other words, by not transitioning between operating modes during an ascent up a hill the driver's desired speed would not be maintained.

533. Again, it is my opinion that a person having ordinary skill in the art would have understood that there would be a reason to combine the cruise control functionality described in Jurgen and Lateur with the hybrid vehicle described in Ibaraki '882. Specifically, a person having ordinary skill in the art would have recognized cruise control may "improve[e] the vehicle's fuel efficiency value by limiting throttle excursions to small steps." (Ex. 1406 [Jurgen] at 14.) Improved fuel efficiency is corollary to Ibaraki '882's stated design goal.

534. Further, cruise control functionality would require a simple modification to the existing control program to input and maintain the *desired cruising speed* setting. And the added cruise control functionality would still leave Ibaraki '882's mode control strategy unchanged. Therefore, adding cruise control to the hybrid vehicle described in Ibaraki '882 would have been an obvious design choice using the already-present controller described in Ibaraki '882 to improve functionality for the driver and the fuel efficiency of the vehicle.

535. It is my opinion that the combination of Ibaraki and Lateur therefore

discloses the controller *thereafter controls the instantaneous torque output by said internal combustion engine and by either or both motor(s) in accordance with variation in RL so as to maintain vehicle speed substantially constant.*

536. <Intentionally left blank>

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XIII. GROUND 7 – CLAIMS 25-26 ARE OBVIOUS OVER IBARAKI ’882 IN VIEW OF FRANK AND THE KNOWLEDGE OF A PERSON HAVING ORDINARY SKILL IN THE ART

A. Reasons to Combine

539. Ibaraki ’882 also discloses a control strategy that operates the vehicle in a MOTOR DRIVE mode, ENGINE DRIVE mode, or ENGINE-MOTOR DRIVE mode. (Ex. 1403 [Ibaraki ’882] at 20:55-21:1, 24:6-30.)

540. Ibaraki ’882 discloses that when the MOTOR DRIVE mode is selected, “the vehicle is driven by operation of only the motor 114.” (Ex. 1403 [Ibaraki ’882] at 24:21-23.) Alternatively, when the ENGINE DRIVE mode is selected, “the vehicle is driven by operation of [*sic*] only [the] engine 112.” (Ex. 1403 [Ibaraki ’882] at 23-26.)

541. Ibaraki ’882 further discloses that during operation in the MOTOR DRIVE mode, “the clutch 130 is placed in the fully released state to disconnect the engine 112 and the motor 114 from each other.” (Ex. 1452 [Ibaraki ’882] at 24:35-38.)

542. It was known that for hybrid vehicles (such as the one illustrated by Figure 8 of Ibaraki ’882) in order to decrease exhaust gas emissions and fuel

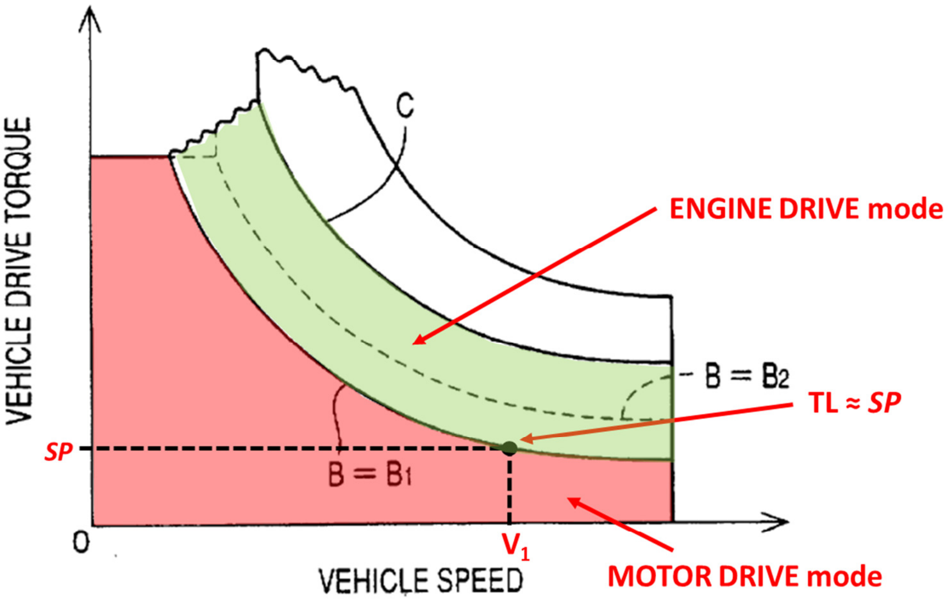
consumption the IC engine would be **turned off** after it is de-coupled from the drive wheels. It would have been known that leaving the IC engine running during the MOTOR-DRIVE mode would be undesirable from both an emissions and fuel consumption standpoint. Otherwise, the engine would be running without providing any benefit – *i.e.*, propelling the vehicle or generating electricity – while consuming unnecessary fuel and emitting unnecessary exhaust. Keeping the engine on after transitioning to the "MOTOR DRIVE mode" for a sustained time would be contrary to an objective of the invention described in Ibaraki '882 to "permit . . . effective reduction in the fuel consumption amount or exhaust gas amount of the engine." (Ex. 1403 [Ibaraki '882] at 2:52-56.)

543. It is therefore my opinion that in order to provide the reduced fuel consumption and emissions, which Ibaraki '882 identifies as a design goal, a person having ordinary skill in the art would have understood that the IC engine would have been shut-down when it is de-clutched during operation in MOTOR-DRIVE mode. In other words, when the vehicle drive torque at a given vehicle speed is below a *setpoint* value, it would have been obvious to de-clutch and shutdown the IC engine. At the very least it would have been obvious.

544. A person having ordinary skill in the art would have also understood that cycling of the engine, motor and/or clutch could occur when the torque required to propel the vehicle (T_L or *road load*) is toggling at or around *setpoint*. For instance, as I have illustrated below the controller may unwantedly cycle between MOTOR DRIVE

mode and ENGINE DRIVE mode.

FIG. 11



Ex. 1403 [Ibaraki '882] at Fig. 11 (Annotated)

545. This cycling would cause the engine to be started and stopped at a high frequency leading to increased emissions and gas consumption. The motor and engine are disclosed as being coupling/decoupling *via* a clutch mechanism. (Ex. 1403 [Ibaraki '882] at 24:35-39.) High frequency cycling of the clutch mechanism would result in these drive sources being rapidly engaged/disengaged to each other and the drive wheels. The shock involved in connecting these devices at a rapid pace could lead to damage to either or both devices. Also, simple starting and stopping of these devices could lead to unacceptable wear and potential damage.

546. Also, high frequency cycling of just the clutch mechanism could make the vehicle un-drivable due to vibration and shock that would result in

connecting/disconnecting the engine and motor rapidly. Also, the clutch mechanism itself would become damaged from such high frequency cycling.

547. In order to prevent unwanted cycling of the engine, motor and/or clutch mechanism, it is my opinion that it would have been obvious to a person having ordinary skill in the art to include a hysteresis based time delay between switching from MOTOR DRIVE mode to ENGINE DRIVE mode or vice-versa. By instituting a time delay before switching before transitioning between these two modes, the hybrid system would prevent, or at least substantially reduce, any unnecessary cycling between the ENGINE DRIVE mode and the MOTOR DRIVE mode at times when the "vehicle drive torque" is hovering at or near *setpoint*.

548. It is my opinion that such a time delay would prevent undesirable starting and stopping of the engine and motor which may potentially damage either or both devices. It is also my opinion that preventing rapid starting and stopping of the engine using a time delay would also lead to decreased exhaust emissions and reduced fuel efficiency.

549. It is also my opinion that such a time delay would prevent the clutch mechanism from connecting and disconnecting the engine to the drive wheels at a rapid rate. It is my opinion that the time delay would prevent unnecessary wear to the clutch mechanism, engine and motor if the torque required to propel the vehicle was hovering around *setpoint*. Without a time delay, clutching the engine to the driveline at a rapid rate would also present a noise and vibration issue that would make the vehicle

undesirable and potentially un-drivable.

550. It is also my opinion that such a time delay would have simply required a change to the already existing control logic taught by Ibaraki '882. Such a modification would have been well-within the programming capabilities of a person having ordinary skill in the art.

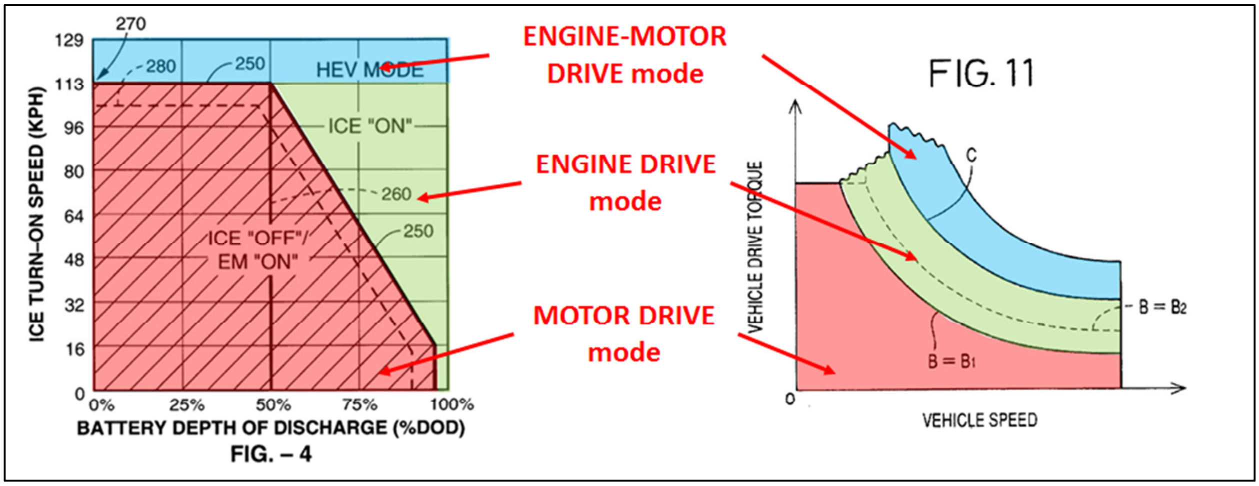
551. To the extent that it is not obvious based on the teaching of Ibaraki '882 alone, Frank teaches a hybrid vehicle having a time delay intended to prevent unwanted cycling on and off of the engine. Specifically, Frank describes the problem of "frequent cycling" of the engine during mode switching that is common to parallel hybrid vehicles like Ibaraki '882. Frank further discloses a solution to the problem of "frequent cycling" is to simply include a time delay when switching between modes.

> As an alternative to separate "on" and "off" thresholds, a single threshold could be used in combination with **<u>a time delay between the "on" and "off" modes to prevent frequent cycling</u>**.

(Ex. 1418 [Frank] at 8:32-37, emphasis added.)

552. A person having ordinary skill in the art would have understood that there is a reason to combine the teaching of Frank with Ibaraki '882. First, both Frank and Ibaraki '882 disclose parallel hybrid vehicles that employ control strategies that switch between operating the vehicle using an electric motor or IC engine. The engines in both systems would therefore be at risk of frequent cycling. There would be a reason to add the teaching in Frank to prevent unwanted cycling in the control

strategy of Ibaraki '882.



Ex. 1418 [Frank] at Fig. 4 **Ex. 1403 [Ibaraki '882] Fig. 11 (annotated)**

553. Also, Frank teaches that cycling the engine also leads to reduced fuel efficiency and increased emissions. (Ex. 1418 [Frank] at 2:44-47.) This is contrary to Ibaraki '882's stated goal of reduced emissions and fuel consumption. (Ex. 1403 [Ibaraki '882] at 2:52-56.) It is my opinion that reducing emissions and increasing fuel efficiency using a time delay between mode switching would provide another reason to combine Frank and Ibaraki '882.

554. Further, it is my opinion that adding a time based delay between switching between MOTOR DRIVE mode and ENGINE DRIVE mode would require nothing more than a software change to the already existing control logic disclosed by Ibaraki '882. A person having ordinary skill in the art would have been capable and knowledgeable to make such a software change to incorporate a time based delay like the one disclosed by Frank.

B. Dependent Claim 25

… ***[25.0] The method of claim 23, comprising the further step of employing said controller to monitor RL over time, and***

555. I understand the term roadload *(RL)* as used in the '347 Patent should be interpreted as "instantaneous torque required to propel the vehicle, be it positive or negative in value."

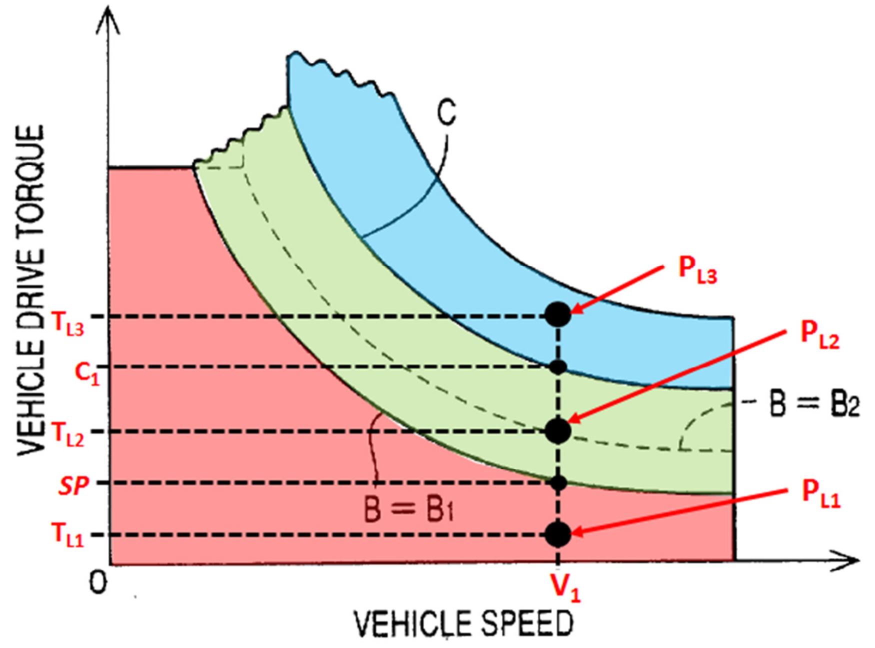
556. As described in greater detail in **[23.7] – [23.9]** above and briefly illustrated below, Ibaraki '882 discloses a "controller 128," which compares the vehicle drive torque (RL) (annotated as T_{L1}, T_{L2} and T_{L3} below) at a given vehicle speed (V_1) to a corresponding *setpoint* (annotated as SP below) along boundary line B to determine whether the vehicle should operate in a MOTOR DRIVE mode or ENGINE DRIVE mode.[32] Ibaraki '882 also discloses comparing the *road load (i.e.*, "vehicle drive torque" annotated as T_{L1}, T_{L2} and T_{L3} below) at a given vehicle speed (V_1) to a corresponding torque point (annotated as C_1 below) along boundary line C to determine whether the vehicle should operate in an ENGINE DRIVE mode or

---

[32] Again, the "vehicle drive torque" at a given vehicle speed is disclosed as being used to determine "a point corresponding to the required drive power P_L" that is annotated on Figure 11 as (P_{L1}, P_{L2}, P_{L3}). (Ex. 1403 [Ibaraki '882] at 23:66-24:2.) The "required drive power P_L" point would have been understood as being "determined" based on a known relationship where Power = Torque * Speed.

ENGINE-MOTOR DRIVE mode.

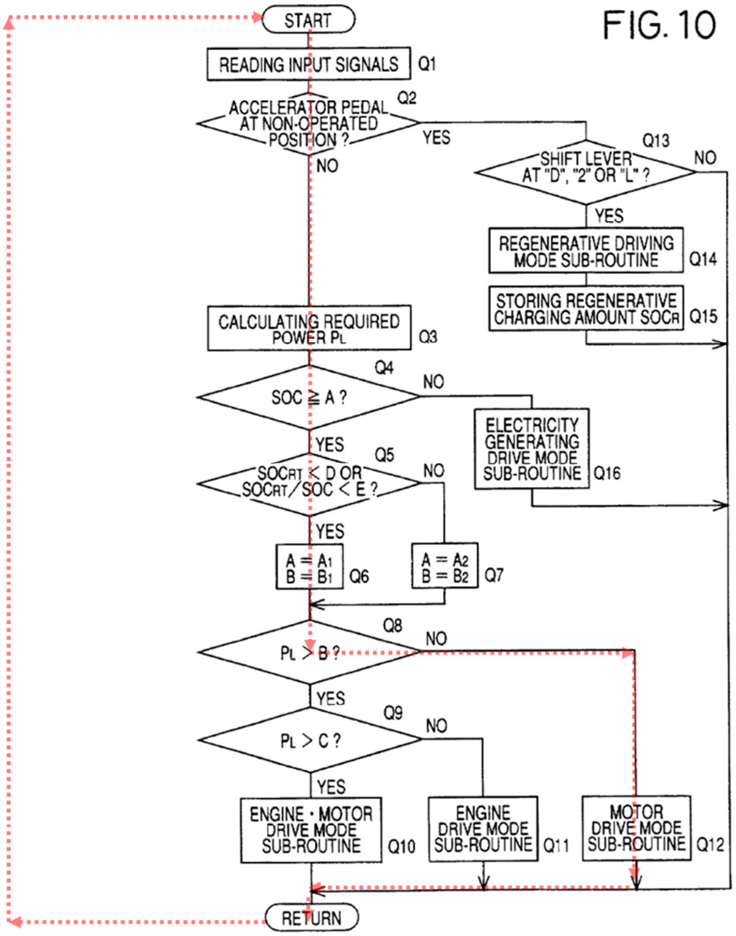
FIG. 11



557. A person having ordinary skill in the art would have understood that "controller 128" of Ibaraki '882 must continuously monitor the *road load (RL)* during vehicle operation (*i.e., over time*) so that the controller 128 has the most updated information needed to determine which "drive mode" the vehicle should operate in. The continuous monitoring of the *road load* (RL) is important because it allows the vehicle to more quickly adapt to changing conditions in vehicle operation to ensure that the vehicle is operating in the correct drive mode to maximize both efficiency and the driving experience.

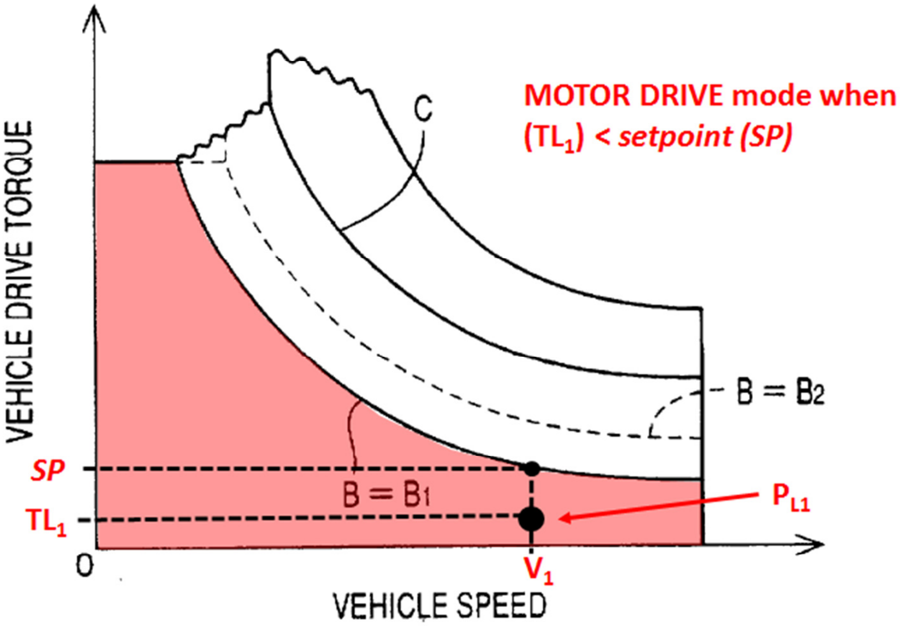
558. Figure 10 of Ibaraki '882 illustrates a "flow chart showing a routine executed" by the controller 128 for determining which "drive mode" to command the

vehicle to operate in. (Ex. 1403 [Ibaraki '882] at 10:66-67.) As I have annotated below, the control logic of Fig. 10 dictates that the motor propels the vehicle in the "MOTOR DRIVE mode" at step Q12 when the vehicle drive torque (*i.e. road load* and annotated in Fig. 11 as T_{L1} below) corresponding to a point of "required drive power P_L" (annotated as P_{L1} on figure 11 below) is less than a *setpoint* (annotated as *SP* in Figure 11 below) along boundary line B.



Ex. 1403 [Ibaraki '882] at Fig. 10 (Annotated)

FIG. 11

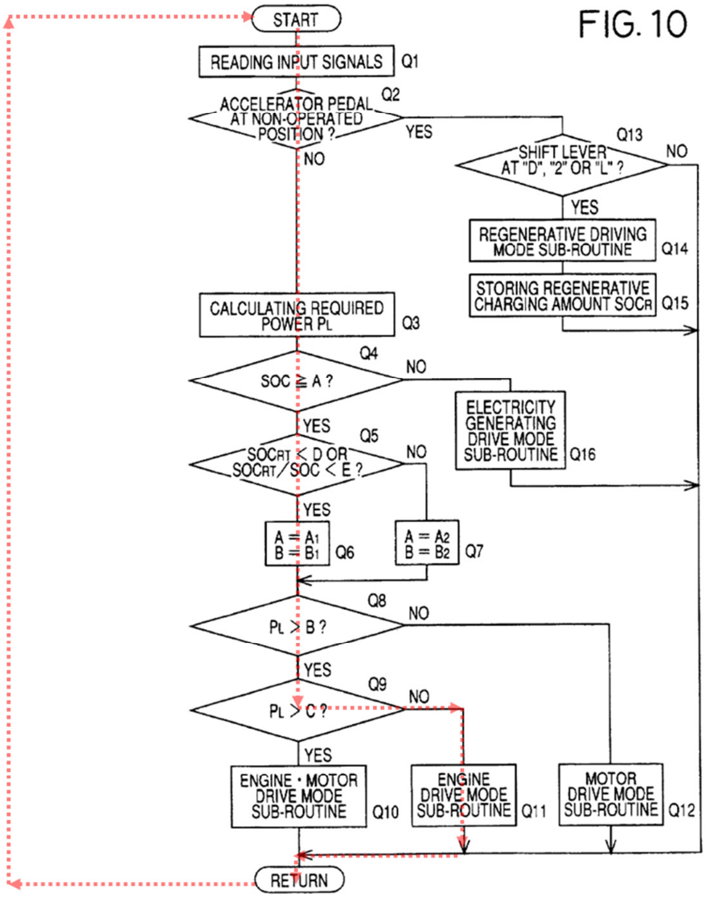


Ex. 1403 [Ibaraki '882] at Fig. 11 (Annotated)

559. As clearly seen in Fig. 10 above, the control strategy of Fig. 10 ends with a step labeled "RETURN." A person having ordinary skill in the art would have understood that logically the "return" step goes back to the "start" step and again analyzes the *road load (RL)* to determine which drive mode to operate in. This is important as vehicle conditions (*e.g.*, vehicle drive torque) may be constantly changing, making it critical that the vehicle continuously update its information to determine the most efficient drive mode in which to operate.

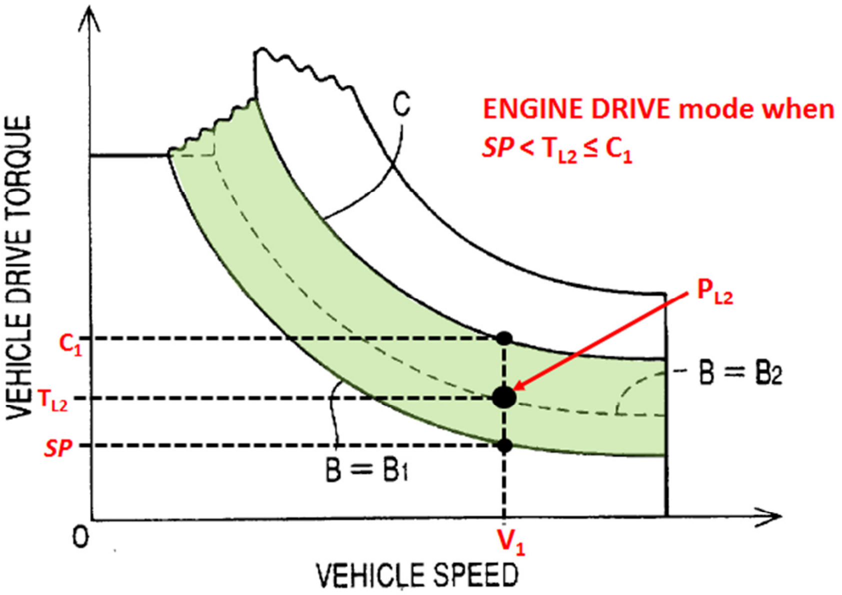
560. Based on the changing of the *road load (RL)*, and as described in above, a subsequent utilization of the control logic of Fig. 10 dictates that the engine propels the vehicle in the "ENGINE DRIVE mode" at step Q11 when the vehicle drive

torque (*i.e. road load* and annotated in Fig. 11 as T_{L1} below) associated with a plotted point P_L (annotated as P_{L2} on figure 11 below) is greater than a *setpoint* (annotated as *SP* in Figure 11 below) along "boundary line B" and less than a torque point (C_1) along boundary line C.



Ex. 1403 [Ibaraki '882] at Fig. 10 (Annotated)

FIG. 11



Ex. 1403 [Ibaraki '882] at Fig. 11 (Annotated)

561. As seen again in annotated Fig. 10 above and for the reasons discussed above, the control strategy "returns" to the "start" and again analyzes the *road load (RL)* to determine which drive mode to operate in. Based on the changing of the *road load (RL)*, a subsequent utilization of the control logic of Fig. 10 dictates that the engine propels the vehicle in the "ENGINE-MOTOR DRIVE mode" at step Q10 when the vehicle drive torque (*i.e. road load* and annotated in Fig. 11 as T_{L1} below) associated with a plotted point P_L (annotated as P_{L3} on figure 11 below) is greater than a *setpoint* (annotated as *SP* in Figure 11 below) along "boundary line B" and greater than a torque point (C_1) along boundary line C.

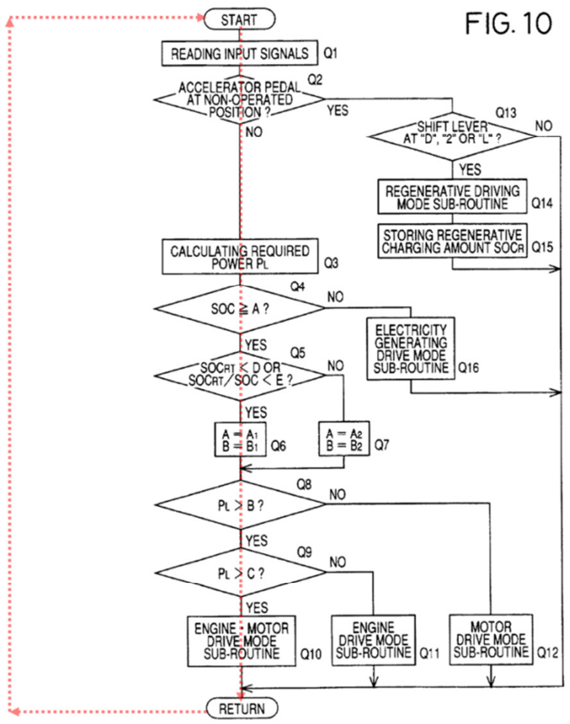


FIG. 10

Ex. 1403 [Ibaraki '882] at Fig. 10 (Annotated)

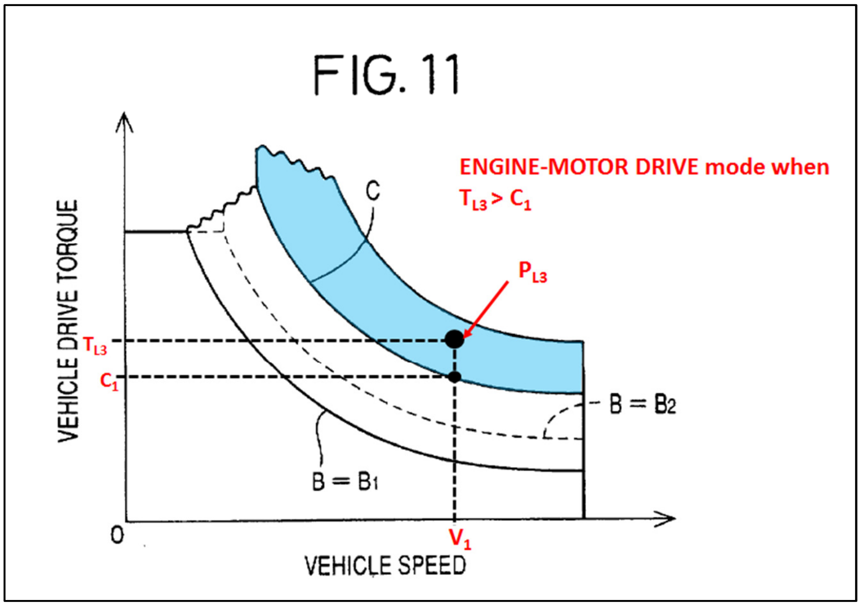


FIG. 11

Ex. 1403 [Ibaraki '882] at Fig. 11 (Annotated)

562. It is therefore my opinion that Ibaraki '882 discloses *employing said controller to monitor RL over time.*

… ***[25.1] and to control transition between propulsion of said vehicle by said motor(s) to propulsion by said engine such that said transition occurs only when RL>SP for at least a predetermined time, or when RL>SP2, wherein SP2 is a larger percentage of MTO than SP.***

563. Again, I understand the term *roadload (RL)* as used in the '347 Patent should be interpreted as an "instantaneous torque required to propel the vehicle, be it positive or negative in value." It is also my understanding that the term *setpoint (SP)* should be interpreted as a "predetermined torque value."

564. Further, it is my understanding that "OR" within the claim is meant to be interpreted to mean "Element A" or "Element B" as follows:

- **Element A** - wherein said controller controls transition between propulsion of said vehicle by said motor(s) to propulsion by said engine responsive to RL reaching SP, such that said transition occurs only when RL>SP for at least a predetermined time; **<u>OR</u>**
- **Element B** - wherein said controller controls transition between propulsion of said vehicle by said motor(s) to propulsion by said engine responsive to RL reaching SP, such that said transition occurs only when RL>SP2, wherein SP2>SP.

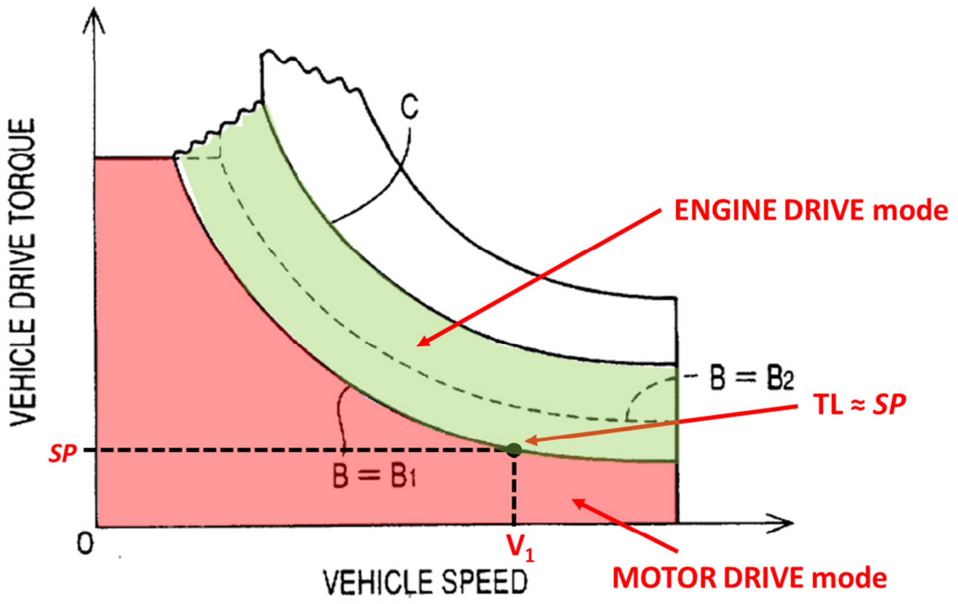
565. Regarding **Element A**, as discussed in **[23.8]** above, Ibaraki '882 teaches

operating the IC engine to propel the vehicle in the "ENGINE DRIVE mode" when the "vehicle drive torque" (*i.e., road load*) is greater than a torque value along "boundary line B" (*i.e., setpoint*).

566. It is my opinion that it would have been obvious to a person having ordinary skill in the art to delay operating the hybrid vehicle described in Ibaraki '882 in the "ENGINE DRIVE mode" *for at least a predetermined time* even after the "vehicle drive torque" exceeds the torque value along "boundary line B." By instituting a time delay before switching from "motor drive mode" to "engine drive mode" the hybrid system would prevent, or at least substantially reduce, any unnecessary toggling between the "ENGINE DRIVE mode" and the "MOTOR DRIVE mode" at times when the "vehicle drive torque" is hovering on or near a point along "boundary line B." This would reduce the threat of erratic starting and stopping of the motor and engine, preventing inefficient starting, and avoidable wear of the motor, engine and clutch mechanism.

567. For example, I have annotated Fig. 11 of Ibaraki '882 below to show a scenario in which the vehicle drive torque (T_L) required to propel the vehicle (*i.e., road load* and annotated as T_L) is about equal to the amount of torque on boundary line "B" (i.*e., setpoint* annotated as *SP*), representing the transition between the MOTOR DRIVE mode and the ENGINE DRIVE mode.

FIG. 11



Ex. 1403 [Ibaraki '882] at Fig. 11 (Annotated)

568. If the vehicle were to transition between the MOTOR DRIVE mode and the ENGINE DRIVE mode *without any delay* as the torque T_L fluctuates above and below the boundary line "B," then the engine and motor would turn on and off at a corresponding rate. Also, the clutch mechanism (*i.e.*, "clutch 130") would be engaged and disengaged – another undesirable feature.

569. It follows that if vehicle drive torque T_L fluctuates above and below the boundary line "B" at a high frequency, the engine would turn on and off at a correspondingly high frequency. It would have been understood that such operation would cause undesirable high frequencies of starting and stopping of the engine and motor. Such a vehicle would not drive smoothly at these moments due to the rapid changes in flow and magnitude of torque as the engine and motor are both repeatedly

started and stopped. Also, the noise of the engine starting and stopping at a high frequency would be undesirable. Finally, frequent starting and stopping of the engine would lead to increased exhaust emissions and reduced fuel efficiency.

570. A person of ordinary skill in the art would have recognized the inherit problems with such a high frequency of transitions between operational modes of hybrid vehicles that correspond to the vehicle drive torque fluctuating above and below the transition point between the operational modes. It would have therefore been obvious to a person having ordinary skill in the art to continue operating the motor to propel the vehicle in the MOTOR DRIVE mode until the vehicle drive torque (*i.e., RL*) has been greater than the predetermined torque value (*i.e., SP*) *for at least a predetermined time*. Doing so would reduce the frequency of starting and stopping the engine, providing a smoother, quieter, and more efficient vehicle. Doing so would reduce the frequency of starting and stopping the engine and motor, providing a smoother, quieter, and more efficient vehicle. Further, a person having ordinary skill in the art would have found it obvious that the control programs stored in the controller could include *predetermined* times for the first and second length of times. Indeed, by including predetermined times in the memory of the controller, the complexity of the algorithm used to perform the steps of claims 6 and 8 would be reduced. This would free-up controller resources, which could instead be used to perform other functions described in Ibaraki '882. Alternatively, including predetermined values for the length of time could reduce the overall complexity of

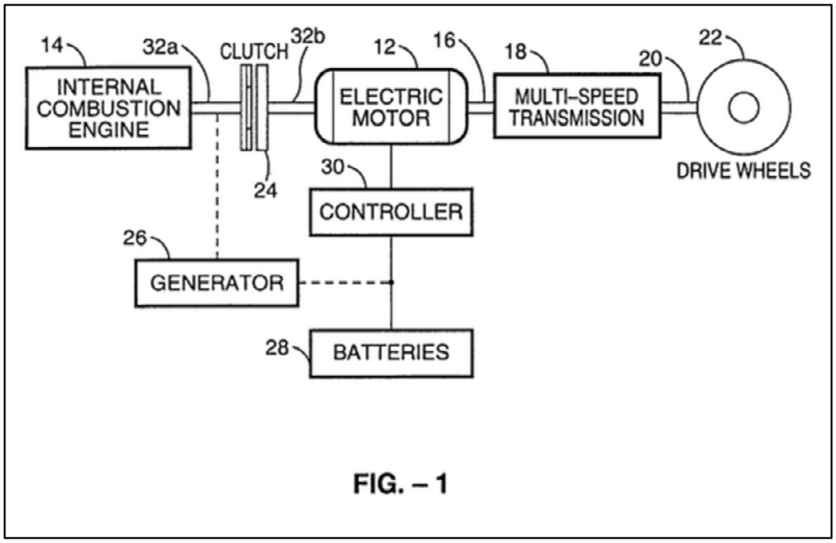
the control program for the controller, and by doing so reduce the complexity of the controller needed for the system. This would provide the benefit of reducing the cost of the controller, while also reducing the resources dedicated (*e.g.*, energy needed to operate, space in the vehicle) to the controller in the system.

571. To the extent that it is not obvious based on the teaching of Ibaraki '882 alone, Frank further supports my opinion that it would have been obvious to a person of ordinary skill in the art to include a delay for a "*predetermined time*" when transitioning between drive modes. For the reasons discussed below, it would have been obvious to a person having ordinary skill in the art to combine the teaching of Frank with Ibaraki '882.

572. Frank "pertains generally to hybrid powered vehicles employing both electric motors and auxiliary power units. . . ." (Ex. 1418 [Frank] at 1:15-17.) Figure 1 of Frank is reproduced below, illustrating an exemplary parallel hybrid vehicle having an IC engine 14 and an electric motor 12, both capable of propelling the vehicle either individually or together. As Frank states:

> By way of example, and not of limitation, the invention provides for operating the hybrid powertrain in a zero emissions vehicle (ZEV) mode and in an HEV mode. In the ZEV mode, the EM provides all driving power while the ICE is uncoupled and turned off. In the HEV mode, operation of the EM and ICE is coordinated for maximum range and efficiency.

(Ex. 1418 ['363 Frank] at 2:25-31.)



Ex. 1418 ['363 Frank] at Fig. 1

573. The control strategy disclosed by Frank monitors the vehicle speed and depth of discharge. Based on these sensed values, Frank transitions between: (1) an electric-motor mode (highlighted in red) where the electric motor is used to drive the vehicle; (2) an engine mode (highlighted in green) where the only the IC engine is used to drive the vehicle; and (3) an engine-motor mode (highlighted in blue) where the electric motor and IC engine are used to drive the vehicle. (Ex. 1418 ['363 Frank] at 7:63-8:37.)

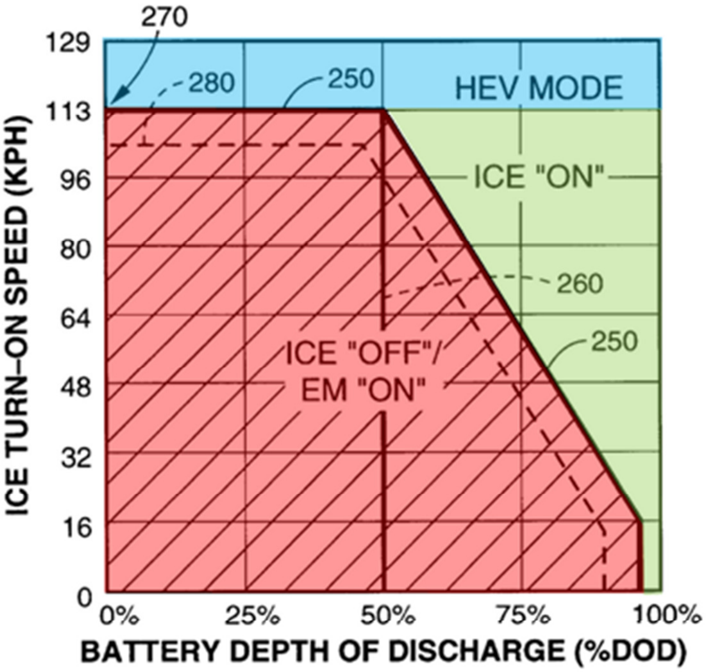


FIG. – 4

Ex. 1418 ['363 Frank] at Fig. 4 (annotated)

574. With respect to Frank's control strategy, Fig. 4 further shows an "on threshold curve" (bold line labeled as "250") and an "off threshold curve" (dashed line labeled as "280").

> Referring also to FIG. 4, the control parameters used for coordinating the operation of the EM 12 and the ICE 14 in step 150 of FIG. 3 are graphically shown. The area below the "on" threshold curve is where the vehicle operates in a ZEV mode, with the EM 12 turned on and the ICE 14 decoupled and turned off. The area above the "on" threshold curve is where the vehicle operates in a HEV mode with the ICE 14 coupled and turned on, and with the EM 12 being used only for accelerating, climbing hills and regenerative braking.

(Ex. 1418 ['363 Frank] at 7:63-8:5, emphasis added.)

575. Although Frank determines whether to operate the ICE based on speed and depth of charge (rather than torque and speed like Ibaraki '882), Frank describes the problem of "frequent cycling" of the engine shared by all parallel hybrid vehicles including the vehicle disclosed in Ibaraki '882. Further, Frank's disclosure of different on/off setpoints applies to any control system, regardless of the variable feature that is serving as the on/off setpoint. Further, Frank discloses that another solution to the problem of "frequent cycling" is to simply add a time delay between switching.

> As an alternative to separate "on" and "off" thresholds, a single threshold could be used in combination with **a time delay between the "on" and "off" modes to prevent frequent cycling**.

(Ex. 1418 [Frank] at 8:32-37, emphasis added.)

576. In this disclosure, Frank explains that "frequent cycling" is preventable by including a time delay when vehicle conditions exceed the threshold in which the hybrid vehicle switches from motor mode to engine mode. In other words, Frank discloses setting a predetermined time for which the vehicle conditions must be conducive to operating in the engine mode before switching the drive source from the motor to the engine. Again, this time delay solution to frequent on/off cycling would apply to any system with on/off control.

577. A person having ordinary skill in the art would have understood that there is a reason to combine the teaching of Frank with Ibaraki '882. Both Frank and Ibaraki '882 disclose parallel hybrid vehicles. As I have further illustrated below, both

Frank and Ibaraki '882 employ control strategies where an electric motor and IC engine are used to drive the vehicle in various operating modes.

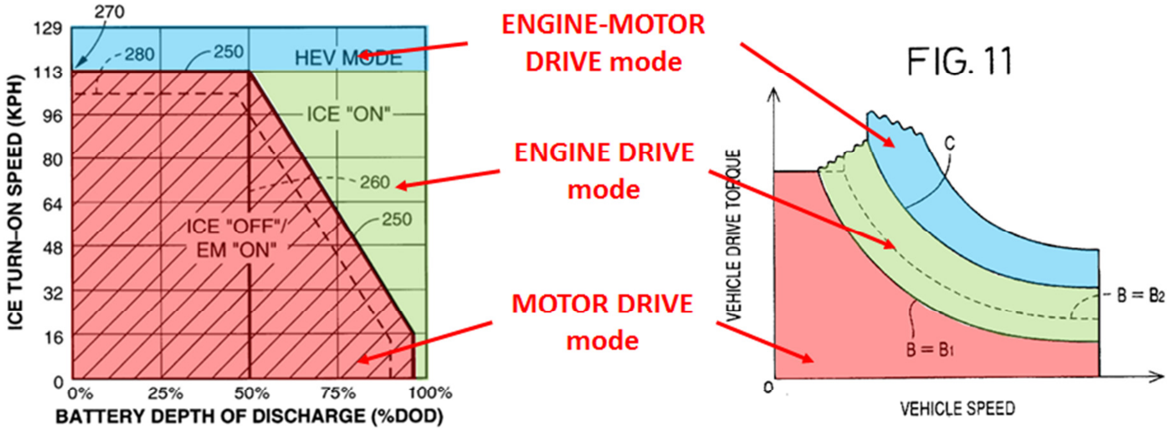


FIG. – 4

Ex. 1418 ['363 Frank] at Fig. 4 Ex. 1403 [Ibaraki '882] Fig. 11 (annotated)

578. As also discussed above, both systems utilize control strategies with threshold values ("On/Off" of Frank and boundary line "B" of Ibaraki '882) at which point their disclosed hybrid systems switch from motor drive mode to engine drive mode. For these reasons, the engines in both systems would be at risk of frequent cycling. Thus, there would be a reason to add the teaching in Frank to prevent frequent cycling in the Ibaraki '882 hybrid vehicle. Indeed, by adding a "time delay" along the boundary line "B" of Fig. 11 of Ibaraki '882, like the time delay taught by Frank, Ibaraki '882 would prevent the known problem of "undesirable or excessive cycling" of the engine. *Id.*

579. <Intentionally left blank>

580. Thus, Ibaraki '882 in view of Frank discloses a controller to *control transition between propulsion of said vehicle by said motor(s) to propulsion by said engine such that*

said transition occurs only when RL>SP for at least a predetermined time, or when RL>SP2, wherein SP2 is a larger percentage of MTO than SP.

C. Dependent Claim 26

… ***[26] The method of claim 23, comprising the further step of employing said controller to monitor RL over time, and to control transition between propulsion of said vehicle by said engine to propulsion by said motor(s) such that said transition occurs only when RL<SP for at least a predetermined time.***

581. Again, I understand the term *roadload (RL)* as used in the '347 Patent should be interpreted as an "instantaneous torque required to propel the vehicle, be it positive or negative in value." It is also my understanding that the term *setpoint (SP)* should be interpreted as a "predetermined torque value."

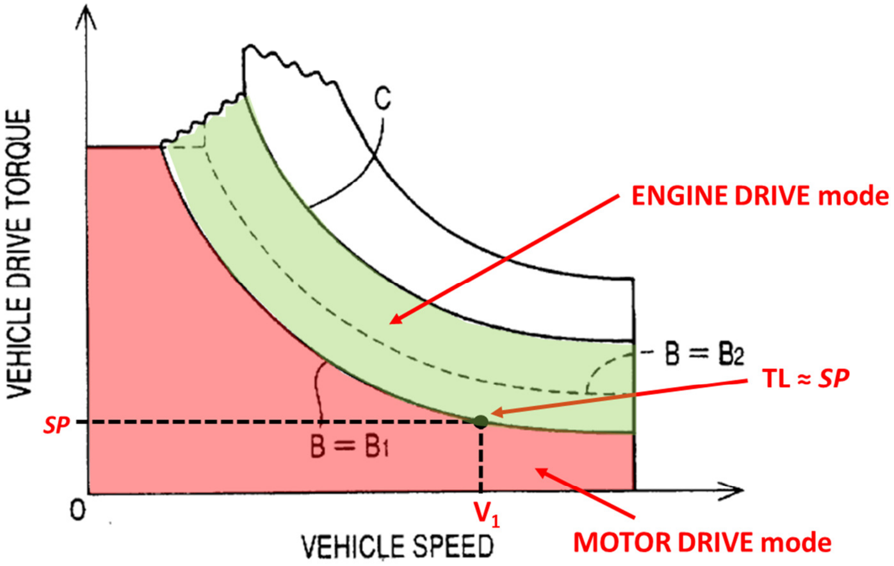
582. As discussed in **[23.7]** above, Ibaraki '882 teaches operating the IC engine to propel the vehicle in the "MOTOR DRIVE mode" when the "vehicle drive torque" (*i.e., road load*) is below a torque value along "boundary line B" (*i.e., setpoint*).

583. It is my opinion that it would have been obvious to a person having ordinary skill in the art to delay operating the hybrid vehicle described in Ibaraki '882 in the "MOTOR DRIVE mode" *for at least a predetermined time* even after the "vehicle drive torque" is reduced below the torque value along "boundary line B." By instituting a time delay before switching from "ENIGNE DRIVE mode" to "MOTOR DRIVE mode" the hybrid system would prevent, or at least substantially

reduce, any unnecessary toggling between the "MOTOR DRIVE mode" and the "ENGINE DRIVE mode" at times when the "vehicle drive torque" is hovering on or near a point along "boundary line B." This would reduce the threat of erratic starting and stopping of the motor and engine, preventing inefficient starting, and avoidable wear of the motor, engine and clutch mechanism.

584. For example, I have annotated Fig. 11 of Ibaraki '882 below to show a scenario in which the vehicle drive torque (T_L) required to propel the vehicle (*i.e., road load* and annotated as T_L) is about equal to the amount of torque on boundary line "B" (i.*e., setpoint* annotated as *SP*), representing the transition between the MOTOR DRIVE mode and the ENGINE DRIVE mode.

FIG. 11



Ex. 1403 [Ibaraki '882] at Fig. 11 (Annotated)

585. If the vehicle were to transition between the ENGINE DRIVE mode

and the MOTOR DRIVE mode *without any delay* as the torque T_L fluctuates above and below the boundary line "B," then the engine would turn off and on at a corresponding rate. Also, the clutch mechanism (*i.e.*, "clutch 130") would be engaged and disengaged – another undesirable feature.

586. It follows that if vehicle drive torque T_L fluctuates above and below the boundary line "B" at a high frequency, the engine and motor would turn on and off at a correspondingly high frequency. It would have been understood that such operation would cause undesirable high frequencies of starting and stopping of the engine and motor. Such a vehicle would not drive smoothly at these moments due to the rapid changes in flow and magnitude of torque as the engine and motor are repeatedly started and stopped. Also, the noise of the engine starting and stopping at a high frequency would be undesirable. Finally, frequent starting and stopping of the engine would lead to increased exhaust emissions and reduced fuel efficiency.

587. A person of ordinary skill in the art would have recognized the inherit problems with such a high frequency of transitions between operational modes of hybrid vehicles that correspond to the vehicle drive torque fluctuating above and below the transition point between the operational modes. It would have therefore been obvious to a person having ordinary skill in the art to change from operating the engine in the ENGINE DRIVE mode to operating the motor to propel the vehicle in the MOTOR DRIVE mode only when the vehicle drive torque (*i.e., RL*) has been below the predetermined torque value (*i.e., SP*) *for at least a predetermined length of time.*

Doing so would reduce the frequency of starting and stopping the engine and motor, providing a smoother, quieter, and more efficient vehicle. Further, a person having ordinary skill in the art would have found it obvious that the control programs stored in the controller could include *predetermined* times for the first and second length of times. Indeed, by including predetermined times in the memory of the controller, the complexity of the algorithm used to perform the steps of claims 6 and 8 would be reduced. This would free-up controller resources, which could instead be used to perform other functions described in Ibaraki '882. Alternatively, including predetermined values for the length of time could reduce the overall complexity of the control program for the controller, and by doing so reduce the complexity of the controller needed for the system. This would provide the benefit of reducing the cost of the controller, while also reducing the resources dedicated (*e.g.*, energy needed to operate, space in the vehicle) to the controller in the system.

588. To the extent that it is not obvious based on the teaching of Ibaraki '882 alone, Frank further supports my opinion that it would have been obvious to a person of ordinary skill in the art to include a delay for a "*predetermined time*" when transitioning between drive modes. For the reasons discussed below, it would have been obvious to a person having ordinary skill in the art to combine the teaching of Frank with Ibaraki '882.

589. Frank "pertains generally to hybrid powered vehicles employing both electric motors and auxiliary power units. . . ." (Ex. 1418 ['363 Frank] at 1:15-17.)

Figure 1 of Frank is reproduced below, illustrating an exemplary parallel hybrid vehicle having an IC engine 14 and an electric motor 12, both capable of propelling the vehicle either individually or together. As Frank states:

> By way of example, and not of limitation, the invention provides for operating the hybrid powertrain in a zero emissions vehicle (ZEV) mode and in an HEV mode. In the ZEV mode, the EM provides all driving power while the ICE is uncoupled and turned off. In the HEV mode, operation of the EM and ICE is coordinated for maximum range and efficiency.

(Ex. 1418 ['363 Frank] at 2:25-31.)

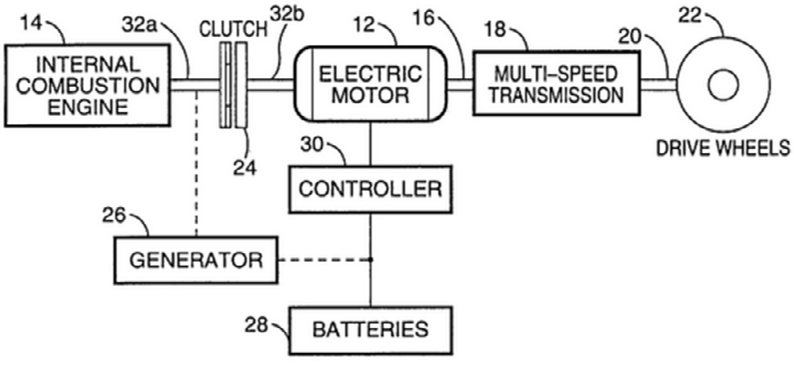


FIG. – 1

Ex. 1418 ['363 Frank] at Fig. 1

590. The control strategy disclosed by Frank monitors the vehicle speed and depth of discharge. Based on these sensed values, Frank transitions between: (1) an electric-motor mode (highlighted in red) where the electric motor is used to drive the vehicle; (2) an engine mode (highlighted in green) where the only the IC engine is

used to drive the vehicle; and (3) an engine-motor mode (highlighted in blue) where the electric motor and IC engine are used to drive the vehicle. (Ex. 1418 ['363 Frank] at 7:63-8:37.)

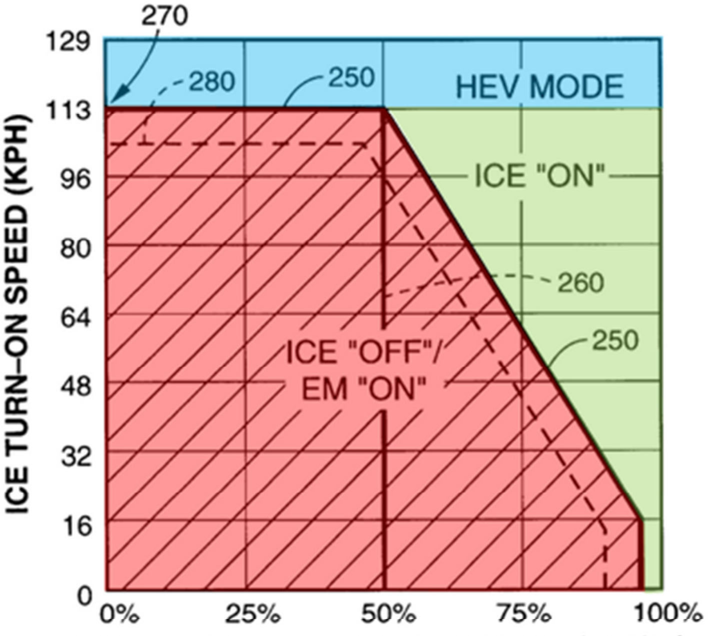


FIG. – 4

Ex. 1418 ['363 Frank] at Fig. 4 (annotated)

591. With respect to Frank's control strategy, Fig. 4 further shows an "on threshold curve" (bold line) and an "off threshold curve" (dashed line).

> Referring also to FIG. 4, the control parameters used for coordinating the operation of the EM 12 and the ICE 14 in step 150 of FIG. 3 are graphically shown. The area below the "on" threshold curve is where the vehicle operates in a ZEV mode, with the EM 12 turned on and the ICE 14 decoupled and turned off. The area above the "on" threshold curve is where the vehicle operates in a HEV mode with the ICE 14 coupled and

> turned on, and with the EM 12 being used only for accelerating, climbing hills and regenerative braking.

(Ex. 1418 ['363 Frank] at 7:63-8:5.)

592. Although Frank determines whether to operate the ICE based on speed and depth of charge (rather than torque and speed like Ibaraki '882), Frank describes the problem of "frequent cycling" of the engine shared by all parallel hybrid vehicles including the vehicle disclosed in Ibaraki '882. Frank further discloses a solution to the problem of "frequent cycling":

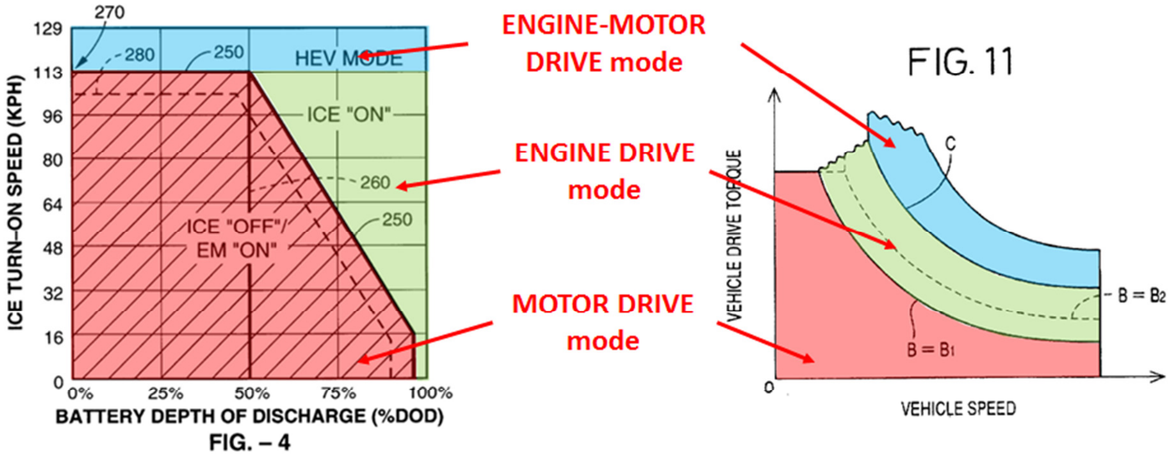
> As an alternative to separate "on" and "off" thresholds, a single threshold could be used in combination with **a time delay between the "on" and "off" modes to prevent frequent cycling**.

(Ex. 1418 ['363 Frank] at 8:32-37, emphasis added.)

593. In this disclosure, Frank explains that "frequent cycling" is preventable by including a time delay when vehicle conditions exceed the threshold in which the hybrid vehicle switches from engine mode to motor mode. In other words, Frank discloses setting a predetermined time for which the vehicle conditions must be conducive to operating in the motor mode before switching the drive source from the engine to the motor.

594. A person having ordinary skill in the art would have understood that there is a reason to combine the teachings of Frank with Ibaraki '882. Both Frank and Ibaraki '882 disclose parallel hybrid vehicles. As I have further illustrated below,

both Frank and Ibaraki ’882 employ control strategies where an electric motor and IC engine are used to drive the vehicle in various operating modes.



Ex. 1418 [’363 Frank] at Fig. 4 Ex. 1403 [Ibaraki ’882] Fig. 11 (annotated)

595. As also discussed above, both systems utilize control strategies with threshold values (“On/Off” of Frank and boundary line “B” of Ibaraki ‘882) at which point their disclosed hybrid systems switch from engine drive mode to motor drive mode. For these reasons, the engines in both systems would be at risk of frequent cycling. Thus, there would be a reason to add the teaching in Frank to prevent frequent cycling in the Ibaraki ‘882 hybrid vehicle. Indeed, by adding a “time delay” along the boundary line “B” of Fig. 11 of Ibaraki ’882, like the time delay taught by Frank, Ibaraki ‘882 would prevent the known problem of “undesirable or excessive cycling” of the engine. *Id.*

596. With this obvious modification, Ibaraki ’882 alone, or in view of Frank, discloses *employing said controller to monitor RL over time, and to control transition between propulsion of said vehicle by said engine to propulsion by said motor(s) such that said transition occurs*

only when RL<SP for at least a predetermined time.

XIV. CONCLUSION

597. In my opinion, all the elements of the challenged claim limitations are disclosed by the references discussed above and that the claims are unpatentable in view of these prior art references.

598. I reserve the right to supplement my opinions to address any information obtained, or positions taken, based on any new information that comes to light throughout this proceeding.

I declare under penalty of perjury that the foregoing is true and accurate to the best of my ability.

Executed on: February 23, 2015

Gregory W. Davis, Ph.D., P.E.