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.: IPR2014-00571

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 1, 6, 7, 9, 15, 18, 21, 23 AND 36 OF U.S. PATENT NO. 7,104,347)

Table of Contents

Exhibit List

Petition Exhibits			
Exhibit No.	**Description**	**Date**	**Identifier**
1001	U.S. Patent No. 7,104,347	n/a	The ’347 Patent
1002	’347 Patent File History	n/a	’347 Patent File History
1003	U.S. Patent No. 5,343,970	Sept. 6, 1994	Severinsky ’970
1004	U.S. Patent No. 5,586,613	Dec. 24, 1996	Ehsani

Declaration Exhibits			
Exhibit No.	**Exhibit No.**	**Exhibit No.**	**Exhibit No.**
1015	Curriculum Vitae of Gregory Davis		Declaration Ex.
1016	Innovations in Design: 1993 Ford Hybrid Electric Vehicle Challenge	Feb. 1994	Declaration Ex.
1017	1996 Future Car Challenge	Feb. 1997	Declaration Ex.
1018	1997 Future Car Challenge	Feb. 1998	Declaration Ex.
1019	History of the Electric Automobile – Hybrid Electric Vehicles	1998	Declaration Ex.
1020	Hybrid Vehicle for Fuel Economy		Declaration Ex.
1021	Hybrid/Electric Vehicle Design Options and Evaluations	Feb. 24-28, 1992	Declaration Ex.
1022	Challenges for the Vehicle Tester in Characterizing Hybrid Electric Vehicles	April 9-11, 1997	Declaration Ex.
1023	Electric and Hybrid Vehicles Program	April 1995	Declaration Ex.
1024	Technology for Electric and Hybrid Vehicles	Feb. 1998	Declaration Ex.
1025	Strategies in Electric and Hybrid Vehicle Design	Feb. 1996	Declaration Ex.
1026	Hybrid Vehicle Potential Assessment	Sept. 30, 1979	Declaration Ex.

Declaration Exhibits			
Exhibit No.	**Exhibit No.**	**Exhibit No.**	**Exhibit No.**
1027	Final Report Hybrid Heat Engine / Electric Systems Study	June 1, 1971	Declaration Ex.
1028	Transactions of the Institute of Measurements and Control: A microprocessor controlled gearbox for use in electric and hybrid-electric vehicles	Sept. 1, 1988	Declaration Ex.
1029	Propulsion System Design of Electric Vehicles	1996	Declaration Ex.
1030	Propulsion System Design of Electric and Hybrid Vehicles	Feb. 1997	Declaration Ex.
1031	Bosch Handbook	Oct. 1996	Declaration Ex.
1032	Design Innovations in Electric and Hybrid Electric Vehicles	Feb. 1995	Declaration Ex.
1033	U.S. Patent No. 6,209,672	Apr. 3, 2001	Declaration Ex.
1034	Introduction to Automotive Powertrains (Davis Textbook)		Declaration Ex.
1035	Yamaguchi article: Toyota Prius, Automotive Engineering International	Jan. 1998	Declaration Ex.
1036	60/100,095 Provisional Application	Filed Sept. 11, 1998	Declaration Ex.

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.

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

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

(2) The relevant legal standards, including the standard for obviousness provided in *KSR International Co. v. Teleflex, Inc.*, 550 U.S. 398 (2007), and any additional documents cited in the body of this declaration; and

(3) 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 1015.

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. I further am a licensed "Professional Engineer" in the state of Michigan.

8. As shown in my resume, most of my career has been in the field of automotive engineering that includes 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 returned to 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. The hybrid electric vehicle work that I worked on at the U.S. Naval

Academy was published in a bound 1994 SAE special publication. (Ex. 1016 at 6-11.)

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 Motor Company, and Chrysler Corporation.

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

24. Attached as Exhibits 1017 and 1018 are the competition papers that were submitted for the 1996 and 1997 competitions for which I served as the faculty advisor. (Ex. 1017 & Ex. 1018.)

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.

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, and other extensive modifications and development of vehicular powertrains.

34. I also serve as faculty advisor to the Society of Automotive Engineers International (SAE) at the national level, on the local Student Branch and for the "SAE Clean Snowmobile Challenge." 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.

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 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. 1036). 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. 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. (Ex. 1019 at 11).

44. I am aware that one of the first functioning hybrid vehicles was designed and built by Justus Entz in May 1897. (Ex. 1019 at 11-13).

45. I am also aware that hybrid vehicle patents extend as far back as 1909

[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").

for U.S. Patent No. 913,846 to Pieper that was granted for a "Mixed Drive Auto Vehicle."

46. I am aware that the hybrid vehicle disclosed by the Pieper patent was likewise assembled as a functioning hybrid vehicle that was publically used. (Ex. 1019 at 13-14).

47. I am also aware of well-known hybrid vehicles that were built and publically used by Baker and Woods in 1917. (Ex. 1019 at 21-23).

48. While these early hybrid vehicles did not include the complex microprocessor based control strategies found in present-day hybrid vehicles, it has always been known that one goal of hybrid vehicles is the possibility of operating the engine at its "optimum efficiency."

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

(Ex. 1020 at 1, emphasis added).

49. It was not until events in the 1970's, however, that 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. 1021 at 3; Ex. 1022 at 3).

50. For instance, 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 accelerated research into, and development of electric and hybrid vehicle technologies." (Ex. 1023 at 4).

51. As a result of this law, multiple fully functional hybrid and electric vehicles were developed by automotive corporations. (Ex. 1023 at 4).

52. I am specifically aware that Ford Motor Company and Toyota Motor Company invested considerable time and money into developing both hybrid and electric vehicles. (*See e.g.,* Ex. 1020 at 1; Ex. 1024 at 4).

53. Further collegiate competitions intensified during the 1990's starting with the 1993-1995 Ford Hybrid Electric Vehicle Challenge. The 1993 Ford Hybrid Electric Vehicle Challenge is attached as Exhibit 1016. By 1994 these competitions had grown to include teams from over 38 universities representing more than 800 students. (Ex. 1023 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" competition. (Ex. 1016 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 vehicle competitions. (Ex. 1017 at 6; Ex. 1018 at 10).

56. Based upon the level of research and development prior to 1998, numerous hybrid vehicle "architectures" were well-known. (*See e.g.*, Ex. 1025 at 4 & 7-8). Hybrid vehicle "architectures" may also be generally referred to as hybrid "topologies" or "configurations." As I explain in detail below, known hybrid vehicle "architectures" included what was commonly referred to as: (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 further known to include: (1) one motor "parallel" hybrid vehicle architectures (¶¶ 73-86 below); and (3) two motor "parallel" hybrid vehicle architectures (¶¶ 87-107 below).

57. As I explain further below, these varying hybrid vehicle architectures differed in how the powertrain (i.e., the engines and motors) was arranged and connected to the wheels. The various architectures were done in order to achieve many of the goals I mentioned above in paragraph 48, including operating the engine at its peak efficiency. (*See e.g.*, Ex. 1020 at 1; Ex. 1025 at 4 & 7).

58. Due to the rapid advancement of computers starting in the 1970's, each of these hybrid vehicles included microprocessor based control strategies for

properly controlling the engine, motor(s), transmission, and/ clutching mechanisms used. (*See e.g.,* Ex. 1024 at 4).

59. While the control strategies varied based on the architecture being employed, the primary goal still focused on operating the engine within its "sweet spot" or "optimum efficiency range." (*See e.g.,* Ex. 1020 at 1; Ex. 1024 at 4).

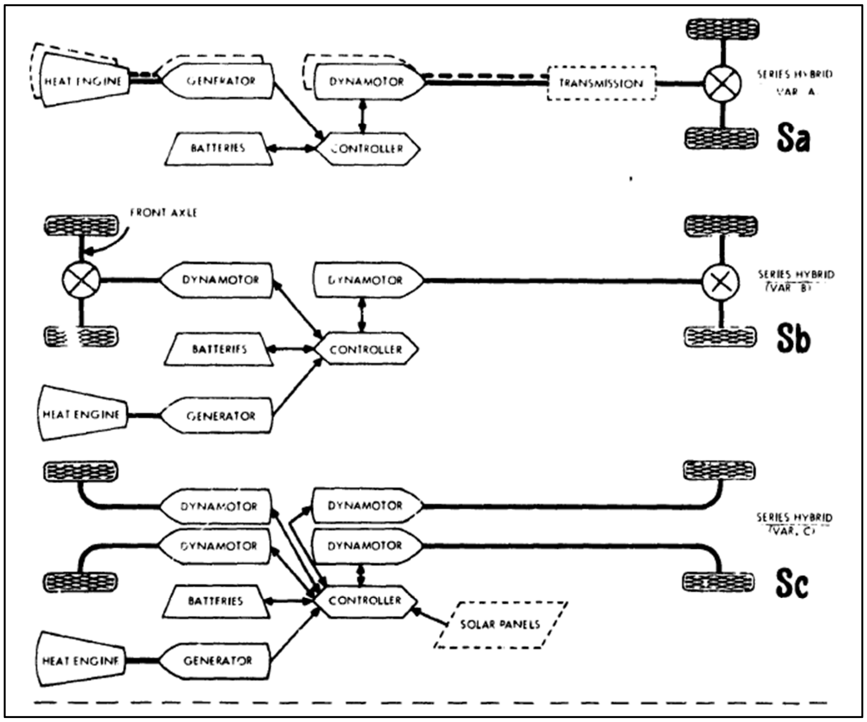
60. Such efficient engine control strategies were desired so as to meet the Federal government's reduced air pollution goals of 1976 and to meet California's "Low Emissions Vehicle" regulation that was enacted in 1990. (Ex. 1022 at 3).

A. "Series" Hybrid Vehicle

61. A person of ordinary skill in the art knew well-prior to September 1998 of the design and operational advantages of "series" hybrid vehicle architectures. (Ex. 1021 at 6-7; Ex. 1025 at 7).

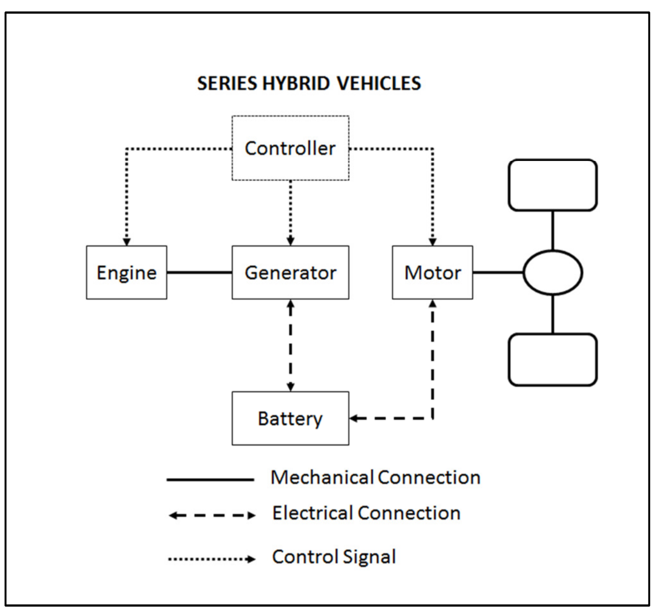
62. In fact, by 1979 it was well-known that "series" hybrid vehicles could be designed in various arrangements that could include one or more electric motors.[2] (Ex. 1026 at 17).

[2] 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. 1026 at 17-Fig. 7)

63. Although multiple configurations were known, I have provided the following exemplary figure to explain the general architecture and operation of a "series" hybrid vehicle.



64. As I illustrated, the motor is always connected to the road wheels. (*see also* Ex. 1021 at 6; Ex. 1025 at 7-8).

65. In other words, the **<u>motor alone</u>** provides the torque required to propel the vehicle. (Ex. 1021 at 6; Ex. 1025 at 15).

66. The engine, on the other hand, is **<u>not mechanically connected</u>** to the wheels and the engine is therefore controlled independently of driving conditions. (Ex. 1021 at 6; Ex. 1025 at 7).

67. In other words, the engine does not provide any of the torque required to propel the vehicle; rather, the engine powers the generator to produce electrical energy that is stored in the battery and/or used by the motor.

68. The primary reason for the engine in a "series" hybrid vehicle was to overcome the limited driving range associated with "pure" electric vehicles. 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. Not only were electrical sources less common than gas stations, it could also require hours to fully charge the battery.

69. Because the engine is controlled independently of the torque requirements of the vehicle, it was well known that the engine would be designed to operate at its optimum efficiency and low emission ranges during the majority of

operation. However, during conditions of low battery state of charge, the engine could be operated above its "sweet spot." Such efficient operation was performed for the sole purposes of operating the generator illustrated by the figure in paragraph 63. (Ex. 1021 at 6-7; Ex. 1025 at 7).

B. "Parallel" Hybrid Vehicle

70. A person of ordinary skill in the art was also aware that prior to September 1998 "parallel" hybrid vehicle architectures existed. (Ex. 1021 at 7-8; Ex. 1025 at 7-8).

71. Again, by 1979 it was well-known that "parallel" hybrid vehicles could be designed in various arrangements that could include one or more electric motors.[3] (Ex. 1026 at 18).

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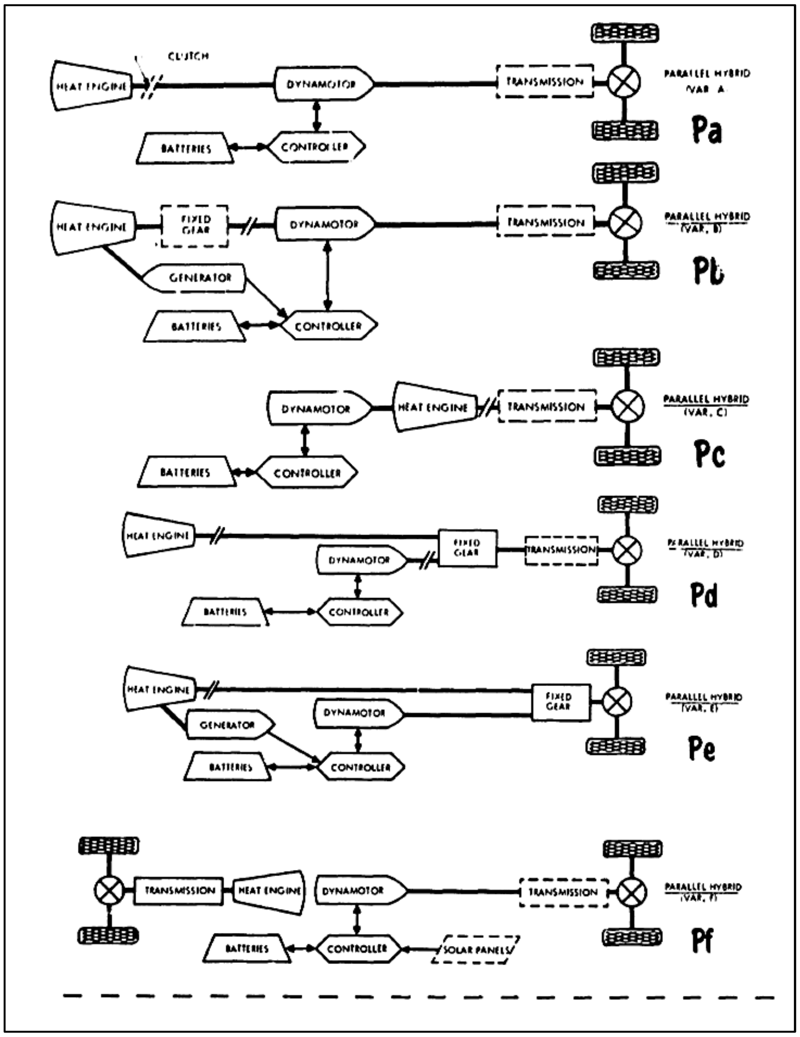
[3] The term "dynamotor" was commonly used to describe an electric motor that was capable of operating both as (1) a motor for propulsion; and (2) as a generator that converts mechanical torque into electrical energy that is stored in the battery.



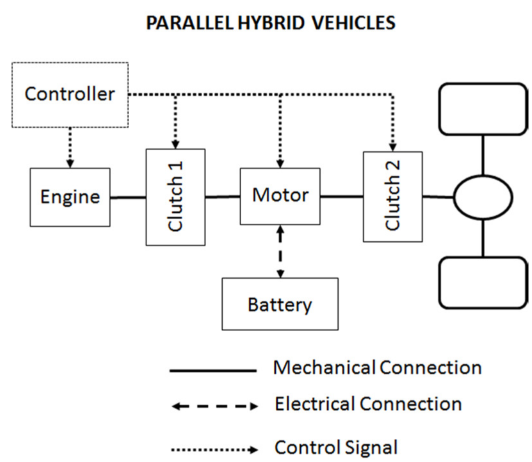
(Ex. 1026 at 18-Fig.7 (cont))

72. As illustrated above, 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. 1026 at

18).[4]

a. One-Motor "Parallel" Hybrid Vehicle

73. Although multiple various configurations existed, I have provided the following exemplary figure 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 "clutches" that were controlled by a microprocessor (i.e., controller).[5] These clutches selectively enabled either or both the engine and motor to provide drive

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[4] 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."

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

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. 1021 at 5).

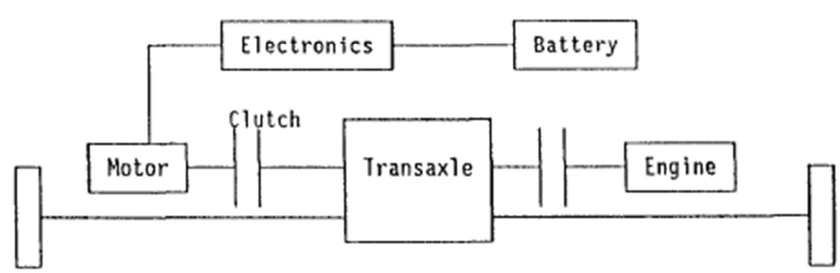


Figure 5. Parallel hybrid driveline schematics.

(Ex. 1024 at 25-Fig. 5)

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

77. Alternatively, the controller could engage "clutch 2" which would

connect the motor to the road wheels. Both “clutch 1” and “clutch 2” could be engaged in order to connect both the motor and engine 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) became 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 was also known prior to September 1998 that the engine in a “parallel” hybrid vehicle could be downsized and controlled to run only at speed and load conditions where engine operation was most efficient (e.g., steady state or highway cruising).

81. It was also known that the traction motor would 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 confirmed 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. 1020 at 17).

83. In other words, 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. 1021 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. 1020 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.

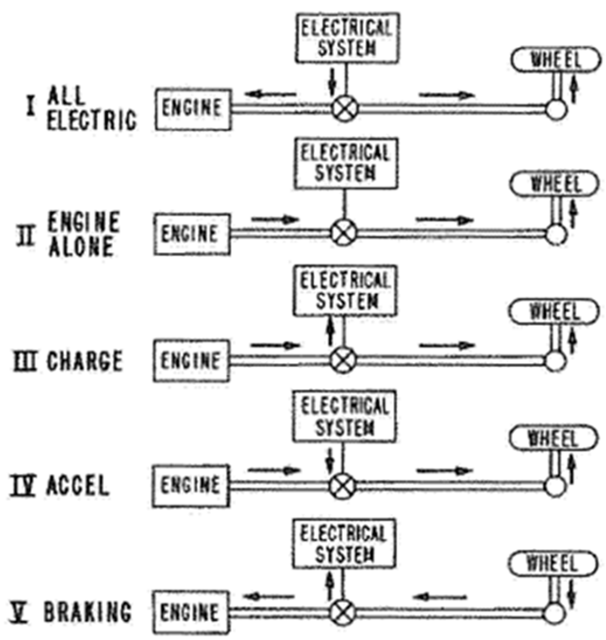


Fig.2 -Five hybrid modes of operation

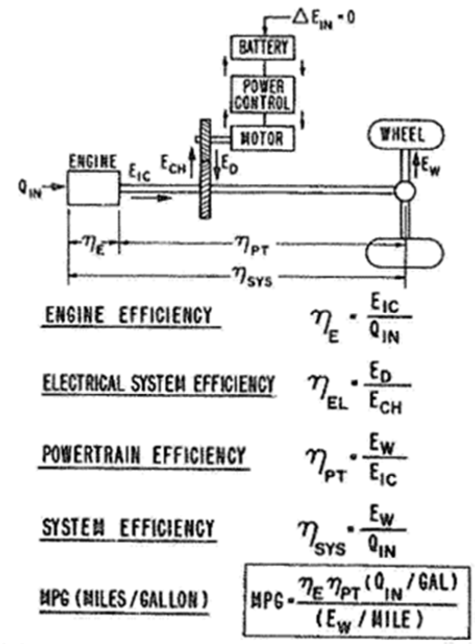


Fig.4 -Average fuel economy for a hybrid vehicle in terms of system efficiencies and energies

(Ex. 1020 at 3-4, Fig. 2 & 4)

85. This disclosure confirms 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. 1020 at 17). In other words, the engine operated at "higher load factors" which provides "increased efficiencies." (Ex. 1020 at 4).

86. It was also known prior to 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. 1020 at 17).

b. Two-Motor "Parallel" Hybrid Vehicle

87. As was illustrated in paragraph 72 above, two-motor "parallel" hybrid vehicles were also well known in the art. (Ex. 1026 at 18; Ex. 1004 at Figs 5-6; Ex. 1025 at 8).

88. In fact, I have provided below an illustration from a 1971 Department of Energy report that describes a well-known two motor "parallel" hybrid vehicle configuration. (Ex. 1027 at 20).

(Ex. 1027 at 20-Fig. 10-7)

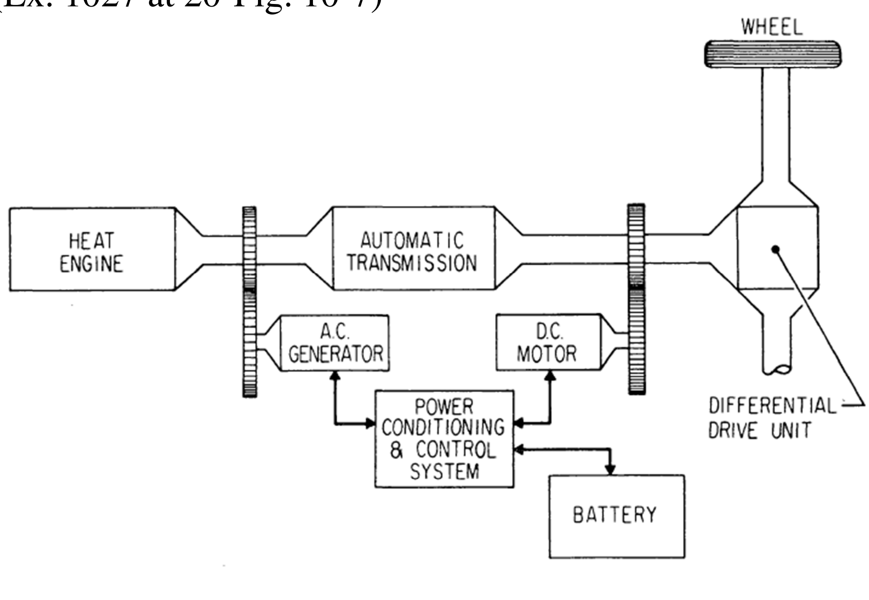


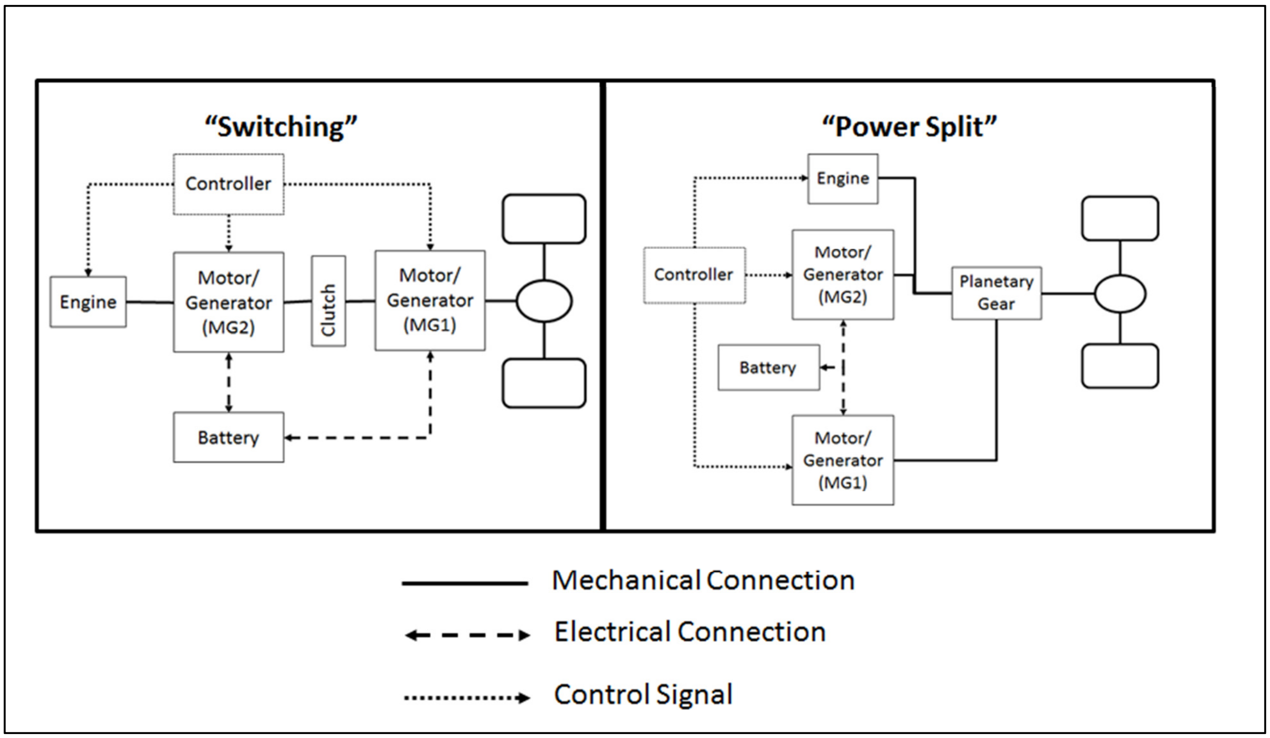
Figure 10- 7. Selected Baseline Parallel Configuration Concept

89. 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. 1027 at 19).

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. Although multiple flavors of architectures existed, I have provided the following exemplary figures in order to explain the architecture and operation of the more common two-motor "parallel" hybrid vehicles that were known in the art prior to September 1998.[6] (*see also* Ex. 1004 at Fig. 5; Ex. 1025 at 8).



92. The significant change between a one-motor and two-motor "parallel"

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[6] By the mid-1990's two-motor "parallel" hybrid vehicles had begun to be referred to as "series-parallel" hybrid vehicles. (Ex. 1025 at 8).

hybrid vehicle is the inclusion of a second motor/generator (illustrated as MG2).[7]

(1) "Switching" Two-Motor "Parallel" Hybrid Vehicles

93. As illustrated in paragraph 91 above, the two-motor "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 paragraph 91 above, the two-motor "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. 1004; Ex. 1025 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. 1025 at 8; Ex. 1004 at Fig. 5).

97. It was also known that the engine would be decoupled during

---

[7] 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.

operation in urban (city) driving where the load or torque required to propel the vehicle was low. (Ex. 1025 at 8).

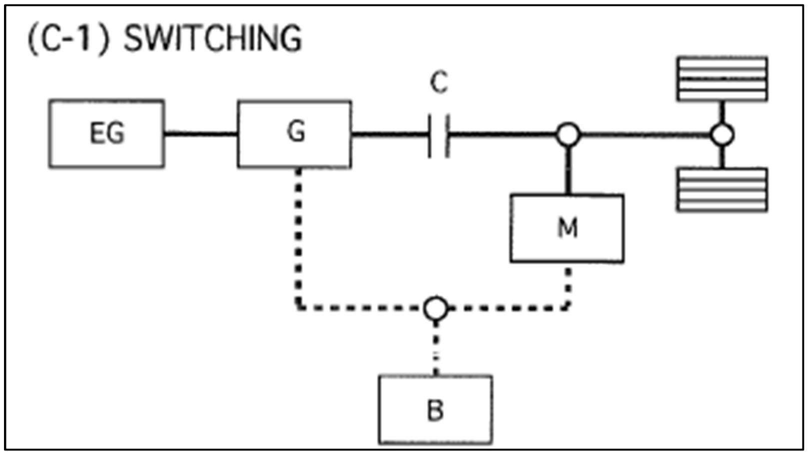
98. With the engine decoupled from the road wheels, the "switching" system could operate like a "series" hybrid vehicle with the engine powering the generator to recharge the battery when needed. (Ex. 1025 at 8).

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. 1025 at 8).

100. For instance, a 1996 SAE publication discloses the following known benefits of a switching "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. 1025 at 8).



(Ex. 1025 at 8-Fig. 1)

101. The known advantage of such operation was that the engine operates inefficiently at low loads. By using the motor to propel the vehicle at low loads the engine would therefore not be operated where it is inefficient. However, at higher loads where engine operation is efficient, the engine could be reconnected to the drive wheels to propel the vehicle.

102. Also, as stated by the 1996 SAE publication, 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. 1025 at 8).

103. Such known advantages were not available with a one-motor "parallel" hybrid vehicle.

(2) "Power-Split" Two-Motor "Parallel" Hybrid Vehicles

104. "Power split" systems on the other hand, were known prior to September 1998 of being capable of operating as both a "series" ***and*** "parallel" hybrid at all times. (Ex. 1025 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. 1025 at 8).

106. "Power split" hybrids have also been known to have been developed as far back as the 1970 system developed by TRW and to have been commercially made available around 1997 by Toyota. (Ex. 1035 at 2).

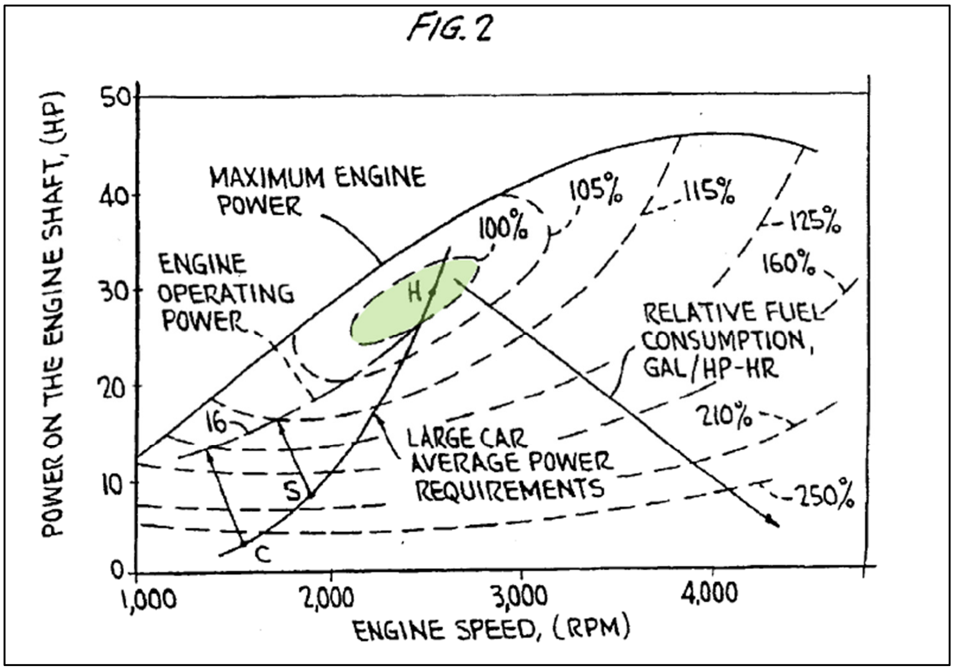
107. Specifically, it is known that in 1997 Toyota commercially released the Prius "power split series-parallel" hybrid vehicle with a control strategy that determined operating modes based on the speed and load (i.e., required driving torque) of the vehicle. (Ex. 1035 at 2).

C. Hybrid Vehicle "Control Strategies"

108. It was known prior to September 1998 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. Although this figure

is not discussed in the text of the ’347 Patent, the parent ’672 Patent does describe this figure. In particular, the ’672 Patent states that “Point H” which I have highlighted in green is “the most efficient region of operation of the engine” (i.e., the engine’s “sweet spot”). (Ex. 1033 at 17:16-19, Figure 2).



(Ex. 1033, Fig. 2, annotated)

110. Such knowledge was also commonly known in other prior art references. For example, a September 1988 publication illustrates an engine map showing efficiency curves for a typical gasoline engine. As 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. 1028, Figure 1)

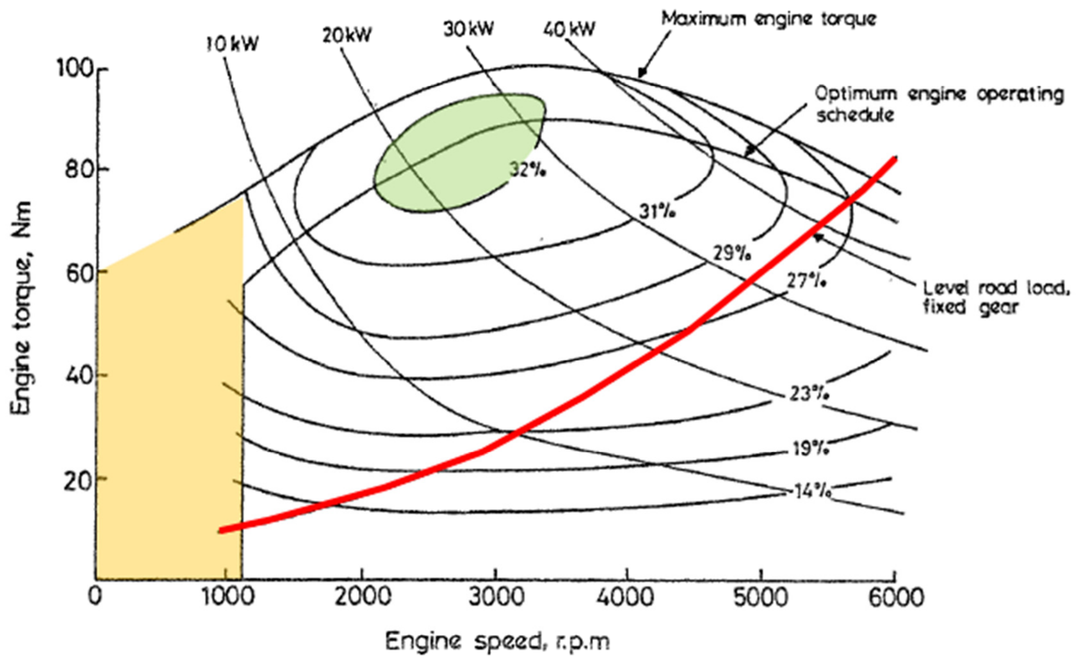


Fig 1 Road-load and engine-operating curves for an ic engine vehicle

(Ex. 1028 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. 1028 at 2).

112. It was known—as illustrated above—that engines 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 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. 1034 at 9).

114. 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 confirms 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. 1029 at 2; Ex. 1030 at 2).

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 confirms 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. 1031at 15-18).

116. 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)[8] 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. During vehicle operation, the tractive effort ($\mathbf{F_{TE}}$) is generally used to overcome the road load forces ($\mathbf{F_{RL}}$).

118. It was also known that if the tractive effort of the vehicle is greater than the road load forces ($\mathbf{F_{TE} > F_{RL}}$), the vehicle is able to accelerate.

[8] A person of ordinary skill in the art understands that Tractive Force = Torque /Radius of Tire (Ex. 1031 at 6-7).

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

119. It was known prior to September 1998 that when a vehicle is travelling up a hill or when the driver requests an increased demand for acceleration, road load forces may become positive. For example, when a vehicle is climbing a hill, a large amount of "tractive effort" ($\mathbf{F_{TE}}$) may be required to overcome the large "road load" ($\mathbf{F_{RL}}$) 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 ($\mathbf{F_{TE}} > \mathbf{F_{RL}}$), the vehicle is able to accelerate up the hill.

120. Lastly, it was known prior to September 1998 that 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" (**F_{TE}**) may be required to overcome the large "road load" (**F_{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 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 figure below (which is the same figure shown in above in paragraph 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.

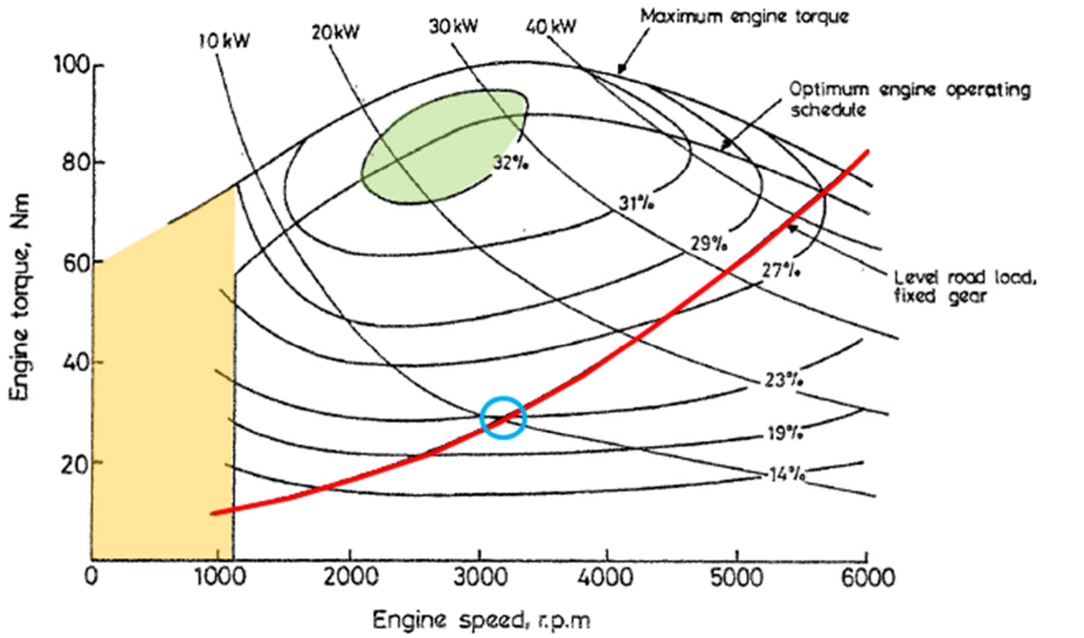


Fig 1 Road-load and engine-operating curves for an ic engine vehicle

(Ex. 1028 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.

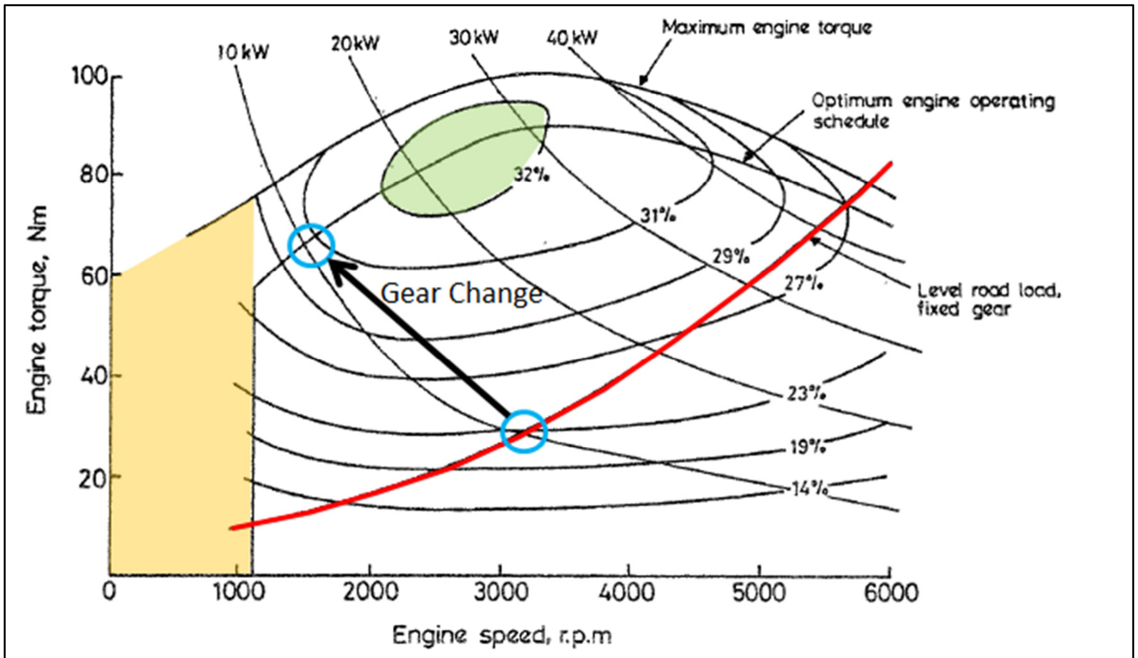


Fig 1 Road-load and engine-operating curves for an ic engine vehicle

(Ex. 1028 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 gear shift points (blue circle to right) is 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 at a more efficient engine operating point which is closer to the engine's "sweet spot."

124. To further improve efficient usage of the engine, hybrid vehicles include a motor which provides 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. It was well known prior to September 1998 that 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. 1033 at 17:25-27).

127. Other prior art references again confirmed this well-known understanding of engines. For example, a 1992 SAE paper described hybrid design options and evaluations states:

> 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. 1021 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 or

vehicle speeds); (2) an "engine-only" mode where the engine propels the vehicle when engine operation is efficient (i.e., higher loads or 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. 1020 at 3).

129. A 1995 SAE article also confirmed that one advantage of a hybrid vehicle has the ability to limit operation of the engine to its "sweet spot" or "optimum efficiency range" while still meeting the load required to propel 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. 1032 at 11).

130. In another example, the 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 an 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. 1020 at 12).

131. Therefore, by September 1998 it was well known that hybrid vehicles were used to improve fuel efficiency by improving engine operation. Again, this was typically accomplished using a set of operational modes that allowed the engine that to be operated at its “sweet spot.”

132. Even though the operating range of the engine was generally limited to its “sweet spot”, the motor was able to provide the tractive effort required to propel the vehicle alone where engine operation was not efficient (i.e. outside the

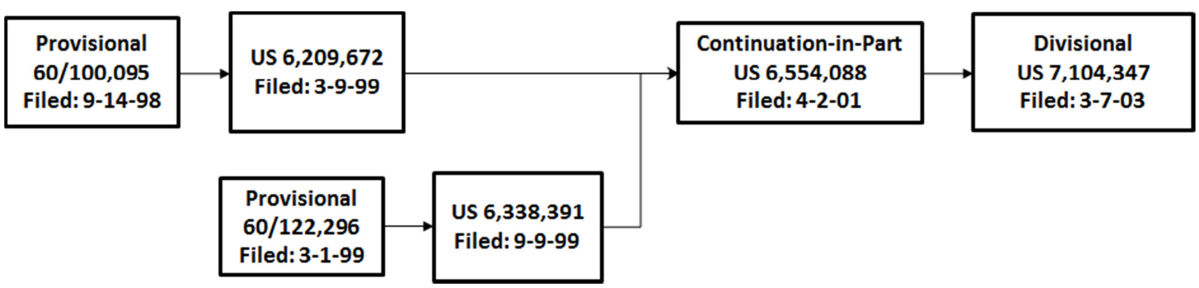
"sweet spot"), or in combination with the engine at high acceleration or driver demands.

133. Control between these modes, however, 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. THE '347 PATENT

A. Effective Filing Date of the '347 Patent

134. It has been explained to me that the '347 Patent is part of an extensive chain of patent filings as illustrated below.



135. The '347 Patent is generally directed to an alleged novel hybrid vehicle architecture (which is referred to in the '347 Patent as a novel vehicle "topology") and control strategy. (Ex. 1001at 11:46-67 & 12:38-57).

136. Starting at the '347 Patent, it has been explained to me that the '347 Patent is what is referred to as a "divisional" patent application which includes a same disclosure as the parent patent application, but claims a distinct invention

different than the parent patent application. Specifically, it has been explained to me that the '347 Patent is a divisional patent application of U.S. Patent No. 6,554,088 ("the '088 Patent").

137. It has also been explained to me that the '088 Patent in turn is a "continuation-in-part" application. It has also been explained to me that a "continuation-in-part" is a patent application that includes additional disclosure or material not found in the parent patent application. Specifically, it has been explained to me that the '088 Patent is a continuation-in-part of U.S. Patent Nos. 6,209,672 ("the '672 Patent") and 6,338,391 ("the '391 Patent").

138. It has further been explained to me that the '672 Patent and '391 Patents claim "priority" to Provisional Application Nos. 60/100,095 and 60/122,296.

139. It has been explained to me that a "provisional" patent application is a placeholder for a patentee for an early priority date.

140. It has further been explained to me that a provisional patent is not examined by the U.S. Patent and Trademark Office and never matures into an issued patent unless the patentee files a "non-provisional" patent application within one year of submitting the "provisional" patent application.

141. It is therefore my understanding that the '672 Patent claims priority to U.S. Provisional Application No. 60/100,095 ("the '095 Provisional"). Likewise, it

is my understanding that the ‘391 Patent claims priority to U.S. Provisional Application No. 60/122,296 (“the ’296 Provisional”).

142. It has been explained to me that based on this priority chain the earliest possibly filing date in the ’347 Patent chain of patent filings is to the ’095 Provisional which was filed with the U.S. Patent Office on September 14, 1998.

B. Prosecution History of the ’347 Patent

143. I have reviewed portions of the file history associated with the ’347 Patent.

144. It is been explained to me that the ’347 Patent issued on September 12, 2006 from U.S. Patent Application No. 10/382,577, (“the ’577 Application”).

145. It is been explained to me that the ’577 Application was filed on March 3, 2003. (Ex. ’347 Patent).

146. It is been explained to me the ’577 Application was originally filed with 16 claims. (Ex. 1002 at 107-112).

147. It is been explained to me the Patent Owner also filed three Information Disclosures with substantive analysis and arguments that were also previously submitted during prosecution of the ’088 Patent. (Ex. 1002 at 135-169).

148. It is been explained to me that on August 11, 2003, a Preliminary Amendment was filed that cancelled claims 1-15, amended claim 16 and added new claims 17-81. (Ex. 1002 at 176-200).

149. It is been explained to me the new claims included independent claims 17, 57, and 74. It has been explained to me that a "preliminary amendment" may be filed before a rejection (i.e. an Office Action) is issued by the U.S. Patent and Trademark Office.

150. It is been explained to me that on May 19, 2004, the Patent Owner filed a Supplemental Preliminary Amendment amending claims 16-80 and adding new claims 81-141. (Ex. 1002 at 203-245).

151. It is been explained to me that independent claim 17 and claim 77 were amended as shown here to delete the limitation "by a clutch":

> ... said internal combustion engine being controllably coupled to said road wheels of said vehicle ~~by a clutch~~ ...

152. It is been explained to me that the Patent Owner also filed a First Supplemental Information Disclosure Statement again citing certain prior art references and providing substantive analysis regarding the prior art. (Ex. 1002 at 246-284).

153. It is been explained to me that on December 3, 2004 a non-final office action was issued by the U.S. Patent and Trademark Office rejecting pending claims 1-142. (Ex. 1002 at 387-393).

154. It is been explained to me that in a February 17, 2005 Amendment, the Patent Owner cancelled claims 16-81 and 123-142 and amended claims 82-

122. (Ex. 1002 at 430-447).

155. It is been explained to me that the applicant amended independent claims 82 and 104 (issued independent claims 1 and 23 of the '347 Patent) to include the following limitation:[9]

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

(Ex. 1002 at 431-432 and 437-438)

156. It is been explained to me that the above limitation was added to these claims in order to overcome the rejections based on U.S. 6,054,844 (Frank) and a non-patent publication titled "A hybrid drive based on a structure variable arrangement" to Mayrhofer.

157. It is been explained to me that neither Frank nor Mayrhofer disclosed an engine that is efficiently operated when loaded "in excess of SP [setpoint], which is now defined to be 'substantially less than the maximum torque output (MTO) of said engine." (Ex. 1002 at 443-444 & 446).

158. It is been explained to me that with regards to the amendment provided, Patent Owner also made the following remarks:

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[9] While the patentee amended other claims, these amendments were primarily directed at correcting typographical errors or to correct claim numbering.

> Thus claims 82 and 104 are the only remaining independent claims. These have both been amended to recite that the engine is run when it is loaded (either by the vehicle's propulsion requirement, the battery charging load, or both) in excess of a setpoint SP, which is now defined to be "substantially less than the maximum torque output (MTO) of said engine". It is respectfully submitted that this recitation clearly and patentably distinguishes over the references relied upon.

(Ex. 1002 at 443-444).

159. It is been explained to me that attached to the Patent Owner's Amendment is a Second Supplemental Information Disclosure that provides substantive analysis of prior art references. (Ex. 1002 at 448-455).

160. It is been explained to me that on April 21, 2005 a first notice of allowance was granted allowing claims 82-122. (Ex. 1002 at 699-702).

161. It is been explained to me that on June 30, 2005 the Patent Owner paid the issue fee and publication fee. (Ex. 1002 at 708-709).

162. It is been explained to me that the Patent Owner also filed a Third Supplemental Information Disclosure citing prior art references that Toyota Motor Company had asserted in a pending District Court litigation ("Toyota Litigation"). (Ex. 1002 at 710-711).

163. It is been explained to me that on October 26, 2005, the Examiner provided a Supplemental Notice of Allowance based on a telephonic interview on October 24, 2005. The interview authorized the Examiner to amend claim 82

(issued claim 1) as follows:

> In claim 82, line 19, after "when torque", --required to be-- has been inserted.

(Ex. 1002 at 1072-1075).

164. It is been explained to me that with the supplemental Notice of Allowance, the examiner initialed the references provided by the Patent Owner in the June 30th IDS. (Ex. 1002 at 1076-1079).

165. It is been explained to me that on January 19, 2006 the Patent Owner filed a petition to withdraw application from issuance along with a Request for Continued Examination. (Ex. 1002 at 1084-1088).

166. It is been explained to me that along with the petition, the Patent Owner filed a Fourth Supplemental Information Disclosure statement to submit further prior art references asserted in the Toyota Litigation that was pending at that time. (Ex. 1002 at 1089-1091).

167. It is been explained to me that on March 27, 2006 the Patent Owner re-submitted the fourth Information Disclosure Statement and provided a CD-ROM to the Patent Office with all of Toyota's trial exhibits from the Toyota Litigation. (Ex. 1002 at 1093-1103).

168. It is been explained to me that on July 11, 2006 a Second Supplemental Notice of Allowance was granted allowing claims 82-122. (Ex. 1002

at 1210-1214).

169. It is been explained to me that the ’577 Application subsequently issued as the ’347 Patent on September 12, 2006.

170. It is been explained to me that the Examiner did not provide any explanation of the reasons for allowance of the claims. (Ex. 1002 at 1211-1214).

VI. CHALLENGED CLAIMS OF THE ’347 PATENT AND PROPOSED CLAIM CONSTRUCTIONS

171. I have been asked to review claims independent claims 1 and 23.

172. I have also been asked to review dependent claims 6, 7, 9, 15 and 21 which depend from claim 1.

173. I have further been asked to review dependent claim 36 which depends from claim 23.

174. 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 am applying the following claim constructions for my analysis regarding unpatentability:

a. “**road load (RL)**,” “**RL**” and “**instantaneous torque RL required to propel said vehicle**” as: “the instantaneous torque required for propulsion of the vehicle, which may be positive or negative in value.”

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

c. **"Low-load 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 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 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*".

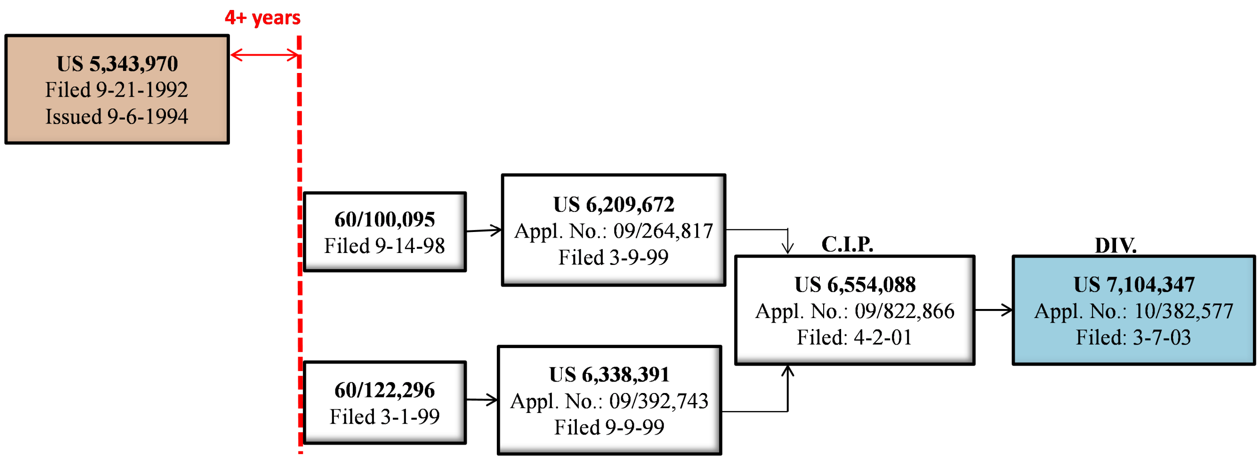
VII. OVERVIEW OF THE PRIOR ART

A. U.S. Patent No. 5,343,970 to Severinsky

175. I understand that U.S Patent No. 5,343,970 by Severinsky ("Severinsky '970") was filed on September 21, 1992, and issued on September 6, 1994. It has been explained to me that Severinsky '970 is considered prior art since it was filed and issued more than one year before the earliest priority date the '347 Patent.

176. As shown in the graphic below, I understand that Severinsky '970 is not part of the '347 Patent family chain for filings. It has been explained to me

that Severinsky '970 is prior art because it issued approximately four years before the earliest priority date of the '347 Patent.



177. I understand that the '347 Patent incorporates Severinsky '970 by reference. It has been explained to me that the '347 Patent includes all of the disclosure of Severinsky '970. However, I understand that this does not preclude Severinsky '970 as being prior art over the '347 Patent.

178. Generally speaking, I understand that Severinsky '970 discloses a control strategy for efficiently controlling an engine and a motor for a hybrid vehicle.

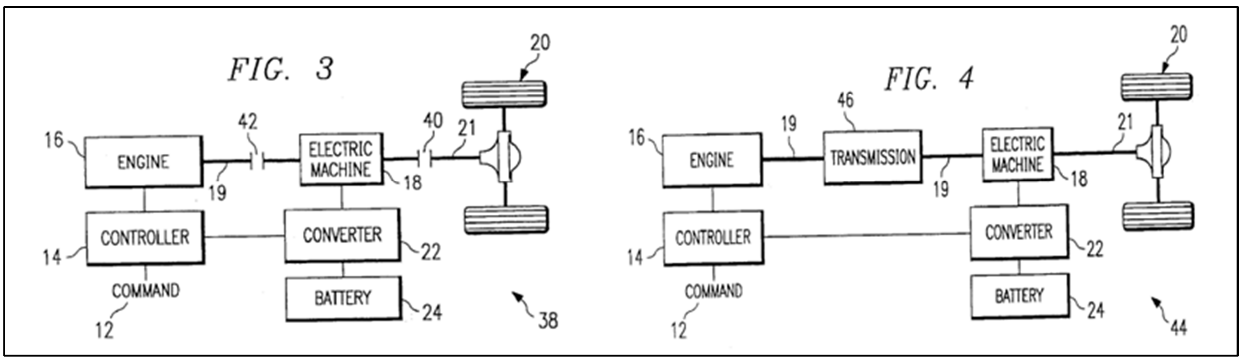
B. U.S. Patent No. 5,586,613 to Ehsani

179. I understand that U.S. Patent No. 5,586,613 by Ehsani ("Ehsani") was filed on September 26, 1994 and issued on December 24, 1996.

180. It has been explained to me that Ehsani, is considered prior art since it issued more than one year before September 14, 1998—the earliest priority date

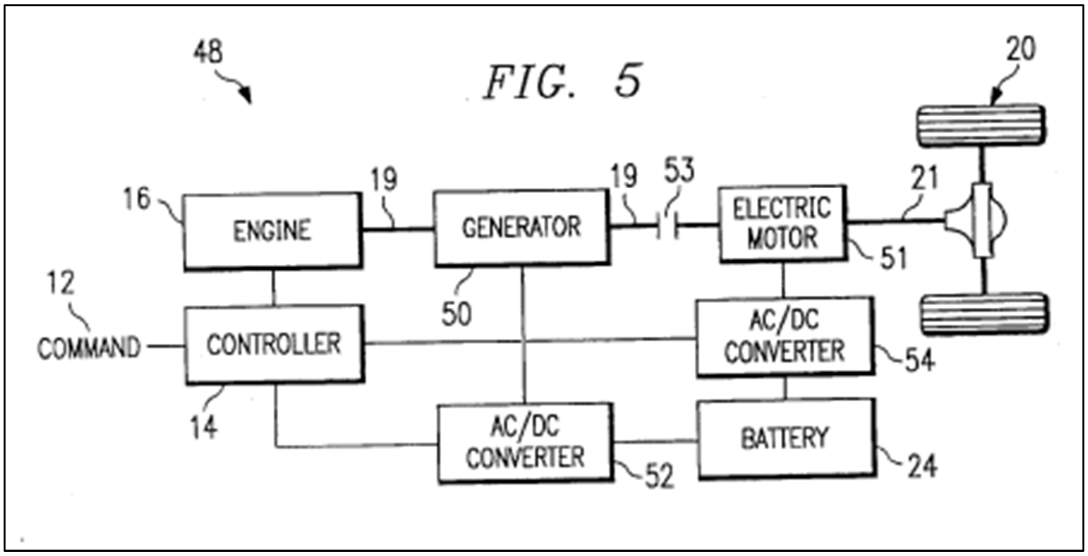
the ’347 Patent.

181. I understand that Ehsani teaches several different hybrid architectures that could be used to improve the efficiency and fuel economy over conventional vehicles. For example, Ehsani discloses several hybrid vehicles architectures that only require one electric-machine (i.e. one-motor; Ex. 1004 at 7:57-8:14; Figs. 3-4).



(Ex. 1004, Fig. 3 & 4)

182. Ehsani also discloses a hybrid vehicle architecture that uses two electric machines” (i.e., “two-motor”) that use both of the electric machines to act as a motor and as a generator. (Ex. 1004 at 3:24-25, 4:33-34)



(Ex. 1004, Fig. 5)

VIII. GROUND 1 – CLAIMS 23 AND 36 ARE OBVIOUS OVER U.S. 5,343,970

183. I understand that the ’347 Patent admits that it is an improvement on Severinsky ’970 stating: “[t]his application discloses a number of improvements over and enhancements to the hybrid vehicles disclosed in U.S. Pat. No. 5, 343,970 (the “Severinsky ’970”), to one of the present inventors, which is incorporated herein by this reference.” (Ex. 1001, 10:37-41).

184. I understand that the ’347 Patent even admits that Severinsky ’970 is prior art and that the ’347 Patent discloses an improvement over Severinsky ’970 such as a “simplified parallel hybrid system” architecture.

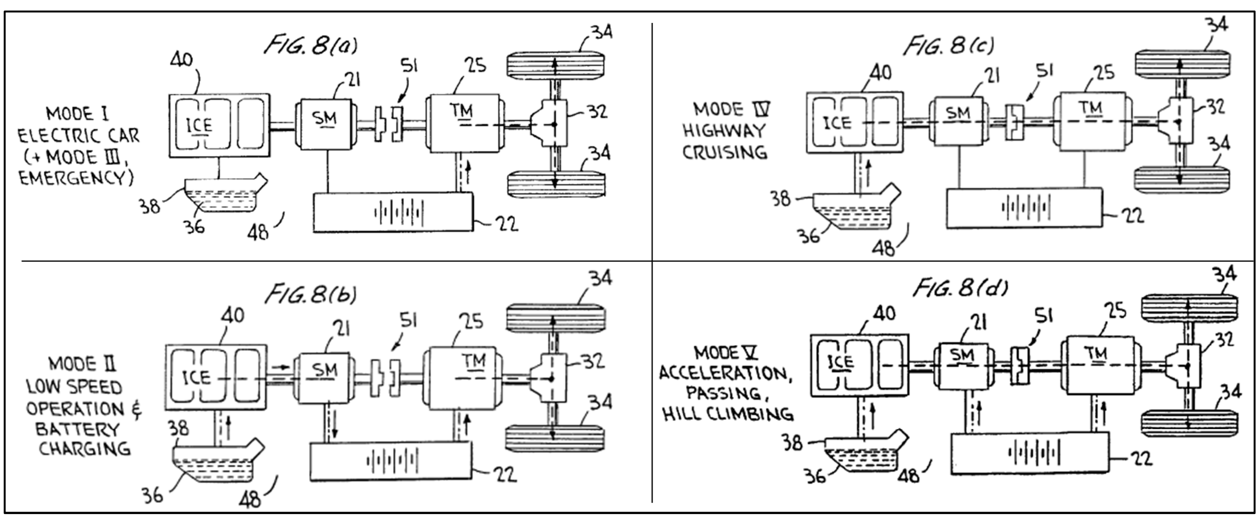
> It can thus be seen that while the **<u>prior art, including the ’970 patent</u>**, clearly discloses the desirability of operating an internal combustion engine in its most efficient operating range, and that a

battery may be provided to store energy to be supplied to an electric motor in order to even out the load on the internal combustion engine, there remains substantial room for improvement. In particular, **<u>it is desired to obtain the operational flexibility of a parallel hybrid system, while optimizing the system's operational parameters and providing a substantially simplified parallel hybrid system</u>** as compared to those shown in the **<u>prior art, again as including the '970 patent</u>**.

(Ex. 1001 at 11:23-34, emphasis added).

185. As can be seen by the figures of the '347 Patent, of which Fig. 8(a)-8(d) are shown below, the '347 Patent states that a "new 'topology'" hybrid architecture is being disclosed that includes an engine and two motors (i.e. "two-motor" hybrid vehicle architecture)[10]

(Ex. 1001, Fig. 8(a)-8(d))



[10] As I explained in paragraphs 87-107 above, "two-motor" hybrid vehicles were well-known prior to September 1998.

186. Although the ’347 Patent states that it was disclosing a “new” two-motor hybrid architecture, claim 23 simply recites that only “one or more electric motors” are required.

187. It is my understanding that based on the recited language claim 23 does not require two-motors. Instead, claim 23 recites a parallel hybrid vehicle architecture having only one motor. As I have discussed in paragraphs 73-86 above, one-motor hybrid architectures were well-known prior to September 1998.

188. I understand that independent claim 23 recites a method of controlling a hybrid vehicle.

189. It is my opinion that the claimed control strategy is the same as the control strategy disclosed by Severinsky ’970.

190. As I explain in greater detail in paragraphs 193-326 below, it is my opinion that Severinsky ’970, which discloses a one-motor parallel hybrid architecture, recites all of the limitations of claims 23 and 36.

191. My opinion is further confirmed based on my review of the ’347 Patent and the ’095 Provisional application. Specifically, my opinion is confirmed based on the fact that both the ’347 Patent and ’095 Provisional application[11]

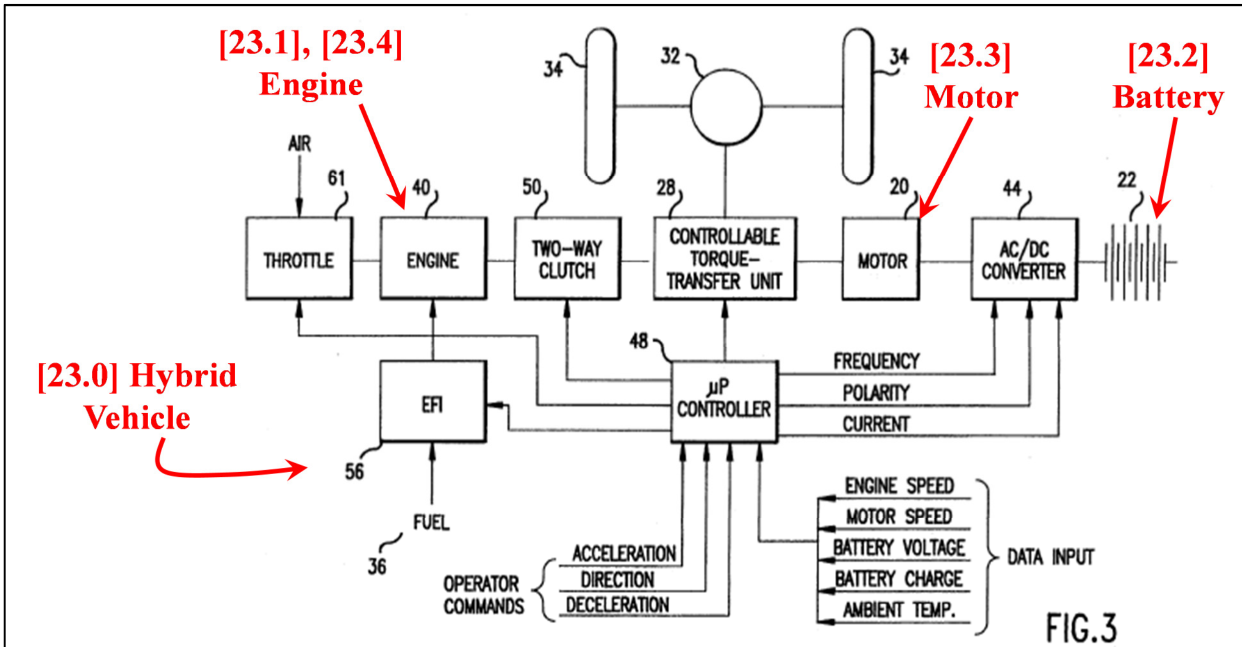
[11] Again, it is my understanding that the ’095 Provisional application was converted into the non-provisional application that issued as the ‘672 Patent (paragraph 134 above).

themselves state that Severinsky ’970 discloses all of the limitations of claims 23 and 36, as described in more detail below.

192. To the extent that the limitations of claims 23 and 36 of the ’347 Patent are not exactly described in the same was as in Severinsky ’970, it is my opinion that even these limitations are obvious in view of the general knowledge that was known to a person of ordinary skill in the art and of the state of the art in September 1998.

A. Claim 23

193. I understand that claim 23 recites a method for controlling a hybrid and the preamble recites the structure of the hybrid vehicle and these structural elements are disclosed by Severinsky ’970, as generally annotated in Fig. 3 of Severinsky ’970, reproduced below.



(Ex. 1003, Fig. 3, annotated)

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

194. Severinsky ’970 is titled “Hybrid Electric Vehicle” and independent claim 15 of Severinsky ’970 claims “[a] method of operating a hybrid electric vehicle” (Ex. 1003 at 24:40-41).

195. The ’347 Patent and the ’095 Provisional also acknowledge that Severinsky ’970 discloses a method of controlling a hybrid vehicle.

> Generally speaking, **the ’970 patent** discloses hybrid vehicles wherein **a controllable torque transfer unit is provided capable of transferring torque between an internal combustion engine, an electric motor, and the drive wheels of the vehicle. The direction of torque transfer is controlled by a microprocessor responsive to the mode of operation of the vehicle**, to provide highly efficient operation over a wide variety of operating conditions, and while providing good performance.

(Ex. 1001, 10:46-57, emphasis added; Ex. 1036 at 2, emphasis added).

196. The ’347 Patent further acknowledges that Severinsky ’970 discloses an “operating scheme” that would be considered a method of controlling a hybrid vehicle:

> For example, **according to the operating scheme of the hybrid vehicle disclosed in the ’970 patent**, in low-speed city driving, the electric motor provides all torque needed responsive to energy flowing from the battery. In high-speed highway driving, where the

> internal-combustion engine can be operated efficiently, it typically provides all torque; additional torque may be provided by the electric motor as 65 needed for acceleration, hill-climbing, or passing. The electric motor is also used to start the internal-combustion engine, and can be operated as a generator by appropriate connection of its windings by a solid-state, microprocessor-controlled inverter.

(Ex. 1001, 10:57-11:2, emphasis added).

197. It is my opinion that Severinsky ’970 discloses a “*method of control of a hybrid vehicle*.”

… ***[23.1] an internal combustion engine capable of efficiently producing torque at loads between a lower level SP and a maximum torque output MTO,***

198. It is my understanding that the term “SP” is an abbreviation for “setpoint” although it is not explicitly stated as such in the claim 23. I also understand that “SP” or “setpoint” as used in claim 23 is proposed to mean a “predetermined torque value.”

199. First, Severinsky ’970 discloses that the engine is activated to operate only at or near its maximum efficiency, at which point the engine torque output is well below the maximum torque output.

200. Severinsky ’970 also discloses that the engine is operated only when it is efficient to do so. Severinsky ’970 discloses efficient engine operation is based

on both the "output power and speed" of the engine.

> More particularly, according to the invention, the internal combustion engine is operated only under the most efficient conditions of **output power and speed**. When the engine can be used efficiently to drive the vehicle forward, e.g. in highway cruising, it is so employed. Under other circumstances, e.g. in traffic, the electric motor alone drives the vehicle forward and the internal combustion engine is used only to charge the batteries as needed.

(Ex. 1003 at 7:8-16, emphasis added).

201. In relation to the most efficient engine operating range, Severinsky '970 states:

> It will be appreciated that according to the invention the internal combustion engine is run only in the near vicinity of its **most efficient operational point**, that is, such that it produces **60-90% of its maximum torque whenever operated**. (Ex. 1003 at 20:63-67).
>
> According to the invention, these parameters are optimized so as to ensure that **the engine is operated at all times at its maximum point of efficiency**, and such that the driver need not consider the power source being employed at any given time.

(Ex. 1003 at 21:34-38, emphasis added).

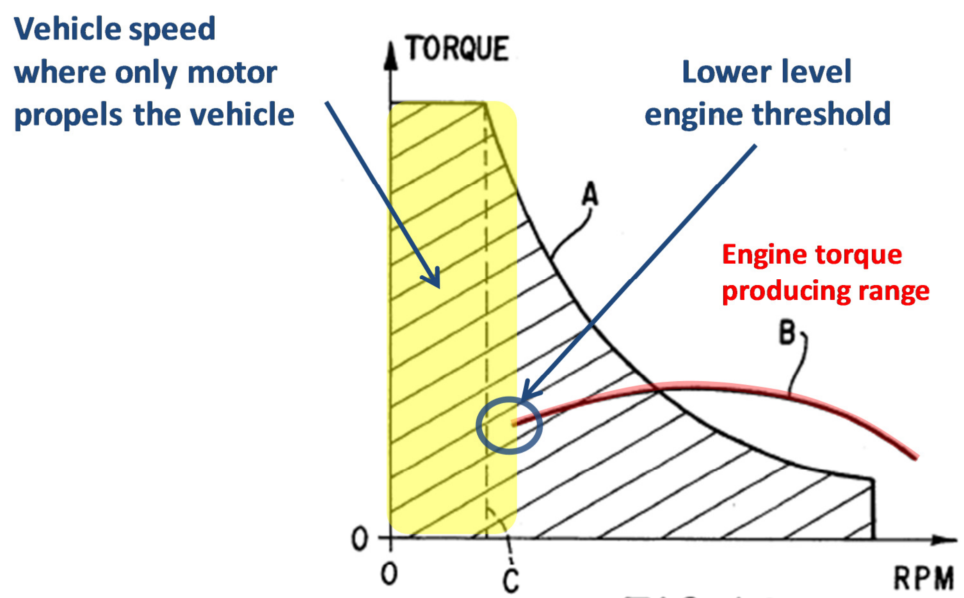
202. Based on this disclosure in Severinsky '970, Severinsky '970 discloses only operating the engine at or near its maximum efficiency. It is also my opinion that the disclosed efficient range of 60-90% of max torque output is the

"sweet spot" of the disclosed engine where operation is most efficient.

203. As discussed above in paragraphs 109-111, it was generally known that all engines have a "sweet spot" range, such as 60-90% of MTO, where torque is efficiently produced. It is also understood that this "sweet spot" range will vary from engine to engine.

204. The lower end of the 60-90% range disclosed by Severinsky '970 would also be known as the proposed "predetermined torque value" or "*setpoint*" below which the engine does not operate. Therefore, it is my opinion that the 60% of MTO is a lower "predetermined torque value."

205. Again, as noted in paragraph 200 above, Severinsky '970 discloses that the engine operates efficiently within a specified conditions of "output power and speed." As shown below, Fig. 14 Severinsky '970 illustrates the engine's maximum torque output curve ("B") in relation to vehicle speed. Curve B does not extend all the way to zero RPM, because, Severinsky '970 states that "no transmission" is employed. (Ex. 1003 at Abstract). Without a multi-speed transmission, the engine is incapable of producing torque at these lower vehicle speeds (i.e. the engine would stall at low speeds).



(Ex. 1003, Fig. 14, annotated)

FIG. 14

206. As I have explained in paragraph 112 above, it was known that engines are typically inoperable below certain speed ranges. Conventional vehicles can overcome this known deficiency by employing a multi-speed transmission.

207. Hybrid vehicles can likewise overcome this deficiency by employing a transmission. Alternatively, a hybrid vehicle can overcome this deficiency by operating the traction motor alone at these lower vehicle speeds.

208. Even the Severinsky '970 recognizes that conventional vehicles overcome the speed limitations of an engine by using a multi-speed transmission with different gear ratios that allows the vehicle to travel at a low speed while maintaining the engine at a speed where the engine can produce torque.

> More particularly, an internal combustion engine produces zero torque at zero engine speed (RPM) and reaches its torque peak somewhere in the middle of its operating range. Accordingly, all vehicles driven directly by an internal combustion engine (other than certain single-speed vehicles using friction or centrifugal clutches, and not useful for normal driving) **require a multiple speed transmission between the engine and the wheels, so that the engine's torque can be matched to the road speeds and loads encountered.**

(Ex. 1003 at 2:2-11, emphasis added).

209. As previously discussed, Severinsky ’970 discloses using the motor 20 for low speed operation, and the engine for highway cruising, in the range at which the engine is most efficient.

210. Moreover, the ’347 Patent admits that Severinsky ’970 is prior art and that Severinsky ’970 discloses an internal-combustion engine that is operated efficiently and never operated below a “predetermined torque value” or setpoint.

> **An important aspect of** the invention as described by the present continuation-in-part application as well as the predecessor applications and **the ’970 patent lies in controlling the operation of the internal combustion engine of a hybrid vehicle so that it is only operated at high efficiency, that is, only when is it loaded to require a substantial fraction...of its maximum torque output**.

(Ex. 1001, 20:52-60, emphasis added).

211. The ’347 Patent further admits:

> For example, **according to the operating scheme of the hybrid vehicle disclosed in the '970 patent**, in low-speed city driving, the electric motor provides all torque needed responsive to energy flowing from the battery. In high-speed highway driving, where the internal-combustion engine can be operated efficiently, it typically provides all torque; needed for acceleration, hill-climbing, or passing. The electric motor is also used to start the internal-combustion engine, and can be operated as a generator by appropriate connection of its windings by a solid-state, microprocessor controlled inverter. For example, when the state of charge of the battery bank is relatively depleted, e.g., after a lengthy period of battery-only operation in city traffic, **the internal combustion engine is started and drives the motor at between 50 and 100% of its maximum torque output, for efficient charging of the battery bank**. Similarly, during braking or hill descent, the kinetic energy of the vehicle can be turned into stored electrical energy by regenerative braking.

(Ex. 1001, 10:57-11:10, emphasis added; *see also* Ex. 1036 at 2, line 17 to 3, line 17).

212. The '095 Provisional and the '347 Patent further admitted that Severinsky '970 discloses an internal-combustion engine that is operated efficiently and never operated below a predetermined torque value.

> **According to an important aspect of the invention of the '970 patent**, substantially improved efficiency is afforded by operating **the internal combustion engine only at relatively high torque output levels, typically at least 35% and preferably at least 50% of peak**

> **torque.** When the vehicle operating conditions require torque of this appoximate[sic] magnitude, the engine is used to propel the vehicle; when less torque is required, an electric motor powered by electrical energy stored in a substantial battery bank drives the vehicle; when more power is required than provided by either the engine or the motor, both are operated simultaneously. The same advantages are provided by the system of the present invention, with further improvements and enhancements described in detail below.

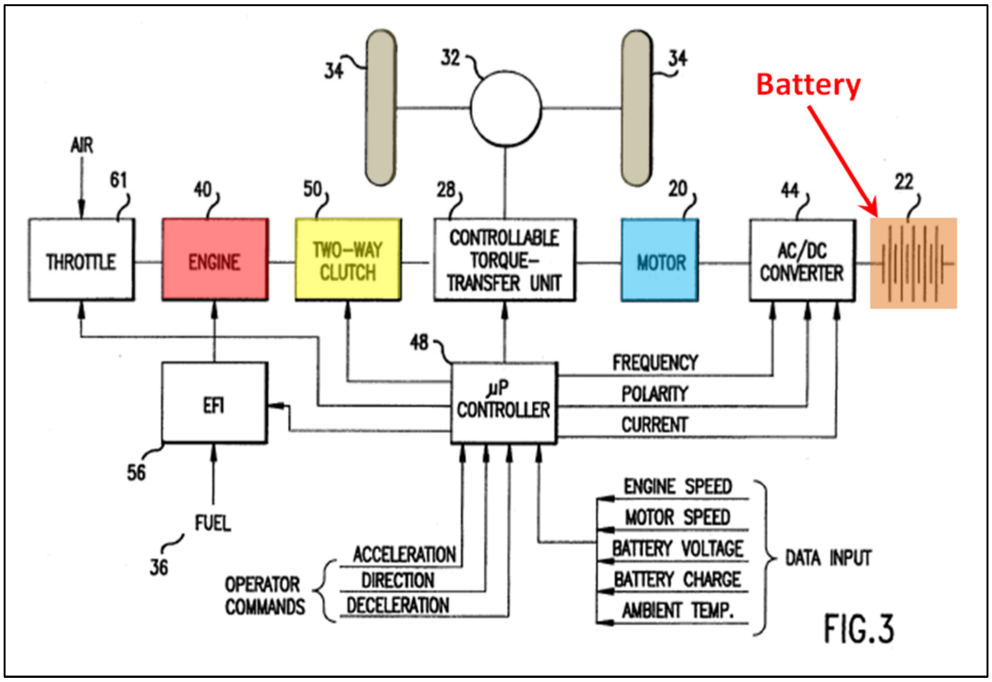
(Ex. 1036 at 8, lines 15-27, emphasis added; Ex. 1001, 25:4-17).

213. Based on the preceding disclosure in the ’347 Patent and the ’095 Provisional, it is my opinion that Severinsky ’970 discloses a lower “predetermined torque value,” which would be considered a “setpoint” below which the engine was not operated.

214. Therefore, it is my opinion that Severinsky ’970 discloses a vehicle comprising “*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, and***

215. Fig. 3 of Severinsky ’970 illustrates and discloses a battery shown as reference numeral 22, as annotated below and highlighted in orange.



(Ex. 1003, Fig. 3, annotated)

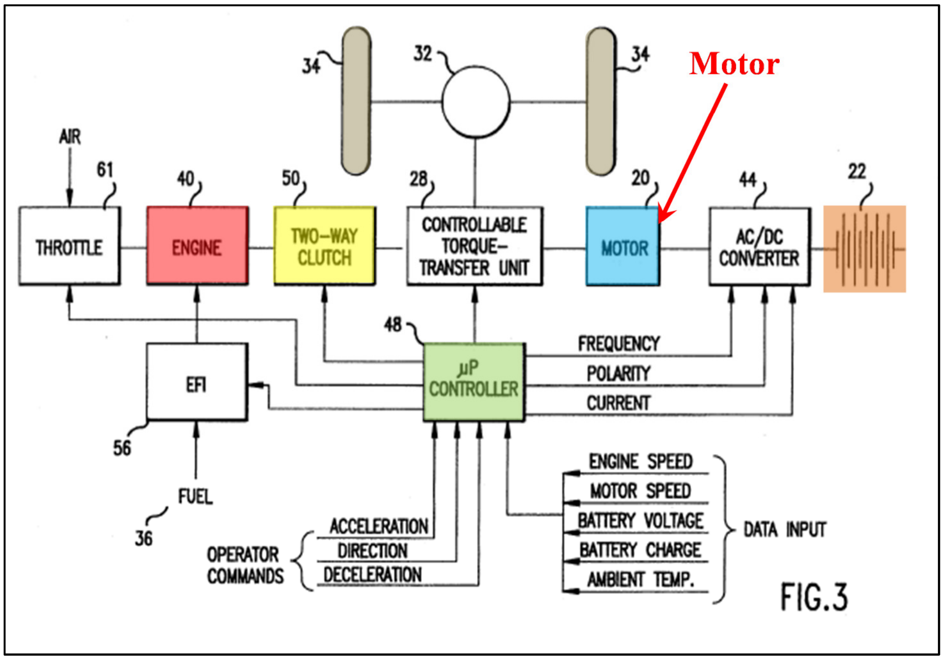
216. Therefore, it is my opinion that Severinsky '970 discloses "*a battery*."

… ***[23.3] one or more electric motors being capable of providing output torque responsive to supplied current, and of generating electrical current responsive to applied torque,***

217. It is my understanding that the limitation "one or more electric motors" only requires one motor.

218. Fig. 3 of Severinsky '970 illustrates and discloses a motor 20, as highlighted below in blue. Fig. 3 also illustrates the motor 20 connected to the wheels 34 (via the torque transfer unit 28). As also shown in Fig. 3, the motor 20 is also connected to the battery 22(via the AC/DC converter 44). At the time of

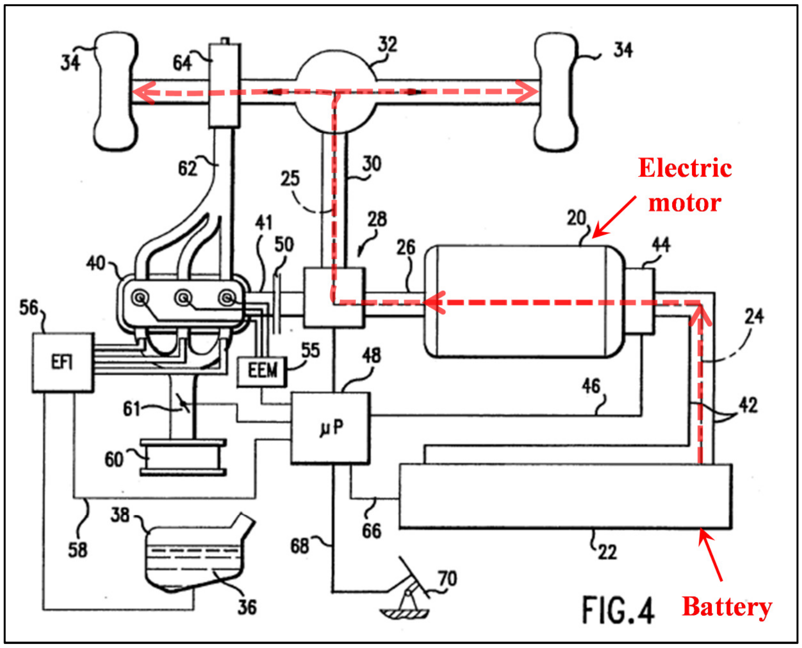
Severinsky '970, in a configuration like Fig. 3, it was known that hybrid vehicles would include a battery that supplied electrical current to run the motor, and vice versa, that the motor could generate current to recharge the battery.



(Ex. 1003, Fig. 3, annotated)

219. The Abstract in Severinsky '970 state that the "electric motor 20" is "operable as a generator to charge the batteries as needed and also for regenerative braking." (Ex. 1003 at Abstract; 9:65-10:14).

220. Fig. 4, reproduced below, illustrates a low speed mode in which the electric motor provides all the torque to propel the vehicle. The dashed lines, as highlighted below, illustrate that the motor 20 is providing torque to vehicle wheels based on current supplied from the battery 22.



(Ex. 1003, Fig. 4, annotated)

221. In describing the operation of the motor in Fig. 4, Severinsky '970 states:

> **The electric motor 20 provides torque,** shown as a dashed line 25, transmitted from the motor output shaft 26 through a torque transfer unit 28 and a drive shaft 30 to a conventional differential 32 and then **to wheels 34 of the vehicle**. Thus FIG. 4 indicates that the **flow of energy** in heavy traffic or for reversing is **simply from battery 22 to electric motor 20**; torque flows from the motor 20 to the wheels 34.

(Ex. 1003 at 10:58-67, emphasis added).

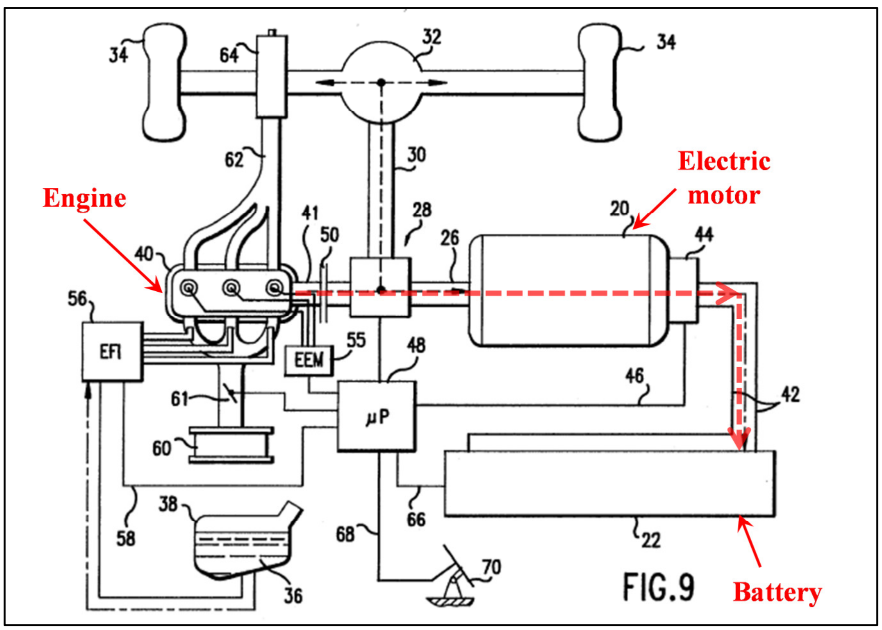
222. Severinsky '970 also discloses that the motor 20 can operate as a generator to generate current responsive to the applied torque from the engine or responsive to the applied torque by the wheels when operated in regenerative

braking mode:

> The battery 22 is charged by **power generated by the motor 20 when operated as a generator**, that is, **when driven by the engine 40** by way of the controllable torque transfer unit 28, or in a **regenerative braking mode**.

(Ex. 1003 at 9:65-10:14, emphasis added).

223. Specifically Fig. 9, reproduced below, illustrates battery charging mode in which the motor 20 is operated as a generator to charge the battery. The dashed lines, as highlighted below, illustrate that the motor 20 is providing current to the battery 22 based on torque applied from the engine.



(Ex. 1003, Fig. 9, annotated)

224. In describing generating operation of the motor in Fig. 9, Severinsky ’970 states:

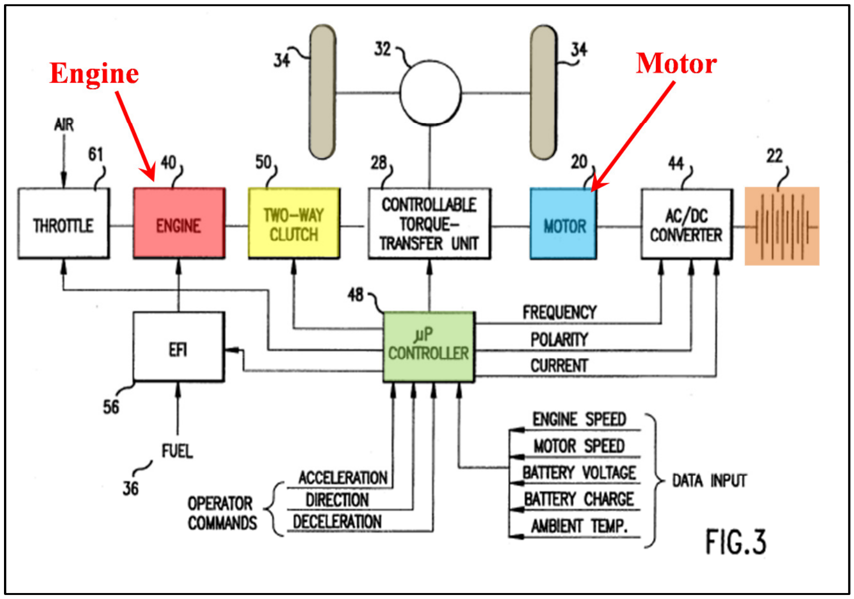
> FIG. 9 illustrates system operation in the battery charging mode. Battery charging takes place automatically, under microprocessor control, responsive to monitoring the state of charge of battery 22 via control signal line 66. **Internal combustion engine 40 charges battery 22 by rotating motor 20, providing AC rectified by switching unit 44 to DC suitable for charging battery 22**. If this mode is entered during driving, internal combustion engine 40 also supplies torque to road wheels 34, as indicated by the dashed lines.

(Ex. 1003 at 15:1-10, emphasis added).

225. Therefore, it is my opinion that Severinsky '970 discloses *"one or more electric motors [i.e. motor 20] being capable of providing output torque responsive to supplied current, and 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:***

226. Fig. 3 of Severinsky '970 illustrates and discloses an engine 40, as highlighted below in red that is connected to the wheels 34 via the clutch 50 (yellow) and controllable torque transfer unit 28. Fig. 3 of Severinsky '970, discloses that the engine is "*controllably connected*" to apply propulsive torque to the wheels.



(Ex. 1003, Fig. 3, annotated)

227. Fig. 3 also illustrates and discloses the microprocessor/controller 48, highlighted in green, connected to the clutch 50 and controllable torque transfer unit 28. It would be understood that the clutch 50 may be controllably engaged/disengaged by the controller 48 to enable torque flow to the wheels 34 from the engine through the torque transfer unit 28.

228. In describing Fig. 3, the Severinsky '970 specification states:

> FIG. 3 shows a block diagram of the drive system of the vehicle according to the invention. **Internal combustion engine 40 is connected by way of a two-way clutch 50 to a controllable torque transfer unit 28.** The torque transfer unit 28 receives torque from engine 40 and/or from alternating current electric motor 20 and transmits this torque to the drive wheels 34 of the vehicle by way of a conventional differential 32.

(Ex. 1003 at 9:58-65, emphasis added).

229. Severinsky ’970 also specifically describes the two mechanisms, the two-way clutch and the torque transfer unit, which control connecting and disconnecting the engine to the wheels:

> Figs. 10 and 11 show respectively a two-way clutch 50 employed to **couple** the internal combustion engine 40 to the drivetrain of the vehicle, and the controllable torque transfer unit 28.

(Ex. 1003 at 15:11-14, emphasis added).

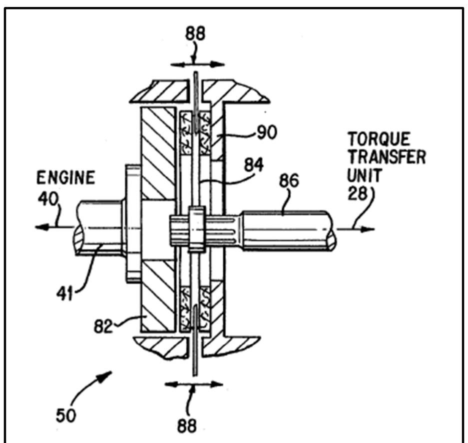


FIG. 10

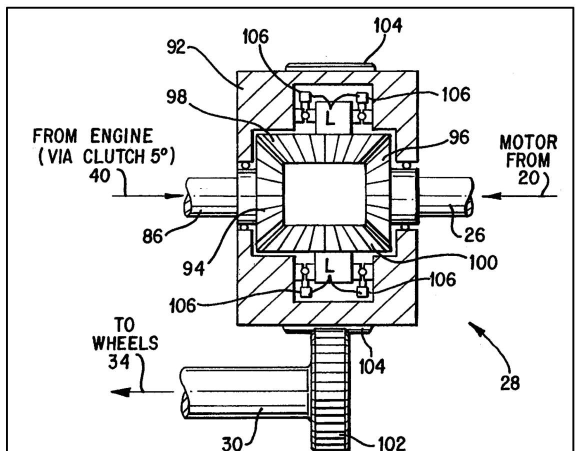


FIG. 11

(Ex. 1003, Fig. 10 & 11)

230. Severinsky ’970 describes operation of the two-way clutch to allow the engine to be coupled/decoupled for transmitting torque:

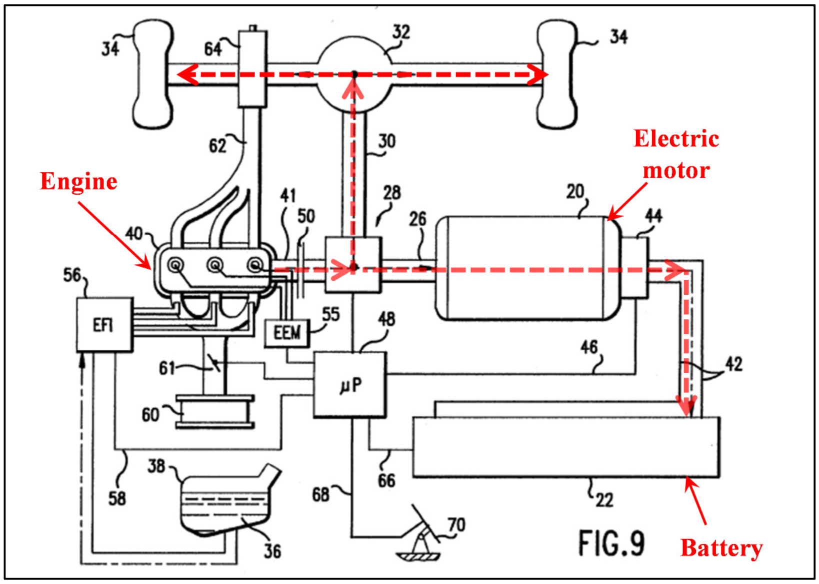
> The two-way clutch 50 shown in FIG. 10 receives torque from an engine flywheel 82 fixed to the engine output shaft 41, and includes a double-sided friction disk 84 splined onto an input shaft 86 of the

> controllable torque transfer unit 28. **A throwout mechanism 88 controlled by microprocessor 48 controls engagement of the friction disk 84 with either the flywheel 82 or a stationary plate 90 fixed with respect to the vehicle. Therefore, depending upon the position of the friction disk 84, torque may be transmitted from engine shaft 41 to input shaft 86, or input shaft 86 can be fixed with respect to the vehicle**, for reasons made clear below.

(Ex. 1003 at 15:20-32, emphasis added).

231. Severinsky ’970 describes operation of the controllable torque transfer unit to which transmits torque to the wheels. For example, Severinsky ’970 discloses that the controllable torque transfer unit then includes a pair of “locking devices 106” that are “operated by microprocessor 48 so that microprocessor 48 can control the torque transfer unit 28 in accordance with the selected operational mode of the vehicle of the invention.” (Ex. 1003 at 16:38-43, *see also* 15:32-17:10).

232. Severinsky ’970, as illustrated in Fig. 9, also discloses a mode where the engine can both charge the battery provide torque to propel the wheels.



(Ex. 1003, Fig. 9, annotated)

233. In describing Fig. 9, Severinsky '970 states:

> FIG. 9 illustrates system operation in the battery charging mode. Battery charging takes place automatically, under microprocessor control, responsive to monitoring the state of charge of battery 22 via control signal line 66. **Internal combustion engine 40 charges battery 22 by rotating motor 20**, providing AC rectified by switching unit 44 to DC suitable for charging battery 22. If this mode is entered during driving, **internal combustion engine 40 also supplies torque to road wheels 34**, as indicated by the dashed lines.

(Ex. 1003 at 15:1-10, emphasis added).

234. Severinsky '970 also describes the that the engine can drive the motor, by way of the torque transfer unit, to charge the battery, Severinsky '970 states:

> The motor 20 receives power from a bi-directional AC/DC power converter 44 comprising a solid-state switching network connected in

> turn to a battery 22. **<u>The battery 22 is charged by power generated by the motor 20 when operated as a generator, that is, when driven by the engine 40 by way of the controllable torque transfer unit 28,</u>** or in a regenerative braking mode.

(Ex. 1003 at 9:65-10:4, emphasis added).

235. Severinsky ’970 further discloses operation of the engine to apply torque to the motor to charge the battery:

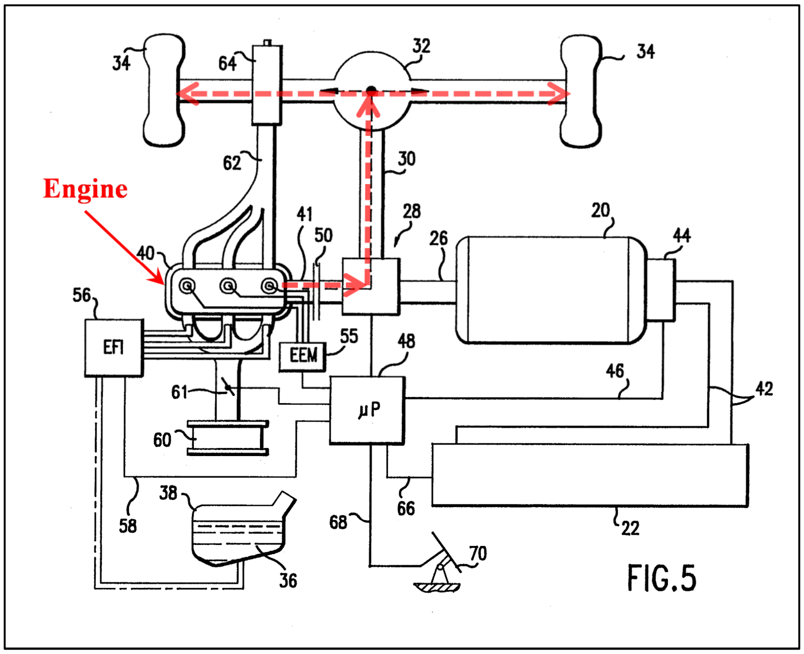
> **<u>More specifically, on occasion it will be desired to charge the batteries while driving the vehicle forward, e.g. in slow traffic. In this mode, the engine output power is divided in order to propel the vehicle forward and to charge the batteries</u>**. Locking devices 106 allow differential operation of the gears within the housing 92 and therefore allow the power output by the engine to be divided as determined to be appropriate by microprocessor 48. Furthermore, by controlling the duty cycle and frequency of operation of the switching elements of controller 44 (see FIGS. 12 and 13), the load provided by the motor to the engine can be controlled. **<u>Thus, at all times the microprocessor 48 may determine the load (if any) to be provided to the engine by the motor, responsive to the load imposed by the vehicle's propulsion requirements, so that the engine 40 can be operated in its most fuel efficient operating range.</u>**

(Ex. 1003 at 16:67-17:15, emphasis added).

236. Severinsky ’970 discloses that the two-way clutch 50 and controllable torque transfer unit 48, in combination, are “*controllably*” operated to connect and

disconnect the engine to the wheels or motor based on the mode of operation.

237. Severinsky '970 also illustrates and describes a highway mode where the engine provides all of the torque required for propulsion of the vehicle.



(Ex. 1003, Fig. 5, annotated)

238. In describing Fig. 5, Severinsky '970 discloses:

> FIG. 5 depicts operation of the system in a highway cruising mode wherein, as indicated above, **<u>all torque required to drive the vehicle</u> at normal highway speeds (e.g. above about 45 mph) is provided by the internal combustion engine 40** supplied with combustible fuel 36 via EFI unit 56. Thus, energy flow as indicated by the dot-dash line is from the tank 38 through EFI unit 56 into engine 40, while torque flows from engine 40 through torque transfer unit 28, to axle differential 32 and thence to road wheels 34.

(Ex. 1003 at 13:66-17:7, emphasis added).

239. The ’347 Patent and ’095 Provisional further admits that Severinsky ’970 discloses an engine connected to provide torque to the wheels as well as apply torque for battery recharging via the motor. The ’347 Patent states:

> **As in the ’970 patent, an internal combustion engine** is provided, sized **to provide sufficient torque to be adequate for the range of cruising speeds desired, and is used for battery charging as needed**.

(Ex. 1001 at 17:24-28, emphasis added)(*see also* Ex. 1036 at 4, lines 13-16).

240. Therefore, based on the specification and figures in Severinsky ’970, and the admission in the ’347 Patent and ’095 Provisional, it is my opinion that that Severinsky ’970 discloses the “*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*.”

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

241. I understand the term “road load,” or “RL,” as used in the ’347 Patent, is proposed to mean “the instantaneous torque required for propulsion of the vehicle, which may be positive or negative in value.”

242. I understand that the claim as being “*determining the instantaneous torque required to propel the vehicle, either positive or negative, responsive to an*

operator command."

243. Turning now to Severinsky '970, while Severinsky '970 does not use the term "road load," Severinsky '970 does disclose determining torque required for propulsion of the vehicle based on driver input, stating:

> **A microprocessor receives control inputs from the driver** of the vehicle and monitors the performance of the electric motor and the internal combustion engine, the state of charge of the battery, and other significant variables. **The microprocessor determines whether the internal combustion engine or the electric motor or both should provide torque to the wheels under various monitored operating conditions.**

(Ex. 1003 at 6:19-26, emphasis added).

244. I understand that Severinsky '970 expressly discloses determining the torque required for propulsion of the vehicle to overcome external forces responsive to an operator command, stating:

> More specifically, on occasion it will be desired to charge the batteries while driving the vehicle forward, e.g. in slow traffic. In this mode, the engine output power is divided in order to propel the vehicle forward and to charge the batteries. Locking devices 106 allow differential operation of the gears within the housing 92 and therefore allow the power output by the engine to be divided as determined to be appropriate by microprocessor 48. Furthermore, by controlling the duty cycle and frequency of operation of the switching elements of controller 44 (see FIGS. 12 and 13), the load provided by the motor to

> the engine can be controlled. Thus, at all times the microprocessor 48 may **determine the load** (if any) to be provided to the engine by the motor, responsive to the load imposed by the vehicle's propulsion requirements, so that the engine 40 can be operated in its most fuel efficient operating range.

(Ex. 1003 at 16:67-17:15, emphasis added).

245. Based on the above referenced disclosure, Severinsky ’970 is using “load” similarly to how “road load” is used in the ’347 Patent. In other words, Severinsky ’970 is using the term “load” to refer to the torque required for propulsion of the vehicle. My opinion is based on the unambiguous statement by Severinsky ’970 that the microprocessor determines the “load” that is required by the engine and motor in response to the load “imposed.”

246. Severinsky ’970 also discloses apportioning the vehicle load requirements between the motor and engine:

> As will be detailed below, the microprocessor 48 controls the flow of torque between the motor 20, the engine 40, and the wheels 34 responsive to the mode of operation of the vehicle. For example, when the vehicle is cruising along the highway, all torque is preferably supplied from the engine 40. However, when the **vehicle starts down a hill, and the operator lifts his foot from the accelerator pedal**, the kinetic energy of the vehicle and the engine's excess torque may be used to drive the motor 20 as a generator so as to charge the batteries. If the **vehicle then starts to climb a hill, the motor 20 is**

> **<u>used to supplement the output torque of engine 40</u>**. Similarly, the motor 20 can be used to start the engine 40, e.g., when accelerating in traffic or the like. The various modes of operation of the system will be described below in connection with FIGS. 4-9, after which further details of the various elements of the system are provided.

(Ex. 1003 at 10:25-43, emphasis added).

247. Based on the disclosure above Severinsky '970 recognizes both uphill and downhill driving conditions. When the vehicle is going **down a hill the torque required for propulsion of the vehicle could be <u>negative</u>** (i.e., traveling down a steep hill). As anyone who has ever driven a vehicle would have experienced, when the vehicle descends down a hill, if the driver does nothing, the weight of the vehicle will cause the vehicle to accelerate due to gravity. This is a commonly known and experienced phenomenon. Therefore, the torque required for propulsion of the vehicle may decrease or possibly become negative when the vehicle. Therefore, the driver needs to press the brake pedal to keep from accelerating.

248. Conversely, when the vehicle is going **up the hill, or when the driver requests the vehicle accelerate,** it is understood that **the torque required for propulsion of the vehicle may be <u>positive</u>**. Again, as anyone who has ever driven a vehicle would have experienced, when the vehicle ascends the hill, if the driver does nothing, the weight of the vehicle will cause the vehicle to decelerate due to gravity. This is a commonly known and experienced phenomenon.

Therefore, the torque required for propulsion of the vehicle is positive when the vehicle is traveling up a hill. Therefore, the driver needs to press the accelerator pedal to either maintain the same speed or to accelerate up the hill. Likewise, anyone who has ever wanted to pass a vehicle understands that in order for the vehicle to accelerate, the driver must further press the accelerator pedal to accelerate past the other vehicle. Such acceleration also requires positive torque to propel the vehicle.

249. Severinsky '970 further confirms that the hybrid control strategy determines the instantaneous torque required for propulsion of the vehicle.

> FIGS. 5-9 show operation of the system in other modes. FIG. 5 depicts operation of the system in a highway cruising mode wherein, as indicated above, **all torque required to drive the vehicle** at normal highway speeds (e.g. above about 45 mph) **is provided by the internal combustion engine 40 supplied with combustible fuel 36 via EFI unit 56.**

(Ex. 1003 at 13:65-14:21, emphasis added).

250. Severinsky '970 also discloses determining the torque required for propulsion of the vehicle based on an "*operator command*."

> Thus FIG. 4 indicates that the flow of energy in heavy traffic or for reversing is simply from battery 22 to electric motor 20; torque flows from the motor 20 to the wheels 34. Under these circumstances, electric motor 20 provides all of the torque needed to move the

> vehicle. Other combinations of torque and energy flow required under other circumstances are detailed below in connection with FIGS. 5-9. **For example, if the operator continues to command acceleration, an acceleration/hill climbing mode illustrated in FIG. 6 may be entered, followed by a highway cruising mode illustrated in FIG. 5**.

(Ex. 1003 at 10:52-11:6, emphasis added).

251. Severinsky '970 further discloses that the operator may account for external forces that act on the vehicle, such as wind resistance and hill gradients, and then provide a change in command in response to changing conditions.

> As the desired cruising speed may vary somewhat, and as **the engine output power required to attain and maintain a given road speed will vary with prevailing wind conditions, road grading and the like, the output torque of internal combustion engine 40 may be directly variable responsive to the operator's control inputs**. Microprocessor 48 monitors the operator's inputs and the vehicle's performance, and activates electric motor 20 when torque in excess of the capabilities of engine 40 is required. Conversely, if excess engine torque is available (see the discussion of FIG. 7 below) it can be transformed into electrical energy in motor 20 and stored by battery 22.

(Ex. 1003 at 13:65-14:21, emphasis added).

252. As I discussed above in paragraphs 113-120, the **textbook definition of "road load"** is the sum of the external forces that act on the vehicle. It is

understood that the sum of the external forces, may include the “wind and road grading” disclosed by Severinsky’970. Such external forces are a known physical occurrence to anyone who has driven a vehicle. For instance, when the vehicle is driving on a windy day, the driver may press the accelerator pedal requesting additional torque.

253. The ’347 Patent and the ’095 Provisional, to which the ’347 Patent claims priority, admit that Severinsky ’970 also disclosed determining the operation state of the vehicle and apportioning the torque requirements to propel the hybrid vehicle, based on operator inputs:

> In each of these aspects of the operation of the vehicle, and **as in the ’970 <u>patent</u>, the operator of the vehicle need not consider the hybrid nature of the vehicle during its operation, but simply provides control inputs by operation of the <u>accelerator and brake pedals</u>**. The microprocessor determines the proper state of operation of the vehicle based on these and other inputs and controls the various components of the hybrid drive train accordingly.

(Ex. 1036 at 5, lines 29-35, emphasis added)(Ex. 1001 at 18:38-45).

254. The ’347 Patent further admits that Severinsky ’970 discloses the same torque-based control strategy:

> **<u>According to an important aspect of the invention of the ’970</u>**, substantially improved efficiency is afforded by operating the internal combustion engine only at relatively high torque output levels,

> typically at least 35% and preferably at least 50% of peak torque. When the vehicle operating conditions require torque of this approximate [sic] magnitude, **<u>the engine is used to propel the vehicle; when less torque is required, an electric motor powered by electrical energy stored in a substantial battery bank drives the vehicle; when more power is required than provided by either the engine or the motor, both are operated simultaneously</u>**. The same advantages are provided by the system of the present invention, with further improvements and enhancements described in detail below.

(Ex. 1001 at 24:64-25:17, emphasis added).

255. Therefore, based on the specification of Severinsky '970, and the admissions of the '347 Patent, it is my opinion that Severinsky '970 discloses "*determining the instantaneous torque RL required to propel said vehicle responsive to an operator command*."

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

256. Severinsky '970 expressly discloses that the controller monitors the state of charge of the battery. Severinsky '970 states:

> A **<u>microprocessor</u>** receives control inputs from the driver of the vehicle and **<u>monitors</u>** the performance of the electric motor and the internal combustion engine, **<u>the state of charge of the battery</u>**, and other significant variables.

(Ex. 1003 at 6:19-23, emphasis added).

> Finally, FIG. 9 illustrates system operation in the battery charging mode. Battery charging takes place automatically, under microprocessor control, responsive to **monitoring the state of charge of battery 22** via control signal line 66.

(Ex. 1003 at 15:1-10).

> According to a preferred implementation of the invention, **microprocessor 48 monitors the state of charge of batteries 22** via line 66 and recharges the batteries whenever the charge is depleted by more than about 10-20%.

(Ex. 1003 at 18:9-12, emphasis added).

257. Therefore, based on the specification of Severinsky '970, it is my opinion that Severinsky '970 discloses the "*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;***

258. I understand the proposed construction of the term "RL" as "the instantaneous torque required for propulsion of the vehicle, which may be positive or negative in value."

259. It is my understanding that the proposed construction of "SP" as being "predetermined torque value."

260. It is my understanding that claim limitation [23.7] should be

interpreted as "*employing said at least one electric motor to propel said vehicle when the torque required to propel the vehicle, which may be positive or negative, is less than said lower level predetermined torque value*."

261. Severinsky '970 discloses that the engine is operated in its most efficient conditions of output power and speed. When the output power and speed are below the engine's most efficient operating condition, the motor is disclosed as being used to propel the vehicle.

> More particularly, according to the invention, the internal combustion **engine is operated only under the most efficient conditions of output power and speed**. When the engine can be used efficiently to drive the vehicle forward, e.g. in highway cruising, it is so employed. **Under other circumstances, e.g. in traffic, the electric motor alone drives the vehicle forward** and the internal combustion engine is used only to charge the batteries as needed.

(Ex. 1003 at 7:8-16, emphasis added).

262. As discussed above in [23.1], Severinsky '970 discloses the efficient output power condition as being between 60-90% of the engine's maximum torque output. The 60% torque value is the lower predetermined torque value (i.e., "*SP*").

> [T]he internal combustion engine is **run only** in the near vicinity of its most efficient operational point, that is, such that it **produces 60-90% of its maximum torque whenever operated**.

(Ex. 1003 at 20:63-66, emphasis added).

263. Again, Severinsky ’970 discloses that the engine operation is based on efficient conditions of output power **<u>and</u>** speed. Based on this disclosure in Severinsky ’970, Severinsky ’970 discloses only operating the engine at or near its maximum efficiency. It is also my opinion that the disclosed efficient range of 60-90% of max torque output is the “sweet spot” of the disclosed engine where operation is most efficient.

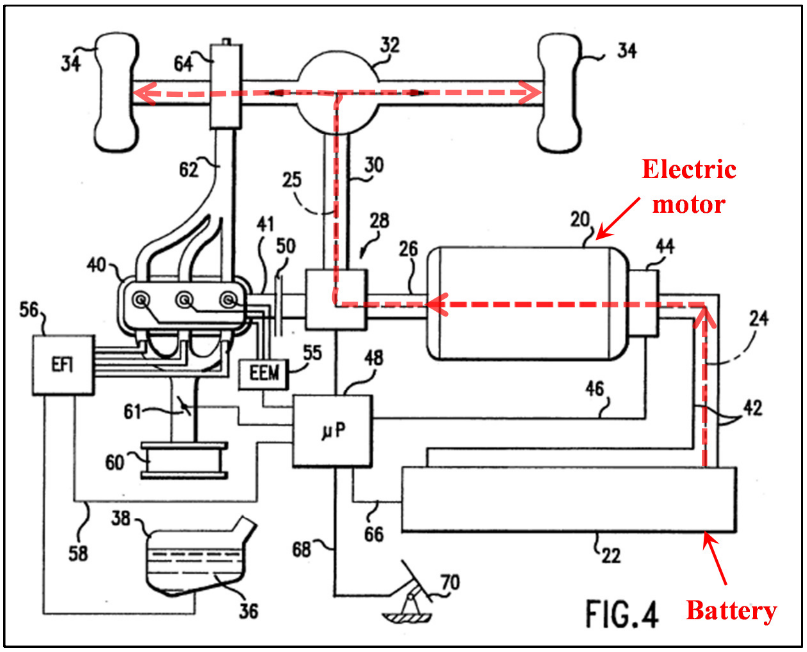
264. Severinsky ’970 discloses operating the motor when the engine operation is inefficient.

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

(Ex. 1003 at 9:47-57, emphasis added).

265. It is my opinion that the Severinsky ’970 discloses a motor operation mode that is based on both the vehicle’s speed and torque requirements. Thus as stated in paragraph 261, when the torque required for propulsion of the vehicle is less than 60% of MTO, the motor is used to propel the vehicle.

266. In fact, my opinion is further confirmed by Fig. 4 which illustrates motor only mode where the motor supplies all of the torque required for propulsion of the vehicle.



(Ex. 1003, Fig. 4, annotated)

267. With reference to Fig. 4, Severinsky ’970 states:

FIG. 4 illustrates operation in <u>**low speed circumstances**, e.g., in city traffic or reversing</u>. As noted, the parallel hybrid vehicle drive system according to the present invention includes an electric motor 20 powered by energy stored in a relatively large, high voltage battery pack 22. Energy flows from battery 22 to motor 20 as indicated by a dot-dash line shown at 24. The electric motor 20 provides torque, shown as a dashed line 25, transmitted from the motor output shaft 26 through a torque transfer unit 28 and a drive shaft 30 to a conventional differential 32 and then to wheels 34 of the vehicle. Thus FIG. 4

> indicates that the flow of energy in heavy traffic or for reversing is simply from battery 22 to electric motor 20; torque flows from the motor 20 to the wheels 34. **Under these circumstances, electric motor 20 provides all of the torque needed to move the vehicle**. Other combinations of torque and energy flow required under other circumstances are detailed below in connection with FIGS. 5-9. **For example, if the operator continues to command acceleration, an acceleration/hill climbing mode illustrated in FIG. 6 may be entered, followed by a highway cruising mode illustrated in FIG. 5.**

(Ex. 1003 at 10:52-11:6, emphasis added).

268. As emphasized above, low vehicle speeds generally coincides with a low vehicle load.

269. However, if the operator demands acceleration or the vehicle begins to climb a hill, the torque required for propulsion of the vehicle **at low speeds** increases and the mode of operation is changed to one where both engine and motor are used to propel the vehicle (as shown in Fig. 6 of Severinsky '970) instead of motor only operation in Fig. 4 above.

270. This example confirms that Severinsky '970 evaluates both speed and power (i.e., torque) requirements of the vehicle when determining the proper operational mode.

271. Therefore, Severinsky '970 discloses that using the electric motor to

propel the vehicle when the torque required for propulsion of the vehicle is less than the lower predetermined torque value of the engine's efficient range. Stated differently, Severinsky '970 discloses that when the torque required for propulsion of the vehicle is less than 60% of MTO (i.e., RL < SP), the motor is used to propel the vehicle.

272. The '347 Patent and '095 Provisional also admit that Severinsky '970 disclosed only operating the engine only in its most efficient operating range and then operating the motor when less torque is required:

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

(Ex. 1036 at 8, lines 15-27, emphasis added; *see also* Ex. 1001 at 25:4-17).

273. A person of ordinary skill in the art, as discussed above, would

understand that the lower end of the efficient torque range would be a lower predetermined torque value of the engine.

274. Therefore, the '095 Provisional and '347 Patent both admit that Severinsky '970 also disclosed operating the motor when the torque required for propulsion of the vehicle was below the torque setpoint.

275. Therefore, based on the specification of Severinsky '970, and the admissions in the '347 Patent and '095 Provisional, it is my opinion that Severinsky '970 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;***

276. I understand the term "RL" or "road load" or "RL" as used in the '347 Patent, should be interpreted as "instantaneous torque required for propulsion of the vehicle, which may be positive or negative in value." Also, it is my understanding that "SP" should be interpreted to mean a "predetermine torque value."

277. It is my understanding that this claim limitation should be interpreted as "*employing said engine to propel said vehicle when the torque required for propulsion of the vehicle, which may be positive or negative in value, is between said lower level predetermine torque value and MTO*."

278. Again, Severinsky '970 discloses that the engine is operated in its most efficient conditions of **output power and speed**. When the output power and speed are below the engine's most efficient operating condition, the motor is disclosed as being used to propel the vehicle.

> More particularly, according to the invention, the internal combustion **engine is operated only under the most efficient conditions of output power and speed**. When the engine can be used efficiently to drive the vehicle forward, e.g. in highway cruising, it is so employed. **Under other circumstances, e.g. in traffic, the electric motor alone drives the vehicle forward** and the internal combustion engine is used only to charge the batteries as needed.

(Ex. 1003 at 7:8-16, emphasis added).

279. As discussed above in [23.1], Severinsky '970 discloses the efficient output power condition as being between 60-90% of the engine's maximum torque output. The 60% torque value would be understood as the lower predetermined torque value (i.e., "*SP*"). Severinsky '970 also confirms that the engine is not operated above 90% of MTO let alone greater than the engine's Maximum Torque Output.

> It will be appreciated that according to the invention the internal combustion **engine is run only in the near vicinity of its most efficient operational point, that is, such that it produces 60-90% of its maximum torque** whenever operated.

(Ex. 1003 at 20:63-67, emphasis added).

280. Severinsky ’970 discloses that the engine provides all propulsion torque for the vehicle at highway cruising speeds. Severinsky ’970 contemplates that these highway cruising speeds occur when the vehicle torque requirements fall within 60-90% of the engine’s maximum torque output range. In other words, Severinsky ’970 discloses an engine that is employed to propel the engine when the torque required for propulsion of the vehicle is between a lower level predetermined torque value and the engine’s MTO. (i.e., SP <RL<MTO).

> FIG. 5 depicts operation of the system in a **highway cruising mode** wherein, as indicated above, **all torque required to drive the vehicle at normal highway speeds (e.g. above about 45 mph) is provided by the internal combustion engine 40** supplied with combustible fuel 36 via EFI unit 56.

(Ex. 1003 at 13:65-14:16, emphasis added).

281. Moreover, the ’347 Patent admits that Severinsky ’970 discloses operating the engine only above a setpoint:

> **As in the ’970 patent, the engine is** sized so that it provides sufficient power to maintain the vehicle in a range of suitable highway cruising speeds, while being **operated in a torque range providing good fuel efficiency**.

(Ex. 1001 at 18:25-28, emphasis added; *see also*, Ex. 1036 at 4, lines 21-24).

282. It was well known in the art at the time of the ’347 Patent that internal combustion engines were inefficient at low torque/speeds, as discussed in

paragraphs 108-112 above. Thus, a person of ordinary skill in the art would understand that operating the engine in a torque range having good fuel efficiency, as the ’347 Patent admits and that Severinsky ’970 also discloses, would necessarily include a minimum predetermined torque value (i.e., “*SP*”) above which engine torque is efficiently produced.

283. Therefore, based on the figures and specification of Severinsky ’970, as well as the admission of prior art in the ’347 Patent, it is my opinion that Severinsky ’970 discloses the “*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***

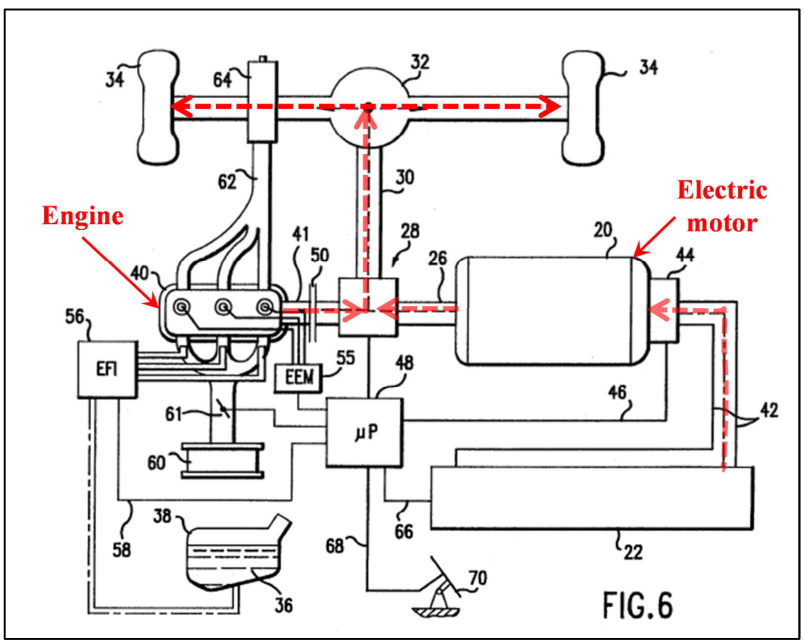
284. I understand the term “RL” or “road load” or “RL” as used in the ’347 Patent, should be interpreted as “instantaneous torque required for propulsion of the vehicle, which may be positive or negative in value.”

285. It is my understanding that this claim limitation should be interpreted as “*employing both said at least one electric motor and said engine to propel said vehicle when the torque required for propulsion of the vehicle, which may be positive or negative in value, is more than MTO*.”

286. Fig. 6 of Severinsky ’970 illustrates and discloses operating the motor

to provide supplemental torque when the torque required for propulsion of the vehicle exceeds the capability (i.e. maximum torque output) of the engine. Severinsky '970 states: "Microprocessor 48 monitors the operator's inputs and the vehicle's performance, and **activates electric motor 20 when torque in excess of the capabilities of engine 40 is required**. (Ex. 1003 at 14:15-18, emphasis added).

287. Fig. 6, reproduced below and annotated, illustrates the acceleration/hill climbing modes where both the engine and motor provide torque to the wheels to propel the vehicle. Specifically Figure 6 discloses a "hill climbing mode" which would be selected purely based on the vehicle's torque requirements.



(Ex. 1003, Fig. 6, annotated)

288. In discussion of Fig. 6, Severinsky '970 states

> **FIG. 6 illustrates operation of the system in a high-speed acceleration and/or hill climbing mode, wherein both internal combustion engine 40 and electric motor 20 provide torque to road wheels** 34. Accordingly, electrical energy, as shown by the dot-dash line, flows from battery 22 to motor 20; additionally, gasoline or another combustible fuel flows from tank 38 to EFI unit 56 so that both internal combustion engine 40 and electric motor 20 can supply torque indicated by the dashed lines to road wheels 34. Again, microprocessor 48 controls operation of both motor 20 and internal combustion engine 40 through switching unit 44 and EFI unit 56, respectively. Low-speed acceleration--up to about 25 mph--is powered by the motor 20 alone.

(Ex. 1003 at 14:21-36, emphasis added).

289. Claim 18 of Severinsky '970 also claims:

> ...wherein during said **acceleration or hill climbing mode** of operation, said flow paths are controlled such that electrical energy flows from said battery to said electric motor, fuel flows from a supply thereof to said engine **and torque flows from said electric motor and said engine to said torque transfer unit and thence to said wheels**.

(Ex. 1003 at 25:26-34, emphasis added).

290. The '347 Patent also admits that Severinsky '970 discloses employing both the motor and the engine when the torque required for propulsion of the vehicle exceeds the engine MTO, the '347 Patent stating:

> **As in the ’970 patent**, the engine is sized so that it provides sufficient power to maintain the vehicle in a range of suitable highway cruising speeds, while being operated in a torque range providing good fuel efficiency; **if additional power is then needed, e.g., for hill-climbing or passing, the traction and/or starter motors can be engaged as needed**.

(Ex. 1001 at 18:25-30, emphasis added; *see also* 36:22-46).

291. In reference to Severinsky ’970, the ’347 Patent also states:

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

(Ex. 1003 at 25:18-28, emphasis added).

292. Therefore, based on the figures, specification and claims of Severinsky ’970, as well as the admission of prior art in the ’347 Patent, it is my opinion that Severinsky ’970 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***

293. I understand the term "road load" or "RL" as used in the '347 Patent, should be interpreted as "the instantaneous torque required for propulsion of the vehicle, which may be positive or negative in value."

294. It is my understanding that proposed construction of "SP" as being "predetermined torque value."

295. It is my understanding that this claim limitation should be interpreted as "*employing said engine to propel said vehicle when the torque required for propulsion of the vehicle, which may be positive or negative in value, is less than said lower level predetermined torque value and using the torque between the torque required for propulsion of the vehicle, which may be positive or negative in value, and the predetermined torque value 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*."

296. Severinsky '970 discloses using the engine's excess torque to drive the motor and charge the batteries when the torque required for propulsion of the

vehicle is less than the engine's efficient torque range.

> As will be detailed below, the microprocessor 48 controls the flow of torque between the motor 20, the engine 40, and the wheels 34 responsive to the mode of operation of the vehicle. For example, when the vehicle is cruising along the highway, all torque is preferably supplied from the engine 40. **However, when the vehicle starts down a hill, and the operator lifts his foot from the accelerator pedal, the kinetic energy of the vehicle and the engine's excess torque may be used to drive the motor 20 as a generator so as to charge the batteries**. If the vehicle then starts to climb a hill, the motor 20 is used to supplement the output torque of engine 40. Similarly, the motor 20 can be used to start the engine 40, e.g., when accelerating in traffic or the like. The various modes of operation of the system will be described below in connection with FIGS. 4-9, after which further details of the various elements of the system are provided.

(Ex. 1003 at 10:26-43, emphasis added).

297. Specifically, Severinsky '970 discloses using the engine to charge the battery when the "*battery indicates the desirability to do so*." A person of ordinary skill in the art would understand the above emphasized language indicates that when the vehicle is traveling down a hill, the torque required for propulsion of the vehicle may be less than the lower predetermined torque threshold (i.e., "*SP*"). However, if the battery requires charging, Severinsky '970 continues to operate the engine during this downhill condition and will operate the engine above the

predetermined torque threshold by using the engine's excess torque to drive the motor as a generator to charge the battery.

298. As anyone who has ever driven a vehicle would have experienced, when the vehicle descends the hill, if the driver does nothing, the weight of the vehicle will cause the vehicle to accelerate because of gravity. Severinsky '970 also discloses using the excess torque from the engine to charge the battery when the vehicle is going downhill as illustrated by the quote in paragraph '296 Provisional. (Ex. 1003 at 10:26-43).

299. Severinsky '970 further discloses that when the battery requires charging, the engine is operated above the 60% predetermined torque value in order to drive the generator to charge the battery. The excess torque is used to drive the generator to charge the battery. Severinsky '970 recognizes that this charge mode may even occur at low vehicle speeds.

> By comparison, **<u>if the battery is discharged by 10-20% and the vehicle speed is below 25-35 mph</u>**, the microprocessor 48 actuates the two-way clutch 50 (see FIG. 10) to connect the engine 40 to the torque transfer unit. Then the motor 20 will start the engine 40 while driving the vehicle, with the microprocessor 48 providing optimal starting conditions as above. Locking devices 106 are released, such that the torque transfer unit 28 operates in differential mode. The microprocessor 48 output current signals provided by microprocessor 48 then controls the speeds of both the engine 40 and the motor 20

> such that the difference in speed of their output shafts is equal to the speed required by the driver for vehicle propulsion. As noted, **engine speed is controlled such that engine 40 provides 60-90% of its maximum power over a wide range of vehicle speeds. Excess power is used to recharge the battery 22**. The microprocessor 48 controls the switching network 44 so that the motor 20 acts as a generator to charge the battery.

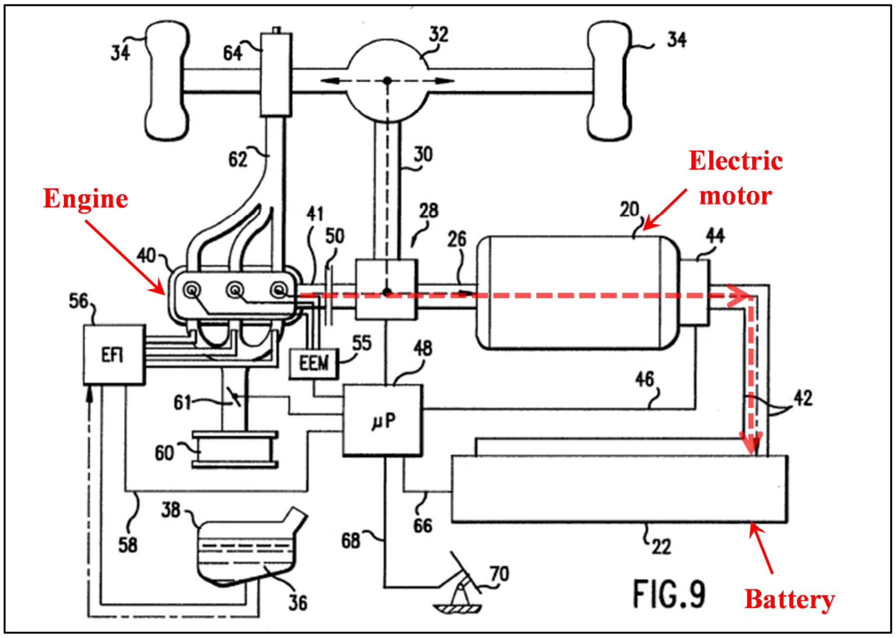
(Ex. 1003 at 17:56-18:5, emphasis added).

300. Fig. 9 of Severinsky '970 also illustrates and discloses operating the motor to regenerative charging torque to consume excess engine output torque and transfer energy to the battery. Severinsky '970 further discloses that regenerative torque is applied when vehicle propulsion requirements are less than the engine output torque during efficient engine operation. Severinsky '970 states:

> Microprocessor 48 monitors the operator's inputs and the vehicle's performance, and activates electric motor 20 when torque in excess of the capabilities of engine 40 is required. **Conversely, if excess engine torque is available** (see the discussion of FIG. 7 below) **it can be transformed into electrical energy in motor 20 and stored by battery 22**.

(Ex. 1003 at 14:15-21, emphasis added).

301. Fig. 9, reproduced below and annotated, illustrates the modes where the engine provides torque to the wheels to propel the vehicle and motor for battery recharging.



(Ex. 1003, Fig. 9, annotated)

302. In reference to Fig. 9, Severinsky '970 states:

FIG. 9 illustrates system operation in the battery charging mode. Battery charging takes place automatically, under microprocessor control, responsive to monitoring the state of charge of battery 22 via control signal line 66. **Internal combustion engine 40 charges battery 22 by rotating motor 20, providing AC rectified by switching unit 44 to DC suitable for charging battery 22. If this mode is entered during driving, internal combustion engine 40 also supplies torque to road wheels 34, as indicated by the dashed lines**.

(Ex. 1003 at 15:1-10, emphasis added).

303. Based on the disclosure in Severinsky '970, the mode illustrated in Fig. 9 is used when the torque required for propulsion of the vehicle was less that

the efficient operating range of the engine.

304. Therefore, a person of ordinary skill in the art would understand that the engine can be operated in its efficient range, and the excess torque can be used to charge the battery, as shown in Fig. 9.

305. Based on this disclosure in Severinsky ’970, a person of ordinary skill in the art would understand that when a vehicle starts down a hill, that the torque required for propulsion of the vehicle, may be negative due to the hill gradient. Since the torque required for propulsion of the vehicle is negative, a person of ordinary skill in the art would understand the negative tractive forces are less than the minimum torque setpoint of the engine.

306. A person of ordinary skill in the art would understand that it is possible to operate the engine so that it produces more torque than is actually required to propel the vehicle, and then using this excess torque to charge the battery via the motor.

307. Moreover, the ’347 Patent admits that Severinsky ’970 discloses using the excess torque from the internal-combustion engine to charge the battery. The ’347 Patent admits that Severinsky ’970 discloses operating the engine in the most efficient range and using the excess torque generated to charge the battery when the torque required for propulsion of the vehicle is less than the efficient engine threshold:

> An important aspect of the invention as **described by the present continuation-in-part application as well as the predecessor applications and the '970 patent lies in controlling the operation of the internal combustion engine of a hybrid vehicle** so that it is only operated at high efficiency, that is, only when is it loaded to require a substantial fraction e.g., 30% of its maximum torque output. That is, the engine is never run at less than 30% of maximum torque output ("MTO").

(Ex. 1001 at 20:52-60, emphasis added).

> For example, **according to the operating scheme of the hybrid vehicle disclosed in the '970 patent**, in low-speed city driving, the electric motor provides all torque needed responsive to energy flowing from the battery. In high-speed highway driving, where the internal-combustion engine can be operated efficiently, it typically provides all torque; needed for acceleration, hill-climbing, or passing. The electric motor is also used to start the internal-combustion engine, and can be operated as a generator by appropriate connection of its windings by a solid-state, microprocessor controlled inverter. For example, when the state of charge of the battery bank is relatively depleted, e.g., after a lengthy period of battery-only operation in city traffic, **the internal combustion engine is started and drives the motor at between 50 and 100% of its maximum torque output, for efficient charging of the battery bank**. Similarly, during braking or hill descent, the kinetic energy of the vehicle can be turned into stored electrical energy by regenerative braking.

(Ex. 1001 at 10:58-11:10, emphasis added).

308. Therefore, based on the figures and specification of Severinsky '970, as well as the admission of the prior art disclosure in the '347 Patent, a person of ordinary skill in the art would understand that Severinsky '970 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.***

309. As discussed above in reference to element [23.1] (paragraphs 200-204), Severinsky '970 discloses that the engine is operated only under conditions where the engine output torque is less than the maximum torque output. (*See* ¶¶ 200-204). Specifically, Severinsky '970 discloses operating the engine between a lower level predetermined torque value (i.e. "*setpoint (SP)*") that is 60% of the engine's maximum torque output and an upper level predetermined torque value that is 90% of the engine's maximum torque output.

310. The '347 Patent also admits that Severinsky '970 disclosed operating the engine at substantially less than the maximum torque output of the engine. The '347 Patent states:

> According to an important aspect of the invention of the ’970 patent, substantially improved efficiency is afforded by operating the internal combustion engine only at relatively high torque output levels, typically at least 35% and preferably at least 50% of peak torque.

(Ex. 1001 at 25:4-8).

311. A person of ordinary skill in the art would understand that 35-50%, or even 60% of maximum torque is substantially less than the peak torque (i.e. MTO) of the engine.

312. Therefore, it is my opinion that Severinsky ’970 discloses “*the torque produced by said engine when operated at said setpoint (SP) is substantially less than the maximum torque output (MTO) of said engine*.”

313. <INTENTIONALLY LEFT BLANK>

… ***[36] The method of claim 23, comprising the further step of performing regenerative charging of the battery when the engine's instantaneous torque output>RL, when RL is negative, or when braking is initiated by the operator.***

314. Claim 36 depends from claim 23, and recites “*the further step of performing regenerative charging of the battery when the engine's instantaneous torque output>RL, when RL is negative, or when braking is initiated by the operator*.”

315. It is my understanding that the construction proposed for “RL” is “the

instantaneous torque required for propulsion of the vehicle, which may be positive or negative in value."

316. As I explained with respect to limitation [23.5] above, Severinsky '970 teaches determining "the instantaneous torque required for propulsion of the vehicle, which may be positive or negative in value."

317. Further, it is my understanding that "OR" within the claim is meant to be interpreted to mean "Element A," "Element B," or "Element C," as follows:

Element A - performing regenerative charging of the battery when the engine's instantaneous torque output is greater than the instantaneous torque required for propulsion of the vehicle, which may be positive or negative in value,

Element B - performing regenerative charging of the battery when … the instantaneous **torque** required for propulsion of the vehicle, which may be positive or negative in value, is negative, **OR**

Element C - performing regenerative charging of the battery when … when braking is initiated by the operator.

318. It is further my understanding that the claim limitation is disclosed by the prior art if any one of the three limitations is satisfied.

319. As discussed above in reference to claim 23, element [23.10], Severinsky '970 satisfies Element A, Element B, **and** Element C.

320. First, Severinsky ’970 discloses Element “A” by using excess engine output torque to recharge the battery:

> Microprocessor 48 monitors the operator’s inputs and the vehicle’s performance, and activates electric motor 20 when torque in excess of the capabilities of engine 40 is required. **Conversely, if excess engine torque is available (see the discussion of FIG. 7 below) it can be transformed into electrical energy in motor 20 and stored by battery 22**.

(Ex. 1003 at 14:15-21).

321. Severinsky ’970 further discloses “Element B” when battery charging occurs during downhill stretches (i.e. negative road load). A person of ordinary skill in the art would understand that when a vehicle starts down a hill, that the torque required for propulsion of the vehicle, may be negative due to the hill gradient:

> However, **when the vehicle starts down a hill,** and the operator lifts his foot from the accelerator pedal, **the kinetic energy of the vehicle and the engine's excess torque may be used to drive the motor 20 as a generator so as to charge the batteries**. If the vehicle then starts to climb a hill, the motor 20 is used to supplement the output torque of engine 40.

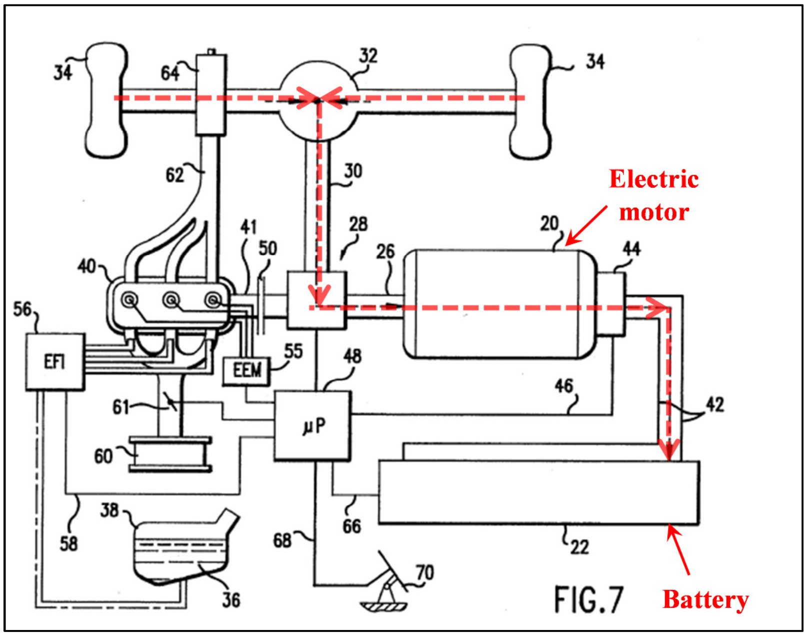
(Ex. 1003 at 10:26-43, emphasis added).

322. Severinsky ’970 also discloses “Element B” by using the kinetic energy of the vehicle during a “coasting mode.” Specifically Severinsky ’970

discloses that when the vehicle is on a "downhill stretch" the kinetic energy of the vehicle is fed back from the road wheels and the "motor 20" is operated as a generator to charge the batteries:

> FIG. 7 depicts operation of the system in a **regenerative braking or coasting mode**, wherein electrical energy is generated by motor 20, rectified in switching unit 44 and fed back to charge batteries 22, as indicated by the position of the arrow head on the dot-dash line connecting switching unit 44 to batteries 22. **Under the control of microprocessor 48, the** … **coasting mode can be entered** … indicated schematically at 70, … **on downhill stretches**. **In this mode the kinetic energy of the vehicle is fed back from road wheels 34** and differential 32 via drive shaft 30 to torque transfer unit 28 to electric motor 20; microprocessor 48 controls appropriate operation of switching unit 44 (see FIGS. 12 and 13) **to generate rectified DC for storage in battery 22 from AC provided by motor 20**.

(Ex. 1003 at 14:37-53, emphasis added).



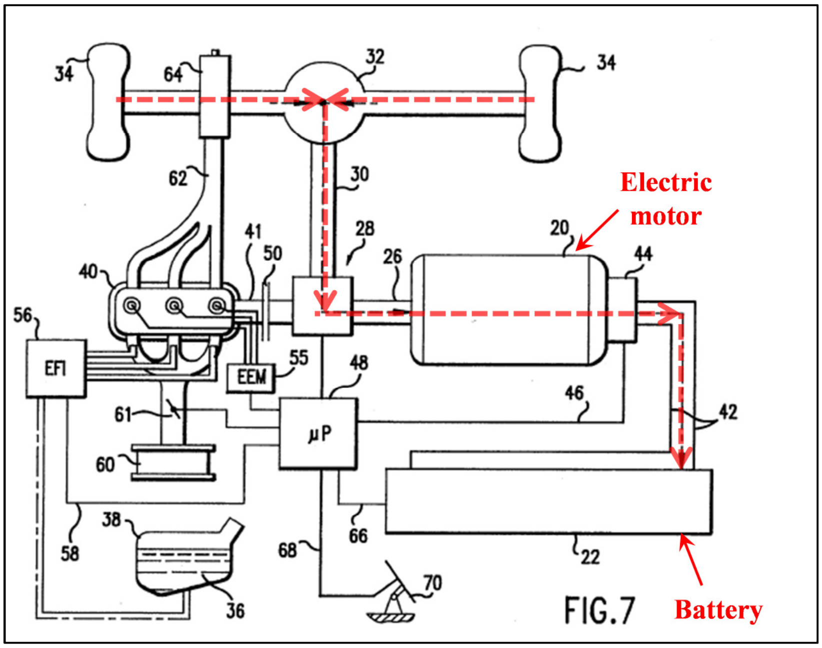
(Ex. 1003, Fig. 7, annotated)

323. It is my opinion that during such "downhill stretches" the "instantaneous torque required for propulsion of the vehicle" may become negative. My opinion is based on simple physics of the vehicle that would have been known prior to September 1998. Specifically, it would have been understood that when a vehicle transitions from either a level road or from a prior uphill descent, the "instantaneous torque required for propulsion of the vehicle" would suddenly drop and could become negative because the mass of the vehicle and gravity would begin to propel the vehicle downhill. Such a common known physics principle would be understood by a person whom has driven a vehicle on a hilly terrain and had to either lift their foot off the accelerator pedal or press down on the brake when travelling downhill.

324. With reference to Fig. 7, produced below, Severinsky '970 also discloses "Element C" during a "recharge mode" when braking is initiated by the operator:

> FIG. 7 depicts operation of the system in a regenerative braking or coasting mode, wherein electrical energy is generated by motor 20, rectified in switching unit 44 and fed back to charge batteries 22, as indicated by the position of the arrow head on the dot-dash line connecting switching unit 44 to batteries 22. Under the control of microprocessor 48, **the regenerative braking[] mode can be entered whenever the driver removes his foot from an accelerator pedal and depresses a brake pedal**, [] indicated schematically at 70… In this mode the kinetic energy of the vehicle is fed back from road wheels 34 and differential 32 via drive shaft 30 to torque transfer unit 28 to electric motor 20; microprocessor 48 controls appropriate operation of switching unit 44 (see FIGS. 12 and 13) to generate rectified DC for storage in battery 22 from AC provided by motor 20.

(Ex. 1003 at 14:37-53, emphasis added).



(Ex. 1003, Fig. 3, annotated)

325. Severinsky '970 further recognizes that the hybrid vehicle performs regenerative braking throughout the specification:

> The motor is operable as a generator to charge the batteries as needed and also for regenerative braking.

(Ex. 1003 at Abstract).

> The battery 22 is charged by power generated by the motor 20 when operated as a generator, that is, when driven by the engine 40 by way of the controllable torque transfer unit 28, or in a regenerative braking mode.

(Ex. 1003 at 9:67-10-4).

> The operator input devices 70 may include accelerator and brake pedals, directional control switches, and the like. Pressure on the

> accelerator pedal indicates to the microprocessor that more power is required; pressure on the brake causes the microprocessor to initiate regenerative braking, as discussed below.

(Ex. 1003 at 13:18-21).

326. Therefore, it is my opinion that Severinsky ’970 discloses all of the limitations of claim 36 including “*performing regenerative charging of the battery when the engine's instantaneous torque output is greater than the torque required to propel the vehicle, when torque required to propel the vehicle is negative, or when braking is initiated by the operator*.”

IX. GROUND 2 – CLAIMS 1, 6, 7, 9, 15, AND 21 ARE OBVIOUS OVER U.S. 5,343,970 IN VIEW OF GENERAL KNOWLEDGE AND FURTHER IN VIEW OF EHSANI

327. Severinsky ’970 discloses the hybrid vehicle architecture having an engine, motor, battery, controller and a control strategy for controlling the engine in an efficient range. It was general knowledge in September 1998 to add a second motor for starting the engine, as evidenced by Ehsani. It is my opinion that claims 1, 6, 7, 9, 15, and 21 of the ’347 Patent obvious based upon Severinsky ’970 in view of the general knowledge of a person of ordinary skill in the art and Ehsani.

A. Motivation to Combine

328. Severinsky ’970 discloses a single motor hybrid vehicle architecture that performs all of the recited functions of the ’347 Patent’s two-motor hybrid vehicle architecture. Severinsky ’970 simply does not disclose a separate “*first*

motor … operable to start the engine."

329. However, starter motors "*operable to start the engine"* were generally known to a person of ordinary skill in the art well before September 1998. Such starter motors would have operated to start the engine in response to a control signal.

330. For example, starter motors have been included on vehicles since 1912 when Charles Kettering patented a "self-starter" motor that was first incorporated in General Motor's 1912 Cadillac vehicles. Kettering's "self-starter" design eliminated the need for the driver to "crank" the engine. Further, an October 1996 4th edition of the Bosch Automotive Handbook confirms that electric starter motors were generally known for starting a vehicle. A person of ordinary skill in the art understands the Bosch Automotive Handbook is a common reference book in the automotive industry. (Ex. 1034 at 23).

331. Due to the long history of starter motors, starter motors are relatively inexpensive and a person of ordinary skill in the art would have known a starter motor could easily be incorporated to start any engine, including hybrid vehicle engines.

332. In fact, Severinsky '970 explains that the vehicle cost, weight and complexity of the "single-motor" hybrid vehicle architecture disclosed by Severinsky '970 was comparable to a conventional engine that included a starter

motor.

> The cost of the engine according to the invention is 30-50% that of a conventional engine. The cost of the clutch and torque transfer unit is no more than 33% of the cost of a conventional automatic transmission. No alternator or starter is required. The cost of the motor, the solid state switching unit, and the increased battery capacity is roughly equivalent to the cost of the components eliminated according to the invention. Weight and manufacturing complexity are likewise comparable.

(Ex. 1003 at 21:42-43).

333. It would have been generally known to a person of ordinary skill in the art that adding a starter motor to Severinsky '970 architecture would have provided advantages to the hybrid vehicle.

334. For example, having a small starter motor would have allowed the hybrid vehicle to be started even when the battery was low, or at low temperatures, because a small starter motor would require less current than the large traction motor, like the traction motor used in Severinsky '970. Also, using a starter motor would improve the noise, vibration and harshness (NVH) qualities of starting and engaging the engine into the driveline system.

335. Further, as also discussed in paragraphs 87-107 above, other "two-motor" hybrid vehicle architectures were also well-known to a person of ordinary skill in the art well prior to September 1998 where the "first motor" could be used

for starting the engine. One specific example of such a two-motor hybrid architecture is disclosed by Fig. 5 of Ehsani.

336. As disclosed by Ehsani, a person of ordinary skill in the art prior to September 1998 was aware of the advantages "two-motor" hybrid vehicle architectures over "one-motor" hybrid vehicle architectures.

337. For example, Ehsani discloses two advantages of a "two-motor" hybrid vehicle. The first advantage is the ability of charging the battery using the first motor while the engine is idling. The second advantage is starting the motor while the engine is disengaged from the driveshaft. As I stated above, starting the motor while disengaged will improve the NVH qualities of the vehicle.

> In operation of this embodiment, **generator 50 can be much smaller than electric motor 51** because it only provides steady state charging at a much lower level than the peaking power of electric motor 51. **This allows charging of battery 24 even during idling of engine 16**. **Furthermore, engine 16 can be started by generator 50, while it is disengaged from the drive shaft 21 by clutch 51**.

(Ex. 1004 at 8:28-34, emphasis added).

338. A person of ordinary skill in the art understood that using the first motor to charge the battery could be accomplished by decoupling the engine and first motor (i.e. generator 50) from the road wheels with the clutch during low load vehicle operation or low speed city driving.

339. With the engine disengaged from the wheels, the engine could still be run at a higher speed/load than what was demanded by the driver. By operating at a high speed/low, where the engine is more efficient, the engine could use the excess torque to drive the first motor (i.e. generator 50) to charge the battery. By keeping the battery charged, the vehicle is capable of being powered for greater distances using the second electric motor 51 which increases the efficiency and decreasing the emissions of the vehicle.

340. Again, a second benefit disclosed by Ehsani is that the first motor (i.e. generator 51) can be operated as a starter motor to start the engine while the engine is disengaged from the drive wheels.

> Furthermore, **engine 16 can be started by generator 50**, while it is disengaged from the drive shaft 21 by clutch 51.

(Ex. 1004 at 8:32-34, emphasis added).

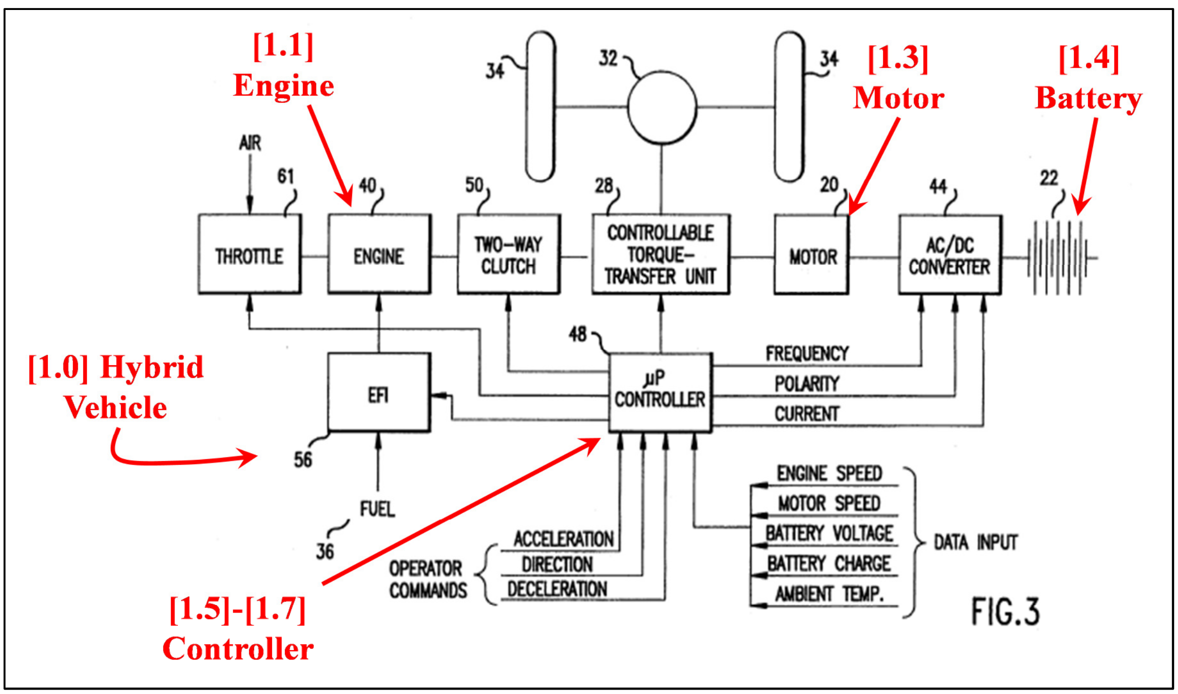
341. It was known that an engine could be started and brought up to vehicle speed before being re-engaged with the drive wheels. By starting the engine while it is disengaged from the wheels by the clutch, noise vibration and harshness (NVH) issues would be greatly minimized.

342. Therefore, it is my opinion that a person of ordinary skill in the art would therefore have been motivated to modify the "one-motor" hybrid vehicle of Severinsky '970 to include a second motor to achieve the additional efficiency,

emissions and quality benefits disclosed by Ehsani and as well as the generally known additional functional benefits of a starter motor with the known design tradeoff of the additional weight.

B. Claim 1

343. I understand that claim 1 is directed to a hybrid vehicle. I understand that claim 1 includes elements that recite the structure of the hybrid vehicle. It is my opinion that these structural elements are disclosed by Severinsky '970, as generally annotated in Fig. 3 of Severinsky '970, reproduced below.



(Ex. 1003, Fig. 3, annotated)

… *[1.0] A hybrid vehicle, comprising:*

344. The Severinsky '970 is titled "Hybrid Electric Vehicle" and

independent claim 1 of the Severinsky ‘970 claims “A hybrid vehicle.” (Ex. 1003 at claim 1, 21:68).

345. The ’347 Patent further admits that Severinsky ’970 disclosed a hybrid vehicle:

> For example, according to the operating scheme of **the hybrid vehicle disclosed in the ’970 patent**, in low-speed city driving, the electric motor provides all torque needed responsive to energy flowing from the battery. In high-speed highway driving, where the internal-combustion engine can be operated efficiently, it typically provides all torque; additional torque may be provided by the electric motor as 65 needed for acceleration, hill-climbing, or passing. The electric motor is also used to start the internal-combustion engine, and can be operated as a generator by appropriate connection of its windings by a solid-state, microprocessor-controlled inverter.

(Ex. 1001 at 10:57-11:2, emphasis added).

346. Based on the title and claims in Severinsky ’970, and admissions in the ’347 Patent, it is my opinion that Severinsky ’970 discloses “a hybrid vehicle”

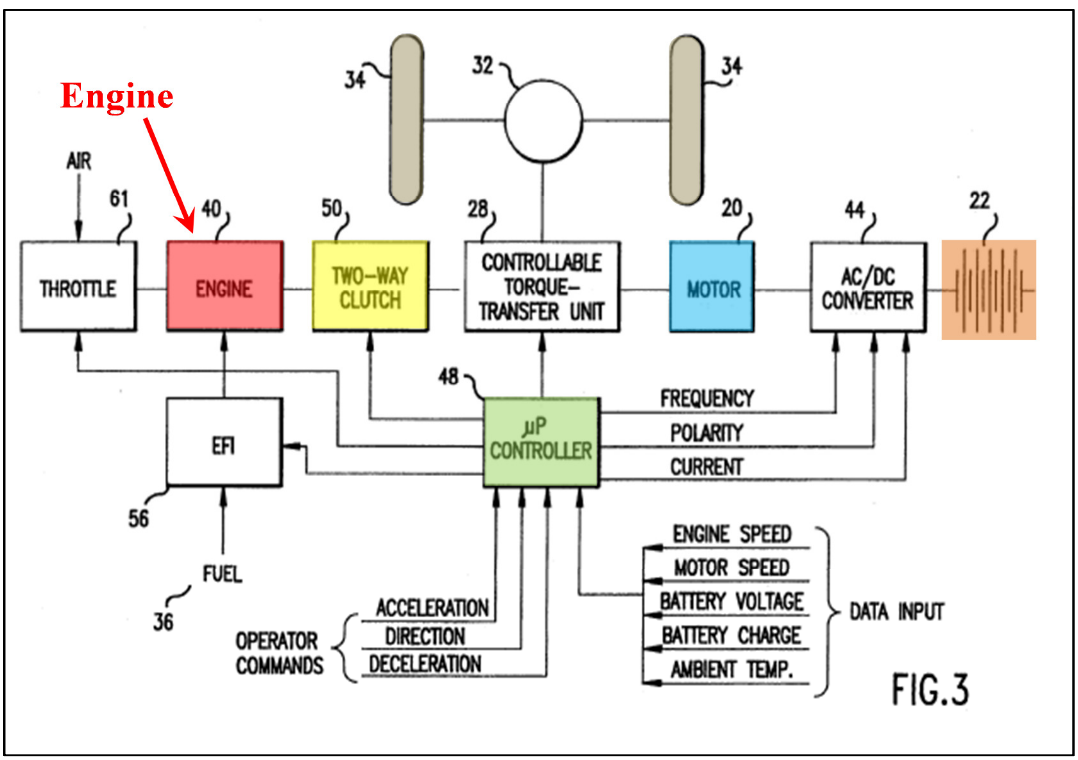
… ***[1.1] an internal combustion engine controllably coupled to road wheels of said vehicle;***

347. As discussed above in reference to claim 23 element [23.4], Severinsky ’970 discloses the engine is controllably connected to the road wheels by way of a clutch and a controllable torque transfer unit.

348. Fig. 8 of Severinsky ’970 illustrates and discloses a “motor 20,” connected to the “engine 40” via the “torque transfer unit 28.”

349. Fig. 3 of Severinsky ’970 also illustrates and discloses an “engine 40” that is connected to the “wheels 34” via the “clutch 50” and “controllable torque transfer unit 28.” Fig. 3 of Severinsky ’970, discloses that the engine is “*controllably coupled”* to apply propulsive torque to the wheels.

350. Fig. 3 also illustrates and discloses the “microprocessor/controller 48” connected to the “clutch 50” and “controllable torque transfer unit 28.” A person of ordinary skill in the art would understand that the “clutch 50” may be controllably engaged/disengaged by the “controller 48” to enable torque flow to the “wheels 34” from the engine through the “torque transfer unit 28.”



(Ex. 1003, Fig. 3, annotated)

351. In describing Fig. 3, the Severinsky ’970 specification states:

> FIG. 3 shows a block diagram of the drive system of the vehicle according to the invention. **Internal combustion engine 40 is connected by way of a two-way clutch 50 to a controllable torque transfer unit 28.** The torque transfer unit 28 receives torque from engine 40 and/or from alternating current electric motor 20 and transmits this torque to the drive wheels 34 of the vehicle by way of a conventional differential 32.

(Ex. 1003 at 9:58-65, emphasis added).

352. Severinsky ’970 describes operation of the two-way clutch to allow the engine to be coupled/decoupled for transmitting torque:

> The two-way clutch 50 shown in FIG. 10 receives torque from an engine flywheel 82 fixed to the engine output shaft 41, and includes a double-sided friction disk 84 splined onto an input shaft 86 of the controllable torque transfer unit 28. **A throwout mechanism 88 controlled by microprocessor 48 controls engagement of the friction disk 84 with either the flywheel 82 or a stationary plate 90 fixed with respect to the vehicle. Therefore, depending upon the position of the friction disk 84, torque may be transmitted from engine shaft 41 to input shaft 86, or input shaft 86 can be fixed with respect to the vehicle**, for reasons made clear below.

(Ex. 1003 at 15:20-32, emphasis added).

353. Severinsky ’970 describes operation of the controllable torque transfer

unit to which transmits torque to the wheels. For example, Severinsky '970 discloses that the controllable torque transfer unit then includes a pair of "locking devices 106" that are "*operated by microprocessor 48 so that microprocessor 48 can control the torque transfer unit 28 in accordance with the selected operational mode of the vehicle of the invention.*" (Ex. 1003 at 16:38-43, emphasis added)(*see also* 15:32 -17:10).

354. The '347 Patent and '095 Provisional further admits that Severinsky '970 discloses an engine connected to provide torque to the wheels as well as apply torque for battery recharging via the motor. The '347 Patent states:

> **As in the '970 patent, an internal combustion engine** is provided, sized **to provide sufficient torque to be adequate for the range of cruising speeds desired, and is used for battery charging as needed**.

(Ex. 1001 at 17:24-28, emphasis added)(*see also* Ex. 1036 at 4, lines 13-16).

355. Therefore, based on the specification and figures in Severinsky '970, and the admission in the '347 Patent and '095 Provisional, it is my opinion that Severinsky '970 discloses the "*an internal combustion engine [40] controllably coupled to road wheels [34] of said vehicle.*"

… ***[1.2] a first electric motor connected to said engine nd [sic] operable to start the engine responsive to a control signal;***

356. Claim 1 recites "*a first electric motor*" and a "*second electric motor.*"

Limitation [1.2] recites that the "*first electric motor*" is used to start the engine. As discussed in limitation [1.3] below, the "*second electric motor*" is recited as being operable to provide torque to the wheels and to operate as a generator to charge the battery. Severinsky '970 does not include the recited additional "*first electric motor*" that is used to start the engine. Instead, Severinsky '970 discloses a single motor hybrid vehicle architecture that performs all of the recited functions of the "*first electric motor*" and "*second electric motor*" recited by claim one of the '347 Patent. Severinsky '970 simply does not disclose a separate "*first motor … operable to start the engine*."

357. However, as I explained in the "Motivation to Combine" section above (paragraphs 328-342) it would have been obvious to modify Severinsky '970 to include a starter motor that is operable to start the engine. Indeed, starter motors "*operable to start the engine"* in response to a control signal were generally known to a person of ordinary skill in the art well before September 1998.

358. For example, starter motors have been included on vehicles since 1912 when Charles Kettering patented a "self-starter" motor that was first incorporated in General Motor's 1912 Cadillac vehicles. Kettering's "self-starter" design eliminated the need for the driver to "crank" the engine. A person of ordinary skill in the art understands the Bosch Automotive Handbook is a common

reference book in the automotive industry. The October 1996 4th edition of the Bosch Automotive Handbook identifies that electric starter motors were generally known for starting a vehicle. (Ex. 1031at 23). Due to the long history of starter motors, starter motors are relatively inexpensive and a person of ordinary skill in the art would have known a starter motor could easily be incorporated to start any engine, including hybrid vehicle engines.

359. Severinsky '970 even acknowledges that prior art "starter" motors existed for starting an engine, stating:

> As the road speed increases, the internal combustion engine is started, using torque provided by the electric motor through the torque transfer unit, such that no separate starter is required.

(Ex. 1003 at 6:36-39).

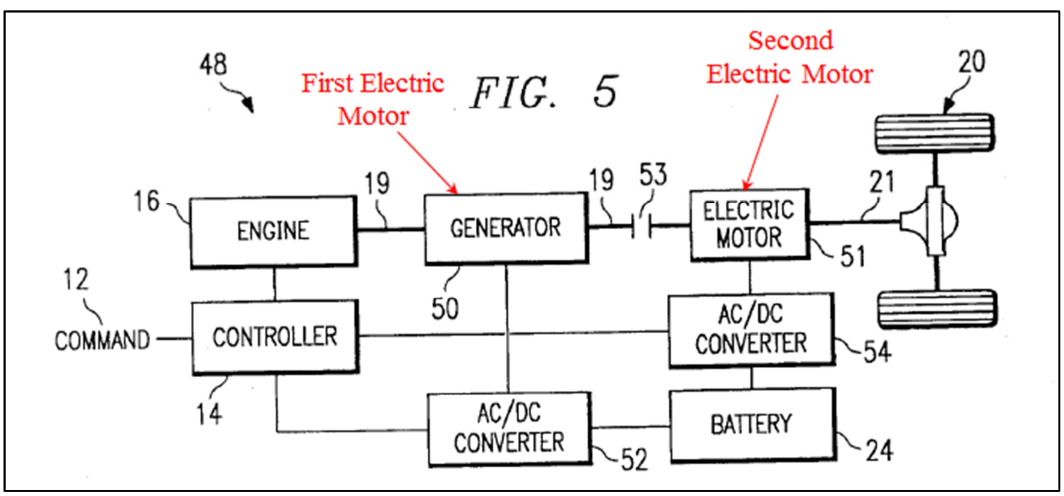
360. It would have been generally known to a person of ordinary skill in the art that adding a starter motor to Severinsky '970 architecture would have provided advantages to the hybrid vehicle. For example, having a small starter motor would have allowed the hybrid vehicle to be started even when the battery was low, or at low temperatures, because a small starter motor would require less current than the large traction motor, like the traction motor used in Severinsky '970. Also, using a starter motor would improve the noise, vibration and harshness (NVH) qualities of starting and engaging the engine into the driveline system.

361. It was also general knowledge that a starter motor was operable to

start the engine responsive to a control signal. For example, a person of ordinary skill in the art would understand that when a vehicle operator turns the ignition switch, the vehicle control provides a signal/current to turn the starter motor which turns the engine.

362. Further, as also discussed in paragraphs 87-107 above, other "two-motor" hybrid vehicle architectures were also well-known to a person of ordinary skill in the art well prior to September 1998 where the "*first electric motor*" could be used for starting the engine.

363. One specific example of such a two-motor hybrid architecture is disclosed by Fig. 5 of Ehsani. As disclosed by Ehsani, a person of ordinary skill in the art prior to September 1998 was aware of the advantages two-motor hybrid vehicle architectures over one-motor hybrid vehicle architectures.



(Ex. 1004, Fig. 5, annotated)

364. Based on Ehsani, a person of ordinary skill in the art would have understood a hybrid vehicle could include a "*first electric motor*" that is operable to include the "dual functionality to act as a motor and as a generator." (Ex. 1004 at 4:33-34). Ehsani further discloses that this "*first electric motor*" could operate as either a motor to start the engine or as a generator to charge the battery.

> In operation of this embodiment, **generator 50 can be much smaller than electric motor 51** because it only provides steady state charging at a much lower level than the peaking power of electric motor 51. **This allows charging of battery 24 even during idling of engine 16**. **Furthermore, engine 16 can be started by generator 50, while it is disengaged from the drive shaft 21 by clutch 51**.

(Ex. 1004 at 8:28-34, emphasis added).

365. Again, Ehsani discloses that the "*first electric motor*" (i.e. generator 51) can be operated as a starter motor to start the engine while the engine is disengaged from the drive wheels.

> Furthermore, engine 16 can be started by generator 50, while it is disengaged from the drive shaft 21 by clutch 51.

(Ex. 1004 at 8:32-34).

366. It was known that an engine could be started and brought up to vehicle speed before being re-engaged with the drive wheels. By starting the engine while it is disengaged from the wheels by the clutch, noise vibration and harshness (NVH) issues would be greatly minimized. The advantage of adding the

"*first electric motor*" disclosed by Ehsani would have provided these advantages.

367. Further, the "*first electric motor*" of Ehsani is also disclosed as being operable as a generator to charge the battery while the engine is disengaged from the drive wheels. Again, this provides an additional fuel economy benefit over the one-motor hybrid architecture of Severinsky '970.

368. One would have known and been motivated to modify Severinsky '970 to include these known benefits disclosed by Ehsani.

369. It was also well known to provide a control signal to start the engine.

370. For instance Ehsani illustrates a controller 14 in Fig. 5 that could be based on a driver input to start the vehicle or a vehicle input based on operation mode.

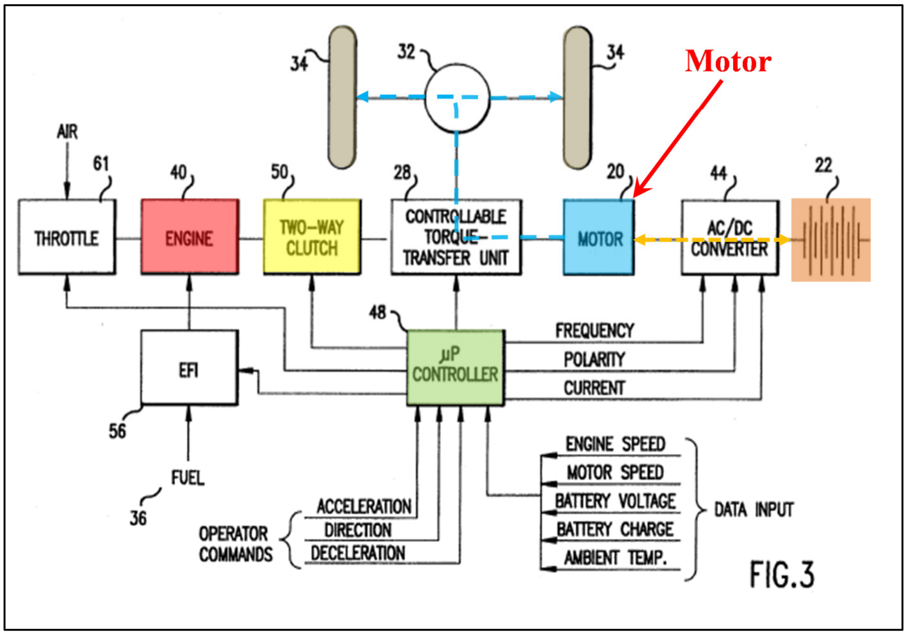
371. A person of ordinary skill in the art would also understand that based on Fig. 5 in Ehsani, that generator 50 is connected to the engine via the link 19 and could act as a starter motor to start the engine based on a control signal from the controller 14 when Ehsani states "**engine 16 can be started by generator 50**". (Ex. 1004 at 8:33-35, emphasis added).

372. Therefore, it is my opinion that a person of ordinary skill in the art would have been motivated to combine the known two-motor hybrid vehicle architecture disclosed by Ehsani to achieve "*a first electric motor connected to said engine nd [sic] operable to start the engine responsive to a control signal*."

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

373. As discussed above in reference to claim 23, limitation [23.3], Severinsky '970 discloses that the motor 20 (i.e., "*second electric motor*") is operable to provide torque to vehicle wheels, and is further operable to accept torque from the engine and provide power to recharge the battery.

374. Fig. 3 of Severinsky '970 illustrates and discloses a motor 20, as highlighted below in blue. Fig. 3 also illustrates the motor 20 connected to the wheels 34 (via the torque transfer unit 28). As also shown in Fig. 3, the motor 20 is also connected to the battery 22 (via the AC/DC converter 44). At the time of Severinsky '970, it was known that the motor would receive electric current from the battery, and vice versa, that the motor is capable of generating current to recharge the battery.



(Ex. 1003, Fig. 3, annotated)

375. The Abstract in Severinsky '970 simply that the "electric motor 20" is "operable as a generator to charge the batteries as needed and also for regenerative braking." (Ex. 1003 at Abstract; 9:65-10:14).

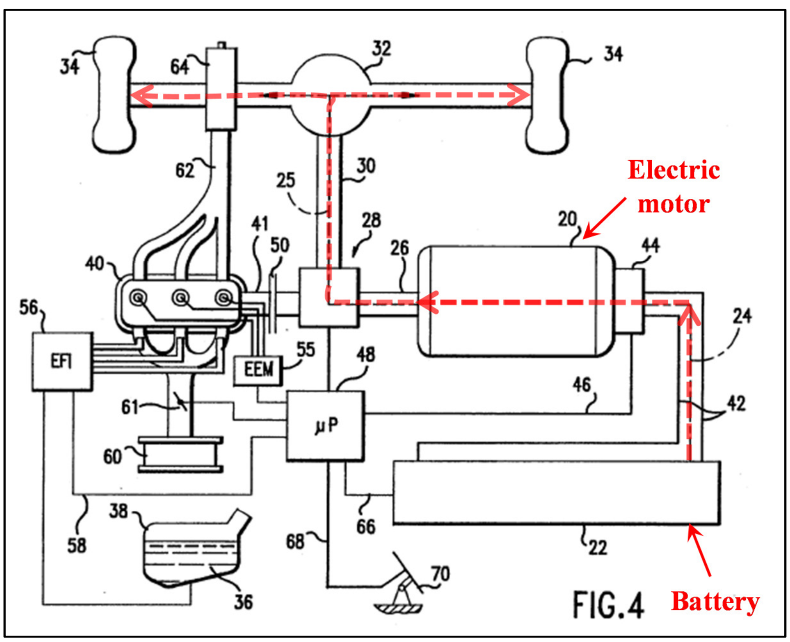
376. Severinsky '970 further describes the function of the motor 20 which can provide output torque and conversely generate current:

> **The motor 20 receives power from a bi-directional AC/DC power converter 44 comprising a solid-state switching network connected in turn to a battery 22. The battery 22 is charged by power generated by the motor 20 when operated as a generator, that is, when driven by the engine 40 by way of the controllable torque transfer unit 28, or in a regenerative braking mode.** A microprocessor controller 48 controls the rate of supply of fuel to engine 40 as indicated at 56, controls the opening of a throttle 61 by

which the engine 40 receives intake air from the atmosphere for combusting the fuel, controls the operation of the two-way clutch 50, controls the operation of the torque transfer unit 28, and controls bi-directional flow of power between the battery 22 and the motor 20 through frequency, current, and polarity signals passed to the bi-directional AC/DC power converter 44.

(Ex. 1003 at 9:65-10:14, emphasis added).

377. Fig. 4, reproduced below, illustrates that the electric motor provides all the torque to propel the vehicle. The dashed lines, as highlighted below, illustrate that the motor (20) is providing torque to vehicle wheels based on current supplied from the battery 22.



(Ex. 1003, Fig. 4, annotated)

378. In describing the operation of the motor in Fig. 4, Severinsky '970

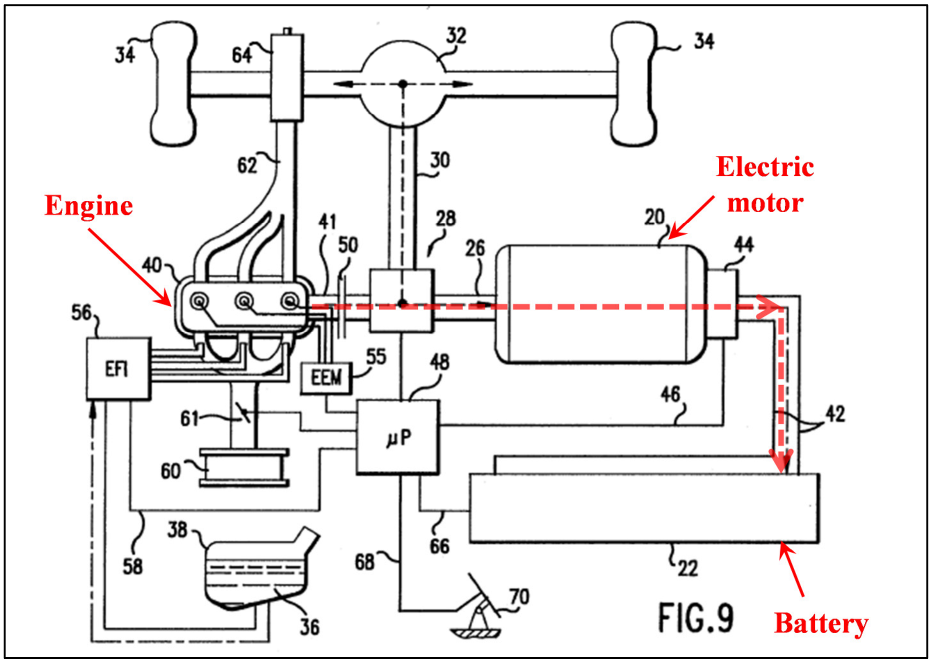
states:

> **<u>The electric motor 20 provides torque, shown as a dashed line 25, transmitted from the motor output shaft 26 through a torque transfer unit 28 and a drive shaft 30 to a conventional differential 32 and then to wheels 34 of the vehicle.</u>** Thus FIG. 4 indicates that the flow of energy in heavy traffic or for reversing is simply from battery 22 to electric motor 20; torque flows from the motor 20 to the wheels 34.

(Ex. 1003 at 10:58-67, emphasis added).

379. Based on this disclosure, Severinsky '970 illustrates and describes a motor being operable as a motor to apply torque to said wheels to propel the vehicle.

380. Fig. 9, reproduced below, illustrates battery charging mode in which the motor (20) is operated as a generator to charge the battery. The dashed lines, as emphasized below, illustrate that the motor is providing current to the battery (22) based on torque applied from the engine (40).



(Ex. 1003, Fig. 9, annotated)

381. In describing generating operation of the motor in Fig. 9, Severinsky '970 states:

> FIG. 9 illustrates system operation in the battery charging mode. Battery charging takes place automatically, under microprocessor control, responsive to monitoring the state of charge of battery 22 via control signal line 66. **<u>Internal combustion engine 40 charges battery 22 by rotating motor 20, providing AC rectified by switching unit 44 to DC suitable for charging battery 22</u>**. If this mode is entered during driving, internal combustion engine 40 also supplies torque to road wheels 34, as indicated by the dashed lines.

(Ex. 1003 at 15:1-10, emphasis added).

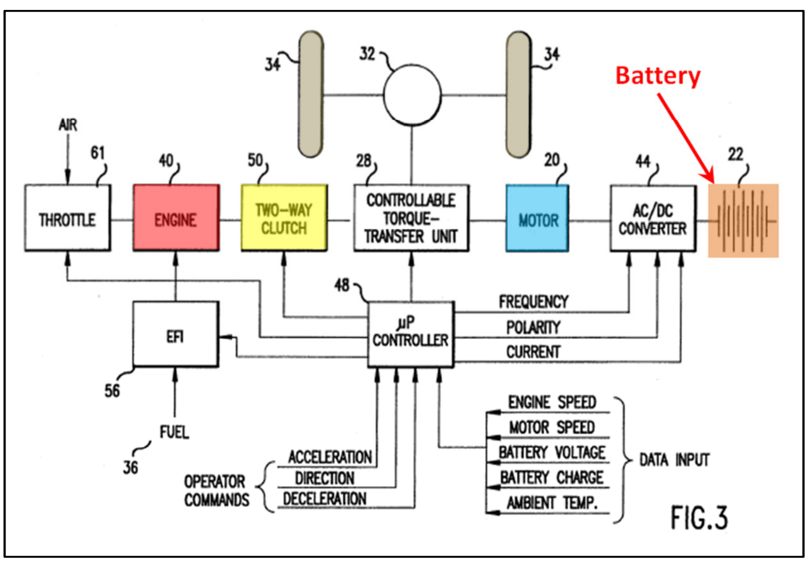
382. Based on this disclosure, Severinsky '970 illustrates and describes a

motor being operable as a generator, for accepting torque from wheels for generating current.

383. Therefore, it is my opinion that Severinsky '970 discloses "*a second electric motor connected to road wheels of said vehicle, and operable as a motor, to apply torque to said wheels to propel said vehicle, and as a generator, for accepting torque from at least said wheels for generating current*."

… ***[1.4] a battery, for providing current to said motors and accepting charging current from at least said second motor; and***

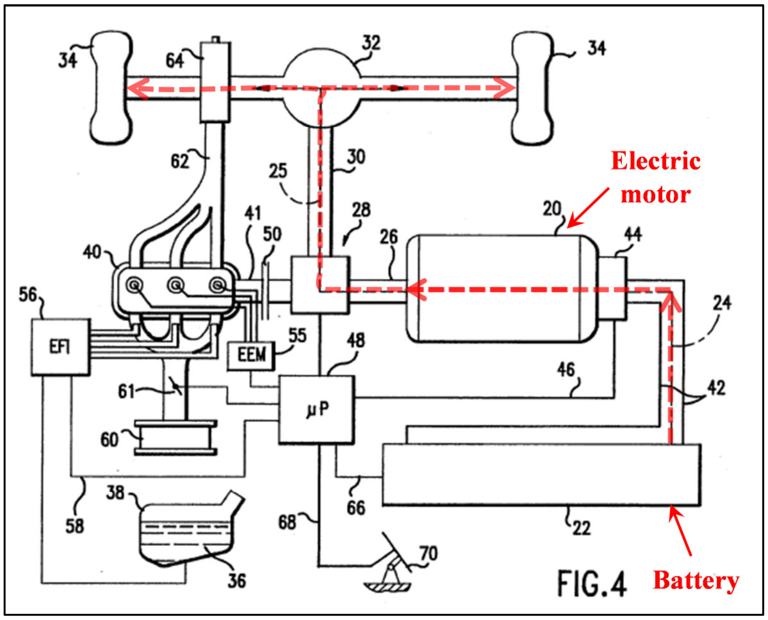
384. As discussed above in reference to claim 23, limitation [23.2], Fig. 3 of Severinsky '970 illustrates and discloses a "*battery*" shown as reference numeral 22, as annotated below and highlighted in orange.



(Ex. 1003, Fig. 3, annotated)

385. Fig. 4 illustrates below illustrates that the battery provides electric

current to the motor 20 when the motor is used to provide propulsive torque to the wheels.

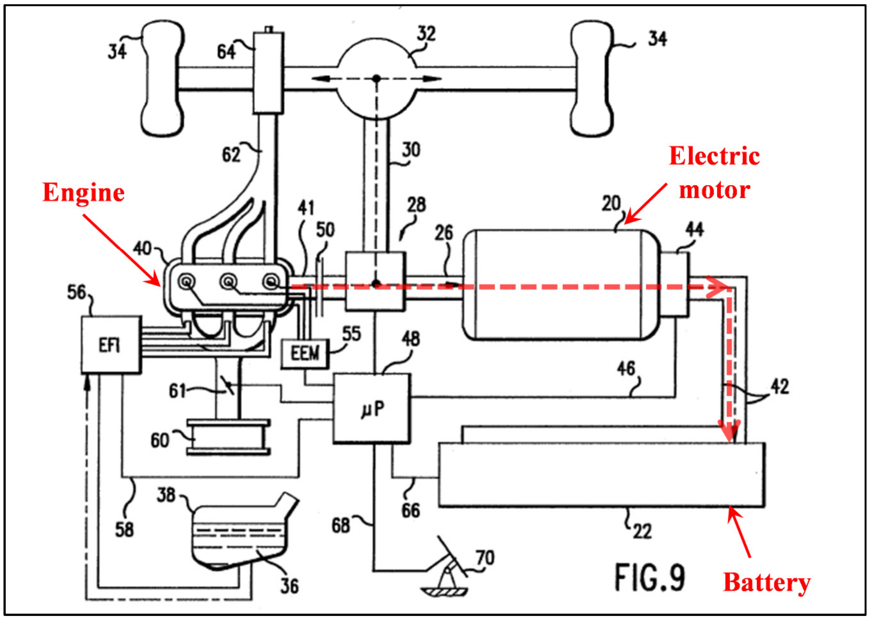


(Ex. 1003, Fig. 4, annotated)

386. Severinsky '970 further describes that the battery may also receive electrical current from the motor when operated as a generator.

> **The battery 22 is charged by power generated by the motor 20** when operated as a generator, that is, when driven by the engine 40 by way of the controllable torque transfer unit 28, or in a regenerative braking mode.

(Ex. 1003 at 9:65-10:14, emphasis added).

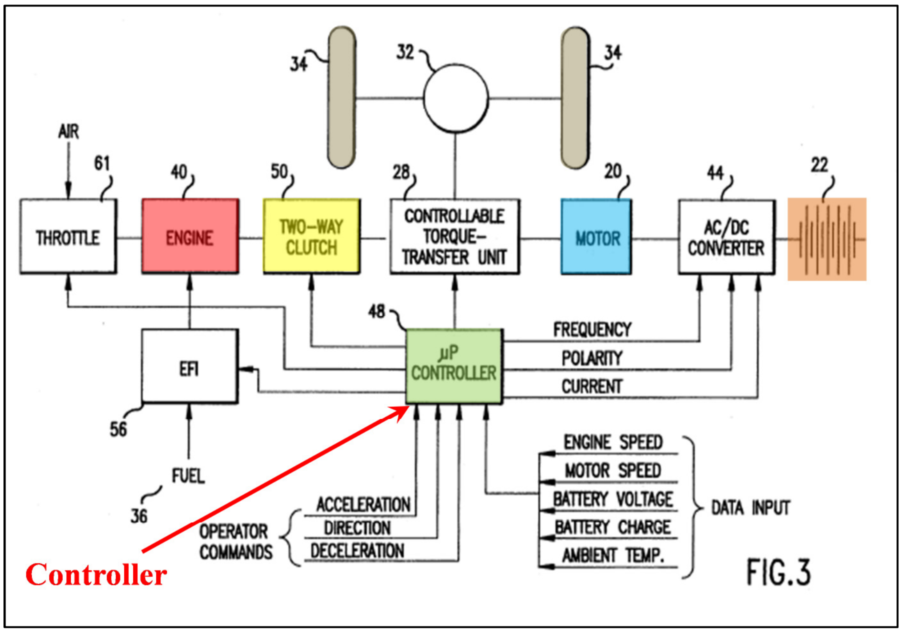


(Ex. 1003, Fig. 9, annotated)

387. As explained in limitation [1.2] above (¶¶ 356-372), Severinsky ’970 does not show both a “*first electric motor*” and a “*second electric motor*.” A person having ordinary skill in the art, however, would have known and been motivated to combine the one-motor hybrid vehicle architecture with the two-motor architecture of Ehsani to gain additional benefits beyond simply starting the engine. Once combined, such a skilled artisan would have further known that the battery would be able to provide current to the first motor (i.e., “generator 50”) of Ehsani when operated as a starter motor to start the engine. Therefore, it is my opinion that Severinsky ’970 discloses “a battery, for providing current to said motors and accepting charging current from at least said second motor.”

… *[1.5] a controller for controlling the flow of electrical and mechanical power between said engine, first and second motors, and wheels,*

388. Severinsky '970 illustrates and discloses a "*controller*" shown as reference numeral 48, as annotated below and highlighted in green.



(Ex. 1003, Fig. 3, annotated)

389. As schematically illustrated in Fig. 3, the controller (48) is connected with the throttle (61), electronic fuel injection (56), engine (40), clutch (50), controllable torque transfer unit (28). A person of ordinary skill in the art would understand that the controller is used to control the mechanical power produced or received by the engine and the motor.

390. Fig. 3 also schematically illustrates the electric connection of the

controller (48) to the AC/DC converter (44). The controller is therefore also used to control electric power that is provided from the motor and battery via the AC/DC converter.

391. In describing the controller illustrated in Fig. 3, Severinsky ’970 states:

> A microprocessor controller 48 controls the rate of supply of fuel to engine 40 as indicated at 56, controls the opening of a throttle 61 by which the engine 40 receives intake air from the atmosphere for combusting the fuel, controls the operation of the two-way clutch 50, controls the operation of the torque transfer unit 28, and **controls bi-directional flow of power between the battery 22 and the motor 20** through frequency, current, and polarity signals passed to the bi-directional AC/DC power converter 44.

(Ex. 1003 at 9:58-10:23, emphasis added).

> As will be detailed below, the microprocessor 48 controls the flow of torque between the motor 20, the engine 40, and the wheels 34 responsive to the mode of operation of the vehicle.

(Ex. 1003 at 10:26-30).

392. As discussed above, Severinsky ’970 does not show both a “*first electric motor*” and a “*second electric motor*.” It would have been obvious, however, that a controller could control the electrical and mechanical power produced and received from a “*first electric motor*,” similar to the “*first electric motor*” shown in Fig. 5 of Ehsani (and as I discussed above in limitation [1.5]).

393. Therefore, it is my opinion that Severinsky ’970 combined with general knowledge or Ehsani discloses “*a controller for controlling the flow of electrical and mechanical power between said engine, first and second motors, and wheels*.”

… ***[1.6] wherein said controller starts and operates said engine when torque require to be produced by said engine to propel the vehicle and/or to drive either one or both said electric motor(s) to charge said battery is at least equal to a setpoint (SP) above which said engine torque is efficiently produced, and***

394. It is my understanding that the term “setpoint (SP)” or the abbreviation “SP” as used in claim 1 is proposed to mean a “predetermined torque value.”

395. Further, it is my understanding that “A <u>and/or</u> B” in the claim is meant to be interpreted to mean “Element A,” “Element B” or “Element A and Element B.”

396. As this is applied to this limitation of claim 1, it is my understanding that limitation [1.6] of claim 1 includes the following elements:

Element A - controller starts and operates said engine when torque require to be produced by said engine <u>to propel the vehicle</u> is at least equal to a predetermined torque value above which said engine torque is efficiently produced. AND/OR

Element B - controller starts and operates said engine when torque require to be produced by said engine to <u>drive either one or both said electric motor(s) to charge said battery</u>, is at least equal to a predetermined torque value above which said engine torque is efficiently produced.

397. As explained above in limitation [1.2], Ehsani discloses that the generator 50 can start the engine. As discussed in the "Motivation to Combine" (¶¶ 328-342) above, a person having ordinary skill in the art would have been motivated to combine Severinsky '970 with Ehsani. Once combined, and as explained above in limitation [1.3] and [1.4], Ehsani discloses that the "generator 50" (i.e., "*first electric motor*") can be used to start the engine and driven to charge the battery.

398. As I previously discussed in limitation [23.1] (paragraphs 198-214) and [23.8] (paragraphs 276-283), Severinsky '970 discloses that the engine is operated only when it is efficient to do so. Severinsky '970 discloses efficient engine operation is based on both the "output power and speed" of the engine. Severinsky '970 discloses the efficient output power condition as being between 60-90% of the engine's maximum torque output. The 60% torque value is the

lower predetermined torque value (i.e., "*SP*"). Severinsky '970 also confirms that the engine is not operated above 90% of MTO let alone greater than the engine's Maximum Torque Output

> More particularly, according to the invention, the internal combustion engine is operated only under the most efficient conditions of **output power and speed**. When the engine can be used efficiently to drive the vehicle forward, e.g. in highway cruising, it is so employed. Under other circumstances, e.g. in traffic, the electric motor alone drives the vehicle forward and the internal combustion engine is used only to charge the batteries as needed.

(Ex. 1003 at 7:8-16, emphasis added).

> It will be appreciated that according to the invention the internal combustion **engine is run only in the near vicinity of its most efficient operational point, that is, such that it produces 60-90% of its maximum torque** whenever operated.

(Ex. 1003 at 20:63-67, emphasis added).

399. The lower end of the 60-90% range disclosed by Severinsky '970 would be considered a "predetermined torque value" or torque setpoint below which the engine is not operate. Therefore, 60% of MTO would be considered a lower level predetermined torque value (i.e., "*setpoint (SP)"*).

400. As discussed above in paragraphs 109-111, it is generally known in the state of the art that all engines have a "sweet spot" range, such as 60-90% of MTO, where torque is efficiently produced. It is also understood that this "sweet

spot" range will vary from engine to engine.

401. Further, as previously discussed in claim 23, Severinsky '970 discloses that the engine is activated to operate *only* at or near its maximum efficiency, at which point the engine torque output is well below the maximum torque output:

> According to the invention, these parameters are optimized so as to ensure that **the engine is operated at all times at its maximum point of efficiency**, and such that the driver need not consider the power source being employed at any given time.

(Ex. 1003 at 21:34-38, emphasis added).

402. Based on this disclosure in Severinsky '970 teaches only operating the engine at or near its maximum efficiency, which is above the lower predetermined torque value. Therefore, it is my opinion that Severinsky '970 discloses "Element A" such that the "controller starts and operates said engine when torque require to be produced by said engine to propel the vehicle is at least equal to a predetermined torque value above which said engine torque is efficiently produced."

403. As also discussed above in claim 23, limitation [23.4], Severinsky '970 also describes the that the engine can apply torque to the motor to charge the battery:

> **More specifically, on occasion it will be desired to charge the batteries while driving the vehicle forward, e.g. in slow traffic. In this mode, the engine output power is divided in order to propel the vehicle forward and to charge the batteries**. Locking devices 106 allow differential operation of the gears within the housing 92 and therefore allow the power output by the engine to be divided as determined to be appropriate by microprocessor 48. Furthermore, by controlling the duty cycle and frequency of operation of the switching elements of controller 44 (see FIGS. 12 and 13), the load provided by the motor to the engine can be controlled. **Thus, at all times the microprocessor 48 may determine the load (if any) to be provided to the engine by the motor, responsive to the load imposed by the vehicle's propulsion requirements, so that the engine 40 can be operated in its most fuel efficient operating range.**

(Ex. 1003 at 16:67-17:15, emphasis added).

404. Based on this disclosure in Severinsky ’970, a person of ordinary skill in the art would understand that the controller 48 controls the engine to operate in its efficient range to drive the motor and charge the battery.

405. Therefore, it is my opinion that Severinsky ’970 also discloses “Element B” where the “controller starts and operates said engine when torque require to be produced by said engine to drive either one or both said electric motor(s) to charge said battery, is at least equal to a predetermined torque value above which said engine torque is efficiently produced.”

406. Therefore, it is my opinion that Severinsky ’970 discloses both alternatives “A” and “B” where “*said controller starts and operates said engine when torque require to be produced by said engine to propel the vehicle* <u>*and/or*</u> *to drive either one or both said electric motor(s) to charge said battery is at least equal to a setpoint (SP) above which said engine torque is efficiently produced.*”

> … ***[1.7] 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.***

407. As discussed above in reference to limitation **[1.6]**, Severinsky ’970 discloses that the engine is operated only under conditions where the engine output torque is most efficient, i.e. in the range of <u>**60-90% of the engine’s maximum torque**</u>. A person of ordinary skill in the art would understand that the lower end of this range would be the lower predetermined torque value or setpoint.

408. As also discussed in claim 23 limitation [23.11], a person of ordinary skill in the art would understand that 60% of maximum torque is substantially less than the peak torque (i.e. MTO) of the engine.

409. Therefore, it is my opinion that Severinsky ’970 discloses “*the torque produced by said engine when operated at said setpoint (SP) is substantially less than the maximum torque output (MTO) of said engine.*”

C. Claim 6

410. Claim 6 depends from claim 1 which I understand means claim 6 requires all of the limitations of claim 1 as well as the limitation "wherein said setpoint SP is at least approximately 30% of the maximum torque output of the engine when normally-aspirated (MTO)."

411. I understand that claim 6 should be interpreted as "wherein said predetermined torque value is at least approximately 30% of the maximum torque output of the engine when normally-aspirated (MTO)."

412. I understand that Severinsky '970 discloses a normally-aspirated engine having a predetermined torque value in relation to the engine efficiency:

> It will be appreciated that according to the invention the internal combustion **engine is run only in the near vicinity of its most efficient operational point, that is, such that it produces 60-90% of its maximum torque** whenever operated.

(Ex. 1003 at 20:63-67, emphasis added).

413. A person of ordinary skill in the art would understand that the lower end of the 60-90% range disclosed by Severinsky '970 would be considered a "predetermined torque value" or torque setpoint below which the engine is not operate. Therefore, a person of ordinary skill in the art would understand the 60% of MTO would be considered a lower level predetermined torque value.

414. A person of ordinary skill in the art would understand that 60% is "at

least 30%."

415. Therefore, it is my opinion that Severinsky '970 discloses "*wherein said setpoint SP is at least approximately 30% of the maximum torque output of the engine when normally-aspirated (MTO*)."

D. Claim 7

416. Claim 7 depends from claim 1 which I understand means claim 7 requires all of the limitations of claim 1 in addition to the additional limitations required by limitation [7.0] – [7.3], below.

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

417. It is my understanding that the term "setpoint SP" is proposed to mean a "predetermined torque value."

418. I understand that the term "road load (RL)" as used in the '347 Patent, is proposed to mean "the instantaneous torque required for propulsion of the vehicle, which may be positive or negative in value."

419. It is my understanding that claim element [7.0] should be interpreted as "*wherein said vehicle is operated in a plurality of operating modes responsive*

to the value for the instantaneous torque required for propulsion of the vehicle, which may be both positive and negative in value, and said predetermined torque value, both expressed as percentages of the maximum torque output of the engine when normally-aspirated (MTO)."

420. As discussed previously (*see* ¶ 398), Severinsky '970 discloses only operating the normally-aspirated engine in the maximum efficient range of 60-90% of MOT. A person of ordinary skill in the art would understand that the lower end of the 60-90% range disclosed by Severinsky '970 would be considered a "predetermined torque value" or torque setpoint below which the engine is not operate. (*See* Ex. 1003 at 20:63-67 and 21:34-38).

421. Therefore, the "predetermined torque value" or "setpoint" is expressed as a percentage of the maximum torque output of the engine by Severinsky '970.

422. As I discussed in claim [23.5] (paragraphs 241-255) above, Severinsky '970 also discloses determining the "*instantaneous torque required for propulsion of the vehicle*." Severinsky '970 also discloses operating the vehicle in response to the torque required for propulsion of the vehicle based on driver input, stating:

> **A microprocessor receives control inputs from the driver** of the vehicle and monitors the performance of the electric motor and the internal combustion engine, the state of charge of the battery, and

> other significant variables. **<u>The microprocessor determines whether the internal combustion engine or the electric motor or both should provide torque to the wheels under various monitored operating conditions.</u>**

(Ex. 1003 at 6:19-26, emphasis added).

423. Severinsky '970 also discloses that the "instantaneous torque required for propulsion of the vehicle" can be positive or negative. For example, Severinsky '970 discloses the torque required for propulsion of the vehicle may be positive based on an operator command for acceleration:

> Thus FIG. 4 indicates that the flow of energy in heavy traffic or for reversing is simply from battery 22 to electric motor 20; torque flows from the motor 20 to the wheels 34. Under these circumstances, electric motor 20 provides **<u>all of the torque needed to move the vehicle.</u>** Other combinations of torque and energy flow required under other circumstances are detailed below in connection with FIGS. 5-9. **<u>For example, if the operator continues to command acceleration, an acceleration/hill climbing mode illustrated in FIG. 6 may be entered, followed by a highway cruising mode illustrated in FIG. 5</u>**.

(Ex. 1003 at 10:52-11:6, emphasis added).

424. Based on the disclosure above Severinsky '970 recognizes both uphill and downhill driving conditions. When the vehicle is going **down a hill the torque required for propulsion of the vehicle could be <u>negative</u>** (i.e., traveling down a

steep hill). As anyone who has ever driven a vehicle would have experienced, when the vehicle descends down a hill, if the driver does nothing, the weight of the vehicle will cause the vehicle to accelerate due to gravity. This is a commonly known and experienced phenomenon. Therefore, the torque required for propulsion of the vehicle may decrease or possibly become negative when the vehicle. Therefore, the driver needs to press the brake pedal to keep from accelerating.

425. Conversely, when the vehicle is going **up the hill, or when the driver requests the vehicle accelerate,** it is understood that **the torque required for propulsion of the vehicle may be <u>positive</u>**. Again, as anyone who has ever driven a vehicle would have experienced, when the vehicle ascends the hill, if the driver does nothing, the weight of the vehicle will cause the vehicle to decelerate due to gravity. This is a commonly known and experienced phenomenon. Therefore, the torque required for propulsion of the vehicle is positive when the vehicle is traveling up a hill. Therefore, the driver needs to press the accelerator pedal to either maintain the same speed or to accelerate up the hill. Likewise, anyone who has ever wanted to pass a vehicle understands that in order for the vehicle to accelerate, the driver must further press the accelerator pedal to accelerate past the other vehicle. Such acceleration also requires positive torque to propel the vehicle.

426. Severinsky ’970 further discloses that the operator may account for

external forces that act on the vehicle, such as wind resistance and hill gradients, and then provide a change in command in response to changing conditions:

> As the desired cruising speed may vary somewhat, and as **the engine output power required to attain and maintain a given road speed will vary with prevailing wind conditions, road grading and the like, the output torque of internal combustion engine 40 may be directly variable responsive to the operator's control inputs**. Microprocessor 48 monitors the operator's inputs and the vehicle's performance, and activates electric motor 20 when torque in excess of the capabilities of engine 40 is required. Conversely, if excess engine torque is available (see the discussion of FIG. 7 below) it can be transformed into electrical energy in motor 20 and stored by battery 22.

(Ex. 1003 at 13:65-14:21, emphasis added).

427. As I discussed above in paragraphs 113-115, the **textbook definition of "road load"** is the sum of the external forces that act on the vehicle. It is understood that the sum of the external forces, may include the "wind and road grading" disclosed by Severinsky'970. Such external forces are a known physical occurrence to anyone who has driven a vehicle. For instance, when the vehicle is driving on a windy day, the driver may press the accelerator pedal requesting additional torque**.**

428. Claim 7 recites that the "*instantaneous torque required to propel the vehicle*" is expressed as a "*percentage of the maximum torque output of the engine*

when normally aspirated." It would have been obvious to express the "*instantaneous torque required to propel the vehicle*" disclosed by Severinsky '970 as a percentage "*percentage of the maximum torque output of the engine when normally aspirated*." Such a conversion would have been nothing more than a simple mathematical ratio based on the "*maximum torque output of the engine when normally aspirated.*" Indeed, Severinsky '970 identifies the maximum torque output of the engine when it is normally aspirated. Severinsky '970 further discloses that an upper bound is defined as 90% of the engine's MTO when normally aspirated. Clearly, MTO of the engine when normally aspirated was known and disclosed by the Severinsky '970. Therefore, this mathematical ratio based on the "*maximum torque output of the engine when normally aspirated*" was obvious based on the data provided within Severinsky '970 itself.

429. The '347 Patent and the '095 Provisional, to which the '347 Patent claims priority, admit that Severinsky '970 also disclosed determining the operation state of the vehicle based on the torque requirements to propel the hybrid vehicle, whether positive or negative:

> In each of these aspects of the operation of the vehicle, and **as in [Severinsky '970], the operator of the vehicle need not consider the hybrid nature of the vehicle during its operation, but simply provides control inputs by operation of the <u>accelerator and brake pedals</u>**. The microprocessor determines the proper state of operation

> of the vehicle based on these and other inputs and controls the various components of the hybrid drive train accordingly.

(Ex. 1036 at 5, lines 29-35, emphasis added)(Ex. 1001 at 18:38-45, emphasis added).

430. The '347 Patent further admits that Severinsky '970 discloses the same torque-based control strategy where the setpoint and torque required for propulsion of the vehicle are expressed as percentages:

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

(Ex. 1003 at 24:64-25:17, emphasis added).

431. Therefore, based on Severinsky '970 and the admission in the '347 patent, it is my opinion that Severinsky '970 discloses "*said vehicle is operated in a plurality of operating modes responsive to the value for the road load (RL) and*

said setpoint SP, both expressed as percentages of the maximum torque output of the engine when normally-aspirated (MTO)."

… ***[7.1] 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,***

432. It is my understanding that the term "setpoint SP" is proposed to mean a "predetermined torque value."

433. It is my understanding that the term "road load," or "RL," is proposed to mean "the instantaneous torque required for propulsion of the vehicle, which may be positive or negative in value."

434. It is my understanding that "*low-load mode I*" is proposed as meaning "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."

435. Based on the interpretations of "RL" and "SP," it is my understanding that this claim limitation should be interpreted 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, wherein said vehicle is propelled by torque provided by said second electric motor in response to energy supplied from said battery, while the instantaneous torque required for propulsion of the vehicle, which may be both positive and negative in value, is less than the*

predetermined torque value."

436. First, as I discuss in limitation [23.7] (paragraphs 258-275) above, Severinsky '970 discloses this operational mode. Specifically, Severinsky '970 discloses and claims a "low speed running mode of operation, [where] said flow paths are controlled such that electrical energy flows from said battery to said electric motor, and torque flows from said electric motor to said torque transfer unit and thence to said drive wheels." (Ex. 1003 at Claim 16; See also 20:63-66; claims 3 & 32). Severinsky '970 also discloses an "acceleration or hill climbing" mode of operation where the "flow paths are controlled such that electrical energy flows from said battery to said electric motor, fuel flows from a supply thereof to said engine and torque flows from said electric motor and said engine to said torque transfer unit and thence to said wheels." (Ex. 1003 at Claim 18, Abstract, 14:22-36).

437. Severinsky '970 discloses that the engine is operated in its most efficient conditions of output power and speed. When the output power and speed are below the engine's most efficient operating condition, the motor is disclosed as being used to propel the vehicle.

> More particularly, according to the invention, the internal combustion **engine is operated only under the most efficient conditions of output power and speed**. When the engine can be used efficiently to drive the vehicle forward, e.g. in highway cruising, it is so employed.

> **Under other circumstances, e.g. in traffic, the electric motor alone drives the vehicle forward** and the internal combustion engine is used only to charge the batteries as needed.

(Ex. 1003 at 7:8-16, emphasis added)

> It will be appreciated that according to the invention the internal combustion **engine is run only in the near vicinity of its most efficient operational point, that is, such that it produces 60-90% of its maximum torque** whenever operated.

(Ex. 1003 at 20:63-67).

438. As discussed above in [23.1], Severinsky '970 discloses the efficient output power condition as being between 60-90% of the engine's maximum torque output. The 60% torque value is the lower predetermined torque value (i.e., "SP").

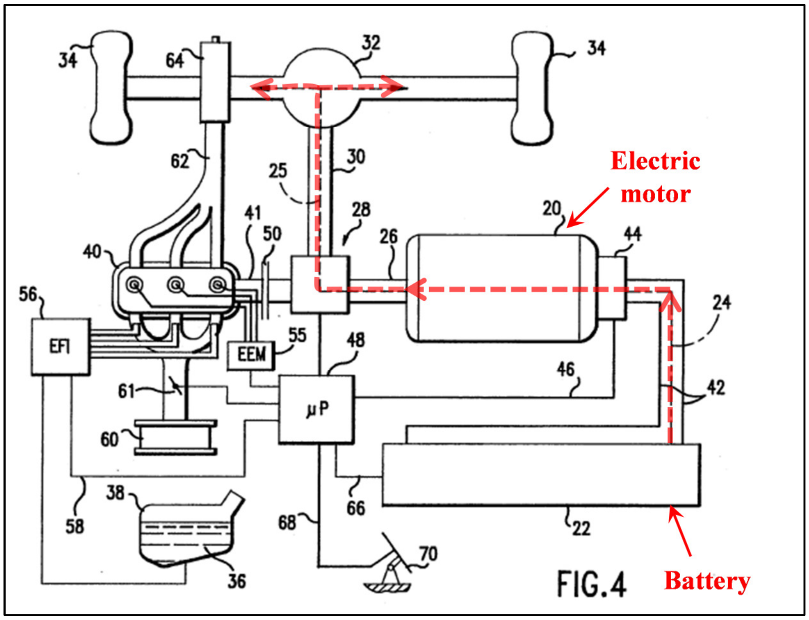
439. Severinsky '970 thus also discloses operating the motor when the engine operation is inefficient operating range.

> **The electric motor**, which is substantially equally efficient at all operating speeds, **is used to supply additional power as needed for acceleration and hill climbing**, and is used to supply all power at low speeds, **where the internal combustion engine is particularly inefficient**, e.g., in traffic.

(Ex. 1003 at 9:52-57, emphasis added).

440. It is my opinion that the Severinsky '970 discloses a motor operation mode that is based on both the vehicle's speed and torque requirements. In fact, my opinion is further confirmed by Fig. 4 which illustrates motor only mode where the

motor supplies all of the torque required for propulsion of the vehicle.



(Ex. 1003, Fig. 4, annotated)

441. In describing Fig. 4, Severinsky '970 discloses:

FIG. 4 illustrates operation in <u>**low speed circumstances**, e.g., in city traffic or reversing</u>. As noted, the parallel hybrid vehicle drive system according to the present invention includes an electric motor 20 powered by energy stored in a relatively large, high voltage battery pack 22. Energy flows from battery 22 to motor 20 as indicated by a dot-dash line shown at 24. The electric motor 20 provides torque, shown as a dashed line 25, transmitted from the motor output shaft 26 through a torque transfer unit 28 and a drive shaft 30 to a conventional differential 32 and then to wheels 34 of the vehicle. Thus FIG. 4 indicates that the flow of energy in heavy traffic or for reversing is simply from battery 22 to electric motor 20; torque flows from the motor 20 to the wheels 34. <u>**Under these circumstances, electric**</u>

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

(Ex. 1003 at 10:52-53, emphasis added).

442. As emphasized above, at low vehicle speeds, generally coincides with a low vehicle load. However, if the operator demands acceleration or the vehicle begins to climb a hill, the torque required for propulsion of the vehicle **at low speeds** increases and the mode of operation is changed to one where both engine and motor are used to propel the vehicle (as shown in Fig. 6 of Severinsky '970) instead of motor only operation in Fig. 4 above. This example confirms that Severinsky '970 evaluates both speed and power (i.e., torque) requirements of the vehicle when determining the proper operational mode. Therefore, Severinsky '970 discloses that using the electric motor to propel the vehicle when the torque required for propulsion of the vehicle is less than the lower predetermined torque value of the engine's efficient range.

443. Severinsky '970 also claims a "low speed mode" where the electric motor propels the vehicle, in claim 3.

> 3. The vehicle of claim 2, wherein said modes include at least:

> a low speed/reversing mode, wherein all energy is supplied by said battery and all torque by said electric motor;

(Ex. 1003 at 22:42-44).

444. Even though the ’347 Patent claims “low-*load* mode I”, in the specification, this mode is actually described as low *speed* operation of the ’347 Patent:

> As noted, **<u>during low-speed operation</u>**, such as in city traffic, the vehicle is operated as a simple electric car, where all torque is provided to road wheels 34 by traction motor 25 operating on electrical energy supplied from battery bank 22. **<u>This is referred to as "mode I" operation</u>** (see FIG. 6), and is illustrated in FIG. 8(a).

(Ex. 1003 at 35:66-36:4, emphasis added).

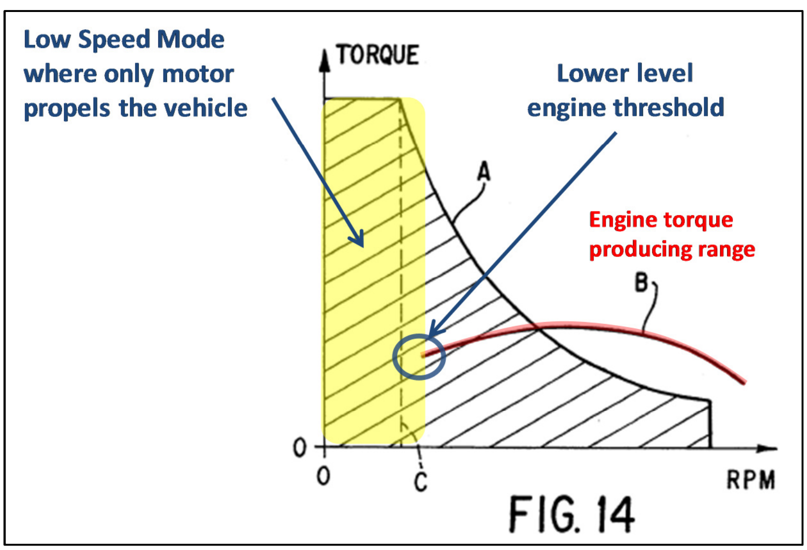
445. The ’347 Patent also admits that Severinsky ’970 disclosed different operational modes based on load.

> **<u>[A]s in the case of the hybrid vehicle system shown in the ’970 patent,</u>** and as discussed in further detail below, the vehicle of the invention is operated **<u>in different modes depending on the torque required</u>**, the state of charge of the batteries, and other variables. **Throughout, the object is to operate the internal combustion engine only under circumstances providing a significant load**, thus ensuring efficient operation.

(Ex. 1003 at 35:7-14, emphasis added).

446. Again, Severinsky ’970 discloses that the engine operates efficiently

within specified conditions of "output power **and** speed." As shown below, Fig. 14 Severinsky '970 illustrates the engine's maximum torque output curve ("B") in relation to vehicle speed. Curve B does not extend all the way to zero RPM, because, Severinsky '970 states that "no transmission" is employed. (Ex. 1003 at Abstract). Without a multi-speed transmission, the engine is incapable of producing torque at these lower vehicle speeds. As I have explained in paragraph 112 above, it was known that engines are typically inoperable below certain speed ranges. Conventional vehicles can overcome this known deficiency by employing a multi-speed transmission. Hybrid vehicles can likewise overcome this deficiency by employing a transmission. Alternatively, a hybrid vehicle can overcome this deficiency by operating the traction motor alone at these lower vehicle speeds.



(Ex. 1003, Fig. 14, annotated)

447. Fig. 14 of Severinsky '970, as annotated and reproduced above,

discloses that the motor is operated below a Point C when torque output of the motor is constant and the vehicle speed is low. Point C also corresponds with the lower end of Curve B which is the speed range where the engine efficiently produces torque.

448. Therefore, it is my opinion that Severinsky '970 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*."

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

449. It is my understanding that the term "setpoint SP" is proposed to mean a "predetermined torque value."

450. It is also my understanding that the term "road load," or "RL" is proposed to mean "the instantaneous torque required for propulsion of the vehicle, which may be positive or negative in value."

451. It is also my understanding that the term "*highway cruising mode IV*" 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."

452. Based on the interpretations of "RL" and "SP," it is my understanding

that this claim limitation should be interpreted 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, wherein said vehicle is propelled by torque provided by said internal combustion engine, while the predetermined torque value is less than the instantaneous torque required for propulsion of the vehicle, which may be both positive and negative in value, and the instantaneous torque required for propulsion of the vehicle, which may be both positive and negative in value, is less than the maximum torque output of the engine*."

453. First, Severinsky '970 discloses a "highway cruising mode" where the "flow paths are controlled such that fuel flows from a supply thereof to said engine and torque supplied by said engine is transferred to said torque transfer unit and thence to said drive wheels." (Ex. 1003 at Claim 16, Abstract, 13:66-14:3). Severinsky '970 also discloses a "highway cruising mode" where the "flow paths are controlled such that fuel flows from a supply thereof to said engine and torque supplied by said engine is transferred to said torque transfer unit and thence to said drive wheels." (Ex. 1003 at Claim 16, Abstract, 13:66-14:3). Likewise, it is my understanding that the '347 Patent discloses that the "highway cruising mode is referred to as "mode IV" operation." (Ex. 1001 at 36:23:39).

454. Severinsky '970 discloses that the engine is operated in its most efficient conditions of output power and speed. When the output power and speed

are below the engine's most efficient operating condition, the motor is disclosed as being used to propel the vehicle.

> More particularly, according to the invention, the internal combustion **engine is operated only under the most efficient conditions of output power and speed**. When the engine can be used efficiently to drive the vehicle forward, e.g. in highway cruising, it is so employed. **Under other circumstances, e.g. in traffic, the electric motor alone drives the vehicle forward** and the internal combustion engine is used only to charge the batteries as needed.

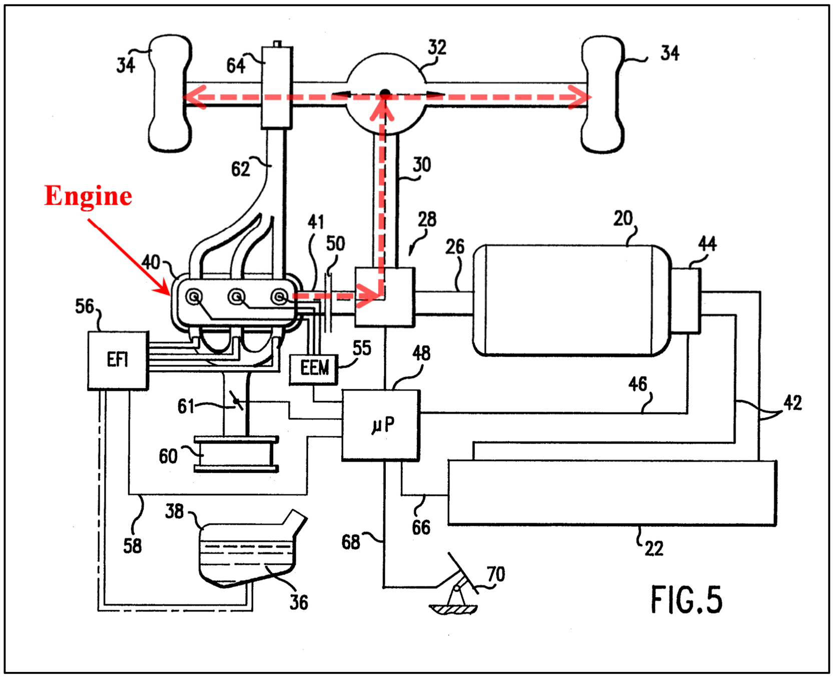
(Ex. 1003 at 7:8-16, emphasis added).

> It will be appreciated that according to the invention the internal combustion **engine is run only in the near vicinity of its most efficient operational point, that is, such that it produces 60-90% of its maximum torque** whenever operated.

(Ex. 1003 at 20:63-67, emphasis added).

455. As discussed above in [23.1], Severinsky '970 discloses the efficient output power condition as being between 60-90% of the engine's maximum torque output. The 60% torque value is the lower predetermined torque value (i.e., "*SP*").

456. More specifically, Severinsky '970 illustrates and discloses using the motor in a "highway cruising mode" in Fig. 5, as annotated below, where torque from the engine propels the vehicle. The dashed lines show the flow of torque from the engine to the wheels.



(Ex. 1003, Fig. 5, annotated)

457. In describing Fig. 5, Severinsky '970 discloses:

> FIG. 5 depicts operation of the system in a **highway cruising mode** wherein, as indicated above, **all torque required to drive the vehicle at normal highway speeds (e.g. above about 45 mph) is provided by the internal combustion engine 40** supplied with combustible fuel 36 via EFI unit 56. Thus, energy flow as indicated by the dot-dash line is from the tank 38 through EFI unit 56 into engine 40, while torque flows from engine 40 through torque transfer unit 28, to axle differential 32 and thence to road wheels 34.

(Ex. 1003 at 13:66-17:7, emphasis added).

458. Severinsky '970 also describes that the engine only provides torque that is less than the MTO.

> It will be appreciated that according to the invention the internal combustion **engine is run only in the near vicinity of its most efficient operational point, that is, such that it produces 60-90% of its maximum torque** whenever operated.

(Ex. 1003 at 20:63-67, emphasis added).

459. Since Severinsky ’970 discloses that the engine is only run at the most efficient range, it is my opinion that Severinsky ’970 operates the engine when the torque required for propulsion of the vehicle is greater than the predetermined torque value (i.e. 60%) and less than MTO (i.e. 90%).

460. Severinsky ’970 also claims a “high speed/cruising mode” where the electric motor propels the vehicle, in claim 3:

> 3. The vehicle of claim 2, wherein said modes include at least: ...
>
> a high speed/cruising mode, wherein all energy is supplied by combustible fuel and all torque by said engine;

(Ex. 1003 at 22:40-47).

461. A person of ordinary skill in the art would understand that “high speed/cruising mode” would be the same as “highway cruising mode” disclosed within the specification of the ’347 Patent.

462. Therefore, it is my opinion that Severinsky ’970 discloses “*a highway cruising mode IV, wherein said vehicle is propelled by torque provided by said internal combustion engine, while SP<RL<MTO*.”

… ***[7.3] 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.***

463. It is my understanding that the term "setpoint SP" is proposed to mean a "predetermined torque value."

464. It is also my understanding that the term "road load," or "RL" is proposed to mean "the instantaneous torque required for propulsion of the vehicle, which may be positive or negative in value."

465. It is also my understanding that the term "acceleration mode V" 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."

466. It is my understanding that this claim limitation should therefore be interpreted 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, 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 the torque required for propulsion of the vehicle,*

which may be positive or negative in value, is greater than the maximum torque output of the engine."

467. First, Severinsky '970 discloses an "acceleration or hill climbing" mode of operation where the "flow paths are controlled such that electrical energy flows from said battery to said electric motor, fuel flows from a supply thereof to said engine and torque flows from said electric motor and said engine to said torque transfer unit and thence to said wheels." (Ex. 1003 at Claim 18, Abstract, 14:22-36).

468. Severinsky '970 discloses that the engine is operated in its most efficient conditions of output power and speed. When the output power and speed are below the engine's most efficient operating condition, the motor is disclosed as being used to propel the vehicle.

> More particularly, according to the invention, the internal combustion **engine is operated only under the most efficient conditions of output power and speed**. When the engine can be used efficiently to drive the vehicle forward, e.g. in highway cruising, it is so employed. **Under other circumstances, e.g. in traffic, the electric motor alone drives the vehicle forward** and the internal combustion engine is used only to charge the batteries as needed.

(Ex. 1003 at 7:8-16, emphasis added).

> It will be appreciated that according to the invention the internal combustion **engine is run only in the near vicinity of its most**

> **efficient operational point, that is, such that it produces 60-90% of its maximum torque** whenever operated.

(Ex. 1003 at 20:63-67, emphasis added).

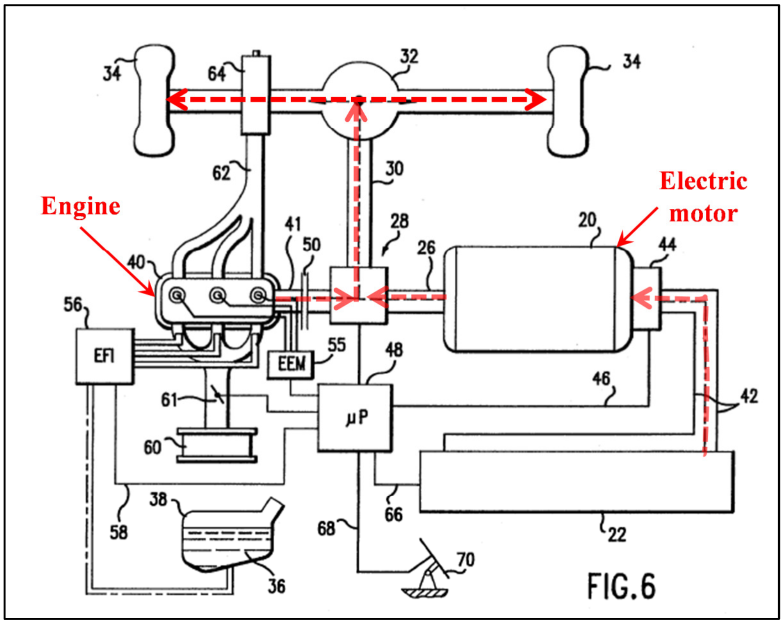
469. As discussed above in [23.1], Severinsky '970 discloses the efficient output power condition as being between 60-90% of the engine's maximum torque output. The 60% torque value is the lower predetermined torque value (i.e., "*SP*").

470. Severinsky '970 discloses using the engine **and** the motor to propel the vehicle when the instantaneous torque required for propulsion of the vehicle is greater than the engine's maximum torque output. For example, the engine and motor drive the vehicle during hill climbing or acceleration:

> When necessary for acceleration or hill climbing, the electric motor is operated to add its torque to that provided by the internal combustion engine.

(Ex. 1003 at 6: 43-45).

471. More specifically, Severinsky '970 illustrates and discloses using the engine and motor to supply torque to the wheels in a "acceleration/hill climbing mode" in Fig. 6, as annotated below. The dashed lines show the flow of energy from both the engine and the motor to propel the wheels.



(Ex. 1003, Fig. 6, annotated)

472. In describing Fig. 6, Severinsky ’970 discloses:

> **FIG. 6 illustrates operation of the system in a high-speed <u>acceleration and/or hill climbing mode, wherein both internal combustion engine 40 and electric motor 20 provide torque to road wheels 34</u>.** Accordingly, electrical energy, as shown by the dot-dash line, flows from battery 22 to motor 20; additionally, gasoline or another combustible fuel flows from tank 38 to EFI unit 56 so that both internal combustion engine 40 and electric motor 20 can supply torque indicated by the dashed lines to road wheels 34. Again, **microprocessor 48 controls operation of both motor 20 and internal combustion engine 40** through switching unit 44 and EFI unit 56, respectively.

(Ex. 1003 at 14:22-35, emphasis added).

473. The ’347 Patent also admits that Severinsky ’970 discloses

employing both the motor and the engine when the torque required for propulsion of the vehicle exceeds the engine MTO, the '347 Patent stating

> As in the '970 patent, the engine is sized so that it provides sufficient power to maintain the vehicle in a range of suitable highway cruising speeds, while being operated in a torque range providing good fuel efficiency; if additional power is then needed, e.g., for hill-climbing or passing, the traction and/or starter motors can be engaged as needed.

(Ex. 1001 at 18:25-30, *see also* 36:22-46).

474. Since Severinsky '970 discloses that the engine is only run at the most efficient range, it is my opinion that the motor is operated to provide extra torque when the instantaneous torque required for propulsion of the vehicle is greater than MTO (i.e. 90%).

475. A person of ordinary skill in the art would understand that "acceleration/hill climbing mode" would be the same as "acceleration mode" where both acceleration and hill climbing have high torque requirements on the vehicle.

476. Therefore, it is my opinion that Severinsky '970 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.*"

E. Claim 9

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

477. It is my understanding that the term "setpoint SP" is proposed to mean a "predetermined torque value."

478. I also understand that the term "road load," or "RL," as used in the '347 Patent, is proposed to mean "the instantaneous torque required for propulsion of the vehicle, which may be positive or negative in value."

479. It is my understanding that claim 9 should be interpreted as "*wherein said operating modes further include a low-speed battery charging mode II, entered while the instantaneous torque required for propulsion of the vehicle, which may be both positive and negative, in value is greater than a predetermined*

torque value and the state of charge of the battery is below a predetermined level, and during which said vehicle is propelled by torque provided by said second electric motor in response to energy supplied from said battery, and wherein said battery is simultaneously charged by supply of electrical energy from said first electric motor, being driven by torque in excess of the predetermined torque value by said internal combustion engine, the combination of said engine and said first motor being disengaged from said wheels during operation in mode II."

480. Severinsky '970 discloses that the engine is operated in its most efficient conditions of output power and speed. When the output power and speed are below the engine's most efficient operating condition, the motor is disclosed as being used to propel the vehicle:

> More particularly, according to the invention, the internal combustion engine is operated only under the <u>**most efficient conditions of output power and speed**</u>. When the engine can be used efficiently to drive the vehicle forward, e.g. in highway cruising, it is so employed. Under other circumstances, e.g. in traffic, the electric motor alone drives the vehicle forward and the internal combustion engine is used only to charge the batteries as needed.

(Ex. 1003 at 7:8-16, emphasis added).

> It will be appreciated that according to the invention the internal combustion <u>**engine is run only in the near vicinity of its most efficient operational point, that is, such that it produces 60-90% of its maximum torque**</u> whenever operated.

(Ex. 1003 at 20:63-67, emphasis added).

481. As discussed above in [23.1], Severinsky ’970 discloses the efficient output power condition as being between 60-90% of the engine’s maximum torque output. The 60% torque value is the lower predetermined torque value (i.e., “*SP*”).

482. As discussed above in paragraphs 109-111, it is generally known in the state of the art that all engines have a “sweet spot” range, such as 60-90% of MTO, where torque is efficiently produced. It is also understood that this “sweet spot” range will vary from engine to engine.

483. Further, as previously discussed in claim 23, Severinsky ’970 discloses that the engine is activated to operate *only* at or near its maximum efficiency, at which point the engine torque output is well below the maximum torque output:

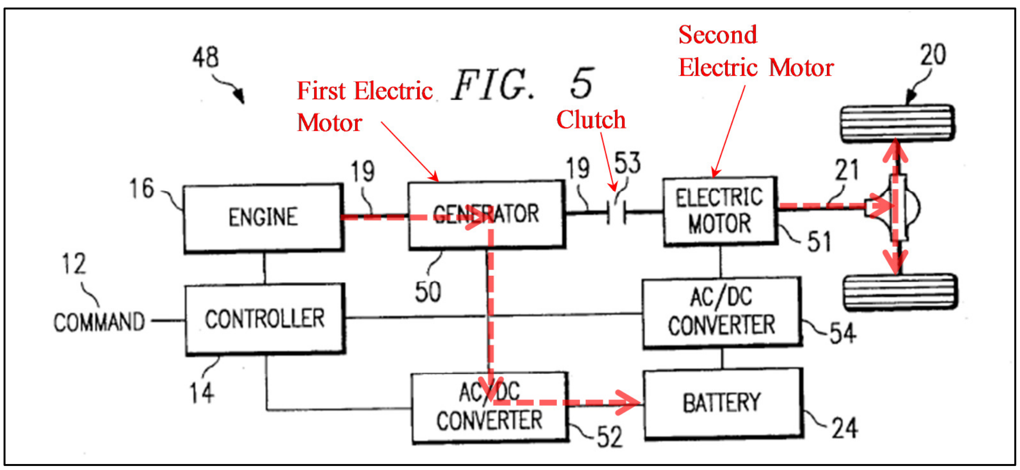
> According to the invention, these parameters are optimized so as to ensure that **the engine is operated at all times at its maximum point of efficiency**, and such that the driver need not consider the power source being employed at any given time.

(Ex. 1003 at 21:34-38, emphasis added).

484. Severinsky ’970 further discloses controlling electric machines based on a predetermined torque value or “setpoint.” Severinsky ’970 discloses that the engine is activated to operate only at or near its maximum efficiency, at which point the engine torque output is well below the maximum torque output.

However, Severinsky '970 does not disclose a "*first electric motor*" that is used to charge the batteries in a "*low-speed battery charging mode II*".

485. Again, as I discuss in the "Motivation to Combine" section (paragraphs 328-342) above it would have been obvious to add the "*first electric motor*" disclosed by Ehsani as illustrated in Fig. 5, reproduced below. Based on Fig. 5 in Ehsani, it would have been obvious that the when the clutch is disengaged, the engine could drive the "*first electric motor*" to charge the battery, and the "*second electric motor*" could provide low speed propulsion to the wheels, as illustrated below.



(Ex. 1004, Fig. 5, annotated)

486. Indeed Ehsani expressly teaches this operation.

> FIG. 5 illustrates an alternate embodiment, ELPH system 48, in which electric machine 18 comprises separate generator 50 and electric motor 51, and converter 22 comprises first converter 52 and

> second converter 54. In the embodiment, ELPH system 48 also includes clutch 53 mechanically coupled between generator 50 and electric motor 51. **<u>Furthermore, generator 50 is mechanically coupled to engine 16 and electric motor 51. Generator 50 is also electrically coupled to first converter 52. First converter 52 is an AC to DC converter. First converter 52 is also electrically coupled to controller 14 and battery 24</u>**. Second converter 54 is electrically coupled to controller 14, electric motor 51 and battery 24.
>
> In operation of this embodiment, generator 50 can be much smaller than electric motor 51 because it only provides steady state charging at a much lower level than the peaking power of electric motor 51**. <u>This allows charging of battery 24 even during idling of engine 16</u>**. Furthermore, engine 16 can be started by generator 50, while it is disengaged from the drive shaft 21 by clutch 51.

(Ex. 1004 at at 8:15-34, emphasis added).

487. Based on this disclosure in Ehsani, it would have been obvious that when the battery was low, the clutch could be disengaged and the engine could be used to drive the "*first electric motor*" (i.e., generator 50) to charge the battery. Indeed, such an operation was known by a person of ordinary skill in the art that the engine and "*first electric motor*" (i.e., generator) could be decoupled from the drive wheels using the clutch, and the "*second electric motor*" could propel the vehicle while the engine and "*first electric motor*" are used to charge the battery. (Ex. 1025 at 8). Again, the "*second electric motor*" could provide the torque

required for propulsion of the vehicle at low speeds, which may be both positive and negative, in value is greater than a predetermined torque value and the state of charge of the battery is below a predetermined level,

488. A person of ordinary skill in the art would have understood that the electric motor 51 was running on energy supplied said battery 24 via the AC/DC converter 54.

489. Therefore, it is my opinion that Ehsani combined with Severinsky ’970 disclose the limitations of claim 9 “*wherein said operating modes further include a low-speed battery charging mode II, entered while RL<SP and the state of charge of the battery is below a predetermined level, and during which said vehicle is propelled by torque provided by said second electric motor in response to energy supplied from said battery, and wherein said battery is simultaneously charged by supply of electrical energy from said first electric motor, being driven by torque in excess of SP by said internal combustion engine, the combination of said engine and said first motor being disengaged from said wheels during operation in mode II.*”

F. Claim 15

490. Claim 15 depends from claim 1 and further recites “*wherein regenerative charging of the battery is performed when the instantaneous torque output by the internal combustion engine>RL, when [RL] is negative, or when*

braking is initiated by the operator."

491. It is my understanding that the term "setpoint SP" is proposed to mean a "predetermined torque value."

492. I understand that the term "road load," or "RL," is proposed to mean "the instantaneous torque required for propulsion of the vehicle, which may be positive or negative in value."

493. Further, it is my understanding that "OR" within the claim is meant to be interpreted to mean "Element A" or "Element B" or "Element C," as follows:

Element A - performing regenerative charging of the battery when the engine's instantaneous torque output is greater than the instantaneous torque required for propulsion of the vehicle, which may be positive or negative in value,

Element B - performing regenerative charging of the battery when … the instantaneous torque **required** for propulsion of the vehicle, which may be positive or negative in value, is negative, **OR**

Element C - performing regenerative charging of the battery when … when braking is initiated by the **operator**.

494. It is further my understanding that the claim limitation is disclosed by the prior art if any one of the three limitations is satisfied.

495. As discussed above in reference to claim 23, element [23.10],

Severinsky ’970 satisfies Element A, Element B, and Element C.

496. First, Severinsky ’970 discloses “Element A” by using excess engine output torque to recharge the battery:

> Microprocessor 48 monitors the operator’s inputs and the vehicle’s performance, and activates electric motor 20 when torque in excess of the capabilities of engine 40 is required. **<u>Conversely, if excess engine torque is available (see the discussion of FIG. 7 below) it can be transformed into electrical energy in motor 20 and stored by battery 22</u>**.

(Ex. 1003 at 14:15-21, emphasis added).

497. Severinsky ’970 further discloses “Element B” when battery charging occurs during and during downhill stretches (i.e. negative road load). A person of ordinary skill in the art would understand that when a vehicle starts down a hill, that the torque required to propel the vehicle, may be negative due to the hill gradient:

> However, **<u>when the vehicle starts down a hill,</u>** and the operator lifts his foot from the accelerator pedal, **<u>the kinetic energy of the vehicle and the engine's excess torque may be used to drive the motor 20 as a generator so as to charge the batteries</u>**. If the vehicle then starts to climb a hill, the motor 20 is used to supplement the output torque of engine 40.

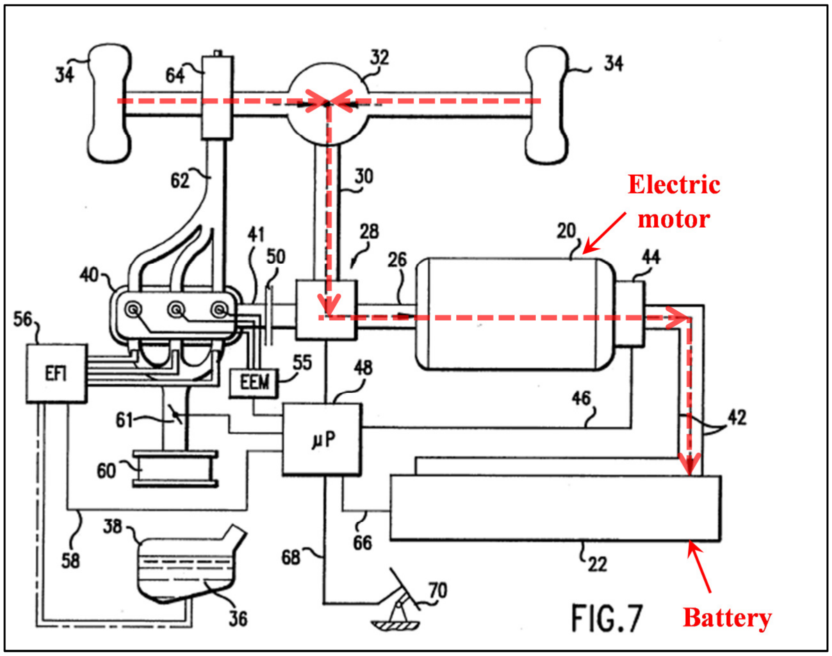
(Ex. 1003 at 10:26-4, emphasis added 3).

498. Severinsky ’970 also discloses “Element B” by using the kinetic

energy of the vehicle during a "coasting mode." Specifically Severinsky '970 discloses that when the vehicle is on a "downhill stretch" the kinetic energy of the vehicle is fed back from the road wheels and the "motor 20" is operated as a generator to charge the batteries:

> FIG. 7 depicts operation of the system in a regenerative braking or coasting mode, wherein electrical energy is generated by motor 20, rectified in switching unit 44 and fed back to charge batteries 22, as indicated by the position of the arrow head on the dot-dash line connecting switching unit 44 to batteries 22. **Under the control of microprocessor 48, the** …**coasting mode can be entered** … indicated schematically at 70, … **on downhill stretches**. **In this mode the kinetic energy of the vehicle is fed back from road wheels 34** and differential 32 via drive shaft 30 to torque transfer unit 28 to electric motor 20; microprocessor 48 controls appropriate operation of switching unit 44 (see FIGS. 12 and 13) **to generate rectified DC for storage in battery 22 from AC provided by motor 20**.

(Ex. 1003 at 14:37-53, emphasis added).



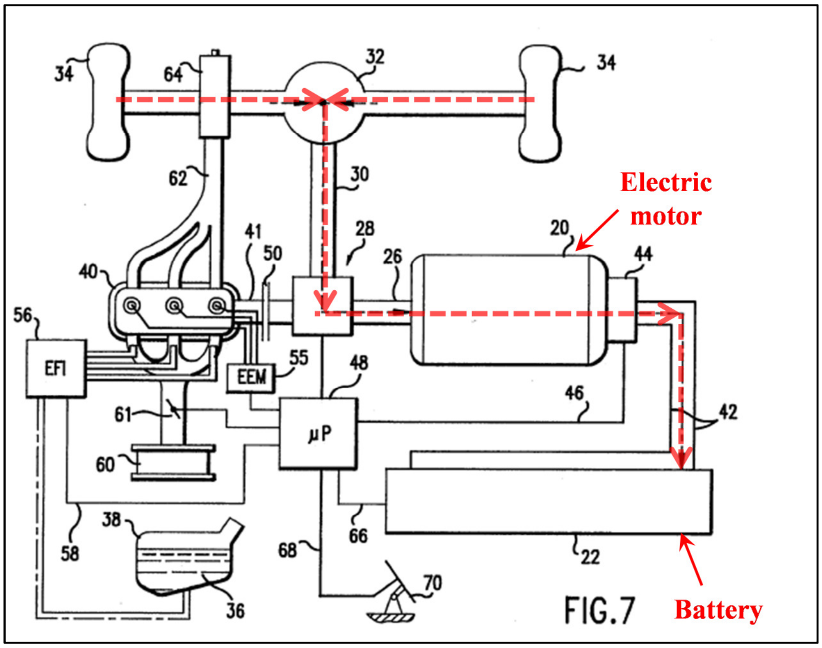
(Ex. 1003, Fig. 7, annotated)

499. It is my opinion that during such "downhill stretches" the "instantaneous torque required for propulsion of the vehicle" is negative. My opinion is based on simple physics of the vehicle that would have been known prior to September 1998. Specifically, it would have been understood that when a vehicle transitions from either a level road or from a prior uphill descent, the "instantaneous torque required for propulsion of the vehicle" would suddenly drop and would become negative because the mass of the vehicle and gravity would begin to propel the vehicle downhill. Such a common known physics principle would be understood by a person whom has driven a vehicle on a hilly terrain and had to either lift their foot off the accelerator pedal or press down on the brake when travelling downhill.

500. With reference to Fig. 7, produced below, Severinsky '970 also discloses limitation "C" during a "recharge mode" when braking is initiated by the operator:

> FIG. 7 depicts operation of the system in a regenerative braking or coasting mode, wherein electrical energy is generated by motor 20, rectified in switching unit 44 and fed back to charge batteries 22, as indicated by the position of the arrow head on the dot-dash line connecting switching unit 44 to batteries 22. Under the control of microprocessor 48, **<u>the regenerative braking[] mode can be entered whenever the driver removes his foot from an accelerator pedal and depresses a brake pedal</u>**, [] indicated schematically at 70… In this mode the kinetic energy of the vehicle is fed back from road wheels 34 and differential 32 via drive shaft 30 to torque transfer unit 28 to electric motor 20; microprocessor 48 controls appropriate operation of switching unit 44 (see FIGS. 12 and 13) to generate rectified DC for storage in battery 22 from AC provided by motor 20.

(Ex. 1003 at 14:37-53, emphasis added).



(Ex. 1003, Fig. 7, annotated)

501. Severinsky ’970 further recognizes that the hybrid vehicle performs regenerative braking throughout the specification:

> The motor is operable as a generator to charge the batteries as needed and also for regenerative braking.

(Ex. 1003 at Abstract).

> The battery 22 is charged by power generated by the motor 20 when operated as a generator, that is, when driven by the engine 40 by way of the controllable torque transfer unit 28, or in a regenerative braking mode.

(Ex. 1003 at 9:67-10-4).

> The operator input devices 70 may include accelerator and brake pedals, directional control switches, and the like. Pressure on the

> accelerator pedal indicates to the microprocessor that more power is required; pressure on the brake causes the microprocessor to initiate regenerative braking, as discussed below.

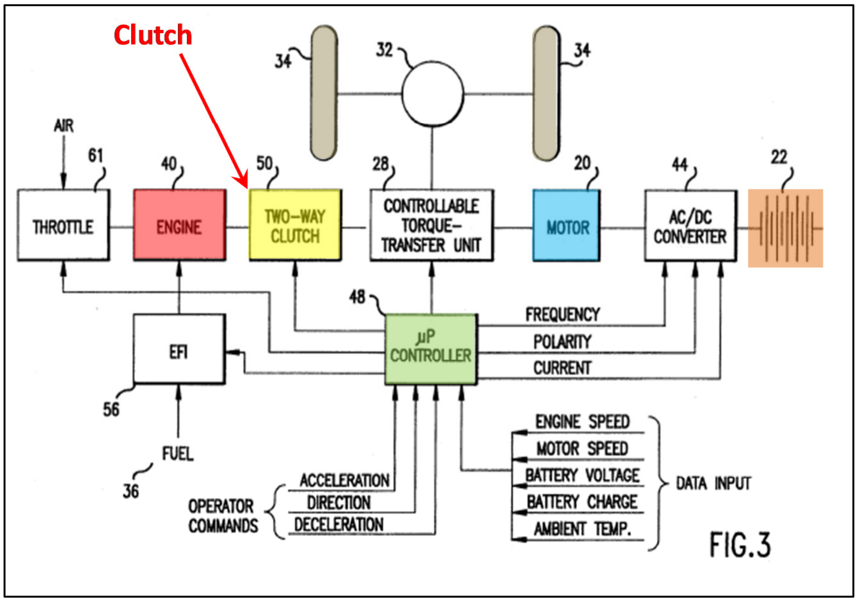
(Ex. 1003 at 13:18-21).

502. Therefore, it is my opinion that Severinsky '970 discloses all of the limitations of claim 36 including "*performing regenerative charging of the battery when the engine's instantaneous torque output is greater than the torque required for propulsion of the vehicle, when torque required to propel the vehicle is negative, or when braking is initiated by the operator*."

G. Claim 21

503. Claim 21 depends from claim 1, and further recites "wherein said engine is controllably coupled to road wheels of said vehicle by a clutch."

504. Severinsky '970 illustrates and discloses, in Fig. 3, annotated and reproduced below, that the engine is connected by way of a clutch (yellow) to the road wheels. The controller selectively engages the clutch to enable torque flow from the engine to the wheels.



(Ex. 1003, Fig. 3, annotated)

505. Severinsky ’970 further describes the clutch in Fig. 3:

FIG. 3 shows a block diagram of the drive system of the vehicle according to the invention. **Internal combustion engine 40 is connected by way of a two-way clutch 50 to a controllable torque transfer unit 28**. The torque transfer unit 28 receives torque from engine 40 and/or from alternating current electric motor 20 and transmits this torque to the drive wheels 34 of the vehicle by way of a conventional differential 32. The motor 65 20 receives power from a bi-directional AC/DC power converter 44 comprising a solid-state switching network connected in turn to a battery 22. The battery 22 is charged by power generated by the motor 20 when operated as a generator, that is, when driven by the engine 40 by way of the controllable torque transfer unit 28, or in a regenerative braking mode. **A microprocessor controller 48 controls** the rate of supply of fuel to engine 40 as indicated at 56, controls the opening of a throttle 61 by which the engine 40 receives intake air from the atmosphere for combusting the fuel, **controls the operation of the two-way clutch 50**, controls the operation of the torque transfer unit 28, and controls bi-directional flow of power between the battery 22 and the motor 20 through frequency, current, and polarity signals passed to the bi-directional AC/DC power converter 44.

(Ex. 1003 at 9:58-10:14, emphasis added).

506. Therefore, it is my opinion that Severinsky '970 discloses "*wherein said engine is controllably coupled to road wheels of said vehicle by a clutch.*"

X. GROUND 3– CLAIMS 1, 6, 7, 9, 15, AND 21 ARE OBVIOUS OVER EHSANI IN VIEW OF U.S. 5,343,970

507. Ehsani discloses the hybrid vehicle architecture having an engine, two motors, battery, and a controller. Severinsky '970 discloses and a control strategy for controlling the engine in an efficient range. It is my opinion it would have been obvious to combine Ehsani with Severinsky '970 to achieve the limitations of claims 1, 6, 7, 9, 15, and 21 of the '347 Patent.

A. Motivation to Combine

508. Ehsani discloses multiple hybrid vehicle architectures.

509. Ehsani also discloses controlling these architectures to improve the "poor fuel economy" typically experienced in conventional vehicles. (Ex.1004, at 2:8-14).

> An additional technical advantage of the present invention is its fuel efficiency, which is typically 2.8 times the current ICE vehicle.

(Ex.1004, at 2:63-65)

510. Similarly, Severinsky '970 discloses implementing a control strategy to limit engine operation above a predetermined torque value will yield improvement in fuel economy on the order of 200-300% and similar reductions in carbon dioxide emissions. (*See* Ex. 1003 at 20:63-21:8).

511. Both Ehsani and Severinsky '970 recognized the problem with conventional engines that are operated below the maximum efficiency range. Ehsani states:

> The engine is sized to deliver the maximum power that the driver is likely to ask for, even though most of the time the driver requires much less than the maximum power. This makes the engine much larger than the average demand required. **<u>The basic problem with such a large engine is that most of the time it will be running at far less than its maximum power, and therefore below its maximum efficiency.</u>** Having a large engine and running it far below its optimum efficiency are the two fundamental reasons for the poor fuel economy of the conventional ICE vehicle.

(Ex.1004, at 2:4-11, emphasis added).

512. Severinsky '970, similar to Ehsani, recognized the problem with a larger engine in conventional vehicles:

> FIG. 1 thus demonstrates that **an internal combustion engine having sufficient horsepower for adequate acceleration and hill climbing capability must be so oversized with respect to the loads encountered during most normal driving that the engine is grossly inefficient in its consumption of fuel.**

(Ex. 1003 at 8:44-49, emphasis added)

513. Both Severinsky '970 and Ehsani teach hybrid vehicle architectures and control strategies for improving fuel efficiency over conventional vehicles.

514. Severinsky '970 discloses an upper improved fuel economy of 300% over conventional vehicles. Again, Ehsani discloses an upper improved fuel economy of 280% over conventional vehicles. Severinsky '970 therefore teaches a control strategy that could potentially increase the fuel economy over conventional vehicles by an additional 20% (i.e., 300%-280%). A person of ordinary skill in the art would have been motivated to try to incorporate the control techniques in Severinsky '970 with Ehsani to achieve this additional 20% improvement in fuel economy. In fact, a person having ordinary skill would have attempted an alternate control strategy to gain even 1% improvement in fuel economy as any improvement in fuel economy is beneficial to vehicle designs.

515. In fact is possible to experiment with different control strategies when seeking to improve fuel efficiency and economy.

516. Ehsani even reinforces this idea and discloses that "alternative control

techniques" could be used to control both the engine and motors for the hybrid vehicle architectures illustrated.

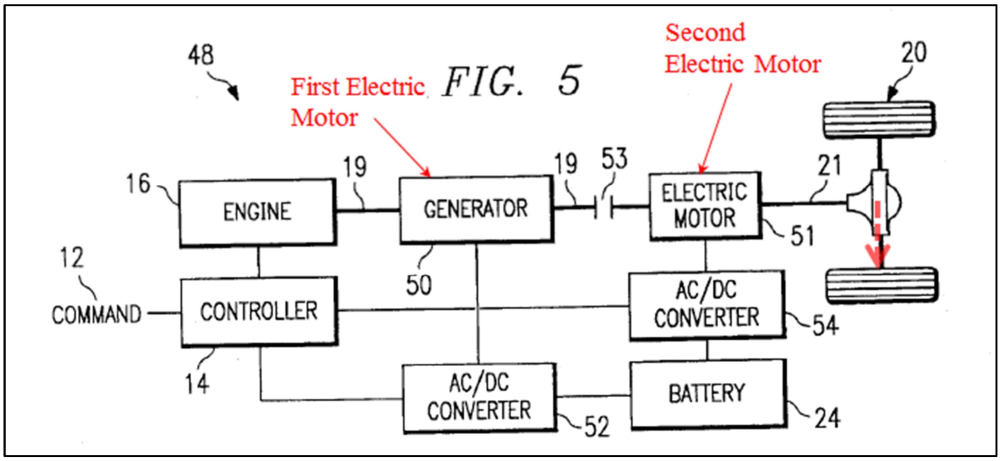
517. For example, Ehsani specifically states: **"Other control techniques may also be used without departing from the intended scope herein**." (*See* Ex.1004 at 7:6-14).

518. Again Ehsani discloses a control strategy that provides a 280% (i.e. 2.8 times) improvement in fuel efficiency over conventional vehicles. Severinsky '970 discloses up to a 300% improvement in fuel economy over conventional vehicles. As such, a person of ordinary skill in the art would have been motivated to try the control strategy of Severinsky '970 in order to achieve a potential 20% further improvement in fuel economy over the control strategy disclosed by Ehsani.

519. In the automotive setting a 20% improvement in fuel economy is substantial.

520. Based on Ehsani, a person of ordinary skill in the art would be motivated to modify Ehsani to control the engine output as described in Severinsky '970 to further improve fuel economy.

521. A person of ordinary skill in the art would have understood the architecture in Ehsani, as shown in in Fig. 5 below, as well as the '347 Patent, were commonly referred to as a "series-parallel" hybrid architecture.

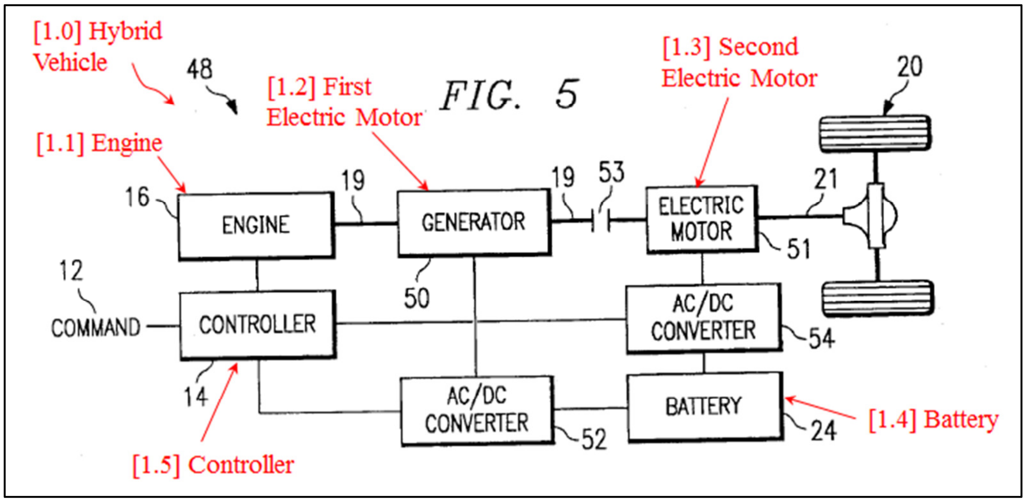


522. This architecture was disclosed by Ehsani in 1992 and was widely known by September 1998, as discussed in the paragraphs 92-103 (*see* also 87-91) above.

523. Therefore, it is my opinion that a person of ordinary skill in the art would have been motivated to use the series-parallel architecture disclosed in Fig. 5 of Ehsani in combination with the engine control strategy in Severinsky '970, as the '347 Patent purports to do, to further improve fuel efficiency and emission in hybrid vehicles.

B. Claim 1

524. I understand that claim 1 is directed to a hybrid vehicle, whereas claim 23 is directed to a method of controlling a hybrid vehicle. I understand that claim 1 includes elements that recite the structure of the hybrid vehicle and these structural elements are disclosed by Ehsani, as generally annotated in Fig. 5 of Ehsani, reproduced below.

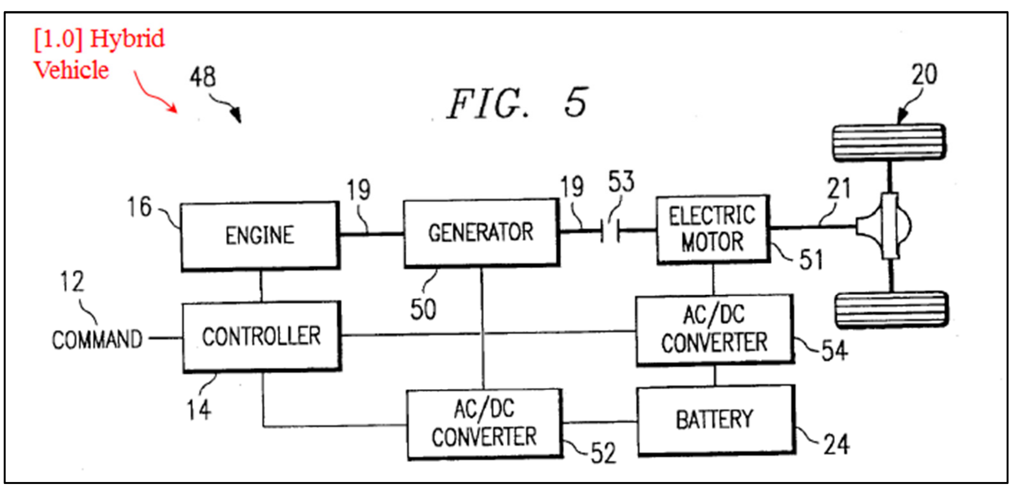


(Ex. 1004, Fig. 5, annotated)

… ***[1.0] A hybrid vehicle, comprising:***

525. Ehsani discloses a hybrid vehicle, both in the title and claims. For example, Ehsani is titled "Electrically Peaking Hybrid System and Method." I also understand that Ehsani claims a "hybrid electric-combustion vehicle drive system…" in claim 1. (Ex. 1004 at 9:14-15).

526. Ehsani also illustrates several hybrid vehicle architectures, such as hybrid system in Fig. 5.



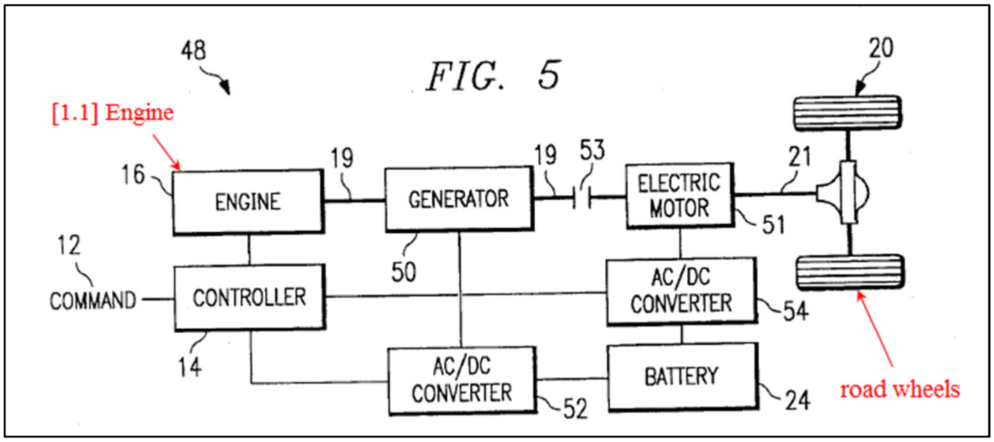
(Ex. 1004, Fig. 5, annotated)

527. With reference to Fig. 5, Ehsani discloses: "where the electric machine functions of electric propulsion and battery charging are divided between **two electric machines**." (Ex. 1004 at 3:23-26, emphasis added).

528. Based on the title, claims and figures, such as Fig. 5, it is my opinion that Ehsani disclosed "*a hybrid vehicle*."

… ***[1.1] an internal combustion engine controllably coupled to road wheels of said vehicle;***

529. Ehsani illustrates and discloses an internal combustion engine controllably coupled to the wheels, in Fig. 5, for example, reproduced below with annotations. Based on Fig. 5 in Ehsani, a person of ordinary skill in the art would understand that engine 16 is connected to the road wheels 20. Also, based on Fig. 5, a person of ordinary skill in the art would understand that the engine 16 could be controllably coupled/decoupled using the clutch 53 and the controller 14. A person of ordinary skill in the art would have understood a clutch is controlled in order to be connected and disconnected.



(Ex. 1004, Fig. 5, annotated)

530. Ehsani also discloses that the engine is electrically coupled to the controller and is mechanically coupled to the wheels:

> **<u>Controller 14 is electrically coupled to engine 16</u>** and converter 22. Engine 16 is mechanically coupled to electric machine 18 through link 19. Electric machine 18 and **<u>engine 16 are mechanically coupled through drive shaft 21 to propulsion device 20</u>**.

(Ex. 1004 at 3:47-52, emphasis added).

531. Ehsani further discloses the controller 14 controlling the engine:

> **<u>Controller 14 manages the system power by controlling engine 16</u>**, converter 22, and battery 24. Controller 14 may also monitor and control the energy used by the traction motors, coolant pump, air conditioner compressor, and other system loads in a vehicle. **<u>Controller 14 may control engine 16 through several alternative control techniques</u>**.

(Ex. 1004 at 7:1-6, emphasis added).

532. Ehsani further describes the engine:

> Engine 16 may comprise any one of many available thermal engines, such as the conventional four-stroke engine, a gas turbine, a Wankle engine, and a two-stroke engine, for example. Other thermal engines may also be used without departing from the intended scope herein.

(Ex. 1004 at 4:60-64).

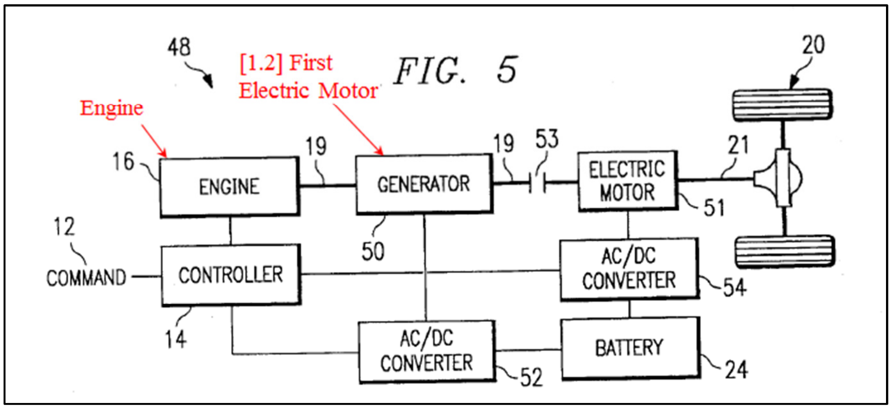
533. Based on the disclosure in Ehsani, a person of ordinary skill in the art would understand that Ehsani discloses that the engine is coupled/decouple to the wheels by the clutch 53. The engine and the clutch are controlled based on the requirements of the vehicle and mode of operation. For example, a person of ordinary skill in the art would understand that the clutch "allows for decoupling of drive shaft 21" to allow the engine to be decoupled from the wheels in order to be driven at a different speed. (Ex. 1004 at 7:61-62).

534. Therefore, it is my opinion that Ehsani discloses "*an internal combustion engine [16] controllably coupled to road wheels [20]*."

… ***[1.2] a first electric motor connected to said engine nd [sic] operable to start the engine responsive to a control signal;***

535. Ehsani illustrates and discloses first electric motor connected to the engine, in Fig. 5, for example, reproduced below with annotations. In describing Fig. 5, Ehsani also states that "engine 16 can be started by generator 50, while it is disengaged from the drive shaft 21 by clutch 51." (Ex. 1004 at 8:33-35).

536. Ehsani also discloses that the electric machines have a "dual functionality to act as a motor and as a generator." (Ex. 1004 at 4:33-34).



(Ex. 1004, Fig. 5, annotated)

537. The term "electric machine" is generically used to describe a "generator," a "motor" or "motor-generator". "Motor, "generator" and "motor-generator" are all used synonymously to describe an electric machine that can be operated to in two modes to provide two functions.

538. For instance, the '347 Patent references the Bosch Automotive Handbook. A person of ordinary skill in the art understands the Bosch Automotive Handbook is a common reference book in the automotive industry. The October 1996 4th edition of the Bosch Automotive Handbook identifies that electric machines are capable of operating as "an electric motor" that converts electrical energy into mechanical energy and as "a generator" when operated in the "opposite direction." (Ex. 1031 at 10)

539. This 1996 Bosch Handbook further describes hybrid architectures that were known at the time of publishing. The handbook specifically states that with reference to hybrid architectures that the "letters M and G indicate whether the operation of the electric machines is motor or generator-based." (Ex. 1031 at 16).

540. Ehsani further emphasizes the dual modes of an electric machine and states:

> The **electric machine** 18 has the dual functionality of providing additional mechanical energy to drive shaft 21 from energy from the battery 24 in the first mode of operation (**motor function**), and providing electrical energy for storage in battery 24 in the second mode of operation (**generator function**).

(Ex. 1004 at 5:25-30, emphasis added).

541. Therefore, a person of ordinary skill in the art would understand that Ehsani' s Fig. 5 illustrating a generator also discloses a motor when operated in a second mode.

542. It was also well known to a control signal to start the engine. A person of ordinary skill in the art would understand that control signal from a controller, such as controller 14 in Fig. 5, could be based on a driver input to start the vehicle or a vehicle input based on operation mode, for example.

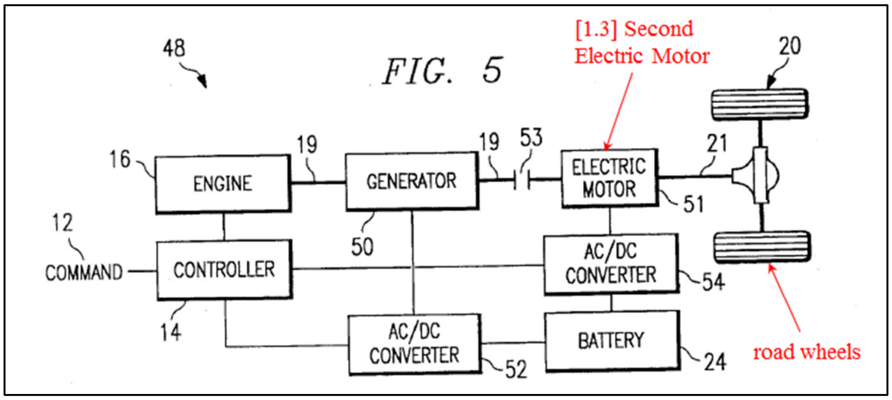
543. Therefore, a based on Fig. 5, Ehsani discloses generator 50 is connected to the engine via the link 19 and could act as a starter motor to start the

engine based on a control signal from the controller 14 when Ehsani states "engine 16 can be started by generator 50". (Ex. 1004 at 8:33-35).

544. Therefore, it is my opinion that Ehsani discloses "*a first electric motor [generator 50] connected to said engine [16] operable to start the engine responsive to a control signal.*"

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

545. Ehsani illustrates and discloses a second electric motor connected to the road wheels, in Fig. 5, for example, reproduced below with annotations. Ehsani also discloses that the electric machines have a "dual functionality of providing additional mechanical energy to drive shaft 21from energy from the battery 24 in the first mode of operation (motor function), and providing electrical energy for storage in battery 24 in the second mode of operation (generator function)." (Ex. 1004 at 5:25-31).



(Ex. 1004, Fig. 5, annotated)

546. As discussed above with regard to [1.2], it was well known to a person of ordinary skill in the art that electric motors could operate in two directions to apply torque when operated in a first direction, and generate electricity when operated in a second direction to accept torque.

547. Based on Fig. 5 in Ehsani, it would have been known to use the electric motor 51, to provide torque to the wheels (20) when the motor 51 is operated in a motor mode. Likewise, it would have been known that the motor 51 would act as a generator to provide current to the battery (24) via the AC/DC converter (54) when the motor is operated in a generator mode.

548. Ehsani further clarifies that the wheels (20) can drive the electric motor:

> In certain situations the drive shaft 21 and **propulsion device 20 will also provide mechanical energy that can be converted into electrical energy for storage**. For example, when the vehicle is

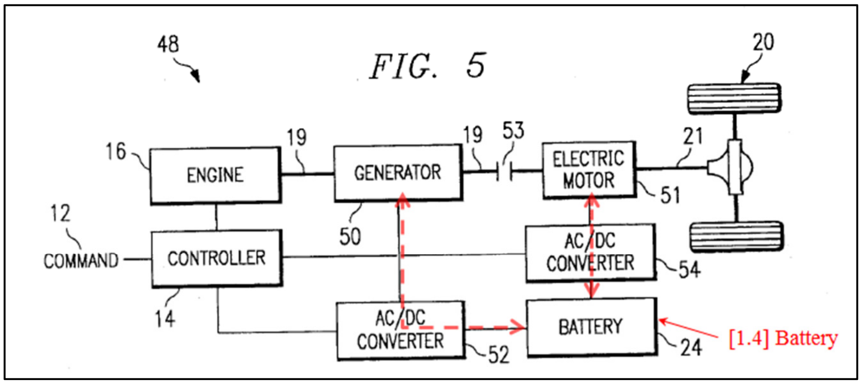
traveling down hill, the **drive train 21 will actually be driving electric machine 18, allowing for generation and storage of electrical energy**.

(Ex. 1004 at 4:46-52, emphasis added).

549. Therefore, it is my opinion that Ehsani discloses "*a second electric motor [51] connected to road wheels [20] of said vehicle, and operable as a motor, to apply torque to said wheels to propel said vehicle, and as a generator, for accepting torque from at least said wheels for generating current.*"

… ***[1.4] a battery, for providing current to said motors and accepting charging current from at least said second motor; and***

550. Ehsani illustrates and discloses a battery 24 connected to both the first motor (50) and second motor (51) by AC/DC converters, in Fig. 5, reproduced below with annotations. Ehsani also discloses that the electric machines have a "dual functionality of **providing additional mechanical energy to drive shaft 21 from energy from the battery 24** in the first mode of operation (motor function), and **providing electrical energy for storage in battery 24** in the second mode of operation (generator function)." (Ex. 1004 at 5:25-31, emphasis added).



(Ex. 1004, Fig. 5, annotated)

551. In describing Fig. 5, Ehsani also discloses that AC/DC converters are connected between the battery and the first and second motors:

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

(Ex. 1004 at 8:22-28).

552. A battery stores and provides DC electric energy. An AC/DC converter converts AC electric energy from the electric machines to DC electric energy that is stored in the battery and vice versa.

553. A person of ordinary skill in the art would understand that the battery 24 in Fig. 5 of Ehsani provides useable energy to the motors. As discussed above with regard element [1.2] (¶¶ 535-542), Ehsani discloses using the generator 50 as a "*first electric motor*" to start the engine by using the electric current from the